

**NATIONAL SCIENCE FOUNDATION
2010
ENGINEERING SENIOR DESIGN
PROJECTS TO AID PERSONS WITH
DISABILITIES**



**Edited By
John D. Enderle**

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Creative Learning Press, Inc.
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FOREWORD

Welcome to the twenty-second annual issue of the National Science Foundation Engineering Senior Design Projects to Aid Persons with Disabilities. In 1988, the National Science Foundation (NSF) began a program to provide funds for student engineers at universities throughout the United States to construct custom designed devices and software for individuals with disabilities. Through the Bioengineering and Research to Aid the Disabled¹ (BRAD) program of the Emerging Engineering Technologies Division of NSF², funds were awarded competitively to 16 universities to pay for supplies, equipment and fabrication costs for the design projects. A book entitled NSF 1989 Engineering Senior Design Projects to Aid the Disabled was published in 1989, describing the projects that were funded during the first year of this effort.

In 1989, the BRAD program of the Emerging Engineering Technologies Division of NSF increased the number of universities funded to 22. Following completion of the 1989-1990 design projects, a second book was published describing these projects, entitled NSF 1990 Engineering Senior Design Projects to Aid the Disabled.

North Dakota State University (NDSU) Press published the following three issues. In the NSF 1991 Engineering Senior Design Projects to Aid the Disabled almost 150 projects by students at 20 universities across the United States were described. The NSF 1992 Engineering Senior Design Projects to Aid the Disabled presented almost 150 projects carried out by students at 21 universities across the United States during the 1991-92 academic year. The fifth issue described 91 projects by students at 21 universities across the United States during the 1992-93 academic year.

¹ The program name is now called the General & Age-Related Disabilities Engineering program.

² This program is now in the Division of Chemical, Bioengineering, Environmental, and Transport Systems (CBET).

Creative Learning Press, Inc. has published the succeeding volumes. The NSF 1994 Engineering Senior Design Projects to Aid the Disabled, published in 1997, described 94 projects carried out by students at 19 universities during the academic 1993-94 year. The NSF 1995 Engineering Senior Design Projects to Aid the Disabled, published in 1998, described 124 projects carried out by students at 19 universities during the 1994-95 academic year.

The NSF 1996 Engineering Senior Design Projects to Aid Persons with Disabilities, published in 1999, presented 93 projects carried out by students at 12 universities during the 1995-96 academic year. The ninth issue, NSF 1997 Engineering Senior Design Projects to Aid Persons with Disabilities, published in 2000, included 124 projects carried out by students at 19 universities during the 1996-97 academic year. NSF 1998 Engineering Senior Design Projects to Aid Persons with Disabilities, published in 2001, presented 118 projects carried out by students at 17 universities during the 1997-98 academic year. NSF 1999 Engineering Senior Design Projects to Aid Persons with Disabilities, published in 2001, presented 117 projects carried out by students at 17 universities during the 1998-99 academic year.

NSF 2000 Engineering Senior Design Projects to Aid Persons with Disabilities, published in 2002, presented 127 projects carried out by students at 16 universities during the 1999-2000 academic year. In 2002, NSF 2001 Engineering Senior Design Projects to Aid Persons with Disabilities was published, presenting 134 projects carried out by students at 19 universities during the 2000-2001 academic year. NSF 2002 Engineering Senior Design Projects to Aid Persons with Disabilities, published in 2004, presented 115 projects carried out by students at 16 universities during the 2001-2002 academic year. In 2005, NSF 2003 Engineering Senior Design Projects to Aid Persons with Disabilities was published, presenting 134 projects carried out by students at 19 universities during the 2002-2003 academic year.

NSF 2004 Engineering Senior Design Projects to Aid Persons with Disabilities, published in 2005, presented 173 projects carried out by students at 17

universities during the 2003-2004 academic year. In 2006, NSF 2005 Engineering Senior Design Projects to Aid Persons with Disabilities was published, presenting 154 projects carried out by students at 16 universities during the 2004-2005 academic year. NSF 2006 Engineering Senior Design Projects to Aid Persons with Disabilities, published in 2007, presented 152 projects carried out by students at 15 universities during the 2005-2006 academic year. In 2010, NSF 2007 Engineering Senior Design Projects to Aid Persons with Disabilities was published, presenting 139 projects carried out by students at 16 universities during the 2006-2007 academic year. NSF 2008 Engineering Senior Design Projects to Aid Persons with Disabilities, published in 2011, presented 118 projects carried out by students at 12 universities during the 2007-2008 academic year. In 2011, NSF 2009 Engineering Senior Design Projects to Aid Persons with Disabilities was published, presenting 160 projects carried out by students at 19 universities during the 2009-2010 academic year.

This book, funded by the NSF, describes and documents the NSF-supported senior design projects during the twenty-second year of this effort, 2009-2010. After the 5th chapter, each chapter describes the projects carried out at a single university, and was written by the principal investigator(s) at that university and revised by the editor of this publication. Individuals desiring more information on a particular design should contact the designated supervising principal investigator. An index is provided so that projects may be easily identified by topic. Chapters on best practices in design experiences, outcomes assessment, and writing about and working with individuals who have disabilities are also included in this book.

Hopefully this book will enhance the overall quality of future senior design projects, directed toward persons with disabilities, by providing examples of previous projects, and also motivate faculty at other universities to participate because of the potential benefits to students, schools, and communities. Moreover, the new technologies used in these projects will provide examples in a broad range of applications for new engineers. The ultimate goal of this publication, and all the projects built under this initiative, is to assist individuals with disabilities in reaching their maximum potential for enjoyable and productive lives.

This NSF program has brought together individuals with widely varied backgrounds. Through the richness of their interests, a wide variety of projects has been completed and is in use. A number of different technologies were incorporated in the design projects to maximize the impact of each device on the individual for whom it was developed. A two-page project description format is generally used in this text. Each project is introduced with a nontechnical description, followed by a summary of impact that illustrates the effect of the project on an individual's life. A detailed technical description then follows. Photographs and drawings of the devices and other important components are incorporated throughout the manuscript.

Sincere thanks are extended to Dr. Allen Zelman, a former Program Director of the NSF BRAD program, for being the prime enthusiast behind this initiative. Additionally, thanks are extended to Drs. Peter G. Katona, Karen M. Mudry, Fred Bowman, Carol Lucas, Semahat Demir, Robert Jaeger, Gil Devey and Ted Conway, former and current NSF Program Directors of the Biomedical Engineering and Research to Aid Persons with Disabilities Programs, who have continued to support and expand the program.

I acknowledge and thank Lindsay Gaedt for editorial assistance. I also appreciate the technical illustration efforts of Justin Morse. Additionally, I thank Ms. Shari Valenta for the cover illustration and the artwork throughout the book, drawn from her observations at the Children's Hospital Accessibility Resource Center in Denver, Colorado.

The information in this publication is not restricted in any way. Individuals are encouraged to use the project descriptions in the creation of future design projects for persons with disabilities. The NSF and the editor make no representations or warranties of any kind with respect to these design projects, and specifically disclaim any liability for any incidental or consequential damages arising from the use of this publication. Faculty members using the book as a guide should exercise good judgment when advising students.

Readers familiar with previous editions of this book will note that I moved from North Dakota State University to the University of Connecticut in 1995.

With that move, annual publications also moved from NDSU Press to Creative Learning Press Inc. in 1997. During 1994, I also served as NSF Program Director for the Biomedical Engineering and Research Aiding Persons with Disabilities Program while on a leave of absence from NDSU. Brooke Hallowell, a faculty member at Ohio University, became the co-editor of this book series beginning with the 1996 edition and ended with the 2007 edition to devote time to other pursuits.

Previous editions of this book are available for viewing at the web site for this project:

<http://nsf-pad.bme.uconn.edu/>

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**ENGINEERING SENIOR DESIGN
PROJECTS TO AID PERSONS WITH
DISABILITIES**

CHAPTER 1

INTRODUCTION

Devices and software to aid persons with disabilities often require custom modification. They are sometimes prohibitively expensive or even nonexistent. Many persons with disabilities have limited access to current technology and custom modification of available devices. Even when available, personnel costs for engineering and support make the cost of custom modifications beyond the reach of many of the persons who need them.

In 1988, the National Science Foundation (NSF), through its Emerging Engineering Technologies Division, initiated a program to support student engineers at universities throughout the United States in designing and building devices for persons with disabilities. Since its inception, this NSF program (originally called Bioengineering and Research to Aid the Disabled, then Bioengineering and Research to Aid the Disabled, and now the General & Age-Related Disabilities Engineering program) has enhanced educational opportunities for students and improved the quality of life for individuals with disabilities. Students and faculty provide, through their Accreditation Board for Engineering and Technology (ABET) accredited senior design class, engineering time to design and build the device or software. The NSF provides funds, competitively awarded to universities for supplies, equipment and fabrication costs for the design projects.

Outside of the NSF program, students are typically involved in design projects that incorporate academic goals for solid curricular design experiences, but that do not necessarily enrich the quality of life for persons other than, perhaps, the students themselves. For instance, students might design and construct a stereo receiver, a robotic unit that performs a household chore, or a model racecar.

Under this NSF program, engineering design students are involved in projects that result in original devices, or custom modifications of devices, that improve the quality of life for persons with disabilities. The students have opportunities for practical and creative problem solving to address well-defined needs, and while persons with disabilities receive the products of that process at no financial cost. Upon completion, each finished project becomes the property of the individual for whom it was designed.

The emphasis of the program is to:

- Provide children and adults with disabilities student-engineered devices or software to improve their quality of life and provide greater self-sufficiency,
- Enhance the education of student engineers through the designing and building of a device or software that meets a real need, and
- Allow participating universities an opportunity for unique service to the local community.

Local schools, clinics, health centers, sheltered workshops, hospitals, and other community agencies participate in the effort by referring interested individuals to the program. A single student or a team of students specifically designs each project for an individual or a group of individuals. Examples of projects completed in past years include laser-pointing devices for people who cannot use their hands, speech aids, behavior modification devices, hands-free automatic telephone answering and hang-up systems, and infrared systems to help individuals who are blind navigate through indoor spaces. The students participating in this program are richly rewarded through their activity with persons with disabilities,

and justly experience a unique sense of purpose and pride in their accomplishments.

The Current Book

This book describes the NSF supported senior design projects during the academic year 2009-2010. The purpose of this publication is threefold. First, it is to serve as a reference or handbook for future senior design projects. Students are exposed to this unique body of applied information on current technology in this and previous editions of this book. This provides an even broader education than typically experienced in an undergraduate curriculum, especially in the area of rehabilitation design. Many technological advances originate from work in the space, defense, entertainment, and communications industry. Few of these advances have been applied to the rehabilitation field, making the contributions of this NSF program all the more important.

Secondly, it is hoped that this publication will serve to motivate students, graduate engineers and others to work more actively in rehabilitation. This will ideally lead to an increased technology and knowledge base to address effectively the needs of persons with disabilities.

Thirdly, through its initial chapters, the publication provides an avenue for motivating and informing all involved in design projects concerning specific means of enhancing engineering education through design experiences.

This introduction provides background material on the book and elements of design experiences. The second chapter highlights specific aspects of some exemplary practices in design projects to aid persons with disabilities. The third chapter addresses assessment of outcomes related to design projects to aid persons with disabilities. The fourth chapter provides details on enhancing students' writing skills through the senior design experience. The fifth chapter addresses the importance of fostering relationships between students and individuals with disabilities.

After the five introductory chapters, 18 chapters follow, with each chapter devoted to one participating school. At the start of each chapter, the school and the principal investigator(s) are identified. Each project description is written using the following format. On the first page, the

individuals involved with the project are identified, including the student(s), the professor(s) who supervised the project, and key professionals involved in the daily lives of the individual for whom the project has been developed. A brief nontechnical description of the project follows with a summary of how the project has improved a person's quality of life. A photograph of the device or modification is usually included. Next, a technical description of the device or modification is given, with parts specified in cases where it may be difficult to fabricate them otherwise. An approximate cost of the project, excluding personnel costs, is provided.

Most projects are described in two pages. However, the first or last project in each chapter is usually significantly longer and contains more analytic content. Individuals wishing more information on a particular design should contact the designated supervising principal investigator.

Some of the projects described are custom modifications of existing devices, modifications that would be prohibitively expensive were it not for the student engineers and this NSF program. Other projects are unique one-of-a-kind devices wholly designed and constructed by students for specific individuals.

Engineering Design

As part of the accreditation process for university engineering programs, students are required to complete a minimum number of design credits in their course of study, typically at the senior level.^{3,4,5} Many call this the capstone course. Engineering

³ Accrediting Board for Engineering and Technology. Accreditation Policy and Procedure Manual Effective for Evaluations for the 2010-2011 Accreditation Cycle. ABET: Baltimore, MD.

⁴ Accrediting Board for Engineering and Technology. Criteria for Accrediting Engineering Programs, 2010-2011. ABET: Baltimore, MD.

⁵ Enderle, J.D., Gassert, J., Blanchard, S.M., King, P., Beasley, D., Hale Jr., P. and Aldridge, D., The ABCs of Preparing for ABET, *IEEE EMB Magazine*, Vol. 22, No. 4, 122-132, 2003

design is a course or series of courses that brings together concepts and principles that students learn in their field of study. It involves the integration and extension of material learned throughout an academic program to achieve a specific design goal. Most often, the student is exposed to system-wide analysis, critique and evaluation. Design is an iterative decision-making process in which the student optimally applies previously learned material to meet a stated objective.

There are two basic approaches to teaching engineering design, the traditional or discipline-dependent approach, and the holistic approach. The traditional approach involves reducing a system or problem into separate discipline-defined components. This approach minimizes the essential nature of the system as a holistic or complete unit, and often leads participants to neglect the interactions that take place between the components. The traditional approach usually involves a sequential, iterative approach to the system or problem, and emphasizes simple cause-effect relationships.

A more holistic approach to engineering design is becoming increasingly feasible with the availability of powerful computers and engineering software packages, and the integration of systems theory, which addresses interrelationships among system components as well as human factors. Rather than partitioning a project based on discipline-defined components, designers partition the project according to the emergent properties of the problem.

A design course provides opportunities for problem solving relevant to large-scale, open-ended, complex, and sometimes ill-defined systems. The emphasis of design is not on learning new material. Typically, there are no required textbooks for the design course, and only a minimal number of lectures are presented to the student. Design is best described as an individual study course where the student:

- Selects the device or system to design,
- Writes specifications,
- Creates a paper design,
- Analyzes the paper design,
- Constructs the device,
- Evaluates the device,

- Documents the design project, and
- Presents the project to a client.

Project Selection

In a typical NSF design project, the student meets with the client (a person with a disability and/or a client coordinator) to assess needs and identify a useful project. Often, the student meets with many clients before finding a project for which his or her background is suitable.

After selecting a project, the student then writes a brief description of the project for approval by the faculty supervisor. Since feedback at this stage of the process is vitally important for a successful project, students usually meet with the client once again to review the project description.

Teams of students often undertake projects. One or more members of a team meet with one or more clients before selecting a project. After project selection, the project is partitioned by the team into logical parts where each student is assigned one of these parts. Usually, a team leader is elected by the team to ensure that project goals and schedules are satisfied. A team of students generally carries out multiple projects.

Project selection is highly variable depending on the university and the local health care facilities. Some universities make use of existing technology to develop projects by accessing databases such as ABLEDATA. ABLEDATA includes information on types of assistive technology, consumer guides, manufacturer directories, commercially available devices, and one-of-a-kind customized devices. In total, this database has over 23,000 products from 2,600 manufacturers and is available from:

<http://www.abledata.com>

or

(800) 227-0216.

More information about this NSF program is available at:

<http://nsf-pad.bme.uconn.edu>

Specifications

One of the most important parts of the design process is determining the specifications, or requirements that the design project must fulfill.

There are many different types of hardware and software specifications.

Prior to the design of a project, a statement as to how the device will function is required. Operational specifications are incorporated in determining the problem to be solved. Specifications are defined such that any competent engineer is able to design a device that will perform a given function. Specifications determine the device to be built, but do not provide information about how the device is built. If several engineers design a device from the same specifications, all of the designs would perform within the given tolerances and satisfy the requirements; however, each design would be different. Manufacturers' names are generally not stated in specifications, especially for electronic or microprocessor components, so that design choices for future projects are not constrained.

If the design project involves modifying an existing device, the modification is fully described in detail. Specific components of the device, such as microprocessors, LEDs, and electronic parts, are described. Descriptive detail is appropriate because it defines the environment to which the design project must interface. However, the specifications for the modification should not provide detailed information about how the device is to be built.

Specifications are usually written in a report that qualitatively describes the project as completely as possible, and how the project will improve the life of an individual. It is also important to explain the motivation for carrying out the project. The following issues are addressed in the specifications:

- What will the finished device do?
- What is unusual about the device?

Specifications include a technical description of the device, and all of the facts and figures needed to complete the design project. The following are examples of important items included in technical specifications:

- Electrical parameters (including interfaces, voltages, impedances, gains, power output, power input, ranges, current capabilities, harmonic distortion, stability, accuracy, precision, and power consumption)
- Mechanical parameters (including size, weight, durability, accuracy, precision, and vibration)

- Environmental parameters (including location, temperature range, moisture, and dust)

Paper Design and Analysis

The next phase of the design is the generation of possible solutions to the problem based on the specifications, and selection of an optimal solution. This involves creating a paper design for each of the solutions and evaluating performance based on the specifications. Since design projects are open-ended, many solutions exist. Solutions often require a multidisciplinary system or holistic approach to create a successful and useful product. This stage of the design process is typically the most challenging because of the creative aspect to generating solutions.

The specifications previously described are the criteria for selecting the best design solution. In many projects, some specifications are more important than others, and trade-offs between specifications may be necessary. In fact, it may be impossible to design a project that satisfies all of the design specifications. Specifications that involve some degree of flexibility are helpful in reducing the overall complexity, cost and effort in carrying out the project. Some specifications are absolute and cannot be relaxed.

Most projects are designed in a top-down approach similar to the approach of writing computer software by first starting with a flow chart. After the flow chart or block diagram is complete, the next step involves providing additional details to each block in the flow chart. This continues until sufficient detail exists to determine whether the design meets the specifications after evaluation.

To select the optimal design, it is necessary to analyze and evaluate the possible solutions. For ease in analysis, it is usually easiest to use computer software. For example, National Instrument's *Multisim*, a circuit analysis program, easily analyzes circuit problems and creates the layout for a printed circuit board. For mechanical components, the use of Dassault Systèmes SolidWorks Corp. *Solidworks* allows for computer-aided-design analysis and 3D drawings. Other situations require that a potential design project solution be partially constructed or breadboarded for analysis and evaluation. After analysis of all possible solutions, the optimal design selected is the one that meets the specifications most closely.

Construction and Evaluation of the Device

After selecting the optimal design, the student then constructs the device. The best method of construction is often to build the device module by module. By building the project in this fashion, the student is able to test each module for correct operation before adding it to the complete device. It is far easier to eliminate problems module by module than to build the entire project and then attempt to eliminate problems.

Design projects are analyzed and constructed with safety as one of the highest priorities. Clearly, the design project that fails should fail in a safe manner, without any dramatic and harmful outcomes to the client or those nearby. An example of a fail-safe mode of operation for an electrical device involves grounding the chassis, and using appropriate fuses; if ever a 120-V line voltage short circuit to the chassis should develop, a fuse would blow and no harm to the client would occur. Devices should also be protected against runaway conditions during the operation of the device and during periods of rest. Failure of any critical components in a device should result in the complete shutdown of the device.

After the project has undergone laboratory testing, it is then tested in the field with the client. After the field test, modifications are made to the project, and the project is given to the client. Ideally, the project in use by the client should be evaluated periodically for performance and usefulness after the project is complete. Evaluation typically occurs, however, when the device no longer performs adequately for the client, and it is returned to the university for repair or modification. If the repair or modification

is simple, a university technician may handle the problem. If the repair or modification is more extensive, another design student may be assigned to the project to handle the problem as part of his or her design course requirements.

Documentation

Throughout the design process, the student is required to document the optimal or best solution to the problem through a series of written assignments. For the final report, documenting the design project involves integrating each of the required reports into a single final document. While this should be a simple exercise, it is often a most vexing and difficult endeavor. Many times during the final stages of the project, some specifications are changed, or extensive modifications to the ideal paper design are necessary.

Most universities require that the final report be professionally prepared using desktop publishing software. This requires that all circuit diagrams and mechanical drawings be professionally drawn. Illustrations are usually drawn with computer software.

The two-page reports within this publication are not representative of the final reports submitted for design course credit; they are summaries of the final reports. A typical final report for a design project is approximately 30 pages in length, and includes extensive analysis supporting the operation of the design project. Photographs of the device may be included in the final report but mechanical and electrical diagrams are often more useful in documenting the device.



CHAPTER 2

BEST PRACTICES IN SENIOR DESIGN

John Enderle and Brooke Hallowell

This chapter presents different approaches to the design course experience. For example, at Texas A&M University, the students worked on many small design projects during the two-semester senior design course sequence. At North Dakota State University, students worked on a single project during the two-semester senior design course sequence. At the University of Connecticut, students were involved in a web-based approach and in distance learning in a collaborative arrangement with Ohio University.

Duke University

The Devices for the Persons with Disabilities course is offered as an elective to seniors and graduate students through the Biomedical Engineering Department at Duke University. The course has been supported since September 1996 by grants from the National Science Foundation, and is offered each fall. The course is limited to 12 students and four to six projects to provide a team atmosphere and to ensure quality results.

The course involves design, construction and delivery of a custom assistive technology device; typically in one semester. At the start of the semester, students are given a list of descriptions for several possible projects that have been suggested by persons with disabilities and health care workers in the local community. Students individually rank order the list, and for their top three selections, describe why they are interested and what skills they possess that will help them be successful. Projects are assigned to teams of one to three students based on these interests and expected project difficulty. Soon thereafter, students meet with the project's supervisor and client. The supervisor is a health care professional, typically a speech-language pathologist or occupational or physical therapist, who has worked with the client. Student teams then formulate a plan for the project and present an oral and written project proposal to define the problem and their expected approach. In

the written proposal, results of a patent and product search for ideas related to the student project are summarized and contrasted with the project.

Each student keeps an individual laboratory notebook for his or her project. Copies of recent entries are turned in to the course instructor for a weekly assessment of progress. During the semester, students meet regularly with the supervisor and/or client to ensure that the project will be safe and meet the needs of the client. Three oral and written project reports are presented to demonstrate progress, to provide experience with engineering communications, and to allow a public forum for students to receive feedback from other students, supervisors, engineers, and health care professionals.

Course lectures are focused on basic principles of engineering design, oral and written communication, and ethics. In addition, guest lectures cover topics such as an overview of assistive technology, universal design, ergonomics and patent issues. Field trips to a local assistive technology lending library, and to an annual exposition featuring commercial assistive technology companies provide further exposure to the field.

Students present their projects in near-final form at a public mock delivery two weeks before their final delivery, which provides a last chance to respond to external feedback. Final oral presentations include project demonstrations. Each project's final written report includes a quantitative analysis of the design, as well as complete mechanical drawings and schematics. At the end of the semester, students deliver their completed project to the client, along with a user's manual that describes the operation, features, and specifications for the device.

For projects requiring work beyond one semester, students may continue working through the spring semester on an independent study basis. A full-time

summer student provides service on projects already delivered.

University of Massachusetts-Lowell

The capstone design experience at University of Mass-Lowell is divided into two three-credit courses. These courses are taken in the last two semesters of undergraduate studies and for the most part involve the design of assistive technology devices and systems. The program costs are supported in part by a five-year grant from the National Science Foundation. Additional funding comes from corporate and individual donations to the assistive technology program at University of Mass-Lowell. Both courses are presented in each semester of a traditional academic year. The combined enrollment averages between 40 and 50 each semester.

The major objective of the first course is for each student to define a major design to be accomplished prior to graduation and ideally within the timeframe of the second course. The process for choosing a design project begins immediately. However, there are other activities that take place concurrently with the search for a project. The most significant of these is a team effort to generate a business plan for securing venture capital or other forms of financing to support corporate development of a product oriented towards the disadvantaged community. The instructor chooses a number of students to serve as CEOs of their company. The remaining students must present oral and written resumes and participate in interviews.

The CEO of each company must then hire his or her employees and the teams are thus formed. Each team is expected to do the following:

- Determine a product,
- Name the company,
- Determine the process for company name registration,
- Generate a market analysis,
- Determine the patent process,
- Generate a cost analysis for an employee benefit package,
- Generate information on such terms as FICA, FUTA, SS, 941, MC, IRA, SRA, I9, and other terms relative to payroll deductions and state and federal reporting requirements,
- Meet with patent attorneys, real estate agents, members of the business community, bankers, and a venture capitalist,

- Demonstrate understanding of the cost of insurance and meet with insurance agents to discuss health and life insurance for employees and liability insurance costs for the company, and
- Explore OSHA requirements relative to setting up development laboratories.

Students carry out these tasks using direct person-to-person contact and the vast amount of information on the Internet.

The teams are also required to understand the elements of scheduling and must produce a Gant chart indicating the tasks and allotted times to take their product through development and make ready for manufacture. A cost analysis of the process is required, and students are expected to understand the real cost of development, with overhead items clearly indicated.

Much of the subject material described above is covered in daily classroom discussions and with guest speakers. During the process of generating the team business plan, each team is required to present two oral reports to the class. The first is a company report describing their company, assigned tasks, their product, and a rationale for choosing their product.

The second is a final report that is essentially a presentation of the company business plan. Technical oral and written reports are essential components of the first course. Two lectures are presented on the techniques of oral presentations and written reports are reviewed by the college technical writing consultants. All oral presentation must be made using PowerPoint or other advanced creative tools.

Early in the course, potential capstone projects are presented; students are required to review current and past projects. In some semesters, potential clients address the class. Representatives from agencies have presented their desires and individuals in wheelchairs have presented their requests to the class. Students are required to begin the process of choosing a project by meeting with potential clients and assessing the problem, defining the needs, and making a decision as to whether or not they are interested in the associated project. In some cases, students interview and discuss as many as three or four potential projects before finding one

they feel confident in accomplishing. If the project is too complex for a single student, a team is formed. The decision to form a team is made by the instructor only after in-depth discussions with potential team members. Individual responsibilities must be identified as part of a team approach to design. Once a project has been chosen, the student must begin the process of generating a written technical proposal. This document must clearly indicate answers to the following questions:

- What are the project and its technical specifications?
- Why is the project necessary?
- What technical approach is to be used to accomplish the project?
- How much time is necessary?
- How much will the project cost?

The final activity in this first course is the oral presentation of the proposal.

The second course is concerned with the design of the project chosen and presented in the first course. In the process of accomplishing the design, students must present a total of five written progress reports, have outside contacts with a minimum of five different persons, and generate at least three publications or public presentations concerning their project. Finally, they demonstrate their project to the faculty, write a final comprehensive technical report, and deliver the project to their client.

Texas A&M University

The objective of the NSF program at Texas A&M University is to provide senior bioengineering students an experience in the design and development of rehabilitation devices and equipment to meet explicit client needs identified at several off-campus rehabilitation and education facilities. The students meet with therapists and/or special education teachers for problem definition under faculty supervision. This program provides significant real-world design experiences, emphasizing completion of a finished product. Moreover, the program brings needed technical expertise that would otherwise not be available to not-for-profit rehabilitation service providers. Additional benefits to the participating students include a heightened appreciation of the problems of persons with disabilities, motivation toward rehabilitation engineering as a career path, and recognition of the need for more long-term research

to address the problems for which today's designs are only an incomplete solution.

Texas A&M University's program involves a two-course capstone design sequence, BIEN 441 and 442. BIEN 441 is offered during the fall and summer semesters, and BIEN 442 is offered during the spring semester. The inclusion of the summer term allows a full year of ongoing design activities. Students are allowed to select a rehabilitation design project, or another general bioengineering design project.

The faculty members at Texas A&M University involved with the rehabilitation design course have worked in collaboration with the local school districts, community rehabilitation centers, residential units of the Texas Department of Mental Health and Mental Retardation (MHMR), community outreach programs of Texas MHMR, and individual clients of the Texas Rehabilitation Commission and the Texas Commission for the Blind. Appropriate design projects are identified in group meetings between the staff of the collaborating agency, the faculty, and the participating undergraduate students enrolled in the design class. In addition, one student is employed in the design laboratory during the summer to provide logistical support, and pursue his or her own project. Each student is required to participate in the project definition session, which enriches the overall design experience. The meetings take place at the beginning of each semester, and periodically thereafter as projects are completed and new ones are identified.

The needs expressed by the collaborating agencies often result in projects that vary in complexity and duration. To meet the broad spectrum of needs, simpler projects are accommodated by requiring rapid completion, at which point the students move on to another project. More difficult projects involve one or more semesters, or even a year's effort; these projects are the ones that typically require more substantial quantitative and related engineering analysis.

Following the project definition, the students proceed through the formal design process of brainstorming, clarification of specifications, preliminary design, review with the collaborating agency, design execution and safety analysis, documentation, prerelease design review, and delivery and implementation in the field. The

execution phase of the design includes identifying and purchasing necessary components and materials, arranging for any fabrication services that may be necessary, and obtaining photography for project reports.

Throughout each phase of the project, a faculty member supervises the work, as do the university supported teaching assistants assigned to the rehabilitation engineering laboratory. The students also have continued access to the agency staff for clarification or revision of project definitions, and review of preliminary designs. The latter is an important aspect of meeting real needs with useful devices. The design team meets as a group to discuss design ideas and project progress, and to plan further visits to the agencies.

One challenging aspect of having students responsible for projects that are eagerly anticipated by the intended recipient is the variable quality of student work, and the inappropriateness of sending inadequate projects into the field. This potential problem is resolved at Texas A&M University by continuous project review, and by requiring that the projects be revised and reworked until they meet faculty approval.

At the end of each academic year, the faculty member and the personnel from each collaborating agency assess which types of projects met with the greatest success in achieving useful delivered devices. This review has provided ongoing guidance in the selection of future projects. The faculty members also maintain continuous contact with agency personnel with respect to ongoing and past projects that require repair or modification. In some instances, repairs are assigned as short-term projects to currently participating students. This provides excellent lessons in the importance of adequate documentation.

Feedback from participating students is gathered each semester using the Texas A&M University student questionnaire form as well as personal discussion. The objective of the reviews is to obtain students' assessment of the educational value of the rehabilitation design program, the adequacy of the resources and supervision, and any suggestions for improving the process.

North Dakota State University

All senior electrical engineering students at North Dakota State University (NDSU) are required to complete a two-semester senior design project as part of their study. These students are partitioned into faculty-supervised teams of four to six students. Each team designs and builds a device for a particular individual with a disability in eastern North Dakota or western Minnesota.

During the early stages of NDSU's participation in projects to aid persons with disabilities, a major effort was undertaken to develop a complete and workable interface between the NDSU electrical engineering department and the community of persons with disabilities to identify potential projects. These organizations are the Fargo Public School System, NDSU Student Services and the Anne Carlson School. NDSU students visit potential clients or their supervisors to identify possible design projects at one of the cooperating organizations. All of the senior design students visit one of these organizations at least once. After the site visit, the students write a report on at least one potential design project, and each team selects a project to aid a particular individual.

The process of a design project is implemented in two parts. During the first semester of the senior year, each team writes a report describing the project to aid an individual. Each report includes an introduction, establishing the need for the project. The body of the report describes the device; a complete and detailed engineering analysis is included to establish that the device has the potential to work. Almost all of the NDSU projects involve an electronic circuit. Typically, devices that involve an electrical circuit are analyzed using PSpice, or another software analysis program. Extensive testing is undertaken on subsystem components using breadboard circuit layouts to ensure a reasonable degree of success before writing the report. Circuits are drawn for the report using OrCAD, a CAD program. The OrCAD drawings are also used in the second phase of design, which allows the students to bring a circuit from the schematic to a printed circuit board with relative ease.

During the second semester of the senior year, each team builds the device to aid an individual. This first involves breadboarding the entire circuit to establish the viability of the design. After

verification, the students build printed circuit boards using OrCAD, and then finish the construction of the projects using the fabrication facility in the electrical engineering department. The device is then fully tested, and after approval by the senior design faculty advisor, the device is given to the client. Each of the student design teams receives feedback throughout the year from the client or client coordinator to ensure that the design meets its intended goal.

Each design team provides an oral presentation during regularly held seminars in the department. In the past, local TV stations have filmed the demonstration of the senior design projects and broadcast the tape on their news shows. This media exposure usually results in viewers contacting the electrical engineering department with requests for projects to improve the life of another individual, further expanding the impact of the program.

Design facilities are provided in three separate laboratories for analysis, prototyping, testing, printed circuit board layout, fabrication, and redesign or development. The first laboratory is a room for team meetings during the initial stages of the design. Data books and other resources are available in this room. There are also 12 workstations available for teams to test their designs, and verify that the design parameters have been met. These workstations consist of a power supply, a waveform generator, an oscilloscope, a breadboard, and a collection of hand tools.

The second laboratory contains computers for analysis, desktop publishing and microprocessor testing. The computers all have analysis, CAD and desktop publishing capabilities so that students may easily bring their design projects from the idea to the implementation stage. A scanner with image enhancement software and a high-resolution printer are also available in the laboratory.

The third laboratory is used by the teams for fabrication. Six workstations exist for breadboard testing, soldering, and finish work involving printed circuit boards. Sufficient countertop space exists so that teams may leave their projects in a secure location for ease of work.

The electrical engineering department maintains a relatively complete inventory of electronic components necessary for design projects, and when not in stock, has the ability to order parts with

minimal delay. The department also has a teaching assistant assigned to this course on a year-round basis, and an electronics technician available for help in the analysis and construction of the design project.

There are occasionally projects constructed at NDSU (and at other universities) that prove to be unsafe or otherwise unusable for the intended individual, despite the best efforts of the student teams under the supervision of the faculty advisors. These projects are not officially documented.

University of Connecticut

In August 1998 the Department of Electrical & Systems Engineering (ESE) at the University of Connecticut (UConn), in collaboration with the School of Hearing, Speech and Language Sciences at Ohio University, received a five-year NSF grant for senior design experiences to aid persons with disabilities. An additional five-year grant was awarded in 2005. These NSF projects are a pronounced change from previous design experiences at UConn, which involved industry sponsored projects carried out by a team of student engineers. The new Biomedical Engineering Program at UConn has now replaced the ESE Department in this effort.

To provide effective communication between the sponsor and the student teams, a web-based approach was implemented.⁶ Under the new scenario, students work individually on a project and are divided into teams for weekly meetings. The purpose of the team is to provide student-derived technical support at weekly meetings. Teams also form throughout the semester based on needs to solve technical problems. After the problem is solved, the team dissolves and new teams are formed.

Each year, 25 projects are carried out by the students at UConn. Five of the 25 projects are completed through collaboration with personnel at Ohio University using varied means of communication currently seen in industry, including video

⁶ Enderle, J.D., Browne, A.F., and Hallowell, B. (1998). A WEB Based Approach in Biomedical Engineering Design Education. *Biomedical Sciences Instrumentation*, 34, pp. 281-286.

conferencing, the Internet, telephone, e-mail, postal mailings, and video recordings.

Senior design consists of two required courses, Design I and II. Design I is a three-credit hour course in which students are introduced to a variety of subjects. These include: working in teams, design process, planning and scheduling (timelines), technical report writing, proposal writing, oral presentations, ethics in design, safety, liability, impact of economic constraints, environmental considerations, manufacturing, and marketing. Each student in Design I:

- Selects a project to aid an individual after interviewing a people with disabilities,
- Drafts specifications,
- Prepares a project proposal,
- Selects an optimal solution and carries out a feasibility study,
- Specifies components, conducts a cost analysis and creates a time-line, and
- Creates a paper design with extensive modeling and computer analysis.

Design II is a three-credit-hour course following Design I. This course requires students to implement a design by completing a working model of the final product. Prototype testing of the paper design typically requires modification to meet specifications. These modifications undergo proof of design using commercial software programs commonly used in industry. Each student in Design II:

- Constructs and tests a prototype using modular components as appropriate,
- Conducts system integration and testing,
- Assembles a final product and field-tests the device,
- Writes a final project report,
- Presents an oral report using PowerPoint on Senior Design Day, and
- Gives the device to the client after a waiver is signed.

Course descriptions, student project homepages and additional resources are located at <http://www.bme.uconn.edu/bme/ugrad/bmesdi-ii.htm>.

The first phase of the on-campus projects involves creating a database of persons with disabilities and then linking each student with a person who has a disability. The A.J. Pappanikou Center provides an MS Access database with almost 60 contacts and a

short description of disabilities associated with the clients in each. The involvement of the Center was essential for the success of the program. The A.J. Pappanikou Center is Connecticut's University Affiliated Program (UAP) for disabilities studies. As such, relationships have been established with the Connecticut community of persons affected by disabilities, including families, caregivers, advocacy and support groups and, of course, persons with disabilities themselves. The Center serves as the link between the person in need of the device and the design course staff. The Center has established ongoing relationships with Connecticut's Regional Educational Service Centers, the Birth to Three Network, the Connecticut Tech Act Project, and the Department of Mental Retardation. Through these contacts, the Center facilitates the interaction between the ESE students, the client coordinators (professionals providing support services, such as speech-language pathologists and physical and occupational therapists), individuals with disabilities (clients), and clients' families.

The next phase of the course involves students' selection of projects. Using the on-campus database, each student selects two clients to interview. The student and a UConn staff member meet with the client and client coordinator to identify a project that would improve the quality of life for the client. After the interview, the student writes a brief description for each project. Almost all of the clients interviewed have multiple projects. Project descriptions include contact information (client, client coordinator, and student name) and a short paragraph describing the problem. These reports are collected, sorted by topic area, and put into a Project Notebook. In the future, these projects will be stored in a database accessible from the course server for ease in communication.

Each student then selects a project from a client that he or she has visited, or from the Project Notebook. If the project selected was from the Project Notebook, the student visits the client to further refine the project. Because some projects do not require a full academic year to complete, some students work on multiple projects. Students submit a project statement that describes the problem, including a statement of need, basic preliminary requirements, basic limitations, other data accumulated, and important unresolved questions.

Specific projects at Ohio University are established via distance communication with the co-principal investigator, who consults with a wide array of service providers and potential clients in the Athens, Ohio region.

The stages of specification, project proposal, paper design and analysis, construction and evaluation, and documentation are carried out as described earlier in the overview of engineering design.

To facilitate working with sponsors, a web-based approach is used for reporting the progress on projects. Students are responsible for creating their own Internet sites that support both html and pdf formats with the following elements:

- Introduction for the layperson,
- Resume,
- Weekly reports,
- Project statement,
- Specifications,
- Proposal, and
- Final Report.

Teamwork

Student learning styles differ among team members. Gender, cultural factors, personality type, intelligence, previous educational background, academic achievement, and previous experience in teams may influence the strengths and weaknesses that individuals bring to team membership. Research pertaining to differences in cognitive style characterized by field dependence versus independence helps to shed light on individual differences among team members and how those differences may affect team interactions^{7,8}. There is strong empirical evidence in numerous disciplines suggesting that students may benefit from explicit training to compensate for or enhance the cognitive

⁷ Tinajero, C., & Paramo, M. F. (1997). Field dependence-independence and academic achievement: A re-examination of their relationship. *British Journal of Educational Psychology*, 67, 2, 199-212.

⁸ Witkin, H.A., & Goodenough, D.R. (1981). *Cognitive Styles: Essence and Origins*. International Universities Press, Inc., NY.

style with which they enter an educational experience, such as a senior design course.^{9,10,11}

Research on effective teamwork suggests that key variables that should be attended to for optimal team performance include:

- Explicit sharing of the group's purpose among all team members,
- Concerted orientation to a common task,
- Positive rapport among team members,
- Responsiveness to change,
- Effective conflict management,
- Effective time management, and
- Reception and use of ongoing constructive feedback.

According to the literature on cooperative learning in academic contexts,^{12,13} the two most essential determiners for success in teamwork are positive interdependence and individual accountability. Positive interdependence, or effective synergy among team members, leads to a final project or design that is better than any of the individual team members may have created alone. Individual accountability, or an equal sharing of workload, ensures that no team member is overburdened and

⁹ Deming, W. (1986). *Out of the crisis: quality, productivity, and competitive position*. Cambridge, Massachusetts: Cambridge University Press.

¹⁰ Katzenbach, J. & Smith, D. (1993). *The wisdom of teams: creating the high-performance organization*. Boston, Massachusetts: Harvard Business School Press.

¹¹ Larson, C. & LaFasto, F. (1989). *Teamwork: what must go right, what can go wrong*. Newbury Park, California: SAGE Publications.

¹² Cottell, P.G. & Millis, B.J. (1994). Complex cooperative learning structures for college and university courses. In *To improve the Academy: Resources for students, faculty, and institutional development*. Stillwater, OK: New Forums Press.

¹³ Jaques, D. (1991). *Learning in groups*, 2nd edition. Guilford, Surrey, England: Society for Research into Higher Education.

also that every team member has an equal learning opportunity and hands-on experience.

Because students are motivated to work and learn according the way they expect to be assessed, grading of specific teamwork skills of teams and of individual students inspires teams' and individuals' investment in targeted learning outcomes associated with teamwork. Teamwork assessment instruments have been developed in numerous academic disciplines and can be readily adapted for use in engineering design projects.

Clearly targeting and assessing teamwork qualities may help to alleviate conflicts among team members. In general, most team members are dedicated to the goals of the project and excel beyond all expectations. When there is a breakdown in team synergy, instructors may sometimes be effective in facilitating conflict resolution.

Timeline development by the team is vital to success, eliminates most management issues, and allows the instructor to monitor the activities by student team members. Activities for each week must be documented for each team member, with an optimal target of five to ten activities per team member each week. When each team member knows what specific steps must be accomplished there is a greater chance of success in completing the project.

History of Teams in Senior Design at UConn

Projects Before the NSF Program

Before the NSF-sponsored program, senior design was sponsored by local industry. During these years, all of the students were partitioned into four-member teams whereby student names were selected at random to choose a particular sponsored project. The projects were complex, and team members were challenged to achieve success. All of the students met each week at a team meeting with the instructor. During the first semester, lectures on teaming and communication skills were given, as well as team skills training. No timelines were used and general project goals were discussed throughout the two semesters. A teaching assistant was used in the course as an assistant coach to help the students in whatever manner was necessary. In general, multidisciplinary teams were not formed since the student backgrounds were not the criteria used to select team members.

Procrastination, a lack of enthusiasm and poor planning were common themes among the students. Most teams encountered significant difficulties in completing projects on time. Conflict among team members was more frequent than desired, and in some extreme encounters, physical violence was threatened during lab sessions. Many students complained that the projects were too difficult, scheduling of team meetings was too challenging, their backgrounds were insufficient, they had difficulty communicating ideas and plans among team members, and they did not have enough time with outside activities and courses. A peer evaluation was used without success.

NSF Projects Year 1

During year one of the NSF senior design program, students worked individually on a project and were divided into teams for weekly meetings. The level of project difficulty was higher than previous years. The purpose of the team was to provide student-derived technical support at weekly team meetings. Students were also exposed to communication skills training during the weekly team meetings, and received feedback on their presentations. In addition, timelines were used for the first time, which resulted in greater harmony and success. The course improved relative to previous years. Many students continued working on their projects after the semester ended.

Throughout the year, students also divided themselves into dynamic teams apart from their regular teams based on needs. For example, students implementing a motor control project gathered together to discuss various alternatives and help each other. These same students would then join other dynamic teams in which a different technology need was evident. Dynamic teams were formed and ended during the semester. Both the regular team and dynamic teams were very important in the success of the projects.

Overall, students were enthusiastic about the working environment and the approach. Although students seemed content with being concerned only with their individual accomplishments, and completing a project according to specifications and on time, this approach lacked the important and enriching multidisciplinary team experience that is desired in industry.

NSF Projects Year 2

During the second year of the NSF senior design program, seven students worked on two- and three-person team projects, and the remaining students in the class worked in teams oriented around a client; that is, a single client had three students working on individual projects. These projects required integration in the same way a music system requires integration of speakers, a receiver, an amplifier, a CD player, etc. In general, when teams were formed, the instructor would facilitate the teams' multidisciplinary nature. Two teams involved mechanical engineering students and electrical engineering students. The others were confined by the homogeneity of the remaining students. All of the students met each week at a team meeting with the same expectations as previously described, including oral and written reports. Dynamic teaming occurred often throughout the semester.

While the team interaction was significantly improved relative to previous semesters, the process was not ideal. Senior Design is an extremely challenging set of courses. Including additional skill development with the expectation of success in a demanding project does not always appear to be reasonable. A far better approach would be to introduce team skills much earlier in the curriculum, even as early as the freshman year. Introducing teamwork concepts and skills earlier and throughout the curriculum would ensure an improved focus on the project itself during the senior design experience.

Timelines

At the beginning of the second semester, the students are required to update their timelines to conform to typical project management routines wherein the student focuses on concurrent activities and maps areas where project downtimes can be minimized. This updated timeline is posted on a student project web page and a hard copy is also attached to the student's workbench. This allows the professor or instructor to gauge progress and to determine whether the student is falling behind at a rate that will delay completion of the project.

Also during the second semester, the student is required to report project progress via the web on a weekly basis. Included in this report are sections of their timeline that focus on the week just past and on the week ahead. The instructor may meet with students to discuss progress or the lack thereof.

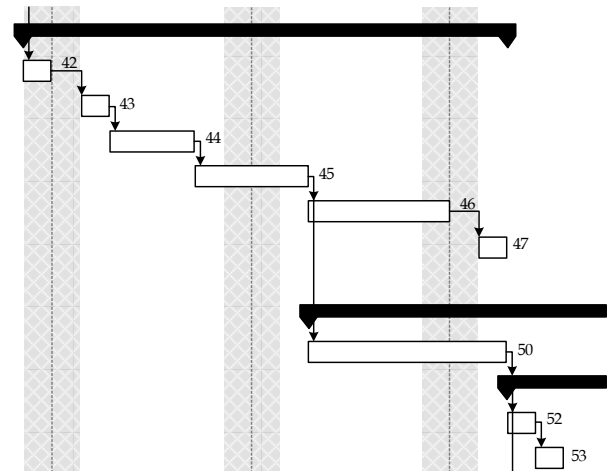


Fig. 2.1. Shown above is a section of a typical timeline. The rectangular boxes represent certain tasks to be completed. These singular tasks are grouped into larger tasks, represented by thick black lines. The tasks are numbered to correspond to a task list that is not shown. The thin lines that descend from task to task are the links. Notice that task 42 must be completed before task 43 can be started. Also, task 45 must be completed before task 46 and 50 can be started. However, task 46 and 50 are concurrent, along with task 47, and can therefore be completed at the same time. No link from task 47 shows that it is out of the critical path.

Theory

The Senior Design Lab utilizes what is perhaps the most easily understood project-planning tool: the timeline. The timeline, or Gantt chart (see Fig. 2.1), displays each task as a horizontal line that shows the starting and ending date for each task within a project and how it relates to others.

The relation of one task to another is the central part of a timeline. The student lists tasks and assigns durations to them. The student then "links" these tasks together. Linking is done in the order of what needs to happen first before something else can happen. These links are known as dependencies. An example of this is a construction project. The foundation must be poured before you can start to erect the walls. Once all dependencies are determined, the end date of the project can be determined. This line of linked dependencies is also known as the critical path.

The critical path, the series of tasks in a project that must be completed on time for the overall project to stay on time, can be examined and revised to

advance the project completion date. If, after linking tasks, the timeline does not result in the required or desired completion date, it is recast. For example, sequential activities may be arranged to run in parallel, that is, concurrently to the critical path whenever this is practicable. An example of this is performing certain types of design work on sub-assembly B while injection mold parts are being manufactured for item A, which is in the critical path. In the case of the Senior Design Lab, the student would schedule report writing or familiarization of certain software packages or equipment concurrently with parts delivery or parts construction. Parallel planning prevents downtime – time is utilized to its fullest since work is always underway. The project completion date is also advanced when assigned durations of critical path tasks are altered. Concurrent tasks should be clearly delineated in the timeline for each project.

It is the planning and mapping of concurrent tasks that make the timeline a project-planning tool. In the modern working world time is a most valuable resource. The timeline facilitates time loading (resource management) by helping the project manager schedule people and resources most efficiently. For example, optimum time loading keeps a machining center from being overloaded one day and having zero work the next day. The timeline schedules “full time busy” for people and equipment, allowing for maximum pay-off and efficiency. In the machining center example, less than optimum time loading would delay any tasks that require usage of the center because a greater number of tasks are assigned than can be accomplished in the amount of time scheduled. Tasks would slide, resulting in delayed projects. The same idea of time loading is also applied to personnel resources. Less than optimal time loading could result in absurd schedules that require employees to work excessive hours to maintain project schedules.

A timeline also allows for updates in the project plan if a task requires more time than expected or if a design method turns out to be unsatisfactory, requiring that new tasks be added. These extra times or new tasks that outline the new design track are logged into the timeline with the project completion date being altered. From this information, the project manager can either alter durations of simpler tasks or make certain tasks

parallel to place the new completion date within requirements.

The timeline also acts as a communication tool. Team members or advisors can see how delays will affect the completion date or other tasks in the project. Project progress is also tracked with a timeline. The project manager can see if the tasks are completed on time or measure the delay if one is present. Alterations to amount of resources or time spent on tasks are implemented to bring the project plan back on schedule. Alterations are also made by removing certain tasks from the critical path and placing them into a parallel path, if practical.

One major advantage of successful project planning using the timeline is the elimination of uncertainty. A detailed timeline has all project tasks thought out and listed. This minimizes the risk of missing an important task. A thoughtfully linked timeline also allows the manager to see what tasks must be completed before its dependent task can start. If schedule lag is noticed, more resources can be placed on the higher tasks.

Method

Discussed below is a method in which a timeline can be drawn. The Senior Design Lab utilizes Microsoft Project for project planning. Aspects such as assigning work times, workday durations, etc. are determined at this time but are beyond the scope of this chapter.

Tasks are first listed in major groups. Major groupings are anything that is convenient to the project. Major groups consist of the design and/or manufacture of major components, design type (EE, ME or programming), departmental tasks, or any number of related tasks. After the major groups are listed, they are broken down into sub-tasks. If the major group is a certain type of component, say an electro-mechanical device, then related electrical or mechanical engineering tasks required to design or build the item in the major group are listed as sub-groups. In the sub-groups the singular tasks themselves are delineated. All of the aforementioned groups, sub-groups, and tasks are listed on the left side of the timeline without regard to start, completion, or duration times. It is in this exercise where the project planner lists all of the steps required to complete a project. This task list should be detailed as highly as possible to enable the project manager to follow the plan with ease.

The desired detail is determined by the requirements of the project. Some projects require week-by-week detail; other projects require that all resource movements be planned. It is also useful to schedule design reviews and re-engineering time if a design or component does not meet initial specifications as set out at project inception. Testing of designs or component parts should also be scheduled.

The second step in timeline drawing is the assignment of task duration. The project planner assigns time duration to each task, usually in increments of days or fractions thereof. If, for example, a task is the manufacturing of a PC Board (without soldering of components), the planner may assign a half-day to that task. All durations are assigned without regard to linking.

The next step is task linking. Here the planner determines the order in which tasks must be completed. Microsoft Project allows linking with simple keyboard commands. The planner links all tasks together with a final completion date being noted. It is in this step where the planner must make certain decisions in order to schedule a satisfactory completion date. Tasks may be altered with respect to their duration or scheduled as concurrent items. The critical path is also delineated during the linking exercise. Once a satisfactory completion date has been scheduled due to these alterations, the planner can publish his or her timeline and proceed to follow the work plan.

Weekly Schedule

Weekly activities in Design I consist of lectures, student presentations and a team meeting with the instructor. Technical and non-technical issues that impact the design project are discussed during team meetings. Students also meet with clients and coordinators at scheduled times to report on progress.

Each student is expected to provide an oral progress report on his or her activity at the weekly team meeting with the instructor, and record weekly progress in a bound notebook as well as on the web site. Weekly report structure for the web page includes: project identity, work completed during the past week, current work within the last day, future work, status review, and at least one graphic. The client and coordinator use the web reports to keep up with the project so that they can provide

input on the progress. Weekly activities in Design II include team meetings with the course instructor, oral and written progress reports, and construction of the project. As before, the Internet is used to report project progress and communicate with the sponsors. For the past two years, the student projects have been presented at the annual Northeast Biomedical Engineering Conference.

Other Engineering Design Experiences

Experiences at other universities participating in this NSF program combine many of the design program elements presented here. Still, each university's program is unique. In addition to the design process elements already described, the program at the State University of New York at Buffalo, under the direction of Dr. Joseph Mollendorf, requires that each student go through the preliminary stages of a patent application. Naturally, projects worthy of a patent application are actually submitted. Thus far, a patent has been issued for a "Four-Limb Exercising Attachment for Wheelchairs" and another patent has been allowed for a "Cervical Orthosis."



CHAPTER 3

MEANINGFUL ASSESSMENT OF DESIGN EXPERIENCES

Brooke Hallowell

The Accrediting Board for Engineering and Technology (ABET)¹⁴ has worked to develop increasingly outcomes-focused standards for engineering education. This chapter is offered as an introduction to the ways in which improved foci on educational outcomes may lead to: (1) improvements in the learning of engineering students, especially those engaged in design projects to aid persons with disabilities, and (2) improved knowledge, design and technology to benefit individuals in need.

Brief History

As part of a movement for greater accountability in higher education, U.S. colleges and universities are experiencing an intensified focus on the assessment of students' educational outcomes. The impetus for outcomes assessment has come most recently from accrediting agencies. All regional accrediting agencies receive their authority by approval from the Council for Higher Education Accreditation (CHEA), which assumed this function from the Council on Recognition of Postsecondary Accreditation (CORPA) in 1996. The inclusion of outcomes assessment standards as part of accreditation by any of these bodies, (such as North Central, Middle States, or Southern Associations of Colleges and Schools, and professional accrediting bodies, including ABET), is mandated by CHEA, and thus is a requirement for all regional as well as professional accreditation. Consequently, candidates for accreditation are required to demonstrate plans for assessing educational outcomes, as well as evidence that assessment

results have led to improved teaching and learning and, ultimately, better preparation for beginning professional careers. Accrediting bodies have thus revised criteria standards for accreditation with greater focus on the "output" that students can demonstrate, and less on the "input" they are said to receive.¹⁵

“Meaningful” Assessment Practices

Because much of the demand for outcomes assessment effort is perceived by instructors as time consuming bureaucratic chore, there is a tendency for many faculty members to avoid exploration of effective assessment practices. Likewise, many directors of academic departments engage in outcomes assessment primarily so that they may submit assessment documentation to meet bureaucratic requirements. Thus, there is a tendency in many academic units to engage in assessment practices that are not truly "meaningful".

Although what constitutes an "ideal" outcomes assessment program is largely dependent on the particular program and institution in which that program is to be implemented, there are at least some generalities we might make about what constitutes a "meaningful" program. For example:

An outcomes assessment program perceived by faculty and administrators as an imposition of bureaucratic control over what they do, remote from any practical implications... would not be

¹⁴ Accrediting Board for Engineering and Technology. Criteria for Accrediting Engineering Programs 2010-2011. ABET: Baltimore, MD.

¹⁵ Hallowell, B. & Lund, N. (1998). Fostering program improvements through a focus on educational outcomes. In Council of Graduate Programs in Communication Sciences and Disorders, Proceedings of the nineteenth annual conference on graduate education, 32-56.

considered “meaningful.” Meaningful programs, rather, are designed to enhance our educational missions in specific, practical, measurable ways, with the goals of improving the effectiveness of training and education in our disciplines. They also involve all of a program's faculty and students, not just administrators or designated report writers. Furthermore, the results of meaningful assessment programs are actually used to foster real modifications in a training program.¹⁶

Outcomes Associated with Engineering Design Projects

Despite the NSF's solid commitment to engineering design project experiences and widespread enthusiasm about this experiential approach to learning and service, there is a lack of documented solid empirical support for the efficacy and validity of design project experiences and the specific aspects of implementing those experiences. Concerted efforts to improve learning, assessment methods and data collection concerning pedagogic efficacy of engineering design project experiences will enhance student learning while benefiting the community of persons with disabilities.

Agreeing on Terms

There is great variability in the terminology used to discuss educational outcomes. How we develop and use assessments matters much more than our agreement on the definitions of each of the terms we might use to talk about assessment issues. However, for the sake of establishing common ground, a few key terms are highlighted here.

Formative and Summative Outcomes

Formative outcomes indices are those that can be used to shape the experiences and learning opportunities of the very students who are being assessed. Some examples are surveys of faculty regarding current students' design involvement, on-site supervisors' evaluations, computer

programming proficiency evaluations, and classroom assessment techniques.¹⁷ The results of such assessments may be used to characterize program or instructor strengths and weaknesses, as well as to foster changes in the experiences of those very students who have been assessed.

Summative outcomes measures are those used to characterize programs, college divisions, or even whole institutions by using assessments intended to capture information about the final products of our programs. Examples are student exit surveys, surveys of graduates inquiring about salaries, employment, and job satisfaction, and surveys of employers of our graduates.

The reason the distinction between these two types of assessment is important is that, although formative assessments tend to be the ones that most interest our faculty and students and the ones that drive their daily academic experiences, the outcomes indices on which most administrators focus to monitor institutional quality are those involving summative outcomes. It is important that each academic unit strive for an appropriate mix of both formative and summative assessments.

Cognitive/Affective/Performative Outcome Distinctions

To stimulate our clear articulation of the specific outcomes targeted within any program, it is helpful to have a way to characterize different types of outcomes. Although the exact terms vary from context to context, targeted educational outcomes are commonly characterized as belonging to one of three domains: cognitive, affective, and performative. Cognitive outcomes are those relating to intellectual mastery, or mastery of knowledge in specific topic areas. Most of our course-specific objectives relating to a specific knowledge base fall into this category. Performance outcomes are those relating to a student's or graduate's accomplishment of a behavioral task. Affective outcomes relate to personal qualities and values that students ideally gain from their experiences during a particular educational/training program. Examples are appreciation of various racial, ethnic, or linguistic

¹⁶ Hallowell, B. (1996). Innovative Models of Curriculum/Instruction: Measuring Educational Outcomes. In *Council of Graduate Programs in Communication Sciences and Disorders, Proceedings of the Seventeenth Annual Conference on Graduate Education*, 37-44.

¹⁷ Angelo, T. A., & Cross, K. P. (1993). *Classroom assessment techniques: A handbook for college teachers*. San Francisco: Jossey-Bass.

backgrounds of individuals, awareness of biasing factors in the design process, and sensitivity to ethical issues and potential conflicts of interest in professional engineering contexts.

The distinction among these three domains of targeted educational outcomes is helpful in highlighting areas of learning that we often proclaim to be important, but that we do not assess very well. Generally, we are better at assessing our targeted outcomes in the cognitive area (for example, with in-class tests and papers) than we are with assessing the affective areas of multicultural sensitivity, appreciation for collaborative teamwork, and ethics. Often, our assessment of performative outcomes is focused primarily on students' design experiences, even though our academic programs often have articulated learning goals in the performative domain that might not apply only to design projects.

Faculty Motivation

A critical step in developing a meaningful educational outcomes program is to address directly pervasive issues of faculty motivation. Faculty resistance is probably due in large part to the perception that outcomes assessment involves the use of educational and psychometric jargon to describe program indices that are not relevant to the everyday activities of faculty members and students. By including faculty, and perhaps student representatives, in discussions of what characterizes a meaningful assessment scheme to match the missions and needs of individual programs we can better ensure a sense of personal identification with assessment goals on the part of the faculty. Also, by agreeing to develop outcomes assessment practices from the bottom up, rather than in response to top-down demands from administrators and accrediting agencies, faculty member skeptics are more likely to engage in assessment efforts.

Additional factors that might give faculty the incentive to get involved in enriching assessment practices include:

- Consideration of outcomes assessment work as part of annual merit reviews,
- Provision of materials, such as sample instruments, or resources, such as internet sites to simplify the assessment instrument design process
- Demonstration of the means by which certain assessments, such as student exit or employer

surveys, may be used to make strategic program changes.

These assessment practices may be used to a program's advantage in negotiations with administration (for example, to help justify funds for new equipment, facilities, or salaries for faculty and supervisory positions).¹⁴

With the recent enhanced focus on educational outcomes in accreditation standards of ABET, and with all regional accrediting agencies in the United States now requiring extensive outcomes assessment plans for all academic units, it is increasingly important that we share assessment ideas and methods among academic programs. It is also important that we ensure that our assessment efforts are truly meaningful, relevant and useful to our students and faculty.

An Invitation to Collaborate in Using Assessment to Improve Design Projects

Readers of this book are invited to join in collaborative efforts to improve student learning, and design products through improved meaningful assessment practices associated with NSF-sponsored design projects to aid persons with disabilities. Future annual publications on the NSF-sponsored engineering design projects to aid persons with disabilities will include input from students, faculty, supervisors, and consumers on ways to enhance associated educational outcomes in specific ways. The editors of this book look forward to input from the engineering education community for dissemination of further information to that end.

ABET's requirements for the engineering design experiences provide direction in areas that are essential to assess in order to monitor the value of engineering design project experiences. For example, the following are considered "fundamental elements" of the design process: "the establishment of objectives and criteria, synthesis, analysis, construction, testing, and evaluation" (p. 11). Furthermore, according to ABET, specific targeted outcomes associated with engineering design projects should include:

- Development of student creativity,
- Use of open-ended problems,
- Development and use of modern design theory and methodology,
- Formulation of design problem statements and specifications,

- Consideration of alternative solutions, feasibility considerations,
- Production processes, concurrent engineering design, and
- Detailed system descriptions.

The accrediting board additionally stipulates that it is essential to include a variety of realistic constraints, such as economic factors, safety, reliability, aesthetics, ethics, and social impact. ABET's most recent, revised list of similar targeted educational outcomes is presented in the Appendix to this chapter. We encourage educators, students and consumers to consider the following questions:

- Are there outcomes, in addition to those specified by ABET, that we target in our roles as facilitators of design projects?
- Do the design projects of each of the students in NSF-sponsored programs incorporate all of these features?
- How may we best characterize evidence that students engaged in Projects to Aid Persons with Disabilities effectively attain desired outcomes?
- Are there ways in which students' performances within any of these areas might be more validly assessed?
- How might improved formative assessment of students throughout the design experience be used to improve their learning in each of these areas?

Readers interested in addressing such questions are encouraged to send comments to the editors of this book. The editors of this book are particularly interested in disseminating, through future publications, specific assessment instruments that readers find effective in evaluating targeted educational outcomes in NSF-sponsored engineering design projects.

Basic terminology related to pertinent assessment issues was presented earlier in this chapter. Brief descriptions of cognitive, performative, and affective types of outcomes are provided here, along with lists of example types of assessments that might be

shared among those involved in engineering design projects.

Cognitive outcomes are those relating to intellectual mastery, or mastery of knowledge in specific topic areas. Some examples of these measures are:

- Comprehensive exams,
- Items embedded in course exams,
- Pre- and post-tests to assess "value added",
- Design portfolios,
- Rubrics for student self-evaluation of learning during a design experience,
- Alumni surveys, and
- Employer surveys.

Performative outcomes are those relating to a student's or graduate's accomplishment of a behavioral task. Some performance measures include:

- Evaluation of graduates' overall design experience,
- Mastery of design procedures or skills expected for all graduates,
- Student evaluation of final designs, or of design components,
- Surveys of faculty regarding student design competence,
- Evaluation of writing samples,
- Evaluation of presentations,
- Evaluation of collaborative learning and team-based approaches,
- Evaluation of problem-based learning,
- Employer surveys, and
- Peer evaluation (e.g., of leadership or group participation).

Affective outcomes relate to personal qualities and values that students ideally gain from their educational experiences. These may include:

- Student journal reviews,
- Supervisors' evaluations of students' interactions with persons with disabilities,
- Evaluations of culturally-sensitive reports,
- Surveys of attitudes or satisfaction with design experiences,
- Interviews with students, and
- Peers', supervisors', and employers' evaluations.

APPENDIX: Desired Educational Outcomes as Articulated in ABET's "Engineering Criteria for the 2011-2012 Academic Year" (Criterion 3, Student Outcomes)¹⁸

Engineering programs must demonstrate that their graduates have:

- (a) an ability to apply knowledge of mathematics, science, and engineering
- (b) an ability to design and conduct experiments, as well as to analyze and interpret data
- (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- (d) an ability to function on multidisciplinary teams
- (e) an ability to identify, formulate, and solve engineering problems
- (f) an understanding of professional and ethical responsibility
- (g) an ability to communicate effectively
- (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- (i) a recognition of the need for, and an ability to engage in life-long learning
- (j) a knowledge of contemporary issues
- (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

¹⁸ ABET, Engineering Accreditation Commission (2011-12). Criteria for Accrediting Engineering Programs. ABET: Baltimore, MD, p. 3.



CHAPTER 4

USING NSF-SPONSORED PROJECTS TO ENRICH STUDENTS' WRITTEN COMMUNICATION SKILLS

Brooke Hallowell

Based on numerous anecdotes offered inside and outside of engineering, age-old stereotypes that engineers lack communication skills may have some basis in fact. However, current work environments for most new graduates in a host of professional biomedical engineering contexts, place such heavy expectations for, and demands on, excellence in oral and written communication that engineers' lack of communication skills can no longer be tolerated as a trade-off for their strengths in science and mathematics. Evolving requirements for communication with interdisciplinary team members, clients, patients, consumers, employers, and the public require that educators of engineers work hard to ensure that students reach a standard of excellence in communication before they enter the workforce. This chapter is offered to provide specific guidance on principles and resources for enriching written communication skills in biomedical engineering students through their NSF-sponsored design project experiences.

A Formative Focus

As discussed in the previous chapter, a formative focus on academic assessment allows educators to use assessment strategies that directly influence students who are still within their reach. A solid approach to formative assessment of writing skills involves repeated feedback to students throughout educational programs, with faculty collaboration in reinforcing expectations for written work, use of specific and effective writing evaluation criteria, and means of enhancing outcomes deemed important for regional and ABET accreditation. Given that most students in the NSF-sponsored Senior Design Projects to Aid Persons with Disabilities programs are already in their fourth year of college-level study, it is critical to recognize that previous

formative writing instruction is essential to their continued development of writing skills during the senior year. Model strategies for improving writing presented here in light of senior design projects may also be implemented at earlier stages of undergraduate learning.

Clarifying Evaluation Criteria

Student learning is directly shaped by how students think they will be assessed. Regardless of the lofty goals of excellence instructors might set forth in course syllabi and lectures, if specific performance criteria are not articulated clearly and assessed directly, then students are unlikely to reach for those same goals. To enhance writing skills effectively through the senior design experience, specific evaluation criteria for writing quality must be established at the start of the senior design experience. Clear expectations should be established for all written work, including related progress reports, web page content, and final reports. Although the examples provided here are oriented toward writing for annual NSF publications, the basic assessment process is ideally applied to other areas of written work as well.

Elements of Writing to be Assessed

What aspects of writing quality are important in writing about senior design projects? The list of specific ideal aspects varies among instructors. Still, consideration of guidelines already proposed may help to streamline the development of finely tuned assessment instruments to shape and evaluate student writing. Each year, the editors of this annual publication on senior design projects send guidelines for manuscript publication to principal investigators on NSF-sponsored Engineering Senior Design Projects to Aid Persons with Disabilities

grants. Those guidelines form the basis for the elements of writing on which writing projects may be evaluated.

A sample grading form, based on the most recent version of those guidelines at the time of this publication, may be found in Appendix A. Explicit writing criteria are specified, and a means for explicit scoring according to those criteria is provided. Instructors may use such a form to evaluate drafts and final project reports. Specific item descriptions and the relative weighting of the value of performance in specific areas may be modified according to instructor preferences. Application of such scoring systems to student course grades will ensure greater student accountability for meeting explicit writing standards.

General categories for analyzing writing performance for project reports include: 1) form and formatting, 2) accompanying images, 3) grammar, spelling, punctuation, and style, 4) overall content, and 5) content within specific sections.

Form and formatting concerns are related primarily to students following of explicit instructions regarding page limitation, spacing, margins, font size, indentations, and headings. Items related to images include the type, quality, relevance and formatting of photographs and drawings used to illustrate reports. Issues of grammar, spelling, punctuation, and style may be largely addressed through adherence to specific conventions for each of these areas. Thorough proofreading and use of computerized checks for spelling and grammar, although frequently recommended by instructors, are not as likely to be carried out by students who are not expecting to be assessed for performance in these important areas.

Areas of overall content evaluation for senior design reports include aspects of writing that are often among the most problematic for undergraduate engineers. One such area is that of using appropriate language when referring to individuals with disabilities. Reports submitted for NSF publications often include terms and descriptions that may be considered offensive by many, such that the editors of this annual publication often engage in extensive rewriting of sections including client descriptions. It is most likely that students engaged in projects for persons with disabilities are

wholeheartedly supportive of their clients, and use such terms out of naiveté rather than any ill intent. Still, the words we use to communicate about other people powerfully influences readers' perceptions of them, especially in cases in which readers may be unfamiliar with the types of conditions those people are experiencing. Using appropriate language is of paramount importance to our joint mission of enabling individuals to live fully and with maximum independence. It is thus critical that instructors provide clear instruction and modeling for appropriate language use in writing about disabilities. In cases where instructors may have outdated training concerning language use in this arena, it is critical that they seek training regarding sensitivity in language use.

Basic guidelines for writing with sensitivity about persons with disabilities are summarized briefly in Appendix B. Using person-first language, avoiding language that suggests that individuals with disabilities are "victims" or "sufferers", and avoiding words with negative connotations are three key components to appropriate language use.

Evaluation of content within specific sections of senior design project reports will help students focus on drafting, appropriately revising and editing reports. By discussing and evaluating specific criteria - such as the use of laypersons' terms in a project description, effective description of the motivation for a particular design approach, and the use of clear, concise technical language to describe a device modification such that others would be able to replicate the design - instructors may help students further hone their writing and revision skills.

A Hierarchy of Revision Levels

Constructive feedback through multiple revisions of written work is critical to the development of writing excellence. Even for the accomplished writer, a series of drafts with a progressive evolution toward a polished product is essential. It is thus important that instructors allow time for revision phases for all writing assignments throughout the senior design experience.

Three basic levels of writing revision proposed by some authors include global, organizational, and

polishing revision¹⁹. Global revision involves a general overhaul of a document. Macro-level feedback to students about their general flow of ideas and adherence to assignment guidelines helps to shape an initially-submitted draft into a version more suitable for organizational revision. Organizational revision requires reshaping and reworking of the text. Helpful feedback to students at this level may involve revising of macro-level issues not corrected since the initial draft, and/or a focus on new micro-level issues of coherence, clarity, relevance, and word choice. Polishing revision entails attention to such flaws as grammatical errors, misspellings, misuse of punctuation, and specific formatting rules for the assignment. Finding patterns of errors and providing constructive feedback about those patterns may help individuals or teams of students learn efficient strategies for improving their written work.

model writing programs for engineering design courses at any level of study, are welcome to submit those to the editors of this book, to be considered for future publication.

Structured Critical Peer Evaluation

Many instructors require several forms of written assignments within project design courses, including the final reports required for submission to the NSF-sponsored annual publication. Consequently, it is impractical or impossible for many instructors to provide evaluation and feedback at three levels of revision for each written assignment. One means of promoting students' experience with critical reflection on writing is to implement assignments of structured critical evaluation of writing using reader-response strategies, with students as editors for other students' work. Students (as individuals or on teams) may be given a basic or detailed rubric for evaluating other students' written work, and explicit guidelines for providing structured constructive comments following critical evaluation.

Resources and Support

Numerous excellent texts are available to promote and provide structure and guidance for the development of essential writing skills in engineering students. Some sample recommended texts are listed in Appendix C. Comments and suggestions from instructors, who have developed

¹⁹ Ohio University Center for Writing Excellence Teaching Handouts [on-line] (2007). Available at: <http://www.ohio.edu/writing/tr1.cfm>

APPENDIX A: Sample Evaluation Form for Project Reports Prepared for Annual NSF Publications on Senior Design Projects to Aid Persons with Disabilities

Item evaluated	Score/ Possible Score
A. Form and formatting	
Does not exceed two pages (unless authorized by instructor)	/2
10-point type size throughout the manuscript	/2
Margin settings: top =1", bottom=1", right=1", and left=1"	/2
Title limited to 50 characters on each line (if longer than 50 characters, then skips two lines and continues, with a blank line between title text lines)	/1
Text single spaced	/2
No indenting of paragraphs	/1
Blank line inserted between paragraphs	/1
Identifying information includes: project title, student name, name of client coordinator(s), supervising professor(s), university address	/2
Appropriate headings provided for Introduction, Summary of impact, and Technical description sections	/2
Total points for form and formatting	/15
B. Images	
Photographs in black and white, not color	/1
Photographs are hard copies of photo prints, not digital	/1
Line art done with a laser printer or drawn professionally by pen with India (black) ink	/2
Images clearly complement the written report content	/2
Photographs or line art attached to report by paperclip	/1
Photographs or line art numbered on back to accompany report	/1
Figure headings inserted within the text with title capitalization, excluding words such as "drawing of" or "photograph of"	/2
Total points for images	/10

C. Grammar, spelling, punctuation, and style	
Consistent tenses throughout each section of the report	/2
Grammatical accuracy, including appropriate subject-verb agreement	/2
Spelling accuracy	/2
Appropriate punctuation	/2
Abbreviations and symbols used consistently throughout (For example, " or in. throughout for "inch;" excludes apostrophe for plural on abbreviations, such as "BMEs" or "PCs"	/2
Uses the word "or" rather than a slash (/) (For example, "He or she can do it without assistance.")	/1
Numbers one through 9 spelled out in text; number representations for 10 and higher presented in digit form (except in series of numbers below and above 10, or in measurement lists)	/1
In lists, items numbered, with commas between them (for example: "The device was designed to be: 1) safe, 2) lightweight, and 3) reasonably priced.")	/1
Consistent punctuation of enumerated and bulleted lists throughout the report	/2
Total points for grammar, spelling, punctuation, and style	/15
D. Overall content	
Excludes extensive tutorials on specific disabilities	/2
Demonstrates appropriate language regarding individuals with disabilities	/3
Avoids redundancy of content among sections	/3
Demonstrates clear and logical flow of ideas	/3
Excludes use of proper names of clients	/3
Citation and reference provided for any direct quote from published material	/1
Total points for overall content	/15

E. Section content	
Introduction	
Includes a brief description of the project in laypersons' terms	/4
Includes problem addressed, approach taken, motivation for the approach, a summary of usual or existing solutions, and problems with these solutions	/4
Summary of impact	
Includes a brief description of how this project has improved the quality of life of a person with a disability	/5
Includes a quoted statement from an educational or health care specialist who supervises the client, or from a significant other	/2
Includes a description of the project's usefulness and overall design evaluation	/5
Technical description	
Clear, concise technical description of the device or device modification such that others would be able to replicate the design	/10
Detailed parts lists included only if parts are of such a special nature that the project could not be fabricated without the exact identity of the part	/2
Text refers to circuit and/or mechanical drawing of the device	/3
Includes analysis of design effectiveness	/5
Concludes with approximate cost of the project, including parts and supplies (not just the NSF's contribution) and excluding personnel costs	/5
Total points for section content	/45

Evaluation Summary

A. Total points for form and formatting	/15
B. Total points for images	/10
C. Total points for grammar, spelling, punctuation, style	/15
D. Total points for overall content	/15
E. Total points for section content	/45
TOTAL POINTS	/100

APPENDIX B: A Summary of Guidelines for Writing about Persons with Disabilities

The World Health Organization (WHO) has launched world-wide efforts to modify the ways in which we refer to persons with disabilities. The WHO emphasizes that disablement is not considered an attribute of an individual, but rather the complex interactions of conditions involving a person in the context of his or her social environment. An early classification scheme proposed by the WHO, the International Classification of Impairments, Disabilities and Handicaps (ICIDH) employs the general terms "impairment", "disability", and "handicap"; a more recent scheme, the ICIDH-2, employs the terms "impairment", "activity", and "participation"; the most recent version, the International Classification of Functioning, Disability and Health (ICF), suggests that body functions and structures, activities and participation should refer to the various contextual aspects of disabling conditions one might experience.²⁰ Healthcare professionals and researchers throughout the world are following suit by de-emphasizing the reference to individuals according to medically-based diagnostic categories, focusing instead on their holistic functional concerns and what might be done to address them. Readers of this book are encouraged to join in this important movement. General guidelines are presented here.

Recognize the importance of currency and context in referring to individuals with disabilities

There are always variances in the terms that particular consumers or readers prefer, and it is essential to keep current regarding changes in accepted terminology.

Refer to "disabilities"

Although the very term "disability" may be considered offensive to some (with its inherent focus on a lack of ability), it is currently preferred over the term "handicap" in reference to persons with physical, cognitive, and/or psychological challenges or "disabilities".

Use person-first language

Person-first language helps emphasize the importance of the individuals mentioned rather than their disabilities. For example, it is appropriate to refer to a "person with a disability" instead of "disabled person," and to say "a child with cerebral palsy" instead of "a cerebral palsied child."

Avoid using condition labels as nouns

Many words conveying information about specific disabilities exist in both noun and adjectival forms, yet should primarily be used only as adjectives, or even better, modified into nouns corresponding to conditions, as in the person-first language examples given above. For example, it is not appropriate to call an individual with aphasia "an aphasic." Although the term "an aphasic individual" would be preferred to the use of "an aphasic" as a noun, such labeling may convey a lack of respect for, and sensitivity toward, individuals who have aphasia.²¹ A more appropriate term would be "person with aphasia." Likewise, it is not appropriate to call an individual with paraplegia "a paraplegic," or to call persons with disabilities "the disabled."

Avoid Language of Victimization

Do not use language suggesting that clients are "victims" or people who "suffer" from various forms of disability. For example, say, "the client had a stroke" rather than "the client is a stroke victim." Say, "She uses a wheelchair," rather than "she is confined to a wheelchair." Say "her leg was

²⁰ World Health Organization (2007). International Classification of Functioning, Disability and Health (ICF) [on-line]. Available: <http://www.who.int/classifications/icf/en/>

²¹ Brookshire, R.H. (1992). An introduction to neurogenic communications disorders. St. Louis: Mosby - Year Book.

amputated...” instead of, “the client suffered an amputation of the leg.”

Avoid words with negative connotations

Words that evoke derogatory connotations should be avoided. These include such words and phrases as affliction, crazy, crippled, defective, deformed, dumb, insane, invalid, lame, maimed, mute, retard, and withered.

Encourage others in appropriate language use

By modeling appropriate language in writing about persons with disabilities, authors take an important

step in helping others to improve in this area. It is also important to help others learn to implement guidelines such as these directly through course work and other educational experiences. Likewise, polite and constructive corrections of others using inaccurate language helps encourage more positive communication as well as more enabling positive societal attitudes, widening the arena for empowering persons with disabilities.

CHAPTER 5

CONNECTING STUDENTS WITH PERSONS WHO HAVE DISABILITIES

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²² Portions of "The Engineering Perspective" were presented at the 40th Annual Rocky Mountain Bioengineering Symposium, April 2003, Biloxi, MS (Barrett, 2003)

INTRODUCTION

For many students, participation in the National Science Foundation (NSF) projects to aid persons with disabilities is a unique experience. Often it is their first opportunity to work with individuals with disabilities. As such, not only must they meet the academic requirements of their senior design project, but in order to be successful, they must also learn about disabilities and related issues. Only when students are able to combine their scientific knowledge with an understanding of other related humanistic factors will they be able to make significant contributions to the field. Therefore, it is imperative for engineering programs participating in the NSF projects to ensure that students have the opportunity to gain the necessary awareness and social competencies needed. Specifically, students need to have a basic understanding of philosophical attitudes toward disability as well as an understanding of assistive technology and how to communicate effectively with persons with disabilities. This awareness and understanding will not only enable students to have a more meaningful experience, but also ensure a more meaningful experience for the individuals with whom they will be working.

Students must also understand the engineering aspects of their project. The engineering aspects may be viewed from two different levels: the programmatic aspects of the project and the engineering details of their specific project. At the program level, projects must be properly scoped for difficulty and required expertise. At the individual project level the projects must meet specific requirements but also must be safe and reliable. Senior design faculty as well as participating students have the joint responsibility of ensuring that these engineering aspects are met.

In this chapter we will discuss these diverse yet related aspects of National Science Foundation engineering senior design projects to aid persons with disabilities. We will first examine the social constructs of disability, followed by the proper language of disability. We will then investigate assistive technology and universal design principles. This chapter will conclude with a discussion of the engineering aspects for a successful design experience.

Models of Disability

There are three predominant social constructs of disability. These models define the source or problem of disability and determines the ways to best address the related issues. The oldest model is the moral model, which posits that disability is caused by moral lapse or sin. It explains disability as a supernatural phenomenon or act of god that serves as punishment and represents the consequences of perceived wrongdoing. It brings shame to the individual and in cultures that emphasize family and/or groups over the individual, the shame spreads to the family and/or group. The person or family carries the blame for causing the disability. In a tenuously more auspicious interpretation of the moral model, disability is perceived as a test of faith (i.e. "God only gives us what we can bear") or as a mystical experience in which one sense may be impaired but others are heightened and the adversity of the disability provides increased emotional and spiritual strength often recognized by the belief that "with the grace of God" the disability can be overcome.

Given the limitations of the moral model, the medical model began to emerge in the mid- 1800s as a result of developing science and improved humanistic medicine. In this model, disability is recognized as a medical problem that resides within the individual. It is a dysfunction, defect, or abnormality that needs to be fixed. The ambition is to restore normality and cure the individual. It is a paternalistic model that expects an individual to assume the role of a victim or sick person and avail themselves to medical professionals and services. The individual is a passive participant. However, as medicine and professionals have advanced in their knowledge and understanding, this model has given way to a more person-centered version, often referred to as the rehabilitation model, in which disability is analyzed in terms of function and limitations. In this paradigm, a more holistic approach is taken. The individual is a more active participant and his or her goals are the basis for therapeutic intervention. The emphasis is on functioning within one's environments. A variety of factors are assessed in terms of barriers and facilitators to increased functioning. This model recognizes disability as the corollary of interaction between the individual and the environment. The individual is recognized as a client and the emphasis is based on assisting the individual in adjusting or adapting. It is important to note that, although this

model derives from a systems approach, the primary issues of disability are still attributed to the individual.

In the last 30 years, another model has emerged: the social model of disability, which is also referred to as a minority group model and/or independent living model. Its genesis resides within the disability rights movement and proclaims that disability is a social construction. Specifically, the problem of disability is not within the individual, but within the environment and systems with which the individual must interact. The barriers that prevent individuals with disabilities from participating fully and equally within society include prejudice, discrimination, inaccessible environments, inadequate support, and economic dependence.

While it is beyond the scope of this chapter to view these constructs in detail, an awareness of these models enables one to examine one's own beliefs and attitudes toward disability. It also helps students understand that they will encounter both professionals and persons with disabilities whose beliefs are rooted in any one (or combination of) these identified constructs. Although it may not be readily evident, these beliefs will impact how students approach their projects, their ability to see beyond the disability and consider other related factors, and their ability to establish meaningful relationships with the individuals they are trying to assist. Therefore, it is highly recommended that all engineering programs establish collaborative partnerships with other disability professionals in order to provide students with an awareness of disability issues. Potential partners include other programs within the university, especially those with disability studies programs, state assistive technology projects, and independent living centers.

Language of Disability

Terminology and phrases used to describe many people (those with and without disabilities) have changed over time. Many words and phrases are embedded in the social constructs and ideologies of our history and the changes in terminology reflect the paradigm shifts that have occurred over time. For example, the terms Native American or African American have changed with the Zeitgeist and no longer reflect the often derogatory words or phrases that preceded them. Although there is often disdain for those that advocate political correctness, it is important to realize that words and expressions can

be powerful and that they do, in fact, communicate attitudes, perceptions, feelings, and stereotypes. They can be oppressive or empowering. The changes in language that have occurred represent an acceptance of diversity and a respect for differences which ultimately impact social change. As professionals and educators, we are in fact, agents of change, and it is our responsibility to recognize the power of language and to use it befittingly in our conversations, discussions and writings.

In regard to disability, the use of person first language (i.e. always putting the person before the disability) recognizes the person first and foremost as a unique individual. In contrast, referring to someone by his or her disability defines them by a single attribute and limits the ability to distinguish who they are as a person from the disability, which in fact they may consider to be a very minute characteristic. For example, the statement "The stroke victim's name is Joe" conjures up a very different image from "Joe is a great musician who had a stroke last year", or "she can't ski; she is paralyzed and confined to a wheelchair" versus "she loves to ski and uses a sit ski device because she has paraplegia and is a wheelchair user." Putting the person before the disability demonstrates respect and acknowledges the person for who he or she is, not for what he or she does or does not have. Although it may seem awkward when one first begins to use person first language, it will become natural over time, it will demonstrate respect, and it will have a positive societal impact. For guidelines on person-first language, a keyword internet search will reveal many resources. For detailed guidelines on writing, see Chapter 4.

Assistive Technology and Universal Design

Assistive Technology (AT) is a general term that describes any piece of equipment or device that may be used by a person with a disability to perform specific tasks and to improve or maintain functional capabilities, thus providing a greater degree of independence, inclusion, and/or community integration. It can help redefine what is possible for people with a wide range of cognitive, physical, or sensory disabilities. AT can be simple or complex. It can include off-the-shelf items as well as special designs. Devices become AT through their application. This technology may range from very low-cost, low-tech adaptations (such as a battery interrupter to make a toy switch accessible) to high-

tech, very expensive devices (such as a powered mobility equipment and environmental controllers).

AT can include cognitive aids, aids to assist with walking, dressing, and other activities of daily living, aids to augment hearing or vision, adaptive recreation devices, augmentative communication aids, and alternate computer access. Services related to Assistive Technology may include evaluation for appropriate equipment and systems, assistance with purchasing or leasing devices, and selecting, defining, fitting, adapting, applying, maintaining, repairing, or replacing equipment and systems. In addition, services could include training and technical assistance for individuals and their families, and/or other professionals. Assistive Technology may be used at home, in the workplace, in the classroom and in the community to provide creative solutions in assisting individuals as they go about their activities of living, learning, working, and playing.

Universal Design (UD) refers to a concept or philosophy for designing and delivering products and services that are usable by people with the widest possible range of functional capabilities. This includes products and services that are directly usable (without requiring assistive technology) and products and services that are made usable with assistive technology.

As noted earlier, the social model of disability focuses on the environment as the most significant barrier preventing people with disabilities from full contribution to all aspects of society. As such, the concepts of universal design have significant potential for remedy (see reference section for resources specific to universal design). The basic premise of universal design is to create access, in terms of the mass marketplace as well as community and information environments, for as many people as possible, regardless of age, size, or ability.

It is estimated that approximately thirty million people have a disability or functional limitation due to injury, illness or aging (Vanderheidin, 1990). With the advances in modern medicine and the emerging inroads in health promotion and disease prevention, people are living longer. Nearly everyone will experience some type of functional limitation during the course of a lifetime. Given such broad prevalence of disability in the general population, the need for universal design becomes self-evident.

The underlying principles of universal design (UD) are available for review at www.design.ncsu.edu, The Center for Universal Design, North Carolina State University. These basic principles provide the philosophical interface between functional limitations/disability and best practices in design. In fact, universal design principles can often simplify the adaptation or even eliminate the need for specialized design created specifically for the individual person. Conversely, when prototype devices are necessary, if they adhere to principles of UD, it is much more likely that the device will also be able to be adopted by others and that the technology will be able to be transferred to other applications. When assistive technology is necessary to support access and/or use of the built environment, products, or information, the understanding that any design must first and foremost respect personal dignity and enhance independence without stigmatizing the individual is critical. This is clearly a quality of life issue for everyone. Working with an individual who has disabilities to develop assistive technology requires the engineer to actively collaborate, respecting the right of each person to self-determination and self-control (Shapiro, 1993).

In general, the areas of functional limitation most amenable to benefit from the concepts of universal design (and assistive technology where necessary) are in the broad categories of: communication, mobility, sensory, manipulation, memory, and cognition. All design should consider and address varying human abilities across each of these domains. The goal of universal design is to eliminate, as much as possible, the need for assistive technologies because the focus of all design is inclusive rather than restrictive. Historically, designs were often based on the young, able-bodied male. With the advent of UD, designers are redefining the user to include as many people as possible with the widest range of abilities.

There are many examples of how assistive technologies have been adopted by the general population. For example, at one time the use of closed captioning was limited to individuals who were hard of hearing or deaf. Today, captioning can be seen on televisions located in public places such as restaurants, airports, and sports bars. Captioning is also used by many people in their own homes when one person wishes to watch TV while another does not. Other examples include ramps, curb cuts

and automatic door openers. Initially designed for individuals who were wheelchair users, it was quickly realized they also benefited delivery personnel, people with strollers, people with temporary injuries, cyclists, etc. In addition, many items related to computer access such as voice recognition, are now employed in a variety of computer and telecommunication applications. When UD principles are employed, the whole environment, in the broadest sense becomes more humane and maximizes the potential contribution of everyone, not just those with disabilities.

As senior design students explore their options for projects, an awareness of disability issues, existing assistive technologies and universal design principles will ensure that their projects incorporate state-of-the-art practices. A list of valuable resources is included at the end of this chapter.

The Engineering Perspective

To provide for a successful Engineering Senior Design Projects to Aid Persons with Disabilities Program, projects must be successful at both the program level and the individual project level. In this section we discuss aspects of a successful program and use the University of Wyoming's program as a case study.

To be successful at the academic program level, a program must successfully address the following aspects:

- Provide a team approach between assistive technology professionals and engineering participants,
- Receive appropriate publicity within assistive technology channels,
- Provide projects that have been properly scoped for difficulty, student team size, and required student expertise, and
- Have mechanisms in place to address the safety aspects of each project and the legal aspects of the program.

To address these needs, the College of Engineering partnered with four other programs to identify the specific needs of the individual. Specifically, the college joined with the Wyoming Institute for Disabilities (WIND) assistive technology program, Wyoming New Options in Technology (WYNOT) (including their Sports and Outdoor Assistive

Recreation (SOAR) project) and the university's special education program.

With this assembled team of professionals, specific duties were assigned to the team members. The WYNOT Project Director served as the coordinator with the community to identify specific assistive technology needs. This was accomplished using a short project application to identify the desired assistive device and the special needs of the individual. Project proposals were initiated by the individual with a disability, his or her family members, caregivers, or teachers, or any of the service agencies in the state of Wyoming. WYNOT was also the key player in the promotion of the Biomedical Engineering Program and Research to Aid Persons with Disabilities (BME/RAPD). Marketing included featured articles in the WYNOT newsletter, posting of project information on the WYNOT website, development of a project website (<http://www.eng.uwyo.edu/electrical/faculty/barr ett/assist/>), public service announcements, and statewide and nationwide press releases.

The WYNOT project director and the engineering PI met on a regular basis to evaluate the suitability of the submitted projects. Specifically, each requested project was reviewed to ensure it was sufficiently challenging for a year-long senior design project. Also, the required engineering expertise was scoped for each project. Once a project was determined to be of suitable scope for an undergraduate design project, the PI coordinated with the appropriate engineering department(s) to publicize the project in the senior design course. This process is illustrated in Fig. 5.1. Overall, an individual with a disability was linked with a student engineering team, which was to provide a prototype custom designed assistive device specific to his or her needs.

Since these projects involve the use of human subjects, students were required to complete an Institutional Review Board (IRB) study prior to initiating a specific project. These studies were completed and submitted to the IRB per federal and university guidelines. Furthermore, projects were delivered to the recipients only after extensive testing. At that time the recipient or his or her legal guardian signed a "Hold Harmless" agreement. This agreement was reviewed and approved by the university's legal office.

At the individual project level, students must:

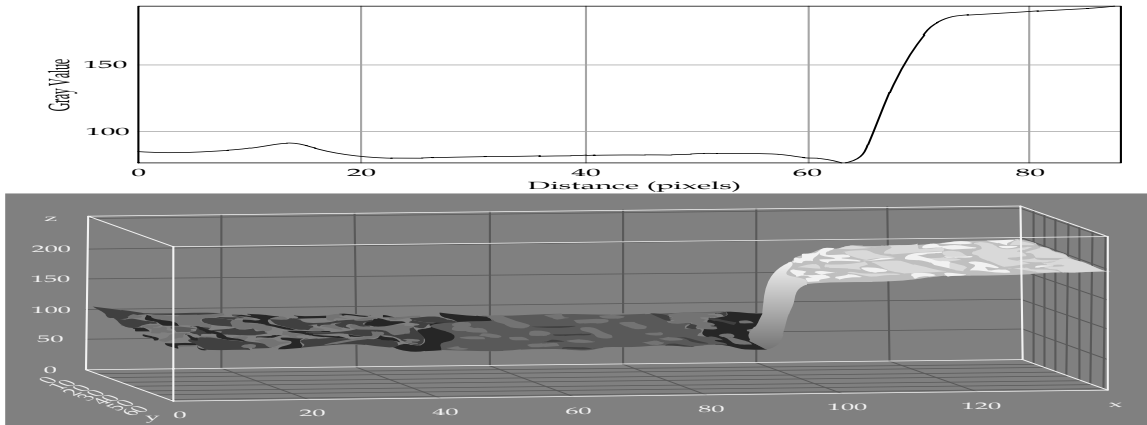


Fig. 5.1. Program Flow for Undergraduate Design Projects to Aid Wyoming Persons with Disabilities (Barrett, 2003).

- Be educated on assistive technology awareness,
- Be committed to delivering a completed, quality project,
- Be aware of available expertise to assist with the technical aspects of the project,
- Work closely with the individual who will be using the project, and
- Provide adequate time in the project schedule for testing and remanufacture if required.

To assist the students in developing these aspects of the project, the PI met with each senior design course at the beginning of the semester. The PI reviewed the purpose of the program, described potential projects, and also emphasized the importance of delivering a completed project. Students were encouraged to meet individually with the PI if they wanted more information about a specific project. At these follow-up meetings, the students were given all available information about the project and a point of contact to obtain more information from the requesting assistive technology agency or individual. Students were encouraged to contact these individuals to begin developing a relationship between the project user and designer.

Many of the projects were interdisciplinary in nature typically involving both mechanical and electrical engineering students. Faculty advisors for the senior design courses set up several “get acquainted” sessions at the local pizza parlor for students to get to know each other and also to review potential projects.

WYNOT also provided training to the engineering students regarding assistive devices and services. This training was provided to all students in the senior design course regardless if they were participating in the assistive technology program. This provided disability awareness to the state’s next generation of engineers.

Expected Benefits

It is a challenge to get a program of this type initiated; however, the potential benefits far outweigh these challenges. Here is a list of potential benefits:

- Provide engineering students multi-disciplinary, meaningful, community service design projects,
- Provide persons with disabilities assistive devices to empower them to achieve the maximum individual growth and development and afford them the opportunity to participate in all aspects of life as they choose,
- Provide engineering students education and awareness on the special needs and challenges of persons with disabilities, and
- Provide undergraduate engineering students exposure to the biomedical field of engineering.

This quote from a student who participated in the program best sums up the expected benefit:

“As an undergraduate student in the college of engineering, this project personally affected my life in many ways. It not only challenged me to think creatively and to be able to come up with an original design, but it also allowed me to see at a young age how the work I do can better other lives. I am proud to have been a part of this project and to know that something that I helped design and build is allowing

people from around the state of Wyoming to be educated about disabilities (Barnes, 2003)."

Resources

Resources on Disability:

The Family Village is a website maintained by the Waisman Center at the University of Wisconsin-Madison,

<http://www.familyvillage.wisc.edu/index.htmlx>

The Library section allows individuals to search for specific diagnoses or general information on numerous disabilities.

The ILRU (Independent Living Research Utilization) <http://www.ilru.org/ilru.html> program is a national center for information, training, research, and technical assistance in independent living. The directory link provides contact information for all Independent Living Centers in the country and US territories.

Resources on Assistive Technology:

The National Institute on Disability Rehabilitation and Research,

<http://www.ed.gov/offices/OSERS/NIDRR/>

funds the state Assistive Technology projects as well as Rehabilitation Engineering Research Centers (RERC). The state projects are excellent resources on a variety of AT issues and the RERC's conduct programs of advanced research of an engineering or technical nature in order to develop and test new engineering solutions to problems of disability. Information on these centers is available through the NIDRR website by searching their project directory for Rehabilitation Engineering Research Centers. These centers specialize in a variety of areas including mobility, communication, hearing, vision, spinal cord injury, recreation, prosthetics and orthotics, and wireless technologies to name just a few. These are excellent resources to learn more on state-of-the-art engineering projects to assist individuals with disabilities.

Another valuable source is the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) <http://www.resna.org/>. This is a transdisciplinary organization that promotes research, development, education, advocacy, and the provision of technology for individuals with disabilities. In addition, by using

the technical assistance project link on the home page, one can locate all of the state assistive technology projects and obtain contact information for his or her particular state or territory.

For specific product information, <http://www.assistivetech.net/> as well as http://www.abledata.com/Site_2/welcome.htm are excellent resources.

Resources on Universal Design:

The Center for Universal Design, North Carolina State University, <http://www.design.ncsu.edu/cud>.

The Trace Research and Development Center, University of Wisconsin-Madison, <http://www.trace.wisc.edu>.

The Center for Inclusive Design and Environmental Access (IDEA), University at Buffalo, New York, www.ap.buffalo.edu/idea.

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CHAPTER 6

CALIFORNIA POLYTECHNIC STATE UNIVERSITY

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College of Science and Math

Departments of Mechanical, Computer, and Electrical Engineering
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THE FOOT AND HAND CYCLE: FIRST ITERATION

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INTRODUCTION

The Foot and Hand Cycle, First Iteration (FAHC1), is an exercise vehicle for persons with varying physical disabilities which prevents beneficial physical exercise through traditional cycling. The FAHC1 allows a rider to use both their hands and feet to power a tricycle intended for street use. Upon completion, the device was given to Central Coast Assistive Technologies Center (CCATC) in San Luis Obispo, CA. It is currently being used by John Lee, who has difficulty using a bicycle due to a degenerative muscle disorder and lack of balance. As a source of beneficial physical exercise. His long term test results are being used to generate requirements for an improved second generation device for use by a wider range of persons with disabilities. Overall, the FAHC1 has great potential for being a fun and useful workout device as well as providing its user with increased mobility.

SUMMARY OF IMPACT

Cycles are a popular choice for recreation, exercise, and sport. Unfortunately, those with limited use of their legs and other persons with physical disabilities are unable to fully participate in these activities because standard cycles are not tailored to their needs. There are currently cycles on the market that are powered by either the user's feet or the hands, but not typically both simultaneously. The FAHC1 fills this gap. The prototype implements both hand and foot movement for power and is specifically designed for a user with limited strength in either or both the hands and feet. This device offers a unique opportunity for the client to exercise both body systems. Both upper and lower body movement is utilized to power the cycle over a flat terrain. Current foot-powered cycles, designed for people with disabilities such as EZ Chair from Premier Designs, have limitations such as relatively high cost and they do not provide upper body exercise. The FACH1 is an ideal platform for a user



Fig. 6.1. Final Product.

to exercise both upper and lower bodies and make use of the combined strength for increased mobility.

TECHNICAL DESCRIPTION

The device is a purely mechanical device. The FAHC1 combines the ergonomics of an elliptical aerobics machine with the traditional pedal and gear system of a recumbent bicycle for its power train. The tricycle is composed of two wheels in the front and one wheel behind the seat. For its frame and other structural components, the FAHC1 uses round steel tubing. A rack and pinion steering system is connected to the power arms to translate the steering motion to an Ackerman setup at the front wheels. The seat is padded with weather-proof material and has shocks on the rear base to isolate the rider from vibrations caused by the road. Braking is accomplished by hydraulic hand brakes on the rear wheel. Among the many user requirements satisfied by this design is a firm upright seat with high visibility. The seat sits at a comfortable height that allows easy transition from a

standard wheel chair. The three wheeled design is extremely stable. The widest geometry of the frame does not exceed 30 inches which allows the vehicle to pass through a standard doorway with the front wheels removed. The force required to initiate motion is comfortable for our sponsor and tester, John P. Lee for whom the cycle is designed. The cycle can be started from rest by the arms, legs or a combination of the two.

Testing results indicated that the vehicle had comparable cruising speed to a standard road bicycle with testing speeds easily reaching 25 mph. The force required to initiate motion is slightly higher than traditional bike design using foot power only. This is due mostly to the fact that the power stroke is initiated normal to the pull of gravity; however, with the addition of hand power, initiating

motion is relatively easy, and sustaining a constant velocity required is the same or less force than a bicycle. The steering is intuitive and easy to control after an average of 10 minutes training on the vehicle. The minimum turning radius is larger than a traditional bike at approximately 13 feet. The final phase of testing was conducted by John Lee. His suggestions for improvements include shortening the length of the foot crank pedal from seven to six inches, shortening the total travel of the power arms from 15 to 12 inches, and raising the seat by 1.5 inches. Mr. Lee is currently performing longer term testing which result in an improved set of requirements for the second generation machine.

The cost to produce the prototype is \$2188.00 in materials.



Fig. 6.2. The Foot and Hand Cycle in action.

THE WIIBFIT

Designers: Steven Pungdumri, Mallory Embree, Bunvandy Taing, Matthew Hall
Client Coordinator: Paul Mortola, Central Coast Assistive Technology Center, San Luis Obispo, CA
Supervising Professor: Dr. Lynne A. Slivovsky
Computer and Electrical Engineering Department
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INTRODUCTION

It can be difficult for people with quadriplegia to participate in certain forms of exercise. The primary intent of this project is to develop a form of exercise for people with quadriplegia, using the Nintendo Wii system. The Wii-B-Fit takes the Wii's engaging and fun game play and adapts it to meet a set of user defined requirements. Individuals with quadriplegia also face very limited access to video games.

Although Nintendo claims the Wii targets a broad demographic, the ingenuity of the Wii's remote actually excludes people with quadriplegia. The Wii requires players to have control of their arms and upper body to make full use of the accelerometer and infrared based remote system. In order to make exercise with the Wii possible, the ability to play the Wii must be an inherent property of the device. Thus, this project will also increase the accessibility of the Wii system to people with disabilities. This in turn will provide those with quadriplegia the opportunity to enjoy the health benefits of physical exercise and play.

SUMMARY OF IMPACT

In general, it can be difficult for people with quadriplegia to find suitable forms of physical activity. Using the Wii and a customized Wiimote, the WiiBfit system makes the Wii accessible to people with quadriplegia and provides a fun form of exercise. Specific design criteria met by the system include a device that operates similarly to store-bought Wiimotes, a remote that can be tailored to a client's specific needs, compatible with at least two Wii games, and provides a fun and safe form of exercise.

The clear impact and potential of this system can be summarized by one user's blog entry. "After my accident, I never expected to be able to play my Wii

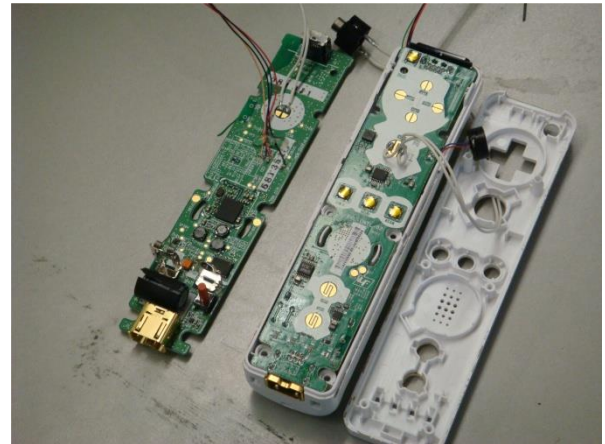


Fig. 6.3. Customized Wiimote. and User Focusing on the WiiBfit game



Fig. 6.4. Client being fitted with the WiiBfit Wiimote.

games. But now, despite my disability, I can play my Wii whenever I want. I can even use it as a physical therapy tool, which is great. It's nice to be able to have fun and exercise at the same time. Now, when I'm using it, I forget that I'm actually exercising.

TECHNICAL DESCRIPTION

The overall system design includes the use of the Polybot custom microprocessor board that is

interfaced to a modified Wiimote to take accelerometer data. The accelerometer data from a standard Wiimote is not sensitive enough to pick up the subtle head movements of many individuals with quadriplegia. The accelerometer signals must be “boosted” before they are fed into the regular Wii console. Software running on the microprocessor interprets accelerometer data and communicates to the Wii console to provide input to the standard Wii games. The mechanical system includes a custom

bandana that can be easily and comfortably attached to the users head with Velcro. This holds the modified Wiimote that can sense the subtle movements of the users head. By boosting the accelerometer signal, the modified Wiimote can then communicate to the main Wii console with inputs that look the same as any Wiimote. This allows the user to play games by themselves or against others.

The cost to produce the prototype is about \$800.00 in materials.



Fig. 6.5. Client focusing on the WiiBfit Wiimote.

SIT SKI FOR THE US ADAPTIVE SKI TEAM

Designers: Marc Bergreen, David Bydalek, Ross Gompertz
Client: Mr. Marlon Shepard, U.S. Adapted Ski Team Member
Client Coordinator: Mr. Jon Kreamelmeyer, Developmental Coach of the US Adaptive Ski Team
Supervising Professor: Sarah Harding
Mechanical Engineering Department
California Polytechnic State University
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INTRODUCTION

The purpose of this project is to design, build, test and deliver a Sit Ski for the US Adaptive Ski Team member, Mr. Marlon Shepard. Mr. Shepard is new to the team and his event is Adaptive Cross Country Skiing. Sit Skis consist of light, form-fitted frames and seats mounted to standard cross country skis that allow the athletes to use poles to propel themselves along with their upper body. The frame and seat of the sit ski are mounted onto the skis using either standard cross country ski bindings, custom proprietary mounts or a combination of the two. Like all team members, he has unique requirements for his Sit Ski in order to optimize performance. Interviews revealed the top design priorities which included reduced weight, increased rider comfort, and increased durability over existing designs. The intent of the project is to develop a new Sit Ski design that can be used in international competition at the Paralympics.

SUMMARY OF IMPACT

Quality Function Deployment (QFD) is used to create engineering specifications from the stated user requirements. This process indicates an interdependence of several of the design specifications. Some of these interdependencies include seat height and restraint systems; as well as sharp edges, pressure points and restraints. The top three most important requirements all relate to holding the user's torso secure. The next most important design requirement is the seat height since this directly affects power transfer and the ability to right oneself after a fall. The last critical requirement is to keep the weight of the device as low as possible. The end result of the design process is a sit ski that will provide Mr. Shepard with the best performance outcome. Initial testing has shown that the design satisfies the majority of the



Fig. 6.6. Custom Sit Ski.



Fig. 6.7. Computer model of the custom Sit Ski.

requirements. Some modifications will need to be made before the winter racing season.

TECHNICAL DESCRIPTION

The final design utilizes a combination of an injection molded plastic seat and a space frame

made from aluminum tubing. These materials are chosen due to their light weight, strength and availability. The design can be broken down into four components including the frame, seat, bindings, and restraints. The frame uses three different tubing sizes to construct a sit ski that is as light and as strong as possible. The bucket seat is constructed from injection molded plastic. The seat is supplied by Enabling Technologies, LLC. After the frame and seat, the third element of our design is the binding system. The sit ski uses two NNN bindings on each ski. They face in opposite directions to keep the skis rigidly attached to the frame. The final element of the design is the restraints which hold the rider in the sit ski. They consist of 2" wide nylon straps for the seat and 1" wide nylon strap to secure the feet to the foot plate. An additional nylon strap is riveted to the footplate and attached to the back seat support so that Mr. Shepard can pull his legs tight

should spasticity occur. This will effectively stretch his calves and allow the spasticity to subside.

The analysis performed on the sit ski design focuses on the strength of the frame. The initial hand calculations performed on the frame gave rough engineering estimates for appropriate sizing. The structure is highly indeterminate and challenging to analyze with traditional methods. Although hand calculations are used to gain an understanding of how the structure responds to loads; a more detailed finite element analysis was used to get a more accurate prediction of frame strength and deflection. The final product performed well in initial testing and has been delivered to the client for further testing next winter.

The cost to produce the prototype is \$1167.00 in materials.



Fig. 6.8. Custom Sit Ski Testing.

THE ADPATED PADDLE LAUNCH VEHICLE

Designers: Duane Menton, Erik Granstrom, Matthew Resendez, Shannon Crilly
Client Coordinator: John Lee, Central Coast Assitive Technology Center, San Luis Obispo, CA
Supervising Professor: Dr. Louis Rosenberg
Mechanical Engineering and Kinesiology Departments and the School of Education
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INTRODUCTION

At California Polytechnic State University, the Kinesiology department has created an adapted exercise program that provides different means of exercise for people in the community. One such activity is the adapted paddle program, which allows community members with varying forms of paralysis to participate in an organized kayaking trip to the local estuary, Morro Bay. This activity provides a fun way to exercise as well as a sense of freedom in the open water that may not be experienced on land. The Adapted Paddle Launch Vehicle (APLV) is a device that allows the kayak launch and retrieval process to be safe and more efficient than previous designs allowed. The APLV allows the kayaker to transfer from their wheelchair into the kayak, and then safely lower the kayak into the water from a boat ramp. After finishing kayaking, the APLV safely brings the kayaker back up the boat ramp.

SUMMARY OF IMPACT

There are five major user requirements that drive the design to insure a successful APLV. The first requirement is that the device be accessible to as wide a range of users as possible. The adapted paddle launch program has clients with a wide range of disabilities; the APLV is usable by the majority. The second user requirement is to make the transfer from the wheelchair to the kayak comfortable and safe. Without meeting this goal, the users may get discouraged and not participate in the adapted paddling program. The third requirement met by the APLV is that it can transport two kayakers (the person with the disability and the volunteer that shares the kayak) and the kayak itself from the top of a boat ramp, down to the water, and back up safely. The fourth user requirement is to make the vehicle easily transportable to and from the launch site. The fifth major requirement is to make sure the vehicle requires little maintenance.



Fig. 6.9. The completed APLV.



Fig. 6.10. Close-up of the 'Dead' Man Breaking System.

The APLV has been commissioned and is used regularly by the adapted paddle program and has made a huge impact on the ease of transferring the participant's' wheelchairs to and from the water. Surveys of the users indicate a high level of satisfaction.

TECHNICAL DESCRIPTION

The APLV consists of two independent systems. The first is a commercially available hoist which is used to transfer the clients from their wheelchairs to and from the kayak. The second system is the APLV which is used to transport riders and kayak to and from the water. The APLV has a rigid frame. It consists of two main rails that support the riders and kayak. These two main rails are detachable with locking pins to allow for easy transportation of the vehicle to the launch site. The rear axle is mounted to the rails and has a handlebar attached to allow for steering. A Delrin flanged bushing acts as the steering mechanism bearing which results in low wear, a smooth feeling and will require no maintenance. Delrin bushings also support the wheels so they roll with much less resistance. Delrin is a high-strength, low-friction plastic that is lightweight and non-corrosive, making it ideal for our needs and works well in the salt-water environment.

The handlebar is equipped with a dead man's brake for speed control of the APLV as it is led down the incline of the boat ramp. This can also be used as an emergency brake. A dead man's brake works like a traditional brake, except the lever is released rather than pulled to engage the brake. The braking system uses a bicycle hydraulic bicycle disc brake that is reconfigured to work backwards, so when the brake lever is released the brake is engaged. With this feature, the cart will automatically stop if the person steering loses their grip on the handle bars. The rigid frame allows for ropes to be attached to the vehicle to help pull the loaded cart out of the water and up the boat ramp if necessary.

The vehicle is fabricated by using common sizes and parts that are readily available from vendors. The APLV frame is made from 6061-T6 aluminum. This aluminum is selected due to its non-corrosive properties and high strength-to-weight ratio. The



Fig. 6.11. Prior to the APLV, Kayaks were launched by assistants carrying the kayak (top) or with the use of hand cart (bottom).

wheels are rated for a load roughly twice that which is anticipated in use. Other parts including the bicycle brake system and various fasteners are readily available and easy serviced.

Thorough analysis of the APLV design was performed prior to construction. A static force analysis was used to find reaction forces in the critical members of both the launch vehicle and lifting mechanism. Deflection, stress and fatigue analysis was performed to insure that the system would perform within specifications.

The total cost to produce the prototype is \$1166.00

THE STRIDER

Designers: Alex Trask, Eric Johnson, Ricardo Garcia
Client: Nathan Cooper who has Spinal Muscular Atrophy (SMA)
Client Coordinator: Amy Cooper, Nathan's Mother, San Luis Obispo, CA
Supervising Professor: Dr. Louis Rosenberg
Mechanical Engineering and Kinesiology Departments and the School of Education
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INTRODUCTION

The overall goal of the STRIDER (STanding RIDER) project is to provide children with Spinal Muscular Atrophy (SMA) or similar illnesses with a device that will allow them to exercise, sustain mild impact to promote bone density growth, and to move around in a vertical position. The STRIDER is designed for the needs of a specific client, Nathan Cooper (a four year old child with SMA). Nathan is a four year old boy in San Luis Obispo, CA with Spinal Muscular Atrophy (SMA). SMA is a neuromuscular disease which results in weakness and limited mobility in the limbs, particularly the legs. Because of this weakness, Nathan is forced to spend most of his time in a sitting or lying position. The STRIDER project resulted in a device that supports Nathan in a standing position, facilitating better circulation and physical exercise. With increased exercise, the hope is that Nathan will develop strength and endurance, breaking some of the barriers previously associated with patients having SMA.

The STRIDER is a mechanical device that supports Nathan in a vertical position and allows him to independently navigate over varied terrain. The adjustability of the STRIDER will accommodate Nathan over the next two years as he grows and gains weight. The lessons learned from the development of the STRIDER will be used in the future to develop a more advanced and universal device for other clients.

SUMMARY OF IMPACT

There is no specific therapy for patients with SMA. Treatment is usually only supportive, with its primary aim towards preventing the development of complications like respiratory infections and scoliosis. Therefore, a new therapeutic strategy that may offer a form of therapy and exercise is of great



Fig. 6.12. The side (top) and rear (bottom) views of the STRIDER.

importance. A recent study conducted in 2005 (see *The Journal of Neuroscience*, August 17, 2005) determined that regular exercise prolongs survival in type 2 SMA on mice. The study consisted of three different physical exercises that tested a mouse's endurance, strength, and ambulatory behavior. Although these tests were conducted on lab mice that share like symptoms and characteristics found in humans with SMA, the article strongly suggests that similar results can be achieved with humans. The results concluded that the mice experienced better sustainability of their motor functions, and lived about 57.3% longer. This research provided the first evidence of the benefits of exercise in SMA patients and might lead to important therapeutic development for humans.

In order to meet the needs of the client, Amy, Nathan's mother, spends a great deal of time and effort trying to find the best means of transportation and exercise for Nathan. His current means of exercise include water therapy, stretching, swinging, and vibration therapy from his current standing electric wheel chair. Missing from this regimen is a therapy that gives Nathan moderate impact in his legs which will help to build up his bone density. High bone density correlates to stiffer bone, which minimizes the chance of braking or fracturing.

The primary need addressed by the STRIDER is that it provides exercise and health benefits for Nathan through the age of six. Nathan needs loading (both static and dynamic) on his bones to promote proper growth and would also benefit from more exercise. Currently Nathan spends time upright in a hip, knee, ankle, and foot orthosis which provides some bone loading, but unfortunately does not provide freedom of movement. To move around Nathan has a Go-Bot® which does not allow him to traverse varied terrain. The STRIDER has the potential to provide Nathan with physical exercise by allowing him to use a limited gait motion to move the system in any direction he chooses. Also the standing position will load Nathan's bones. Ultimately it will provide Nathan with necessary exercise and increased mobility to explore his world.

The design requirements for the STRIDER are developed to meet the needs of Nathan. The main user requirements are to provide exercise and health benefits for Nathan, be able to provide him with these benefits through age six, be enjoyable, durable, lightweight, compatible or in place of HKAFO,



Fig. 6.13. Nathan moving around in his Go Bot.

adaptable for future improvements, variable weight bearing for different levels of exercise, maneuverable, cleanable and maintainable.

These user requirements were used to develop a more detailed list of quantifiable engineering requirements that were necessary to satisfy Nathan's needs

TECHNICAL DESCRIPTION

The design of the STRIDER is governed by a specific set of engineering requirements developed to satisfy Nathan's needs. The first major requirement is to provide for multi-terrain use. To accomplish this requirement, the system is designed with four large wheels and an adjustable suspension system. A coil over suspension is located between the support harness and the lower frame. This system can be adjusted both in height (to accommodate Nathan as he grows) and in spring stiffness. The springs are relatively soft which will isolate Nathan from large ground induced shocks as the STRIDER moves. The springs also allow Nathan to "walk" using the system as he can bounce up and down to alternatively touch the ground and lift his feet as he

propels himself forward. A system of nuts and screws allow adjustable pre-tensioning of the spring to accommodate Nathan as his weight changes over the next few years.

The basic frame supporting the system is made from 6061-T6 aluminum to keep the system relatively light. This allows Nathan to move the STRIDER under his own power. This independence is an incentive for Nathan to get more exercise. The castor in the front wheels allow the system to be "steered" through inputs by either Nathan's feet or by his mother. Handles in the back allow a parent to use the system more or less like a stroller. An optional footplate is provided when the STRIDER is used as an upright stroller to keep Nathan's feet from dragging on the ground. This can be removed when Nathan is using the STRIDER independently. The post at the back of the STRIDER allows the carriage to move vertically as Nathan is moving. The carriage has a welded structure which allows the attachment of Nathan's harness. This carriage can be replaced with a larger structure as Nathan grows. Lastly, the STRIDER is designed to be collapsible so that it can be transported easily in a duffel bag.

Safety is a top priority in the STRIDER's development. One of the primary concerns is stability. The system was design to insure no tipping when placed on a 30° incline. Basic static analysis indicated a base width of 20 inches or more to ensure stability up to 40°. Testing validated the design. The harness support is made from tubing with a minimum wall thickness of 0.5 inches and an outside diameter of one inch. This provides an ample factor of safety with regard to any structure failure. The end result was a system that Nathan is delighted to use. It also allows Nathan more independence from his Mother in how he obtains exercise. The STRIDER will provide an enjoyable way to exercise and health benefits for Nathan for the next two years. Long term testing results will be analyzed to developed design criteria for a more universal product.

The cost of materials and supplies to produce the STRIDER was approximately \$1356.78.



Fig. 6.14. Nathan enjoying his new device.



Fig. 6.15. SolidWorks Model of the STIDER.



CHAPTER 7

DUKE UNIVERSITY

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UPPER BODY WORKOUT DEVICE

*Designers: Olivia Chang, Rish Sinha, Kevin Story, Prashant Swaminathan
Client Coordinator: Nancy Curtis
Supervising Professor: Larry Bohs
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INTRODUCTION

Our client is a 21-year-old man with cerebral palsy. He wants to exercise his upper body to gain strength and improve his range of motion. The Upper Body Workout Device consists of a steel frame with a cable and pulley system on each side, allowing him to exercise each arm individually. Forearm sleeves attach in three different positions to allow workouts targeting the biceps, triceps, and deltoid muscles. Resistance is varied using free weights. The device also includes a repetition counter to provide motivation and to track progress.

SUMMARY OF IMPACT

The Upper Body Workout Device enables the client to exercise either arm in three different ways, complimenting the lower body exercises he can perform using a previously constructed device. The client's mother commented, "The possible positive ramifications of this device are immeasurable."

TECHNICAL DESCRIPTION

The Upper Body Workout Device (Fig. 7.1) consists of a steel frame, two upper pulleys, two lower pulleys, two drawer glides, two weight platforms and weight poles, three sets of tension cables, two metal hooks, two forearm sleeves and a repetition counter.

The steel frame is constructed from 2.5" x 1.5" steel tubing, and weighs 150 lbs. The frame is 72" tall, 40" wide, and 48" long. The frame is split in half at the top and bottom crossbeams, held together by two 24" angle braces bolted at 8 locations on each brace. At the top crossbeam, two 1" square holes provide clearance for the tension cables.

Two 2" diameter pulleys reside at the top of the frame. Two additional 1.5" diameter pulleys mount on the vertical beams, 6" from the ground. Two 24" x 1.5" drawer glides are mounted on the outside of the vertical beams, 10" off the ground. Two 4.5" x 5"



Fig. 7.1. Upper Body Workout Device.

L-brackets attach to the drawer glides, each holding a 6" x 7" High Density Polyethylene platform to hold weights.

Solid aluminum rods, 6" long x 1" diameter, provide mounting pins to stabilize the weights, each having a circular hole in the center.

Vinyl-coated 1/8" steel tension cables secure to the top of the drawer glides. These main cables loop around the top of the frame, over the upper pulleys, and through the clearance holes. At the user-end of each cable is a loop, created using standard cable hardware. Two additional sets of 20" long cables are

used for the shoulder-fly exercises. Additionally, two 78" tension cables are permanently looped through the lower pulleys for the bicep exercise. For the shoulder fly and bicep exercises, the appropriate cables attach to the main cable using karabiners.

The forearm sleeves are modified from Ossur brand 10" Vinyl Wrist Cock-Ups. Two nylon straps made from seat-belt material, sewn near the wrist area and forearm area of the brace, provide attachment points for quick-link threaded connectors, each 6.25" long x 7/32" diameter. These connectors attach to the ends of the appropriate cables using karabiners.

A repetition counter, consisting of a microcontroller, LCD display and magnetic sensors, provides the user with a count of the number of repetitions for each exercise.

Fig. 7.2 shows the client with the overall device. The cost of components of the device is about \$1300, including the cost of welding (\$500) and powder-coating (\$250), both of which were donated.

The client is wearing a forearm sleeve, and the repetition counter is visible on the left vertical support.



Fig. 7.2. Client and designers with the device.

SUPPORTIVE PLAYGROUND VEHICLE

Designers: Vanessa Kennedy, Ming Li, Emily Liu, Allen Yu

Client Coordinator: Cathron Donaldson

Supervising Professor: Larry Bohs

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INTRODUCTION

Due to congenital myopathy, our three-year-old client has difficulty playing independently and interacting with her peers on the playground. She cannot hold her head and trunk upright without assistance, and has little strength in her extremities. The goal of this project is to design and develop a safe, supportive vehicle she can use to be more active on the playground. The vehicle has a four-wheeled frame that allows for ease of entry. Pedals drive the rear wheels, while the client handlebar steers the front wheels. The rear handlebar allows an assistant to help the client in propelling forward. The seat and seat pads are tailored to support the client safely and comfortably. With this vehicle, the client can have more fun and interaction on the playground.

SUMMARY OF IMPACT

The supportive playground vehicle allows the client to be more interactive with her peers on the playground. She exercises her arm and leg muscles while propelling herself forward with new independence. This vehicle provides both a means of therapy and child friendly fun for the client. The client's therapist commented, "The vehicle is ... increasing peer interaction during recess activities and putting her at the same level as her peers. And of course, there is the overall effect of strengthening her mobility and muscles." The client exclaimed, "I can't believe it! Fantastic!"

TECHNICAL DESCRIPTION

The Supportive Playground Vehicle (Fig. 7.3) uses the frame, wheel, and gear system of the Kettler Kettcar Classic. A highly adapted seat made from the Graco Turbo Booster seat is attached to the frame. The vehicle also has a modified client handlebar, custom made pedals, and a detachable assistant handlebar.



Fig. 7.3. Supportive Playground Vehicle

The vehicle frame is appropriated from the Kettcar, a four-wheeled playground vehicle. The frame is made of durable, high-carbon steel and measures 22" x 21" x 37". The gear and chain system is fully enclosed in a protective plastic case, and the wheels feature a long-lasting dual-layer safety tread.

The supportive seat uses a modified Graco Turbo Booster seat. Additions include six removable cushions: two side thigh cushions, two side head supports, a lumbar support, and a cylindrical neck support. All cushions are upholstered in mildew and water-resistant vinyl, and are attached with Velcro for easy removal and adjustment. For added safety, the supportive seat also includes a custom seat belt made from nylon webbing. The seat belt is comprised of a lap belt and two shoulder straps, and is adjustable through plastic D-ring fasteners.

The client handlebar is made from a 2" long x 3/4" diameter length of metal conduit, bent into an ergonomic shape for maximum comfort and ease of steering for the client. The client handlebar is covered in sweat-and-shock-resistant cork tape, making it easy to grip and preventing the user's hands from slipping off.

The assistant handlebar is made from a 7' length of 3/4" metal conduit, bent in a U shape so an assistant can comfortably push the vehicle. Also covered in cork tape, the assistant handlebar is removable, allowing the client optional independent movement as well minimizing size for storage and transportation. The height of the bar adjusts using a spring-plunger system, accommodating assistants of

different heights. The width of the assistant handlebar is 22.5", and the possible heights are 46", 48", and 50".

The pedals of the vehicle include an HDPE plastic base and a PVC heel cup, made from a 2" length of 4" diameter pipe cut, shaped and sanded. The pedal base measures 6.5" x 3.5", and the heel cup measures 2.5" in height. A second base piece connects the custom pedal to the original pedal by compression; two wing nuts allow for adjustment of the fore and aft position. Finally, the pedals feature Velcro-adjustable canvas straps, securing the user's feet to the plastic base. The replacement cost for the device is approximately \$300, not including the cost of the Kettcar.



Fig. 7.4. Client and designers with the Supportive Playground Vehicle.

CUSTOM POWERED SCOOTER

*Designers: Dave Chen, Brian Chon, Ian Gao, Bryan Lawlor
Supervising Professor: Larry Bohs
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INTRODUCTION

Our client is an active eleven-year-old boy. He has Thrombocytopenia with Absent Radius (TAR) syndrome, resulting in short arms, and his legs have limited strength and flexibility. He requires a device that will assist him in traveling but not be as cumbersome and restrictive as his electric wheel chair. The Custom Powered Scooter includes a custom seat, handlebars, auxiliary wheels for stability, and foot-controlled accelerator and brakes. A custom freewheel allows him to free scooter when he doesn't need motor power. The device gives the client more freedom in transporting himself.

SUMMARY OF IMPACT

The Personalized Scooter allows our client to be more independent. After several months of use, his mother commented, "The scooter ... has been very useful and helpful for [him]. We take it to the library, the movies, and to church. On his new scooter, he is able to explore, learn and not worry about his legs hurting or being tired. He is also able to go around the block with our family and enjoy the outdoors!"

TECHNICAL DESCRIPTION

The Custom Powered Scooter (Fig. 7.5) is modified from an E200 Razor electric scooter. Custom additions include a free-wheel mechanism, adjustable seat, auxiliary wheels, extended handlebar, and foot-mounted brake and accelerator controls.

A one-way bearing (model CKS20, www.vxr.com), incorporated into the back wheel allows the scooter to free-scoot. Two custom adaptors, machined from aluminum, secure the bearing to the rear wheel with a press fit. One adapter connects the outer surface of the bearing to a sprocket driven by the motor, and the other adapter connects the inner surface of the bearing to the hub of the rear center wheel.



Fig. 7.5. Custom Powered Scooter.

A threaded stainless steel rod 10mm in diameter serves as a rear axle to mount two auxiliary 8" pneumatic tires. A support frame, made from a 1/4" thick x 1" wide x 21" long strip of steel, attaches to both sides of the axle from the scooter frame to prevent flexing of the axle. Wheel guards, made from aluminum strips 1/4"x1"x16.5" long, attach to the back axle and cover each of the auxiliary wheels, preventing inadvertent catching of the wheels on low objects.

A Schwinn™ No Pressure Bike Seat is attached to an aluminum plunger .995" in diameter and 1' long. The plunger is encased by a seat post and allows for 8" of height adjustment. The seat post is 1.25" in diameter at the base, 1" at the top, and 14" long. The seat post is secured to a plate on the scooter frame with a short, 3" long aluminum sleeve having a 2"

outer diameter and a 1.25" inner diameter, which fits around and bolts to the base of the seat post.

The handbrake of the E200 was moved from the handlebars and is secured to the right side of a 20" long, 7/8" diameter steel rod, attached to the front base of the scooter with a custom aluminum adapter. A plastic pedal allows the client to control the brake with his right foot. The hand throttle of the E200 was moved from the handlebars and secured

to the left side of the steel rod. A plastic pedal allows the client to control the speed with his left foot.

Bicycle handlebars are bolted to a U-shaped bar attached to a handlebar stem. The handlebar stem fits into a 21.5" long shaft of 1" inner diameter bicycle tubing, which is welded to the neck of the scooter. Fig. 7.6 shows the client using the Custom Powered Scooter. The cost of the components for the device is approximately \$380, not including the cost of the Razor E200.



Fig. 7.6. Client using the Custom Powered Scooter.

WHEELCHAIR-ATTACHED LAWN MOWER

*Designers: Anna Beck, Maggie Finch, AJ Ford, Brianna Vey
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
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INTRODUCTION

Our client is a manual wheelchair user who wants to mow her own lawn. The goal of this project is to design a lightweight mower that can easily attach to her wheelchair. The design includes a plastic base with wheelchair attachments that allow the base to be suspended above the ground in front of the client's wheelchair without impeding the wheelchair's motion. Two cordless electric grass shearers attach to the base, providing a 12" cutting width. A switch in the upper attachment allows the client to easily turn the shearers on and off.

SUMMARY OF IMPACT

The device provides an even cut only on very smooth surfaces, because the shearers move up and down as the wheelchair travels over uneven terrain. Future work may consider a flexible suspension with a front wheel or wheels to help keep the shearers at a consistent height. Such devices were not considered because of concerns that they would make the front of the wheelchair too heavy for the client to "wheelie" as she desired for tight turns in her yard.

TECHNICAL DESCRIPTION

The main components of the Wheelchair Lawn Mower (Fig. 7.7) are the shearers, the base, the shearer-base mount, the support arms, the foot-bar hooks, and the L-bracket attachments. The commercial shearers (Homelite, model UT44170) weigh 2.1 pounds and have a battery life of about 1 hour.

The base is constructed from 1/2" thick high-density polyethylene (HDPE). The lateral length at the front is 19", and the width from front to back in the center is 11".

The shearer-base mount attaches the shearers to the base. A 1/2" threaded zinc rod (not shown) passes through existing holes in each shearer, and fastens into HDPE blocks, which attach to the base.

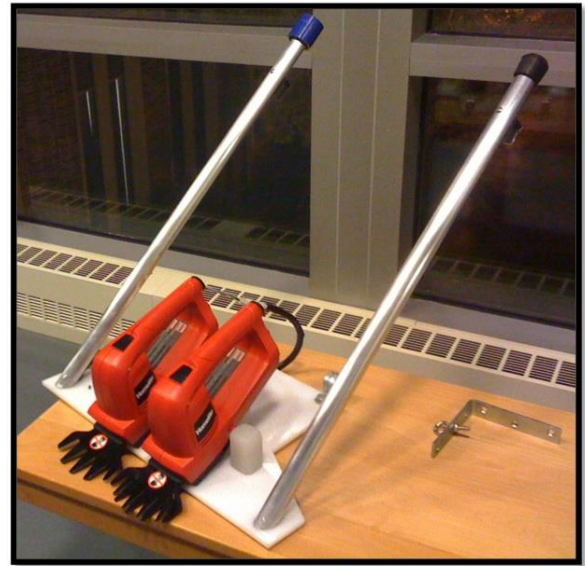


Fig. 7.7. Wheelchair-Attached Lawn Mower.

The support arms attach the base to the wheelchair near the seat. Constructed from 1" aluminum tubing, each support arm contains a solid aluminum rod press fit at the bottom end, which is threaded to provide a secure attachment to the base with a 3/8" bolt.

The device attaches to the footrest area of the wheelchair with two foot bar hooks, 1" diameter single-ended conduit clamps secured to the rear of the base with 3/8" bolts. The user slides these hooks over the footrest bar.

To hold the base up, the support arms connect to an L-bracket attachment on each side of the wheelchair. Each L-bracket attachment includes an eye bolt fastened to a 5" x 1" x 1/8" L-bracket, one end of which slides into a slot below the seat. These slots are attached for a previous project. The eye of the bolt provides an attachment location for support arm hooks fastened to the upper ends of each

support arm. To mount the device, the user slides in the L-bracket attachments, puts the foot bar hooks over the footrest bar, and then puts the support arm hooks into the eye bolt ends.

The power switches for both shearers are wired in parallel, and the wires extended to the top of the right support arm, where a single toggle switch allows easy on/off control. The replacement cost for this device is approximately \$200.



Fig. 7.8. Client using the device.

UNIVERSALLY ACCESSIBLE CONTACT CEMENT APPLICATOR

*Designers: Ian Gong, Jing Guo, Mike Kotecki, David Tainter
Client Coordinators: Joe Bumgarner, Jamie Gills, OE Enterprises
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
Duke University
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INTRODUCTION

The goal of this project is to create a device that enables employees with disabilities at OE Enterprises, Inc. to quickly and safely apply contact cement to pieces of foam insulation. Contact cement is used to glue foam pieces together to make insulation elbow joints. The Universally Accessible Contact Cement Applicator allows employees to swipe pieces of foam across a rotating roller to apply a thin, even layer of contact cement. The disposable roller is housed within a removable glue tray fabricated from high-density polyethylene. Glue trays housing either 9" or 4 1/2" rollers can be inserted depending on the size of the foam pieces. A D-profile connection attaches the axle of the roller to a DC motor, which rotates the roller. The device makes the task of applying contact cement to foam pieces more accessible to a wide range of employees.

SUMMARY OF IMPACT

The device provides employees with a quick, easy, and safe way of applying contact cement to pieces of foam insulation. Replacing the former method of hand brushing, the device increases the accessibility of this employment opportunity. The adjustable glue scraper ensures that a desired amount of contact cement stays on the exposed part of the roller during use. Jamie Gillis, OE's Business Development Manager, reported that the device not only increased efficiency, but allowed clients who could not previously perform the task to do so. One OE client, after using the device, said "That's a real good unit. I like that much better than brushing."

TECHNICAL DESCRIPTION

The Contact Cement Applicator is comprised of a base, glue trays, roller mechanism, glue scraper, and drive motor. The base, constructed from 1/2" High Density Polyethylene (HDPE) includes vertical side

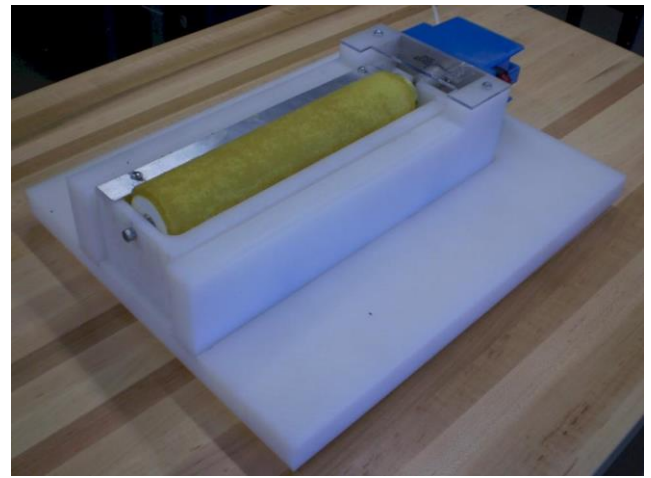


Fig. 7.9. Universally Accessible Contact Cement Applicator

walls that house the glue trays. Rubber feet on the bottom of the base prevent movement as the client exerts forces during use. HDPE withstands the solvents in both the contact cement and the lacquer thinner used for cleaning.

Two HDPE glue trays are included, one for a 9" roller, and the other for a 4.5" roller, to help conserve glue on narrower pieces of foam. Holes on either end of the glue trays accommodate the roller axle, allowing the roller to rest just above the bottom of the glue tray.

The roller mechanism includes the roller axle, onto which a commercial glue roller slides. At one end of the roller axle, a D-profile connector allows the axle to mate easily with the shaft of the drive motor. An adjustable scraper, made of sheet aluminum, mounts to the edge of one of the base side walls to remove excess glue from the roller.

The drive motor is a 12V DC gear motor that runs at a speed of 6.8rpm. An insulating electrical box

houses the motor. An LED switch attached to the box exterior provides easy on/off control, and a DC wall adapter supplies power to the motor.

A clear protective plate over the D-profile connector prevents injury due to moving parts, and maintains visibility for aligning the D-profile connector and the motor shaft.

The device is designed for easy cleaning. The glue tray can be detached from the frame and electrical components of the device and submerged in lacquer thinner. After 30-60 minutes, the supervisor can then clean the glue tray with stripping gloves and a metal-bristled brush. The roller can easily be removed and discarded after each day's use. The cost of parts for the device is approximately \$150.



Fig. 7.10. Client using device.

INTERACTIVE DELIVERY CART

Designers: Anumeha Goel, Linda Qu, Karen Schroeder, Alaina Pleatman

Client Coordinator: Susan Parker, PT, Durham County Schools

Supervising Professor: Dr. Larry Bohs

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INTRODUCTION

Elementary school students with disabilities often have difficulty interacting with teachers and other children due to cognitive and physical limitations. The goal of this project is to design a delivery cart that serves as both a learning and therapeutic tool, providing a safe, customized, and fun device from which the students learn to assume responsibility and practice essential skills. Students make deliveries of items such as newspapers to other people and classrooms throughout the school. Key features include color-coded bins, left-right signaling, braking, and handle height adjustment. The delivery cart is a unique resource in a special needs classroom and equips children to integrate work and social environments as they grow older.

SUMMARY OF IMPACT

The delivery cart is a unique therapeutic device for elementary school students with disabilities, helping to promote motor skills as well as work ethic and responsibility. It is accessible to students with a wide range of ages and physical abilities. The design is safe, adaptable, and interactive, allowing teachers and therapists to gradually add accessories as students develop their cognitive and motor skills. Our supervisor commented, "Because the device was made for several targeted children it will certainly benefit them, but I am very pleased that it can benefit multiple users, even in the future. It's wonderful for teaching a multi-step task, in that some steps can be added or eliminated commensurate with the child's skill level."

TECHNICAL DESCRIPTION

The main components of the Interactive Delivery Cart are a height-adjustable handle, hand brakes, dashboard for holding a communication device and task cards, color-coded bins, turn signals, a base for additional storage, tip-stoppers and wheelchair adaptation accessories. The cart is modified from a commercial shopping cart.



Fig. 7.11. Interactive Delivery Cart

The custom-bent handlebar adjusts in height for use by both children and adults. Knob screws on either side loosen and tighten the vertical supports to slide the handle to the desired position. Tennis grip tape allows for a comfortable grasp.

Hand brakes, modified from commercial walker brakes, allow users to slow themselves down when moving on uneven surfaces or downhill. The brake handles are secured to the left and right undersides of the handlebar, and are squeezed to engage the rubber-coated brake friction levers, which are mounted near each rear wheel.

The dashboard is constructed of 0.125" thick acrylic and features a ledge to hold the student's communication device. A Velcro strip directly above the communication device displays task cards corresponding to the color-coded individual bins; these cards may be selected from the task card binder. The dashboard is securely supported on the back wall of the cart's large basket.

Color-coded bins, lined with colored felt, allow children to learn and distinguish between various colors in association with the delivery tasks. The

bins are easily removed according to the teacher or supervisor's preference. Red vinyl covering the cart sides makes the design more aesthetically pleasing and reduces sharp corners.

The base is constructed from 0.25" clear acrylic and is useful for additional or bulky item storage. The front edge curves upward as a ledge to prevent items stored on the base from falling. Tip-stoppers attached to the front corners of the cart frame

normally ride 1/8" above the ground, but make contact if the cart is tipped laterally.

To help reinforce the concept of left and right, a custom circuit voices a recorded message, "Turning left" or "Turning Right", as well as lighting one of two turn signals as the cart makes a turn. The circuit detects the rotation of the front center wheel with reed relays and a magnet using an ATtiny2313 microcontroller. It is powered by a 9V battery. Replacement cost is about \$240.



Fig. 7.12. Client using the Interactive Delivery Vehicle.

BIRDIE BUDDY – WHEELCHAIR MOUNTED CAMERA AND BINOCULARS

*Designers: Kaicheng Liang, Shaun Lim, Xuan Ding, Claire Vinson
Supervising Professor: Larry Bohs
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INTRODUCTION

Our client, an avid photographer and birdwatcher with quadriplegia, desires a way to hold his camera and binoculars steady. The Birdie Buddy clamps securely to a bar on the wheelchair base frame, unfolds from a compact form on the side of the wheelchair and holds a camera or binoculars at eye level. The device can be conveniently activated, stored, or removed from the wheelchair. The device provides firm support of the weight of the camera or binoculars, convenient switching between the two pieces of equipment, and an adjustable viewing angle.

SUMMARY OF IMPACT

The Birdie Buddy gives our client greater independence. Before his accident, he was an avid birdwatcher and photographer. He commented, “It allows me to independently load my binoculars or camera on a tripod of sorts, which mounts to my chair. The device is flexible enough in that it allows me many different angles for viewing ... this device is a wonderful item that now greatly enhances the enjoyment of bird watching! ... I love it!”

TECHNICAL DESCRIPTION

The Birdie Buddy is composed of four parts including a hinged clamp, which is affixed to the left side of the client’s wheelchair, a moving arm, a camera mount and a binoculars mount. The clamp makes use of a curved surface as well as an L-plate to ensure a stable connection between the wheelchair base and the rest of the device. The clamp secures to the wheelchair frame with a single four-arm knob screw.

The moving arm lifts upward and rotates, providing resting and viewing positions. The



Fig. 7.13. Birdie Buddy with binoculars attached to client’s wheelchair.

mechanism involves a grooved cylinder, within which a solid rod with a set screw moves. The groove guides the movement of the solid rod, such that the user lifts and rotates from the resting to the viewing position. The bottom of the arm contains a protruding set screw which keys into a corresponding slot in the base, fixing its orientation. A horizontal member at the top of the moving arm contains a vertical hole that accepts either the camera or binoculars mount.

Both the camera and binoculars mounts use a modified microphone stand hinge mounted to a solid aluminum pin. To use the device, the user slides the pin into the corresponding hole in the

horizontal member, and rotates the hinge to obtain the desired viewing angle. Friction within the hinge holds the camera or binoculars steady. The cost of parts is approximately \$230.



Fig. 7.14. The client using the camera with the Birdie Buddy.

WHEELCHAIR LAWNMOWER

Designers: Shwetadwip Chowdhury, Shekar Eswarakrishnan, Wei Han, Xiao Li

Client Coordinators: Pam Duncan

Supervising Professors: Kevin Caves and Richard Goldberg

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INTRODUCTION

Rhonda is an avid gardener and enjoys working outside, tending her garden and lawn. Several years ago, she sustained a spinal cord injury and as a result, she now relies on a manual wheelchair for mobility. She cannot push a lawn mower and push her wheelchair at the same time and has to ask for help or pay someone to maintain her lawn. She has good upper body strength and can propel her chair throughout her yard, and she is highly motivated to be independent again with lawn care.

The purpose of this project is to enable our client to mow her lawn independently, efficiently, and safely, while sitting in her wheelchair. To accomplish this task, a string line trimmer is modified with operation similar to using an upright vacuum cleaner, pushing and pulling with one arm. A mount is added to the client's wheelchair so that she can easily transport the mower to and from her shed. The overall design is effective in allowing our client to mow her lawn independently and efficiently.

SUMMARY OF IMPACT

This device gives our client the ability to mow her grass, which she has not been able to do since her spinal cord injury. It also enables her to do an activity that she has always loved and enjoyed. Our client said "I am so excited about this mower. When I was walking, I used to love mowing my grass. Now I can do it again. My yard is my haven - this will be perfect!"

TECHNICAL DESCRIPTION

The design consists of three major components including a string line trimmer, wheels to provide support and mobility, and a mounting device to secure the trimmer on the wheelchair.

A commercially available trimmer (Worx GT String Trimmer/Edger) is chosen because of its high



Fig. 7.15. Client lifting the lawn mower device.

capacity, lightweight lithium battery and its adjustability. The trimmer has an extendable shaft and a rotating joint that allows adjustment of the angle of the handle relative to the cutting head. A locking mechanism is removed from the joint to allow free motion of the handle (e.g. like an upright vacuum cleaner) to ensure the string remains level while cutting.

Support and mobility is achieved by attaching wheels to the string trimmer. The weight is supported by the two large wheels on either side of the cutting head. In addition, a pair of small wheels is attached directly behind the trimmer to provide additional points of contact with the ground so that the cutting head remains level. The side wheels are adapted from a pull cart for golf bags, and they are attached to the trimmer by a custom connector fabricated from HDPE plastic. The rear wheels are attached to the trimmer's edging guard.

A mower mount is connected to the front of the client's wheelchair to hold the mower while Rhonda moves to different locations in her yard, or to and from her storage shed. This "gun rack" mount is

created using PVC tubing, which connects to the wheelchair using a custom mounting bracket developed for a previous project.

The cost to develop the device is \$296, including the cost of the Worx string trimmer.



Fig. 7.16. Client using the lawn mower while sitting in her manual wheelchair.

WALK IT OUT

*Designers: Ellie Hwang, Soo Choi, Laura Ferraro
Client Coordinators: Kyle Covington, PT
Supervising Professors: Kevin Caves and Richard Goldberg
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INTRODUCTION

Regina is a 21 year old female who sustained a traumatic brain injury at a young age. She has trouble coordinating her muscles and she has significant spasticity in her movements. As a result, Regina uses a manual wheelchair for mobility, but she is currently working with a therapist to use a walker. She has several types of walkers but they all are difficult to use because as she leans onto the walker for support, it moves away from her, putting her at risk of falling. In addition, Regina has several postural problems that make using a walker difficult. In therapy sessions, two individuals are required to help Regina walk, one to spot her to prevent a backward fall, the other to apply a stopping force to the walker if it lunges forward.

The goal of this project is to modify a walker for Regina to provide her with safe and independent use. The modified walker incorporates a new handlebar, a ski brake for resistance, a reminder bar for her posture and a walking bar for inhibiting crossing of her legs. When the client uses the modified walker, she holds a handle bar directly facing her, similar to that of a shopping cart. As she walks forward and applies downward force on the bar, the braking system activates and increases the stopping resistance on the walker. This successfully slows the client down, prevents her from falling forward, and allows her to walk independently. Meanwhile, the posture bar corrects the client's posture by preventing her hips from moving too far forward. Overall these changes help her use the walker independently.

SUMMARY OF IMPACT

The client commented "I can't wait to use my new and improved walker. It will be so nice to walk around without someone (Mom) hanging on to my walker so it doesn't go crashing into something because I can't control it. I am hoping that I will be able to get up and walk across the room with no



Fig. 7.17. Modified Walker

help. I like how you made the walker slow down so it doesn't go out-of-control fast. I like that I can just stand there so I don't always have to sit down. It will make my legs stronger. I really want to thank you for putting so much work into it, and not giving up when it didn't work at first."

TECHNICAL DESCRIPTION

The client's commercially available U-Step walker is used, which employs a handlebar cable braking system. The brakes work in a manner similar to bicycle brakes. The client activates a brake lever, which pulls on a cable and causes a brake pad to press against the rear wheels on the walker, which slows it down. The brake cables on the U-step meet at the front of the walker at a joint called the junction bar. When she activates either hand brake, the cable pulls the junction bar which rotates and activates

both brake pads. The client can also activate the brakes by pushing down on a curved bar across the front of the walker. This existing bar has a gentle curve which does not allow Regina to spread her hands widely on the bar. Therefore, a new braking bar that is ergonomically more suitable for the client is included, providing a wider grip for Regina to give her more stability. The bar is padded using foam and bike grip tape.

When the client presses either the brake lever or the braking bar, brakes will be applied to both rear wheels. However, the braking force is not enough to prevent the lunging of the walker for our client. As a result, a ski brake is included to apply additional braking force. This is made of wood with cushion on the bottom to provide more friction. It rests on the floor and is attached to the front of the walker. A new junction bar is fabricated with an additional metal lever that runs to the top of the ski brake. When the client engages the brakes, the junction bar rotates and the lever presses down on the top of the ski brake, increasing the downward force on the ski, thus increasing the braking force to the walker.

Two postural bars are incorporated into the modified walker. A pelvic reminder bar is attached to the walker in front of Regina facing her hips. During walking, Regina tends to arch her back and push her hips forward, making her prone to falls. The reminder bar is positioned so that if Regina's hips move forward, the contact with the bar will remind her to correct her posture. Similarly, the walking bar is positioned horizontally at knee level, connected to the back of the walker, passing between her knees and continuing about two feet past her. The walking bar provides a tactile reminder to Regina to not internally rotate her legs.

The modified walker has greatly improved the client's ability to walk independently. The new braking system successfully slows down the walker before it slides forward, and it is easy for the client to use effectively. The posture bars improve Regina's walking postures leading to a noticeable improvement in the client's balance and ability to steer the walker.

The cost to develop the device is \$153.



Fig. 7.18. Client using the modified walker.

ROCK'N ROLLER

Designers: Manny Fanarjian, Doug Giannantonio, and Michael Kramarz

Client Coordinators: Nancy Hoopingarner, PT, Lachanda Black

Supervising Professors: Kevin Caves and Richard Goldberg

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INTRODUCTION

Jill is a high school student with shaken baby syndrome (SBS) that has resulted in severe cognitive, visual and physical disabilities. She is unable to speak and, due to poor muscle coordination, only has voluntary control of her head and right hand. She enjoys both movement and listening to music but cannot currently perform either of these tasks independently. Jill spends most of her day sitting in a manual wheelchair that she cannot propel herself. While the teachers take Jill on walks as often as possible, they simply do not have enough time to dedicate to her, due to the other students in the classroom that also need their attention.

The goal of the Rock'n Roller is to allow our client to experience motion and music as independently as possible. The device consists of a motorized platform onto which Jill's chair is loaded and secured. The platform gently slides back and forth along a drawer slide track for a distance of 10 inches. Jill can access a switch adapted MP3 player loaded with 101 of her favorite songs. The MP3 player and the platform motor are controlled by two separate switches, which can be mounted in our client's reach, using either her head or right hand. The overall design is able to support a large amount of weight, can be stored in the cramped classroom, and is easily transported by one person.

SUMMARY OF IMPACT

The device is designed to make our client's time at school more enjoyable. Our project advisor is "very impressed" with its functionality, our client's teacher said that she is "extremely excited to use this device with [our client]." During the final delivery of the completed device, Jill repeatedly screamed with joy. Her classroom teacher reports that this was a rare display from Jill and that she appeared to be extremely happy while using the device.

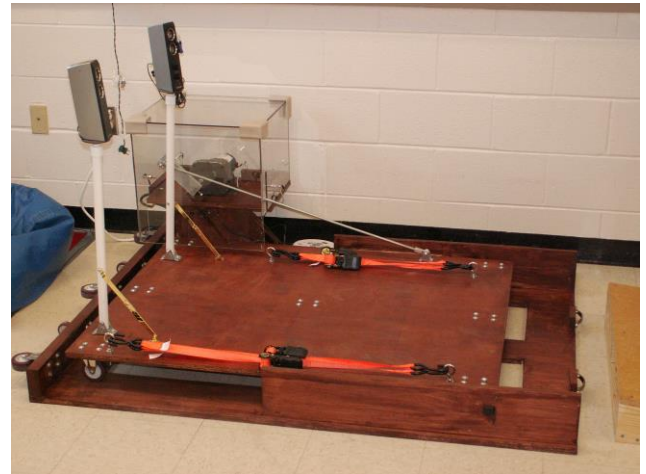


Fig. 7.19. Wheelchair Rock'n Roller.

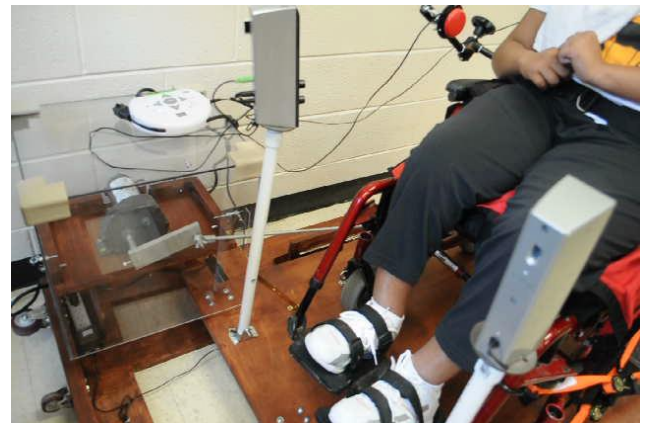


Fig. 7.20. Close up of the platform and motor.

TECHNICAL DESCRIPTION

The Rock'n Roller has three major components. The platform and base are made from a sheet of 3/4" birch veneer plywood, chosen for its strength and appearance. The top platform rolls on a set of nine two inch casters. The platform is guided via two 24 inch full extension drawer slides that also serve to keep the platform in place while transporting it. The

motor is a 12V, 6.5 amp gear motor capable of generating 45 ft-lbs of torque. A custom motor shaft attachment is included and a three foot rod connects the motor shaft to the top of the platform. As the motor turns at 6 rpm, the shaft attachment makes a 10 inch diameter rotation, which the rod translates into ten inches of linear movement of the top platform. The motor and shaft attachment are covered with a clear acrylic box to prevent injury but to still allow observation by other students. Biscuit jointing is used throughout to provide a professional appearance and durable connection. An Ablenet Powerlink controller enables Jill to control the device operation through switch activation.

The platform comes with a three foot loading ramp, so that teachers and aides can easily transfer Jill's

wheelchair on and off the platform. Once in place, the chair is secured using four commercially available cargo tie downs connected to each of four eyelets bolted to the platform surface. All materials and attachments methods are engineered with significant factors of safety.

The system employs a switch adapted MP3 player that allows Jill to advance to the next song when she presses a switch. The MP3 player is connected to amplified speakers attached to custom folding mounts. These mounts position the speakers in front of Jill so that she can hear her music without disrupting the other students in the class.

The cost to develop the device is \$487.



Fig. 7.21. Client using the Rock'n Roller device.

PICASSO'S ASSISTANT: ADJUSTABLE EASEL AND MARKER HOLDER

Designers: Doug Helferich, Nissar Ahmed, and Sushma Reddy
Client Coordinator: Nancy Hoopingartner, PT
Supervising Professor: Kevin Caves and Richard Goldberg
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INTRODUCTION

Our client is an artistic high school student with cerebral palsy (CP), who enjoys drawing with markers. However she has severe contractures in her fingers, which makes it difficult for her to grasp and release marker pens when desired. Every time she needs a new marker, a teacher or aide manually opens her fingers and places a marker in her hand. Also, her range of motion is limited, and as a result, she can only access a portion of the drawing surface.

An adjustable easel that fits on her lap tray is designed in this project. The drawing surface rotates and has an adjustable tilt angle. The client can rotate the surface independently. A teacher or aide can adjust the tilt angle, although once the optimal angle is set, adjustments will be rare. The device also includes a marker holder so that she can access up to eight different markers. She can slide the marker holder out of the way when desired.

SUMMARY OF IMPACT

The client tested prototypes and provided feedback throughout the project development to insure that the device would meet her needs. Her teacher said that “the device has allowed [the client] to be more independent with her drawing” and that she is “really excited when she gets to use it.”

TECHNICAL DESCRIPTION

The easel consists of a stable base and an adjustable drawing surface, both of which are made of furniture grade plywood. The top surface is mounted to a backing using a lazy Susan, which allows the surface to rotate relative to the backing. The plywood backing is connected to the base with a hinge along the front edge. Several adjustments are possible. The drawing surface is 14" x 20" and the client can access about half of this area at any one time. By rotating the top surface, the client can



Fig. 7.22. The client with her adjustable easel resting on her lap tray.

position any part of the paper within her range for drawing. By tilting the easel surface, the teacher or aide can adjust it to the ideal drawing angle for the client. There is a latching mechanism to hold it at an appropriate angle. This consists of a wooden post that is hinged to the center of the backing, and it fits into one of six slots on the base, allowing for six different angle adjustments.

The drawing surface has two large clips on the left and right sides to hold the paper, notebook, or pad in place.

The marker holder allows the client to independently access any one of eight markers. Initially, the teacher or aide loads the markers, with the caps removed. The client can remove and replace the markers at any time. The holder is an enclosed box made of acrylic. The top plate has eight holes, spaced one inch apart and in a single row. On the inside of the box, the bottom plate is covered with a layer of Spenco (Spenco Medical Corporation, Waco, TX) to keep the marker tips from drying out.

When placing a marker in the holder, the client has a difficult time letting go of the marker. As a result, some resistance is needed to keep the marker in place as she tries to release it from her hand. This is accomplished by putting a layer of foam material underneath the top plate of the holder. The foam has holes that are slightly smaller than those of the acrylic, providing a snug fit for the markers. This resistance is great enough to help her let go of the markers when replacing them, but not so great that it is difficult for her to remove them from the holder when desired.

For the client to access the marker holder, the ideal location is directly in front of the easel. However, it is then in the way of her drawing. Therefore, a mechanism is included that assists the client in sliding it out of the way. The marker holder connects to custom wood mount in the shape of an elongated letter "C". This attaches to a drawer slide that is connected to the base of the easel. There is a handle on the end of the wood mount, and the client can grab this handle and move the marker holder left and right as necessary.

The total cost of the device is \$83.



Fig. 7.23. The client drawing, using her easel and marker holder

ADAPTED GARDEN TOOLS FOR A CHILD WITH TAR SYNDROME

*Designers: Christopher Kobe, Matthew Baron, and Kalen Riley
Client Coordinator: Anne Stanton, OT
Supervising Professor: Kevin Caves and Richard Goldberg
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INTRODUCTION

Our client is an active, resourceful, intelligent twelve year old boy. He was born with a rare genetic condition called TAR (thrombocytopenia with absent radius) Syndrome. In addition to missing a radius bone in his forearm, our client has a shortened humerus and an immobilized right knee and left ankle joint. As a result, he has restricted movement of his extremities, resulting in limited grip, reach, strength, and mobility. In addition, our client quickly fatigues after standing up for a short period.

Our client is interested in gardening, but it is difficult for him to independently maintain a garden due to his physical limitations. Our goal is to develop custom tools and equipment that enable him to perform all of the desired gardening tasks. Conventional and ergonomic tools available on the market do not adequately satisfy our client's needs. In his past gardening experiences with store-bought tools, he was not able to generate enough force to manipulate the soil. As a result, he requires custom tools to accomplish tasks needed for gardening.

STATEMENT OF IMPACT

Our custom tools take advantage of the client's core and lower body strength as well as the dexterity in his feet. The tools enable him to effectively and easily carry out necessary gardening tasks, such as raking, shoveling, and manipulating the soil, so that he can plant and harvest crops. Perhaps most important, these tools are enjoyable for our client to use and have increased his interest in and passion for gardening. The client said that the tools "will help me grow foods that I like and have given me something to do independently that I enjoy and can have fun doing".



Fig. 7.24. The custom gardening tools. From top to bottom: the working end of the weeding tool, shoe tool for raking, integrated body-rod with hoeing tool.

TECHNICAL DESCRIPTION

The overall design of this project includes three types of devices including a weeding rod, a tool attachment to the client's shoe, and an integrated body-rod with tool. These three tools can be used to collectively fill all roles of maintaining a garden. The client can use the rod for weeding, the shoe attachment for digging and raking, and the integrated body-rod for hoeing.

The weeding rod enables the client to remove weeds from the garden. It consists of a rod that is attached to a conventional, hand-held weeding tool at its working end. The rod is 4.5 feet long, has a 0.625 inch diameter, and is made of aluminum. To attach the rod to the weeding tool, a connector rod of $\frac{1}{2}$ inch diameter and 8 inches in length is included, also made of aluminum. The weeding tool inserts into a bored-out portion of the connector (diameter of $\frac{1}{2}$ inch matches hollow tool rod inner diameter of $\frac{1}{2}$ inch), and two bolts are added for increased strength. The other end of the connector is solid, and it is co-welded to the main rod for a secure fit. To use this tool, the client holds the rod against his body and drives the tool into weed-ridden soil. A foot peg is attached near the working end to help in directing and driving the tool. This peg is a $\frac{1}{2}$ inch diameter aluminum rod that is bolted onto a set screw collar, which is then secured to the rod. The client uses his foot to help move the working end up and down to displace weeds.

The client uses the shoe tool for raking and shoveling soil. The base structure is a commercial bike pedal with a toe clip. This connects to a metal tool, either a small rake or shovel, which is adapted from a conventional store-bought tool and inserted into a metal connecting block under the pedal. The connecting block is made from an aluminum plate and milled into a T shape. The tool inserts into the bottom end of the "T", and the flat end of the connector is bolted to the front of the bike pedal. The toe clip is also bolted onto the pedal and it secures the client's shoe to the device. For securing these connections, there are set screws inserted through the "T" connector and into milled slots on the tool. A fender washer holds the top, flat surface of the toe clip so that it does not flex up when used. To use this tool, the client slips his foot into the attached shoe pedal and performs the task while seated.



Fig. 7.25. The client using the integrated body-rod tool for hoeing.

The integrated body rod combines characteristics of both previous devices.

It incorporates a hoe that is harvested from a store-bought tool, a "J" shaped rod that wraps around the client's back, and a foot peg attached to the rod that enables the client to generate extra force with his foot. A rectangular connection device is inserted into the hoe tool head and screwed on. This is then connected to the rod by two bolts. The opposing end of the rod has a padded brace made by bending the end of the metal rod to mold around the client's back and neck. This allows the client to pull back on the device to assist in action. An arm brace is positioned perpendicular to the rod and angled towards the client's body to allow him to stabilize the device. This is constructed from $\frac{1}{2}$ inch aluminum rod that is bolted onto a set screw collar, which is then secured to the rod. This design allows the body-rod to be free of any deformation from connection devices and maintain its structural integrity. To use this tool, the client sits on a stool, grasps the rod and inserts his foot into the toe clip, and uses his entire body to assist in hoeing.

The overall cost of these devices is \$328.

COMBINATION SEED DISPENSER AND PLANTING MECHANISM

Designers: Robert Dodson, Dongwoon Hyun, and Victor Lieu

Client Coordinator: Kimi Dew

Supervising Professor: Kevin Caves and Richard Goldberg

Department of Biomedical Engineering

Duke University

Durham, NC 27708

INTRODUCTION

Our clients are a number of individuals who require assistance in a greenhouse at Goodwill Industries. They perform a variety of tasks involved in planting and growing crops, and Goodwill donates the resulting produce to the Food Bank of Central and Eastern North Carolina. The clients have either developmental disabilities or traumatic brain injuries, involving both cognitive and physical issues.

The staff at Goodwill Industries requires a system to help the clients with planting seeds. The clients plant seeds in flats, consisting of 12 trays of 2x2 cells for a total of 48 cells per flat. Each client seeds two to three flats per day, so the number of seeds planted is quite extensive. The seeds are small and difficult to discern from the soil. The disabilities of our clients result in difficulties with perception, dexterity, and focus. The current method has staff members spreading seeds on a Styrofoam plate. The clients then push the seeds off of the plate, and into the cells. However, this method is imprecise and tedious. Depending on the client, they have trouble with one or more of the following tasks: picking up the seeds, planting only one to two seeds per cell, and keeping track of which cells have already been seeded. No current solution covers the entire breadth of needs for the clients. Handheld seeders are available but often require greater dexterity than is available by our clients. In addition, they fail to guide the clients so they can keep track of which cells they have already seeded. Our system needs to help our clients with the seeding task, while also providing them with a sense of independence.

SUMMARY OF IMPACT

The combination seed dispenser and planting mechanism helps employees at Goodwill Industries to focus on and complete their task of planting

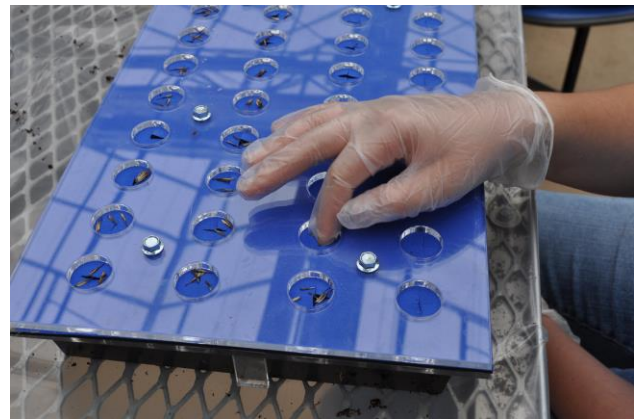


Fig. 7.26. Client is using her finger to push the seeds through the valves into the cells below (top); Client is using the seed dispenser to place seeds onto template (bottom).

seeds, while reducing frustration and fatigue. It makes the experience of planting seeds enjoyable. The Goodwill Nature Center Coordinator, Kimi Dew, was pleased with the outcome of our project, and particularly liked the bright colors of the neoprene, which significantly improved the contrast between the seeds and their background. She stated: "Our participants have developmental and physical disabilities, which limits accuracy when we

are seeding. It also makes seeding frustrating for the participant and the facilitator because of overuse of seeds and inaccuracy. The template seeder and dispenser were devised to help the participant partake in a detailed activity with accuracy and success, while allowing them independence. It also works for a variety of seed sizes and a variety of disabilities and is appealing by texture and visual stimulation. I am very happy with the project and the ease of operation and function.”

TECHNICAL DESCRIPTION

Our final design is composed of two main components. One is a template that the clients place over the seed flat. It is exchangeable between flats. The second part is the seed dispenser. It requires some setup by the Goodwill staff, and dispenses only a few seeds at a time.

The purpose of the template is to show the client the locations of each seed cell. They load the template with seeds, and then push them through to seed cells below. Each template is composed of two 11"x22" sheets of acrylic, with a sheet of colored neoprene sandwiched in between them. The three layers of the template are connected together using 8 bolts and nuts. The acrylic sheets have a 12x4 pattern of 1" diameter holes that line up over each of the 48 seeding cells. There are also diaphragm valves cut into the neoprene sheets under each hole in the acrylic. The diaphragm valve is an "X" shaped slit, which will hold the seed until it can be recognized by the client, who then pushes it through the valve into the cell. The neoprene then reverts back, closing the valve. Acrylic L-brackets are glued onto the edges of the template so that it stays in the proper position over the flat.

The clients can use the custom seed dispensers to distribute one to two seeds onto each hole in the template. Its operation and appearance is similar to that of a syringe. It is made of a PVC pipe cut lengthwise in half, with a loading hole drilled in on



Fig. 7.27. Three clients using templates, one of them in conjunction with the seed dispenser.

one side. A cut with a length of 0.2" thick acrylic and with width equal to the outer diameter of the PVC, and cut a 0.1" deep groove into one end (called the dispensing end) are made. The PVC is glued to the top of the acrylic strip with the groove sticking out. This is called the loading chamber. A cut with length of 0.1" thick acrylic, called the slide, is then made with width equal to the inner diameter of the PVC pipe. A hole is drilled on one end of the slide, with hole size dependent on the size of the seed to be planted. A small piece of plastic is glued on that same end of the slide to act as a stopper. The other end is slid up through the loading chamber. A semicircle of 0.2" acrylic is glued onto the pipe on the dispensing end so that there is not a gap between the slide and the semicircle. The same is done on the other end. Finally, a small spring and a rubber stop are placed onto the other end of the slide to form the plunger. Seeds are loaded into the loading chamber through the large hole, and a stopper is placed into the hole to prevent seeds from coming out. The client uses the seed dispenser by placing the guide in the hole and pressing down the plunger. After every hole in the template is seeded, the clients poke the seeds through the valves using their fingers.



CHAPTER 8

THE OHIO STATE UNIVERSITY

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KAYAK ASSISTIVE DEVICES FOR INDIVIDUALS WITH SPINAL CORD INJURY

Student team: Greg Bader, Erin Parsons, Emily Blake, Cathy Pratt, Jess Glenn
Client Coordinators: Dr. Jane D. Case-Smith, Dr. Carmen P. DiGiovine, Theresa F. Berner
Community interest: The Adaptive Adventure Sports Coalition
Supervising Professor: Dr. Robert A. Siston
Department Mechanical and Aerospace Engineering
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INTRODUCTION

Open water kayaking is a fun, recreational outdoor activity that requires balance, endurance, and upper body strength. These assistive devices give independence during kayaking for individuals with minimal upper body function due to C6 spinal cord injury (SCI). The devices assist with two specific functions: holding the paddle and supporting the weight of the paddle while maintaining a full range of motion for normal kayaking maneuvers. To facilitate holding the paddle, a twist and lock male to female attachment secures the kayaker's hands to the paddle. A retractable wire that is attached to the center of the paddle supports the paddle weight. Upon completion, these devices were presented to a non-profit organization, The Adaptive Adventure Sports Coalition (TAASC), for recreational use. TAASC previously used thera-band straps to maintain a functional grip of the paddle, but the kayaker's hands frequently fall out of the straps.

These assistive devices address the functional requirements to provide further independence to individuals with C6 SCI during kayaking with an aesthetically pleasing and comfortable solution.

SUMMARY OF IMPACT

Individuals with C6 SCI have little access to outdoor adventure activities due to their limited lower body mobility. TAASC is a teaching program that gives individuals with disabilities the opportunity to participate in adventure sports. For example, TAASC has weekly open water kayaking trips for participants and volunteers for up to five consecutive hours. Individuals with C6 SCI are either tethered to another kayak or ride in tandem with another person. Kayaking is a unique opportunity to give individuals with SCI the ability to participate on the same level as their peers, and promoting independence during kayaking trips will enhance the experience further.



Fig. 8.1. Kayaking Assistive Device.

These devices can provide individuals with C6 SCI the ability to kayak individually during TAASC's open water kayaking trips.

TECHNICAL DESCRIPTION

The paddle grip modification includes a male hand attachment and a female paddle attachment (Fig. 8.2). The male attachment pieces were fabricated from a 3-D object printer with a stainless steel pin inserted in the shaft for reinforcement. The male attachment is secured to a wheelchair push glove with thread and glue. The female attachment pieces mounted on the paddle include four 3-D object printed parts and four PVC pipe clamps. The hollow shaft in the female pieces has a slotted horizontal channel so the male piece can twist securely into place. The kayaker turns their hands with the thumbs inward to align the male pins above the female slot, and then pushes the male attachment into the slot. The kayaker can then rotate their hands so the male pins slide into the horizontal channel.

The paddle supporting device is rigidly attached to the front of the kayak with a set of four bolts and three custom built aluminum sheet attachments (Fig. 8.3). A bent rectangular piece underneath the kayak is used as a rigid stabilizer for the two pieces on the top of the kayak. A tool retractor with variable tension adjustment is used to support the paddle weight. The tool retractor wire runs through a hollow aluminum shaft that provides a point of support vertically above the kayaker's hands. The aluminum shaft has adjustable angle capabilities to adapt to various sizes of kayakers. The edges of the aluminum sheets are lined with rubber inside the kayak to reduce the risk of skin irritation.

One of the benefits of this design is that the paddle grip and support devices do not need to be used concurrently. Individuals can choose to use the paddle grip device without the paddle support device. Also, the paddle grip device allows a quick release of the paddle for the kayaker's safety. The support mechanism does not restrict the range of motion of the paddle, allowing the kayaker to use the paddle to push off of objects or paddle backward.

The approximate cost of all materials was \$2,960.

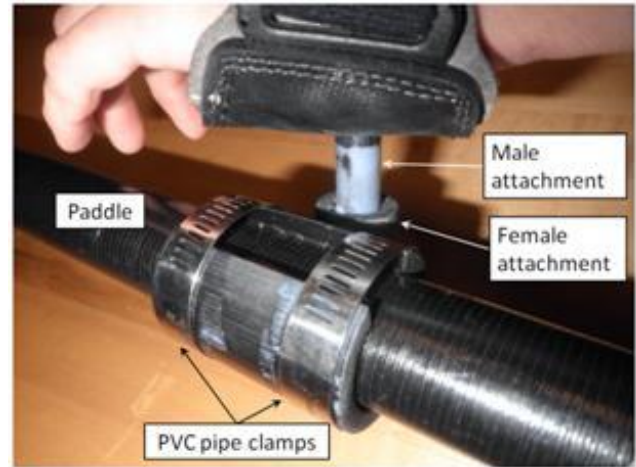


Fig. 8.2. Paddle hand grip device.



Fig. 8.3. Paddle support device

UNIVERSAL LOCK: A DEVICE THAT ALLOWS CHILDREN WITH DISABILITIES TO OPERATE A SCHOOL LOCKER

Designers: Jeffrey E. Domas, Robert L. Smith, James A. Suchocki, and Lauren L. Fisher
Client Coordinators: Dr. Jane D. Case-Smith, Dr. Carmen P. DiGiovine, Theresa F. Berner
Community interest: Dublin City Schools, Dublin Ohio
Supervising Professor: Dr. Robert A. Siston
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The Ohio State University
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INTRODUCTION

In middle school and in high school, almost every student secures their locker with a dial combination lock. Although dial combination locks are the most common, some other typical locks are word combination locks or padlocks. However, none of these locks fully accommodate the entire population of students in high school or in middle school. Although it is impossible for a lock or any other device to be usable by the entire population, there is currently a large portion of the school age population that cannot use the standard locks on the market. These individuals, such as those with cerebral palsy or a spinal cord injury, cannot use these locks because they do not possess all of the motor and cognitive skills necessary to open a standard lock. There are a number of currently available locks specifically designed to accommodate people who are unable to operate a standard lock; however, these locks either do not fully address their needs or are prohibitively expensive. Therefore, a large population would benefit from a new lock design which would allow those with cognitive or physical deficits to operate their school locker in a similar manner to their peers. Our team designed a new lock to accommodate these students with physical and cognitive deficits better than any commercially available lock. After our final design was chosen from a number of alternative solutions, we went through a number of design, build, test, and redesign cycles. After three of these cycles were completed, we were able to produce a lock prototype that was ready for clinical testing. We tested our device at Karrer Middle School with 6th, 7th, and 8th grade students on May 26, 2010. This clinical testing was very successful, as 9 out of 10 students with special needs and 31 out of



Fig. 8.4. Front view of lock prototype with remote.



Fig. 8.5. Student using the lock.

31 typical students were able to use our lock. In addition, the responses from the student surveys were overwhelmingly positive because most

students could operate our lock more easily than they could operate their own lock.

SUMMARY OF IMPACT

We created this universally designed lock in order to better accommodate approximately 600,000 students in the United States who cannot operate a standard lock. Through extensive research, we determined that many of these 600,000 students did not possess the physical and cognitive skills required to operate a standard lock. We defined that the problem with standard locks is the high level of physical and cognitive skills required to operate them. Therefore, our team determined that in order to better accommodate these students, our new lock must require less physical and cognitive skills to operate than current standard locks. In order to create a lock that addresses this problem, we defined a number of project requirements that would guide our group toward a solution to this problem. Next, we created a number of alternative solutions that would fulfill our project requirements. After we created these alternative solutions, we evaluated each design against criteria formed from our project requirements. The alternative solution that scored the highest against these criteria was selected to be our proposed solution. Our proposed solution was an electronically actuated, remote controlled, built-in lock that allowed the user to unlock their locker by use of a remote control. Through several design, build, test, and redesign iterations we created a lock prototype that allowed the user to unlock their locker using a remote control. This demonstrated that our design significantly reduced the amount of cognitive and physical skills required to operate a lock for a school locker. Therefore, our team successfully created a new lock design that better accommodates the 600,000 students in our target population.

TECHNICAL DESCRIPTION

Our lock is an electronic lock that is controlled by a remote control. The remote sends a binary code through an infrared signal in order to unlock the lock. The solenoid is controlled by a microcontroller circuit in the lock that interprets the infrared signal from the remote. A solenoid within the lock body controls the locking and unlocking. The lock will



Fig. 8.6. Rear view of lock and lock circuit.

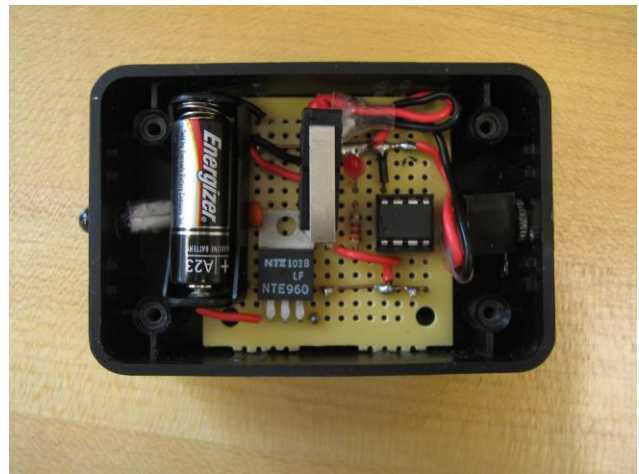


Fig. 8.7. Remote circuit

only unlock when the binary signal sent from the remote matches the binary code stored in the microcontroller. The remote is designed to be easily actuated by an individual with limited cognitive and physical skills. In addition, the remote has a 3.5mm jack so that an external switch of the user's choosing can be used to actuate the remote. This additional feature allows a wider range of individuals to use our lock because our design is compatible with a wide variety of existing switches. Further information regarding our lock design may be obtained by contacting the principal investigator.

The costs of parts and materials was about \$700.

THE TRAY FOR A POWER WHEELCHAIR

Designers: Katherine Bovee, Michael Brezina, Michael Eggerichs, Matthew Yoak, Samar Shalash

Client Coordinators: Dr. Jane D. Case-Smith, Dr. Carmen P. DiGiovine, Theresa F. Berner

Supervising Professor: Dr. Robert A. Siston

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INTRODUCTION

Wheelchairs allow people to lead an active lifestyle by decreasing mobility limitations and giving them an efficient means of travel. While wheelchairs have done much to increase the independence of people with disabilities, wheelchair users still face some limitations. Due to the height of manual and power wheelchairs, tables tend to be either too low to permit a wheelchair to slide underneath or too high for the client to comfortably use while sitting in their wheelchair. Although there are a variety of wheelchair trays available commercially, many of the trays lack the functionality needed to make them useful to people. The standard tray designs are either a full or half size tray that straps onto the armrests of the wheelchair. While current trays provide a flat surface for clients, many power wheelchair users lack the strength and dexterity to remove and attach the tray without assistance. Power wheelchairs offer a number of challenges when designing a compatible tray. Power wheelchairs have a joystick that the person uses to control the movement of the wheelchair. The location of the joystick, near one of the armrests, prevents a tray from being attached by sliding directly onto armrests. To address the shortcomings of the previously designed wheelchair trays and to increase the independence of power wheelchair users, the goal of our project is to design a tray for C6 Spinal Cord Injury (SCI) power wheelchairs that can be stored on the wheelchair when not in use.

SUMMARY OF IMPACT

The requirements for the tray are defined to meet the American with Disabilities Act and through interviews with power wheelchair users. Power wheelchair users now have the ability to deploy a tray when needed, however when not in use the tray can be stored on the chair by the power wheelchair user. The final tray design is stable, customizable, and is able to be attached to all power wheelchairs manufactured by Permobil and Invacare. The

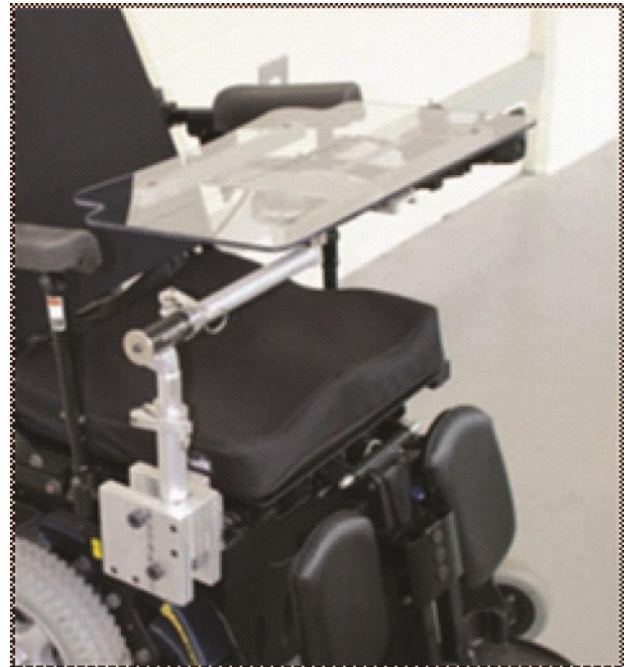


Fig. 8.8. The Tray for a Power Wheelchair.



Fig. 8.9. Solid Model of Tray for Power Wheelchair.

requirement of the tray meeting ADA requirements was upheld because some of the compression clamps found on the tray require more than 5 pounds of force to operate. As a result, depending on the degree of a C6 SCI users disability determines whether they are able to independently operate our tray.

TECHNICAL DESCRIPTION

The entire tray assembly is comprised of aluminum, anodized aluminum, and steel. The aluminum

makes up the entire tray aside from the screws, which are made of steel, and the track located underneath the tray surface, which is made of anodized aluminum. The tray assembly weighs 9.25 pounds. The tray requires eleven steps to deploy from the stored position on the side of the wheelchair and nine steps to retract back to the stored position. The total amount of parts in the assembly is 76. The targeted and resulting functional requirements can be found in Table 8.10.

The final cost of the tray is \$1335.82

	Specifications	Target	Results
Functional	Stores on power wheelchair	Yes	Yes
	Amount of load tray can support with no deflection	15 lbs	5.9 lbs
	Amount of load supported with 5 degrees of deflection	60 lbs	36.7 lbs
	Able bodied person required assistance to deploy/retract tray	No	No
	Assistance required to deploy/retract tray	No	Yes

Table 8.10. Functional Requirements

THE GAIT TRAINER FOR CHILDREN WITH CEREBRAL PALSY

Designers: Erin Ansley, Ryan Bucio, Brianne Cattran, Keira Gaudette, and Chantale Levert

Client Coordinators: Dr. Jane D. Case-Smith, Dr. Carmen P. DiGiovine, Theresa F. Berner

Supervising Professor: Dr. Robert A. Siston

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INTRODUCTION

The gait trainer is designed to improve the user's gait and encourage normal gait motion. After observing children with Cerebral Palsy, it is clear that existing walkers and gait trainers need to be improved to encourage normal gait. Many of these assistive walking devices do not encourage proper postural alignment and had insufficient weight support. The motivating factor behind designing this gait trainer is that there are hundreds of thousands of children with CP who require a device to aid them in walking and to encourage more social interaction with their environment and with their peers (www.cerebralpalsy.org).

After completion, the gait trainer was tested with children at The Nisonger Center in Columbus, OH. There were two children at this center with Cerebral Palsy who tested our gait trainer. Ultimately, our gait trainer is intended to promote ideal postural alignment, normal gait, and increased social interaction.

SUMMARY OF IMPACT

Many gait trainers and walkers do not focus on improving postural alignment or encourage normal gait for children with Cerebral Palsy, but are designed to get the child from point A to point B. This provides no long term benefits for the child. The main design requirement for our gait trainer is to enable the user to stand with proper postural alignment and to encourage the child to support most of their own weight, leading to increased muscle awareness, socialization, and independence. The health benefits of standing include an increase in circulation, muscle activation, as well as bone and muscle growth. Standing also helps to normalize respiratory function by encouraging proper posture and allowing the chest to expand properly while breathing. Standing also causes the stretching of



Fig. 8.11. Final prototype of gait trainer.

muscles, which can help reduce muscle spasticity and aid in better joint development.

TECHNICAL DESCRIPTION

The final gait trainer design consists of a postural alignment system (vest and back pad), weight support system (harness), caster wheels with multiple drag options, and a lightweight and adjustable Aluminum frame. A harness that attaches to the frame helps support 50% of the client's weight while he is walking. Often children with CP have poor muscle strength and tone and the harness will help to give the users the ability to stand. The amount of weight that the harness supports is important, because if it supports too much weight, then the child will be in a seated position and not standing up properly with their feet flat on the ground. For this reason, the harness is designed to be very adjustable.

It is also very important that the gait trainer be adjustable to fit each client properly. The straps and buckles of the vest and harness are all easily

adjustable. The frame is also adjustable in height and width. The back pad can also be adjusted to move towards the front or back of the device as well. The adjustable back pad will help to increase the stability of the device and also allow the child to move forward in the device to be closer to a table, for meals or play.

The frame of our gait trainer must be strong and stable because the frame needs to withstand static and dynamic loads from the child. Several characteristics are included in the frame so that is practical and effective: it supports the harness, vest and back pad, is open in the front to make it easier for the users to approach a table or interact with their peers, and is also lightweight so that a child with minimal leg strength is able to use our device. The frame is also adjustable and constructed of durable materials that will last several years as the child grows. Once the child grows out of the gait trainer, another child will be able to use the device. The frame is the foundation of our design and must be robust, lightweight and safe.

Lastly, the inclusion of brakes, variable drag options, swivel locks, and the directional capability of the Rifton Medium Pacer wheels are extremely beneficial for our gait trainer. Having locks on the wheels allow the child to be able to stand in one location without needing to control the device. The locks also provide a more stable, stationary frame for the caregiver when they are trying to get the child into and remove the child from the device. The variable drag provides an additional method to control the pace of the child when walking and the swivel locks, if needed, will help to guide the child in a straight line. Finally, the directional option on the wheels will not allow the child to move in reverse if the child is likely to tip over backwards. These Rifton wheels are used for the two front wheels of the device, with two stroller wheels in the back. These four features on the Rifton Medium Pacer wheels are valuable for the device and help to accommodate children with different needs.

The total cost of parts and material is approximately \$916.



Fig. 8.12. Child using the gait trainer final prototype

DYNAMIC COMPRESSION VEST FOR CHILDREN WITH AUTISM

Designers: Gregory Chernov, Jarred Kaiser, Jessica Modlich, Shea Mogg, Sarah Chafins, Laura Piper
Client Coordinators: Dr. Jane D. Case-Smith, Dr. Carmen P. DiGiovine, Theresa F. Berner
Community interest: Easter Seals of Central Ohio
Supervising Professor: Dr. Robert A. Siston
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INTRODUCTION

The dynamic compression vest is designed to provide sensory integration to children with autism in order to help them process sensory input in an organized way. Current devices on the market that provide sensory integration include weighted vests that apply a downward force to the child and static compression clothing. Children assimilate to the static compression these devices provide, so the effect wears off. These devices must also be removed at least every 30 minutes. The dynamic compression vest allows the application of the compression to vary so the child does not assimilate to it, and without the need to remove the vest frequently.

SUMMARY OF IMPACT

The vest applies dynamic sensory integration to children with autism so the calming effect last for a longer period of time. This allows children to be more comfortable in their environment and engage in more activities. The vest also helps parents and caregivers. Since the vest will apply compression only at timed intervals, the vest can be worn all day,

and the parents or caregivers will not have to remember to remove the vest.

TECHNICAL DESCRIPTION

The vest consists of an electrical sub-system, a pneumatics sub-system, and the vest itself. The compression is provided through five rubber bladders within the vest which inflate and deflate at timed intervals. There are two bladders in the front of the vest and three in the back, and they inflate so the anterior and posterior have the same pressure at the same location. This requires control of three rows of bladders.

The bladders are modified blood pressure cuffs, and a diaphragm pump is used to inflate and deflate them. The bladders are connected to the pump through solenoid valves by 1/8 inch tubing. The timing of the inflation and deflation is controlled by a microcontroller. The top row of bladders inflates first, and then moves to the bottom row. The bladders all hold pressure for one minute, and then they deflate. This quick timing hopefully allows for the child to not habituate to the pressure so the vest will be more effective than static devices. While

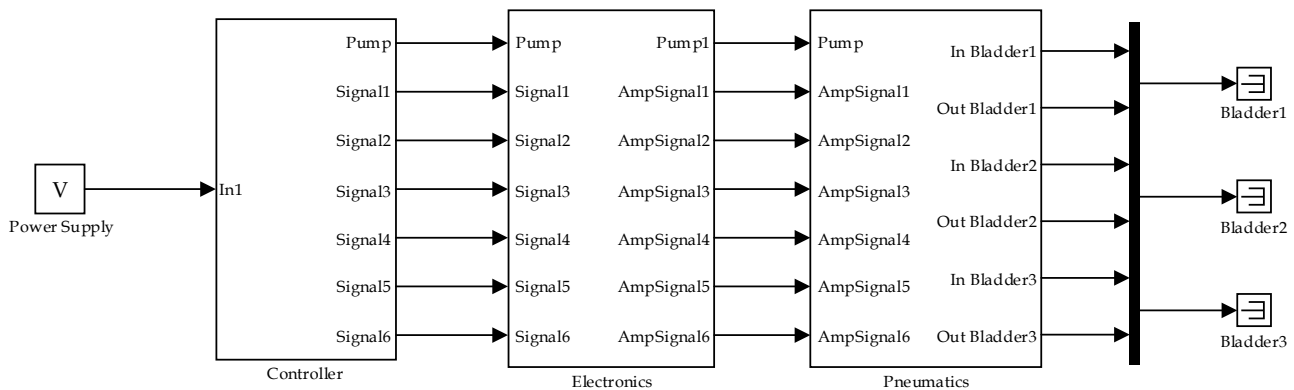


Fig. 8.13. Diagram of entire system.

there is no evidence to support this timing scheme, further testing will be done to modify the timing. The inflation and deflation is achieved through a feed forward system. Feedback will also be implemented in future prototypes to determine the pressure within the bladders.

In order to supply the correct voltage needed to each component an electrical circuit is used, which is currently on a breadboard, but will eventually be moved to a circuit board. The circuit in this prototype supplies 12 V to the pump and two of the valves, 6 V to the remaining four valves, and 5 V to the microcontroller. The circuit is powered by a standard laboratory voltage source.

The vest has internal compartments to hold the bladders in place. The vest is split into an internal fabric and an external fabric to ensure the air pressure within the bladders is being applied directly to the torso and not inflating outwards. The internal material is rayon, and the external material is reinforced cotton. For this prototype, the pneumatic and electronic systems are located outside the vest, however, in future prototypes these will be inside the vest, so the vest will be portable when children wear it.

The cost of all materials is around \$900.

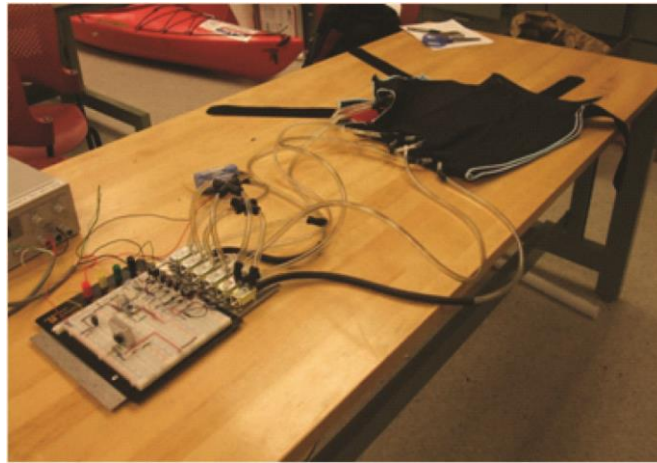


Fig. 8.14. Picture of pneumatic and electrical system.



Fig. 8.15. Internal bladder compartments in vest

TIME MANAGEMENT DEVICE FOR CHILDREN WITH DOWN SYNDROME

Designers: Krista Alley, Kristen Cornelius, Elise Dew, Alex Hegedus, Kyle Johnson, Cecilia Shiroma, Carrie Weisbecker and Katie Whitehouse

Client Coordinators: Dr. Jane D. Case-Smith, Dr. Carmen P. DiGiovine, Theresa F. Berner

Community interest: Down Syndrome Association of Central Ohio

Supervising Professor: Dr. Peter Rogers, Dr. Robert A. Siston

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INTRODUCTION

The Ohio State University Time Team (TT), in partnership with the Down Syndrome Association of Central Ohio (DSACO), is designing and commercializing a product that provides two primary benefits including that the product improves the independence of children with Down syndrome learning to manage time, and the resulting commercial income provides an alternative revenue source to help sustain our non-profit partner. Current methods to help manage time, including drawing out events and kitchen timers, do not focus on the needs of children with Down syndrome. DSACO and the TT worked together throughout the design development to validate each step. The product visually displays pictures of events in their chronological order, a proportional comparison of the events' duration, and a real-time representation of time passing through the event sequence. To make sustainability possible, a unique agreement is in place with the university through which they will exclusively license all newly created intellectual property at no fee to ensure all royalties return to the non-profit partner and to our program. The TT is piloting this project and creating a unique social enterprise model that provides an effective social outreach while providing entrepreneurial students with a learning opportunity.

SUMMARY OF IMPACT

The time management device for children with Down syndrome created by the TT serves multiple purposes. First, the product will increase the self-sufficiency of children by enabling them to manage their time independently. The goal is to provide a tool to aid children learning the concepts of time, relationships between the timing of multiple events, and sequential reasoning. The product will also help

mitigate the frequency of occasions that a caregiver must remind the child to stay on task. One of the final main goals of the project is to provide an alternative revenue source to help sustain DSACO and the Social Innovation program to benefit future projects. In providing a revenue source to DSACO, many children with Down syndrome will continue to receive critical services provided by the organization. The design abides by the project requirements and will continue the validation process to ensure it fulfills its goal.

TECHNICAL DESCRIPTION

The product fulfills the need for time management by implementing two main functions: providing a visual sequence of events and displaying a proportional amount of time. It presents time and events in a simple and effective way using multiple sensory stimuli that specifically address the cognitive and physical disabilities of children with Down syndrome. The time device linearly portrays several tasks in chronological order, shows expected task duration in relation to its surrounding events, and depicts elapsed and remaining time for the event series using a dynamic proportional LED light bar. The LED bar is capable of displaying up to five separate colors, indicating lengths of time for the five different tasks. The user chooses the lengths of time by way of potentiometer knobs and those lengths program into the device upon each use. The lights turn off at a constant rate as time passes, showing a decrease in the length of time left. Pictures of the event tasks lay over individual backgrounds whose colors correspond to the colors on the LED. Based on results from validation testing of preliminary concepts conducted with 21 parents of children with Down syndrome, the device employs interactive features to provide the child a

sense of accomplishment. Visual reinforcement of the completion of a task takes the form of a window that closes over the event's picture. Closing the window also closes a circuit loop, activating a positive sound. The device is robust, portable and adaptable. It has visual appeal, is easy to use, and

requires minimal set up time. Currently, there are no products similar to this on the market. The team conservatively forecasts cumulative revenues for the first three years of production at \$2.5 million (represents selling 50,000 units at \$50.00). The total project cost is \$2529.97.

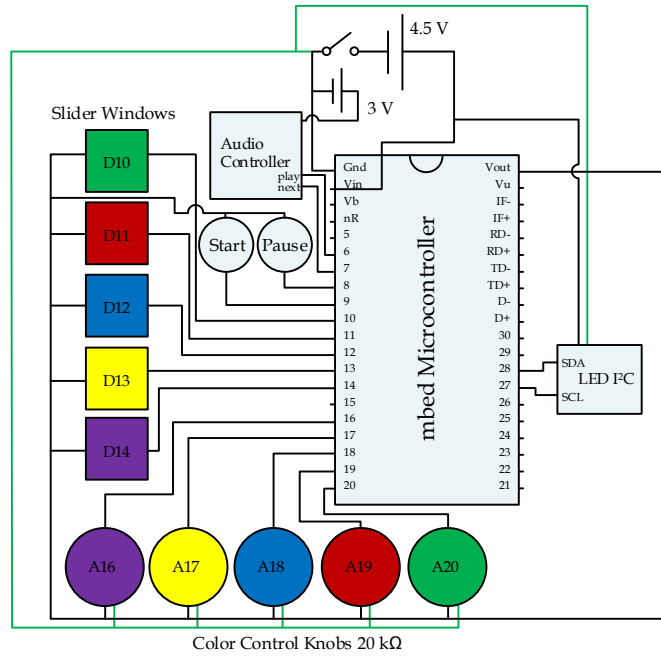


Fig. 8.16. Control System.



Fig. 8.17. Basic design of the device.



CHAPTER 9

ROCHESTER INSTITUTE OF TECHNOLOGY

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BALANCE TRAINING TOWER

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INTRODUCTION

The goal of this project is to develop a balance-training rehabilitation device for clients of the Physical Therapy Clinic at Nazareth College. Current methods of balance training include a standing Balance Master device and a highly subjective method of asking the client to reach to a target held by the therapist. This new device is designed to close the gap between these methods by providing an objective measure of reaching ability for clinic clients who use wheelchairs. It will give the clients illuminated targets at challenging distances and patterns of reach, and it will be easy to use for both the therapist and the client. The form of the device is a tower equipped with seven capacitance buttons. Each button has a bank of multicolor LEDs above and below to indicate to the user which button to try to reach, when a successful hit has been made, and also when the user has either hit the wrong button or has run out of time. The tower is preprogrammed with two games, which prompt the user to respond to different patterns of highlighted buttons.

SUMMARY OF IMPACT

The final device was used at the clinic for two months before the clinic closed for its summer session. During this time, many clients used the tower and the clinic coordinator reported that users were excited to compete against one another and therapists were continuing to include the use of the balance tower in their patient plans. In addition, the new device only requires one therapist to work with the client, rather than two: one to hold a target and one to support the client. This has improved the morale of some clients who, unbeknownst to the team, had actually felt bad for having to use more of the clinic's resources. It also increased the

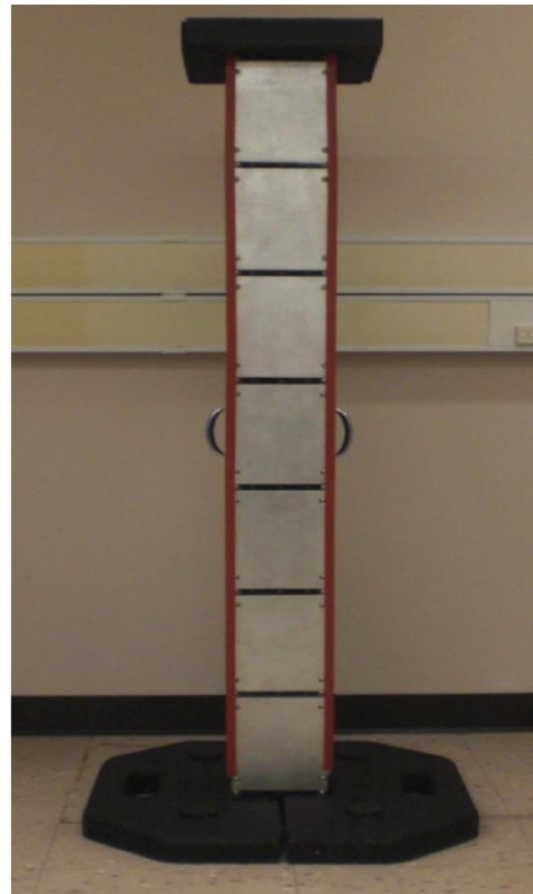


Fig. 9.1. Final constructed tower.

effectiveness of the staff as the same amount of therapy can be carried out with one less person.

TECHNICAL DESCRIPTION

In order to assess the need for balance training at the clinic, an assessment was made of the current methods of balance training by the physical therapists (PT) and patients with various disabilities.

To fill the gaps at the Physical therapy clinic, there is a need for a device for seated balance training, that is simple to use and visually stimulating to the patient. The unit is designed such that once it is set up the therapist can focus on the patient rather than the object they need to reach. Being able to quantify the patient's ability to balance will help track the patient's progress throughout their therapy sessions.

The clinic requires a device that supports rehabilitation, is safe, adjustable, easy to use, and can be easily stored and transported.

Capacitance buttons are chosen as the patient user interface because they do not require the user to actually 'push' a button with a significant amount of force and instead are activated by proximity. This way, the exercise can focus directly on balance and range of motion rather than ability to generate enough force to activate a button. The buttons are created by using a B6TS-04LT, a 16-bit microcontroller designed to detect patient touch by detecting the change in capacitance. Touching one of the output channels changes the capacitance between the output and ground with the body's capacitance. The touch sensor detects the change and the output of that channel and changes voltages, which is detected by the microcontroller. Each capacitance touch sensor, Sensing IC, controls four aluminum "buttons" on the tower.

The users are provided with both visual and audio feedback. RGB LEDs are used as both target and status/state indicators. A series of RGB LEDs above and below each button denotes the current target, a successful touch of the target, or an incorrect target touch. RGB LED's are used as opposed to traditional single color LED's to limit the number of wires in the tower. As displayed in Figure 9.2, blue illuminates indicating the target, green indicates that the correct target has been touched, and red indicates either that the incorrect target has been activated or that time has expired. A PC Beep speaker is included to provide auditory feedback; the tower will beep once each time the target is successfully hit.

For easy maintenance for the clinic, the device is designed to run on a pack of four interchangeable lithium strength batteries for power. By utilizing a battery-powered solution rather than AC wall power, the portability of the device is maximized. Four AA batteries are used to provide a 6V rail

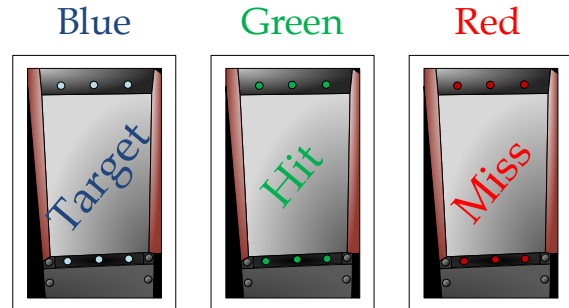


Fig. 9.2. LED lighting scheme.



Fig. 9.3. Tower base and cart.

which is then stepped down to 3.3V using a voltage regulator. The 3.3V powers the LED's, Capacitance Buttons, and microcontroller. The batteries can be accessed through a removable door located near the base of the tower.

An LCD display screen in the main tower displays the current status, control actions, setup communication, and game choices. Additionally, it displays relevant information following the exercise for the PT to record on a standard worksheet. The chosen screen is a Serial Enabled 20x4 LCD with Black on Green display. It is chosen based on the low (5V) power supply it requires and the fact that it can be coded in C. The screen also includes firmware that allows adjustment of the backlight brightness.

For the needs of the design, the MSP430-F16(11) microcontroller is used due to the extremely low power design, and the large number of digital inputs and outputs and ~50kB flash memory. This board also offers ZigBee wireless connectivity, for future implementation of communication between multiple towers. Furthermore, the ability to program

in C, as well as the numerous online examples significantly shortens the learning curve. The MSP430 is mounted on an easily accessible platform in the middle of the tower. It is placed in the middle of the tower to minimize the amount of wire required to connect it to all seven capacitance buttons and all eight LED sets. The maximum length of wire required for any connection is now half the height of the tower.

Wiring harnesses are designed and included to organize the inside of the tower, using zip ties and electrical wire. To reduce interference of the wire conducting the capacitance chip to the aluminum plates, the wires were wired in separate harnesses. The two soldering breadboards are arranged on opposite sides to keep wires clean and organized. The MSP430 is designed so that the wires are out of the way of the hinged door, for easy access to the JTAG port and the battery pack. To simplify the wiring within the tower a color coded system is included. Dark red is used for components requiring 3.3V, light red is used for 5V components, and the color of the wires going from the LEDs corresponds with the color the LED emits.

Software development is a very important aspect of the project. Programming was initially composed in C, and transferred to the flash of the MSP430 board via serial/JTAG during testing. Utilizing ISR techniques to queue button inputs and target statuses, the board supports an extremely small time delay when sending and receiving signals from the tower. The program development process is broken down into three phases.

Phase I includes the development of a "skeleton" class design, port identification, address detection, and Input/Output testing. The use of various portions of code during debugging, development, and testing indicated that it was best to use multiple classes. Because of the freedom within the IAR Embedded Workbench, setting up variables at runtime is straightforward. Port identification for the MSP430F1611 is provided in the datasheet, specific to the DZ1611 model. By identifying the addressing properties of the MSP430, setting up ISR interrupts and accurately locating debug errors is made much easier. Input and Output testing took up the majority of debugging time, mainly due to a non-shielded wire issue. After using technologies provided to us by members of various other MSD teams to verify the issue, wire was rerun using a

shielded option and I/O test harness. Upon successful completion, I/O testing is marked as "continued development" in order for us to continually debug at each port or breadboard modification.

The next phase consists of the selection of a compiler and in-code documentation. The IAR Embedded Workbench provided by TI proves very useful. The comprehensive documentation provided by TI is used throughout the project; in-code documentation was completed to allow even for a first-time user of the MSP430 to quickly understand port I/O and ISR scheduling.

The final phase is game development. For the initial revision, two games are included: Random Touch and Timed Touch. For both games, the physical therapist is prompted to select the target buttons that should be enabled for game use. Random Touch randomly lights one of the enabled targets, lights that target in blue, and gives the patient a pre-assigned amount of time to reach and press the target. If successful, a chime plays, and the LED rows will illuminate green, otherwise the red LEDs light. The second game, Timed Touch, shows each enabled target, in order, from top to bottom, and records the amount of time taken to reach each target.

Safety features are added to the tower, including an impact protective foam halo around the top of the device, removable rubber edges on the corners, and a rubber base, along with a cart to minimize the physical therapist lifting requirements. The tower displays good stability and will not become unstable and tip unless it is pushed past 24.5°, which corresponds to a 2 foot displacement at the top of the tower or a 1 foot displacement at the center.

The client has been provided a simple user's manual that was summarized in two pages so it can be attached to the device. An operator output sheet is also included so that at each physical therapy session that the product is used, the PT can record important information. The sheet will also act as a simple instruction manual as well, since the order of the questions resembles the game design.

The total cost of the project is \$2006.00.

More information is available at <http://edge.rit.edu/content/P10005/public/Home>

Table 9.1. Benchmark training devices.

Device	Advantages	Disadvantages
PT holds object	<ul style="list-style-type: none"> • Simple to use • No set-up • No storage space 	<ul style="list-style-type: none"> • No objective measure of patient progress • Boring • Requires two PTs to be present
SMART Balance Master	<ul style="list-style-type: none"> • Objective measure of patient progress 	<ul style="list-style-type: none"> • Standing only • Difficult to use • Frustrates patient
Nintendo Wii Fit	<ul style="list-style-type: none"> • Stimulating Game • Too much for patients with low cognitive ability 	<ul style="list-style-type: none"> • Nintendo does not support “Physical Therapy” • Difficult to determine what actual training is happening

Table 9.2. Engineering metrics and final results.

Engineering Metrics	Marginal Value	Ideal Value	Achieved
Max tilt angle before falls	10°	20°	19°
Height of device	40”	60”	61.5”
Response time (to/from lights)	3500ms	1000ms	425ms
Set up time	2 min	1 min	2 min
Button Sensitivity	0.2 lb	0.1625 lb	Negligible
Average # of levels complete	3	5	8/15
Minimize spatial confines	3ft ³	2 ft ³	2’x1’
Optical visibility (contrast)	70	90	98%
Volume	60 dB	80 dB	80 dB
Time to Sanitize	2 min	1 min	1 min
Time to disassemble	3 min	1 min	2 min
Parts that can be replaced	75%	100%	0%



Fig. 9.4. Balance training tower in use.

BALANCE TRAINING BICYCLE

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Industrial Engineering Designer: Lindsay Power

*Mechanical Engineering Designers: Christopher Crowley (Lead Engineer), Kristin Gagliardi
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Supervising Professor: Dr. Elizabeth DeBartolo

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INTRODUCTION

This device is a redesign of a prior senior design project. The Physical Therapy clinic at Nazareth College engages a variety of clients in need of balance training, and looking for a challenge. The balance training bicycle introduces some controlled instability similar to that experienced on a freestanding bicycle without the risks associated with actual bike riding. Clinic clients in need of balance training are those who have had strokes, or those who have other neurological conditions that cause an imbalance in strength between the left and right sides of their bodies.

SUMMARY OF IMPACT

The redesigned system meets or exceeds the customer's most critical needs. The primary improvements from the past designs are that the new device has more comfortable handlebars, has a more clearly visible, intuitive display, improves stability in the upright-and-locked position, and provides a simpler, more reliable method of providing support and/or resistance to the users as they tilt. Although the bicycle is delivered after the clinic closed for the summer session, the physical therapists who will be using the system next year have ridden the bicycle and are excited to begin using it with their clients in the fall.

TECHNICAL DESCRIPTION

The design was broken into three subsystems including the frame, tilt mechanism, and electronics (measurement and display). The frame is designed to incorporate commercial off-the-shelf products where possible. It includes a standard set of bicycle handlebars, a standard bicycle seat and seat post, and a pedal-flywheel-brake system from a spinning bike. The tilt axis is inclined 15° from horizontal to

provide a more natural tilt feel to the rider. Stress analysis results showed a minimum factor of safety of 1.11 for a 300lb passenger, with the critical location being at the adjustment holes in the seat post. A solid plug is included to increase the factor of safety.

The tilt mechanism is based on a set of removable exercise bands to provide tilt resistance. Tensile testing of the bands (according to ASTM D348-07) and basic statics yielded tilt resistance data. The team tested several attachment methods for the bands, and the one that was most secure and easiest to remove involved tying each band onto a carabiner; this enables the therapist to easily snap extra bands on and off. A hard stop is also incorporated, to provide a limit beyond which the rider cannot tilt. This was done using a length of rope clamped onto a locking carabiner. Three different tilt ranges, and three different accompanying rope lengths are provided to the clinic.

The electrical system is designed around an inclinometer that provides information about how far the rider has tilted from an upright position. The clinic clients would like to receive both visual and audio feedback, so the inclinometer data is used to generate an LED indicator of tilt and to create a beeping sound that changes in both pitch and frequency as the rider tilts farther off-balance.

The total cost of the project is approximately \$1555.70

More information is available at <http://edge.rit.edu/content/P10001/public/Home>

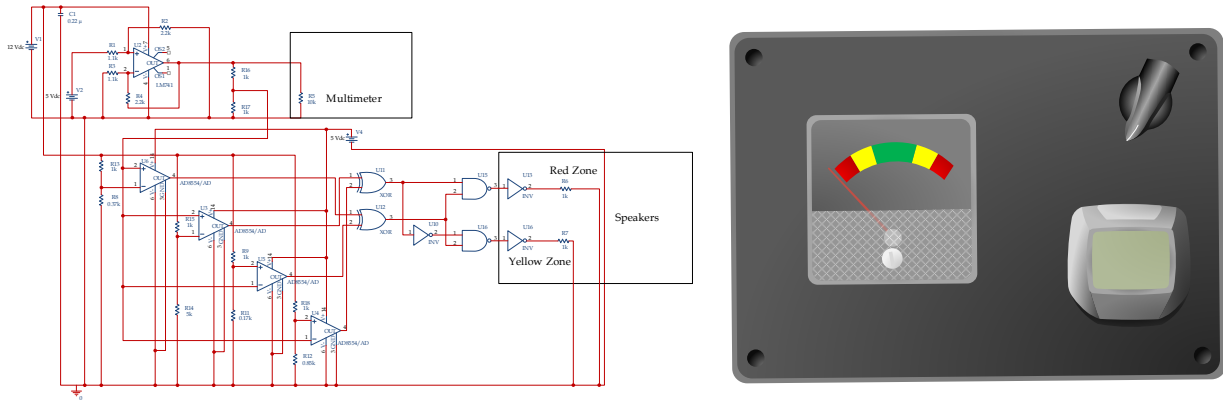


Fig. 9.5. (a) Electrical schematic and (b) final display.



Fig. 9.6 Balance training bicycle.

DYNAMIC KEYBOARD

Mechanical Engineering Designers: Robert Piccirillo, Joshua Locke, Alex Moulton, Marie Hammer
Electrical Engineering Designers: Obadiah Pulscher, Adam Stull (Team Leader), Andrew Robertson, Xingwang Gao
Client Coordinator: Prof. Dino Laury, National Technical Institute for the Deaf
Supervising Professor: Prof. George Slack
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INTRODUCTION

Text entry applications such as word processing, email notes, and instant messaging all share a common keyboard scheme. For people who are hearing impaired, these application tools have been effective in communicating with others who cannot sign. During the act of speaking and signing, the integration of thought and emotion occurs simultaneously and seamlessly with little overt thought. In contrast, text entry differentiates or separates thought and associated emotion. The keyboard only captures keystrokes and thus loses emotional expression, even though the act of typing may carry some covert emotions. The goal of this project is to take these learned skills of speaking and signing and use them to enable us to enrich the value of text entry. Though this project may help everyone, it may have a greater impact on individuals who are deaf. Two teams worked in series on this project.

SUMMARY OF IMPACT

The project to date has resulted in the development of a force-sensitive keyboard that has been tested with some users. The original intent of the project was to develop a keyboard that could detect enough differences in the user's typing patterns to automatically add an emotional indicator to the text, but testing with users showed that this could not be done reliably. The resulting design is a keyboard that can measure different typing forces and that is comfortable for most users (nine out of 10 individuals trying the keyboard liked the way the keyboard felt and the way it responded to their key strikes). The device functions based on learned typing skills, rather than learning how to interpret each user's intent, but it will still satisfy the original intent of the project. The next step will be to begin software development that will allow users to set defaults such as "hard 'A' strike for angry" or "light 'W' strike for whisper".

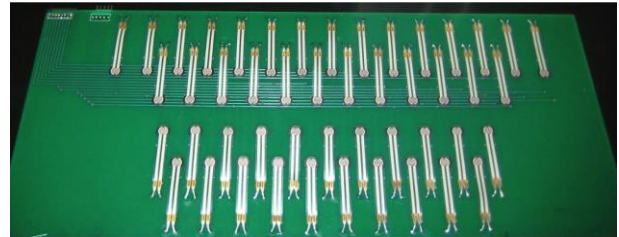


Fig. 9.7. Modified spring configuration for keyboard keys.

TECHNICAL DESCRIPTION

The team chose to use a standard Sun Microsystems Type 7 keyboard as the platform for the device. Underneath the force-sensitive keys the team opted for a force sensitive resistor (FSR). The FSR is comprised of two plastic ribbons, with a layer of resistive ink in between. As pressure is applied to the sensor, its resistive value changes. It is highly durable when used properly, has a very low profile, and has a 0.2" diameter active region.

On top of the FSR, the team removed the standard silicone bubble spring that is common on many keyboards and replaced it with a foam cushion. The silicone bubble spring is non-linear, and requires a fairly significant force to initiate motion; this would eliminate the possibility of using a low-force keystroke to convey some sort of emotion. The foam cushion (Figure 9.7) was rated positively by nine out of 10 users in testing, and could easily be integrated with the keyboard and sensor system.

There are over 70 commonly used character and functions keys on the average keyboard. To allow for analysis of force applied to each key individually, a system had to be devised to simplify the number of information paths required to accomplish this. A total of 75 sensors are required to cover all of the associated typing keys, and every key must be monitored by a standard

microcontroller. A “sensor matrix” was derived to allow for a minimal number of required inputs and outputs on a microcontroller. 15 input signals and 5 output signals will be utilized to create a “row-column” array containing all applicable keys. An MM74HC4514N 4-16 IC decoder will be used to further minimize the number of inputs required by providing all 15 input signals (one discarded) in cycle from 4 microcontroller outputs. Using this configuration, 4 outputs, and 5 inputs will be required to monitor all 75 sensors. The 5 output signals will be provided by 5 LMC660CN op-amp based amplification circuits, each fed by 15 sensors.

The team chose an Arduino MEGA as the controller device. The MEGA contains 18 analog inputs, and 32 digital outputs, with a digital output toggle

frequency of ~100k Hz and USB capability. The team did their own PCB layout for the controller interface board, which houses the amplification circuits, and also created PCBs for the main keyboard sensors (Figure 9.9 and for the number pad sensors). The final assembly is shown in Figure 9.8.

This project was partly supported by the Ronald D. Dodge Faculty Development Grant. Total cost was approximately \$1400, with \$500 support from the National Science Foundation through the RAPD program.

More information is available at
<https://edge.rit.edu/content/P10002/public/Home>
 and
<https://edge.rit.edu/content/P10003/public/Home>

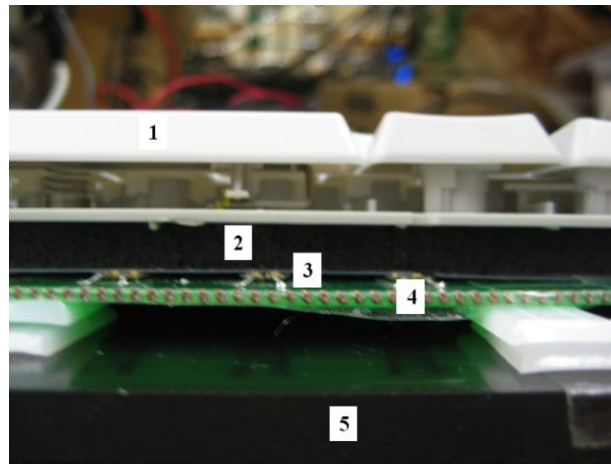


Fig. 9.8. Keyboard assembly: 1) Key Matrix, 2) foam compressive layer, 3) keyboard contact sheets, 4) force sensitive resistor PCB, and 5) ABS back plate.

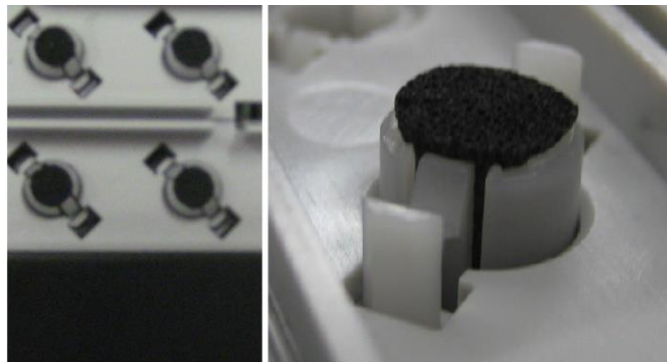


Fig. 9.9. Force sensitive resistor PCB.

LEAK TEST STATION PROCESS IMPROVEMENT

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INTRODUCTION

The goal of this project was to design and build a pressure test device for use by employees at ARCWorks, a light manufacturing facility employing individuals with developmental disabilities. The existing test fixture relied on water to pressure-test, so it was messy, subjective, and it slowed down the assembly line. The current process involves an employee taking a cap, screwing it onto a bottle, plunging the bottle under water, and looking for air bubbles that may be escaping, which would indicate a leak. Employees are generally paid on a per-piece basis, so it is important to make the process as clear, safe, and efficient as possible.

SUMMARY OF IMPACT

The team took a two-pronged approach to the problem. First, they designed a new test fixture for employees on this line to use. The fixture is still under development, and is expected to be completed over the summer. It will allow a worker to run two tests simultaneously, and provides a very simple, objective indication system: A green LED indicates a good part, a red LED indicates a bad part, and a yellow LED indicates that a test is in progress. The second aspect of the project was to improve the manufacturing process. The team implemented a 5S (Sort, Set, Shine, Standardize, and Sustain) system in two phases, which gave the operators a sense of ownership and pride in their accomplishments.

TECHNICAL DESCRIPTION

The design team chose a vacuum pressure approach, because it would be the simplest for the operators to use. The pressure test fixture the team designed and built is shown in Figure 9.11. The cap sits upon a soft rubber to create a seal. The two red buttons seen at the front left and right of the base plate are for the operator to initiate the test. The use of two buttons ensures that the worker will not run the risk of

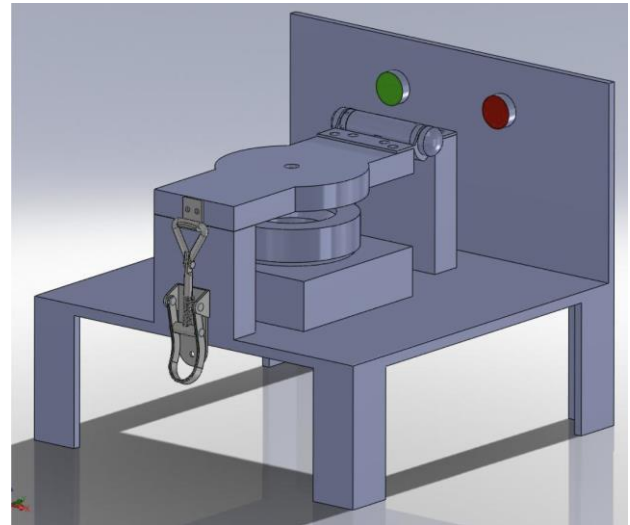


Fig. 9.10. Pressure test fixture.

injuring their hands or interfering with the test. Shown behind the cap, at the top of the back plate, are the red and green light indicators. These indicators show the results of the test: red for a bad part and green for a good part. The yellow light is illuminated when the test is in progress. Below and behind the fixture (not shown) is a differential pressure sensor to measure the speed of pressure drop and a vacuum pump to pressurize the fixture.

Operation of the machine is simple and intuitive for the operator to use. The operator will take a cap from their “incoming” lane. The operator will then place the cap onto the test fixture. Next the operator will press the two-hand start button. This will allow the machine to run unassisted by the operator. The vacuum will then run and determine if there is a good seal on the cap. If the seal is bad, a red light will indicate to the operator that the part is bad, and if the part is good a green light will appear. The vacuum will then release its pressure, allowing the operator to remove the cap and place in its respective bin. This process can be run

simultaneously on both of the stations on the machine. Examples of good and bad part pressure curves are shown in Fig. 9.12.

To allow the system to function autonomously from a PC interface, the team used a Programmable Logic Controller (PLC) to control the system. The PLC will turn on the vacuum pump, read the pressure sensor, and control the indicator lights according to the pressure readings (pass, fail, or in-progress). The PLC also reads in a user-set switch position that indicates the particular configuration of cap being tested.

The final system testing indicated that the vacuum test fixture resulted in more rejected parts than the water test system, partly because workers did not formerly hold the caps under water for a specific amount of time, and some leaks only become apparent over time. However, the new system did allow two parts to pass that actually failed the water test. Final work on this device is being done during the Summer of 2010.

The total cost of the project was \$2106.

More information is available at <https://edge.rit.edu/content/P10008/public/Hom>



Fig. 9.11. Actual pressure test system built.

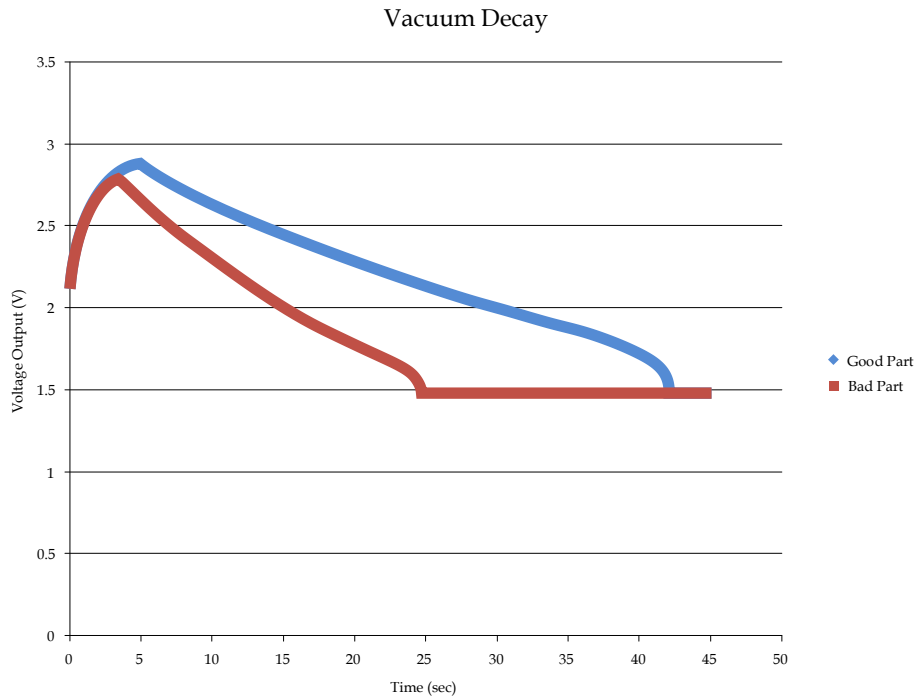


Fig. 9.12. Examples of good and bad vacuum test data.



CHAPTER 10

ROSE-HULMAN INSTITUTE OF TECHNOLOGY

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INTRODUCTION

The Press-fit Grip (PFG) and the Ready to Roll (RTR) are designed and implemented to help a client with Cerebral Palsy (CP). The goal of each design is to help our client be more independent. The client lacks fine motor control in his hands, which makes it difficult for him to complete daily tasks on his own. One of these tasks is holding the paper cups that are served at restaurants. Several cup holders are readily available commercially, but none of the available options fit his hand well enough to meet his needs. The client also volunteers twice a week at the local Animal Shelter where he unfolds and stacks newspapers so that another volunteer can easily roll them up and store them for later use in the animals' cages. The RTR is designed to improve the client's independence in his volunteer position at the Animal Shelter.

SUMMARY OF IMPACT

The design criteria for the PFG and the RTR are defined by the client's capabilities and the fact that he wants to do accomplish as much as possible independently. Because he lacks fine motor control, it is imperative to keep the PFG and the RTR simple and without intricate parts that may cause him frustration. Not only do these devices allow him to complete the processes on his own, but it also allows the person that would normally be helping him to focus efforts elsewhere. The PFG is essentially a custom-made cup holder that will hold all of the restaurant cups that the client uses on a regular basis and is specifically designed to fit his hand, thereby making it as easy as possible for him to hold. The RTR is a device that allows him to do the entire newspaper rolling process independently. That is, he can unfold, stack, and roll the newspapers entirely by himself.

TECHNICAL DESCRIPTION

The PFG is composed of two pieces: a housing/handle that is rapid prototyped and a piece of washable, viscoelastic memory foam set inside it

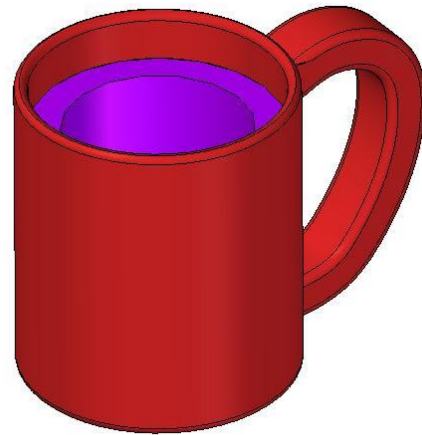


Fig. 10.1. CAD drawing of the final Press-fit Grip (PFG) design.

to securely hold the restaurant cups. This design is a very simple and is chosen over alternative design solutions due to superior performance capacity in the categories of washability, durability, ease of maintenance, and thermal insulation. The PFG was tested and is currently successfully used by the client.

The RTR is composed of three subsystems: the frame, the roller, and the crank. The frame is constructed completely of wood and it is designed to be adjustable in order to fit multiple newspaper sizes. The frame is also designed to be easily broken down, to make the device easy to transport. The roller is made of two parallel dowel rods. The paper can be stacked in between these dowel rods and rolled around both simultaneously. The crank is modeled after the client's silverware in order to ensure he will be able to grip the handle. When the crank is turned, the newspaper will roll around the parallel dowel rods, creating the roll of papers. This design is chosen over alternative design solutions due to superior durability, portability and ease of

cleaning. The RTR was tested and successfully used by the client.

The cost of parts and materials for these two systems is about \$250.

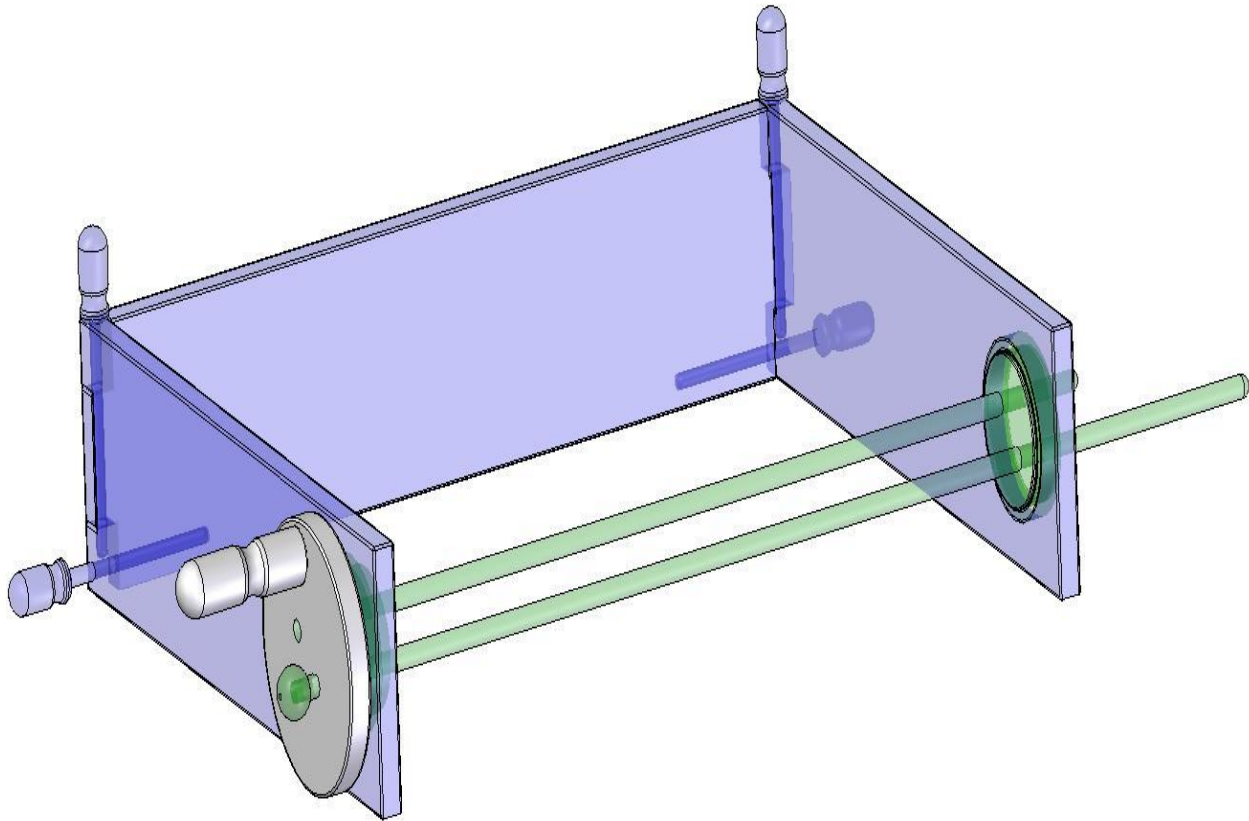


Fig. 10.2. CAD drawing of the final Ready to Roll (RTR) design.

VISION COOKING CHALLENGE: CUSTOM LIGHTING FOR CLIENTS WITH LIMITED VISION

Designers: Lauren Christensen, Sarah Dempsey, and Sabrina Liechty
Supervising Professors: Dr. Kay C Dee, Dr. Renee Rogge, and Dr. Glen Livesay
Rose-Hulman Institute of Technology
Department of Applied Biology & Biomedical Engineering
Terre Haute, IN 47803

INTRODUCTION

The Octopus is designed to provide people with limited visual abilities a custom light source to improve their ability to perform essential daily activities, such as cooking. There are many types of lamps or other auxiliary light sources that may be helpful to persons with limited visual abilities. Our client, however, has tried these solutions without much success. Therefore this design includes a custom lamp with light emitting diode (LED) light bulbs. The device is equipped with four flexible arms, each with an LED light bulb at the end. The flexible arms allow the user to adjust the location of the light. The advantage of multiple arms means that the user can choose to focus light in more than one direction, a larger location, or increase the intensity of the light (by focusing more than one in the same location). Testing with the client was done to determine the best light source for the individual. The lights chosen to test were LEDs, halogen lights, compact fluorescent lights and several different colored lights. The client responded positively to LED lighting as well as yellow and green lighting. The intensities of each light were also adjustable by means of dimmer switch.

SUMMARY OF IMPACT

The Octopus is designed specifically for one client, but the device may benefit many other clients with similar needs. Since the device is easily used and portable it would be able to be transferred to other people with similar vision challenges who would also benefit from such a device. There are also several other applications that may be modified for different types of vision impairments based on the design of the Octopus.

TECHNICAL DESCRIPTION

The Octopus is comprised of three subsystems: the base and stem, the arms and light attachment and the wiring.

The base and stem are made from aluminum. The overall dimensions were 2'x2'x1.2" for the base and



Fig. 10.3. The Octopus design as implemented.

2"x2"x20" for the stem. Located on the stem are four on-off switches and four dimmer switches, allowing for independent control of each of the lights. To better insulate the circuit, the bottom piece of the base is made from Lexan.

The flexible arms attached to the stem by a 4" round weatherproof junction box. The arms are made from flexible steel conduit. At the other end of each arm are customized 48-LED light bulbs. The light bulbs are stock parts that are slightly modified by removing select internal elements.

The circuitry for each of the lights is housed in the base. The lamp, being made from metal, is initially insulated from conducting electricity by having a Lexan base for the circuit where it can attach. Next, there is ample space above the circuit, where the top

of the base is. Lastly, the circuit is also grounded through a screw on one side of the base. A microchip is used to produce a pulse width modulation (PWM) signal. Pulse width modulation is a more optimal way to cause the light to dim opposed to the typical method with causes LEDs to

flicker. The PWM is a square wave of a fixed voltage but with a variable duty cycle. The dimmer switch is actually a variable resistance, which is used to control the duty cycle.

The overall cost of parts and materials for this device is approximately \$350.

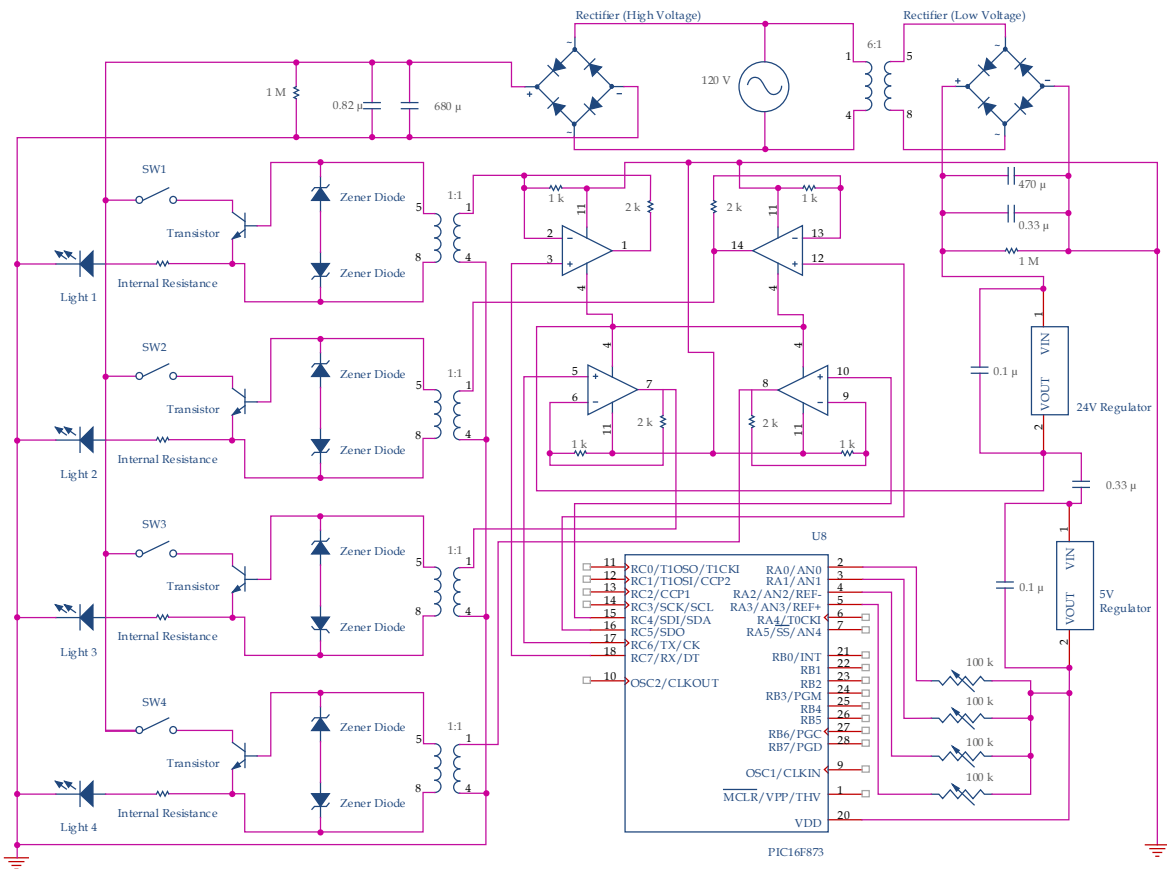


Fig. 10.4. Circuit diagram for the Octopus.

THE GRAVITY ROLLER: A FEEDING DEVICE FOR INFANTS WITH CLEFT PALATE AND/OR CLEFT LIP

Designers: Annie Bullock, Emily Dentler, Bryan Poulsen and Erinn Sheridan
Supervising Professors: Dr. Kay C Dee, Dr. Renee Rogge and Dr. Glen Livesay
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Terre Haute, IN 47803

INTRODUCTION

The Gravity Roller (GR) is designed for infants with cleft palate and/or cleft lip who are unable to create a seal around a nipple while feeding. The GR provides a simple, safe, and cost effective solution to the problems with the current technology on the market. The GR attaches to a regular baby bottle and provides fluid control to both the caregiver and the infant. The regulation valve at the top allows the caregiver to control the rate of fluid flow through high, medium, low, and off settings and the ball valve allows the infant to have off/on control. Infants have natural tongue “flicking” and pressing motion when feeding. This design takes advantage of these instincts, so that when the ball in the ball valve is depressed, formula will flow down the tongue without requiring a seal around a nipple. A proof-of-concept prototype was developed, but is not currently available for use by an infant due to the utilization of materials that are not food-safe.

SUMMARY OF IMPACT

The design criteria for the Gravity Roller are defined by the needs and physical constraints of the caregiver and infant. Current devices on the market are either adapted from existing devices for other problems or they are cheap and ineffective. The bottle the client was given to use was simply a thin walled squeeze bottle with a long tube on the end. The tube was inserted into the baby’s mouth and formula was squeezed down their throat. This required a lot of practice as the caregiver must know exactly how much to squeeze to allow feeding while also preventing choking of the infant. Also, the thin walls result in rapid temperature loss and the 3oz bottle was inconvenient because it would have to be refilled during a single feeding session.

The client desires a cheap device that would provide a better way to feed her child by giving both the child and the parent control of the formula flow



Fig. 10.5. The Gravity Roller

while also retaining heat longer and holding more than 3oz of fluid. It is also desired for the design to have a low learning curve for the caregiver, so if necessary, people other than the primary caregiver may feed the infant.

TECHNICAL DESCRIPTION

The GR is developed as a proof-of-concept prototype and is not food safe. It consists of four subsystems: a standard off-the-shelf bottle, the Regulation Valve (1), the Ball Valve (2), and the Delivery Tube (3). This device is developed to be used with the Avent series of bottles, a popular brand in the United States. The design may also be adapted for use with other bottle brands. Before starting, the formula is prepared as desired by the caregiver. Once the prepared formula is in the bottle, the GR is screwed on. When it is time to feed the

infant, the device is inverted and the regulation valve is unlocked and turned to the desired flow setting: Off, Low, Medium, or High. Formula flows from the bottle through the delivery tube and the infant can then roll or push his or her tongue against the ball valve to release formula. The entire GR (without the bottle) is approximately five inches long from the bottle connection to the tip of the ball valve and two and a half inches in diameter at its widest point. The regulation valve is made of rapid-prototyped ABS plastic with the exception of the lock and spring which are machined from stainless steel and aluminum, respectively. The regulation valve consists of interlocking plates that allow for rotation relative to each other but do not allow for the passage of formula (or other liquid) between the inter-locking grooves. A series of progressively larger overlapping holes can be selectively uncovered by releasing the spring-loaded lock from a groove and turning the regulation valve to the desired flow setting.

The regulation valve is connected to the Avent bottles via the Avent lid. The nipple is removed from the commercial product and the lid is cemented to the inside cylindrical surface of the top of the GR, thus providing a threaded, leak-proof interface between the GR and the bottle. The delivery tube and infant controlled ball valve are made of type 304 stainless steel (5/16 inch outer diameter) and are connected together and to the rest of the GR using JB Weld epoxy. The ball valve contains a solid stainless steel ball slightly larger than the opening in the valve (similar to a hamster bottle). The delivery tube contains a 135° angle so that when the bottle is held at 45° (as is normal during infant feeding), the ball valve can be presented parallel to the infant's tongue.

The total cost of the project is approximately \$125.00 for materials and supplies.

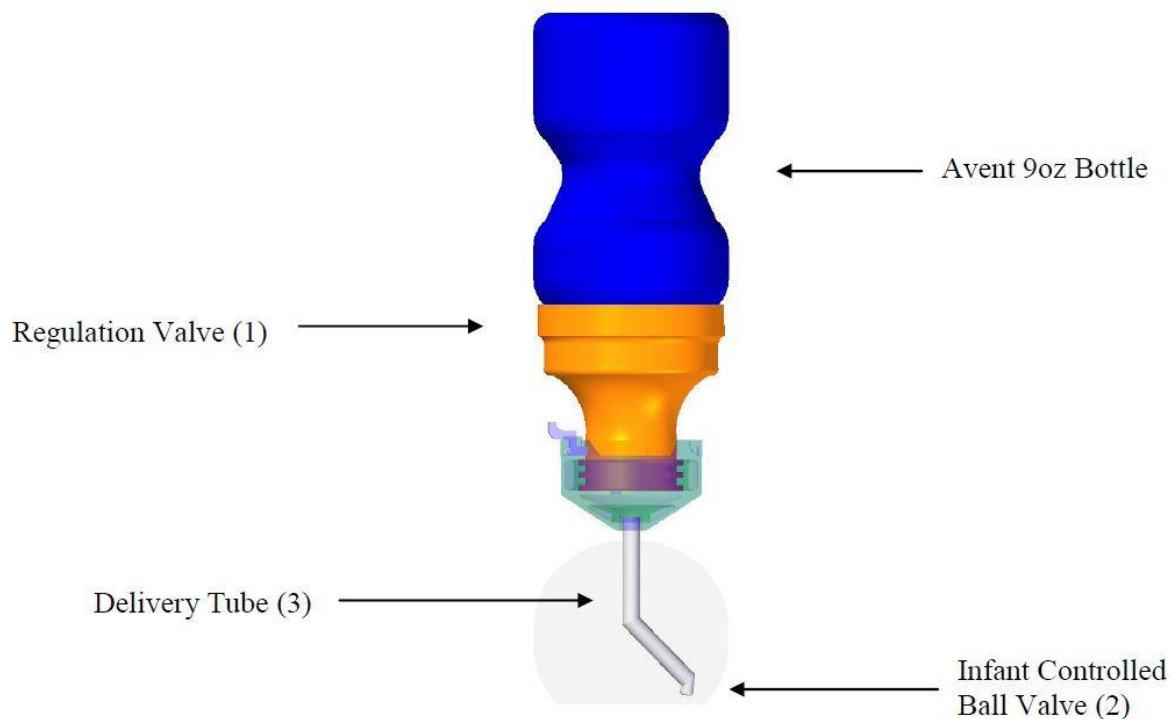


Fig. 10.6. Detailed CAD Drawing of the Gravity Roller.

THE SWIVEL PLOW: A PORTABLE SWEEPING DEVICE

Designers: Lauren N. Griggs, Erin B. Johnson, and Didem Tunc
Client Coordinator: Ruth Tobias, Covered Bridge, Terre Haute, Indiana
Supervising Professors: Dr. Kay C Dee, Dr. Renee Rogge and Dr. Glen Livesay
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Department of Applied Biology & Biomedical Engineering
Terre Haute, IN 47803

INTRODUCTION

The Swivel Plow is an assistive device that allows a wheelchair user to sweep floors without an assistant holding and guiding the broom. The client was diagnosed with Hemimegalencephaly, which is a condition where one side of the brain has a dysplastic malformation. This often leads to severe seizures, and after the client experienced several severe seizures, he underwent a hemispherectomy to remove the right side of his brain. This left a limited range of motor skills in the left half of his body. He has difficulty walking and therefore uses a wheelchair. The client currently holds two jobs: sweeping the hallways at a local school and sweeping the floors at a local business. The client requires a device that can be used with only one hand and offers him a support system other than his assistant. The Swivel Plow attaches to the crossbars of a wheelchair and is currently in use by the client at both of his jobs.

SUMMARY OF IMPACT

The design criteria for the Swivel Plow are defined by the capabilities and needs of the user. As a result of the HME, the user needs a safe and durable device that is easy to use. The job assistant and parents require a device that is easy to clean and attach, since the user works at two job sites and needs to transport the device between these locations. This device allows for the user to perform his job without the assistant holding the broom.

TECHNICAL DESCRIPTION

The swivel plow has a V-shaped broom to assist the client in sweeping a larger surface area and allows the dirt and debris to be collected at the center. The broom head connects to the broom shaft by a clip that allows the broom to adjust by rotating the clip. The broom has a quick release clamp attached to the shaft. This quick release clamp allows the broom to



Fig. 10.7. The Swivel Plow.

be connected to a u-joint. This joint provides movement either vertically or horizontally so the user still has control of the broom. However, if the user accidentally releases the broom, the broom does not fall to the floor. On the other side of the u-joint is a hollow aluminum rod with through holes drilled into it. A solid aluminum rod is inserted into the hollow rod to create length adjustability on the device by utilizing a drop pin. If the user needs the device to extend further past his feet, his assistant can lengthen the device by removing the drop pin and adjusting the rods to the proper length. The aluminum rod that inserts into the hollow rod connects via a custom made quick install clamp to the wheelchair. This attachment stabilizes the broom, while still allowing the user to maintain control of the broom.

The Swivel Plow is safe for both the client and the people around him. The broom shaft is cushioned with neoprene so the client cannot hurt himself if he accidentally hits a part of his body with the device. The clamp that attaches the broom to the u-joint eliminates the risk of the user throwing the broom shaft and hitting someone else nearby. The device is also durable due to the aluminum and steel that

comprise the subsystems which will withstand the forces applied by the user. The client was able to control the broom during testing and was able to complete his job tasks without requiring an assistant to control the broom.

The cost of parts and material of this design is approximately \$400.

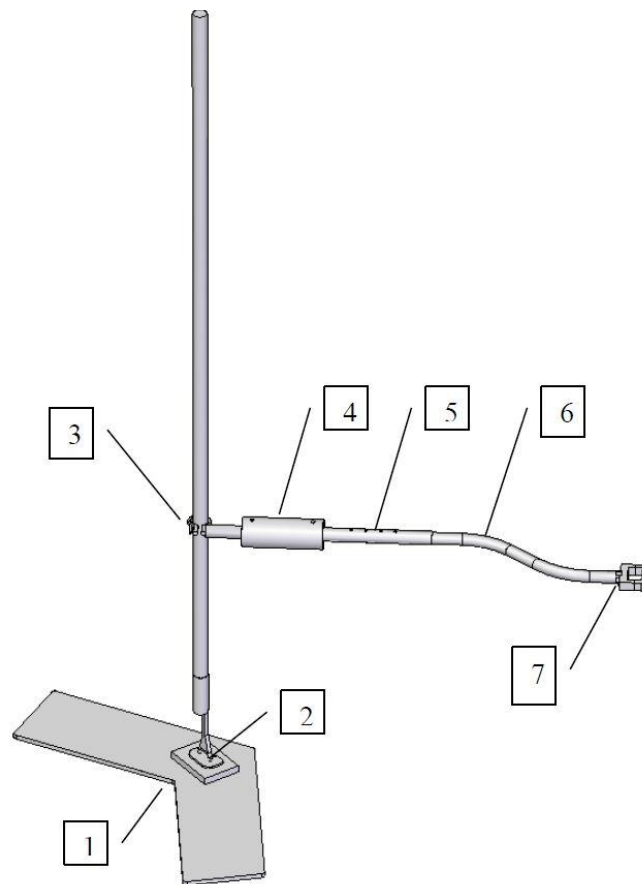


Fig. 10.8. Detailed CAD drawing of the Swivel Plow illustrating the key features.

NICU ACCESS DOOR: A DEVICE DESIGNED TO INCREASE SECURITY AND SANITATION

Designers: Sara Hong, Dan Sullivan, and Darcie Thomas
Supervising Professors: Dr. Kay C Dee, Dr. Renee Rogge and Dr. Glen Livesay
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INTRODUCTION

The access point to a local Neonatal Intensive Care Unit (NICU) is currently inconvenient for both nurses and parents wishing to visit their child. As it is, the door may be opened by anyone from the inside and there are no strict security measures in place to prevent entry of unauthorized persons. In order for someone to gain access to the NICU, they must wash their hands, then use their freshly cleaned hands to knock on the unsanitary door until a nurse or another parent inside the NICU comes to the door and opens it from the inside. A better design for the NICU access point which addresses each of these critical design flaws of the current system is created in this design. In this new design, visiting parents arrive at the NICU door and step on a foot pedal which activates a notification light inside the room at the nurse's station instead of knocking on the door to gain nurses' attention. Once a nurse inside the NICU sees the flashing blue light located at the central nurse's station and is notified of the presence of a visitor outside the door, the nurse then swipes the barcode on an identification badge and the door automatically opens, waits for a couple seconds, and closes again on its own. This design solves the security issue of the current system because it must be an authorized NICU nurse who activates the door to open for a visitor. Nurses inside the NICU are able to look out through the door's window and make sure it is a visitor they recognize before activating the door to open. This part of the design also makes it quicker and easier for the nurses to identify a visitor and grant them access because the barcode scanner is located at the nurse's station and takes only a second to activate. A prototype of the access system was developed to demonstrate to hospital administrators prior to incorporation of a new security system.



Fig. 10.9. NICU access door.

SUMMARY OF IMPACT

There are two criteria which are required for the design to meet the needs of the client. These criteria are security and sanitation. Without either of these considerations, the final design does not solve the initial problem. The remaining criteria are created based on nurse and parent feedback. These criteria include the amount of time it takes to operate the system, cost, the amount of construction required to install, and the overall sound level of the system.

TECHNICAL DESCRIPTION:

The final prototype is divided into five different subsystems including the opening subsystem, barcode and database subsystem, mounting and power supply subsystem, stability subsystem, and the visitor notification subsystem. The opening subsystem is comprised of a residential automatic door opener and electromagnetic lock system. This

eliminates the need for the nurses to physically touch the door handle to open it. The barcode and database subsystem is created by purchasing a barcode swipe card reader. This allows for only the nurses to open the door with their authorized ID badge. The mounting and power supply system is created to ensure the appropriate amount of power is sent to each electrical component and to ensure each element of the final design solution is securely installed onto the prototype. The physical connections are achieved through Velcro and a staple gun. The stability subsystem is created out of

plywood board and wood supports. The stability platform supports the entire weight of the system and has wheels which allow for transportation of the prototype during construction. The final subsystem, the visitor notification subsystem, is created through using a blue light and foot pedal which are mounted on top of the door frame and on the stability platform respectively. These components allow for the visitor to catch the attention of the busy nurses working inside of the NICU.

The final cost of the prototype, including a representative door, is approximately \$500.

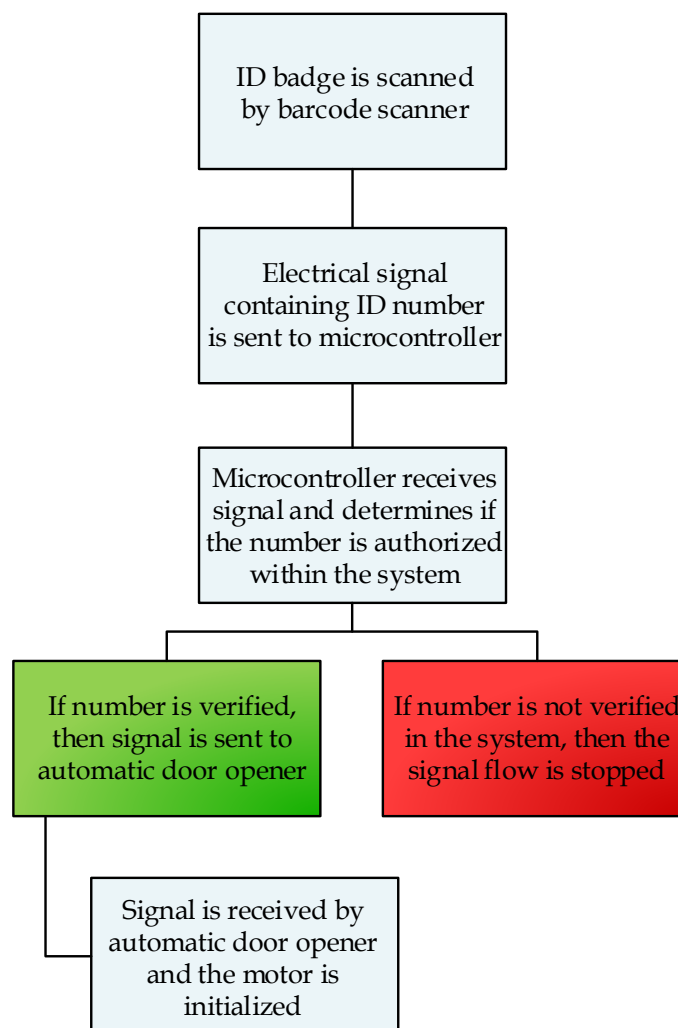


Fig. 10.10. Signal flow for the NICU access door.

GALILEO: A DEVICE TO INCORPORATE A LAPTOP ONTO A WHEELCHAIR

Designers: Cody Austin, Elaine Houston, Leah Howard, Haocheng (James) Zhou
Client Coordinator: Josie Newport, Terre Haute South High School, Terre Haute, IN
Supervising Professors: Dr. Kay C Dee, Dr. Renee Rogge and Dr. Glen Livesay
Rose-Hulman Institute of Technology
Department of Applied Biology & Biomedical Engineering
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INTRODUCTION

The Galileo is a device that aids wheelchair users in independently accessing and storing laptops. The current design completely automates the process because the client has a very limited range of motion and limited physical strength due to a brittle bone condition. The Galileo attaches to the base of a wheelchair and allows for adjustability in its motions as it is deployed. The main subsystems are the track and cart, telescoping arm, laptop encasement, and the electronics with user interface. Currently there are no existing products on the market which meet the needs of our client.

SUMMARY OF IMPACT

The Galileo will improve the quality of life of the client by increasing her independence. Currently an assistant must get her laptop out and then store it for her every time she needs to use it. This automated device will increase her level of independence. Currently the design is not entirely functional. The electronics are the main control of the system which incorporates all of the safety systems of the Galileo. This device needs further testing before it can be approved. After rigorous trouble-shooting, the Galileo should be ideal for those who have limited range of motion and physical strength to access their laptop on a wheelchair.

TECHNICAL DESCRIPTION

The device is composed of many different materials, many of which are custom machined by the team.

The track and cart subsystem of the Galileo performs the duty of moving the armature along a track to working position, or back to storage position in the protective shield. The system is made from aluminum for its good strength to weight properties. The design incorporates a motor for

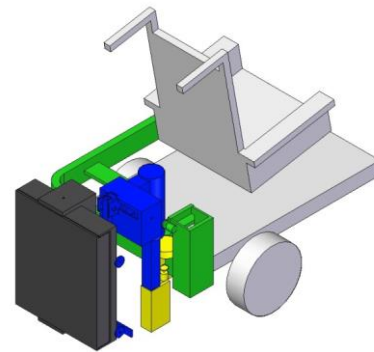


Fig. 10.11. Simplified overview of Galileo attached to a wheelchair in storage position.

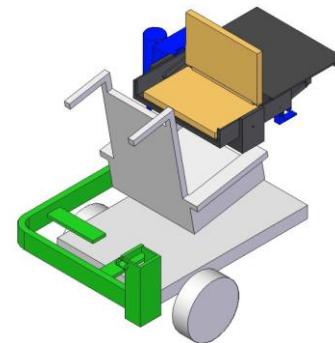


Fig. 10.12. Simplified overview of Galileo attached to a wheelchair in working position.

running the cart along the track, and one for controlling the draw arm in the back shield. There are three support bars that fasten onto the base of the power wheelchair through bolts.

The laptop is encased in the laptop attachment system by Velcro straps. The laptop attachment system automatically opens and closes the laptop using a tension wire attached to the computer. The automated opening feature allows a user with minimal strength to reach or to open the laptop. The

case is made of polypropylene, providing the laptop with a weatherproof and water resistant storage compartment for transportation wherever it is needed without requiring external assistance.

The laptop attachment system connects to the telescoping arm system. The telescoping arm system moves the laptop up and down and through the use of a linear actuator, pulls the laptop horizontal through a pulley system, and rotates the laptop through the use of an internal gear assembly. All these motions are controlled by the user through the user control interface. This system allows for significant variability in the positioning of the laptop relative to the user to enhance ergonomics involved in the usage of the laptop.

All of the above systems are controlled by a user interface that includes momentary rocker switches for controlling all movements and an emergency stop button for safety. The device is powered by a 12V battery for the motors and four AA batteries for the controls. All of the control is mediated by a microcontroller which takes the inputs from the user, the various safety limit switches, IR sensors, and also acts as the motor controller to control the seven DC and stepper motors in this device.

The cost of parts and material for this design is about \$3000.

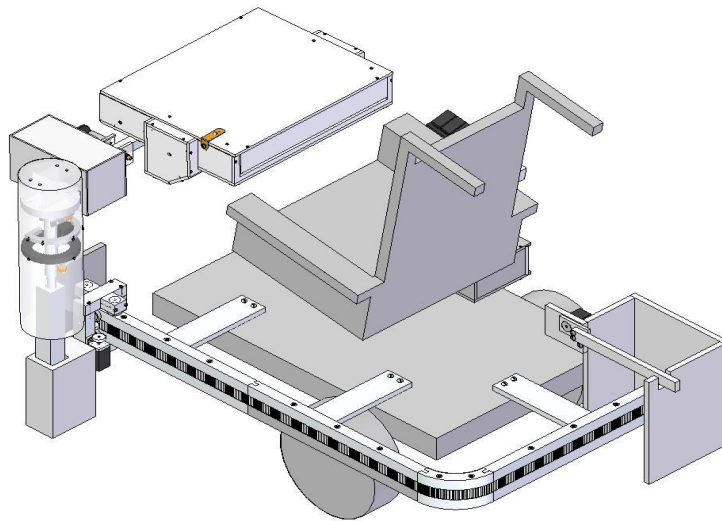


Fig. 10.13. Detailed assembly drawing of Galileo attached to the wheelchair

DYNAMIC TRANSHUMERAL PROSTHESIS: A DEVICE THAT PROVIDES EXTENDED REACH AND GRASP TO A CHILD WITH UNDERDEVELOPED FOREARMS AND HANDS

Designers: Justin Druba, Dan King, and Kyle Harbison
Supervising Professors: Dr. Kay C Dee, Dr. Renee Rogge and Dr. Glen Livesay
Rose-Hulman Institute of Technology
Department of Applied Biology & Biomedical Engineering
Terre Haute, IN 47803

INTRODUCTION

The client for which this device is designed has Fryns-Hofkens-Fabry Syndrome. This condition is characterized by congenital underdevelopment of the ulna and radius bones of the forearm. Fryn-Hofkens-Fabry Syndrome is extremely rare and the extent of the symptoms varies from patient to patient. The client has no forearms and has only his middle and index fingers on each hand; therefore, he does not have the ability rotate his hand without moving his shoulder. This condition limits the client's upper extremity functionality because he does not have the ability for much mechanical use of his arms or strength in his fingers. This limits his abilities to perform many everyday activities such as using the restroom, getting dressed, playing, and performing classroom activities. He currently uses a reaching stick to help him with certain tasks, but it is largely ineffective for most activities. Due to the rarity of ulnar and radial hypoplasia, which affects

fewer than 200,000 people in the US population, there are currently no devices commercially available to assist individuals with this condition with everyday tasks. However, there are many devices that are designed to help those with similar disabilities. Numerous upper arm prostheses have been designed for amputees and others with congenital conditions. Simple shoulder shrug arm prostheses are among the most common. None of these devices are specifically designed for someone lacking forearms. The goal for this design project is to design, develop, and deliver a device that will promote independence for the client in performing day to day activities.

SUMMARY OF IMPACT

The final prototype device is functional; however, our client's fingers are not yet strong enough to manipulate the elbow joint and completely close the hand. At the completion of the prototype there are



Fig. 10.14. Dynamic Transhumeral Prosthesis.

several recommendations for further investigation and development of the dynamic transhumeral prosthetic. The elbow joint as currently designed and built requires too much force to manipulate its position. It is recommended a different elbow joint be investigated to obtain the necessary force to effectively manipulate the joint to within the range of the client's finger strength. It is further recommended that different foams be researched in order to provide the client with the most comfortable fit possible. The current prototype uses polyurethane foam on the inside of the socket that may be replaced with softer memory foam. It is also recommended that expert sources are contacted for their advice on developing the most effective socket for the client.

Although the prototype device is not currently in use by the client, it would be a viable solution if increased finger strength is gained.

TECHNICAL DESCRIPTION

The transhumeral prosthesis that is designed to establish lower arm utility for the client is comprised of three subsystem including the hand, user input, and socket. The hand subsystem is designed around the concept of a linked-lever mechanical system that preserves adaptive adjustment as the fingers are flexed around an object. Therefore, the hand would passively adjust to objects being grasped by the

client. The hand subsystem may also provide mechanical advantage through a system of cable and pulleys, and allows the client to grasp and hold objects using the strength of only one finger. The hand subsystem connects directly to the forearm of the prosthesis, which is designed under the user input subsystem. The user input subsystem provides a means for the client to manipulate the prosthesis in order to better interact with his environment. The subsystem is comprised of a Polyvinyl Chloride (PVC) pipe, cables, and a network of pulleys and springs that give greater mechanical advantages in both strength and functional range. One finger allows the client to control the hand and the other to bend the elbow. The user input subsystem is securely connected to the two ABS plastic braces at the end of the socket subsystem. The plastic braces are then attached to the ABS plastic sleeve via numerous ratcheting snaps that firmly attach the device to the client's arm. It incorporates two different designs in order to provide the client with the most security and stability when interacting with his environment. Velcro® straps and a back strap securely attach the ABS plastic sleeve to the arm and allow the prosthesis to withstand typical and falling forces it may be exposed to in all three dimensions.

The cost of parts and materials for the project is about \$350.

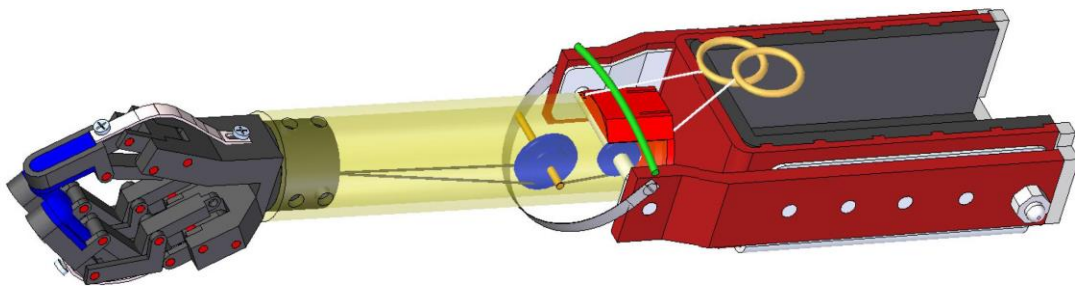


Fig. 10.15. Detailed assembly diagram of the final transhumeral device.



CHAPTER 11

STATE UNIVERSITY OF NEW YORK AT BUFFALO

School of Engineering and Applied Sciences
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Principal Investigator:

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“ASSIST TO EXIT,” TILT-LIFT AUTOMOTIVE SEAT

*Student Designers: Ben Blankenship
Faculty Designers: Gary Olson (Machine Shop)
Supervising Professor: Dr. Joseph C. Mollendorf
Department of Mechanical and Aerospace Engineering
State University of New York at Buffalo,
Buffalo, NY 14260-4400*

INTRODUCTION

Kugelberg-welander disease is a genetic disease that originates from the inheritance of a rare recessive gene. The pairing of two of these particular recessive genes from each parent leaves the child with a progressive lifetime upper girth muscle atrophy of the arms and legs. The muscles affected are the quadriceps, hamstrings, biceps, and triceps. Without the functional use of the formerly mentioned muscles, a person has extreme difficulty rising and lowering from a seated position. The objective of the “Assist to exit,” tilt-lift automotive seat, shown in Fig. 11.2, is to provide our client with an ease of raising or lowering himself safely into or out of a car from a seated to a standing position, or vice versa.

SUMMARY OF IMPACT

This device can aid in increasing the capabilities of clientele in their daily activities and lives, while providing them with safe independence, with an aesthetically pleasing and unimposing assistance. The device offers stability and may also offer rehabilitation qualities as well. The “Assist to exit,” tilt-lift automotive seat meets limitations with convenience.

TECHNICAL DESCRIPTION

This device is designed with care and a researched understanding of all existent requirements of the client with considerations pertaining to relevant engineering specifications of an automobile. The tilt-lift itself is an Acme power screw, chain, and sprocket driven scissor lift that is designed with one side hinged in order to facilitate tilt. The drive train system’s mechanisms are run by an electric 12 V DC custom 5-1 geared motor to the mechanical lift. Total travel speed of the system as an output is approximately 12-16 seconds, differing slightly due to differences in weight of the users. Furthermore, the torque of the system generates enough force to

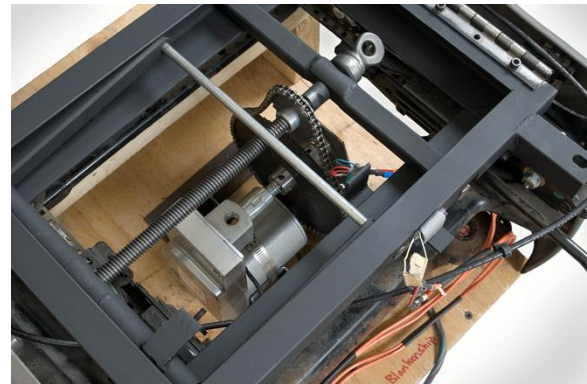


Fig.11.1. Interior Mechanical Components.



Fig.11.2. Seat at 45 Degrees.

support the users' weight. The range of motion of the device is from 0 degrees to 45 degrees.

Ergonomically, 45 degrees was found to be the optimum rotation angle of tilt for the seat to effectively achieve stated objective while sufficiently supporting/relieving negative pressure to the lumbar vertebrae.

There were many considerations of embodiment of design utilized in the lift design prototype. Assembly deliberations made the device fully capable of being disassembled for maintenance or ease of repair. Parts are fastened using cotter pins, nuts and bolts, set screws (sprockets), and clamps (motor to the mount). Furthermore, materials for certain parts are selected based on functionality properties. The lift frame is mainly constructed of cold rolled steel for the mechanical properties of strength and ease of machining and welding. Nylon wheels are used in the moving parts for their ability to easily roll on steel with low amounts of friction. Brass is used as a low friction bushing material for support of the steel motor shaft.

Additional stability and maintenance of functionality as well as safety are key factors in this design. Limit switch electrical components are utilized to set the extreme maximum and minimum bounds of the systems rotation of tilt. These limit switches are triggered by micro-adjustable fine thread bolts. The advantages of tight tolerances on individual components were also utilized to create a successful design.

The total price of the project is \$90.33. Weibert's Auto Place of Youngstown, NY donated the automotive seat.



Fig.11.3. Seat in Down Position While in Use.



Fig.11.4. Seat in Upward Position While in Use.

SOAP DISPENSING WASHCLOTH MITTEN

*Student Designer: Joel Gabrielson
Supervising Professor: Dr. Joseph C. Mollendorf
Client: Dorothy Klein
Department of Mechanical and Aerospace Engineering
State University of New York at Buffalo,
Buffalo, NY 14260-4400*

INTRODUCTION

The Soap Dispensing Washcloth Mitten eliminates the need to directly handle soap and body wash while in the bath or shower. The washcloth can be worn on either hand. Inside the washcloth is a refillable bladder that dispenses liquid soap to the palm of the hand when pressure is applied.

SUMMARY OF IMPACT

This design allows the user to reapply soap as needed without using a separate bar of soap or body wash container. People with hand pain or poor dexterity using wet and soapy materials in the shower can be difficult. If one of these slippery items were to fall to the floor, people with back or neck pain may find it difficult to retrieve them. These problems are solved by combining the soap and washcloth into one easy to use item.

TECHNICAL DESCRIPTION

The soap dispensing system consists of just a few key components. A two-tube infant blood pressure bladder is used to hold the soap. It is made of a soft and flexible neoprene material with two long tubes extending from it. On the end of one tube is a threaded male adapter with a screw on cap. With the cap unscrewed, the soap is easily squeezed into the bladder using a plastic bottle. The second tube, used for dispensing the soap, runs over the fingertips and ends at the palm of the hand. A check valve is placed along this tube to only allow for flow away from the bladder. The valve also provides the necessary resistance to keep the soap from leaking, allowing an applied pressure to force the soap out.

This soap dispensing system fits into the washcloth mitten through a flap on the back of the hand. The mitten is made of two separate pieces of washcloth material. The first is a rectangular piece, sewn together on three sides to form the mitten. The



Fig. 11.5. Washcloth Being Filled.



Fig. 11.6. Backside of Unassembled Device.

second piece, whose purpose is to house the dispensing system, is sewn on the outside of the first piece. Once in place, the dispensing tube runs through a passage to the palm of the hand. The filling attachment protrudes through an opening on the back of the hand for convenient access. A button closes and opens the flap, allowing for the removal of the dispensing system if necessary. The design of the mitten is such that it can be worn comfortably on either hand.

The total cost of this project is \$53.



Fig. 11.7. Washcloth Mitten Soap Dispensing Front Side.

BATH SEAT WITH ASSISTED CLEANING SYSTEM

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Engineering Machine Shop Design: Gary Olson
Clients: Kathleen Harrison
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INTRODUCTION

The object of the shower chair is to provide an easy solution for independent personal hygiene for individuals who are unable to stand for extended periods of time. The chair is specialized to help persons whom have difficulty washing their backs. The back washer is a runoff water power that has been rerouted from the shower plumbing, spinning the turbine and engaging a scrubber.

SUMMARY OF IMPACT

The project adds ease to showering by eliminating the need to reach around to scrub difficult to reach areas of the back. It provides the ease and comfort of a shower chair while also providing another service that would be beneficial for those who have difficulty reaching their back. This allows the user to still enjoy independent hygiene while being able to clean more area of the body in an efficient manner.

TECHNICAL DESCRIPTION

The bath seat with assisted cleaning system consists of a stool, a back rest and the turbine driven back washer. The back washer is built into the backrest. The back washer turbine is driven by water rerouted from the pipe attached to the shower. The backwasher consists of loofah attached to a dish which is spun by the turbine. The spinning motion moves the loofah which assists in cleaning the users back. It can easily be operated by a switch which the user can reach from a seat position on the stool. The switch has multiple settings depending on the speed and power preference of the user.

The stool seat is made of a hard plastic with drainage holes. The plastic was also molded with a handle to make carrying easier for the user. The plastic seat is mounted to steel legs which are adjustable for user preference and height needs. Each of the chair leg bottoms is equipped with a one inch diameter suction cup for easy attachment to the



Fig. 11.8. Full View of Device.

bath floor. They provide extra safety and stability during use as well as while entering and exiting the chair.

The chair rest is attached to the stool through prefabricated holes located on the plastic seat. The backrest prototype is constructed of one inch PVC piping. The mounting system was constructed by inserting solid PVC with internal threading into the hollow PVC pipe and inserting a screw to connect the back rest to the stool. The back washing system is located between and slightly backset from the

upper and lower back supports. The lower backrest support is adjustable and each support is covered with pipe insulator for added comfort. The back washing system is backset keeping the user from putting full weight on the back washer during motion or while the chair is in use. The turbine system is mounted on a sheet of polycarbonate which is held in place by two PVC rods. Each rod is cut open to slide in the polycarbonate sheet for added support. An extra brick of solid PVC is used to construct housing for the tube of the turbine system to prevent excessive vibration and motion during use.

The backwashing system is created by remodeling a car washing brush. The turbine and gear ratio allow for the proper power and speed. A disk is made from polycarbonate which mounts to the spinning

plate from the car brush and also serves as the base to attach the loofah. The polycarbonate washing disk consists of three holes to help drain moving water from the system. The loofah is sewn to the disk with fishing wire and a series of holes. The disk is connected to the spinning plate with screws and fasteners. The backside of the turbine housing is attached to the polycarbonate sheet with screws and locking nuts.

The device works with the water outflow of a typical household plumbing system. It provides the users with the force and speed required to help in back washing. The chair design is limited to the size of the users back it can reach since the disk is eight inches in diameter.

The total cost of the chair is \$82.62; it does not include the plumbing system for the chair.

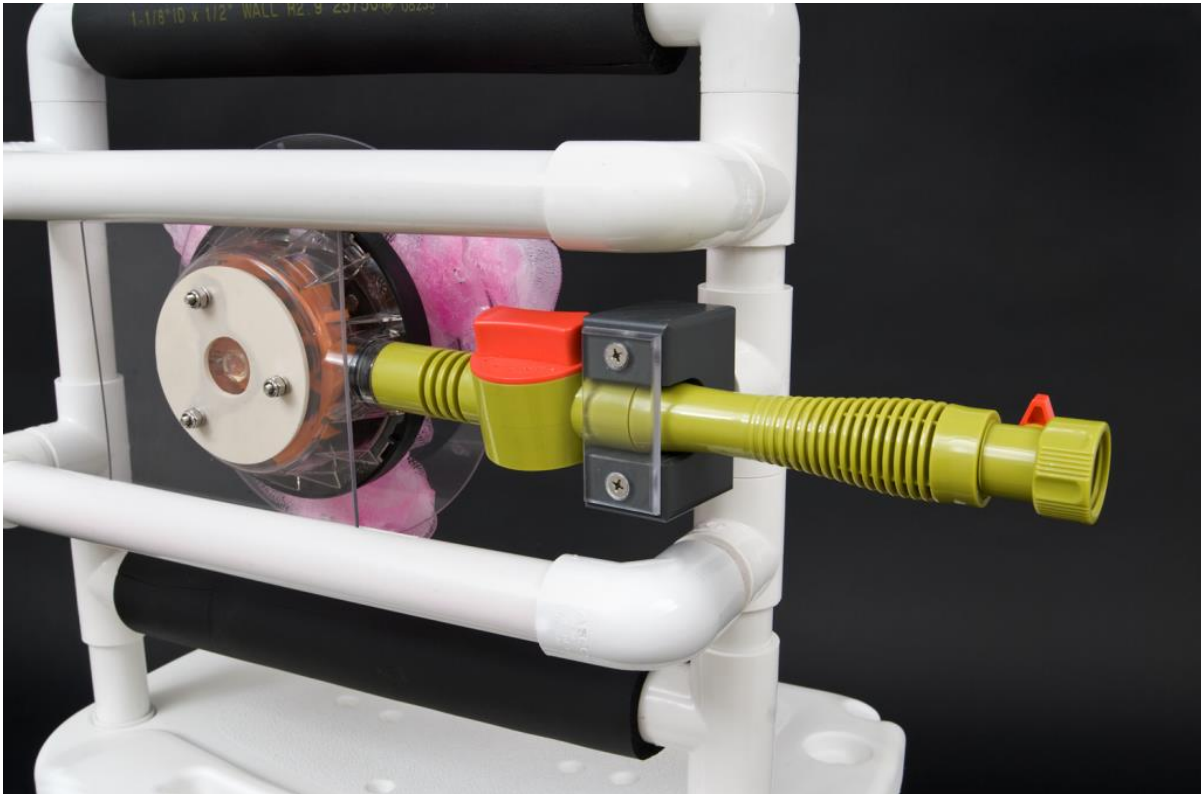


Fig. 11.9. Close Up of Back of Device.

PORTABLE OBJECT DETECTOR FOR VISUAL IMPAIRMENTS

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INTRODUCTION

The existing white cane for the blind has a few problems that limit mobility of its users. Oftentimes visually impaired people have to swing their white cane in order to detect what is in front of them. The user has to worry about hitting people or objects with the cane. It lacks the ability to detect a moving particle. Also, the cane cannot detect objects that are located above a certain height. The goal of the Portable Object Detector for Visual Impairments, shown in Fig. 11.10, is to provide the visually impaired with better mobility and an enhanced safety than exists with the white cane.

SUMMARY OF IMPACT

The Portable Object Detector for Visual Impairments allows individuals who use this device to navigate independently with minimal contact with obstacles. The implementation of ultrasonic sensor technology to detect objects can minimize the risk of injuries during the contact. Also, the pitch given off by the piezoelectric transducer allows the user to sense how far the obstacle is located. This device can locate objects without fear of collision and avoids embarrassing cane contact with other pedestrians. Also, this device decreases any entrance restrictions, like those of restaurants and vehicles. This device offers the all the benefits of the white cane with better mobility and safety.

TECHNICAL DESCRIPTION

The Portable Object Detector for Visual Impairments consists of four main electronic parts including an ultrasonic sensor, a piezoelectric transducer, a power supply, and a microcontroller board. The spatial position of an obstacle can be measured using the ultrasonic sensor (see Fig.11.11). The ultrasonic sensor transmits a pulse and measures the traveling time of echoes that are reflected from the obstacle. This device receives advanced knowledge of a clear path for up to three meters in front of

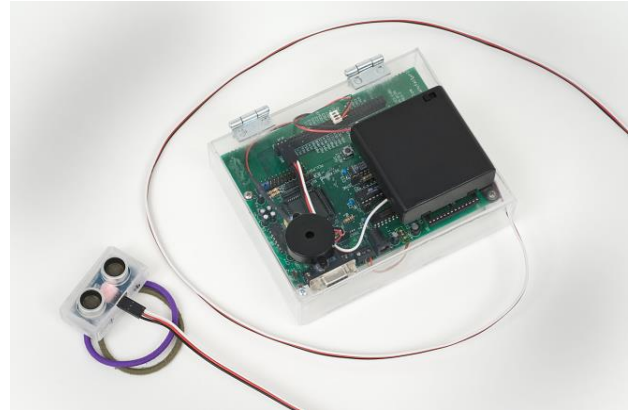


Fig. 11.10. Portable Object Detector for Visual Impairments.



Fig. 11.11. Ultrasonic Sensor.

sensor. Under the control of the microcontroller, the sensor emits a short 40 kHz burst. This burst travels through the air, hits an object and then bounces back to the sensor. The sensor provides an output pulse to the microcontroller board that will terminate when the echo is detected. The travel time of the pulse corresponds to the distance to the target object. The ultrasonic sensor is mounted in a palm size case with two bands attached to it. The user can wear the sensor around their hand. The connecting

cable which connects the ultrasonic sensor to the microcontroller board is 1.7 meters long. This connecting cable is capable of being placed inside of the shirt so as not be visible to bystanders (see Fig.11.12). The sensor is capable of detecting objects up to 3.3 meters away. However, the device is programmed to respond to the object from one centimeter up to three meters. The piezoelectric transducer is used to alert the user by producing an audible sound. The high pitch and low pitch

indicate close and far objects respectively. The microcontroller board is installed in an acrylic case which has the dimensions of 12.5 cm by 15 cm by three cm. The battery holder has an on or off switch and holds four AA batteries which can power the device for up to thirty hours of constant use. Temperature can have an effect on the speed of sound traveling through the air. However, for the typical use of this device, the effect is not significant.

The total cost of the prototype is \$140.



Fig. 11.12. Complete Portable Object Detector for Visual Impairments in Use.

EYEGASSES WITH ADJUSTABLE BRIDGE AND TEMPLE

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INTRODUCTION

These eyeglasses are designed for children with Down syndrome. The glasses are made to be adjustable at the temple length, bridge width and the lens angle. They are adjustable at three points to accommodate many users. The objective of the design is to be unobtrusive, safe, reliable, inexpensive, easy to use, and comfortable.

SUMMARY OF IMPACT

The design of these glasses will improve the vision, comfort and ease of use for any person that has trouble with common glasses, including children with Down syndrome. Many children with Down syndrome have an increased risk of eye and vision disorders. It is therefore beneficial to offer a pair of eyeglasses that can be easily adjusted so that they fit comfortably and function properly.

TECHNICAL DESCRIPTION

The design of the glasses is developed based on the realization of the inconvenience common eyeglasses are for children with Down syndrome. Research shows that these children with Down syndrome are prone to vision disorders and have slightly different facial anatomy compared to unaffected children. The distance between their face and ears is shorter, the ears tend to bend outward, and a smaller nose is usually observed.

The design of these eyeglasses is convenient for many users as it is adjustable at the length of the temple, lens angle and width of the bridge. The adjustable temple piece is taken from an existing pair of safety eyeglasses which has this feature. The lens of the eyeglasses can tilt and uses small clutches



Fig. 11.13. Full View of Eyeglasses.



Fig. 11.14. Adjusting the Tilt Angle.

that are attached to both the temples and the sides of the lenses to allow angle changes. The width adjustable bridge consists of a threaded middle piece. Two threaded rods are screwed into the middle piece creating the bridge. As the user turns the middle piece, the bridge width will extend and retract depending on the turned direction.



Fig. 11.15. Eyeglasses Being Used.

PORTABLE LOWER BODY STRETCHING STATION

Student Designers: Te Ngee Lim

Client: Te Ngee Lim

Faculty Designers: Kenneth L Peebles, William H Macy, Roger Teagarden

Supervising Professor: Dr. Joseph C. Mollendorf

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INTRODUCTION

Recovery from lower body injuries can require an extremely long time. Usually therapy involves a lot of patience and constant stretching exercises to heal. The Lower Body Stretching Station is designed to assist people with temporary lower body disabilities or injuries in performing various physical therapy stretching exercises at one station. The station can be accommodated by users of virtually any size. The technology can also be used by healthy person as a form of stretching or exercise. The goals of the stretching station are that users can complete a stretching workout in a station which is inexpensive, user-friendly, portable, efficient and durable.

SUMMARY OF IMPACT

Stretching exercises such as a hamstring stretch, hip stretch, split squatting, and others can be done using the stretching station. By using the station, the amount of time required to do the different stretching exercises is greatly reduced. The users also have better form while stretching on the stretching station. Moreover, the stretching station is portable. Parts can be easily stored in the pipes container and carried around.

TECHNICAL DESCRIPTION

The stretching station consists of two parts; the exercise foam mats and the stretching supporter. The foam mats are ½-inch thick interlocking gym mats. The interlock function increases the flexibility and portability of the stretching station. Two layers of thin fiberglass plates are added to the top and bottom of the foam mats to spread the stress along the fiberglass plate area. This increases the strength of the foam mats to prevent damage or failure at critical points. Three interlocking foam mats are used to form the base. These mats are joined together by resistance tubes to form a handle so that they can be transported. Another function of the resistance tubes is for the stretching exercises. Both



Fig. 11.16. Full View of the Assembled Design Prototype



Fig.11.17. View of Unassembled Design Prototype.

the foam mats and stretching support are attached using threaded flanges. Therefore, they can be removed when they are not needed.

The stretching support is made from one-inch and one and a quarter-inch PVC pipes. The material is selected because it is inexpensive compared to metal, lightweight, durable, and readily available. In addition, most of the pipes are joined using male and female threaded fittings so that they can be detached and stored in a long round container. The container is made out of a round paper box with an

adjustable length shoulder strap. The portability of the stretching station makes it perfect for transfer and storage. The stretching supporter is also height adjustable. It is created by sliding the one-inch pipe into the one and a quarter-inch pipe. Five inches of height range is provided. The adjustable pipes are locked using spring-loaded pins. It accommodates most individuals for stretching with the stretching station.

The top of the stretching supporter is used for balancing while doing either the hip or split squat stretching. It can also be used to do hamstring stretching where the back of the heel rests on the top of the pipe. The two grip handles, located in the middle of the stretching supporter, are then used to pull the leg toward the body. It works as if the user is trying to pull the back of the thigh toward the body using the hand. An extra layer of rubber insulation is added around the pipe to increase the comfort level while resting the heel or gripping the pipe.

The stretching supporter is adapted to the base to allow users to perform more stretching exercises. More adapters can be designed and added to increase the number of possible stretching exercises.

The total cost of this project is \$75.



Fig. 11.18. Picture of Stretching Exercise.



Fig. 11.19. Showing Portable Design.

ELECTRONIC LIFT CHAIR

Student Designer: Kah Xiung Low

Faculty Designers: Kenneth L Peebles, William H Macy, Roger Teagarden

Supervising Professor: Dr. Joseph C. Mollendorf

Laboratory Equipment Designer (Electronic): Roger Krupski

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INTRODUCTION

The Electronic Lift Chair is designed primarily for a person with a leg disability or the elderly who has difficulty standing up from a seated position. Typical chairs do not meet the height of the table. Such individuals have difficulty in adjusting the chair since they experience weakness in their legs and are unable to hold themselves in a sitting position while the chair is rising. Usually a chair is adjusted by hydraulics, but this is a poor solution for people who cannot lift themselves. Therefore, this design is based on electric power.

SUMMARY OF IMPACT

People with a disability may experience difficulty in reaching the height of the table due to the inconvenient design of a common chair. This device is specifically designed to solve the problem by providing a convenient height control mechanism for these individuals. The device is also fitted with wheels so it can be easily transported.

TECHNICAL DESCRIPTION

The device is made of three major parts including the base, the scissor jack and the seat. The base of the device includes wheels, a supporting frame and an adaptable base which attaches the scissor jack. The supporting frame and wheels are parts from the original purchased chair. The adapter is made from a $\frac{1}{4}$ inch steel plate which is machined to increase its stability, and is bolted to the base of the scissor jack.



Fig.11.20. Full View of the Device.



Fig. 11.21. View of Maximum Height of the Device.

The most challenging part of the design is the scissor jack which powers the whole device by a motor. A motor that fits the required torque and RPM based on calculations is included in the design. The threaded rod of the scissor jack is connected to the shaft of the motor by a coupling, which was machined from the machine shop. A set screw is placed to turn the threaded rod by the motor shaft. The motor is attached to the scissor jack by an L-bracket which is clamped by a two pipe clamp.

Another challenge of the project is to determine a suitable location for the limit switches. The purpose



Fig. 11.22. View of the Minimum Height of the Device.

of the limit switches is to open the circuit when the chair reaches its maximum and minimum height to avoid damage to the motor. The maximum height is six inches from the minimum point. The seat for the device is obtained from the original purchased office chair and is attached to the scissor jack by an adapter. The adapter is made by a U-bracket which enables the bracket to be bolted onto the top of the scissor jack.

The total cost of the project is \$218.99.

HEIGHT ADJUSTABLE HANDLE FOR A CANE

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INTRODUCTION

The Height Adjustable Handle for a Cane is designed to aid people in standing up from a seated position. Other similar devices do not allow for quick and easy use. With these other devices, adjusting the handle takes considerable time. Therefore, it takes a long time to get up from a seated position. The purpose of this project was to design a handle that can be used on a standard cane and be moved to any height on the shaft of the cane.

SUMMARY OF IMPACT

While using a standard cane people with disabilities struggle while trying to get up from a seated position. The various height range of the handle will allow the user to get up from a variety of seated heights. The user can get up with ease by adjusting the handle to any height quickly.

TECHNICAL DESCRIPTION

The Height Adjustable Handle for a Cane consists of a cane, an adjustable component from a pipe clamp, a handle, a handle grip, and two mounting bolts and nuts. The aluminum cane has a 7/8 inch outside diameter and a height of 43 inches. The adjustable component of the pipe clamp is used for locking the handle at a desired height. The part of the pipe clamp is made of a cast-iron housing, three hardened steel tabs, and a spring. The diameter of the cast iron housing is drilled to a diameter of 15/16 inches to fit the shaft of the cane. The diameters of the three tabs from the pipe clamp are cut to 15/16 inches. The handle of the cane is made from 1/2 inch galvanized steel pipe cut to a length of six inches. The mounting end is flattened using a vice and then mounted to the top surface of the adjustable component of a pipe clamp's housing with two bolts and nuts. A handle grip rests over the galvanized pipe for comfort. The adjustable handle is painted. The height adjustable handle locks into place with the use of the pipe clamp. Three tabs and a spring on the part use friction to hold it at the desired height on the cane. When the three tabs are



Fig. 11.23. Entire Device.



Fig.11.24. Height Adjustable Handle.

compressed, the handle slides freely up and down the shaft of the cane. When the tabs are released the handle locks into place. The handle's range of motion is from the top of the rubber bottom of the cane to where the handle of the cane starts. The handle can travel 34 inches and locks in at any position on the shaft of the cane. A person using the cane can adjust the handle by squeezing the tabs together and moving the handle to any location in its range of motion. This is easily accomplished from a seated position. Once the person is up they can adjust the handle again to the desired height for walking or rotate the handle off to the side to be out of the way.

The cost of the project is \$60.



Fig. 11.25. Cane in Use.

FOLDABLE AND SITTABLE FOREARM CRUTCHES

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INTRODUCTION

The foldable and sit-able forearm crutches are designed to replace standard forearm crutches. Standard forearm crutches are designed for people who have leg disabilities. The sole feature of this device is to assist people with leg disabilities and not only provide enhanced mobility but also offer an easier way to store and use the crutches like a seat when not needed for walking.

The crutches provide additional features from standard crutches as they are foldable and provide a seat. Both crutches can fold into three pieces. The crutches can also be joined with a piece of cloth to provide a seat.

SUMMARY OF IMPACT

This device allows the user to fold the crutches in order to easily store them. The fabric hooks on both crutches allow the user to sit down. These features assist with placement of the crutches inside a car or when carrying in a narrow place. With the addition of the fabric cloth, users can enjoy another attribute of the modified crutches, which is sitting between the crutches. Therefore, these tailored crutches will offer those with disabilities in their legs many solutions and added features over standard crutches.

TECHNICAL DESCRIPTION

This entire device consists of a pair of crutches, eight pieces of short aluminum plate, four pieces of long aluminum plate, eight pieces of medium aluminum plate, eight bolts, fourteen nuts, six hooks and a piece of fabric cloth. The crutch is cut into three bars and assembled with multiple pieces of aluminum plate and joined with bolts and nuts. The eight pieces of short, medium and long aluminum plates are bolted on the crutches and tightened with nuts. The center part of the crutch is attached with three



Fig. 11.26. Entire Device.



Fig.11.27. Device Configured for Sitting.

hooks and used to hold the fabric cloth. The eight pieces of medium aluminum plate add strength. The four pieces of long aluminum plate act as a connector for holding the two crutches together and also strengthen the supporting point. The eight pieces of short aluminum plate provide joints along the crutch that was cut into three pieces which allow for folding.

The total cost of this device is \$40, excluding the pair of crutches which was donated by Sheridan Surgical.



Fig. 11.28. Device in use as crutches

WHEELCHAIR SHOPPER

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INTRODUCTION

The Wheelchair Shopper is designed to assist wheelchair users in a supermarket environment. A typical power driven supermarkets cart allows a person to move through the store, but limits them to only the lower shelves. This product allows an individual to shop unaccompanied without the limitation of not being able to reach the top shelf. Also, after the desired item is selected, there is increased storage space so that all desired items may be transported at once.

SUMMARY OF IMPACT

This device enables wheelchair users to have more independence while shopping. Also, supermarkets may observe an increase in shoppers, due to the increased convenience and opportunity that this product provides for a wider range of people.

TECHNICAL DESCRIPTION

This device consists of two main components that can be attached to any standard wheelchair. These components are a pneumatic lift system and a storage rack system.

The pneumatic lift system works in the same way as one would operate a barber chair. There is a foot operated pump and release, for raising and lowering the chair, respectively. This system is attached to the underside of the seat and has the capability of lifting the whole wheelchair and storage system off the ground. The total lift that can be achieved with this chair is about eight to nine inches.

This system is constructed using an old salon chair. The lift is attached to $\frac{3}{4}$ " plywood, which in turn is attached to the seat of the chair with $\frac{1}{4}$ " bolts. The size of the base of the salon chair is extensively modified to fit between the wheels.



Fig. 11.29. Wheelchair Shopper.



Fig. 11.30. Close up of Pneumatic Lift System.



Fig. 11.31. Fully Raised Lift System.

This cast iron base is cut down on almost all sides, but still provides good support and balance when the lift is extended to its maximum height. Cutting down the thick cast iron base also helps in reducing the overall weight of the device. Since the base accounts for the majority of the weight, this enhances the mobility of the device.

Another modification to the base is the addition of metal rods, which extend through vertical supports on the wheelchair. They prevent the base from rotating while the chair is moving. This also increases the overall rigidity of the device.

The base is mounted with slider disks to reduce the effort required to move the chair. These disks also help ensure that the base does not damage the floor.

The second system, the storage system, is used for placing items while shopping. A shopping basket can easily be attached to the racks, as well as numerous bags, through the use of sliding hooks.

This system is constructed using standard $\frac{1}{2}$ " PVC pipe and various fittings. $\frac{3}{4}$ " Tees are used to slide along the $\frac{1}{2}$ " track with minimal resistance, even with bags attached. The rack is supported with cross bracing PVC. The product was tested to about 50 pounds of force successfully.

The cost for this project is \$50.

Aside from the applications that this product can be applied to in a supermarket, this wheelchair may be used in a home without the storage system. This would allow for its users to reach higher cabinets and drawers that would normally not be accessible. It can be used for cleaning purposes as well. Overall, it will offer wheelchair users more independence.

FOLD-AWAY PORTABLE ACCESS RAMP

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INTRODUCTION

For people with limited mobility, stairs can prove to be a challenge. The goal of the Fold-Away Portable Access Ramp is to create an easily-accessible ramp that can be used almost anywhere with minimal setup time. Traditional wheel chair ramps are usually permanent constructions and are not always available. The Fold-Away Portable Access Ramp can be used anywhere, giving users access to places they may not have been able to previously go.

SUMMARY OF IMPACT

This device will make it convenient for someone who needs to roll an object, such as a wheelchair, hand-truck, or cart, up a set of stairs where there is no permanent ramp available. The folding design allows for convenient storage, occupying a minimal amount of space.

Future designs could make use of lighter composite materials which would make the ramp more light weight. This would allow the ramp to be carried on the back of a wheel chair.

TECHNICAL DESCRIPTION

The device is composed of five 2 x 1 foot rectangular segments. Each segment is made of four pieces of 1 x 1 inch aluminum square tubing, which are welded together to form a frame.

Inside the frame there are five pieces of 2 x ¾ x 11 inch pine that support the plywood ramp surface. The ramp surface is made from ¼ inch plywood that is fastened to the five pieces of pine with wood screws. The surface is painted with a textured paint to prevent slipping on the ramp.

Hinges are placed between each adjoining ramp segment on opposite sides. This allows the ramp to fold like an accordion. The ramp utilizes two sliding lock mechanisms between each segment of the ramp to lock the ramp in its unfolded position. The locking mechanisms are made of ¾ x ¾ x 6 inch

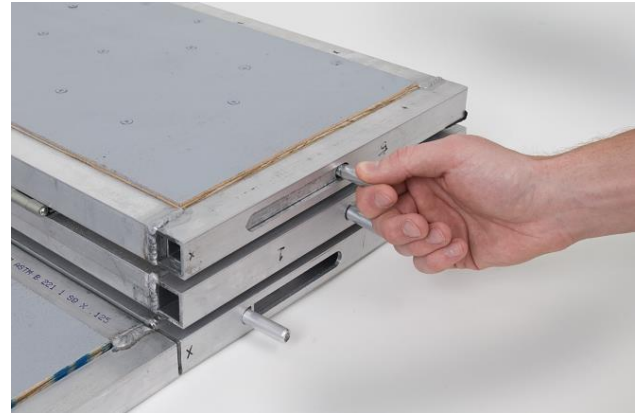


Fig. 11.32. Locking Mechanism Collapsed.

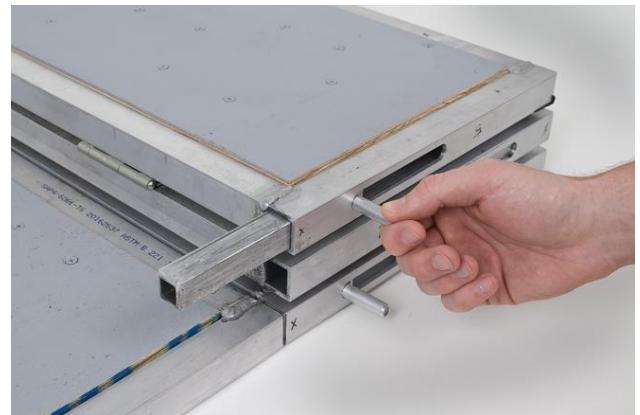


Fig. 11.33. Locking Mechanism Extended.

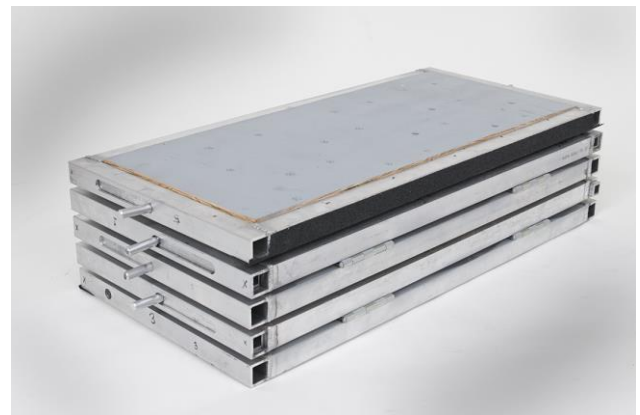


Fig. 11.34. Folded Ramp.

aluminum square tubing with an aluminum rod for a hand grip. The locking mechanisms are located coaxially in the frame pieces and in a slot that is milled in the rectangular frame.

The recommended improvements of this project are to make use of lighter materials such as plastic, aluminum, or a composite material for the ramp

surface, to reduce weight. In addition, the sliding lock mechanisms could be made from steel to allow for easy sliding inside the aluminum square tube.

The total cost of this project is \$131.



Fig. 11.35. Ramp in Use.

EXERCISE MOBILE

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Faculty Designers: Gary Olson, Kenneth Peebles, Roger Teagarden
Other Designers: Russell Boedo
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INTRODUCTION

The goal of the Exercise Mobile is to allow a person with limited leg mobility to experience the sensation of running. Traditional wheelchairs can be used for exercise but the users are restricted to a sitting position while moving the wheelchair. The Exercise Mobile gives a person a great upper body and cardiovascular workout along with the feeling of running or walking.

SUMMARY OF IMPACT

The Exercise Mobile provides a means of upper body and cardiovascular workout while giving people with limited or no leg mobility the feeling of running. The person is assisted into the machine and suspended from the frame. Their legs are strapped in the foot holders, which hold their legs in place while they drive the machine forward. The Exercise Mobile can not only improve and maintain an individual's physical health, but it can also enhance a person's mental well-being. The exercise simulates what it would be like to have full leg mobility while getting an upper-body and cardio workout. This could help the physical and mental health of the users, and it also has the potential to give the person a longer and happier life. The gearing system on the Exercise Mobile allows for one speed output.

The device is a slow moving prototype. In actual production, the Exercise Mobile would have a range of gears so that the person can travel at higher speeds if desired. To slow down the machine the user uses a brake handle on the left arm of the machine that is connected to a brake band and drum. This allows the user to slow down or stop the Exercise Mobile without trouble.



Fig. 11.36. Exercise Mobile.

TECHNICAL DESCRIPTION

The Exercise Mobile is comprised of four main components including the chassis, brake system, the suspension system, and the drive system. The frame of the chassis is made from pieces of 2x6 lumber. In actual production, aluminum would be best because it is lightweight and doesn't rust.

The rear and drive wheels are 10 inches diameter, while the front of the chassis is equipped with three inch casters for stability. The rear wheels each have a collar that connects the wheels to the rear axle. The rear axle is connected to the chassis by two self-aligning pillow bearings. The rear axle is also where the brake system is located. The brake system consists of a brake band and drum. The brake band is connected to a brake line, which is connected to a brake handle. When the user presses down on the handle it compresses the band on the drum and slows down the machine.

The chassis is also connected to the suspension system, which consists of three main components including a safety harness, a cage, and adjustable chains. The safety harness is connected to the cage by the adjustable chains. Adjustable chains allow people of different sizes to easily use the machine. The cage of the Exercise Mobile is made up of a two inch exhaust pipe. The user must be assisted into the device.

The main system of the Exercise Mobile is the drive system. It consists of an old exercise machine, a set of gears, and a standard bike chain. The modified exercise machine is called the Fitness Flyer. It allows the user to get a leg and upper body workout in a stationary position. It is modified so it can be connected to the chassis with ease. The user's feet are strapped onto the footrests of the Fitness Flyer. Their legs move back and forth when driving forward.

In order to keep the machine moving forward at all times 16 toothed free wheel sprockets are used and connected to the gearbox. This allows the user to push the handles forward and backwards without resistance when driving the machine. There is a sprocket connected to each side by pillow bearings. They connect the free wheel sprockets and drive sprockets on the drive wheels. They also give a higher gear ratio which allows the machine to move at a fast pace. The drive sprockets are directly connected to the drive wheels. The drive system is



Fig. 11.37. Exercise Mobile in Use.

also used to turn. By pumping one arm only the machine can be turned like a Bobcat turns. One wheel or side stays stationary while the other drives, causing the machine to rotate to the users desire.

This machine is revolutionary as it allows the user to drive the vehicle forward while getting an upper body workout, cardiovascular workout, and the sensation of running.

The total cost of the project is \$193. The Exercise Mobile's weight, without the user, is 86 pounds which may be reduced if a lighter material is used.

UNIVERSAL RAILING RUNNER

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INTRODUCTION

The objective of this project is to design and build a device capable of carrying a moderate payload up or down a staircase. It is intended for a person with a disability who may find it unsafe or impossible to accomplish without aid. The resulting design, named the Universal Railing Runner, is comprised of a compact electrically driven runner and a specially designed railing. The railing and the runner fit together intricately to provide a safe, precise, stable, and smooth railing aid. A small motor powers a drive-wheel that mounts on the top of the runner. It is designed to carry up to 25 pounds. Additional assistance and safety is also provided to the users by a mounted arm protruding away from the handrail, which allows for easier gripping. The design allows for the universal railing runner to be mounted on any staircase. Therefore it is extremely versatile and provides benefits for a wide range of customers.

SUMMARY OF IMPACT

This product will be very advantageous for customers who have difficulty climbing staircases while carrying their belongings. Example payloads include laundry, groceries, and packages. The design allows the user to grasp to the runner while the belongings are carried alongside them. The universal railing runner makes it extremely easy for the user to move objects up and down the staircase because it requires minimal effort by the user. Also, by allowing a grip for the user to grab, support is provided for the user as they move with the runner, providing a safe and easy way to go up and down the stairs.

TECHNICAL DESCRIPTION

The runner resembles a U-shaped bracket that envelopes the top and both side surfaces of the custom railing. Eight bearings give the runner the necessary moment and thrust support for carrying a payload suspended toward the center of the staircase. There are four bearings at either end,



Fig. 11.38. Four Bearings.

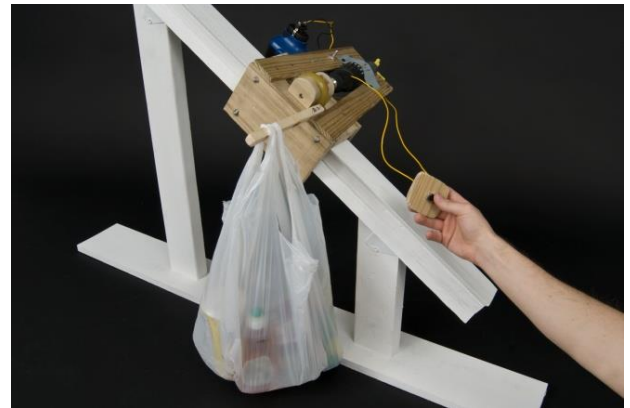


Fig. 11.39. Universal Railing Runner in Use.

mounted to the runner that rides along the precisely cut surfaces of the railing. The railing cross-section looks something like an X shape. The four bearings at either end of the runner make contact with the 45 degree angle surfaces on both sides of the railing. The X-shaped cross-section with four bearings gives complete moment and thrust support to the runner in every direction.

The motor-house assembly is mounted to the side of the runner. It provides space for a directional switch and a power button. The user can switch between forward and reverse, as well as turn the motor on and off as they move up the staircase with the payload. There is also a grip mounted to the runner

for support as the user moves with the runner. The motor housing is constructed to prevent the motor from spinning inside the housing to eliminate the risk of not providing any drive to the wheel. The support pins and drive shaft are very intricately manufactured.

The railing dimensions need to be precise enough to match the forty-five degree angle of the pins. This provides complete moment counteraction in order to avoid slip between the runner and the railing. This

allows for the most surface contact between the pins and the railing. It was understood that depending on the slope that existed between the bearings and the railing, more or less weight would be able to be carried. By aligning the pins and railing perfectly, we were able to move twenty-five pounds up the staircase.

The total cost of the Universal Railing Runner is \$101.

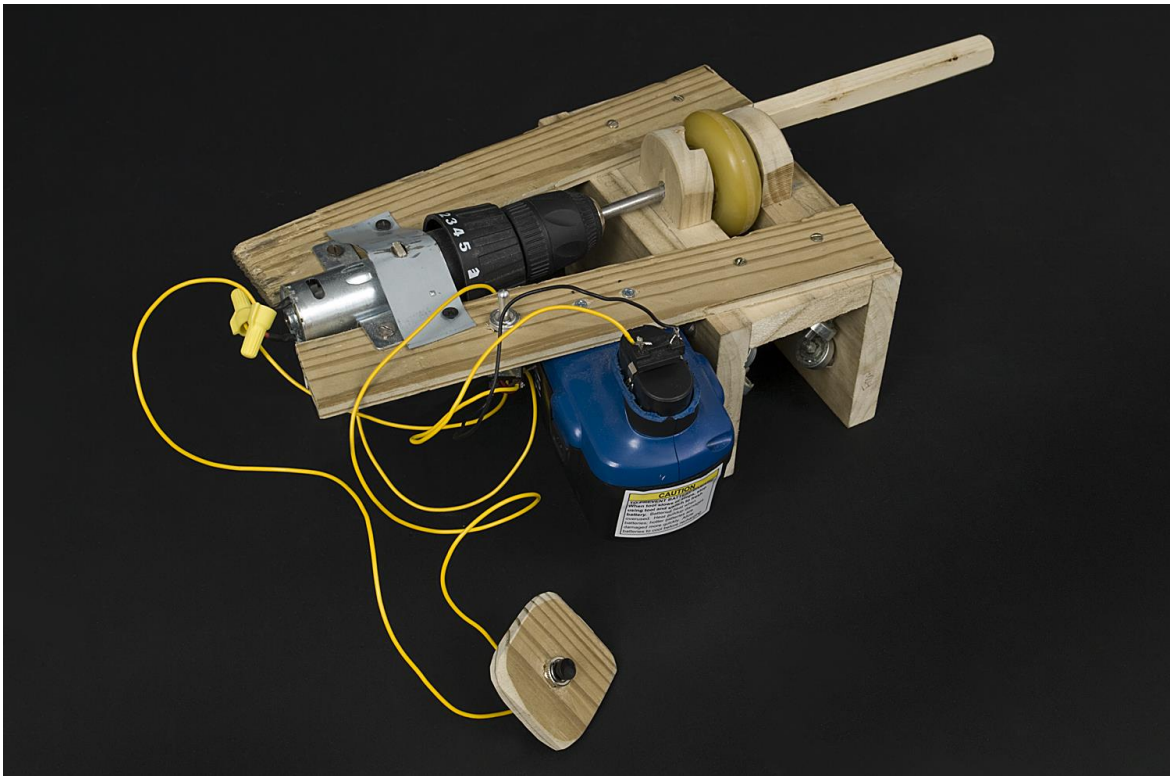


Fig. 11.40. Railing Runner Device.

THERMALLY CONDITIONED THERAPEUTIC KNEE BRACE

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INTRODUCTION

The goal of the Thermally Conditioned Therapeutic Knee Brace is to provide a user with limited dexterity or motor functions the means to effectively rehabilitate a knee injury without risking further harm to the knee. By combining the rehabilitative functions of thermo-electric heating and cooling with the protection and support of a knee brace, the user is able to rehabilitate an injury without ever having to remove the protection provided by a knee brace or support. The goal of the device is to effectively integrate heating and cooling elements into a knee brace without compromising support.

SUMMARY OF IMPACT

The convenience of this device will benefit not only those with limited dexterity, but any patient recovering from a knee injury. By combining rehabilitative functions with knee support, the healing process is not only easier, but faster. The ability of this device to ice and then heat the knee in rapid sequences allows inflammation and swelling to be easily managed, thereby promoting faster, more complete healing.

TECHNICAL DESCRIPTION

The knee brace consists of two main components; the heating and cooling mechanism and the knee brace mechanism. The heating and cooling mechanism, when described at the point of skin contact, is a thermally conductive gel-filled pack comprised of polyethylene that surrounds the knee. The motion of the user provides convective flow in the gel that helps to maintain a constant temperature distribution throughout the knee brace. Mounted to the outside of the gel pack are six thermo-electric coolers. These components, known as Peltier coolers, function on the principle of the Peltier effect. This phenomenon occurs when a thermo-electric device, supplied with a voltage, creates a temperature



Fig. 11.41. Knee Brace on User.

difference on either side of the component. The thermo-electric coolers used are mounted with the cold side down so as to remove heat from the knee when a voltage is applied. With a reversal of the polarity of the coolers, the heat flow switches direction, supplying the knee with heat. In this manner, the knee can be both heated and cooled using the same mechanism with only a reversal in polarity required. However, in order to remove heat to cool the injured joint, heat must be dissipated

from the hot side of the thermoelectric units. This requires a heat sink and forced air convection. Therefore, heat sinks are mounted to each thermoelectric cooler and placed inside a length of square stock aluminum in order to direct air flow. Opposite the heat sink, a fan is incorporated to move air over the thermo-electric cooler at high velocity. This removes enough heat to cool the injured knee and to prevent the thermo-electric units from overheating.

Both the thermo-electric coolers and fans operate off of a 12 volt DC current, supplied by an outside power source. However, the possibility of powering the unit by battery is attainable as the current draws could be supplied by a variety of battery power sources. By powering the knee brace using batteries, the thermally conditioned therapeutic knee brace would be more portable. This would allow the user to wear it at all times, providing more convenience.

The knee brace component of the design incorporates many of the characteristics of commercially available knee braces. These include mechanical bracing and stiffening to support the knee to prevent further injury to the joint. This is accomplished by using materials like neoprene and elastic to provide comfort and support. The features unique to this knee brace are the elastic strapping to keep the thermo-electric coolers in constant contact with the user.

This enables an increase in the amount of heat removed or supplied, and increases airflow passages



Fig. 11.42. Fans for Brace.

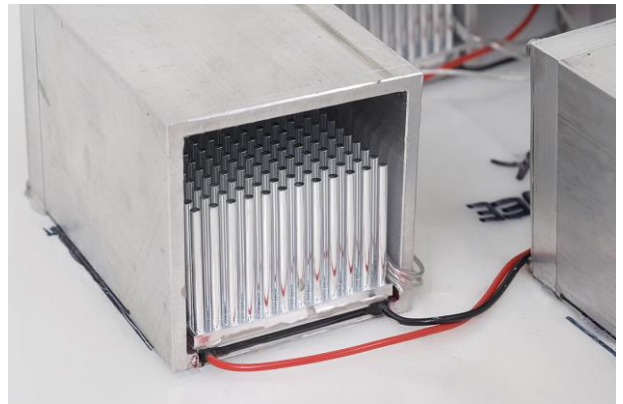


Fig. 11.43. Peltier Coolers.

to allow excess heat to be easily and efficiently dissipated.

The total cost of this project is \$250.

GOLF BALL TEE-UP AND PICK-UP AID

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INTRODUCTION

The Golf Ball Tee-Up and Pick-Up Aid is a device that uses a two-step process to pick up a golf ball off the ground and then tee it up on a golf tee. The device is targeted towards individuals who have back pain or disabilities.

SUMMARY OF IMPACT

Golf is a very popular game with an estimated 50 to 60 million players in the country. The game is enjoyable for many different people with varying skill levels and physical capabilities. Some individuals who lack the ability to bend over due to back pain or disability would benefit from a device that helps them tee up and pick up a ball without bending over. The goal of the design is to meet the needs for a golfer with a back disability. This device allows more people with disabilities to stay active and participate in golf.

TECHNICAL DESCRIPTION

There are two main components to this device. The first component is the ball picker mechanism. The design of this attachment is in the shape of a C with a circular profile. The component has a slightly smaller diameter than the diameter of a U.S. standard golf ball of 1.68 inches. This device is used by either pressing down on the ball which then "pops" the ball up through the C shaped device or by scooping the ball. The material used to make this attachment is polycarbonate, due to its flexible nature. Other plastics may also be acceptable for full-scale production.

The second component of this device is the tee-up attachment. The attachment's shape has a slanted slot that allows for the fitting of different diameter tees. However, most golf tees have a shaft diameter of approximately 1/8". The user takes a golf tee and places the thicker portion of the tee against the bottom of the shaft. Then by pushing the tee into the slanted tee holder, the tee will lock in place. When



Fig. 11.44. Ball Picker Attachment.

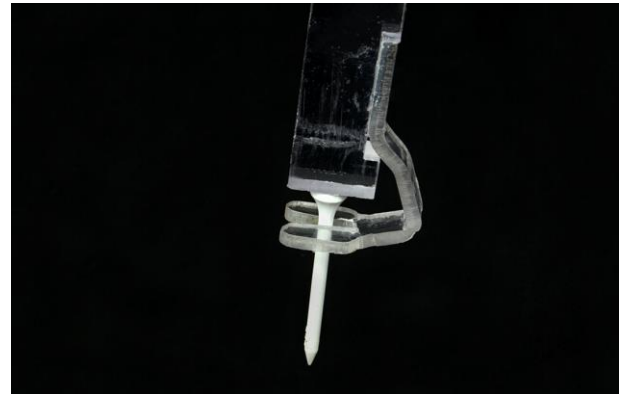


Fig. 11.45. Tee-Up Attachment.

the device secures the tee, the user holds the shaft vertically, perpendicular to the ground, and press the shaft downward to insert the tee in the ground. When the tee is in the ground, the user can then remove the tee from the device by simply moving it horizontally. The friction between the tee and the ground will hold the tee in place.

The tee-up procedure is a two-step process:

- 1) Lock the tee into place by sliding the tee into the "wedge" and applying pressure inward and against the butt of the shaft. The user then inserts the tee into the ground by thrusting the shaft downward.

2) Use the ball picker to “pop” the ball into place by applying pressure downward on the ball. The ball will rest on top of the picker and then is placed on top of tee.

Both attachments are made from a polycarbonate sheet of 3/16” thickness. The different designs of the attachments are drawn and analyzed on CAD software and then machined using a band saw. The shaft of the device is 41” long and 1/2” by one inch. The widths of both attachments are also 1/2” in order

to make a perfect fit with the side of the shaft. The shaft is also made from polycarbonate.

The straight ends of the attachments are bent using a heat gun. Methods that are more precise may be used in automated manufacturing. The shaft is milled to 3/16” and attached using acrylic solvent for a strong flush fit. The weight of the device is one lb. and fits nicely in a golf bag.

The total cost of the project is \$32.25



Fig. 11.46. Ball Tee-Up Demonstration.

MECHANICAL COAT RACK

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INTRODUCTION

The goal of the Mechanical Coat Rack is to give a user with limited reach the ability to easily access items within the closet. Standard closets are built with the clothing rack and shelving at a height that is well within reach for someone who is standing. However, this can be strenuous for different groups of people, including wheelchair users and children. Permanent bars and shelves built at a lower height with the intention of providing an easier reach presents the problem of poor utilization of vertical space. This device addresses both issues by allowing the clothing rack and shelving to be lowered to the user's desired height. Once in the desired location, the clothing rack will rotate like a carousel. These two combined features allow for a much more efficient use of closet space.

SUMMARY OF IMPACT

This device can reduce time and aggravation for a person with a height disadvantage. The idea of the device is to create a "One-Size Fits-All" closet, which can be used by anyone. This device can be equally suitable for many different users with varying heights and levels of ability. This ultimately gives the user full control of desired height levels of the shelving and clothing.

TECHNICAL DESCRIPTION

There are two isolated systems within the device. The first is the vertical motion of the clothing rack and the second is the carousel rotation of the clothing. A motor turns the drive shaft, which is connected to a gear. The gear is meshed with a second gear that is welded to a #35 martin sprocket and permanently attached to a $\frac{1}{2}$ " threaded rod. A #35 chain runs across the closet and connects to a second thread rod assembly. Due to the fact that the distance between the two rods is a very long, an idler sprocket is added at the midway point to create the proper tension on the chain. A $\frac{1}{2}$ " nut and plate assembly is threaded onto the rod and acts as a mover. When the motor is turned on, the threaded



Fig. 11.47. Mechanical Coat Rack.

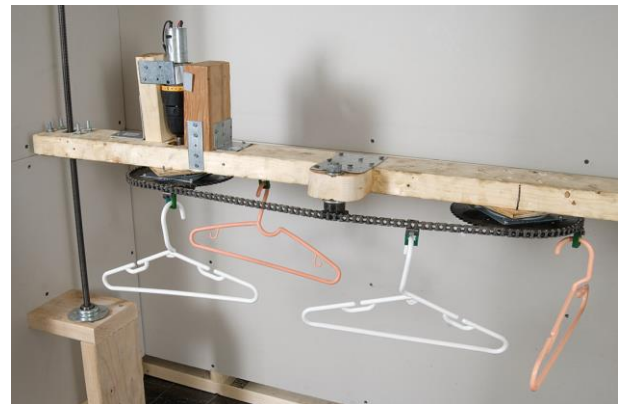


Fig. 11.48. Rack at Lower Accessible Height.

rods spin, which allows the nut and plate assembly to move vertically up or down, depending on the motor direction. The threaded rods are mounted in ball bearings to reduce friction and to provide stability. The motor is wired to a momentary switch to prevent the device from constantly running. In addition, there is a three-position switch that gives the motor the "Reverse-Lock-Forward" position.

The second system is the carousel rotation feature. A second motor drive shaft is set-screwed to a $\frac{1}{2}$ " sprocket hub. The hub is permanently welded to the 6" diameter #35 sprocket. Once again, an idler sprocket is added to create the proper tension on the

chain. There are special chain linkages added into the chain that allow for mounting hangers onto the carousel. This motor is wired to an "On-Off" switch,

which will simply allow for the rotation of the carousel in one direction.



Fig. 11.49. Coat Rack at Regular Position in Prototype Closet (Not actual Height).

INTERFACE FOR ADAPTIVE AND RETROFIT CABINETS

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INTRODUCTION

The focus and objective of this project is to design and build kitchen cabinets that have adjustable heights in order to become more accessible and convenient for anyone who has trouble reaching tall objects. Tens of thousands of cabinets are installed every year in kitchens and bathrooms, sometimes for tens of thousands of dollars. Our system allows people of every height to have access to all items they store without the clutter of step stools or extension grabbers.

SUMMARY OF IMPACT

Our device involves a motorized two-dimensional pivoting cabinet system that attaches to many types of preinstalled cabinets, and allows a simple one-touch user interface for easy accessibility. The cabinet may be lowered to a desired height with the touch of a switch, and remain there until the user wishes to raise the cabinet back into its resting place.

The factor of safety has been addressed in material choices including the four square tube extension arms, u-joints, and brackets, which are all made of 1/8" steel. The full scale model will also have a cable run to the motor so customers will not have to fear the system being weak, under built, or capable of falling. This is a low cost, easy to use product that will allow all users an easier, safer way of getting items from out of reach places in kitchen cabinets.

TECHNICAL DESCRIPTION

The cabinetry system is made up of three main components including a cabinet, pulley system, and motor device. The cabinet that is used for the model is a half scale representation of a cabinet used in a kitchen. The cabinet is what holds the contents. It utilizes a shelf which effectively doubles the surface to store its contents. The dimensions of our half scale model are 12"x15"x6". The material used to construct the cabinet is half inch plywood, with half



Fig. 11.50. Motor to Move Cabinet.

inch gussets for support in the corners. The half inch plywood is also used to mock up a wall surface for convenience. In normal operation, the cabinet device would be mounted securely to a wall.

The pulley system is comprised of four steel square tubes used as arms to raise and lower the cabinet into position. Four tubes are used to ensure that there is no binding and that the cabinet had sufficient support when in operation. The square steel is connected to the wall and cabinet with U-



Fig. 11.51. Full Cabinet.

brackets. This optimizes the range of motion of operation which allows the cabinet to mount flush to the wall when in the upper most position. The cord which connects to the cabinet is looped around the “wall” and connected to the motor. When the motor is activated the cord begins to unravel or ravel on a shaft depending on whether the device is being lowered or raised.

For ease of fabrication, the motor is simply a battery operated power drill. The use of a power drill provides an economic package including the motor, switch, and power to operate the device. It also has the ability to easily connect a shaft. The power drill is mounted to the back of the wall. Shaft and



Fig. 11.52. Raised Cabinet.

support are also mounted to the wall in a fashion that securely fastens the shaft in a horizontal position. The drill has the ability to reverse direction which provides the easy vertical function of the cabinet.

In normal production, the cabinet would be a full size scale similar to what the customer has in their kitchen. The system has the ability to be retrofitted in the existing cabinetry so the customer does not need to buy new cabinets. An AC motor system would also be a bit more complex. The switch would be placed into a position with easy access and plugged into a wall socket.

The total cost of the project is \$60.

SEAT ATTACHMENT FOR WALKER

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INTRODUCTION

This purpose of this project is to provide assistance to individuals with disabilities through use of a walker. There are also users who are in varying types of rehabilitation phases and may need to rest after a tiring workout that would also benefit from this device. The goal is to provide users with a walker to assist in walking, and also a seat for whenever they may require one. The design must be safe and easy to use for users with restricted mobility.

SUMMARY OF IMPACT

The seat attachment for a walker allows the user to sit on the walker itself without having to carry a chair or portable seat. The seat is designed to attach onto a walker without changing the structure of the walker. Another goal of this feature is to protect the original strength of the walker in order to maximize safety for the user. Existing users of walkers do not need to purchase a new walker that comes with an attached seat, like many that are being offered on the market. This design can be used on most standard walkers, and is less expensive than other similar solutions. Users are only required to complete one step to sit and two steps to walk with the walker.

TECHNICAL DESCRIPTION

The design consists of four metal holders, four sets of bolts and nuts, and two lightweight aluminum tubes. A seat is hand sewn and made from heavy duty fabric.

The metal holder is made from an aluminum 6061-T6 square bar measuring 1 x 1.4 x 2 inch. The square bar is cut, drilled, and machined into a U-clamp like metal holder. It is used to clamp the aluminum tubes onto the four corners of the walker. A total of four metal holders are placed on the corners of the walker. The aluminum tubes that are used to hold the left and right sides of the seat are locked horizontally by the metal holders on the aluminum



Fig. 11.53. Walker with Seat Attachment.

tube's ends. The tube has two through holes with $\frac{1}{4}$ in. diameter at both ends. They are centered and 0.4 in. away from both the ends. The locking mechanism is created by inserting a $\frac{1}{4} \times \frac{9}{5}$ in. bolt through the metal holder and aluminum tube. The bolt is held in position by a washer and an acorn nut. The aluminum tubes are 12.5 in. long and have one inch outer diameter. The wall thickness is measured at 0.065 in. to give better strength.

According to ASTM B221, the 6061-T6 metal holder has 95 Brinell hardness, 45 ultimate KSI, modulus of



Fig. 11.54. Walker Seat in Use.

elasticity at 10,000 KSI and ultimate shear strength at 30 KSI.

The seat is made from canvas material. It measures 28 x 11 inches before sewing. After sewing, it measures 20 x 11 inch where the eight inches are distributed equally on both sides. This creates two through-holes to allow aluminum tube insertion. Two sticky ties are sewed measuring 23 in. long. Each sticky tie is inserted into the seat's hole. When the seat is in use, the position is locked by using the sticky ties that tie on the walker's tubes.



Fig. 11.55. Seat in Position for Walker Use.

The seat can support up to 190 pound applied load. For an increase in weight support, the seat material needs to be stronger. However, the weaker material is used because it is affordable and easier to process using hand sewing. A stronger fabric requires machine sewing and can be seen on most portable chairs or director's chair. Machine sewing also increases efficiency for mass production purpose.

The total cost of this project is \$59.00.

PORTABLE STEP-STOOL

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INTRODUCTION

The purpose of this project is to provide a means for any person with limited ability to reach objects at tall heights. A simple stool to slightly increase height would serve to remedy most of these difficulties. This portable step stool will allow individuals, who need a bit of extra height, a portable and non-obstructive stool. Acting as a cane when not in use, it is simple to carry and store, and does not draw unnecessary attention to its user.

SUMMARY OF IMPACT

The device provides greater independence for any person with a height disadvantage. No longer will help be needed to reach simple objects, like a clothing rack or kitchen cabinet. The slim, lightweight design will not hinder the normal routine and can easily be brought along to work or a store to compliment daily tasks. Typical collapsible step stools collapse flat, into a bulky, "crushed box" shape. The aesthetically pleasant form of the cane will appeal to potential customers not wishing to draw undue attention, as it is not immediately clear that the device also serves as a step stool. The quick conversion between cane and step stool can be accomplished in mere seconds, and the reversal requires nothing more than grasping the handle and picking it up.

TECHNICAL DESCRIPTION

The Portable Step-Stool is 26 $\frac{3}{4}$ " tall when being used as a cane, and 14" high when being used as a step stool. The legs are made from $\frac{5}{8}$ " and $\frac{11}{16}$ " steel tubing and $\frac{5}{8}$ " aluminum rod, while 1" aluminum plate is used in the end supports, and $\frac{1}{2}$ " aluminum plate is used for the step and handle. The fasteners consist of 20 rounded head 8-32 screws, four sunken 8-32 screws, and on $\frac{1}{4}$ -20 sunken screw. Permanent fastening is accomplished via eight spring pins located in the center joints. Also, 20 nuts are employed to hold the 8-32 screws, with an additional four used to stabilize the legs in the stool



Fig. 11.56. Device as a Cane.



Fig. 11.57. Device in Stool Form.

configuration. A modified rubber cane tip is employed at the base, to make contact with the floor without slipping.

When being employed as a cane, the user simply needs to grasp the handle and push the end into the ground. To convert to a step stool, the cane must be turned upside down. This will cause the metal sleeves to drop, exposing the center joints. Then, the user must guide the legs in folding outward, into a pyramid shape. Holding the stool in this configuration, it needs to be flipped back over and

placed on the ground. Then the user may step onto the stool, either with or without the use of a stabilizer (such as a desktop, counter, or wall). To return to the cane configuration, the user picks up the stool by the handle, and the metal sleeves fall back into place, locking the center joints against folding.

This device is constructed using several donated and scrap materials. As a result, the final cost was \$10.00.



Fig. 11.58. Device in Use as a Stool.

CRANK-DOWN CLOSET COAT RACK INSERT

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INTRODUCTION

People who use wheelchairs may experience limited reach due to the fixed height of their wheelchairs. The objective of this project is to design and build a coat rack which could be rotatable 90 degrees and inserted into a closet. The purpose for the Crank-down Closet Coat Rack Insert is to lower the rack to a position where it is easier for wheelchair bound people to hang their clothes in a closet. This device can be operated with one hand by two installed bicycle crank sets. The crank sets may be built for either right or left hand use.

SUMMARY OF IMPACT

The Crank-Down Closet Coat Rack Insert is easy to install. It is hand-operated, which saves electrical energy for home use. It assists wheelchair users who live independently. The cost for building this device is inexpensive, making it an affordable solution for a wide variety of people.

TECHNICAL DESCRIPTION

The device is comprised of six main components including a 21.5" x 28" x 16" wooden frame, a U shaped rack, a removable handle bar, two 4.5" long springs, two different dimension crank sets and a roller chain. The two different dimension crank sets each have their own handle, and the crank sets are

connected by a roller chain. To operate, the handle of the small crank set is rotated, which is followed by the rotation of the larger crank set.

The U shaped rack is made by welding three different lengths of aluminum pipe, which have a one inch outer diameter and an 0.865" inner diameter. Cranking down of the small crank set brings the rack down to the user. 1.375" outer diameter roller bearings are inserted into the holes drilled behind the crank sets to reduce friction.

The removable handle bar is another feature of this device. It is covered by a leather cover to reduce slippage. The removable handle bar is stored in the aluminum box located in the right bottom corner of the wooden frame. The removable handle bar can screw into the handle of the small crank set, making the crank down movement easier to operate.

Two springs are connected between the right side of the U shaped rack and the wooden frame. The spring force helps the rack to return and stay at its original position if the hanging clothes are too heavy. The prototype of Crank-Down Closet Coat Rack Insert can support approximately 25 to 30 pounds of clothes. The total weight of this device is approximately 15 pounds, not including the weight of the wooden frame, and total cost is \$74.



Fig. 11.59. Crank-Down Insert Device.



Fig. 11.60. Device Lowered.

HEIGHT AND TILT ADJUSTABLE MOBILE TABLE

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INTRODUCTION

The Height & Tilt Adjustable Mobile Table enables people who use a wheelchair the ability to use a table anywhere they want inside a house. Unlike most movable tables, this mobile table not only can be used for conventional purposes such as eating and writing, but can also be tilted at different angles for ease of reading and drawing. In addition, the height adjustable feature can easily transform this table into an over-bed table not only for persons with disabilities but for seniors as well.

SUMMARY OF IMPACT

This table is height adjustable, which makes it compatible with people of all sizes as well as different models of wheelchairs. The table is also tilt adjustable, which provides users with the most comfortable angle to read and draw. There is a detachable holder, which is stored under the table when not in use which can be attached to the table top to prevent books or drawing pads from slipping off the table top when the table is tilted. Since the table is movable, it has the tendency to move away from users in wheelchairs when pressure is applied; thus the two bungee cords at both ends of the table are intended to hook on the two armrests of a wheelchair to counteract this movement.

TECHNICAL DESCRIPTION

The device is comprised of three main components including the base, the vertical support, and the table top. Each main component was built separately and assembled at the end for design simplicity and ease of shipment.

The base is constructed of three sections of 2" by 4" lumber, two 20" long and one of 34" long. Connections between sections are made using several metal brackets which also strengthen the critical locations of the base. Four casters are mounted with screws to each corner of the base to provide mobility for the table.



Fig. 11.61. Table at Lowest Position.



Fig. 11.62. Table at Its Tallest Position.

The vertical support is composed of two sections of aluminum pipes, each 22" long. The lower post has an outer diameter of 1.5" and an inner diameter of 1.25". The upper post has an outer diameter of 1.3". In order to implement the pin-and-hole insert mechanism which provides the height adjusting feature, the upper post was turned down using a lathe to an outer diameter of 1.248". Ten 0.25" holes were drilled on the upper post with 2" spacing and one 0.25" slot is grooved on the lower post. The height of the table is adjusted by inserting a 0.25" pin into the hole that gives the desired height and the slot of the lower post holds the table in the particular height by securing the pin. This design allows a height adjustment from 24" to 42". The lower post is welded to a 3.5" by 4" aluminum plate which serves as the surface of contact with the base.

The table top is cut out from a piece of 0.5" thick plywood to a dimension of 20" by 34". It is mounted with two pipe clips to an aluminum pipe with a length of 34" and an outer diameter of 1.3". This acts as the support as well as the pivoting point of the table top. One end of the pipe is welded perpendicularly to a short section of aluminum pipe, having the same dimension as the lower post. The other end is welded to a 4.5" square aluminum plate. A series of 0.25" holes are drilled on the square plate in the pattern of a quarter-circle. Different tilt angles are adjusted by pinning the table top to the different holes.

The assembly of the table is done easily by connecting the bottom plate of the vertical support with four #20 bolts. The short pipe that is welded to one end of the table top support is inserted into the top of the vertical support. A 0.25" pin is used to lock in place. One end of a bungee cord is hooked to the upper post while the end of the other bungee cord is attached to the square plate. This provides the counteracting force to resist the movement of the table when the hooks are connected to the armrests of a wheel chair. The detachable holder is made out of a 2" by 11" plywood and is stored under the table top with Velcro. Two small pins are embedded inside and the holder is attached to the table top perpendicularly by inserting the pins into the pre-drilled holes on the table top.



Fig. 11.63. Table Turned Flat.



Fig. 11.64. Table in Use.

The total cost of the project was \$60.

PORTABLE OBSTACLE COURSE FOR CHILDREN WITH DISABILITIES

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INTRODUCTION

Many occupational therapists' clientele includes children with mental disabilities. A wide variety of exercises are used that tailor to the mobility issues of their patients. Several of these exercises involve bulky equipment, which makes transportation an issue. The purpose of this project is to combine four commonly utilized exercises into one portable piece of equipment.

SUMMARY OF IMPACT

Occupational therapists (OT's) that work with children with disabilities have a need for portable and effective therapeutic devices. With this device, OT's can have the advantage of an entire obstacle course designed for easy transportation and effective therapeutic treatment. In addition, the obstacle course allows the patients to become more engaged in the treatment process, while having fun at the same time.

TECHNICAL DESCRIPTION

The Portable Obstacle Course consists of four main components: the steamroller, the agility ladder, a tunnel and the equilibrium balance board.

The walls and base of the steamroller are constructed out of pinewood, with cylindrical rollers that are constructed from 2" and 3/2" PVC piping. The compressive force the rollers generate is accomplished by two 6" bungees attached between the top and bottom rollers providing 20 pounds per inch of force. In addition, the rollers are able to expand beyond the constraints of the sidewalls by employing extension supports. This adds an additional 10" of maximum height.

The agility ladder is constructed from 1 3/4" PVC pipe and braded rope. The ladder design is unique because the height of the rungs is adjustable. This



Fig. 11.65. Entire Device Ready to Move.



Fig. 11.66. Entire Obstacle Course.

provides a more challenging task for the patient. In order for the height to be adjusted, a custom support brace, made of wood, is used to allow the PVC pipe to stack on top of one another.

The tunnel obstacle is six feet long and nineteen inches in diameter and was purchased as such.



Fig. 11.67. The Tunnel.



Fig. 11.68. The Agility Ladder.

The final component of the obstacle course is the equilibrium board. This is constructed from a 21" square piece of $\frac{3}{4}$ " plywood attached to two, 2" by 20" rockers. The two rockers allow the board to move in the lateral direction. Attached to the top of the board is a piece of 8" by 12" maple wood. Carved into the wood is a snake-like maze, deep enough to fit a small marble. The task for this



Fig. 11.69. Balance Board.

obstacle is to navigate the marble through the maze by moving back and forth in the lateral direction. The maple is cut so that its height decreases with a slope of roughly 4.75° allowing for the marble to move down in the vertical direction, without assistance from the user.

WHEELCHAIR HAND-CRANK TRICYCLE CONVERSION ATTACHMENT

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INTRODUCTION

The objective of this project is to develop a non-permanent hand-crank tricycle attachment for a wheelchair that is fully controlled with a user's upper body. This device allows individuals with lower-body limitations to have more mobility, speed and maneuverability. It also may be used as an attachable recreational device. Another use would be to offer individuals who require upper-body physical therapy a more enjoyable alternative to current traditional rehabilitation methods.

SUMMARY OF IMPACT

This device is designed for individuals who have physical limitations or are confined to a wheelchair. Some scenarios this device may be used for include traveling longer distances, such as several city blocks to get to work or through a large park. It may also be used for disabled children, providing them with a way to ride a bicycle with their peers if they are unable to pedal with their feet. This device may also be used by individuals who need upper-body physical therapy. The tricycle attachment offers an enjoyable alternative to the traditional stationary hand-pedaled devices, or Upper Body Ergometers (UBE's) that are commonly used in physical therapy today.

TECHNICAL DESCRIPTION

The tricycle conversion attachment is constructed of steel tubing and several components found on standard bicycles. A unique feature of this device is that installation does not alter the wheelchair frame in any way. The tricycle attachment clamps over the cross-brace of the wheelchair, located below the seat. This is accomplished by using two pieces of steel pipe; placing one on top and one below the cross support and securely clamping the device on by tightening the two sets of nuts and bolts.



Fig. 11.70. The Hand-crank Tricycle Conversion Attachment.

The attachment is also divided into two parts including an under-seat component which can remain attached to the wheelchair, and the hand-crank or wheel component which can be removed or attached as desired. Two clevis pins are used to attach the two components together to allow for a quick and easy conversion from wheelchair to tricycle. When the tricycle attachment is in use, the two front caster wheels of the wheelchair are lifted off of the ground by approximately two inches. This allows the user to control the tricycle more easily.

There are several components of the tricycle attachment that are completely adjustable. On the clamping device that attaches to the wheelchair, there are several bolt holes. This allows for adjustments to make the tricycle comfortably fit the user's arm reach and height. Adjustments can be made by either moving the attachment forward or backward, as well as up or down. This is done by adjusting which bolt hole is used. Similarly, the tricycle conversion attachment also features an adjustable foot rest. A bolt can be loosened and the footrest can be swung outwards to either accommodate longer leg lengths, or so the user can instead use the footrests on the wheelchair. These

adjustments make this device user friendly for adults and children.

This device is controlled through a combination of hand-pedaling and steering. Steering can be done by turning the hand-crank mechanism left or right while pedaling. Like a standard bicycle, the user is propelled by completing full 360 degree forward rotations. By backpedaling, the user will initiate the coaster break. If for some reason the user needs to go in reverse while using this device, the two wheels of the wheelchair can be used. Chain guards are installed to prevent any hand injuries due to the

close proximity of the hand-crank mechanism and the chain. Several reflectors are also installed as precautionary safety measures.

If this product were to be manufactured commercially, it would be beneficial to have adjustable gearing so the user can select a gear ratio that is customized to their personal comfort and ability level.

The total cost of this project is \$26. The wheelchair used for this project was generously donated by Sheridan Surgical, Inc.



Fig. 11.71. Tricycle Conversion Attachment in Use.

PORTABLE LIGHTWEIGHT SEAT-LIFT AID

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INTRODUCTION

The objective of the Portable Lightweight Seat-Lift Aid is to provide assistance for people who have difficulty getting to a standing position from chairs. The device is designed to be lightweight so it can be moved from chair-to-chair with relative ease. Lift-chairs do exist on the market but most are immobile and the few portable models that exist typically require an electrical power supply. The Portable Lightweight Seat-Lift Aid relies on air power to provide the necessary lift. The prototype is designed to fit many different seat sizes.

SUMMARY OF IMPACT

Many individuals have difficulty moving from a seated position to a standing position for various reasons. This device is designed to “inflate” the user into a standing position so that there is less stress on the body while getting up. This device is light and portable so it is suitable for everyday use in a variety of locations.

TECHNICAL DESCRIPTION

The prototype is constructed primarily from angle iron, flat steel, and plywood. The body of the prototype consists of two main parts including the base frame and the lifting arms. The base frame consists of two pieces of angle iron fastened with bolts to a cut of flat steel. The 1” wide flat steel additionally serves as a handle for the device. The bottom of this base frame is constructed out of plywood.

The lifting arms are connected to the base frame with a long threaded rod which enables hinge-like movement. The lifting arms contain the seat of the device, which is made of plywood. The seat is padded with 3” polyurethane foam. The high height of the foam helps prevent the user from sinking into a chair which may make standing even more difficult.



Fig. 11.72. Deflated Device in Use.



Fig. 11.73. Inflated Seat-Lift in Use.



Fig. 11.74. Device Inflated.

The device is powered by an “Air-Wedge” bladder that requires manual hand pumping. The bladder is located under the lifting arms and remains flat while deflated. Squeezing the attached bulb inflates the bladder which is then filled and the device’s seat begins to rise. At maximum inflation the user is in a less stressful position to rise out of their seat. The



Fig. 11.75. Device.

seat is lowered by pushing the bladder’s release valve.

The total cost of the prototype is \$62. The prototype is limited by the size and availability of suitable air bladders. Currently the prototype uses a bladder that inflates to a height of approximately 3”. Future prototypes should include a bladder twice as large.

INTRAMUSCULAR AUTOMATIC INJECTOR

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INTRODUCTION

The goal of the Intramuscular Automatic Injector is to provide patients diagnosed with Multiple Sclerosis who are prescribed Interferon beta-1a, an easier process to administer their medication. Typically, these patients are required to self-administer their medication by means of an intramuscular injection either in the Vastus Lateralis muscle or the Deltoid muscle. In some cases, the patient may wish to have another individual provide the shot that is trained in administering intramuscular shots. The delivery of these shots can be a stressful event. The device designed in this project attempts to provide MS patients with an easier way to administer their medication.

SUMMARY OF IMPACT

Many patients suffer from anxiety with regard to self-injection, a mild form of Trypanophobia commonly referred to as "needle phobia". As a consequence, the individual is unable to administer their own medication. This device addresses that issue. By shrouding the needle and automating the injection procedure for intramuscular shots, an "out of sight, out of mind" effect is created. This relieves the patient from the anxiety that is induced from the sight of the needle and the anticipation of the insertion. It also makes it easier for a second party to administer the shot as it is automated.

TECHNICAL DESCRIPTION

The automatic injector consists of three major components including the frame, the drive system, and the carriage. The frame is fabricated from a 7" long, 2" x 1" rectangular aluminum tube. The frame provides support for the carriage and carriage release mechanism, and shrouds the needle prior to injection. Grooves are cut into the frame to allow access to the carriage to insert the syringe for use, and to guide and provide limit stops to the carriage. Limit stops are required on the carriage to prevent the needle from injecting too deep or with excessive force during the intramuscular injection procedure.

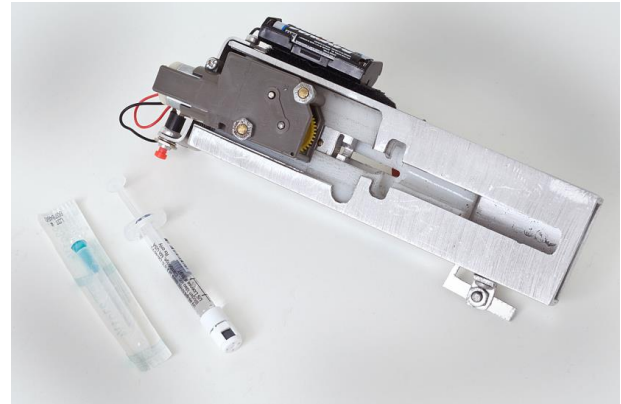


Fig.11.76. Front of Injector.

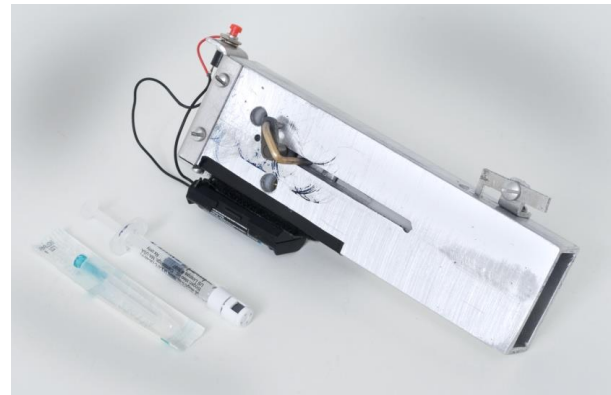


Fig. 11.77. Back of Injector.

The drive system consists of a 4-Speed Crank Axle Gearbox from Tamiya set to a 441:1 gear ratio and FA-130 Mabuchi drive motor. The motor provides sufficient torque to transfer rotational force that is converted to linear motion, to drive the plunger on a syringe outward for aspiration and inward to administer the medication intramuscularly. Electric power is provided by two AAA batteries.

The carriage is a 4-3/4" long, 1-3/4" x 3/4" Teflon block with the main function of housing the syringe. It also holds the mechanical parts that provide linear motion. Additionally, it supports the drive system. Prior to administering the injection the carriage is drawn back against a resisting spring force and held

in place by the carriage release mechanism. Upon initiation of the injection, the carriage release is depressed and the spring force drives the carriage forward, inflicting the needle protrusion.

The total cost of the project is \$14.98.

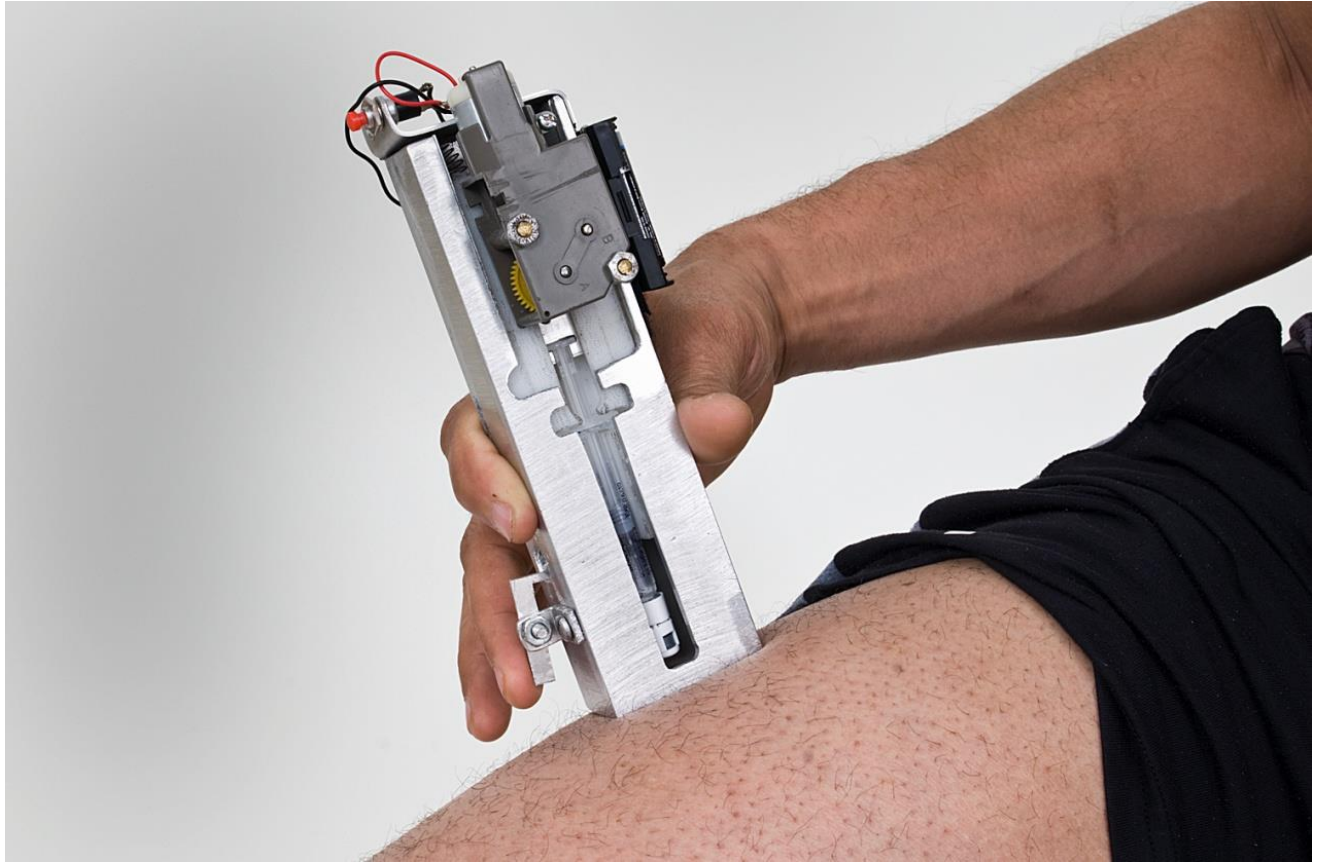


Fig. 11.78. Injector in use.

ERGONOMIC CRUTCHES

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INTRODUCTION

The purpose of the Ergonomic Crutches is to reduce the discomfort associated with traditional crutches. Due to the design of standard crutches, the user usually experiences some pain and discomfort in the muscles, irritation on the skin of the underarm as well as joint pain in the wrists. Due to the cost and production limitations faced by crutch manufacturers, modern crutches are simple, cheap, and offer great support. They do exhibit extremely poor ergonomics and cause much user discomfort. By utilizing current crutch designs and adding new features to add to user comfort, the final product aims to make a person's time spent on crutches a more tolerable experience.

SUMMARY OF IMPACT

Reducing the discomfort that a person experiences while on crutches can allow the user to spend more time being mobile, reduce the time spent nursing the irritation produced by crutch discomfort, and spend more time attending to the injury that is causing the use of crutches in the first place. The reduction of stress on the user's wrists has a significant effect on comfort. This is especially important for people who are constantly on the move, such as students, athletes, and those working in the professional world, such as in an office.

TECHNICAL DESCRIPTION

Since the purpose of this project is to improve the design of existing crutches, a pair of standard aluminum crutches has been used as a starting point. Although wooden crutches are slightly easier to machine to accept the new hardware, aluminum crutches are lighter than wooden units. To allow the handgrips to slide up and down with a range of approximately four inches, a slot is machined in each side of each individual crutch using a milling machine. Unfortunately, by removing material from the already thin aluminum tube, the overall strength of the tube is lowered, making the tube much less resistant to lateral bending when the weight of the



Fig. 11.79. Device in use.



Fig. 11.80. Additional Cushioning.



Fig. 11.82. Collapsed Handgrip



Fig. 11.83. Extended Handgrip



Fig. 11.81. Moveable Handgrip

user is applied. A set of machined and polished steel pipes is added to the structure to compensate for this weakness and to add strength to the overall structure. To accommodate the movement of the handgrip, a slot equal in dimensions to the slot cut in the aluminum tube is machined in each pipe. Finally, a set of holes is drilled in each pipe and secured to the aluminum tube using $\frac{1}{4}$ "-20 hardware, an industry standard. This reduces costs and is used to prevent movement. Due to the milling process, the edges of the slots are slightly sharp. To prevent user injury, a few additional "sleeves" are machined from aluminum to act as a sliding barrier between the user's skin and the edges of the slots. All surfaces on the pipes and sleeves are sanded smooth and polished on a lathe to increase visual appeal and reduce abrasion. Heavy duty storm door return springs are adapted to be used on the handgrips, and are extremely cost effective.

Adjustability for users of various heights is retained through the normal push-button adjustment for height. Handgrip height is also adjustable by moving the upper mounting point of the spring to a different notch in the aluminum tube, similar to the original design. To reduce underarm abrasion, a pair of soft foam sponges is cut to size and secured to the original hard foam pad. These can easily adapt to the shape of the user's underarm.

The total cost of this project is \$23.11

CANOPY ATTACHMENT FOR WHEELCHAIR

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Faculty Designers: Kenneth L Peebles, Bill Macy, Roger Teagarden

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INTRODUCTION

The canopy attachment for a wheelchair is an attachment device that provides protection for users from different kinds of weather that attaches on the back of a traditional wheelchair. The main objective for the attachment design is to provide protection to suit users of different sizes and ages. A secondary objective is to be easily attachable with little time needed to install. The attachment is also very easy to use and inexpensive to acquire.

SUMMARY OF IMPACT

The canopy attachment is designed to protect wheelchair users in different kinds of weather conditions. The canopy is attachable and detachable to a traditional wheelchair without damaging its original structure. The attachment is designed to be placed on the designated location on the back of the wheelchair. It uses the handles of the wheelchair as the base and support for the entire attachment. For its implementation, the users first sit on the wheelchair. To adjust the height of the canopy, the buttons are depressed from the two adjustable bars and the height of the whole canopy attachment can be adjusted by raising or lowering the two bars. For the adjustable bars to be placed to the desired height, they have to be adjusted to the same height. For example, the users have to adjust the height of the canopy by adjusting four supporting bars of the walker. The users also can adjust the length of the canopy by pushing or pulling the aluminum bar which is attached to the back of the canopy. This allows varying canopy heights to satisfy different heights and user preferences. This mechanism also allows the users to adjust the length of the canopy according to the weather conditions.

TECHNICAL DESCRIPTION

There are six adaptive parts that form the adjustable and extendable canopy. The first adaptive part is assembled by using two I-braces to serve as the base. They connect the adjustable bars to the handle of the



Fig. 11.84. Connecting Mechanism.



Fig. 11.85. Extending Mechanism.

wheelchair. The handle serves as the support for the weight of the attachment. The l-brace is screwed to the bar and to the handle of the wheelchair.

The second part of the attachment is the adjustable bar, which allows the canopy to be adjusted. This bar is similar to the adjustable portion of crutches that have holes and pins to adjust them. In order to connect the adjustable bar to the aluminum height increment bar, two plastic hollow connectors were used. A plastic material is used in the design because it is light weight and low in cost. The plastic connectors are also easy to shape and drill.

For the third part of the attachment design, two aluminum bars are used to adjust height increments and the displacement bars were used to allow for extension. There are four holes on each aluminum bar which connect them to the displacement bar. Aluminum is used because it is lightweight.

After the increment bar, the fourth adaptive part of the attachment design is the extendable mechanism for the length adjustment of the canopy. This mechanism is made of steel and purchased entirely from the Swiss furniture store. The mechanism is in a crossed steel pattern to make the mechanism easy to extend and close. In order for smooth operation during extension, lubricant oil is used in the intersection to decrease the friction.

A pair of aluminum bars is attached in between the two adjustable bars. These two bars serve as a constraint to stabilize the entire design. These bars act as the backbones of the attachment.

An aluminum bar is attached to the canopy which serves as the push handle to extend or close the canopy. Tablecloth material was chosen for the canopy material because it is low in cost, lightweight, and is aesthetically pleasing.



Fig. 11.86. Extended Canopy.

This design was tested under different weather conditions including wind and rain. The canopy was stable and firm while testing under windy conditions.

The total cost of this project is \$ 40.00.

VISUALLY IMPAIRED SMART CANE OR WALKER

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INTRODUCTION

The goal of this project was to aid people that use walking sticks as a means for mobility. The daily use of walking sticks was taken into consideration and improvements are made to enhance the user's ability to navigate through a human rich environment. This unit was made to be as portable as a normal walker but with sensors added to read the heat signatures of bodies next to or ahead of the user.

SUMMARY OF IMPACT

The "Visually Impaired Smart Cane or Walker" is versatile in nature. Depending on the user's main needs, the cane or walker can be adapted to different environments. The parameters of this cane are based on the need to know where a body is positioned based off the user's reference frame. The body could be human or an animal like a cat or dog. This walker will enable its user to get approximated locations of any living body. Living with a pet will now be a little more comfortable for the visually impaired.

TECHNICAL DESCRIPTION

The walker system consists of the main skeleton of the system. The main skeleton is the removable aluminum cylindrical shafts used as the main component for mobility while using the walker. It comes in three pieces. All three can be separated if necessary. There is also a fourth piece used to help those with hand function limitations. These removable parts allow for easy storage and portability. Also, the bottom of the walker is assembled with an irremovable smooth hard plastic spherical bottom to compensate for various surfaces.

Unlike other walkers, there is a small body added at the lower end of the walker on the lower removable part. This is the housing for the passive inferred sensors, PIR, that are employed in the design. These sensors are to detect changes in body heat. If a heat source is registered to the sensor, an output signal is



Fig. 11.87. Leading Tip of Smart Cane with Sensors.



Fig. 11.88. Entire Smart Cane Device.

given off in a range of up to five volts. If no signal is output, then the signal is left as zero volts.

To finish the system, sets of wires are used along with three nine volt batteries and a buzzer. They are used to complete the circuitry and allow for the sensors to work. The system gives an output signal that is converted by the buzzers into auditory signals. Each sensor is set to a certain sensitivity level based off the variable resistor located on the circuitry of the sensors.



Fig. 11.89. Smart Cane in Use.

PILL HOLDER FOR SPLITTING

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INTRODUCTION

The goal of this project is to assist in the splitting of prescription pills. The device is designed to help hold pills securely in place while the user splits them. Splitting pills accurately with a conventional pill splitter can be difficult to do, due to the fact that the pill has a tendency to move while it is being split. This design also compensates for a variety of different pill sizes.

SUMMARY OF IMPACT

Pill splitting has become a very popular way for people to save money on prescription medications. This is due to the fact that drug companies charge similar prices for varying doses of medication. For example, a popular online pharmacy charges \$90.00 for 30 tablets of 10 mg of Lipitor and \$124.00 for 30 tablets of 20 mg of Lipitor. If the larger dose is purchased and simply split in half, the patient could save a great deal of money. Although this is a popular practice, it does come with its risks. While splitting a pill with a conventional splitter it is possible to split the pill unequally, resulting in an overdose one day and an under dose the other. This device ensures equal dosage by holding the pill steady during splitting.

TECHNICAL DESCRIPTION

The design of the holder is based on a store bought pill splitter. The splitter is mounted on a wooden base, which is machined to have a raised flat portion that is of equal height to the pill splitter's cutting platform. A machined metal slider is placed on this raised platform and is held in place by a cover that



Fig. 11.90. Full View of Holder.

slips over the base. There is a very small gap left for the slider to slide back and forth between the base and the cover. The metal slider is then used to hold pills in place as it slides in and out of the "V" shaped cutting platform of the pill splitter.

The metal slider has two ends to it. The end that the user pushes and pulls from is wide and easy to grip, with smooth, curved edges. The other end is the part that holds the pill. It comes to a point which is bent at a 90° angle and has a slit down the middle of it. The end is bent so that it evenly pushes the pill into place. The slit is present to allow for the blade of the pill splitter to pass fully through the pill.

The entire project weighs approximately one pound and costs \$7.00.

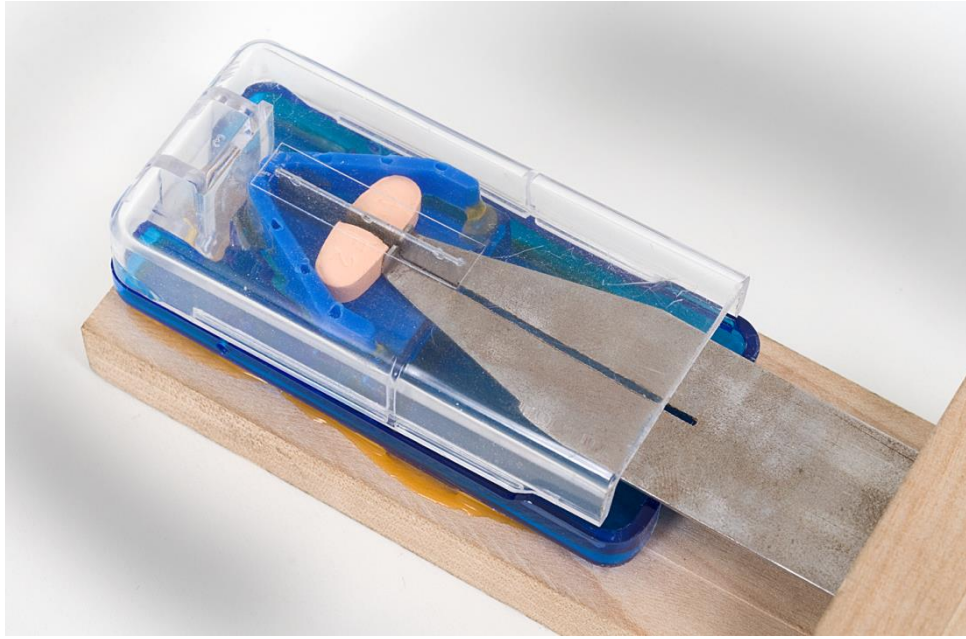


Fig. 11.91. Pill Splitting Process.



Fig. 11.92. Close Up of a Split Pill by Device.

STORABLE WHEELCHAIR DESK

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INTRODUCTION

It can be very difficult for a wheelchair user to find an area of a table that is accessible to them. Whether there is no desk available in a classroom or the lack of a hard surface in varying locations, the Storable Wheelchair Attachment addresses this problem. The Storable Wheelchair Attachment is a desktop that is attached to the back of the wheelchair and can be easily accessed whenever the user desires. The device allows to a hard surface whenever needed.

SUMMARY OF IMPACT

The Storable Wheelchair Attachment allows wheelchair users' access to a hard desktop surface at all times. They can write on paper, set down a drink and even type on a laptop without the hassle of finding a surface that can accommodate their wheelchair. When the desktop is not needed, it is stored behind the wheelchair, which allows for normal use of the wheelchair. Therefore, the user will always have access to a desktop surface while still being able to use the wheelchair without interference.

TECHNICAL DESCRIPTION

The design of the attachment is based around three main points including allowing for a sufficient amount of surface space, creating a device that is as lightweight as possible and creating a device that does not hinder normal wheelchair function when not in use.

To address the first issue of having a sufficient amount of surface, a typical L-shaped school desktop is used for the hard surface. This allows for a proper sized workspace. The shape of the desktop enables the device to act as an armrest as the hard surface covers the right armrest of the chair.

It also wraps around the rider for a close fit, which allows for easy reach of the entire surface. When the surface is not in use it can be moved to the side,



Fig. 11.93. Device in its Storage Spot.

folded down, pushed around to the back of the wheelchair, and attached by magnet to the backrest.

In order to make this device as light as possible two aluminum bars are used. One bar is connected to a backrest that is attached to the wheelchair. The backrest is connected to the wheelchair at four points. The top two points are loops that go over the back handlebars of the chair. The bottom two points are connected to the side bars of the wheelchair's backrest. This backrest has a piece of soft foam on the front for the user's comfort. The bar that is connected to the backrest is in a horizontal position. The second bar is connected to the desktop by a continuous hinge that runs 21 inches of the 25-inch aluminum bar. A pull pin attaches these two aluminum bars to each other. When the desktop is not in use, the second bar closes and is in a horizontal position above the first bar. In order to keep the second bar in the closed position a magnetic plate is screwed on to the bar. The plate catches a magnet that is attached to the backrest. This design allows the wheelchair to function normally when the surface is not in use, as the entire device is stored behind the wheelchair.

To use the desktop, the user reaches around the back and pulls on it. The desktop swings around the right

side of the wheelchair on the aluminum bar. Then the desktop is lifted up from the vertical position to a horizontal position and moved over the armrest. In order to lock the desktop in the horizontal position there is a small piece of wood attached to the bottom

of the desktop. This piece is rotated 90° and is then pressed against the aluminum bar, which stops the desktop from folding down along the hinge.

The cost of this project is \$42.



Fig. 11.94. Full View of Device.

HEARING AID BATTERY INSTALLER

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Client: Walter Burns
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INTRODUCTION

The Hearing Aid Battery Installer is intended for users who are both hearing impaired and have arthritis. There exist many individuals who experience joint pain and also have varying levels of hearing loss. Installing a hearing aid battery can become a very challenging, frustrating and even a painful task. This device eases this process tremendously by allowing the user to relax their hand to a more natural position, and to pick-up and place the battery without ever having to flex their joints. In order to further simplify the process, a custom mold of the hearing aid is made in order to hold the hearing aid while the battery change is completed. The device also uses a bright LED to light the workspace, increasing the ease of use for those that have vision problems.

SUMMARY OF IMPACT

This device simplifies a task that can be extremely difficult. Making a tool like this available to the public at an affordable cost could make life, for someone with arthritis, easier and more independent.

TECHNICAL DESCRIPTION

This device works on basic DC circuitry, electromagnetic principles, and most importantly, ergonomics. The device has two main components; one which holds the hearing aid and a second which lifts and inserts the battery.

In order to hold the hearing aid, a custom mold is made of a hearing aid with molding clay. The mold is simply an impression of the hearing aid with its battery tray is left open. Once dried, the mold allows the user to easily insert the battery into the hearing aid. On the bottom of the mold are four rubber feet to avoid slipping in any direction.

The device to lift the battery serves two functions. It allows the user to lift the battery with an



Fig. 11.95 Hearing Aid Battery Installer.



Fig. 11.96. Device in use with LED On.

electromagnet probe while lighting the workspace with a bright LED. The DC circuitry is organized in a parallel fashion to perform these two functions. One branch of the parallel circuit is formed with the bright LED and a 220 Ohm resistor. The resistor creates a large enough voltage drop to safely light the LED. The other branch of the circuit is made of the electromagnet with a 10 Ohm resistor. The 10 Ohm resistor limits the current flow of the overall circuit. The electromagnet is made with a five inch machined cylindrical iron-rubber compound wrapped in 40 feet of 36 gauge magnet wire. The

iron-rubber compound allows the electromagnet to completely demagnetize when there is no current through the wire. This is important due to the small weight of the battery. The electromagnet is covered in electrical tape in order to protect the wire wrapping. The circuit is powered with a 7.5 volt, two amp DC power supplies with the two functions wired in parallel.

The outer casing of the device is made with PVC piping. The case contains the entire circuit described above. Protruding from the front of the device is the electromagnet probe. This is what is used to pick up the magnet. Branching out of the side of the device is gooseneck tubing to help guide the LED to the workspace.

The red button on the top of the device activates both the LED and the electromagnet. The device, as mentioned earlier, is powered by the DC power supply at the back of the device.

A key focus to this design is ergonomics. The invention is easily cradled by a right handed user and the button is perfectly placed for the thumb. The gooseneck tubing doesn't interfere with the user's hand and easily bends to the desired location. Another important consideration with regard to ergonomics was the design of the mold. The mold allows the user to place the hearing aid easily in a custom fitting while restricting motion in any direction during battery installation. Overall, the device is easy to operate and puts much less stress on the user.

UNIVERSAL MOUNTING ACCESSORY TRAY SYSTEM (UMATS)

*Student Designers: Christopher D. Williams
Supervising Professor: Dr. Joseph C. Mollendorf
Department of Mechanical and Aerospace Engineering
State University of New York at Buffalo,
Buffalo, NY 14260-4400*

INTRODUCTION

Persons with disabilities use their wheelchairs or walkers for many hours during the day. As a result, they perform many daily tasks in a seated position. The objective of this project is to design and fabricate a mechanism to aide in the mobility of an individual with disabilities. The device is designed to be used in many settings, and is ideal for a rehabilitation center. It will help to increase the independence of wheelchair users as well, helping them to carry out daily activities without assistance. The Universal Mounting Accessory Tray System helps to overcome some of these problems by providing a simple work station which is easily mounted and removed from a conventional wheelchair or walker. Another objective is that the system be lightweight and provide a tray which can be pivoted to a variety of angles and positions. The device is vertically adjustable to accommodate many users and then swivels out of the way for easy exit from the wheelchair or walker. The individual using the device requires no additional assistance and gains advantages they would not otherwise have when using a simple desk. This workstation is specifically tailored for simple and efficient use with a wheelchair.

SUMMARY OF IMPACT

The device enables wheelchair users to gain more independence by being able to more easily to perform day to day activities in different environments. Such daily activities may include reading a book, using a laptop, and eating or preparing snacks. Most importantly, the system is lightweight, durable, and portable. It is designed to assist the user in everyday tasks, allowing them to become more active in their everyday lives.

TECHNICAL DESCRIPTION

The system consists of four main components including a tray made of wood which may also be



Fig. 11.97. UMATS Connected to Wheelchair.

fabricated from polycarbonate, a frame aluminum clamp which is designed to fit on any pole or bar on a wheelchair or walker frame, two double end rod swivel joints, and a telescoping aluminum tube which provides the custom height adjustment. The universal head allows the user to attach other components such as an umbrella.

The Universal Mounting Accessory Tray System is easily mounted and removed from any existing wheelchair without major modifications. The system is made to be adapted and mounted before or over the arm of any wheelchair or walker using the swivels for multi-pivotal motion. The desired



Fig.11.98. UMATS in Use.

location is locked via the lever operated screws. The height adjustment for displacement is made vertically by means of a telescoping tube and pin assembly, and then locked in the desired position. The unit uses a tray, mounted and supported by a swivel joint, which is able to be vertically and angularly adjusted about its axis via a nut locking assembly which is activated when turned counterclockwise.

The system also incorporates several different linkages to automate motion in various directions.



Fig.11.99. UMATS with an Umbrella Attached.

The first is that the desktop is able to move vertically via universal swivel arms. The second rotates the system back and forth to create a suitable angle to read a book or other work. The third lowers or raises a locked tray to the user's preferred height for eating or other tasks that may require different heights. All work performed by the system is manual. The total weight of the system is approximately 3.5 pounds.

Total cost of project is \$25.00

ABDUCTOR PILLOW WITH BUILT-IN HEEL FLOATERS

Student designer: Agnieszka Danuta Zyrek
Supervising Professor: Dr. Joseph C. Mollendorf
Client: Tadeusz Anthony Zyrek
Department of Mechanical and Aerospace Engineering
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INTRODUCTION

The objective of this project is to design and build an abductor pillow with built-in heel floaters for patients with hip replacements. An abductor pillow with no straps and incorporated heel floaters will provide pressure relief to both heels. A built-in heel floater design is easy to use and will maximize patient compliance.

SUMMARY OF IMPACT

This product is convenient and easy to use. This one piece device eliminates the need to improvise in order to reduce pressure on the heels during recuperation. It is simple, durable, lightweight and easier to use than currently available devices. Materials chosen for the design are durable, and the top and bottom of the pillow can be cleaned with soap and water. The sides of the pillow and heel floater covers are coated with sheep skin which is a natural material and will aid in pressure and shear force reduction where skin comes in contact with the pillow and bedding. As a result, the sheep skin will help protect the skin from abrasions and blistering, thus aiding in patient recovery. It will also prevent future complications and minimize the cost and time of recovery. The pillow may be used for patients undergoing hip replacement in a hospital, rehab centers or even in a home setting. To use this pillow, the patient needs to be in a supine position lying in bed. Both lower extremities should be abducted approximately one foot apart at the heel. The cushion should be placed with the heel floaters against the mattress, and the smaller end towards the pelvic area in such a way that the wider end of the cushion is horizontal with the soles of both feet. The heels should be placed on top of the heel extenders and adjusted for patient comfort.



Fig. 11.100 Abductor Pillow.

TECHNICAL DESCRIPTION

Materials considered for the design are a high density foam cushion cut in a T-shape, marine quality vinyl and sheep skin. The prototype is constructed from materials available through donations. The body of the pillow is shaped from the cushion. The heel floaters consist of two foam pool noodles, joined together for added stability. The foam noodles are threaded via the center opening with a one centimeter vinyl tube. This tube runs throughout the length of heel floaters and the body of cushion. Duct tape is used to join all surfaces and mimic marine vinyl. The sides of the cushion and heel floaters are coated with sheep skin, which is attached to the prototype pillow with sewing glue. For the final product, the sheep skin is washable, and attached with Velcro. The final dimensions of the six pillow parts are as follows a total length of 57 cm, width of 79 cm, height of 16 cm, a heel floater of 20 in length, width of 15 cm for the heel floater, and heel floater height of 10 cm.

The total cost for this prototype is \$0.00 due to donations.



Fig. 11.101. Abductor Pillow in Use.



CHAPTER 12

STATE UNIVERSITY OF NEW YORK AT STONY BROOK

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LIFT N' GO - ASSISTIVE MEDICAL WALKER

*Designers: Thomas Galeotafiore, Justin Miles and Jeffrey Renert
Supervising Professors: Dr. Anurag Purwar and Dr. Yu Zhou
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INTRODUCTION

The purpose of this design is to create a device to assist people with limited leg strength in moving from a seated to a standing position and subsequently function as a stabilizing device for walking. Existing products for lifting a person into a standing position are generally heavy, cannot fit through standard doorways, require assistance from other people, and/or cannot be used as a standard walker. To address these problems, an assistive device combining the lift and walking functions, named as "Lift N' Go" was created in this project. Designed in a compact way, the device mainly consists of two six-bar linkages driven by two synchronized linear actuators and supported by a wheeled frame; which lifts the user from the seated to the standing position, and then allows the user to use it as a walker. Tests with perspective clients, up to 250 pounds, show that the prototype provides stable and comfortable lift-up support.

SUMMARY OF IMPACT

The Lift N' Go can be used by a wide range of people, including those with lower-body debilitating ailments and elderly patients with weakness in legs. Many of these people are able to walk with the assistance of a standard medical walker once in a standing position, but the process of standing can be an arduous task requiring assistance from others. In the most severe cases, this can completely immobilize a person who does not have assistance. People who require assistance to stand up or sit down will find that our device makes their life easier and increases independence because they will no longer need assistance standing or sitting. Its compact size allows the Lift N' Go device to be used effectively in residential homes as well as in hospitals and rehabilitation clinics to help patients regain strength in their legs.



Fig. 12.1. Prototype and CAD drawing of Lift N' Go.

TECHNICAL DESCRIPTION

The Lift N' Go consists of two six-bar linkages driven by two synchronized linear actuators and a supporting aluminum frame.

The innovative six-bar linkage is designed such that the output link, which supports the user at the armpit, replicates the shoulder joint motion path of the natural human standing and sitting process, and moves in curvilinear translation to maintain stable support to the human body. Our intention is to maximize user comfort through an ergonomic design that promotes natural motion. The six-bar design allows for a more compact and capable mechanism with less design constraints, compared with an equivalent four-bar linkage. By allowing an input-to-output distance magnification, an 8-inch stroke linear actuator is able to provide the necessary 19-inch vertical displacement of the output link.

The Lift N' Go utilizes two linear actuators running in parallel with position sensors for closed-loop synchronization control, which avoids unbalanced loading of the actuators. They are triggered by a wired controller operated by the user in the "switch until released" mode, and each actuator has a limit switch that stops the actuator once it is fully retracted or extended. This type of logic allows the user to easily abort the actuation process when he or she deems necessary. The actuators are powered by a small 24 VDC rechargeable battery pack that provides enough energy for use during an entire day. The actuators are rated at 2500 N (~560 lbs.) and are selected based on the dynamic analysis for a 300 pound individual. They move at a speed of ~0.4 inch/second when fully loaded, and the entire lifting process takes approximately 20 seconds.

The frame is constructed of 1-inch square 6061-T6 aluminum alloy tubing with 1/16-inch walls. It is designed to contain the linkages and to be lightweight without sacrificing strength and



Fig. 12.2. Demonstration of Lift N' Go.

stability. Total locking casters (swivel and rolling lock) are adopted to maintain the mobility of the device and the stability when in the locked position. In addition, forearm and underarm supports are designed to be adjustable for a wide range of users and for increased stability and comfort. A hip harness and sling support are adopted to decrease the requirement of upper body strength input and to enhance the safety features, allowing the user to rest the entire body weight during the lift process or in the standing posture.

The cost of parts and supplies for this project is \$1983.

ASSISTIVE HANDCYCLE

Designers: Claire Maxey, Mathias Wendt and Benoy Varghese
Client Coordinator: Dr. Thomas Rosati, Premm Learning Center, Oakdale, NY
Supervising Professor: Dr. Yu Zhou
Department of Mechanical Engineering
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INTRODUCTION

A special handcycle is custom-designed and constructed for a child with a complete left-side weakness. Due to the weakness in left side, the child tends to use his right arm and hand whenever possible, which prevents him from regaining the strength in his left side. No existing commercial assistive device is available for solving his problem, which was the motivation for this mobility and rehabilitation device. A tricycle is modified to provide an effective solution for improving the control of the client's left arm and leg. A sprocket-chain system is created to enable the user to ride the tricycle by hand. A disc brake is incorporated as an engaging mechanism to ensure that the left hand and left arm are actively involved in riding the tricycle. Corresponding to the hand-driving design, the steering of the handcycle is designed to use the feet. After finalization, the prototype assistive handcycle will be delivered to the client.

SUMMARY OF IMPACT

The custom-designed assistive handcycle provides an effective solution to the client, which is not available from existing assistive products. With this device, the client can steer with his feet and pedal with his hands, and in particular, engage his left hand more than usual, which will assist him to rehabilitate his left side while providing him with more mobility. Moreover, the handcycle design can be easily extended to fit the needs of different children and adults with other levels of left or right arm weakness.

TECHNICAL DESCRIPTION

A Schwinn Meridian Adult Tricycle is used, considering the cost of prototyping and the size to accommodate the individual.

To transform the tricycle into the handcycle, the frame is extended with an additional support on which the hand pedals and engaging mechanism are attached. The foot pedals are removed. A lower sprocket is placed on their shaft, which receives the force and motion delivered by a chain from the upper sprocket engaged to the hand pedals. A chain guard is added to cover the chain for enhanced safety.

The engaging mechanism is particularly designed to force the client to use his left side. The core is a standard bicycle disc brake. The disc is connected to the right side of the upper bracket along with the hand pedal. The caliper of the break is attached to the frame such that the bottom bracket fits properly over the disc. A spring in the brake caliper is connected to one end of a rotating link so that the pads clamp down on the disc when the user releases the left brake lever. The disk break ensures that the left break lever is held down in order for the child to rotate the pedals. When the brake lever of the engaging mechanism is released, the spring locks the brakes and the crank cannot be turned. When the break lever is held down, it stretches the spring and thus releases the brakes.

The steering system includes a set of links that connect the front fork to a foot-controlled pedal. The foot pedal is attached to the frame from below such that it can rotate left or right. When the foot rest is parallel to the ground, the front wheel is straight forward. When the user pushes down his right foot, the links connecting the foot pedal and the front fork pull the front fork and wheel to the right, causing the handcycle to turn right. When the user pushes down with his left foot, the steering links pull the front fork and wheel to the left, causing the handcycle to turn left.

The cost of parts and supplies for this project is \$680.

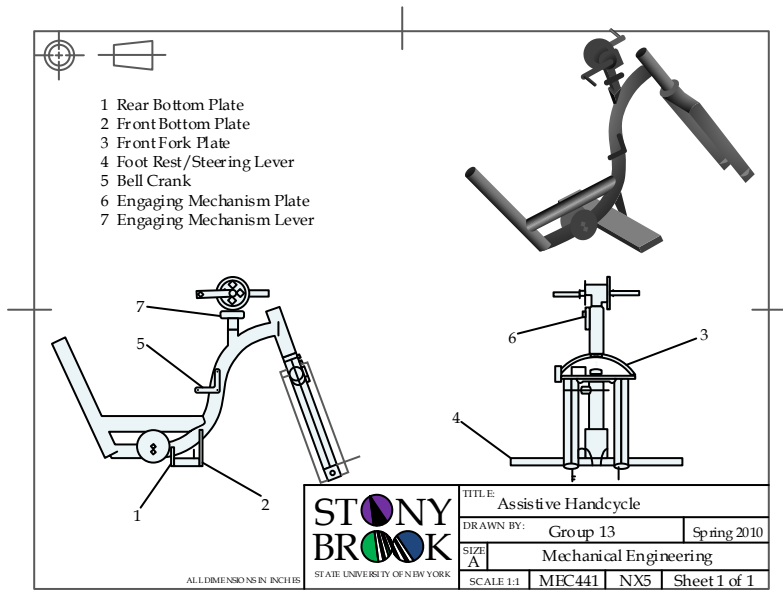


Fig. 12.3. Assistive Handcycle CAD drawing



Fig. 12.4. Assistive Handcycle Prototype.

THE BOUNCE-N-WALK - MODIFIED BABY WALKER

*Designers: Cini Abraham, Peter Feka and Sean Heaney
Client Coordinator: Dr. Thomas Rosati, Premm Learning Center, Oakdale, NY
Supervising Professors: Dr. Chad Korach and Dr. Yu Zhou
Department of Mechanical Engineering
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INTRODUCTION

In this design project, a special baby walker is custom-designed to assist a five-year-old girl. She has been diagnosed with multiple syndromes, including Seckel syndrome, Dandy-Walker syndrome, and hypertonicity, and is unable to walk or crawl. She also tends to lose her breath when extending her neck backwards. There is no existing commercial product to assist our client. Our device design uses the child's weight to propel the walker by bouncing and moving her legs up and down. Extra support is also provided to prevent her from arching her neck backward and which inhibits her breathing.

SUMMARY OF IMPACT

Our device allows the client to sit or stand while using her own movement to move the device forward when desired. Such a lightweight mobile device meets the present needs of both the child and her caregivers. The additional benefits include providing a learning tool for walking and enabling the child to play with other children, helping to develop her social skills as well. The client's quality of life will be improved in a variety of areas. Our client and her family were very happy to see the prototype, and the client wanted to use it immediately. The prototype will be delivered to the client after finalization.

TECHNICAL DESCRIPTION

The user will control the device through the use of a pedal. A curved bar from under the pedal connects to the cable and pulls it when the pedal is rotated downward. A pulley directs the cable from the pedal to a spring-loaded drum. The purpose of using such a component is that the shaft will transmit the rotation in one direction and allows the cable to retract to its start position. On every down-stroke of the pedal, a cog-set turns the front wheel to

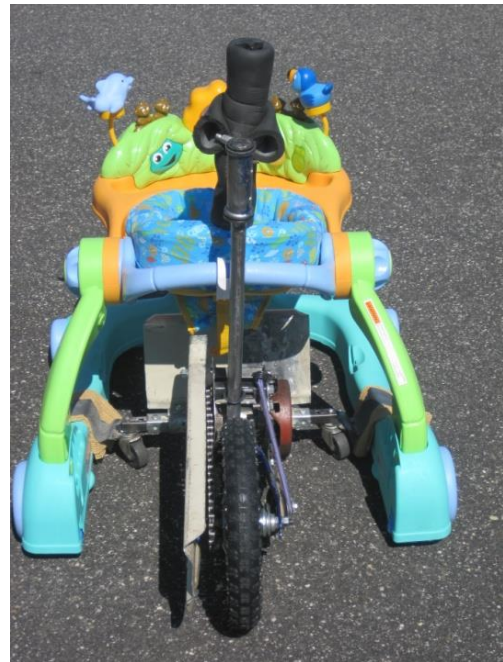


Fig. 12.5. Front View of the Bounce-n-Walk.



Fig. 12.6. Side View of the Bounce-n-Walk.

move the walker. The pedal then returns to its start position such that the next down stroke can be made. Square tubes are welded to the mechanism to provide extra support. The above assembly is designed as an attachment to a standard baby walker. With two bent steel plates, it can be clamped onto the plastic frame of the walker near the caster wheels. The pedal and its pivots are made of metal plate, but a soft rubber is used to cover the pedal to soften the impact of the client's feet.

As its base, a baby walker is implemented such that it does not obstruct attachment of the device from

behind. A head support is also added to the seat. It is made of insulation material that is soft and pliable. Underneath this material is a coil spring that allows the client's head to move forward but not backward.

Our design converts a baby walker into a walker trainer on which the client can lean in a standing position and bounce on the pedal.

The cost of parts and supplies for this project is \$520.

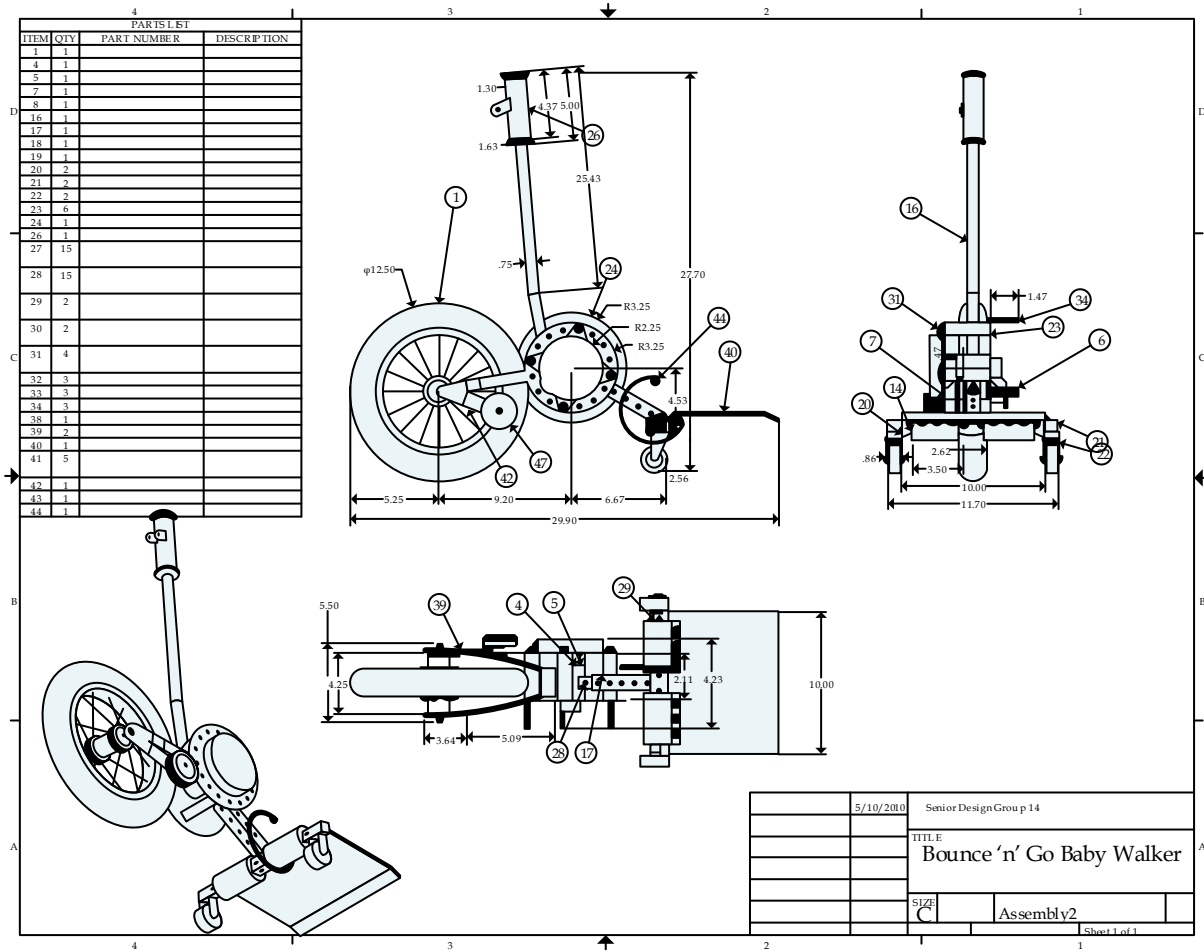


Fig. 12.7. CAD Drawing of the Bounce-n-Walk.

THE TECS DEVICE: TECHNOLOGICALLY ENHANCED CIRCULATORY SYSTEM DEVICE

*Designers: Anthony De Filippo, Mohamed Mahmoud and Emilio Ron
Supervising Professor: Dr. Yu Zhou
Department of Mechanical Engineering
State University of New York at Stony Brook
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INTRODUCTION

Maintaining comfort is important for people with disabilities who have to sit for extended periods of time in wheelchairs or lie on beds. Lack of comfort often means muscle fatigue and skin conditions that can result in pain and even more serious medical situations. A common solution is to move the patient once a while, which requires the assistance of caretakers who can lift the patient. This is a task that can sometimes be overlooked as well. This project introduces a solution by designing a device that can be mounted into various types of seats to make users more comfortable during extended periods of sitting or lying down. By rotating an array of steel coils cushioned underneath the seat cover, this device alters the pressure points that the user experiences at a controllable time interval. It promotes the circulation of blood and oxygen to reduce skin irritation and muscle fatigue.

SUMMARY OF IMPACT

Bedsore and Decubitus ulcers are serious problems for those who develop discomfort from extended periods of sitting in wheelchairs or lying down on beds. Our design provides an effective and economic mechanical solution to offer users comfort and relief, and achieves a higher weight capacity than existing air-pressure based products. Besides wheelchairs and beds, we also envision that this device can serve a broader population in offices, schools, vehicles and much more.

TECHNICAL DESCRIPTION

This device functions by alternating the pressure points that the user experiences at a user identified time interval. To accomplish that goal, an array of flexible steel coils which are fixed to three horizontal shafts rotate underneath the seat. A DC motor drives the coils through a transmission train consisting of a gearbox, two chains and several sprockets which are attached to the output of the gearbox and the input



Fig. 12.8. TECS Prototype.

of the shafts. The transmission train is designed to provide the desired high torque and low speed. A tensioner using two sprocket idlers is added to eliminate any slack in the chains. The pressure points that the user experiences are determined by the position of each winding of the coils. The coils are vertically flexible so that they can contour to the seated user to increase the surface contact area. They were covered with a soft foam cushion to avoid hard contact. Rotating the coils will give the user a "massage" which facilitates the release of tension in the muscles and the skin.

A motor controller, which can work in two modes including automatic and manual, is included in the design. The automatic mode is controlled by a cyclical timer circuit. With this circuit, one can control how long the motor runs by setting the corresponding time intervals. The manual mode is controlled using a switch circuit to turn on and off the motor which allows the motor to spin forward or backward. A relay circuit is added to supply enough power to the motor.

The cost of parts and supplies for this project is \$896.



Fig. 12.9. Opened TECS Prototype.

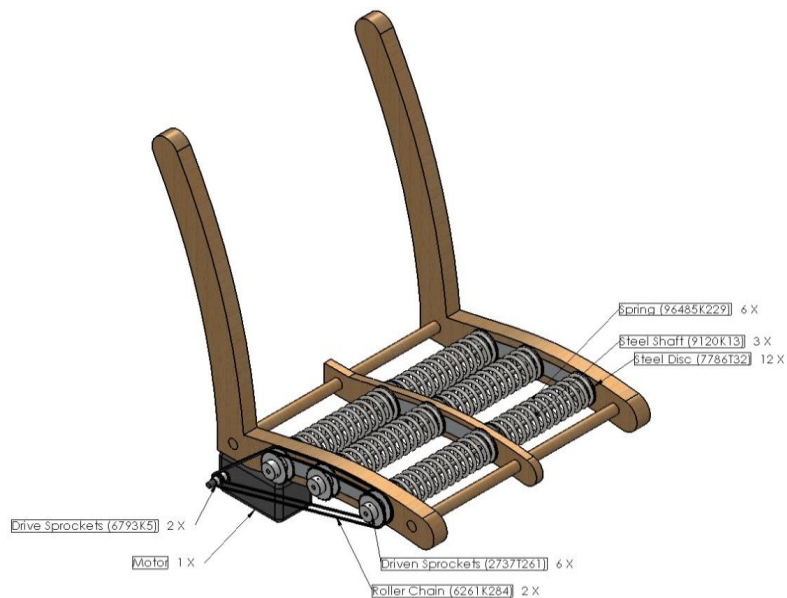


Fig. 12.10. CAD Drawing of TECS Assembly [Isometric View].

AUTOMATED WHEELCHAIR DESK

*Designers: Nick Felicetta, Stephen Morales and Tarun Dey
Supervising Professors: Dr. Lisa Muratori and Dr. Yu Zhou
Department of Mechanical Engineering
State University of New York at Stony Brook
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INTRODUCTION

An automated wheelchair desk is designed to provide convenience for students using wheelchairs to move a desk and book bag to the seating area. Students in wheelchairs tend to have difficulty in accessing books and other school supplies. Similar products on the market are not automated and require assistance from another person to bring forward the desk or book bag. This project provides a solution that enables a wheelchair-bound student to control the desk from his or her seated position using a simple toggle switch.

SUMMARY OF IMPACT

This device will benefit the large population of students that use wheelchairs, allowing them to do their schoolwork in wheelchairs at their convenience. Users will have the control to bring the desk to their laps with minimal effort from a comfortable seated position. The use of this device will give them more independence in daily activities. The same idea can be easily extended to benefit other wheelchair users by providing them the convenience of carrying and easily accessing their belongings.

TECHNICAL DESCRIPTION

The input of the entire system involves a DC gear motor that supplies rotational motion to the vertical drive-shaft which rotates the desk assembly from the back of the wheelchair to the front. The vertical drive shaft is fixed onto the wheelchair back through rod ends. The desk is supported by a horizontal support arm which is connected to the top of the vertical drive shaft via a shim. The transmission is designed to rotate the desk from its initial to final upright position (270 degrees of rotation) in three seconds.

The user controls the rotation of the desk using a switch. In the forward mode, the desk is rotated from its home position to its final upright position. The wheelchair user can detach the backpack from the assembly and place it on a hook, and then bring



Fig. 12.11. Vertical End Rod Assembly.



Fig. 12.12. Desk in the folded position.

the desk to its final horizontal position for use. To put the desk back, the user first brings it to the upright position, and switch the motor rotation to the backward mode to return the desk to its home position.

The materials are carefully selected to meet the safety and mobility standards as well as the size restriction. While 303-Stainless steel is used most often for small components, such as shims, pins,

bolts, nuts and washers, 6061-Aluminum is used for larger components, such as the horizontal support arm, rotating desk support arm, support gusset and the motor baseplate. The desk was made of ABS Plastic with the dimensions $\frac{3}{4}$ "x12"x12".

The cost of parts and supplies for this project is \$883.

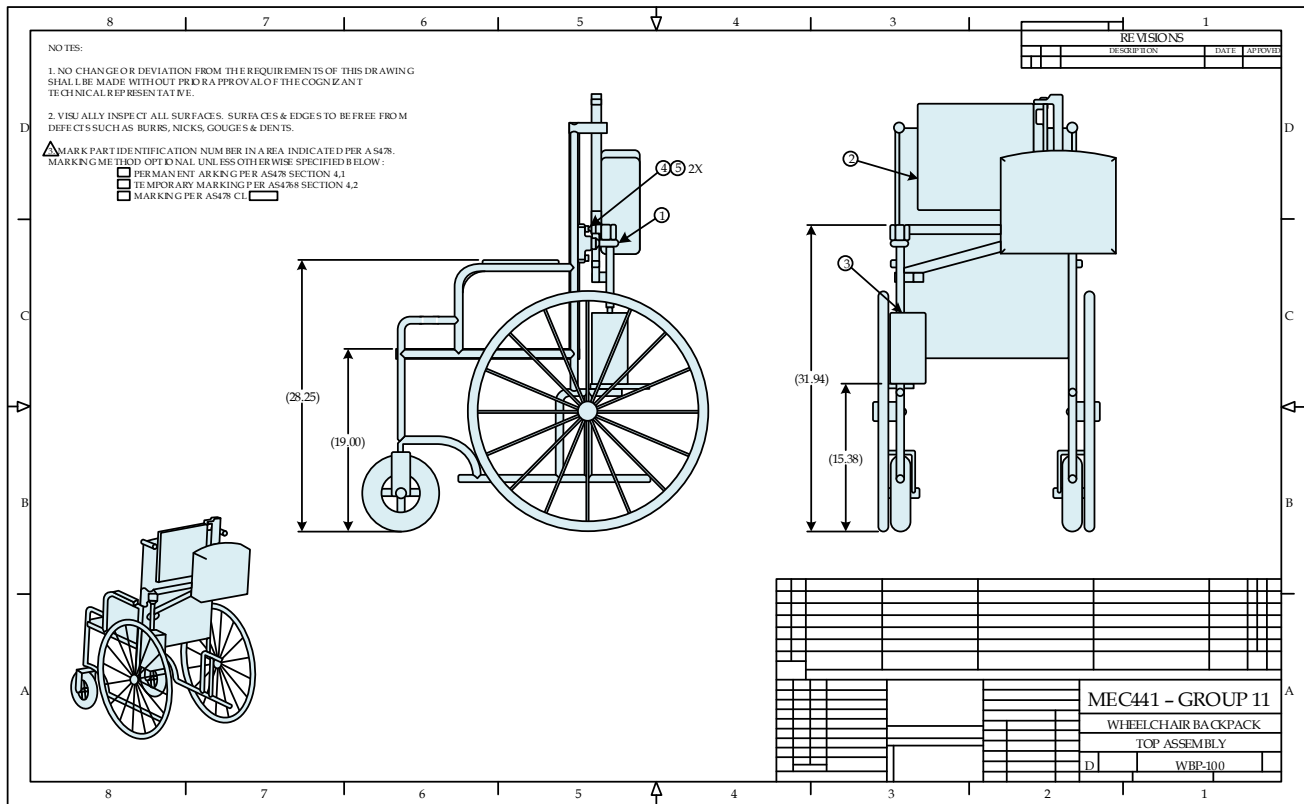


Fig. 12.13. CAD Drawing of the Wheelchair Desk Assembly.

SOLAR-POWERED AUTOMATIC WINDOW

Designers: Chris Galasso, Jia Han and Kevin Li

Client Coordinator: Dr. Thomas Rosati, Premm Learning Center, Oakdale, NY

Supervising Professor: Dr. Yu Zhou

Department of Mechanical Engineering

State University of New York at Stony Brook

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INTRODUCTION

The solar-powered automatic window is designed for people with disabilities and the elderly who are unable of opening a window due to diminished arm strength or other physical detriments. This window operates on battery power which is charged through a solar panel, and slides horizontally upon being triggered with a remote control. This design targets various facilities for people with disabilities, such as the Premm Learning Center, and is also suitable for personal use in residential houses.

SUMMARY OF IMPACT

This project aims to help any person that has difficult opening standard windows. The solar-powered automatic window is easy to operate (with a remote control), which offers clients the convenience to control air flow at home, school or workplace. It gives them more freedom and independence in their daily lives at home and at work, and allows them to enjoy fresh air and desirable room temperature at their leisure. Powered by harvesting solar energy, the system is self-sustained, and can be incorporated into any green technology-based facility.

TECHNICAL DESCRIPTION

The mechanical body of the solar-powered automatic window is a 36" x 36" vinyl window that opens and closes through horizontal sliding. The driving power from a DC motor is transmitted through a pulley-belt set. One pulley is fixed to the drive shaft of the motor, while the other is fixed to a 2" steel shaft that is fixed between two flanged mount bearings in the wall. The window is fixed to the belt with a high strength epoxy. To overcome the friction force involved in sliding a vinyl window, several rollers are placed along the bottom edge of the window panel. This reduces the friction force and allows the use of a low torque, low power-consumption motor to automate the sliding process. The motor is controlled through the use of a remote



Fig. 12.14. Prototype of the Solar-Powered Automated Window.

control and can move the sliding window pane to the desired position. Careful consideration is taken to ensure that the overall size of the mechanical components is easily retrofitted into a standard house wall without protruding from it.

To power the motor, a 5000mAh battery is used, which is constantly charged by a 15W solar panel. The output power of the solar panel is regulated to prevent the battery pack from overcharging. A remote control is designed using a radio frequency transmitter, which has two buttons to toggle individual relays to trigger the corresponding modes of the onboard motor controller. The onboard motor controller then sends the appropriate signal to the motor which controls the forward or backward rotation to open or close the window.

The cost of parts and supplies for this project is \$759.21.



Fig. 12.15. Circuitry and Installation.

NATURAL GAIT GUIDANCE MECHANISM

Designers: Frank Loiacono, Joshua McNeil and Tahzib Safwat
Client Coordinator: Thomas Rosati, Premm Learning Center, Oakdale, NY
Supervising Professor: Dr. Yu Zhou
Department of Mechanical Engineering
State University of New York at Stony Brook
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INTRODUCTION

In this project, a device is custom designed for a child who is nearly paralyzed on the left side of his body and is capable of limited movement on the right side. Though he can stand and walk using a gait trainer powered by his stronger leg, the other leg is not able to assist him in locomotion. To provide a solution, this design involves an assistive mechanism attachable to an existing gait trainer, such that the child can propel it himself. Once his stronger leg makes a step, it will propel the gait trainer to move him forward. The other leg will be attached to the device. As he moves forward, the device will subsequently move his weaker leg forward in a natural gait.

SUMMARY OF IMPACT

This gait guidance mechanism is designed to address the needs of a specific client due to an unbalanced strength in his legs, enabling him to use a standard gait trainer and guiding him through a proper walking technique. It will encourage him to use a gait trainer to rehabilitate the leg muscles in his weaker leg and promote natural gait motion. For individuals with muscular dystrophy and other serious leg disabilities, it is very challenging to stand and especially difficult to walk. With improvements in medicine and medical procedures, there is much hope for those with debilitating conditions to experience significant recovery. Rehabilitation is of great importance for them to regain muscle strength and walking capability. The design idea of this project can be extended to match the needs of different patients, by studying and encouraging the natural gaits of different individuals.

TECHNICAL DESCRIPTION

The assembly of the gait guidance mechanism is fixed onto a main aluminum plate which is attached to a gait trainer along the longitudinal direction. When the client takes a step with his dominant leg, he will propel the gait trainer and himself forward.

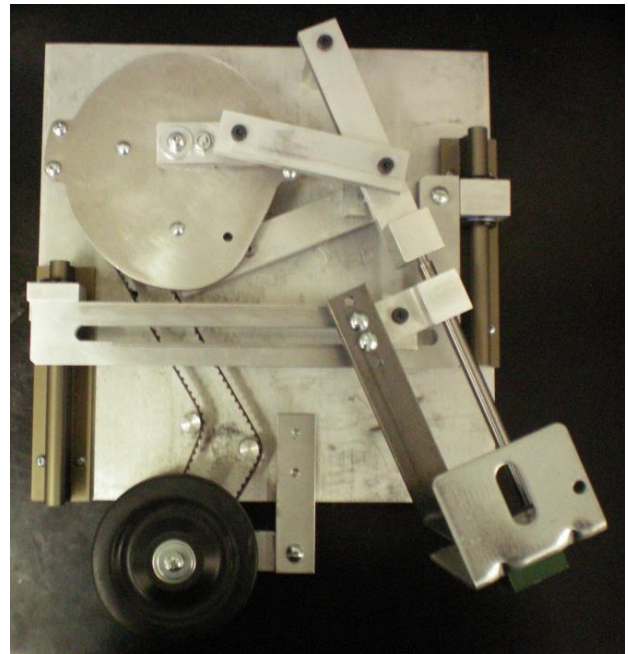


Fig. 12.16. Prototype of the Gait Guidance Mechanism.

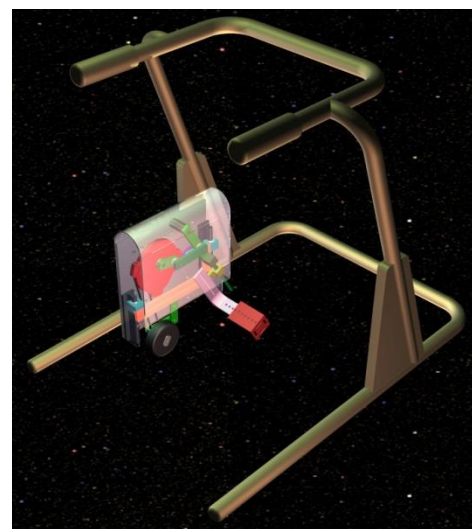


Fig. 12.17. The Mechanism Attached to the Gait Trainer.

As he moves forward, the device will subsequently move his weaker leg forward in a similar walking motion. The gait length and orientation is fixed, and is determined by measuring the ideal step that the client should take.

The driving power of the mechanism comes from a wheel that is kept in contact with the ground. As the gait trainer moves forward, by either the user's own power or the supervisor's assistance, the friction between the ground and the wheel drives the mechanism. The input power from the wheel is transferred to other moving components of the gait guidance mechanism through a pulley set consisting of two pulleys connected by a flat belt. One pulley is attached to the axle of the driving wheel, while the other is attached to the axle of a cam. The cam is specifically designed to deliver the vertical

component of the natural gait motion, with the cam contour determined by analyzing the client's ideal gait. The cam drives a four-bar linkage which governs the horizontal position of the weaker leg. The ankle of the client's weaker leg will be held by a brace at the output of the linkage. As the cam rotates, the four-bar linkage will move the client's ankle forward and backward to repeat the ideal gait.

The gait guidance mechanism has a compact design, with all components fitted onto a one square foot back plate. Being attached to and supported by the frame of a gait trainer, it does not add extra load to the user.

The cost of parts and supplies for this project is \$667.

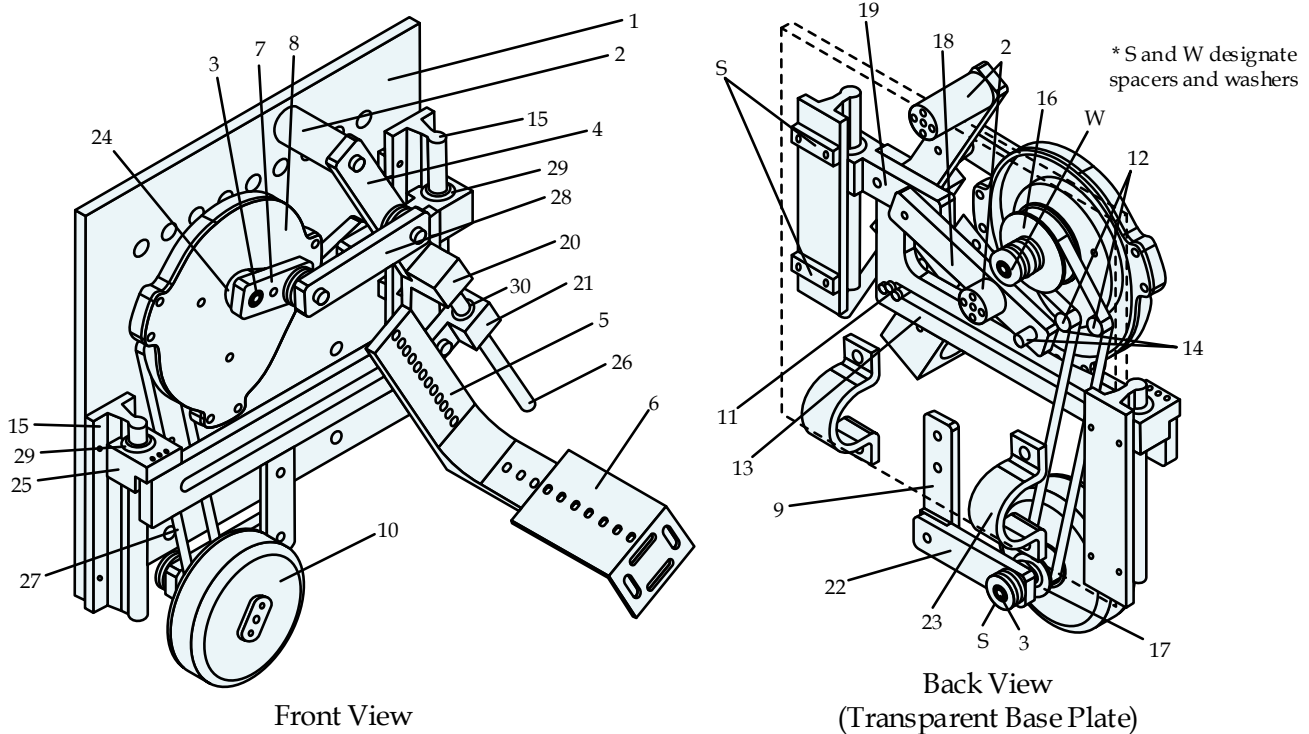


Fig. 12.18. CAD Drawing of the Assembly of the Gait Guidance Mechanism

THE RUMBLE AIDE

*Designers: Safid Bakar, Juan Pinales, Edgar Suarez and Matthew Walker
Supervising Professor: Dr. Christopher Weyant
Department of Materials Science and Engineering
State University of New York at Stony Brook
Stony Brook, NY 11794*

INTRODUCTION

The goal of this design is to create a travel aid device for visually impaired people. The Rumble Aide consists of two ultrasonic sensors to detect frontal and overhead obstacles and provide comprehensive assessment of the user's surroundings. Depending on the proximity of a frontal obstacle, the device will provide haptic feedback or vibrate; and if there is an overhead obstacle, the device will provide auditory feedback or a "buzz". It is designed to improve the range of awareness provided by existing solutions such as traditional canes and guide dogs.

SUMMARY OF IMPACT

The Rumble Aide design is a compact, light-weight and user-friendly obstacle detection device. It is capable of both overhead and frontal detection of objects, each with a distinct feedback mode for easy differentiation. Comparing with other aide systems such as canes and dogs, our device provides a much broader obstacle detection range, has a comparable or even longer lifespan of usage, and requires little maintenance. This device is able to improve the quality of life for visually impaired people by helping them move around independently with wider object detection capability.

TECHNICAL DESCRIPTION

The Rumble Aide consists of two ultrasonic sensors, four motors and a buzzer controlled by a BASIC Stamp 2e Module microcontroller with a 9 V battery as a power source. Additional components include N-Channel MOSFETs and voltage regulators.

The 9V battery power source is transformed to proper voltage inputs for the vibration motors

(which run on 3V) and the ultrasonic sensors (which run on 5V). The 3V for the vibration motors is obtained by passing the 9V through an adjustable voltage regulator (which has been set to provide a maximum of 3V). The 5V for the ultrasonic sensors is obtained by passing the 9V through a constant 5V voltage regulator.

The microcontroller controls the two ultrasonic sensors (which are capable of sensing from 2cm to 3m). Each ultrasonic sensor has two components: a transmitter and a receiver. The transmitter sends short ultrasonic signals, and the receiver collects the signals reflected back by nearby objects. The P-BASIC programming in the BASIC Stamp converts the signal traveling time into distances. Then the microcontroller triggers the motors or the buzzer depending on the location of the obstacle. If the obstacle is frontal, the motors will vibrate. The intensity of the vibration depends on the proximity of the obstacle, with all motors vibrating when an obstacle is within two feet of the user and one motor vibrating if the obstacle is four to seven feet from the user. If the obstacle is overhead (close to the head), the buzzer will ring.

The electronic components are enclosed in a homemade PMMA casing. A handle protrudes from the back, made of an aluminum rod covered with PE foam, and a strap is designed to provide extra support to the user.

The cost of parts and supplies for this project is \$965.

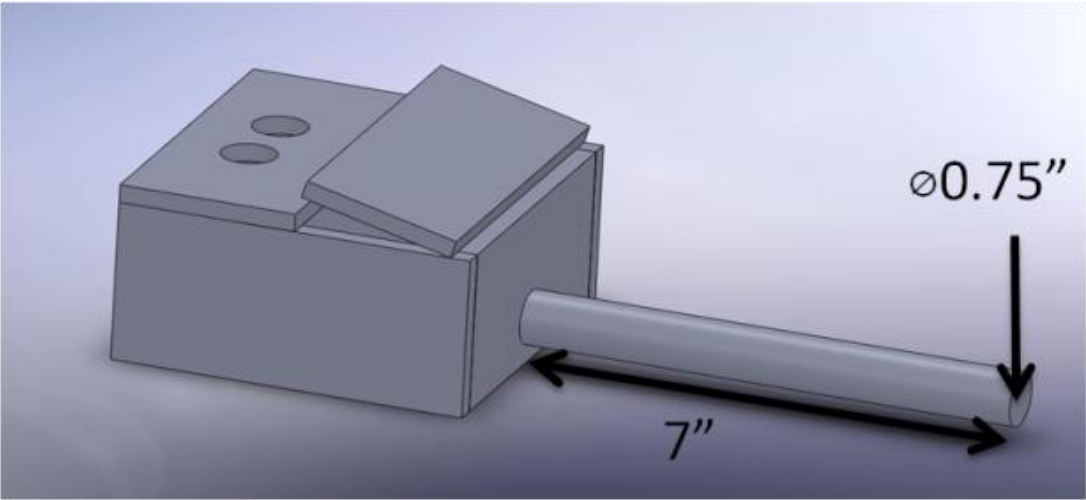
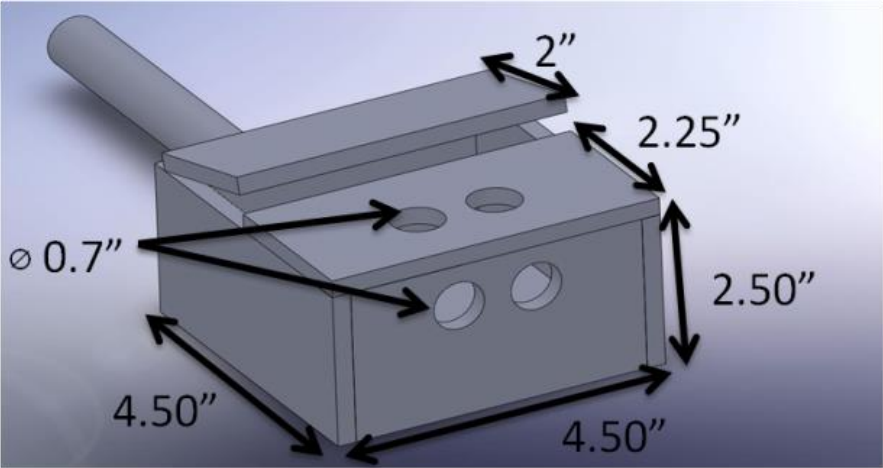


Fig. 12.19. Casing of the Rumble Aide.



CHAPTER 13

TULANE UNIVERSITY

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WHISPERLIFT INTEGRATIVE SEATING ENVIRONMENT

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Client Coordinator: Sister Marie Noel

Benjamin Banneker Elementary, New Orleans, LA 70118:

Supervising Professors: Cedric F. Walker, Ph.D. P.E., Ronald C. Anderson, Ph.D.

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INTRODUCTION

Our client has arthrogriposis multiplex congenita, a condition often manifested by missing muscles and ankylosed joints. She is able to walk, but has difficulty getting into or out of standard classroom seats. Elevating her hands to a school desk to manipulate writing instruments and books tires her because she must contort her body to use the standard seating and desks at school.

We designed a battery powered elevating seat that she can sit on and adjust independently. This gives her better access to desktops and computers. The seat has wheels so that she can take it from classroom to classroom. However, the design prevents rolling whenever the seat is elevated.

An additional problem is book and pencil retrieval. Most students carry these in backpacks that they either place beneath their desk or hang from their chair. Once seated, our client must ask a teacher or classmate to retrieve the correct item for the current activity. This design also includes a book and pencil holder that the client can load before she sits down. This fastens to the desktop within her reach when she is seated.

SUMMARY OF IMPACT

Our client liked the chair immediately. She enjoyed that it looks similar to other school chairs, and that its operation is quiet and unobtrusive. The control interface is intuitive and simple, so that both the client and teacher could operate it immediately. Its onboard battery permits operation away from electrical outlets.

The client is able to move this system between classrooms by herself. She no longer has to sit uncomfortably to write on the desk surface or use a keyboard at a computer. When she first used the



Fig. 13.1. Whisperlift chair with control cable.



Fig. 13.2. Book and pencil holder.

chair, her teacher said that it was the first time he had seen her sit with her back straight. The school

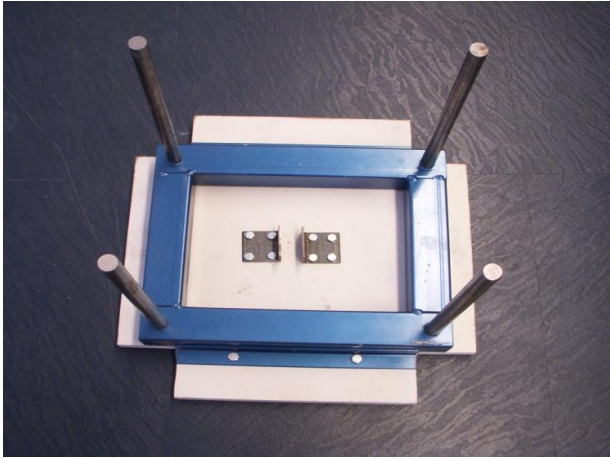


Fig. 13.3. Baseplate with guide rods.

supply holders have also increased the client's independence as they keep her school materials within reach at all times.

TECHNICAL DESCRIPTION

The lifting chair uses a standard school chair mounted on a wooden frame. Within the wooden frame is a guide system consisting of four 1" metal rods. These rods fasten to a metal plate that is, in turn, fastened to the plywood baseplate. This restricts baseplate motion to one degree of freedom relative to the chair frame.

Centered in this assembly is a linear actuator originally designed for hospital beds. This actuator has a 150 mm stroke and a 4000 N force capability and includes a controller and integral battery.

The chair has two modes: mobility mode and lifting mode. The mode is dependent on actuator position and requires no operator action other than to control the single actuator. The chair is in the mobility mode when the actuator is retracted. The baseplate is lifted from the floor and all the weight is on the four caster wheels. These permit the chair to be rolled from place to place.

In the lifting mode, the actuator extends the baseplate to the floor. This puts the weight of the chair and occupant on the baseplate, lifting the chair and its caster wheels from the floor. In this mode the chair won't rotate or move laterally, but its height is continuously adjustable.



Fig. 13.4. Chair in lifting mode.



Fig. 13.5. Chair in mobility mode.

The supply holders are made from wood and a commercially available desk pencil holder. Toggle clamps reversibly attach it to a desk or tabletop, permitting transfer from one desk to another. Moving supply holders along with the chair can create complications, so two tailor-made ones for the classrooms our client uses most were constructed.

The cost of materials and supplies of this design is \$900.

ALL-TERRAIN TRANSFER DEVICE WITH DETACHABLE SEAT

*Team Designers: Donald R. Campbell, Alison Douglas, Xun Michael Liu:
Client Coordinator: Dan Forman
Louisiana Outdoors Outreach Program
Supervising Professors: Cedric F. Walker, Ph.D., P.E., W. Lee Murfee, Ph.D.
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INTRODUCTION

The purpose of the Louisiana Outdoors Outreach Program (LOOP) is to provide a unique hands-on experience to educational and recreational outdoor programs, activities, and services to underprivileged youth. One activity is a canoe trip for students from local schools. Difficulties with students with limited strength, mobility, or motor control arise in three specific areas: 1) when transferring between a bus or van and the canoe, 2) ingress and egress from the canoe, and 3) seating support within the canoe.

The launch site terrain is often too steep, rough, and muddy for ordinary wheelchairs to easily traverse. Lifting the students to place them into the canoe strained the backs of the staff. Often additional staff would be required to support and stabilize the student continuously during the ride.

The All-Terrain Transfer Device (ATTD) addresses these main concerns. It is a wheelchair with two major parts: a wheeled base and a removable seat with trunk and leg support. The wheeled base permits transport over rough or soft ground. The seat provides grips for the staff to hoist the seat with the student from the base to the canoe. The seat provides back support and stability for the student during the canoe ride.

SUMMARY OF IMPACT

With the new ATTD system, the staff is no longer required to carry the clients to the canoes or support them during their canoe ride. This reduces physical strain on the staff while simultaneously giving the clients more freedom and independence. Ease of transfer into and out of the canoe is also enhanced by the provision of lifting handles.



Fig. 13.6. All-Terrain Transfer Device.



Fig. 13.7. Staffer demonstrating seat portion in a canoe.

The seat itself requires no fastening in the canoe. For safety and convenience it will float in water. It easily accommodates the mandatory life jackets. The low profile of the seat permits paddle use. An added benefit is the seat's portability for use during picnic stops during the ride.

TECHNICAL DESCRIPTION

The ATTD consists of two major components: the wheeled base and the chair frame. The wheeled base, shown by Fig. 13.6, contains the all-terrain wheels on a rectangular wooden frame, handles for pushing the device on land, and a place to hang the wheel chocks. The chocks are a simple and obvious way to keep the base from rolling on a slope.

The base is a simple wooden frame made from 2" x 4" and 2" x 6" (nominal) stock. The joints are fastened with carriage bolts. Uprights in the rear support handles that are convenient for pushing. The frame has a crosspiece and lugs that engage with the seat. This prevents improper placement of the seat on the base and provides a secure fastening so that the seat will not slide off the base during transport. Both the base and the seat are marked with orange cues to help guide proper alignment when the seat is being placed on the base. The front two wheels are fixed, but the rear two roll on casters. This provides adequate maneuverability and far better steering than having all four wheels on casters.

Fig. 13.9 shows the seat. The bottom and back are pieces from a commercially available deck chair with the frame removed. These are secured in a frame made from 2" x 2" wood members.

The seat structure contains a leg rest that supports the legs during transport and transfer, so that legs don't bump into obstructions or get caught beneath the seat.



Fig. 13.8. Wheeled base with chocks in storage position.



Fig. 13.9. Seat portion of transfer device.

Nylon rope loops attached to the frame allow for seat lifting by the staff. These loops are an improvement on the originally designed rigid lifting handles because they are lighter and fold out of the way between lifts. PVC pipe (1.5") forms the handles on each. They are filled with polymer foam to provide buoyancy and to keep them from slipping on the rope.

EVACUATION COT DESIGNS

Team Designers: Xavier Alvarez, Lin Bai, James Gallagher, Todd Johnson:

Client Coordinator: Manda Mountain

St. Margaret's Nursing Home, New Orleans, LA 70117:

Supervising Professors: Annette Oertling, Ph.D., W. Lee Murfee, Ph.D.

Department of Biomedical Engineering

Tulane University

New Orleans, Louisiana 70118

INTRODUCTION

A local nursing home has an evacuation plan to transfer its residents and emergency staff to a remote site, a church gymnasium. The home had over a hundred trundle beds for the residents for the evacuation for Hurricane Katrina. This was a very stressful event complicated by the beds themselves. Problems with the beds include that they are low to the floor requiring the staff to bend or kneel to service the residents, and would tip over if a person were to sit on the edge. The legs also sometimes fold, collapsing one end of the bed, and the beds are also unable to accommodate the various necessary head elevations for many residents.

The home is concerned about large costs in replacing all the existing beds. Designs need to be cost effective and repeatable by the facility staff using their technical knowledge and skills and available tools and materials.

This design includes a two-part solution. The first part is a modification of the existing trundle beds to make them more safe and usable. The second is a modification of a commercial cot that has head elevating capability. For each of these, manuals and templates for the staff to use in making the modifications are included.

Existing cot stability is enhanced by removing the original caster wheels and replacing them with 2" x 3" wooden feet. These extended the legs to the full width of the bed stabilizing it so that weight put on the edge of the bed no longer overturns it. The feet also add to the height of the bed, raising the patients to a more comfortable position for the staff to give proper care.

A commercial folding cot with head elevation capabilities is used for that requirement. Handrails are added to ensure safety for use by the facility's residents on feeding tubes.



Fig. 13.10. Modified trundle bed showing new feet, wing nuts, and bungee cord.

SUMMARY OF IMPACT

Many of the residents have sufficient mobility to get into and out of bed independently, and the staff generally encourages this. When the beds tipped or collapsed, there was the danger of injury, so independence was discouraged during the evacuation. The bed modifications alleviate this problem.

The simple modifications to existing cots for the head elevation requirement are a perfect solution. Upon presentation, Professional staff and administrators stated "This is great. It meets all our needs."

This two-part solution is also economic for our clients.

TECHNICAL DESCRIPTION

Modification of the Existing Bed

When deployed, the existing trundle bed measures 74" x 31" by 11" high. It has casters on the center two of four legs for ease of transport when folded, and they are inset a half foot from the edge of the bed.



Fig. 13.11. Modification of the new cot.



Fig. 13.12. Rail attachment hardware.



Fig. 13.13. Portion of template for shaping the bed rail. The rail is shown in black.

The stability of the bed is improved by removing the center casters and adding wooden studs to provide feet on all four legs (Fig. 13.10). These feet, made of 2" x 3" stock are attached using hanger bolts through existing holes in the steel frame. Lock washers and wing nuts allow the feet to be secured without the use of tools. The addition of these feet, along with the home's selection of a thicker mattress, raises the bed to a more comfortable height.

To prevent the collapsing of the legs at the head and foot of the bed, eyelet screws are attached to the wooden studs and a bungee cord wrapped around the frame is secured by the eyelet screw. This, plus the removal of the casters on the center legs, reduced the tendency for the legs to fold under.

Casters are added to the sides of the center feet to enable rolling of the bed when it is folded. These casters do not touch the floor when the bed is deployed.

An instruction manual is included so the staff may assemble, disassemble, or alter the beds as needed.

The parts for modification are \$27.30 per bed.

Modification Of The New Cot

For the head elevating feature required by the tube-feeding residents, the MedSled Products Surge Cot #4 is used. It has a built-in adjustable head elevator, low maintenance requirements, is not excessively expensive and is collapsible for storage. Its design includes feet on the outside four corners, so it is inherently more stable than the original trundle beds. It accepts the home's preferred mattress, and its dimensions (78" x 32" by 18") make it suitable for both the residents and the staff.

Our design requires no mechanical modifications to the cot itself. Since the design of the cot makes it difficult to change the head elevation while the bed is occupied, a nylon strap that would operate the latch of the elevator mechanism, while the staff member was supporting the head frame, is included in the design. This modification makes changing head elevation of a patient quick and easy for a single staff member.

This cot lacks one important feature: a side rail that the residents may use as a handle for sitting up or stabilizing entry or exit from the bed. A rail of 1" PVC pipe that can go on either side of the cot is also included. The PVC rail is stiff and strong enough for this application. The rail attaches to the frame using standard piping support hardware. In order for the staff to replicate the rail, a full-sized wooden template that holds the piping in shape is included. The commercial cot lists at \$189.95, and the cost of the parts required to adapt each cot is \$20.23, for a total of \$210.18 per unit.

COMPACT LIFT DEVICE WITH RECUMBENT SLING

Team Designers: Austin Dobbins, John B Huck, Joshua W Thieman:

Client Coordinator: Scott Songy:

Supervising Professors: David A. Rice, Ph.D., P.E. and Cedric Walker, Phd, P.E.

Department of Biomedical Engineering

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INTRODUCTION

Our client has quadriplegia caused by spinal injury. He is usually assisted by family members who are unable to lift him without a hoist. He wishes to travel with his family using several modes of transportation, but the lack of a suitable lift for transfers hinders the process. He requires a lift that can be easily transported by both private and commercial vehicles. Since his power chair is semi-recumbent, he needs a sling system that enables him to remain recumbent during a transfer.

Most patient lifts are too heavy and cumbersome to transport easily. Those that are light and collapsible do not accommodate our client's size and sling constraints. Fig. 13.14 shows our lift design. The structure is similar to a Hoyer lift, but we added two major features: a hinge on the base of the mast enables the mast to fold between the support legs, and an angled boom that curves around the hydraulic jack during stowage.

Maintaining recumbence during transfer requires a new sling and cradle design (Fig. 13.15). The design includes an 8-point adjustable cradle system and a two-part sling. Having the sling in two parts makes it easier for the caregivers to place it under our client. Each sling part has four suspension points for good stability. The two parts clip together for safety and comfort during transfer.

SUMMARY OF IMPACT

This system design meets the goal of enabling our client to use both private and commercial transportation. Weight and size of commercial lifts preclude easy transport by air or automobile as well as difficulty in handling them between transport modes.

This system enables the family to lift and transfer our client as needed. The system folds and stows



Fig. 13.14. Computer rendering of the collapsible hoist frame in both its stowed and deployed configurations.

without tools. In the folded position it meets the weight and size limits for checked luggage on airlines. Further, it rolls easily on its casters and can be lifted into an automobile by one person.

TECHNICAL DESCRIPTION

The lift device uses a combination of 2" x 2" x 3/16" square aluminum tubing for the main structure. Steel components are fabricated from 1/4" plate and 2.5" x 2.5" x 3/16" square tubing. The steel components connect the structure and provide attachment points for casters, the hydraulic jack, and other rigging and attachment points. All hinge joints (leg swivels, mast to base, and boom to mast) are fitted with 1/4" hitch pins as axles. Removable,

ball-detent hitch pins lock in place each of these hinges. The metal framing provides a strength factor of safety of 3 for our client.

The wheels support the load with a large safety factor, yet have a profile low enough to fit under our client's wheelchair and most commercial beds. The wheels at the tips of the legs swivel, but those beneath the mast do not.

Standard 80/20 T-slot aluminum extrusions and hardware, widely used in industrial prototyping, form the frame of the cradle. A shop specializing in awning manufacture fabricated the sling. A commercially available hand operated 2-ton hydraulic jack with 15" travel provides the lifting force.

An eye-bolt at the tip of the boom with a heavy duty quick connect chain link permits connection of the cradle to the lift.

When folded, the lift will fit into a 20" x 12" x 60" volume. This meets the common length limit of 62" for checked luggage. Fabrication largely with aluminum permits meeting the weight limits.

The overall cost of the system excluding labor is approximately \$700. This includes the sling (\$150) and jack (\$80).



Fig. 13.15. Hoist with cradle in its folded or travel configuration.



Fig. 13.16. Team members demonstrating the hoist and sling. Note the 8-point sling cradle and the straps connecting the two parts of the sling.

HYDRAULIC CHANGING TABLE

Team Designers: Shanna Connolly, Jardin Leleux, Garrett Gros

Client Coordinator: Sister Marie Noel

Supervising Professors: Cedric F. Walker, Ph.D. and W. Lee Murfee, Ph.D.

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INTRODUCTION

A local elementary school has several students who need special care including diaper changing and other hygienic procedures. These students spend significant time reclining on floor mats. This makes it difficult for the staff that must either lift the students onto a changing table or service them while they lie on their mats.

This design focuses on a changing table and transfer system to make it easier for both the staff and the students to accomplish this task. A commercial lift table with a foot powered hydraulic jack forms the mechanism of the changing table. The top and base of the table are lengthened and provided with a mattress pad and safety rails.

The mattress pad is stiffened internally along its edges with PVC pipe and provided with pull straps (Fig. 13.19). This allows the mattress to serve as a transfer pad. For lifting from the floor, the student is slid onto the transfer pad. Then the transfer pad is slid onto an air mattress. Inflating the air mattress raises the student to the lowest height of the changing table. Pulling the pad from the air mattress to the lift is a simple lateral transfer. Then the lift is pumped to a height convenient for the staff. This procedure is reversed to place the student back on the floor.

SUMMARY OF IMPACT

The device is used primarily for one student, a 14 year old boy with severe disabilities. He cannot ambulate or sit without support. He generally lies on a floor pad throughout the day. With the new system, his aides no longer have to stoop or kneel to change him. They also found that, until he gains more weight, that our transfer pad may be used directly between his floor pad and the changing table. In addition, the changing table's wheels provide for easy transport from room to room and to evacuate in case of emergency.



Fig. 13.17. Team members demonstrating changing table in its raised position.



Fig. 13.18. Table in lowered position.

At home, the student plays in an oversized infant's playpen. The student's mother would like a similar table that she can use at home.

TECHNICAL DESCRIPTION

The lifting table is modified from the Hydraulic Scissor Table Cart (Model 93116, Harbor Freight Tools, Camarillo, CA). This table is rated to lift 1000 pounds from 11" to 34.5". The table rolls on 5" casters.

The original table width and length is 20" x 32". This is extended to 72"L x 30"W. Two 2" x 2" 11 gage lengths of steel structural tubing were cut to 69" each and fastened to the 2.125" metal skirt of the existing table top using four 5/16" steel socket-head bolts each. A Samsonite Premium Commercial folding table top (Mfr PN CSC36170PTS1-36170PTS1-1) is fastened to the steel extensions via four 5/16" steel socket-head bolts.

For stability, two lengths of the 2" square steel structural tubing are cut to 61" and affixed to the lower rolling frame of the existing cart using five 5/16" black steel socket-head bolts each. To relocate the fixed casters of the original cart, a 29" length of steel tubing is fastened to the upper surface of the lower metal extensions with two 1/2" bolts. 1/8" thick metal plates are cut and welded to the lower surface of this 29" metal crossbar to serve as mounting surfaces for the fixed casters.

To eliminate play in the existing scissor-legs and cope with the added moment produced by increasing the table overhang, the scissor tracks are bolstered using metal inserts. The upper tracks are reinforced with 1/8" thick 1" x 1" angled black steel fastened to the inside of the track via five countersunk #8 bolts each. The lower tracks are reinforced using 1" wide 14ga Aluminum flat-bar bolted to the lower surface of the track using four #8 bolts each.

For safety, three 1" x 6" Douglas fir planks serve as railings along the tabletop edges. Two are fixed. A third side is fastened to the tabletop using four heavy duty hinges bolted through the table. This side is able to fold 180 degrees to increase access to the table surface during transfers. It is held in the



Fig. 13.19. Fold-down side rail with gate latch

upright position by a heavy duty universal gate latch. A small pin is mounted to the hinged plank and a self-latching hitch mounted to the nearest fixed railing receives the pin as the hinged plank reaches the upright position. The latch is located to be within reach of the operator and not easily accessed by someone on the table surface.

A 2" thick vinyl covered foam mat is modified as follows. Two lengths of schedule 40 PVC are hand-sewn to the inner seams of the vinyl covering. Nylon straps are fastened to the PVC and extended through the vinyl covering to the opposite side, under the other length of PVC and through the opposite seam. They then loop back through the seam and return to attach to the original length of PVC. This forms the handles of the continuous nylon strap. The same is done for the opposing side. When in tension, the nylon straps tighten and transfer forces to the PVC opposite the handles in tension. Reactionary forces cause the PVC to move upward and in the direction of tension, forcing the vinyl mat to "cup" slightly. This action makes sliding the mat easier, and "hugs" the student more securely in place while the straps are pulled.

The air mattress and pump are standard and are available commercially.

The cost of replicating this design is \$860, excluding labor.



CHAPTER 14
UNIVERSITY OF ALABAMA AT
BIRMINGHAM

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WHEELCHAIR LIFT FOR ADULTS WITH CEREBRAL PALSY

Designers: Luis Font, Brad Jones

Client Coordinator: Deborah Gustin, OTR/L; LINCPPoint, UCP of Greater Birmingham

Supervising Professors: Dr. Alan Eberhardt¹, Dr. Tina Oliver²

1 Department of Biomedical Engineering, 2 Department of Mechanical Engineering

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INTRODUCTION

LINCPPoint provides employment opportunities through a program called Gone for Good, which employs disabled adults to sort paper on a conveyor belt for shredding. The majority of their employees are restricted by a wheelchair, thus they are unable to reach the conveyor line. The client requests a wheelchair lift that permits a wheelchair user to reach the work area, thus allowing them to do their daily duties. A prototype was completed last year with NSF RAPD support; however, the device had some limitations, including mobility, range of motion and an inconvenient collection of wires that were deemed hazardous by the staff at LINCPPoint. The goal of this project is to modify the existing wheelchair lift, to reduce weight and footprint, improve mobility, and improve functionality in the working environment. This will allow the user ample height to reach the conveyor line as well as allow staff members at LINCPPoint to move the lift when not in use. The device will support the weight of the heaviest wheelchair and user, which is approximated to be 400 lbs. Each user is allowed to work a maximum of 2.5 hours each day, thus the device must maintain constant elevation throughout their shift.

SUMMARY OF IMPACT

This device will allow the users ample height to reach the conveyor line, as well as allow staff members at LINCPPoint to move the lift when not in use. The device has not yet been delivered; however, we anticipate a very positive impact on the LINCPPoint facility, allowing new users to participate

in the Gone for Good program activities. We hope the system proves to be durable and provides years of safe use for the staff and workers at LINCPPoint.

TECHNICAL DESCRIPTION

After meeting with the staff at LINCPPoint, a battery-powered mechanism was determined to be the best solution to accommodate their request to eliminate the wires. The design allows the employees to use the wheelchair lift in any place in the facility without depending on the length of the power cord and the electricity outlets in the facility. Two electric twelve-volt jacks that run from a 12 volt battery provide the lifting mechanism. Each jack has a lift capacity of 2200 pounds and the maximum load used for the design was 1100 pounds, resulting in a safety factor well above 3. The footprint of the design is not changed since the employees at LINCPPoint are satisfied with the size of the previous design. The final design consists of a base that supports a platform and the lift mechanism. The base is constructed of tube steel and is able to withstand the weight that the actuators push against it and has a "pull handle" for easy transportation. A platform with dimensions of 30x40 inches is constructed with a steel mesh base overlaid by bamboo flooring material to accommodate the user in the wheelchair. A battery charger is attached to provide easy re-charging of the battery. Spring loaded casters are kept from the first design, which allow the device to roll when unloaded.

The completed design is shown in Fig. 14.1, and the total cost for the completed device is \$1081.

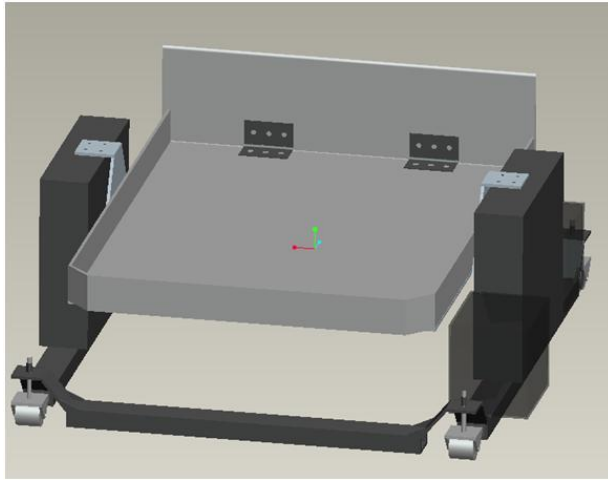


Fig. 14.1. CAD drawing (left) and completed prototype wheelchair lift (right) for LINCPoint. The design features battery powered car jacks for lift, reduced weight as compared to an earlier design, and spring loaded casters for mobility when not in use.

AN ADULT SENSORY STIMULATION STATION

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Birmingham, Alabama 35294

INTRODUCTION

LINCPPoint is a non-profit organization that provides a variety of opportunities to patients ranging from physical therapy to a paid work experience. Patients with more severe developmental disorders, those most likely to take advantage of aural-visual stimulatory devices, are cared for by attending personnel and are provided everything from physical therapy and skill training to craft projects and other stimulatory tasks designed to improve quality of life. LINCPPoint is seeking to expand their capabilities by adding an aural-visual stimulatory device to their therapy inventory. The student design team has the task of developing an interactive adult sensory stimulatory station for use, at any one time, by four to six developmentally challenged individuals while at the LINCPPoint facility. In addition to the interactive features, it was requested that the staff have some interaction and control.

SUMMARY OF IMPACT

Patients with cerebral palsy can display sensation, perception, concept formation, and symbol formulation deficiencies, which can greatly inhibit learning, reasoning, and general cognitive function. Sensory stimulation is one of the older treatment methods used in the care of CP patients. Love (1969) evaluated the effects of aural stimulation, visual stimulation, and combined aural-visual stimulation on CP patient wellness and found that combined

aural-visual treatment resulted in improved motor control for articulation. These results illustrate the benefits of combined aural-visual stimulation as a non-evasive treatment method for CP that clearly produces marked improvements in CP patient motor function.

The completed design was delivered to LINCPPoint and early reports are overwhelmingly positive, indicating that the users enjoy the device and that the staff find it extremely useful in their interactions with the users.

TECHNICAL DESCRIPTION

The device is constructed of wood, with an octagonal base to provide stability, riding on six casters for mobility. A pull handle is attached to the device along with a label indicating that movement of the device should be performed by pulling the device using the handle. A stability analysis was performed that ensured the device would not tip during transport from room to room. The device contains an interactive bubble tube, removable tactile boards, rope lighting, a laptop connected to a projector and speakers, as well as an aroma therapy element. Large button, hand-held switches allow the user to control the colored lights in the bubble tube (red, yellow or blue), while the LINCPPoint staff access the laptop to control the audio/video.

The laptop is a donation, bringing the final costs for the design to \$1,256.

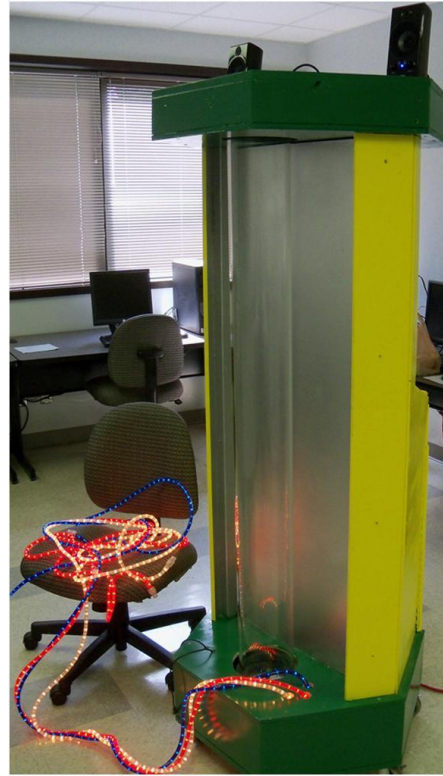
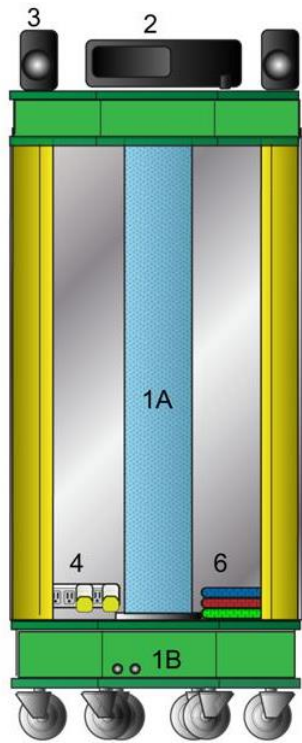


Fig. 14.2. (Left) Schematic and (Right) completed sensory stimulation device including: bubble tube (1A), interactive controls of the bubble tube (1B), projector (2), speakers (3), aroma therapy (4), tactile boards (5), and rope lights (6).

UNIVERSAL HEADREST ASSESSMENT DEVICE

Designers: Allison Wade, Justin Lesley, Melissa Schaefer, and Komi Vovor Dassu
Client Coordinator: Michael Smith, PT; Hand in Hand, UCP of Greater Birmingham
Supervising Professor: Alan Eberhardt, PhD
Department of Biomedical Engineering
University of Alabama at Birmingham
Birmingham, Alabama 35294

INTRODUCTION

Many individuals who are confined to wheelchairs are unable to hold their heads up due to a lack of control of their neck muscles. In these situations, headrests are attached to the wheelchair in order to help the individual hold their head upright and to be able to see straight in front of them. However, currently available headrests can be very expensive and difficult to adjust. Michael Smith, physical therapist at Hand in Hand, expressed the need for a wheelchair headrest assessment device that could be transferred to a number of different wheelchairs, and able to accommodate children between the ages of 2 and 5 years old. He requested a headrest assessment device that can accommodate a variety of headrest pads and arrangements such that it can be used to test the best headrest type for each specific child. It also needs to be easily adjusted to work with a variety of wheelchair and patient sizes.

SUMMARY OF IMPACT

The completed device was delivered to Hand in Hand and early reports indicate that the design was successful in meeting the project goals. It easily adapts to the variety of wheelchairs used at the daycare and also provides for an assortment of headrest pads to be easily interchanged to determine the optimum configuration.

TECHNICAL DESCRIPTION

After analyzing all options, the Otto Bock Headrest Adapter Kit was selected for mounting this headrest assessment device to the wheelchair frame. S.T.S clamps are used to attach the adapter kit to the chair and three sizes of S.T.S clamps (3/4", 7/8", and 1") were purchased to ensure that this device can be used with a variety of wheelchair sizes. For the headrest mount subsystem, three 6061 aluminum rods (1/2" x 24") are mounted to the back of Otto Bock Headrest Adapter Kit. One rod was placed in the center of the chair to accommodate the neck rest pad and the generic centered headrest pads. The other aluminum rods are placed on either side of the center rod to accommodate a range of widths for the cheek and temple pads. These outer rods will have the ability to slide horizontally across the Otto Bock Headrest Adapter Kit and be locked in place in any desired position. Each vertical rod incorporates a machined clamp which also holds the headrest bar. A custom cube clamping system attaches the headrest bars to the vertical neck pieces.

The final cost of the device is \$673.82.

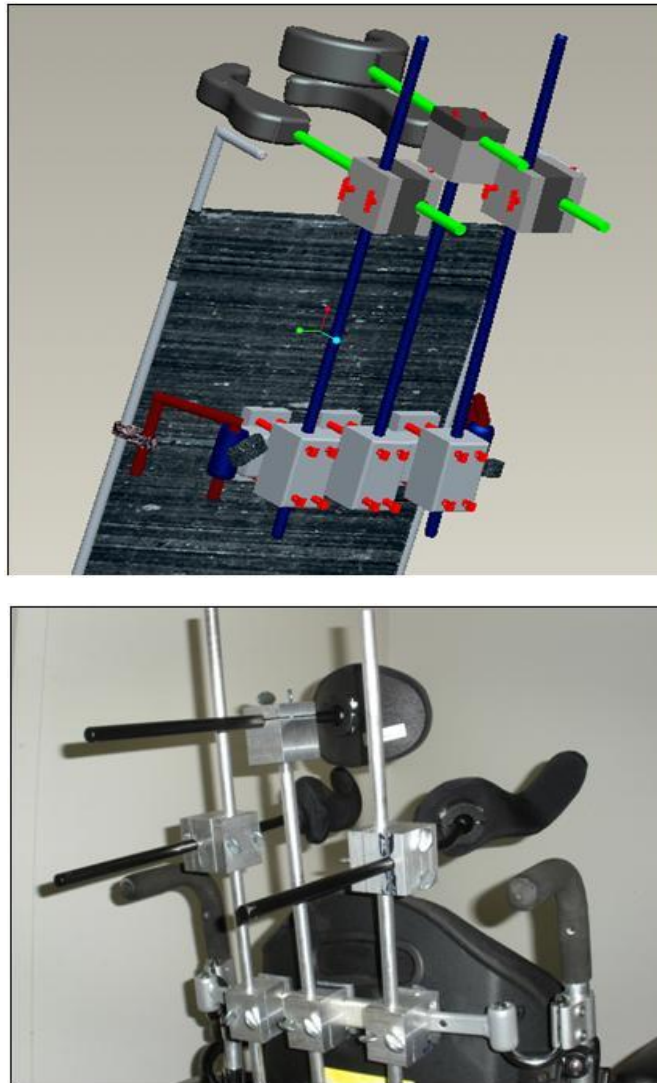


Fig. 14.3. CAD drawing (top) and photo (bottom) of completed wheelchair headrest assessment device. Tennis balls were added to each of the protruding bars to ensure safety during use.

WHEELCHAIR TRAINER

Designers: Olajide Akinsanya, Ricky N. Bowling II, Reshu Saini, and Wassamon Viriyakitja

Client Coordinator: Mr. Billy Ronilo at Children's Rehabilitation Services (CRS)

Supervising Professor: Alan Eberhardt, PhD

Department of Biomedical Engineering

University of Alabama at Birmingham

Birmingham, Alabama 35294

INTRODUCTION

Children's Rehabilitation Services (CRS) provides rehabilitation services to an estimated 175 children per year. Mr. Billy Ronilo is a physical therapist working with CRS. Many of Mr. Ronilo's clients include children ages 2-4 with cerebral palsy (CP). Children visit to learn how to operate powered wheelchairs. However, in some situations children cannot travel to CRS, so Mr. Ronilo must train them at home. At the time the project began, the client used a rear wheel drive Invacare Power Tiger (PT1) and a center wheel drive Invacare Storm TDX5 for training purposes. Mr. Ronilo employed the two wheelchair trainers because some children operate the wheelchairs more effectively with their head, while others are more comfortable operating wheelchairs with their hands or feet. The objective of the present design is use the two trainers to create a single wheelchair trainer for children ages 2-4 with CP capable of both joystick and head array control. The design needs to include a larger Invacare Power Tiger base (PT2 provided by CRS) with Orbit seating and tilting capabilities and a novel, transferable joystick mounting device capable of multiple degrees of freedom to accommodate a defined range of motion.

SUMMARY OF IMPACT

According to physical therapist, Mr. Billy Ronilo, before an insurance company is willing to provide powered wheelchairs to children with CP, the children must demonstrate their ability to use the wheelchair effectively. The completed device allows Mr. Ronilo to more efficiently and effectively use his travel time to train children with disabilities on wheelchair operation.

TECHNICAL DESCRIPTION

The first task involved transferring components from the PT1 and Storm TDX5. Using a simple toolkit, including Allen wrenches, hand wrenches, and power tools, the student team was able to transfer the head array and control from the Storm TDX5 and the batteries, seat, control box, and joystick from the PT1 to PT2. The team was also able to unplug the Storm TDX5 control box with the head array attached, and plug it directly into the PT1 control box. A simple key sequence on a hand-held Invacare programmer is used to program the electronics to accept the head array and control box. To address the need for an emergency stop mechanism, a ribbon switch is plugged into the Storm TDX5 control box, which responds to bending and allows the attendant to stop the wheelchair. The Storm TDX5 control box, which contains inputs for the head array and the kill switch, plugs directly into the PT1 control box, which contains an input for the PT1 joystick. Together the control boxes provide wheelchair mobility using either the joystick in the first drive mode or head array system in the second drive mode. The joystick of the wheelchair trainer must be highly adjustable so that the client can access the optimal joystick position for each child at CRS. In order to allow for joystick adjustability, an easily transferable joystick mounting device capable of accommodating a defined range of motion (as listed in the design constraints) is included in the design. In addition to being adjustable, the mounting device is easily transferable. Our clients can use the device for children who need either hand or foot control.

The final device and fully functional wheelchair are shown in Figs 14.4 and 14.5. The total cost is \$270.03.

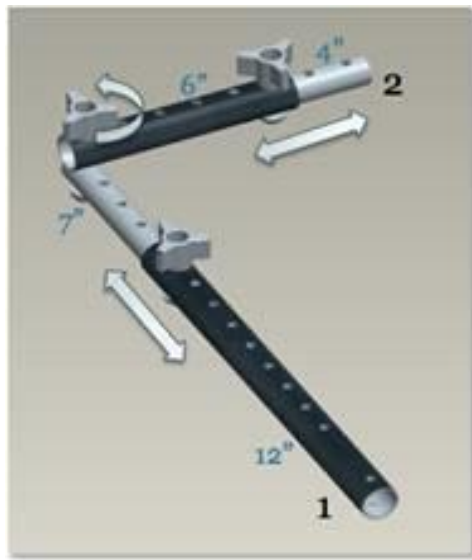


Fig. 14.4. CAD drawing of device.



Fig. 14.5. Photo (left) of the adjust-able joystick mount, which was designed to be attachable at two sites permitting hand control (right) or foot control.

CLIMBING WALL FOR CHILDREN WITH SPECIAL NEEDS

Designers: Jason Quinn, Todd M. Hyche, Adrienne Elliott, Ashley Farr, Brian Webber

Client Coordinator: Mary Beth Moses; The Bell Center of Homewood

Supervising Professor: Alan Eberhardt, PhD

Department of Biomedical Engineering

University of Alabama at Birmingham

Birmingham, Alabama 35294

INTRODUCTION

The Bell Center of Homewood requested a climbing apparatus for children ages 2 to 4 with varying levels of disabilities. The design is constrained to an area of 56 square feet and a maximum platform height of 3 feet. Ms. Mary Beth Moses, a physical therapist at the Bell Center, requested that two ramps be included in the design. To account for varying degrees of disability, one ramp was to be angled at a 45° and the other at a 30° from the ground surface. As requested by the client, toys and a slide were to be incorporated into the structure to provide rewards and to encourage children to climb the apparatus. The design is capable of being fully disassembled with most of the components being stored within the base.

SUMMARY OF IMPACT

The completed device was delivered and early reports indicate that the device has been extremely well received by the users and staff at the Bell Center. The climbing wall accommodates children of varying sizes and levels of ability and the curved slide allows one staff to handle more than one child at a time. The ease of disassembly is especially appreciated along with the ability to store the parts within the base of the system.

TECHNICAL DESCRIPTION

The two ramps, base walls, and platform are composed of Nida-Core/E-glass sandwich

composites. The sandwich composite structure is made by vacuum processing. The process involves layering the composite. Each side of the 1.5 inch Nida-core is coated with vinyl ester resin and then the two E-glass woven rovings are placed on each side. The composite is then placed within a bagging material and a vacuum is pulled while curing. Attachment points are needed so that screws and bolts are secure in the design. Holes are drilled in each panel that requires fasteners. Resin with chopped glass fiber is used to fill the holes. C-channels are added to the edges to provide a finished edge and also provide support to prevent the composite from delaminating.

The four walls constructed form the perimeter of the base. Each wall is attached to each other using two 4" x 4" brackets, secured 8 inches from the top and bottom from every corner using 0.25 inch fasteners specified by ASTM A307. The safety walls and ramps are attached to the base by custom engineered brackets. The base has a four point bolt arrangement. The ramps are made with 1 inch diameter aluminum pipes that slide into holes on the base and are secured using 0.25 inch pins. The pins are removable so that the apparatus can be disassembled. The slide, periscope, and wheel are purchased directly from a manufacturer.

The total cost of the design is \$970.

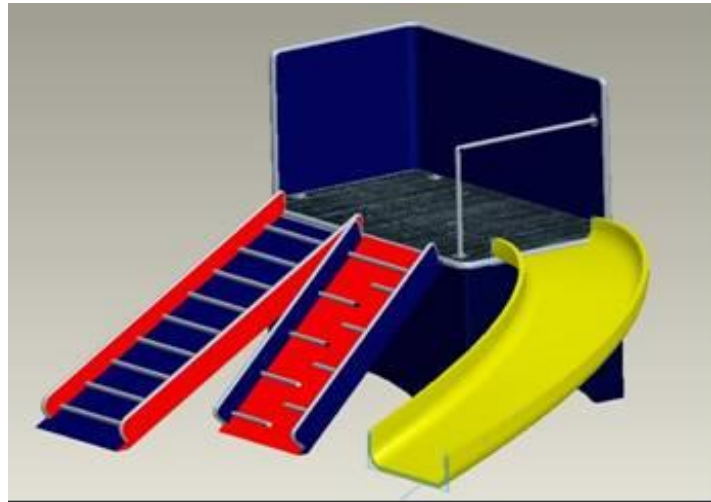


Fig. 14.6. CAD drawing of climbing wall device for children.



Fig. 14.7. Photo of completed climbing wall device for children at the Bell Center. The composite structure features two climbing surfaces for varying levels of ability, and the entire structure is easily disassembled for storage.

STANDING BOXES FOR ADULTS WITH CEREBRAL PALSY

Designers: Eight teams of four students = 32 freshman engineering students
Client Coordinator: Deborah Gustin, OTR/L; LINCPoint, UCP of Greater Birmingham
Supervising Professor: Alan Eberhardt, PhD
Department of Biomedical Engineering
University of Alabama at Birmingham
Birmingham, Alabama 35294

INTRODUCTION

LincPoint serves people with disabilities by providing them access to occupational and physical therapists as well as job training. Cerebral Palsy is a disorder caused by abnormal development or damage to one or more parts of the brain. The problems associated with this disorder are difficulty controlling and coordinating muscles, walking, sitting, standing, and many other motor skills. The staff at LINCPoint requested the design of an enclosed standing box with an adjustable height table top at an affordable cost, which is also stable, mobile, and lightweight. The design constraints of this project are cost (\$250/device), time (5 weeks), mobility (device was to be moveable by female staff

when not in use); and adjustability (height of working surface should adjust to accommodate different sized adults. The devices must also be safe and aesthetically pleasing.

SUMMARY OF IMPACT

Each student team completed the design task within the time allowed and under budget. The devices range from simple wooden structures with ramps and hand-driven adjusters, to complex devices that incorporate a car jack to adjust the height of the working surface. Upon completion, the staff inspected the devices and chose four to take back with them for use at LINCPoint. Examples of the standing boxes are illustrated in Figure 14.8.

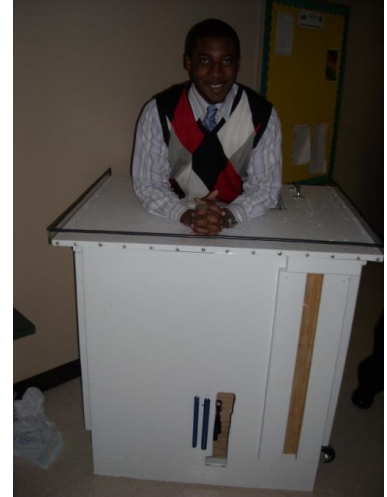


Fig. 14.8. Example adjustable height standing boxes completed by the freshman engineers in EGR 100 Introduction to Engineering. Each of these devices, along with one other (not shown) were selected for use by staff at LINCPoint to serve adults with cerebral palsy.



CHAPTER 15

UNIVERSITY OF CONNECTICUT

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THE HANSS WITH BIOFEEDBACK AND MULTI-FUNCTION TABLE: ENCOURAGING CORRECT ANATOMICAL SEATED POSITIONING FOR A CHILD WITH CEREBRAL PALSY

Designers: Mark Galiette, Liz Hufnagel, Dan Tichon

Supervising Professor: Dr. John Enderle

Biomedical Engineering

University of Connecticut

Storrs, CT 06269

INTRODUCTION

The client is a 10 year old girl with cerebral palsy. She spends most of her time throughout the day in a power wheelchair that she is able to operate and control. Due to weak neck and back muscles, the client's head is almost constantly in a downward flexed position. She is able to raise her head for a few seconds at a time but cannot maintain the position. A head and neck support device (HANSS) has been designed to help position the client with shoulders and head in a correct anatomical position. This will limit strain and discomfort that the client currently experiences. The HANSS features a biofeedback system, which encourages the client to assume correct anatomical position without the instruction of her parents or teachers. Schoolwork and extracurricular activities are very important to the client. The limitations of her power wheelchair include the inability to allow her access to certain desks and small areas. An ideal space for the client to do her school work, computer work, and crafts would be right in front of her on an easily adjustable and accessible desk top. One main function of this multi-function table is to raise her papers and books to eye level through the use of a linear actuator and tilt table. This will limit the strain on the client's neck and eyes, as she usually peers down to her lap to read or do homework.

SUMMARY OF IMPACT

Many devices currently available on the market are very restrictive in nature. The client is free-spirited and encouraged to express herself by her parents and teachers. A head and neck support device is designed to allow movement, but to encourage the

client to remain in the correct position. Within the pillow cushioning of the HANSS are three light-touch sensors. When activated, these switches complete a circuit that outputs music through an iPod. This positive feedback will remind the client of the benefits of maintaining correct posture. Repeated use of the HANSS will begin to reprogram incorrect muscle memories and lead to a healthier and more relaxed neck and spine. Using the multi-function table to read materials at eye level will further improve the posture and muscles involved in correct positioning. Aside from the practical applications of these devices, the health rewards are numerous and very important to a young and growing child.

TECHNICAL DESCRIPTION

The HANSS is constructed using a stainless steel frame and covered in soft high density neoprene foam. The dimensions are custom fit to the contours of the client's neck and shoulders. The result is a comfortable neck pillow with side flanges that pull the shoulders backward and encourage a tucked chin position. An adjustable gooseneck can increase or decrease the resistance and support provided by the device. An optional Snap-On chin support further encourages correct positioning. The HANSS features a biofeedback system that uses positive and negative rewards. Through a series of three switches embedded in the cushion of the HANSS, the client is able to activate a circuit with iPod capabilities. Music will play through headphones connected to an RF transmitter box attached to the back seat of the wheelchair. This encourages the client to keep her head in an upright position and make contact with the switches. When the circuit is deactivated, a

signal is sent to an RF receiver, which activates a vibrating coin motor. This motor and PCB board are compactly designed to fit on a wrist band that can be attached to the client's wrist, arm, wheelchair, or placed on a table. This vibration reminds the client that she must reposition her neck in order to make contact with the switches. This feature is optional and can be turned off at any time. The positive and negative reminders, along with the durable and soft strength of the HANSS support physically and mentally allows the client to begin reprogramming muscle groups to favor the correct undistorted seated position.

The second device is the multi-function table. This table is constructed from a welded aluminum frame and Plexiglass table top. The frame sits on a lightweight aluminum telescoping support that connects to the base and frame of the wheelchair. A linear actuator is in place within this frame to allow easy raising and lowering of the table through the use of a toggle switch. The table also has tilt capabilities and a flip-up book ledge on which to rest papers. The table features a storage space within the frame for keeping personal belongings. The vertical support shaft is securely fastened to the base and frame of the wheelchair with three positioning adjustment brackets, one aluminum securing clamp, and two strap clamps. This limits any unwanted horizontal movement of the desk. The desk raises materials to the client's eye level, tilts materials to the desired angle for reading, and also serves as a support for the client. The client will be able to push off of, or lean on the desk in order to reposition or adjust herself in the wheelchair. The table has been designed to fit the client's current wheelchair model. The support arms feature adjustable lengths in the horizontal direction accommodating for the client's growth. The table can be removed from the support shaft, or the entire device can be removed from the wheelchair.

The combination of the HANSS and multi-function table will promote healthier living habits for the client. Fig. 15.1 shows the combined use of these products on the wheelchair. Equally as important, the HANSS will improve communication skill



Fig. 15.1. HANSS and multi-function table.



Fig. 15.2. HANSS and multi-function table attached to power wheel chair.

between the client and friends, and the multi-function table will provide a place for the client to perform all of the daily activities that she loves. The recreational use and health benefits of these devices, along with the custom dimensions and biofeedback system, set this design apart from any devices available on the market.

The cost of materials is approximately \$750.

THE ATPC-X42 ALL-TERRAIN POWER CHAIR

Designers: Niaz Khan, Selome Mandefro, Alex Mann, Vikram Shenoy
Supervising Professor: Dr. John Enderle
Biomedical Engineering
University Of Connecticut
Storrs, CT 06269

INTRODUCTION

The all-terrain power chair (ATPC) is designed to have a low center of gravity so that it can allow for the operation on uneven terrain without the fear of the chair tipping over. After the all-terrain power chair was completely built and fully operational, it was presented to the client in Tolland, Connecticut. The client has cerebral palsy which affects her ability to sit up straight and limits her motor skills. She enjoys exploring the outdoors, and therefore it is necessary for her to have a safe wheelchair to operate in her rugged backyard. The ultimate intention of the ATPC is to enable the client to explore the outdoors where there is uneven terrain without tipping over and righting herself, as has occurred in the past.

SUMMARY OF IMPACT

The client, her parents, and her physical therapist contributed to the design criteria. The device needs a low center of gravity with a wider base to maintain stability, but still be high enough to have clearance from the ground. The wheels also need to be large enough to function on rough terrain. These features allow greater chair stability and prevent it from tipping. For safety purposes, the constraints necessary are a seat belt and a harness that attach to the frame of the device. These constraints keep the client upright and help her maintain the proper posture while operating the chair. A right-handed joystick is necessary, as the client still has control of her right arm and hand, as was a kill switch for safety purposes. There is also a sensor with an alarm that warns the client of slopes that are too steep and an auto-actuation mechanism, which keeps the client level. The auto-actuator also helps the client maintain proper posture by actuating the seat upwards while she goes down a hill and vice versa. Finally, since portability is necessary, the device can be taken to different locations including inside the



Fig. 15.3. The ATPC-X42 All-Terrain Power Chair.

house or transporting it by van or SUV by limiting the width of the chair to less than 32 inches.

TECHNICAL DESCRIPTION

The ATPC is made from a number of smaller subunits that operate together. Mechanical parts include the seat, which is made of a jelly cushion for comfort. The size of the seat is 16 inches deep, 18 inches wide and a height of 19 inches. The chassis is used from an existing power chair. The frame is modified from a Quickie S626. The seat mount was widened to accommodate the client, with one-inch spacers to increase the width to 16 inches (see Fig. 15.3). The tires used are two larger (4.5 inches wide), off-road tires in the rear which are individually powered by two electric motors. The size of the tires accounts for increased stability and traction. Two smaller (3.5 inches wide), off-road tires in the front are used to prevent compromising the chair stability. The front tires are placed into custom-made front casters that extend from the chassis.



Fig. 15.4. Autodesk Inventor 2009 model of the ATPC-X42.

The electrical and software components control the actions of the mechanical parts. The power module is the main control center, and the controller used is the Penny and Giles Pilot+. The batteries that are used are two PowerSonic 12 Volt batteries connected

in series. The joystick is used as the controlling mechanism. There is also manual and automatic actuation control. The automatic actuation circuit uses two ADXL335 accelerometers, to control the tilt of the seat. The accelerometers are programmed using a microcontroller. Therefore, the actuator will automatically adjust the seat relative to the incline of the terrain. The accelerometers also are connected to a buzzer that will inform the user when they are approaching hills that are too steep for the device.

The total cost of the ATPC project is \$1085, which was under the allotted budget of \$1300. However, certain parts were donated for this project. If the full price of each part was paid, the total cost of the ATPC would be approximately \$4000. This is still much cheaper than other similar devices currently on the market, which are sold for prices ranging from \$12,000 to \$18,000.

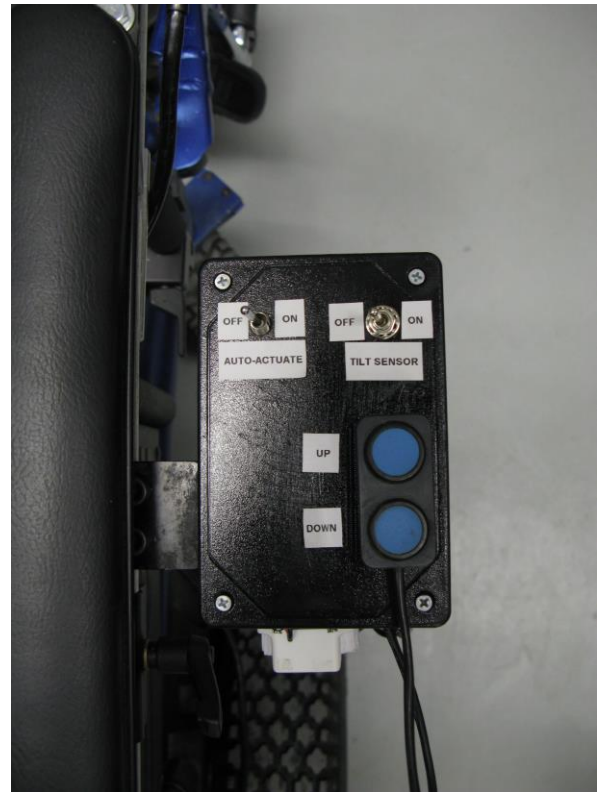


Fig. 15.5. Control mechanisms, incl. joystick (L) and actuation (R).

ASSISTIVE WALKING DEVICE

A Gait Trainer for Individuals with Cerebral Palsy
Designers: Scott Kopp, Andy Czyzowski, Sijie Jason Wang
Supervising Professor: Dr. John Enderle
Biomedical Engineering
University of Connecticut,
Storrs, CT 06269

INTRODUCTION

Many individuals with cerebral palsy (CP) have difficulty learning to walk. Often, irregular leg muscle control can make the learning process very difficult, or impossible. Currently available solutions are often too expensive or not supportive enough. There is a need for a low-cost, highly adjustable gait training device for children with cerebral palsy.

The Assisted Walking Device (Fig. 15.6) fills this need. It is designed to provide gait training for children with cerebral palsy. With practice, the child can climb into the device from the rear and pull herself into the arm and chest rests. A button press closes the leg braces, securing the child. For additional support, a broad four-point strap can be attached by an assistant. Depending on the child's abilities and needs, components such as the arm rests, leg closing mechanisms, and leg braces can be removed by the end user. Also, the device incorporates a piston-spring mechanism so that it will challenge the user to improve her abilities, rather than simply suspend her.

By providing a gateway to self-sufficient mobility, the Assisted Walking Device will substantially increase the independence and quality of life for children living with cerebral palsy. The completed device will be delivered to a local client.

SUMMARY OF IMPACT

The device will have a substantial positive impact on the client's life. She has significant internal rotation in her legs, especially in a standing position. This involuntary motion prevents her from learning to walk. In addition, she has difficulty supporting herself with her legs for more than a few seconds at a time due to low muscle strength.

By incorporating strong yet lightweight padded leg bracing and ankle-foot orthoses fixed to the braces (Fig. 15.7), the device provides lateral and rotational



Fig. 15.6. The Assisted Walking Device.

support for the client. This design works well in retaining her legs in a standing position, and the allowed range of motion facilitates a walking gait.

However, she can use it initially as a simple standing device in order to strengthen and acclimate her muscles. This design enables the client to independently lift herself into the device from the rear and press a button to lock the motorized leg braces. A hydraulic piston provides mild spring force, so that she must work in order to remain upright. The client's physical trainer helped in the planning and troubleshooting stages of the project. Her comments directed the positioning and range of motion of the legs, as well as the positioning of the

arm and chest supports. Her help was invaluable in designing and fine-tuning the device. We feel that this design will provide our client with a platform for developing muscular tone and gait.

TECHNICAL DESCRIPTION

The device is fabricated from a wide variety of materials. The base, primary stalks, arm, hip, and chest rests are repurposed parts from salvaged walkers and wheelchairs. All other structural metal pieces are fabricated from 6061 aluminum bar stock. A 50 pound gas spring is used to gently suspend the entire structure. Therefore, our client must exert some effort to remain in the standing position. The spring will not allow her to fall completely, but will sag several inches under the client's weight, acting as a feedback mechanism for strong posture. The device uses rear-entry ankle-foot orthoses to reduce the client's tendency to scissor and rotate her legs. The calf and leg braces are curved to fit the client's legs, and are upholstered in soft neoprene foam. A motor and actuator assembly at the rear of each brace allows the client to enter the braces and close them by pressing a button.

The circuitry is based around a PIC16F877 microcontroller, which drives an H-bridge to control the opening and closing of the motors and actuators. The motors first swing the leg mechanism shut, and then the actuators extend to lock the device. Motor activation is controlled by timing. Power is supplied by two 9V batteries. One powers the microcontroller, and a second powers the H-bridge and all of the moving elements.



Fig. 15.7. Leg braces.

The cost of all parts and materials is approximately \$1000. If new parts are purchased rather than salvaged, the total cost would be approximately \$1500.

THE PORTABLE COMPACTABLE POWER WHEELCHAIR

Designer: Kristie Astoria and Nathan Storie

Client Coordinator: Susan Lucek

Supervising Professor: Dr. John Enderle

Biomedical Engineering

University of Connecticut

Storrs, CT 06269

INTRODUCTION

The portable compactable power wheelchair is designed to provide a patient with cerebral palsy with independent and easy transportation. Cerebral palsy can affect an individual's balance, movement, and posture. Typically, it causes loss of muscle control and motor activities, and most patients who suffer from the disease are permanently confined to a wheelchair. Powered wheelchairs are inconvenient for long distance travel because they are heavy, bulky, and usually not portable. The portable wheelchairs that are currently available are not powered, and therefore, our client needs assistance to move around. The powered wheelchair, presented in this design, has the ability to separate into three parts so that portability is as easy as possible. The chair also gives the patient control of their motion through a joystick. Upon completion of the power wheelchair, it will be donated to a family located in Storrs, CT with a 10 year-old daughter who has Cerebral Palsy.

SUMMARY OF IMPACT

The wheelchair design is based on the needs of the client's family to have a portable wheelchair that allows for the client to be independent. The family has difficulty transporting the current wheelchair in their minivan, and the client quickly outgrows portable chairs that have been used in the past. The designed wheelchair takes into consideration the client's medical needs and provides easy portability by separating into three lightweight pieces. Since the client has slightly more control of the right side of her body, an easily controlled joystick is mounted on the right side of the chair. The chair also provides supportive straps to prevent the client from constantly leaning forward. Additionally, foot straps are placed on the foot rests to keep the client's feet in the appropriate position.



Fig. 15.8. Portable compactable power wheelchair.

TECHNICAL DESCRIPTION

The overall structure of the portable compactable power wheel chair is based on the Invacare A1m Travel Power Wheelchair. This power wheelchair also separates into three parts: the base frame, the chair assembly, and the battery. The electrical system contains a joystick, speed control, and two motors. The motor has a friction attachment that drives the wheelchair by rubbing against the outer edges of the wheels. A modified frame of the Invacare wheelchair is used in this design. The chair frame and base frame are made of aluminum Pipe Schedule 80 (nominal 0.75", OD 1.05", ID 0.824"). The chair frame is modified to better suit the client by reducing the width from 18 inches to 15 inches. Also, the chair frame folds for easy travel. The frame is also modified by moving the central cross bar

forward 6 inches to mount a motor plate to the two transmissions and two motors.

The entire electrical system of the At'm Wheelchair is used in this design. The main alteration in the design was changing the motors from the friction drive system into direct-drive motors. This was done by creating two transmissions that reduce the RPMs of the motor. Each transmission has a gear reduction of 7.2. These two transmissions are designed to be of two different lengths so that when they are mounted, the motors will be offset. The motors are arranged in a tiered manner in order to reduce the width of the chair as much as possible.

Supportive restraints are also placed on the footrest. Lastly, two seat belt straps are bolted to the seat frame—one around the waist and the other crossed over the front of the patient from the shoulder to the waist. These prevent the patient from leaning too far forward or falling out of the chair.

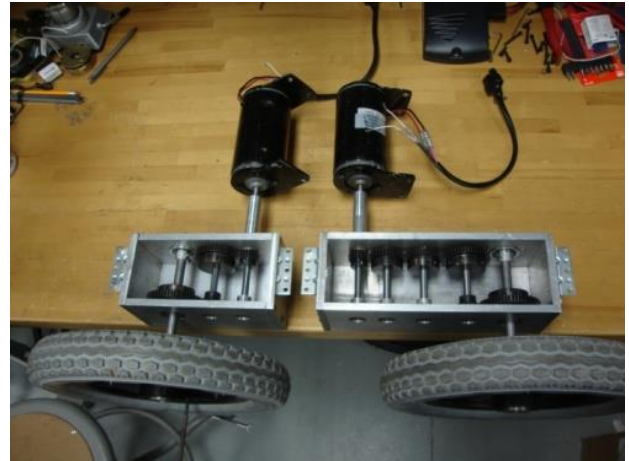


Fig. 15.9. Transmission Designs

The total cost of the parts and materials is approximately \$806.



Fig. 15.10. Portable chair frame; unfolded and folded.

THE JOE-KART

Designers: Morgan Templeton, Marek Wartenberg, Michael Fitzpatrick

Client Coordinator: Katrina Toce Southington, CT

Supervising Professor: Dr. John Enderle

Biomedical Engineering

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INTRODUCTION

This project is to design and fabricate a specialized go-kart for a child with Cerebral Palsy. The client has limited coordination and limb dexterity which prevents him from properly operating pedals and steering devices found on commercially available recreational go-karts. In order to solve this problem, the client has a remote control that will be operated by the parents. The remote control allows use of the go-kart immediately.

In order to ensure the maximum amount of safety, it was requested, by the client, that the go-kart be battery powered. Additionally, a multitude of other safety features were implemented in order to ensure maximum comfort and security. The seating area is designed to be adjustable to accommodate future growth as well as supportive to compensate for certain muscle weakness. The go-kart is designed and fabricated to meet the needs and requests of the client. The final product is a go-kart that is more user-friendly to the client than any commercially made product available.

SUMMARY OF IMPACT

The client is a 6 year old with Mixed type Quadriplegic Cerebral Palsy (CP) and a second diagnosis of Global Apraxia. He has severe motor planning issues and requires many repetitions to learn simple patterned movements. His CP restricts his movement, his balance and proprioception, and he is unable to walk, stand or sit-up without assistance. The Joe-Kart is specifically designed around these limitations, giving him full use of the go-kart. He and one other person will be able to comfortably sit in the go-kart. The go-kart is also remote controlled so that he will be able to ride in the go-kart while a parent operates it from outside the kart. The Joe-Kart gives the client a full sense of mobility and freedom, while also allowing him to spend quality time with his parents.

TECHNICAL DESCRIPTION

The chassis option selected for the design is the prefabricated Stingray complete go kart chassis kit from Northern Tool. This option, though at first seemingly expensive, ultimately saved money on labor and potential raw material cost. This option is chosen mostly to save time on welding and machining a chassis, allowing for more time to design higher quality subunits. The secondary benefit, as stated, is in the event of mistakes (welding or machining), money will not be lost re-purchasing damaged, unusable materials. This complete chassis kit comes with tires, wheels, brakes, cables, and 60-tooth sprocket.

This chassis has dimensions of 72 x 43.5 x 47.25 in (l x w x h) and is functional for two people. This double seat model is chosen because it allows for the client's parents to ride along. The remote control will allow for the parent to operate the kart from a distance as well as from within the kart itself. By selecting a two seat model the client's parents can sit in the kart with the client coaching him to learn the controls. This will increase time spent bonding as well as providing constant positive feedback to increase our client's pattern movements, eventually leading to complete individual control.

The chassis is equipped with a seat and seatbelts. These do not meet the required specifications for the kart and are therefore not used in the project. Instead of a single bench seat, this project implemented two separate seats; one specialized for the client, the other for the passenger. The passenger seat is a standard bucket seat on the left side of the go-kart. This seat is equipped with the seatbelt provided to ensure passenger safety. The specialized seat for the client is based on his existing wheelchair seat, providing all the similar adjustable supports such as head and neck, trunk, waist and groin. The specialized seat also has foot rests and foot straps to safely keep the client seated and protected. A seat from an old wheelchair is used.

This seat is very similar to the client's current wheelchair. It has the appropriate supports that are needed and also comes with a harness. The seat is modified so that it can be attached to the chassis. The client's seat is on the right side of the go-kart. This allows the left handed controls to be in the center of the go-kart.

The steering mechanism for the go-kart is designed to be quick and responsive to handle optimum maneuverability while also being able to withstand the forces exerted on the system while it executes turns while in motion. Since the client lacks the motor control to be able to steer the go-kart manually, the steering system is powered and controlled by a gear motor which powers a rack and pinion. The rack and pinion is connected to the wheel brackets via tie rods. The linear displacement of the rack, due to the rotation of the pinion, will result in a translational movement of the wheels which steer the car left and right.

The go kart is powered by a C40-300 MagMotor. Since the drive motor draws a much higher current, the speed controller for the drive motor must be much more robust and durable to handle the high current load. A 4QD-300 speed controller designed by SLT Technology, Inc drives the main motor. A transmission box to transfer torque from the motor was included in this design as well. This is accomplished through a specific gear ratio to increase the torque applied to the axle.

The client does not possess the capability to push down a brake pedal which means that this process also needs to be done mechanically. This system implements gear motor and motor drivers that are controlled by the receiver in order to safely and effectively apply brakes to the moving go kart.

The go-kart uses three deep cycle batteries. These batteries have an output voltage of 12V. Two batteries are put in series to create 24 V which powers the drive motor. These batteries are 500 CCA each. The third battery powers the steering, braking, and all other systems. This battery is larger and has 665 CCA. Any battery that satisfies these needs can be used.



Fig. 15.11. The Joe-Kart.

The go-kart consists of two different methods of control. This first is a remote control with two single axis joysticks. One controls steering, and the other controls speed, and braking. A switch is used to drive the go-kart in reverse. When in reverse, all of the functions will work the same; however, when the accelerator is pushed, it goes backwards.

The remote can also be mounted into the chassis to create a second method of control. This dashboard is mounted to the chassis via a mounting arm. The mounting arm can move side to side and front to back. This allows the parents to use the controls or point them to the client. It also allows the controls to be out of the clients reach so that he does not accidentally hit something.

The cost of the Joe-Kart is approximately \$5,000.

THE AUTOMATED RETRACTING COASTER SLIDE

Designers: Hillary Doucette, Stephen Kustra and Sarmad Ahmad

Client Coordinator: Katrina Toce

Supervising Professor: Dr. John Enderle

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INTRODUCTION

The Automated Retracting Coaster (ARC) Slide is designed for a child diagnosed with cerebral palsy. This condition affects the client's motor control and inhibits his ability to fully control his posture and limbs. The six year old client enjoys playing outdoors and is in need of recreational equipment to accommodate his needs.

The concept of ARC Slide was based on the "Extreme Coaster" manufactured by the Step2 Company on which the client has previously ridden. The Extreme Coaster, however, does not account for the client's additional requirements. The car for the "Extreme Coaster" has no support or restraints to help maintain trunk posture and also requires the supervisor to manually push the rider and car up the slide to allow for additional descents down the ramp. This strain on the supervisor inspired the need for a recreational device that would help maintain the client's posture and eliminate the supervisor's need to manually push the car back up the slide. These two constraints are the foundation on which the ARC Slide design was based. The ARC Slide (Fig. 15.12) is a recreational device equipped with a car (Fig. 15.13) that supports the client's trunk and hips, a lift motor with an actuator that automates slide descent of the car down the ramp, and a winch with nylon rope that hooks to the car and retracts it back to the platform. The hook automatically releases using a spring loaded mechanism (Fig. 15.14) such that the car can descend down the track again without help from the supervisor. This device thereby eliminates the need for the car to be manually pushed up the ramp and eliminates the need for a manual push to begin descent. Currently, there are no devices on the market that possess these functions.

SUMMARY OF IMPACT

This device has improved the quality of life for the client in numerous ways. Primarily, the client is



Fig. 15.12. The ARC Slide ramp and platform.



Fig. 15.13. The ARC Slide car.

now able to experience the outdoors and enjoy recreation in a safe and fun manner. The device also promotes a sense of independence because the supervisor needs only to hook the rope to the rear of the car. The strain on the supervisor is greatly decreased as the need to push the car up the ramp or push the car to begin descent is eliminated. The supervisor only needs secure the rider in the car with three nylon restraints. This device can be modified to fit a wide range of riders and provide multiple users with a safe outdoor recreational experience.

TECHNICAL DESCRIPTION

The structure of the ARC Slide is composed of both pressure treated and composite lumber. These wood types can endure extreme weather conditions year round. The pressure treated lumber is coated with a UV protection stain that will increase the lifetime of the device. The ARC Slide has a 10 foot ramp made of pressure treated wood and a 45 inch long platform track made of composite wood. The platform, however, is composed of both composite and pressure treated decking. With a height of 36 inches from the ground, the ramp has a 17° angle of elevation that allows for moderate acceleration down the ramp. The ramp track and platform are attached together using two ¾" diameter by 5 inch long pins. These pins insert into the top of the platform through steel plates that attach to each side of the ramp. The ramp and platform attachment allow for the platform track and ramp track to coincide; ensuring a smooth ride. The winch motor is attached to the rear of the platform while the lift motor is mounted on the rear underside of the platform. A 12V battery powers the motors as well as a photoelectric sensor, a wireless module, motor controllers, and a three color status tower light. Fig. 15.15 depicts the rear of the platform with the retraction, lift, and release systems. The ARC slide motors are wirelessly controlled using a four channel RF transmitter and receiver powered using the 12V DC battery. A 40 pin PIC16F874A is used as the controlling unit, with safety features programmed into the PIC such that the motors can only turn on at designated times. Two motor drivers power the winch and lift motors on and off upon input signals from microcontroller. A limit switch is used to stop the track lift when it reaches the starting position on the platform. A photoelectric sensor detects the car wheels as the car retracts and signals the microcontroller to stop the winch motor from retracting the car.

The microcontroller has 6 inputs; four inputs from the wireless receiver, an input from the photoelectric sensor, and also an input from the position switch. The different outputs from the microcontroller change the color of the LED tower light and power on and off the motors. A 12-24V DC boost converter supplies sufficient power to the 24V LED tower light while using a 12V DC battery.

When the photoelectric sensor is not triggered, the winch motor can be powered in both the forward

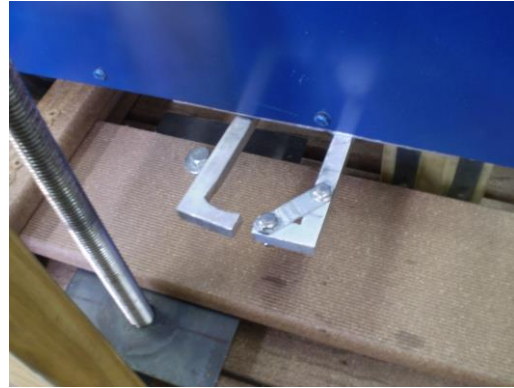


Fig. 15.14. Spring Loaded Hook Release.



Fig. 15.15. The winch, lift, and release systems.

and reverse direction. When the motor is not being powered, the LED tower light illuminates green. However, when the winch motor turns on, the tower light illuminates red to indicate a change in status of the system. When the photoelectric sensor's beam is blocked by the car, the microcontroller does not allow any signals to be sent to the winch motor, and therefore the winch remains off. After the car is completely retracted, the LED tower light emits green again; indicating that the lift motor can be powered in the forward direction only. The lift motor will elevate the rear of the platform track until the car begins descent and the photoelectric beam is unbroken. When the photoelectric sensor is no longer triggered, the lift motor can only be powered in the reverse direction until platform track contacts the limit switch. The microcontroller also inhibits the winch from retracting if the platform track is elevated and the limit switch is not triggered. These components and safety measures ensure a safe ride for the user while riding the ARC Slide. The final cost of the parts and materials is approximately \$1,800.

CONTROL PANEL FOR CHILD WITH CEREBRAL PALSY

Designers: Robert Blake, Craig Goliber, and Alanna Ocampo

Client Coordinator: Katrina Toce

Supervising Professor: Dr. John Enderle

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INTRODUCTION

The remote setup is composed of a battery-powered control panel, which turns an Emerson CD player and Coby DVD player ON and OFF, using an RF signal. Fig. 15.17 describes this setup. The control panel runs on a single 9V battery, which may be replaced by unscrewing the battery compartment located in the base of the panel. The CD player and DVD player must each be run on the adapter supplied by the manufacturer, as the new wiring associated with the remote control does not allow for the use of the batteries. Instructions for running the CD and DVD players may be found in the manufacturer's manuals and any problems associated with those devices, outside of those related to remote control, may be addressed to the manufacturer.

SUMMARY OF IMPACT

The purpose of this device is to increase the client's independence and to enable greater interaction with his environment. This device will help the client feel a greater sense of independence and also provide a stimulating and fun way to control his DVD and CD players.

TECHNICAL DESCRIPTION

The transmitting end of the setup includes a Basic Stamp 2 (BS2) microcontroller and takes input from the four jelly bean buttons for the functions PLAY and STOP for both the CD and DVD players. The output of the BS2 goes to the transmitter which sends out the corresponding RF Signal to the receiving end, depending on which button is



Fig. 15.16 Control Panel.

pressed on the panel. The 9V battery is connected to the rest of the circuit, via the toggle switch, and regulated to 5V.

The receiving end of the setup includes a BS2 which takes in the RF signal from the transmitter. The whole circuit receives its power from the CD or DVD player's own power source, which is then regulated to 5V. The BS2 outputs to two 5 VDC 0.5 amp DPST mini relays (R56-7D.5-6), one for PLAY and one for STOP. Each relay has one end of its coil attached to the output from a microcontroller pin and the other end of the coil is grounded. The two other pins of the relay (the switch) are connected across either the PLAY or STOP switch within the CD or DVD player.

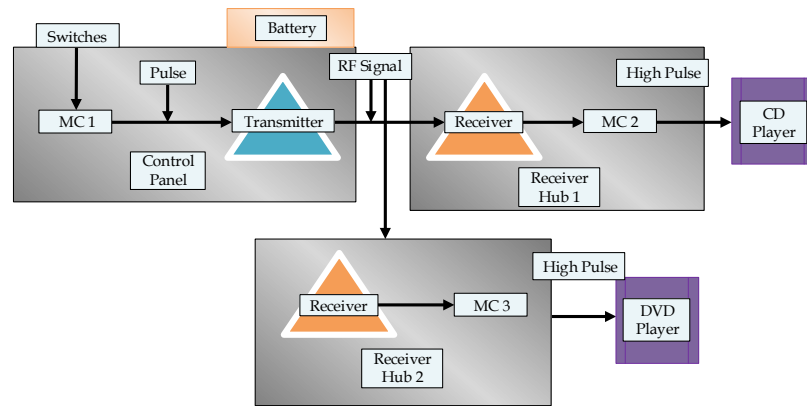


Fig. 15.17. Control panel setup

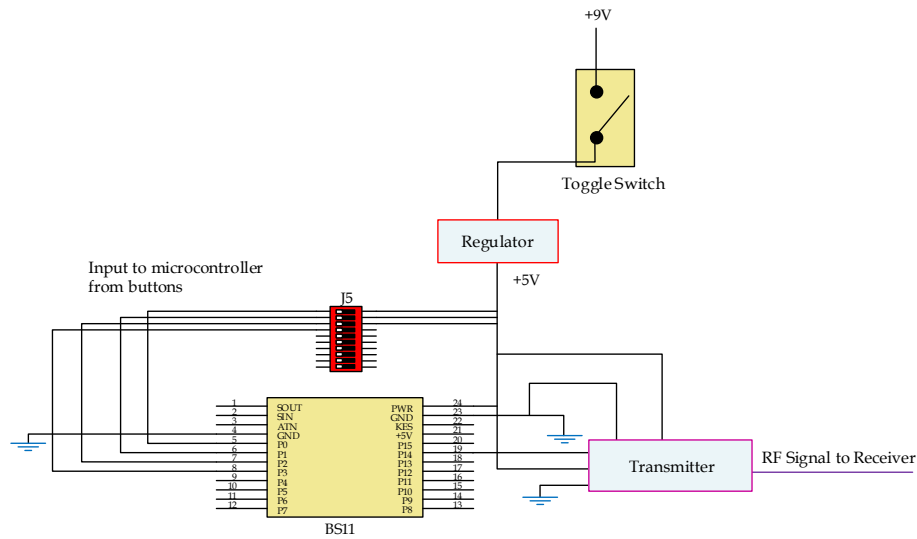


Fig. 15.18. Transmitting end in control panel

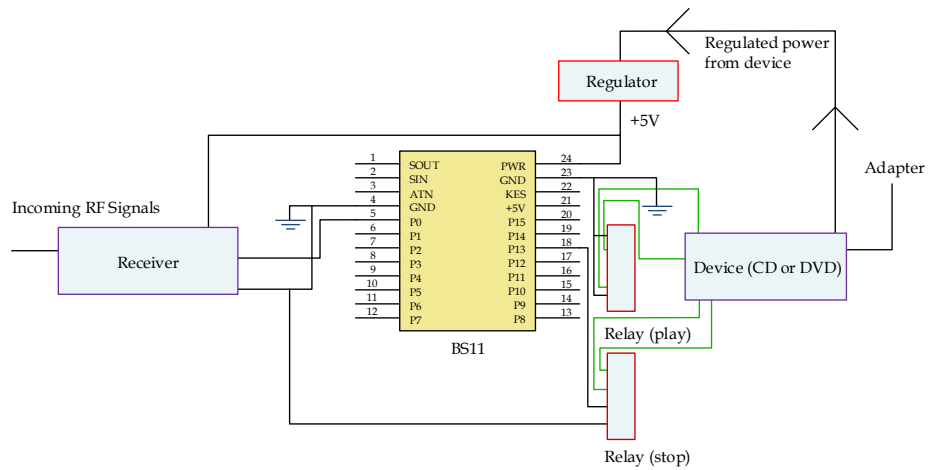


Fig. 15.19. Receiving end

ADAPTED HUNGRY, HUNGRY HIPPOS BOARD GAME

*Designers: Robert Blake, Craig Goliber, and Alanna Ocampo
Client Coordinator: Katrina Toce, Southington, CT
Supervising Professor: Dr. John Enderle
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INTRODUCTION

The Adapted Hungry, Hungry Hippos Board Game is designed to provide a client with cerebral palsy the ability to independently operate and play the game Hungry, Hungry Hippos. The assistive device utilizes an electrical and mechanical operating system, which when activated, supplies all the necessary movements and forces required to play the game. This device was designed for a client with poor muscle tone, and as a result cannot exert the needed force to play the game independently. A commercially available product is on the market to address this issue; however it utilizes a pulley and lever system which still requires sufficient force. The approach taken when designing the assistive device is to completely eliminate the need for a force to be applied, while at the same time maintaining a level of physical involvement for the client.

SUMMARY OF IMPACT

The design of the Adapted Hungry Hippos device is built around the capabilities of the client. By creating this assistive device which allows for full operation of the board game, an independence which is rewarding to the client is achieved. By utilizing this device the client has gained a new level of involvement that was previously unachievable, and is now able to independently interact with others while playing this game.

TECHNICAL DESCRIPTION

The housing unit of the assistive device is fabricated from galvanized aluminum sheet metal. The characteristic high strength and low weight of aluminum made this material ideal for providing the necessary support throughout the design, while at the same time minimizing the weight of construction. The housing unit's base is constructed using a series of folds from a single piece of sheet metal along with the use of spot welds and rivets.



Fig. 15.20. The Completed Assistive Device.



Fig. 15.21. Joey enjoying his new game.

The cover pieces are fabricated in a similar manner and attached to the housing unit with sheet metal screws.

The assistive device operates the board game's levers by using two electrical DC geared motors that

run off of six volts, and rotate at 70 revolutions per minute. A DC geared motor was chosen because it supplies the needed torque required to operate the levers while at the same time maintaining a small profile. Also a motor with 70 revolutions per minute was chosen because that is considered the average operating speed when manually using the levers while playing the board game.

Attached to the electrical motors are two swing arms which are the actual mechanisms that interact with the board game. Each swing arm is attached to the motor's output shaft, and when activated rotates about the motor axis, and repeatedly hits the board game levers thus activating the game. The primary swing arm is fabricated out of aluminum and provides the needed force to the main board game lever which is responsible for obtaining the marbles during play of the game. The secondary swing arm was fabricated out of ultra-high molecular weight polyethylene which is chosen because the force required is not extremely high, while the material can still take repeated wear without breaking. The function of this secondary swing arm is to interface with the marble release mechanism on the board game, and supply marbles to the playing field.

The mechanical components, that the assistive device utilizes, are connected together in a simple electrical circuit which runs off of a battery compartment that supplies six volts from four "AA" batteries. The device is operated by a large push button. When the button is pressed and held, the electrical circuit is closed and the motor swing arm setup is activated. The push button used is removable from the actual assistive device, which makes storage easy. The way this is accomplished is through a 3.5mm mono electrical jack. The push button contains a similar 3.5mm mono prong which can then be plugged directly into the jack which is located on the housing unit. The cost of parts and material needed to complete this project is approximately \$90.



Fig. 15.22. Primary Motor and Swing Arm

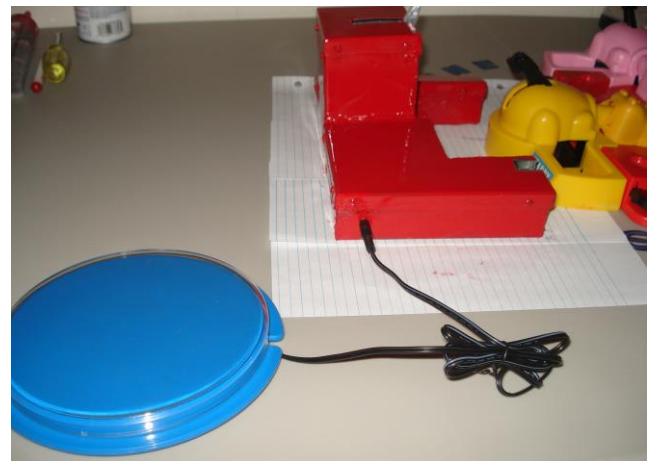


Fig. 15.23. Push Button and Housing Unit Interface

MEMORY RECALL GAME

Designers: Robert Blake, Craig Goliber, and Alanna Ocampo

Client Coordinator: Dr. Brooke Hallowel, Ohio University

Supervising Professor: Dr. John Enderle

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INTRODUCTION

This Memory Game application is written in C# using the .NET framework libraries. The Microsoft Windows Visual Studio 5.0 environment is used to code the game. The intent of this game is to improve memory recall in patients with Alzheimer's, dementia, or short-term memory loss, through the use of images and repetition. The game allows the user to upload personal pictures, create lists of persons (names and photos), called scenarios, and then run these lists within the game space. As each picture in the selected scenario appears, the user says the name of that person into the microphone and the game discerns if this is the correct response or not and then gives feedback. The game times the length of the scenario and the score for each run, and then these statistics may be viewed in both table and graph form. All data is saved by the game. There are other memory games on the market; however, they do not offer the flexibility and tailored scenarios that this software game allows.

SUMMARY OF IMPACT

This design of a memory game application to enhance memory recall in people with Alzheimer's or other short-term memory impairments will have a societal impact on those who make use of the software. A human being's ability to interact with those around them is an irreplaceable aspect to life, which, if impaired by cognitive disabilities, can have heart-breaking consequences for those affected by the disability and their loved ones. Being able to recognize the faces of people they love, say their names, and engage them on a level similar to that before their memory impairment began can greatly increase quality of life for those with memory impairments

TECHNICAL DESCRIPTION

The application consists of several subsystems. An intuitive user interface allows the user to access the

full functionality of the application through a menu system. Additionally, a profile database keeps track of the users of the program, their associated persons, scenarios, and photos. A handler class is used to create files containing information on a scenario or load a scenario file. A speech handler class is used to enable speech input for names during a user's scenario session.

Upon entering the application, the user is prompted to create or select a profile. The list of current profiles is loaded from the profile database. Creating, editing or switching profiles can be accessed at any time from the top menu bar of the program window. The default interface upon admittance shows a list of recent scenarios, a button to run those scenarios, and an option to create new scenarios. Creating or editing a scenario brings the user to a list of persons attached to that user's profile. Persons may be added to the scenario list in a one-to-many relationship so a person can be used more than once in a single scenario. Additional persons may be added from within the Administrator role user interface. A panel containing various fields pertaining to a person are available from the edit/create person menu option. A person and photo library are maintained within each user profile database.

The User session is automatically initialized when a scenario is run. The application window then switches to full screen mode and the first round commences. A round consists of a photo being displayed to the User and the User speaking the correct phonemic pattern into the microphone. The round is then scored for correctness and a new round is shown until all rounds in the scenario are exhausted. The user interface then reverts to the Administrator role and display statistics.

The back end of the memory game application consists of a profile database. The profile database is stored and encrypted in save files and handled

through a Data Access Object. A specially designed class is used to create encrypted scenario files. These files consist of the person list associated with the scenario and any other settings needed to run the scenario. This enables exporting and importing files between workstations or directories.

Speech recognition is an essential characteristic of the memory game application. The program achieves this by using the system.speech reference of the .NET libraries. This reference imports Speechlib SDK 5.3 for Windows Vista operating systems and SDK 5.1 for Windows XP operating systems. A speech handler class handles all speech interaction

containing methods to start and stop listening, identify and compare phonemes, and store phonemes for comparison.

A properly installed microphone is necessary for the speech components of the memory game application to work. Using the Windows speech training wizard increases the accuracy with which the speech libraries can recognize the User's voice. The memory game application requires Windows XP or Windows Vista. A CD-Rom drive is required for installation. .Net 3.5 libraries must be installed on the system for the application to run voice components properly.



Fig. 15.24. Screen image of the memory recall game.

ADAPTED SNOW SLED

Designers: Robert Blake, Craig Goliber, and Alanna Ocampo

Client: Joey Toce, Southington, CT

Supervising Professor: Dr. John Enderle

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INTRODUCTION

The purpose of this device is to provide a safe and secure way for the client to enjoy playing in the snow. The client suffers from cerebral palsy that inhibits his motor function. Therefore, the sled must keep him secure while riding around. The key features required by the client include that the device offer full support for his head and trunk, an adductor between his legs, and a full harness. Currently, no devices exist that meet the client's specific needs. The adapted sled is designed and built by attaching a full harness swing seat to a sled.

SUMMARY OF IMPACT

The client loves the outdoors, especially the snow in winter. Prior to the adapted sled, there was no safe way for the client to play in the icy conditions. Since receiving his new sled, the client enjoys going outside in the snow even more than before and loves riding around in his new sled. His parents are very pleased as they know he is safe when using this device.

TECHNICAL DESCRIPTION

The plastic swing seat with full harness is attached to the sled via one inch high density polyethylene. Three stainless steel bolts, fender washers, nuts, and split lock washers are used on each side to secure the seat to the sled. Two PVC tubes are bolted with four stainless steel bolts and nuts from the back corners of the sled to the back of the seat to provide



Fig. 15.25. Adapted Sled.

support. The last part of assembly involved replacing the existing rope with a new one. The holes in the front of the sled, where the previous rope was attached, were drilled out to fit the larger diameter of the new rope. Since the rope is made of nylon, the ends were burned to prevent fraying after being tied to the front of the sled. The design was very simple but effective as it met all of the client's specifications. The final cost of parts is less than \$100.

CHAPTER 16

UNIVERSITY OF MASSACHUSETTS AT LOWELL

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TOUCH-2-SPEAK: A SOFTWARE APPLICATION THAT AIDS THOSE WHO ARE CHALLENGED WITH COMMUNICATION

Designer: Anthony Maglio

Client Organization: Shore Collaborative, Chelsea, MA

Client Coordinators: Bob Wierzbicki, Shore Collaborative, Chelsea, MA

Supervising Professors: John Fairchild

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INTRODUCTION

The Touch-2-Speak (T-2-S) application is designed to help students who are unable to communicate verbally with their teacher. A software solution utilizing touch-screen technology is chosen to address the communication barrier because teachers and students find touch-screen software applications intuitive and fun to use. Also, software is generally versatile and applications can be created to meet specific and unique needs.

The T-2-S aids communication through two main functions. The first and primary function is called the Communication Tool and it allows those with communication disabilities to communicate with others by touching a grid of pictures displayed on a computer's touch-screen. Each picture has a unique pre-recorded audio clip that is related to what the picture displays. When a picture is pressed its audio clip is played. The idea is that the person with the disability can identify what they want to communicate by finding and touching one of the pictures.

The second function is called the Schedule/Calendar/Time Tool; this function provides answers to some of the most common questions asked by the students. This part of the application will display a clock, a calendar, a picture portraying the current classroom activity, and a picture portraying the next scheduled classroom activity on the touch-screen. At any time, a student can and press the clock on the computer to hear what time it is, the calendar to hear the date, the current activity to hear what the current activity is, or the next activity to hear what the next activity will be.



Fig. 16.1. Communication Tool.

There are devices on the market that are similar to the primary function of the T-2-S, however they are limited in the number of pictures they can hold at a given time and are not as versatile in other ways. The Schedule/Calendar/Time Tool makes this application unique; the devices that are similar to the Communication Tool do not have the added features provided in the Schedule/Calendar/Time Tool. There are no such devices in the marketplace that combine all of the functionality that is built into the Touch-2-Speak.

SUMMARY OF IMPACT

The design of the T-2-S is based upon the unique communication needs of the students at Shore Collaborative. It improves the quality of life of students by giving them the ability to communicate their needs. Also, this application gives the users a

sense of independence in the classroom because they can access the computer to determine the time, date, current activity, or next activity. The T-2-S application has also been a benefit to the classroom teachers because they are no longer interrupted by students wanting to know the date, time, current activity, or next activity. Consequently, the teacher has more time to focus on other, and possibly more important, matters. Overall, this application is very useful in the classroom setting.

TECHNICAL DESCRIPTION

The Touch-2-Speak application is written in LabVIEW version 8.5. When using picture and audio files in an application, one of the biggest concerns when writing code is available memory. Therefore, the operations must be as efficient as possible or memory issues could arise. The efficient use of common routines located in different parts of the application are used to avoid re-writing code. Each part of the application is designed using a state machine. A communication system is in place to allow the different parts of the application to communicate with each other. Expandability of the picture library is an important aspect and is

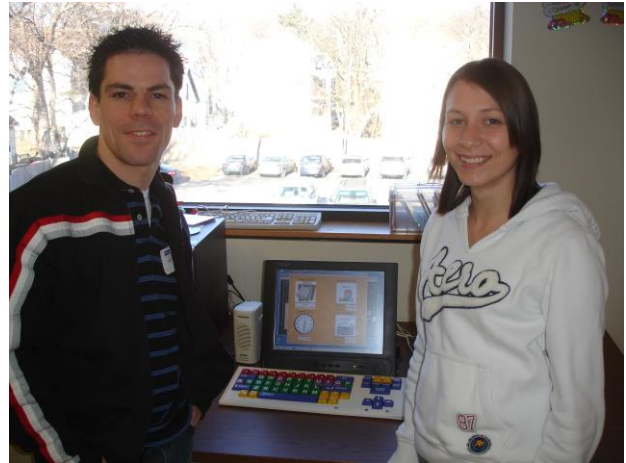


Fig. 16.2. Picture of Client, Myself, and the Project.

included as one of the features in the application. This allows the teachers to add new pictures. The design for this application is well suited for its purpose. This application has much to offer and all critical specifications are met. There are no associated costs with this application as no parts or materials were required. The touch-screen computer was provided by the client.

SPEAK AND REACT: A CAUSE AND EFFECT DEVICE PROVIDING POSITIVE REINFORCEMENT THROUGH MULTIPLE SENSORY STIMULI BY WAY OF USING SPEECH.

Designer: Bryan Cripps

Client Coordinator: Lisa Szweczyk, the Nashua Center, Nashua NH

Supervising Professor: James Drew

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INTRODUCTION

The Speak and React Device (SRD) is designed to provide positive reinforcement through multiple stimuli by way of speech. This can be beneficial to individuals with limited vocabulary of speech abilities. This device is simply a noise activated wireless switch that enables use of an outlet receptacle. The device consists of two plastic enclosures, the first enclosure is the transmit portion of the device and it is powered by battery. The other portion of the device is the receiver and it is powered by an outlet receptacle. Upon completion, the SRD was presented to the Nashua Center for mentally changed persons in the Nashua, New Hampshire area.

The SRD is intended to be used as a learning device requiring users to use their voice more to communicate. The SRD can be used to help create a natural instinct of expressing desires verbally. The SRD can be used to administer a variety of exercises to encourage speech as a means of communication.

SUMMARY OF IMPACT

The design criteria for the SRD are defined by the varying capabilities of each client at the Nashua Center. The coordinators at the center often struggle trying to communicate with the clients. Most of the clients are able to understand what the coordinators are saying, but lack the ability to verbally respond. Over time, general behavioral patterns can be observed and associated with certain desires, but this communication method can be ambiguous to the instructors and requires extensive personal experience with each client. Current communication exercises with the clients can be monotonous and



Fig. 16.3. Client and device.



Fig. 16.4. SRD Transmitter.

the instructors often have trouble keeping their clients' attention. The SRD assists coordinators by making the speech exercises blend with the individual's favorite activities, which in turn

stimulate their senses. Supplemental devices can include a radio, video player, lamp, fan, and vibrating seat, and many other devices that can be plugged into a standard electrical outlet

TECHNICAL DESCRIPTION

The SRD is housed in two black plastic enclosures, a large enclosure (5" x 8" x 3") and a small handheld enclosure (2" x 4" x 0.5") made by Serpac. The benefit of using plastic enclosures includes an overall lighter weight and it also provides nonconductive material which will protect the user from electric shock.

Triggering of the AC receptacle is done using an Electret Condensing Microphone (ECM) which is then amplified from 1 to 43 times the intensity than the original signal. That signal is then rectified producing a DC voltage as a signal. The DC voltage will vary depending on the intensity and loudness of the tone going into the ECM. The varying DC voltage is fed into the positive input of a comparator, where a fixed DC voltage is set on the inverting input. The fixed voltage on the negative input sets the minimum voltage needed. When the DC voltage is larger than the minimum voltage, the comparator will output a "high" voltage, in this case 5. The output of the comparator goes into an input pin of Parallax's Basic Stamp 2 (BS2). The logic of the BS2 is as follows; two inputs are needed to be a high (5V), when the requirement is met, the BS2 will then output 5V. The second input voltage needed by the BS2 comes from a three position slide switch. The switch is tied to a 5V source that will supply a set of three input pins, individually set "high". Depending on the position of the switch depicts what input pin on the BS2 will be "high", in turn determining how to delay the Solid State Relay (SSR). The output of the BS2 is connected to the SSR, which is the driving mechanism switching the AC receptacle on and off.



Fig. 16.5. SRD Receiver.

Aside from the signal chain processing, additional circuits were needed including the DC power circuit that supplied power to the entire receiver chain. This was accomplished by tapping off from the AC receptacle on the receiving device and directing the 110 VAC into a step-down transformer (SDT). This SDT reduced the AC power to 12.6 VAC. The AC power was then converted to DC by using a similar bridge rectifier as used in the signal chain conversion. The rectified DC power is then used to supply two voltage regulators, the first regulator outputs five volts and the other regulator outputs nine volts.

With safety in mind, separating the AC receptacle from the user was paramount. The microphone was isolated from the power source supplied by the 110 VAC. This required wireless transmission from the user's microphone to the switching unit, which was achieved by using an analog audio transmitter and receiver. Both are paired to work with each other at the same frequency. The transmit chain consists of an ECM and the analog audio transmitter, that run on two AA batteries.

The cost of parts and materials was about \$150

SMART HAT: A DEVICE THAT ENABLES CHALLENGED CHILDREN TO CONTROL AN MP3 PLAYER WITH HEAD MOTION.

*Designer: Charbel Abi Samra
Client Coordinator: Bob Wierzbicki
Supervising Professor: John Fairchild
Electrical and Computer Engineering Department
University of Massachusetts-Lowell
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INTRODUCTION

The Smart Hat is designed to help children with limited mobility control an MP3 player using the motion from their head. The Smart Hat is a one size fits-all head band that enables the users to play, run forward, backup and stop the MP3 player. The device consists of a headband, a transmitter unit mounted on the wheelchair and a boom box. It was presented to the Shore Educational Collaborative in Chelsea, MA. Clients at this center have a variety of disabilities. Most are unable to eat or wash by themselves. The Smart Hat is intended for a teenager who is unable to voluntarily move any body parts other than his head. It will help him to gain independence.

SUMMARY OF IMPACT

Although there are some changes to the physical structure of the device, the effectiveness of the device is maintained and client's safety is ensured by shielding the sensor mounted on the head band. The adapted device allows him to take part in the decision-making process concerning his interaction with his environment. The device was delivered to Shore Educational Collaborative. The final result of the project has fulfilled the client's request of controlling an MP3 player using specific head motions. The client is now playing and stopping the music by himself as opposed to asking an assistant to help him. One of the caretakers commented that the client is enjoying the device very much. She added that he is listening to music more frequently just because he likes the device.

TECHNICAL DESCRIPTION

A dual-axis accelerometer is used as a motion detector. It is mounted on a headband and is



Fig. 16.6. The Smart Hat.



Fig. 16.7. Picture of inside of the transmitter.

connected to the transmitter unit by an USB cable. The transmitter unit consists of a microcontroller, an encoder, DIP switch, and a RF transmitter. A switch found on the transmitter's unit is used to activate

and deactivate the transmitter. The microcontroller (BASIC Stamp 2) is used to read the values of the tilts. It compares the readings to a specific threshold ($x1=2700$, $x2=2100$, $y1=2700$, $y2=2100$) and triggers high output signals. Each of the BASIC Stamp's pins had a 220 ohms resistor to protect the chip from burning out. The unused pins are grounded. A decoder decodes the BASIC Stamp's output and the signal was transmitted by the RF transmitter.

The receiver unit mounted in the radio consists of an RF receiver with a decoder to decode the signal. In addition, a 4066 IC is used to control the four buttons of the Mp3 player: play or pause, stop, forward and backward buttons. The 4066 contains four switches with four control signals. When any of the control signals is excessively high, the corresponding switch closed. A voltage regulator is used to reduce the power coming from the radio's AC/DC converter from twelve volts to five volts. The encoder's address is set by an 8-DIP switch. The address pins of the encoder and the decoder are set to the same logic level in order to communicate with each other. The 10K pull-up resistors are connected at the DIP switch's output pins.

The cost of parts and materials is about \$173.



Fig. 16.8. Picture of the client with the device.

THE MUSIC MACHINE: A DEVICE THAT ALLOWS PHYSICALLY AND MENTALLY HANDICAPPED PEOPLE TO PLAY DRUMS

Designer: Darin Casbarra

Client Coordinator: Lisa Szweczyk, Nashua Center, Nashua, NH

Supervising Professor: John Fairchild

Electrical and Computer Engineering Department

University of Massachusetts Lowell

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INTRODUCTION

The music machine (MM) is designed to give persons with physical and mental disabilities a simple and easy way to play the drums. This device is comprised of a panel of five buttons that are used as inputs to a microcontroller. When pushed, each button causes a drum stick to strike one of the five drums. The drum stick is moved by a solenoid and spring. Once completed, the MM will be delivered to the Nashua Center in Nashua, NH. The MM provides persons with disabilities with an opportunity to engage in a social and a creative activity such as playing drums in sing-alongs. This device also provides a cause and effect example that may be beneficial as a form of therapy.

SUMMARY OF IMPACT

The design criteria for the MM are based on the abilities of the clients that visit the Nashua Center. Many of these clients experience physical restrictions of coordination and dexterity. By controlling the movement of a drumstick with an array of buttons, more standard movements are required to interact with the device. By using the MM, the clients can join in with sing-alongs and engage in social interactions with peers.

TECHNICAL DESCRIPTION

The MM is constructed by attaching platforms to each individual percussive part of a child's drum set. There are five parts to the kit which include a snare drum, a kick drum, a rack mounted tom, a high hat cymbal, and a rack mounted cymbal. The platforms are made of wood and attached using L brackets and hose rings. Structures in the shape of H's are made standing on the platforms top surface. The sides of these H structures are made of aluminum and their center lines were screws. The

screws are driven through one end of a drumstick. The other end of the stick is positioned over the percussive part to which the platform is attached. Between the H's frames and percussive part, the drumstick is attached to a rod that is extended downward to the tops of solenoids which are mounted on the platforms top surface.

The solenoid moves the rod up and down, which moves the drum stick up and down. This movement strikes a drum or symbol and makes a sound. The movement of each solenoid is controlled by pulses sent from a Basic Stamp 2 (BS2) microcontroller IC. The BS2 is programmed in PBasic language to send out a high-low pulse. When the pulse is high, the solenoid rod is pulled down by a magnetic field and a percussive part of the drum set is struck. When the pulse is low, the magnetic field is turned off and a spring returns the rod to its upward position. The lengths of the pulses are controlled through a rotary switch setting. Each position sends 5VDC to one of the pins of the BS2. These voltages are programmed to dictate the lengths of the pulses.

Each solenoid is made to correspond to a different button on a control panel. When one of the buttons is pressed, it takes voltage away from one of the pins of the BS2. This makes the BS2 send out a pulse to move the corresponding solenoid. These pulses are connected to the base pins of transistors. When the pulses are high, 24VDC is allowed to run through the transistor's collector pin, to an emitter pin, which powers the inductor of one of the solenoids. These inductors generate the magnetic fields that pull the rods down.

A power switch in series with a 120VAC to 24VDC power supply is used to activate the device. Once set to on, an LED lights up to indicate the device is on.

and the power supply sends 24VDC to the circuit with the solenoids and transistors and a circuit that turns it into 5.6VDC that is used to power the BS2. The BS2 requires 5.5-15VDC to be activated. Eight 1N4004 diodes in series are used to make this

voltage because each diode has a 0.7VDC drop across it. When in series, these voltage drops add up to 5.6VDC.

The cost of part and materials is about \$400.



Fig. 16.9. Client with final product.

THE PIVOTING BALL KICKER: A DEVICE THAT PROVIDES RECREATION TO CHILDREN WITH AMBULATORY HANDICAPS

Designer: David Alan Haynes

Client Coordinator: Bob Wierzbicki, Shore Educational Collaborative, Chelsea, MA

Supervising Professor: James Drew

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INTRODUCTION

The pivoting ball kicker is designed to provide recreational entertainment to children confined to a wheelchair. The basic premise is that a wheelchair user can join in when their peers are kicking a ball around or to each other. The device enables them to do this. The pivoting ball kicker is a kicking device mounted on a rotating platform. Rotation (aiming) of the kicker is controlled by a device similar to a joystick.

Once the kicker is pointed in the desired direction a separate button on the controller causes the ball to be kicked. In order for the ball to be kicked again it must be placed by hand back in the kicking slot of the device. This can also be done by rolling the ball accurately back into the kicking slot. Ultimately, the pivoting ball kicker can be used as an interactive game involving several players positioned around the kicker who each try to roll the ball back into the slot after it is kicked to them.

SUMMARY OF IMPACT

The design of the pivoting ball kicker is based on the requests of the client coordinator and defined by the abilities of its intended users. The children at the facility have various physical and behavioral disabilities. Each day at playtime, several of the students are only able sit along the sidelines and watch while the other children participate in various activities including kicking a ball to each other. The therapists wanted a way to include everyone in playtime activities. The pivoting ball kicker allows all students to be able to experience the fun physical activities available at playtime.



Fig. 16.10. The Pivoting Ball Kicker, Clients and Designer.

TECHNICAL DESCRIPTION

The main structural components of the pivoting ball kicker are 15/32" interior grade plywood, and 11, 12 and 17 gauge steel. The materials are chosen for their structural integrity and availability as salvaged material from a local sheet metal shop. Plywood comprises the platforms of the assembly. A bottom platform is stationary to the ground while a second platform pivots above it. The two platforms are separated by a bracket assembly containing the hub and axle of a 20" bicycle wheel. The second platform contains the kicking assembly. The main frame of the kicking assembly is built of 11 gauge steel which has been formed into a 3 1/4" by 3 7/16" rectangular tube. Two identical solenoids sit on top of this which power the kicking arm. The kicking arm is made of 3/4" wide 12 gauge steel. The pivoting of the top base is accomplished by two identical DC gearhead motors with 4.9" wheels. These are mounted on opposite sides of the top base

along a center line perpendicular to the kicking direction. Power to the system is supplied by two identical rechargeable 12 volt sealed lead acid batteries. The solenoids use the full 24 volts of the two batteries in series. The pivot motors operate at 12 volts. This voltage provides the desired pivot speed without the need of any additional modification. The pivot motors also need direction

control so an Infinion TLE-5206-2 H-Bridge chip is used. This chip also protects against back EMF that may be caused by sudden changes of direction in the motors. Four AA batteries provide the 6 volts that control this chip. Stop switches are also inserted into this circuit to limit the pivot range to approximately 80° from center in either direction.

The total cost of parts and materials is about \$160.

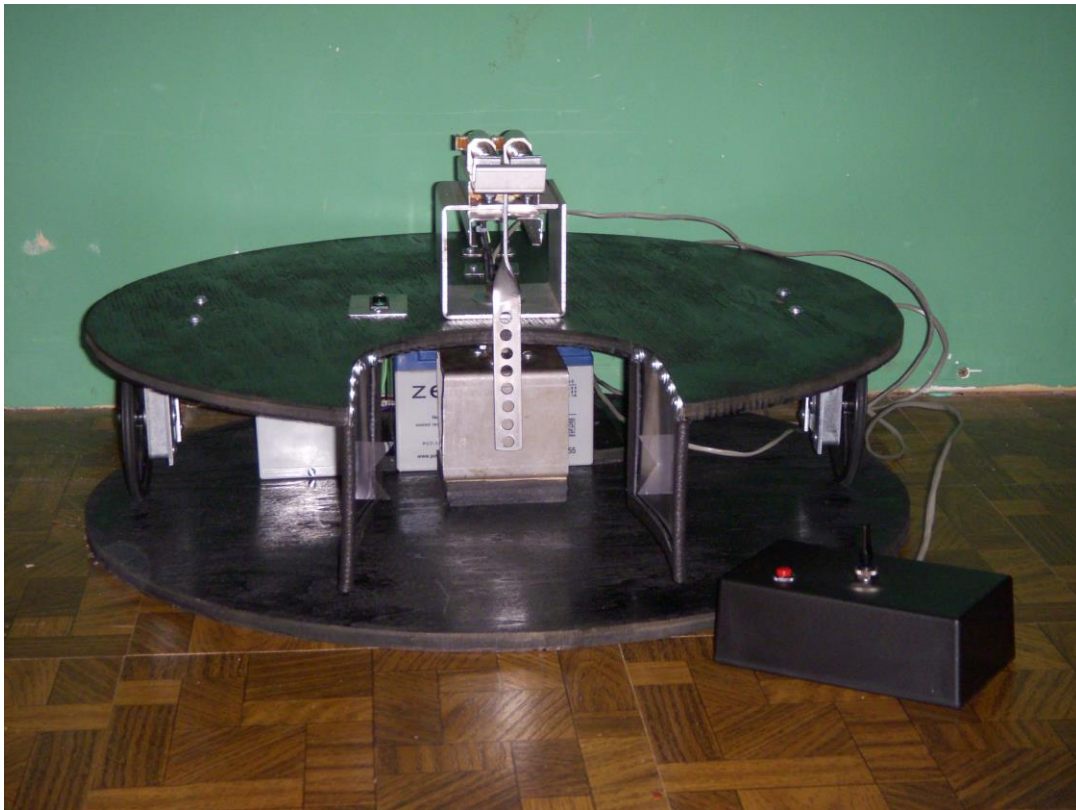


Fig. 16.11. The Pivoting Ball Kicker.

THE INGREDIENTS MEASURING SYSTEM: A KITCHEN AID FOR INDIVIDUALS WITH GROSS MOTOR CONTROL

Designer: David H. Mailloux
Client Coordinator: Lisa Szewczyk, The Nashua Center, Nashua, NH
Supervising Professors: Alan Rux and Senait Haileselassie
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INTRODUCTION

The Ingredients Measuring System (IMS) is designed to enable individuals who lack fine motor control to accurately measure different types of liquid and dry ingredients. The system consists of four electromechanical fluid pumps and valves for measuring four different types of liquids and six specifically designed sleeve valves for measuring two different types of dry ingredients. The entire setup is implemented in a Plexiglass box. After completion, the IMS was given to the Nashua Center in Nashua, New Hampshire. The individuals at this center have a number of different physical and mental disabilities, which include gross motor control of their hands. In particular, a simple task, such as measuring flour or water, can be quite cumbersome for someone who experiences spasms or other difficulties controlling movement in their hands. Therefore, the IMS is intended to provide assistance in measuring various ingredients.

SUMMARY OF IMPACT

The IMS is designed for those with dexterity issues at the Nashua Center. The center plans to incorporate the IMS into cooking classes taught to individuals having only gross motor control and other physical and mental handicaps. These cooking classes are intended to teach food preparation and facilitate communication while preparing food skills. Through the use of the IMS system, individuals will be able to accurately measure wet and dry ingredients, while reinforcing cognitive skills such as following a recipe.

TECHNICAL DESCRIPTION

The IMS is constructed using $\frac{1}{4}$ inch clear acrylic Plexiglass, which is precision-cut using a Trotec Speedy 300 Laser Cutter/Engraver. This material is

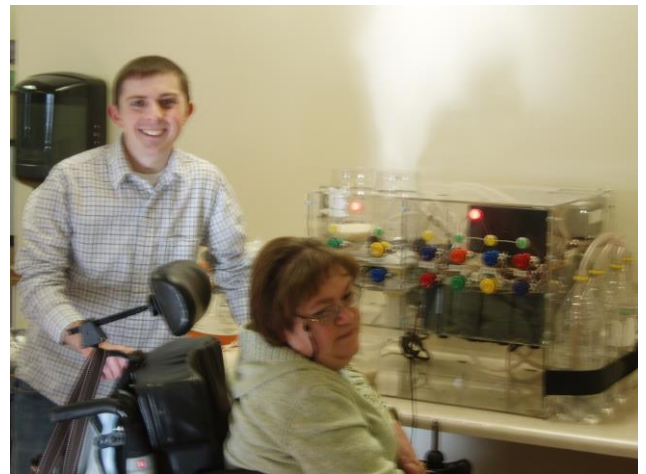


Fig. 16.12. Student Delivering Product to Client.

chosen because of durability and off-the-shelf availability. The overall box is designed with mortise and tendon style joints to further increase durability, while aiding in the assembly process. Between each joint a $\frac{3}{4}$ inch 10-32's screw and nut are incorporated using a cross notch.

To implement a means for measuring liquid ingredients, four beverage style valves and pumps are taken from a fountain machine similar to the ones seen at many fast food restaurants.

Each valve operates on 24VAC, which is controlled through a solid state relay. The solid state relays are then triggered by a PIC microcontroller. The pumps are fully automatic and supply a constant pressure of 45psi without the need for any microprocessor control.

For the measurement of dry ingredients, sleeve valves are included using Plexiglass and stainless steel sheet metal. Essentially, a stainless steel sleeve

is sandwiched between two pieces of Plexiglas, which slide on matching tracks. The sleeve valves are positioned to slide into a plastic graduated cylinder. They are actuated using hobby style servos, which is interfaced with a servo controller triggered by the PIC microcontroller. Using a combination of three sleeve valves per cylinder, all six major units of measure are obtained ($\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$, $\frac{2}{3}$, $\frac{3}{4}$, & 1 Cup). That is, between the top sleeve and bottom sleeve is $\frac{1}{3}$ of a cup, and between the top sleeve and middle sleeve is $\frac{1}{4}$ cup. For all other units of measure, the aforementioned are repeated.

The logic circuit for the project is implemented using a 40-pin PIC18F4520 microcontroller. This device operates at 32MHz, and has 32KB Memory, along with USART serial communication capabilities. The serial communication is necessary to talk to the Pololu 727 Servo Controller for controlling the dry ingredients setup. The PIC microcontroller utilizes 13 user inputs; six units of measure and six types of ingredients to select from, and one service mode switch. The code for the microcontroller is structured to vary the valve flow timing needed to measure liquid. The valves have a constant flow rate. For example, when triggered for one second, they will dispense up to 3.5oz of liquid depending upon the adjustment to the valve.

The cost of the parts and material is about \$900.

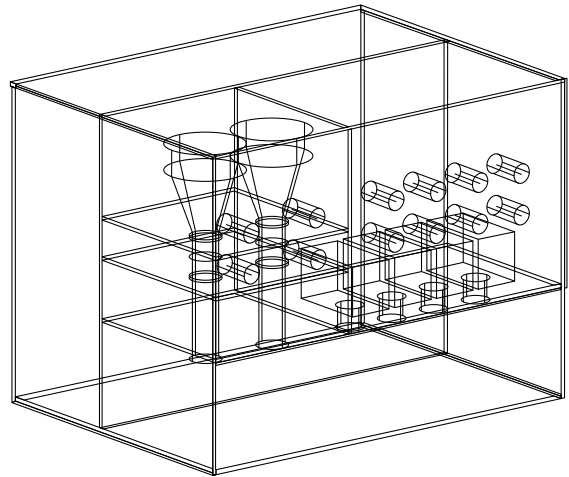


Fig. 16.13. The Ingredients Measuring System.



Fig. 16.14. Example of Mortise (Top View).

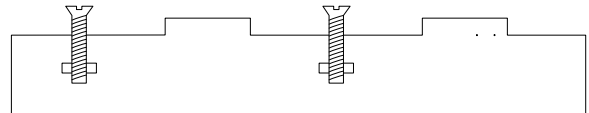


Fig. 16.15. Example of Tenon with Screws (Side View).

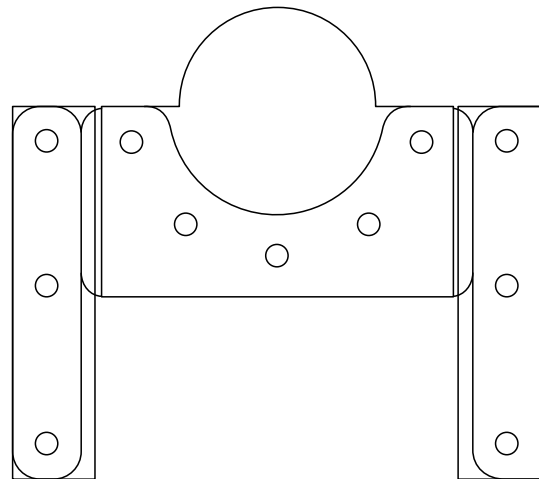


Fig. 16.16. Dry Ingredients Sleeve Valve.

WIRELESS TIMER AND CLOCK: A WALL MOUNT CLOCK WITH A WIRELESS CONTROLLER FOR A TIMER UNDER THE CLOCK

Designer: Jay Noble

Client Coordinator: Bob Wierzbicki

Supervising Professor: James Drew

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INTRODUCTION

The Wireless Timer and Clock is built to time seizures while the client is in a wheelchair. This product will be used to time the duration of a client's seizures. The clock and timer will be on the wall and the start and stop buttons will be located on the wheelchair. The teacher will start the timer at the beginning of the seizure and stop it at the end of the seizure. This device will be delivered to the North Shore Collaborative, MA upon completion. This facility is a school for students who have physical and mental disabilities.

SUMMARY OF IMPACT

The client requires wireless means to time seizures of a particular student. The device has a clock and a timer which can be used to indicate the length of a seizure. At different durations, it will be the assistant's responsibility to give medication to the student that fit requirements of his physician. This is important because medication has to be given to the client if the seizure lasts over 10 minutes. This device allows the assistant to more quantitatively time the seizure and therefore administer more adequate care. The device is used to start timing the seizure from the wheelchair and the wall mounted Clock and Timer is large enough to be seen from the entire room.

TECHNICAL DESCRIPTION

The lay out for the timer and clock circuit consists of three pic24s and two SAA1064 LED drivers and is designed to fit in a wall mounted box with the dimensions H7.5",W10",D3". The clock is located at the top of the box while the timer is at the bottom. The timer is controlled by a wireless transmitter that is supplied with 3.3 volts for its pic24 on the wireless controller. The wireless signal is transmitted to the

timer board where it is received by the receiver chip. This will turn on the timer and the LED's then begin counting. The two buttons on the wireless transmitter are start or stop/reset.

At the start of a seizure, the teacher will initialize the timer that is located on the wall by pushing the start button located on the wheelchair. This starts the timer once it reads the wireless signal that is sent to the wall mounted box. At this point, the teacher can then pay full attention to the student until the seizure is over. They will then push the stop button on the wheelchair to stop the timer. The time can then be recorded into the student's log book that travels with them all day.

The clock circuit is a standalone circuit that uses the pic24 to keep time and use the driver to send the 9 volts to the display. The clock runs on its own pic24 at 3.3volts, while the SAA1064 is supplied with 9 volts with a current that can be varied within the programing. The code written to the pic 24 includes seconds, minutes, hours, days, weeks, months and years. With a built in calendar, the program can also accommodate for daylight savings time. If the clock was to lose time, there are buttons to reset the time.

The two seven segment displays interface with the SAA1064 by dual inputs from two seven segment LED's to the same pins. The driving current and voltage are controlled by two NPN transistors, that cycle through the four LED's, so that none of the LED's are on at the same time. Thus, saving power that would otherwise be lost if all the LED's were on at the same time.

The power for the wireless controller is supplied by two AAA batteries. With the pic controller working on energy saving mode, the batteries will not drain

over a short period of time. As for the power for the clock and timer, circuits can be plugged into the wall because the seven segment LEDs will source to much current for batteries.

Cost of parts and material is about \$250.



Fig. 16.17. Completed Device.

WIRELESS SWITCH ACTIVATED SLIDE PROJECTOR: AN ENTERTAINMENT DEVICE THAT PROVIDES VISUAL STIMULATION TO A PERSON WITH CEREBRAL PALSY AND MENTAL RETARDATION

Designer: Michael Gravell

Client Coordinator: Lisa Szewczyk, Nashua Center, Nashua, NH

Supervising Professor: Professor Alan Rux

Electrical and Computer Engineering Department

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INTRODUCTION

The Wireless Switch Activated Slide Projector (WSASP) is designed to provide visual stimulation to a person with cerebral palsy. Our client, named Cheryl, is a student at the Nashua Center.

The device is basically a slide projector with a wireless remote. The wireless remote has two capability switches for forward and reverse operation. The wireless remote control also has a mode switch for switching into manual mode and slideshow mode. Upon completion, the WSASP was presented to the Nashua Center in Nashua, NH. The children and adults at this center have multiple mental and physical disabilities. Most depend on one of the employees at the Nashua Center to help them for many daily tasks. The WSASP is intended to provide children and adults an opportunity to access entertainment independently.

SUMMARY OF IMPACT

The design for the WSASP is based upon the capabilities of the clients and the needs of the center. The employees at the Nashua Center are always encouraging the children and adults to do things on their own in order to improve their quality of life. Consequentially, the employees wanted an easy-to-use entertainment device. This device is visually stimulating and also gives the client a sense of independence and improves their quality of life.

TECHNICAL DESCRIPTION

The WSASP is made from a KODAK Ektagraphic III slide projector. The slide projector comes equipped



Fig. 16.18. Wireless Switch Activated Slide Projector.



Fig. 16.19. Transmit and receive modules.

with a wired remote control. To allow for portability and ease-of-use, the wired remote control

is converted to a wireless remote control using an RF transmitter and receiver. Its control buttons are replaced with capability switches.

To advance slides, the client presses one of the large jelly buttons on the transmitter end of the remote control. This sends a signal to the receiving end which is connected to the slide projector. There are two solid-state relays at the receive end. When voltage is applied to one of the solid-state relays, the connection is closed for either forward or reverse operation. Due to the low voltage requirement to power the transmitter and receiver, a DC power supply comprised of four AA batteries is used.

The WSASP has three switches, two power switches and a mode switch. The power switches turns the transmitting and receiving modules on and off. The mode switch allows the client to select either manual mode or slideshow mode. The use of manual mode or slideshow mode is determined by the client's caregiver. If the client can operate the WSASP easily, then the client's caregiver can choose manual mode. If the client fatigues easily, then the client's

caregiver can choose slideshow mode. The transmit module is equipped with two mono adapters to allow the client to plug in their own capability switches. The transmit module is also equipped with a piezoelectric speaker which generates a sound when one of the capability switches is pressed, in order to generate auditory stimulation for the client.

The WSASP has two modes: manual and slideshow. Manual mode allows the client to display the next slide by pushing the forward button on the wireless remote control. Manual mode also allows the client to display the previous slide by pushing the reverse button on the wireless remote control. In slideshow mode the client pushes the forward button causing the slide projector to display the next three slides in ten second intervals. Slideshow mode also allows the client to push the reverse button which causes the slide projector to display the previous three slides in ten second intervals.

The cost of parts and materials is about \$350.



Fig. 16.20. Cheryl with the WSASP.

ELECTRIC PUSHER FOR A STANDARD WHEELCHAIR: AN ALTERNATIVE TO MOTORIZED WHEELCHAIRS

Designer: Nathan Sar

Client Coordinator: Bob Wierzbicki, Shore Educational Collaborative, Chelsea, MA

Supervising Professor: Alan Rux

Electrical and Computer Engineering Department

University of Massachusetts at Lowell

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INTRODUCTION

The Electric Pusher (EP) is designed as a low-cost alternative to motorized wheelchairs that allow wheelchair users to navigate with ease. Motorized or electric wheelchairs are more than a thousand dollars per chair but with this design, the cost is about a quarter of that price. The EP unit consists of two DC motors, two wheels, a control box, a joystick and two batteries. The EP frame is constructed from a salvaged frame off an old wheelchair. Two motors are attached to either side of the frame, and a set of wheels and tires are attached to the motors. The joystick is used to control the motors via the control box and thus allows for all range of motion. Two 12-volt batteries powers motors. They are also the power source for the control box. The batteries and control box are attached within the framed unit. The EP unit is mounted on the back of a standard wheelchair. The joystick can be placed on the back of the wheelchair or on the armrest. These two locations are for either the caretaker or the individual, respectively.

SUMMARY OF IMPACT

At Shore Educational Collaborative, there are many wheelchair users that have functional use of their

arms. Propelling oneself in a manual wheelchair can be tiresome. With the electric pusher, this workload is greatly reduced. Also, the cost with this device is greatly reduced, making it a product that can be available and beneficial to a wider group of individuals.

TECHNICAL DESCRIPTION

The frame of the EP is salvaged from the lower portion of a motorized wheelchair called the Quickie P100. The motors and wheel assembly are also salvaged from the Quickie P100. A PIC microcontroller, PIC16F876A, is chosen because of its dual Pulse Width Modulation (PWM) channels to control two H-Bridges, which drives the motors. The H-Bridges are made up of power transistors and optoisolators. The PIC takes the analog signals from the joystick, which consists of two five thousand ohm potentiometers. The analog signals are converted to digital signals with the built in analog to digital converter on the PIC. A program is written to compute the joystick location and send the correct speed and direction to the H-Bridge circuit. Also on the joystick is a button that is used for releasing the electrically engaged motor brakes.

The costs of parts and materials is about \$200.00



Fig. 16.21. Frame Assembly.



Fig. 16.22. Electric Stroller.

VOICE ACTIVATED REMOTE CONTROL: A BOX THAT IS CONNECTED TO TOY CAR REMOTE SO THAT IT CAN BE ACTIVATED BY VOICE

Designer: Nirak So

Client: Bary Dussalt- Veteran Hospital, Bedford, Massachusetts

Supervising Professor: Alan Rux

James Francis College of Engineering

University of Massachusetts- Lowell

Lowell, Massachusetts 01854

INTRODUCTION

Voice Activated Remote Control (VARC) is designed to help patients that are unable to use both arms and legs to play with a toy car. The device is comprised of a voice recognition box and the toy car remote control. Upon completion, the device was presented to the Veteran Hospital in Bedford, Massachusetts. For a patient who is unable to use arms or legs, operating a remote control toy, such as a car, can be somewhat challenging. The VARC is adapted to provide the client ease of use and simplicity. The VARC ultimately is intended to give the patient a sense of relaxation and joy. It also offers the client independence.

SUMMARY OF IMPACT

The design criteria for the VARC are defined by the capabilities of the patients and the needs of the hospital. The client at Veteran Hospital has physical disabilities which prevent him from operating standard remote controls. The caretakers are often very busy and are not able to spend long periods of time with any one patient. Instead of relying on the caretakers to operate the toy car for him; with the help of the VARC, the patient is now able to operate the toy car and change the speed as he desires by himself. The VARC provides the patient a control over the toy car and as new form of interaction with their environment.

TECHNICAL DESCRIPTION

The physical structure of the project consists of a box and a remote. The 9 volt DC adapter is the power source. A 9 volt back up battery may be used if the patient is away from AC outlet.

A 5 volt-Regulator regulates 5 volts to all the components in the block diagram. The data is

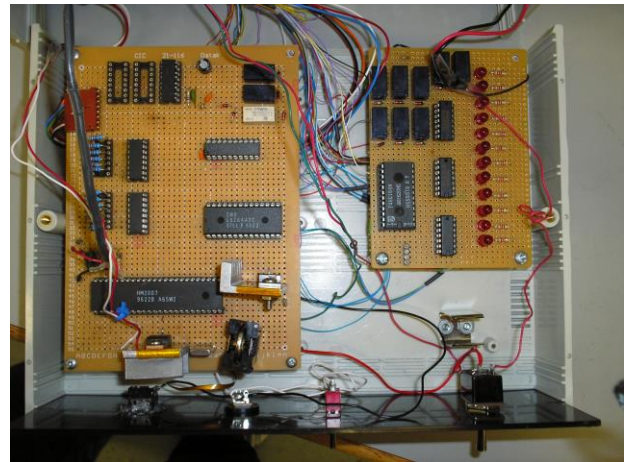


Fig. 16.23. Remote control and voice recognition box.

received through the microphone. The HM 2007 voice recognition chip recognizes the data stored in the SRAM memory. There are two options for back up memory power: LM 317 or 3 volt Lithium Battery. The LM317 is not used because it is more complex than the 3 volt Lithium battery.

The Octal D Latch relayed the data to the Seven Segments and to the Decoder. The Seven Segment has a built in decoder that can convert the binary digits to decimal. The decimal number displays in the LED.

The Decoder had 15 outputs. When one output is on, the rest of the output must be "off". Only one output is "on" at the time. The decoder is active low, so the inverter is added to each output. The relay requires minimum 2.4 volts and 16.7 milliamps for switching. The output voltage and current of the decoder is 3.12 volts and 37 milliamps. The relay is initially open. When the output of the decoder is zero, there is no function. However, when the output of the

decoder is one, the jumper is shorted. To control the speed and angle, a combination of wires is used. Some functions require only two wires while other

functions require three wires. Each wire is connected between the relay and the toy car remote switch.

The cost of parts and material is about \$219.

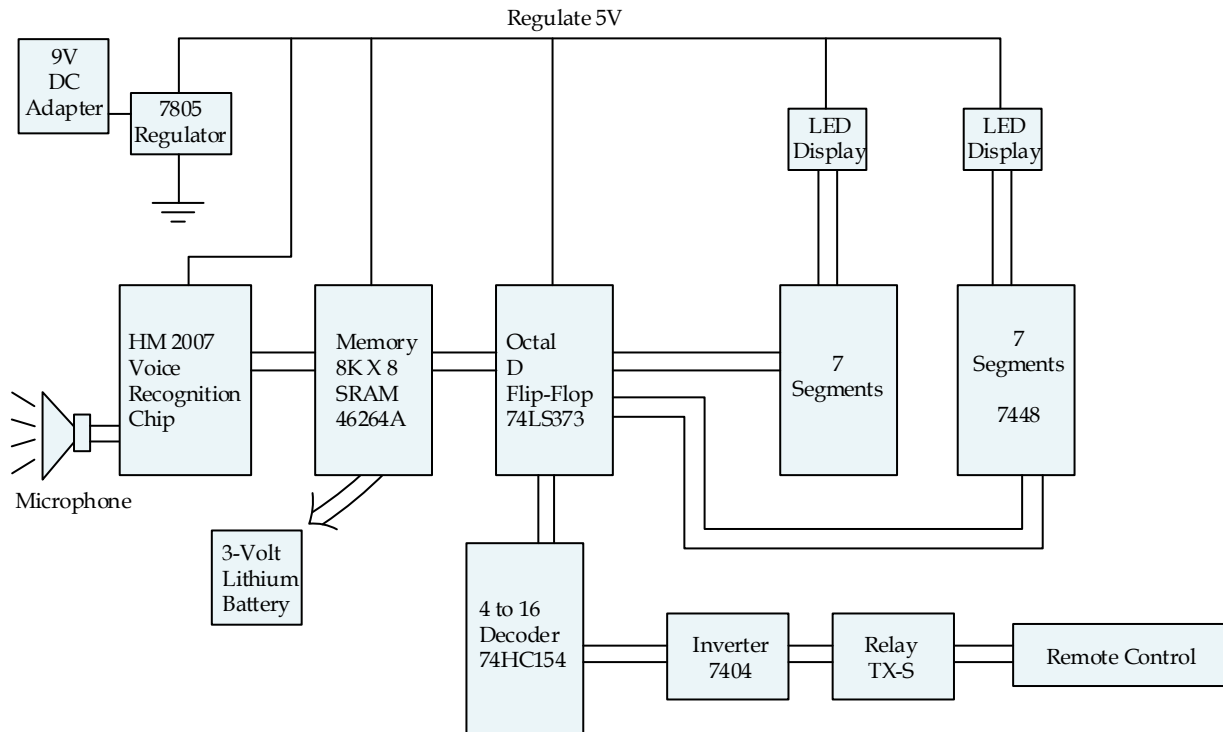


Fig. 16.24. The block diagram.



Fig.16.25. The client with completed device.

INTERACTIVE SENSORY MUSIC BOX: A DEVICE THAT PROVIDES VISUAL AND AUDITORY STIMULATION TO A PERSON WITH MULTIPLE HANDICAPS, WHILE ALLOWING THEM TO PARTICIPATE WITH MUSIC

Designer: Seth Tardiff

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INTRODUCTION

The Interactive Sensory Music Box (ISMB) is designed to provide visual and aural stimulation to people with multiple handicaps. Some of the children, in Mindy Kate's class at Lowell High School in Lowell Massachusetts, have a limited range of motion and poor motor skills. Thus, they lack the coordination to play a musical instrument. The ISMB is intended to provide the students with the enjoyment of playing a musical instrument along to music at the touch of a button. The ISMB box has six buttons and ten lights on the top and three speakers on the front. It enables the user to play along with the music which the ISMB provides as the user watches lights blink to the beat of the music. Upon completion, the ISMB was presented to Mindy Kate's classroom for use in their sensory room.

SUMMARY OF IMPACT

The design criteria for the ISMB are defined by the capabilities of the students in Mindy Kate's classroom at Lowell High School. In Mindy's classroom there is a sensory room which contains devices which provide different kinds of stimuli to the students for recreational purposes. The caregivers require a new device that plays music and blinks lights while also giving the children the chance to control and interact with the device. The ISMB provides the children with an opportunity to have a positive interaction with music. It also provides a lesson in cause and effect. As the students press the buttons they can stop and start the music as well as press buttons that make music.



Fig. 16.26. The Interactive Sensory Music Box.

This shows the students that their actions can have an effect on their external environment.

TECHNICAL DESCRIPTION

The ISMB has three primary functions. Firstly it provides auditory stimulus by playing preloaded music. Secondly it provides visual stimulation by blinking LED lights to the beat of the music, and thirdly it provides musical interaction by allowing the user to press four buttons which trigger samples of percussion instruments. To complete these functions, a series of electrical and mechanical components were utilized.

The electrical components can be broken into three sections including the instrument sample storage circuit and amplifier, the Mp3 module and amplifier, and the beat detection circuit and LEDs.



Fig. 16.27. Client with project.

The instrument sample storage circuit uses four ICs as its main components. These are a Parallax SX-28 micro controller, a 24LC16B EEPROM chip, an ISD4004 sound recording and playback chip, and an NJRM2073D audio amplifier chip. The SX-28 is used to control the ISD4004. It is programmed to record the instrument samples onto the ISD4004. It is then used to play back those samples. The EEPROM chip is used to store the locations of the sound clips on the ISD4004 so that when a certain sound on the chip needs to be accessed, the SX-28 will know where to look for it. The NJRM2073D in conjunction with an 8 ohm speaker load is connected to the output of the ISD4004 so that the instrument sample sounds can be heard at an audible volume. The MP3 module is a device that stores songs in the MP3 format. It has switches which control the volume, select the next track, and play and pause the music. To hear the music being played, the MP3 module is connected to another NJRM2073D chip with two 8

ohm speakers as the load for a stereo configuration. The beat detection circuit utilizes an NTE1549 dot/bar display driver IC as its main component. This chip senses analog voltage changes by use of comparators. It drives ten LEDs which flash in consecutive order as volume changes within the audio itself occur, usually corresponding to the rhythm of the song. The output on the amplifier is connected to the MP3 module which also provides the input for the NTE1549.

The ISMB is powered by four 1.5 VDC two thousand nine hundred milliamp-hour alkaline batteries in series to provide a total of 6VDC. This is used to power the amplifier ICs and the beat detection circuit. A 3 VDC Bel Power DC/DC converter is used to provide a steady three volts to the instrument sample storage circuit. This is because of the 3VDC for which the ISD4004 needs to operate. From the three volts that the DC/DC converter provides two voltage regulator diodes in series provide the 1.6 VDC that operates the Mp3 module.

The mechanical components of the ISMB include seven switches. Six of these switches are 2.5 inch large arcade style switches. These switches are mounted to the top of the box and are the main control switches. Four of these switches connect to the input of the SX-28 and are used to access the instrument samples that are stored on the ISD4004. The other two switches are connected to the Mp3 module and are used as a play and pause button and a next-track button. The seventh switch is a toggle switch, that is mounted to the back of the box, and used as the on and off switch for the device.

The cost of parts and material is about \$210.

THE SWITCH-ACCESS CONTROLLED AIRBRUSH: A DEVICE THAT ENABLES INDIVIDUALS WITH LIMITED HAND DEXTERITY TO PAINT WITH AN AIRBRUSH

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INTRODUCTION

The Switch-Access Controlled Airbrush (SACA) is a painting work bench/station designed to be used for recreational painting activities by individuals with limited hand agility. By touching and pushing or rocking a large single button, the airbrush will spray paint and move vertically and horizontally. A ventilated fume-hood is constructed on top of a push cart with wheels so the device can be easily moved around within the activities room at the Nashua Center. Upon completion, SACA was presented to the Nashua Center for Severe/Multiple Handicapped Individuals in Nashua, New Hampshire. Many of the Nashua Center's clients have cerebral palsy and other disabilities that prohibit them from fine motor control of their hands. Presently, the painting activities are carried out by hand-over-hand guidance with the help of an assistant or teacher. Ultimately, SACA is intended to aid an individual with limited use of their hands to move an airbrush by themselves while enabling them to paint.

SUMMARY OF IMPACT

The design criteria for SACA are defined by observing the clients and their current level of painting capabilities. The aid of a staff assistant provided hand-on-hand instruction in applying paint to a paint brush and moving it around on paper. As a result, the in-home coordinator desired an airbrush that would spray paint by touching a switch and having the airbrush move around with directional control. With an airbrush, paint can continuously be applied and only needs to be refilled periodically. The SACA device allows the



Fig. 16.28. Stepper Motor Drive Assemblies.

user control over painting by simply touching and pushing a button. Furthermore, the SACA paint station provides a stimulating, safe, and rewarding opportunity for artistic creativeness and independent development.

TECHNICAL DESCRIPTION

The fume hood is constructed from a piece of sheet metal 36x36x24-inch. Large axial fans are installed in the back of the hood with filter material to catch and

vent any overspray from the airbrush. The device uses non-flammable, water-based paint. Inside the fume-hood there is a 2-foot fluorescent lamp for light. The master switch located on the side of the fume-hood powers both the lamp and power to the circuit board enclosure. The fume hood is fastened on top of a push cart with wheels so that is mobile. The cart has a bottom shelf where the 1/3 horsepower air-compressor for the airbrush is located. Fastened underneath the fume hood to the cart is a steel cabinet enclosure measuring 12x12x4-inch that houses the control circuit boards and power supply. On the front of the enclosure are switches for the two axial fans, power supply, and speed control knob for the movement of the airbrush. It is important to note that at least one of the fans has to be on in order to switch on the power supply. This is to ensure that there is proper ventilation when the airbrush is spraying paint. Also, there are two 2-amp fuses for the fans and the power supply. Line voltage 120-Vac is supplied to the fans, light, air-compressor, and enclosure. A 120-Vac to 12-Vdc/3-amp power supply inside the enclosure is used to power the motor circuit board and switch circuit board.

The airbrush is mounted on two sets of metal rail drive assemblies installed inside the fume-hood. The

vertical drive assembly is 24-inches in length and the horizontal drive assembly is 30-inches in length. Stepper motors are used to drive the airbrush left-to-right and up-and-down. Stepper motors are chosen for their micro-stepping capability.

Inside the steel cabinet enclosure there is a power supply and two circuit boards. There is a motor-drive circuit board and a switch circuit board to implement logic inputs from the button and limit switches. The transmittance beam limit switches are mounted on both ends of each drive assembly to detect and disable the stepper motors when the airbrush is driven to the end of the drive assembly. The limit switches prevent the user from continuously driving the motors when the airbrush is pushed to the end of the drive assemblies. The switch-circuit board contains a sensor circuit that detects touch on the button which opens a pneumatic solenoid attached to the air-compressor controlling the paint spray. Both circuit boards contain 12VDC to 5VDC converters for 5V logic supply. The motor drive circuit board also contains a variable voltage regulator, regulated at 9V for the motors.

The cost of parts and material is about \$783.00



Fig. 16.29. Student Showing Project to Art Class Teacher.

THE AUTOMATIC PAGE TURNER: A DEVICE THAT ASSISTS CHILDREN AND ADULTS WITH LIMITED OR NO MOVEMENT OF THEIR ARMS

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INTRODUCTION

The Automatic Page Turner is designed to assist people with limited or no movement of their arms in turning the page of a book. The device is designed to be used for books of varying sizes. The Automatic Page Turner is a wooden book holder with small motors attached to the sides which perform various functions.

One of the motors lifts the page using an aluminum rod with two fans attached that creates suction. A second motor turns the page using a steel metal rod as a wiper similar to that of a windshield wiper. A final motor holds the pages down while the device is in standby mode. The Automatic Page Turner was delivered to the Shore Education Collaborative in Chelsea, MA upon completion. Most of the previous designs cost over one-thousand dollars. The cost of this device is about half of that. This design offers an economic and affordable solution to previous designs.

SUMMARY OF IMPACT

This project is designed for the needs of some of the residents of Shore Education Collaborative. The main purpose of this project is to help children with limited or no arm movement in turning the page of a book while reading. This will give them more independence from their caretakers and perhaps encourage reading. This design employs the use of the wall outlet due to complexity.

TECHNICAL DESCRIPTION

The template of the Automatic Page Turner is a wooden book holder made by Levenger called the Cubi Agenda Stand. It is basically a wooden box

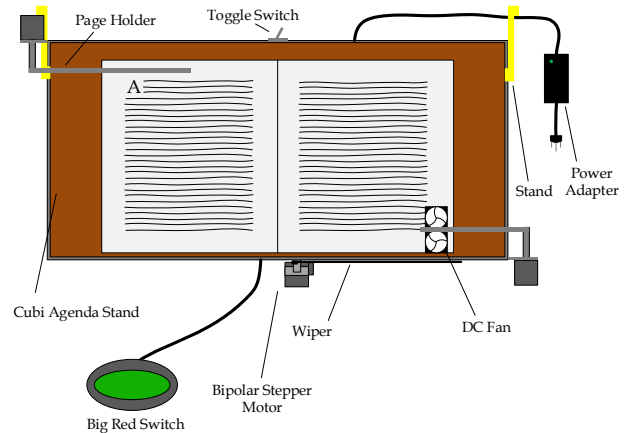


Fig. 16.30. Diagram of Page Turner.

with a wooden stand attached to the top. It comes with a compartment for book storage which is modified to be the storage area for the circuit board. The stand part of the book holder is screwed to the box. The back has a small stand so that the Automatic Page Turner can be used at an angle.

All of the mounted parts are attached to a piece of steel strapping. Three bipolar stepper motors are mounted to the book holder. One strip is laid out on the front of the book holder which holds one of the motors to the right side of the project. There is an identical strip attached to the back. A smaller strip is placed in the front to hold one of the motors. One of the motors is used to lift the page using two small 40mm x 40mm x 6mm 5V DC fans to generate a vacuum. Another motor is used as a wiper to sweep underneath the page once it had been lifted. The

last motor is used to hold the pages down while the user reads.

The motors use rods of various sizes to perform their given functions. The wiper uses a 1/8 inch steel rod to sweep underneath the pages. Steel is chosen because of its bending property; it is easy to shape the wiper into the desired shape. The other motors use 1/4 inch diameter aluminum rods to hold the fans and to hold the pages down. The fans are attached to pieces of aluminum. Aluminum is very rigid and light which made lifting the rods easier for the motors. These rods are lifted upwards against gravity whereas the wiper only moves clockwise or counterclockwise. All of the aluminum rods are adjustable in the horizontal direction for various book widths. The fans are glued onto the rod using epoxy. The fans have a guard glued onto them to prevent accidents and enhance safety features.

The device is turned on using a toggle switch and is activated using the large push button. All the user needs to do is touch the button and the device will perform its operation. This button is free-moving. The button attaches to the circuit via a jack similar to that of a headphone jack. This means that the buttons can be easily replaced if the current one is damaged, or another button, that may be more suitable to the user, is desired.

The circuit is stored inside the wooden box portion of the book holder. There is another 5V DC fan mounted on the side of the device to keep the circuit board cool during operation. The circuit itself is mounted on the drawer that is inside the box, allowing for easy access. The circuit is made up of three microcontrollers to driver to motor setups. One microcontroller controls setups, and two BJT drivers to control the three fans. The microcontroller used is the PIC16F684.

The device can only be powered by the wall outlet. The wall outlet uses a 9V, 4A, AC to DC adapter. The battery option would have used eight D-sized rechargeable batteries and would have needed to have been stored in a separate container which would plug into the project. The inclusion of batteries made the overall device extremely large, so only an outlet adapter is included in this design.

The cost of the parts/materials is approximately \$250.



Fig. 16.31. Client Using the Automatic Page Turner.

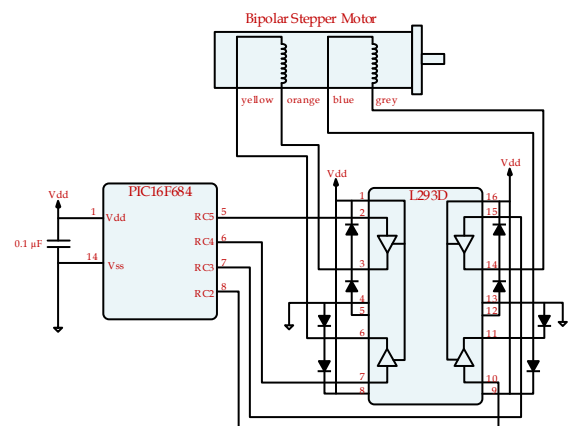


Fig. 16.32. PIC16F684 to Bipolar Stepper Motor

MICROPROCESSOR CONTROLLED POWER SPLITTER (MCPS): A DEVICE THAT PROVIDES CONTROL OF FIVE GROUND FAULT CIRCUIT INTERRUPTER (GFCI) OUTLETS TO ASSIST INDIVIDUALS WITH MULTIPLE DISABILITIES

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INTRODUCTION

The Microprocessor Controlled Power Splitter (MCPS) is designed to assist individuals with multiple handicaps.

The client requires a power-supply apparatus that offers a broad range of multiple use capabilities.

The MCPS allows for the safe operation of high-voltage equipment through the use of low-voltage momentary switches. This custom designed unit gives the user independent control of five Ground Fault Circuit Interrupter (GFCI) outlets by manipulating five color-coordinated low-voltage momentary switches. The unit is equipped with an independent programmable timer for each outlet as well as a remote kill-switch. The primary purpose of the MCPS is to allow individuals to interact with and experience change in their environment.

SUMMARY OF IMPACT

The Nashua Center provides specialized care and support to individuals of all ages with developmental or acquired disabilities, including poor cognitive and motor skills. The design criteria, as requested by the vocational coordinator, serve to support the capabilities and varying skill levels of the clients they serve. The MCPS device will be used to assist individuals with various tasks such as cooking for example, facilitating the individual's control over kitchen appliances through the toggling of jelly bean switches. The jelly bean switches also allow the user to start, stop or reinitialize a programmed time sequence. In addition, the MCPS comes with five independent timers that power



Fig. 16.33. Microprocessor Controlled Power Splitter (MCPS).

devices requiring a limited time of operation, for example, massage devices, heating blankets or lights. It will be stimulating and convenient for the individuals to have some control over the devices plugged into the MCPS. It allows them to take part in the decision making processes concerning their interactions with the environment.

TECHINCAL DESCRIPTION

The MCPS is enclosed in a portable steel box weighing 16 pounds and measuring: Height - 5", Width -14", Depth - 10". The unit works in two modes, Passive and Timers. In the Passive mode a Liquid Crystal Display (LCD) shows five different color outlets.

Each GFCI outlet is controlled by a color-matched, single-momentary switch. Individuals press the 2ND and the CLEAR buttons on the keypad and the MCPS switches to Timers mode. The LCD shows five different timers.

The MCPS is turned on by pressing the white button protected under a transparent cover on the back of the unit. The MCPS is initialized in the passive mode. At this stage, the outlets can be operated by the momentary jelly bean switches.

To use equipment that requires time limits, the key pad is used to set the time frames. The user first presses the 2ND key and then the CLEAR key. The LCD then shows the time set and the time remaining screen. The user presses the white arrow keys to navigate to the desired timer and selects which outlet to set a time for. Then 2ND key is pressed again which enables the red arrows. The red arrows are used to navigate the cursor to the desired digit setting. When the cursor is on the desired digit setting the number is keyed in. The ENTER key is then pressed to begin the time count. Each timer controls the color-coded corresponding outlet.

The CLEAR key is pressed to clear the "Time Set". The "Time Remaining" can be deleted by pressing the CLEAR button on the key pad. Pressing the momentary switch stops the progress of the timing function, pressing it again, allows the time to reset and begin again.

The MCPS is comprised of three main components. The Main Control Circuit is responsible for controlling the device, the RF Circuit provides remote power cut-off, and the Cooling Circuit, which provides cooling of the unit.

The Main Control Circuit is based on a PIC32 microcontroller; three 16F684 microcontrollers, and a QVDA display with a built in microchip driver-SSD, 1906.

Microcontrollers U2, U3 and U4 are responsible for scanning the five Momentary Switches, the key pad and the drive Solid State Relays (SSR's) through BSS 100 transistors respectively.

The U1 microcontroller operates the MCPS in two modes. In the Passive mode, the U2 microcontroller performs a function to determine which momentary

switch was pressed and then transmits this data to the U1 microcontroller. The U1 microcontroller makes the decision as to which outlet needs to be enabled and then transmits the data to the U4 microcontroller, which drives SSR through BSS 100 to enable an outlet. The U3 microcontroller determines which buttons are pressed on the key pad and transmits the data to the U1 microcontroller. The U1 microcontroller reads the data and decides which timer and outlet needs to be set active. When a timer is activated, the U1 microcontroller transmits data to the U4 microcontroller, whose function is to turn an outlet ON through transistor BSS100 and SSR respectively.

When the momentary switch is pushed, the U2 microcontroller detects it and transmits a serial signal to the U1 microcontroller. The U1 microcontroller executes an interrupt, which resets the time on the "Time Remaining" to zero. When the "Time Remaining" is set to zero the U1 microcontroller transmits data to the U4 microcontroller to turn the outlet OFF. The same momentary switch pressed a second time will start a timer using a previously set time.

The RF circuit is comprised of receiving and transmitting circuits respectively. When the momentary switch is pressed the U8 encoder sends data to the U7 transmitter. The U7 transmitter transmits signals to the U5 receiver. The signal from the U5 receiver goes to the U6 decoder, which activates the BSS 100 transistor and works as a switch. When the gate of the BSS 100 transistor is set high, a circuit breaker with a remote trip signal (Schurter TA45-ABDWK 150A4-AZM01) is tripped through the SSR.

The cooling cycle is designed by using a U11 microchip TC 620 with a built in thermistor, a U10 TC 4469 Logic-Input CMOS quad Driver and two cooling fans. The U11 microchip is set to sense temperature in ranges of 0°C-25°C (Fan Off), 25°C-50°C (Fan Low), and 50°C-Up (Fan High). This design gives dual speed temperature control. A signal from the U11 microchip goes to U10 TC 4469 which is responsible for driving two cooling fans. The fans are arranged to work in a push-pull configuration. This allows the forcing of a stream air through a heat sink.

The cost of parts and materials is \$1200.00.



Fig. 16.34. Client using the device.

CHAPTER 17
UNIVERSITY OF NORTH CAROLINA AT
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TIME CARD PACKAGING SYSTEM

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INTRODUCTION

Goodwill Industries is a non-profit organization that offers specialized job training and placement services for people with disabilities. They have a longstanding contract with a company that produces timecard-punching machines. For this contract, one of the tasks is to package user manuals, timecards, keys, and hardware into small Ziploc bags, which are then boxed and sold with the machines. This is a challenging task because of the small size of the bags, which are barely large enough to fit the enclosed items. Our client has Cerebral Palsy and experiences frequent spasms in her hands. It is difficult for her to handle and package these items independently. Furthermore, our client uses her dominant hand while working and has trouble controlling her opposite hand, which can hinder her efforts.

The objective of this project is to design and manufacture an assistive device that enables the client to perform the bag filling task with one hand. This device should enable our client to easily, neatly, efficiently, and independently insert the materials into the Ziploc bags. It should be durable, portable, and accessible for use by a number of Goodwill employees with other disabilities.

SUMMARY OF IMACT

With the Time Card Packaging System, our client can insert time cards and pamphlets into a Ziploc bag within the desired industry standard time period. This device will have an enormous impact on our client's efficiency and versatility in the workplace. One of the Goodwill staff members, Jeff Fleming, stated that, "on the work floor we have only a few jobs that this client is able to perform, and though she can do these jobs she does not complete them in a timely manner (the minimum time standard). With this device, she can not only do



Fig. 17.1. The Time Card Packaging System.



Fig. 17.2. Client loading the papers and bag into the device.



Fig. 17.3. Client using the device; the papers are now in the bag.

another job, but she can perform the job within the minimum time period.”

TECHNICAL DESCRIPTION

There are two important steps to this task: holding the papers together, and sliding the papers inside an open Ziploc bag. The device consists of (a) a funnel-shaped piece of acrylic; (b) a linear guide block that glides along a rail below it; (c) a Ziploc bag securing mechanism; and (d) a hand stabilization bar. In order to perform the task, our client pushes a Ziploc bag over the funneled end of the acrylic, secures it in place, and then drops her stacked materials onto the loading platform directly in front of the guide block. Next, using the guide block, which is attached to the rail, she slides the papers into the tapered, funneled section of the acrylic. At this point, the edges of the papers begin to curl, temporarily reducing their width and allowing them to easily slide into the opened Ziploc bag. Once out of the funnel and inside the bag, the papers will return to their full, original width. The filled bag is then removed and replaced by another empty one, allowing our client to perform her tasks in quick succession.

The funnel and base are made of acrylic and cut with a laser cutter to the proper shape. Using a heat gun, the acrylic was warmed until soft and malleable. It was then bent around a prefabricated mold in order to achieve the desired funnel shape. Methylene chloride was used as a solvent to fuse all of the acrylic pieces together into one solid unit. This manufacturing process ensures that the funnel surface is free of scratches, bumps, cracks, etc., to reduce friction and allow smooth and unhindered transfer of the papers into the Ziploc bags.

An anodized aluminum guide rail is mounted onto the base of the device. A zinc-chromate steel guide

block with a self-lubricating PTFE liner comprises the piece that slides along the rail. Attached to the top of this guide block is a plastic pusher, made using a Fusion Deposition Modeling (FDM) system, designed to be ergonomic by offering the user multiple gripping options. There is an acrylic loading platform attached to the front of the guide block, and a hinged acrylic flap that the client lowers on top of the papers. Because the papers are sandwiched between these two layers of acrylic, they stay organized as the client pushes them through the funnel.

A securing mechanism to prevent the Ziploc bags from slipping off the end of the funneled acrylic while the materials are being loaded is utilized in this design. This simple yet effective mechanism, which acts like seatbelt for the bags, consists of a thin strip of molded acrylic, self-adhesive foam padding and Velcro. To secure a Ziploc bag on the end of the funnel, the clients flips the acrylic strip across the bag and funnel, and attaches it to the opposite corner of the base with Velcro. When finished, our client can simply release the Velcro connection to remove the bag and packaged materials.

Our client has trouble controlling her non-dominant hand, which can hinder her work efforts and slow her overall progress. Our device employs a hand stabilization bar to occupy her non-dominant hand. The bar was manufactured from a 1-3/4” diameter acrylic dowel rod. This gives her more control over her movements as well as a counter-force while she is loading the materials into the Ziploc bags.

The total cost of this device is \$100.

WHEELCHAIR ACCESSIBLE MOTION SIMULATOR

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Client Coordinator: Earll Williams

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INTRODUCTION

Our clients are students at a local middle school who have disabilities. Most of these students use manual wheelchairs that they are unable to propel independently. They enjoy movement, as they smile and laugh when their teacher enthusiastically rocks their wheelchair. However, this becomes tiring and for the teacher. The goal of our project is to design a platform that can safely rock a wheelchair under the control of a teacher or aide. The device should produce tilting motion in four directions: left, right, forward and backward. In addition, the device should be capable of being stowed in a crowded classroom.

SUMMARY OF IMPACT

The device will allow the clients at Lowes Grove Middle School to enjoy the sensation of movement while seated in their wheelchair. One of the instructors at the school stated that "this was a real treat for us to watch. I really enjoyed watching [the client] having fun, smiling and laughing, and pushing his buttons. It's a good sensory activity for the kids since they are limited in their mobility. So it was a real treat, thank you." Therefore, we believe that our device made a beneficial impact for the clients and will continue to be a great device for future students.

TECHNICAL DESCRIPTION

This device consists of a static base, a moving platform, and a control system to activate the movement. The base is made out of $\frac{3}{4}$ " reinforced plywood with dimensions of 36"x40". This wide base of support prevents the device from tipping over during use. Metal braces, arranged around the perimeter of the base, are attached to provide extra strength and prevent the wood from warping. A central support is attached to the geometric center of the base, and it supports most of the weight of the moving platform and the client. At the top of the

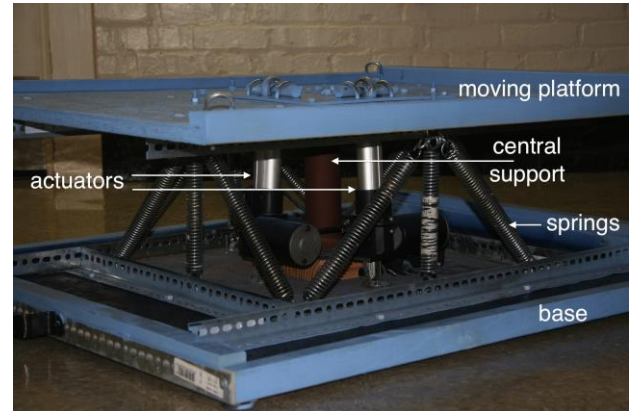


Fig. 17.5. Side view of the Wheelchair Accessible Motion Simulator.

central support is a ball and socket joint, which connects to the moving platform and allows tilting in any direction. Additionally, 12 springs connect from the base to the platform and are used to provide further support of the platform while allowing for its motion.

The control system consists of two linear actuators, along with their power source and joystick controller. The actuators are bolted to the base, and the moving arm is attached to the platform with ball and socket joints. As a result, there are three points of support between the base and platform: the central support at the origin, an X axis actuator, and a Y axis actuator. Using the concept that three points create a plane, the device is able to tilt through a range of angles in any direction, while still remaining sturdy.

The actuators are located 4.5" away from the origin. This was the ideal distance to provide the desired range of tilt angles and angular velocity, in addition to providing the required force. These actuators are rated at 400 pounds of force and move at a speed of 0.59"/sec. Furthermore, these actuators have a stroke length of 2", which provides approximately

12.5 degrees of angular movement front to back and side to side. The actuators are connected to a power supply. The teacher or aide moves the actuator using a joystick, which allows intuitive control of the tilting in all four directions.

The platform, which is made out of $\frac{3}{4}$ " reinforced plywood, is where the client's wheelchair sits during use of the device. The teacher or aide secures the wheelchair onto the platform using straps which are manually tightened with a ratcheting system. In addition, there are metal supports on the underside of the platform, arranged in a geometric rectangle around the connection to the central pivot. This provides extra strength to the platform. There are a number of connections between the base, the control system and the platform as described above. A wooden ramp is also constructed to permit the teacher or aide to easily wheel the students on and off the platform.

The cost of the project is \$650.

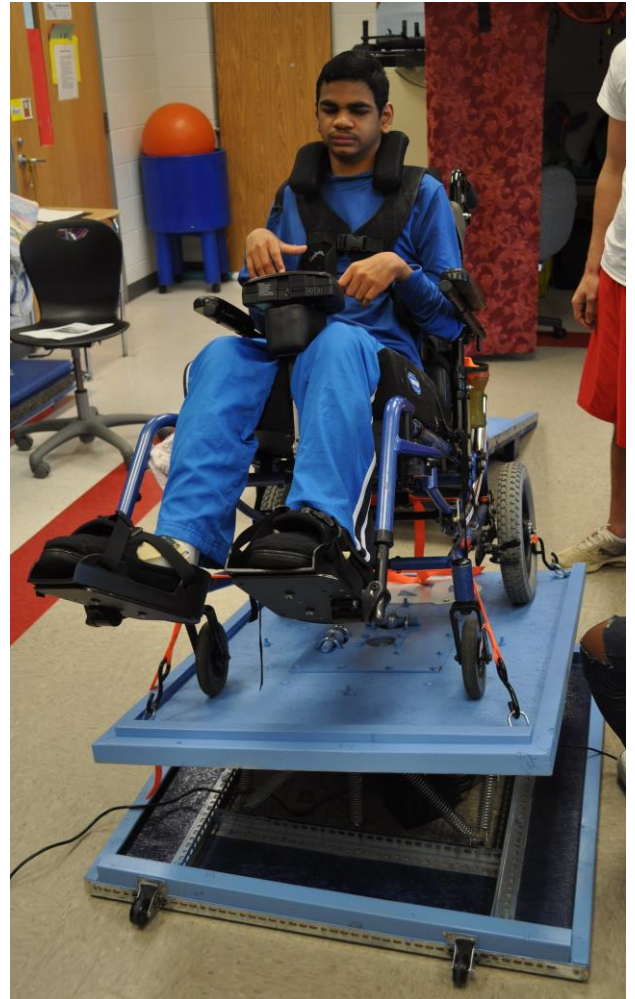


Fig. 17.4. Client enjoying a ride in his wheelchair.

LIFT ME UP

Designers: Ankit Gupta, Jillian Haac, Nabil Khan, and Vishal Rao

Client Coordinator: Charlotte Hughes, PT

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INTRODUCTION

Our client is an 8-year old girl who sustained a spinal cord injury two years ago that left her with paralyzed lower extremities and mild respiratory complications. Using her arms, our client can propel a manual wheelchair and move independently on the floor. However, she cannot independently transfer herself between her wheelchair and the floor. As she continues to grow, it now takes two assistants to safely transfer her to the floor and vice-versa. Unfortunately, our client does not always have access to two assistants in a home or classroom setting. This limits her ability to participate in classroom floor activities, and makes it difficult for her to get in and out of her wheelchair at home. There are no current products on the market that can assist our client with getting to and from the floor. While there are devices that are utilized to move loads vertically, most are designed to lift cars or industrial crates and exceed the force needed to lift a person; this renders current products both cost prohibitive and unsafe for human use.

The goal of this project is to develop a device that allows the client to move between her wheelchair and the floor with the assistance of only one other person. Using her arms, she can perform a depression lift to lift her body weight up five inches. Therefore, the device platform needs to get within five inches of the target height of the floor or wheelchair seat. The device must be lightweight, compact and portable so that our client's caretakers are able to easily transport it between school and home.

SUMMARY OF IMPACT

"The 'Lift Me Up' project will allow a young girl with paraplegia to get out of her chair and sit on the carpet with her peers during several activities during her school day. She feels more a part of the group when she is on the floor with them rather

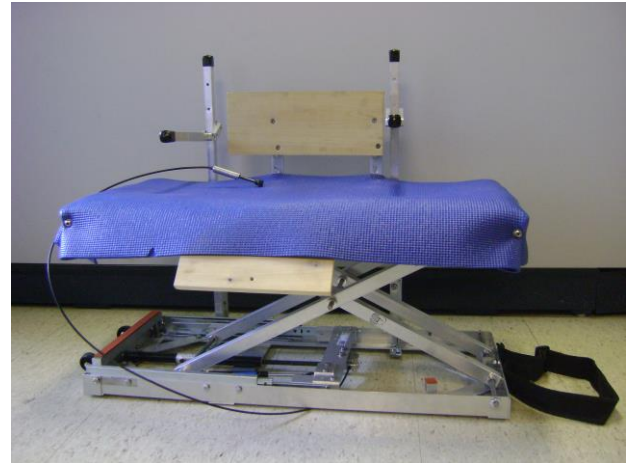


Fig. 17.6. The Lift Me Up device, with the platform about half way between its highest and lowest positions.

than sitting above them in her chair, where she feels more separate. She has adequate sitting balance so she feels safe on the floor but she is only able to get out when there are two teachers in the classroom to safely lift her back into her chair. The student may also use the lift at home so that she can join her younger sibling for play on the floor and then move safely back to her chair with assistance from only one adult" commented Ms. Charlotte Hughes, School Physical Therapist.

TECHNICAL DESCRIPTION

The device has a platform that moves up and down to allow our client to transfer between her wheelchair and the floor. The operation is similar to that of an adjustable office chair, in which the user pulls up on a lever to unlock a gas spring; de-weighting allows the spring to push the chair up, while the weight of the user on the chair will push it back down. In our device, the client pushes a button to unlock the gas spring, allowing the lift to move up when she de-weights herself, or move down when her weight is on the platform.

Our device is based on a scissor lift design, which is often used in an industrial setting in order to lift heavy objects. It consists of two sets of diagonal arms attached to each of the corners of the top and bottom platform. The scissor lift mechanism is efficient because it provides a large vertical height displacement for a small mechanical input force. The lift is made out of 1" square aluminum tubing with a wall thickness of 1/8". This provides the device with adequate strength, but is also lightweight. On one side of the bottom and top platform, the crossing, diagonal arms are mounted to heavy-duty drawer slides. This allows the ends of the arms to move horizontally along the top and bottom frames, as the platform is raised and lowered.

A lockable gas spring is used to apply the force needed to control the raising and lowering of the platform. The gas spring sits inside the frame of the bottom platform and it produces the force needed to push the arms of the scissor lift up. The locking action is controlled by a button that attaches to the gas spring via a cable.

Because our client does not have control over her legs, a system is developed in which she pushes on armrests to de-weight herself. The armrests slide up and down a pair of vertical stability bars. These stability bars attach to the bottom platform and they are 30" tall. They are located to the left and right of where our client sits on the platform. When our client tilts the armrests at an angle, she can slide the armrests up and down along the stability bars to reach a comfortable position, no matter the current height of the platform. When she applies a downward force on the armrests, they do not slide because of friction, and they can support her entire weight. When she de-weights herself, the gas spring can extend to raise the platform.

Aluminum angle-strips are used to create a rectangular frame for the top and bottom platform. A steel wire frame manufactured for cabinet shelving is used to create the surface for the top platform. A yoga mat is attached to this wire frame



Fig. 17.7. The device lifts up the client as she de-weights herself.

as a seat cushion to ensure comfort. The surface of the yoga mat allows our client to slide on it while she is transferring onto the platform, but it also has some friction to prevent unexpected slipping.

There is a short ramp, about five inches long, extending from the front of the platform, which will direct our client's legs away from the scissor lift mechanism. This will help to avoid any possible injuries that could occur if her legs went under the platform while it is lowering. This same ramp will assist our client in moving onto the platform from the floor when the device is in its lowered position. There is also a backrest made of a lightweight wood attached to the top platform between where the armrests are positioned. This ensures that our client will not fall back off of the platform while it is moving or during transfer.

To make the device portable, wheels are attached to the short side of the bottom platform. A strap is attached to the opposite side so the parent or teacher can pull the device while it is rolling on its wheels. The device weighs 30 pounds, so an adult can lift it into a car or over steps. The final cost of this device is \$545.

ON-TASK TIMER: AN ELECTRONIC SCHEDULING TOOL FOR AN EMPLOYEE WITH AUTISM

Designers: Jakub Dmochowski, Michael Millard, Sergio Olivas, Bradley Brown

Client Coordinator: Gena Brown

Supervising Professor: Richard Goldberg

Department of Biomedical Engineering

Room 152 MacNider, CB # 7575

University of North Carolina at Chapel Hill

Chapel Hill, NC 27599

INTRODUCTION

Our client, a 20-year-old male with autism, works at a plant nursery. This is arranged through Goodwill Industries' placement services and a Goodwill job coach supervises the client there on a daily basis. Our client is assigned a set of specific tasks at work each day, ranging from folding boxes to working on garden chores. While he can independently perform each of his tasks, he has difficulty transitioning between tasks because he becomes engrossed in his current activity. As a result, his job coach has to help him transition throughout the day.

Our goal is to develop a device that improves his ability to transition between tasks, furthering his independence in the workplace. He may also use the device at home to transition between household chores. There are several important criteria. The device needs to be portable without impeding our client's ability to work as the nursery spans a half-acre. An audible prompt to transition would not be effective because the nursery is located next to active train tracks. Finally, due to the fact that the nursery is mostly outdoors, the device must be safe and durable in an outdoor environment.

A device based on an iPod Touch (Apple Computer, Cupertino CA) was developed in this design. The iPod Touch is a handheld computer that has a large touch screen for user interaction. In order to fasten the device to the client, we enclosed the iPod Touch in a custom case that straps to the user's forearm. The case also includes a vibration motor that prompts the user to transition.

SUMMARY OF IMPACT

"The client does a variety of jobs at a plant nursery. This tool will be instrumental in structuring his day and affording him the ability to transition from task



Fig. 17.8. The supervisor programs the day's schedule using an intuitive iPod Touch application.

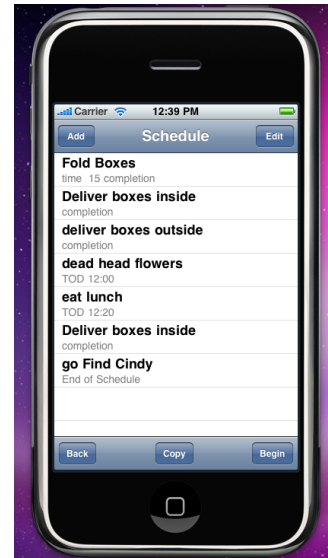


Fig. 17.9. iPod Touch.

to task with little or no intervention from another staff member. This is huge in a place where people are very busy and the client needs to be able to work independently.” -Gena Brown, Goodwill Job Coach.

TECHNICAL DESCRIPTION

The iPhone Software Developer Kit was used to develop the application. The software application is divided into two modes: the task scheduling mode for the supervisor and the operational mode for the client. The task scheduling mode allows a supervisor to generate a schedule for the day. In the Task Editor, the supervisor can create or edit a particular task. Parameters include a name, instructions, and a picture. The supervisor can also choose from the following alarm settings: work for a specified length of time, work until a certain time of day, or work until completion (i.e. until entire stack of boxes are folded). In the Schedule Editor, the supervisor can look at the list of tasks stored in memory and use their finger to slide them into their desired order for the day.

The supervisor or client touches the BEGIN button to transition to the Operational Mode, which executes the schedule for the client. Because this is the client’s user interface, it has a user friendly layout with a single large button, an image of the current task, and instructions entered by a supervisor. For the alarm settings that are time-dependent, there is a progress bar. When time expires, the client is alerted by vibrations from the case. This instructs him to touch the button, making a check mark appear and turning off the vibration. A new screen displaying a picture of the next task will then appear. The client must then touch the BEGIN button to indicate he has started the next task. This process will continue until all tasks set for the day are completed.

To complement the iPod Touch application, a custom vibrating case is constructed to provide tactile cues when it is time for the client to transition. The application triggers the vibration motors by playing a “song” stored on the iPod Touch, which consists of a low frequency tone. The audio output jack connects to custom circuitry, which uses a comparator to amplify the audio signal and drive the vibration motors. A rechargeable lithium-



Fig. 17.10. Client using the On-Task Timer, mounted to his left forearm.

polymer battery, with a capacity of 1000 mAh, powers the electronics. With the use of a low-power comparator, the fully charged battery will operate for approximately two weeks, assuming daily use of four hours. A built-in recharging circuit based on the MAX1555 integrated circuit is also included in the design.

The structure of the case is designed with two compartments. The front compartment houses the iPod Touch. The case has a large window that provides full access to the iPod Touch screen, while covering the “home” button to prevent the client from using that button to exit the program. The rear compartment houses the electronics and vibration motors. Finally, adjustable Velcro straps are used to secure the case onto the client’s forearm.

The case is modeled using computer aided design software and made from ABS thermoplastic on a fused deposition modeling (FDM) system. ABS is a lightweight, durable material that can withstand environmental conditions. To ensure the client’s safety, edges of the case are rounded.

The total cost of this device is \$250, including the cost of a \$107 software license from Apple, but not including the cost of a donated iPod Touch.



CHAPTER 18

UNIVERSITY OF SOUTH FLORIDA

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DEPLOYABLE ROBOTIC BASE

*Designers: Sam McAmis, Thierry Ku, Minh Nguyen, and William Keese
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
Department of Mechanical Engineering
University of South Florida
Tampa, Florida 33620-5350*

INTRODUCTION

The deployable robotic base was developed to assist the user in performing tasks that are difficult to do without another person's assistance. This device can be attached to a variety of power wheelchairs and can be easily removed. The device is deployed via a lifting arm mechanism accessed by the user on the side of the chair. Fig. 18.1 shows the prototype.

SUMMARY OF IMPACT

According to National Health Care Survey in 1994, there are 54 million or 20.6 % of people in the United States who live with some form of disability. There are 1.6 million people who need a wheelchair for mobile assistance. Approximately 96% of wheelchair users have had some form of functional limitation. This robot can then be used to assist the individual perform tasks he or she may not ordinarily be able to do without assistance. Also, this device has the potential for reducing dependence on others.

TECHNICAL DESCRIPTION

This device was designed and developed as a deployable robotic base that can link to a power wheelchair. This robotic base could be attached or detached to the back of the wheelchair and be lifted or released by a lifting arm mechanism. This design project had three main goals: 1) the robot would be able to move in multiple directions easily and be built in such a way that any additional devices, such as lifting arms, could be attached to it for future development; 2) the robot attachment mechanism



Fig. 18.1. The Deployable Base Attached to a Wheelchair.

would be versatile to use on any location on different wheelchairs; 3) the robot could be attached and detached to a variety of wheelchairs.

The device is made of an aluminum base with slots on the ends for the lift arm to be inserted. The base has a wheel track system so that the chair can move with the base on the ground. The lift arm is made of square aluminum tubing. A pulley-track system with two dc geared motors is used for the lifting mechanism. Fig. 18.2 shows the aluminum base attached to a wheelchair by the lift arms. Fig. 18.2a demonstrates the device in the deployed position for use. Fig. 18.2b shows the device in storage.

The cost of the parts and materials was about \$2000.

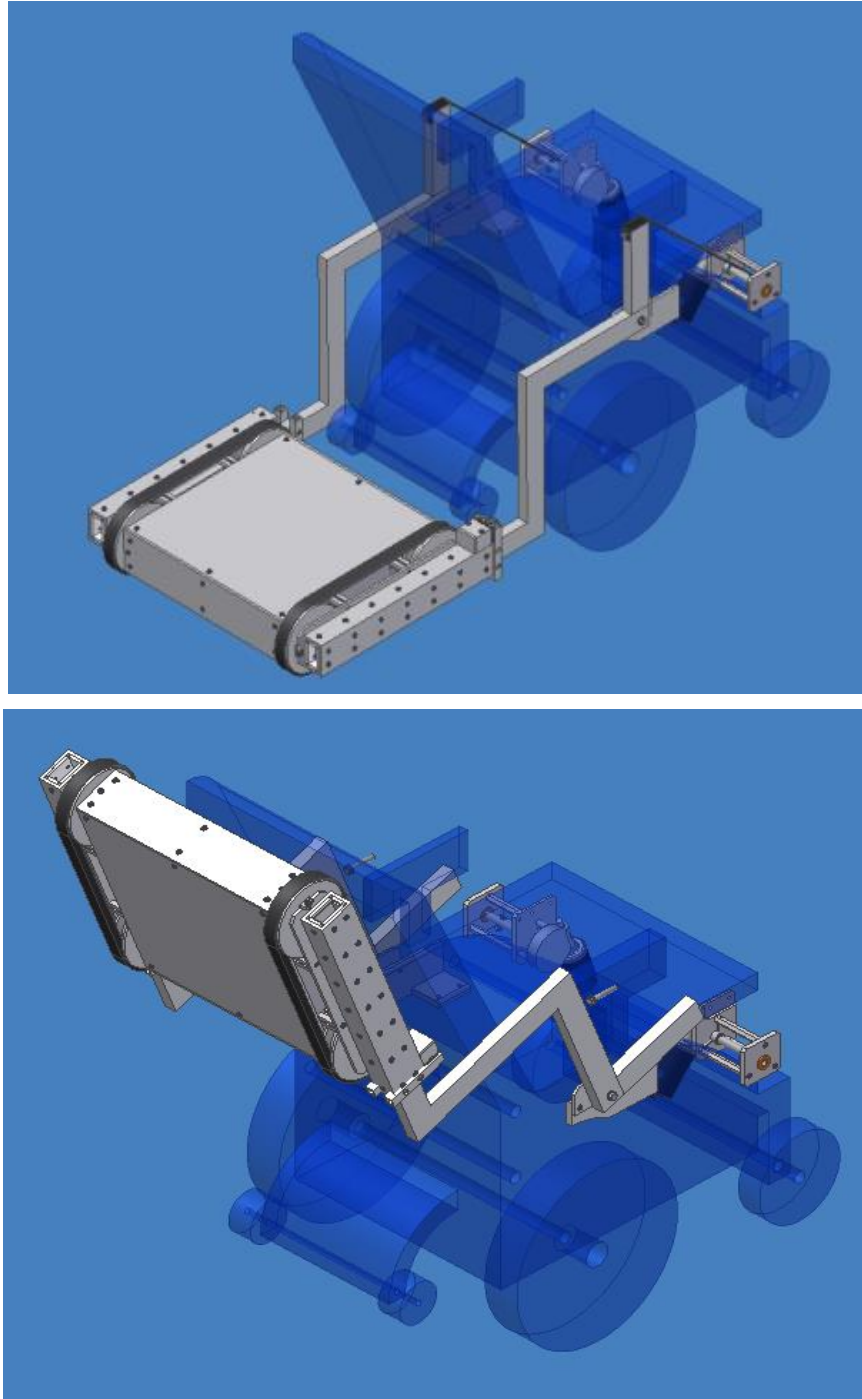


Fig. 18.2. a) Lift Arms in Lowered Position (top) and b) Lift Arms in the Up-right Storage Position (bottom).

PORTABLE LIFTING CHAIR: BED TRANSFER DEVICE

Designers: Arlin Beechy, David Demaree, Mario Simoes, and Ryan Smith
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
Department of Mechanical Engineering
University of South Florida
Tampa, Florida 33620-5350

INTRODUCTION

The purpose of designing a portable hotel bed transfer device is to make it easier for people with disabilities to transfer to and from bed. Hotel beds often measure anywhere from five to fifteen inches higher than the average household bed. This device is meant to be portable for ease of use and transportation within the hotel.

SUMMARY OF IMPACT

This device allows the individual to transfer safely from a wheelchair to a hotel bed with little or no assistance from another.

TECHNICAL DESCRIPTION

The Portable Lift Chair (PLC) is an all-in-one device that is capable of moving an individual weighing up to 250 pounds, in and out of a hotel bed. Its main movements are translational vertically and horizontally, and rotationally. The main components of the design are: 1) a telescopic two-stage lifting column; 2) a DC high torque gear motor, Dayton 1/20 HP, 21 RPM, 12V, 3A; 3) a Torqspline lead

screw, 1.5 inches per revolution; 4) a custom seat, made from 3/4" AL 6061-T651 flat plate; 5) safety handlebars; 6) stabilizing base frame; 7) and sliding top plate.

A seat is attached to a two-stage telescoping lift column which is compact and can be adjusted to a variety of bed heights. Also attached are side rails, made from 0.065" 1" OD seamless steel tubing, for arm rests for user safety. An important feature is the transport system at the top of the lift column that gives the user complete 360° rotational freedom. It allows indexing at various angles so that as the user disembarks from the device, it can be securely locked to transfer to the bed safely.

The lead screw at the base of the device provides motorized translational movement. The user can transfer from a wheelchair onto the seat of the PLC; then move close to the bed for ease of transporting to the bed. Fig. 18.3 shows a CAD drawing of this device.

The cost of the parts and materials was about \$3500.

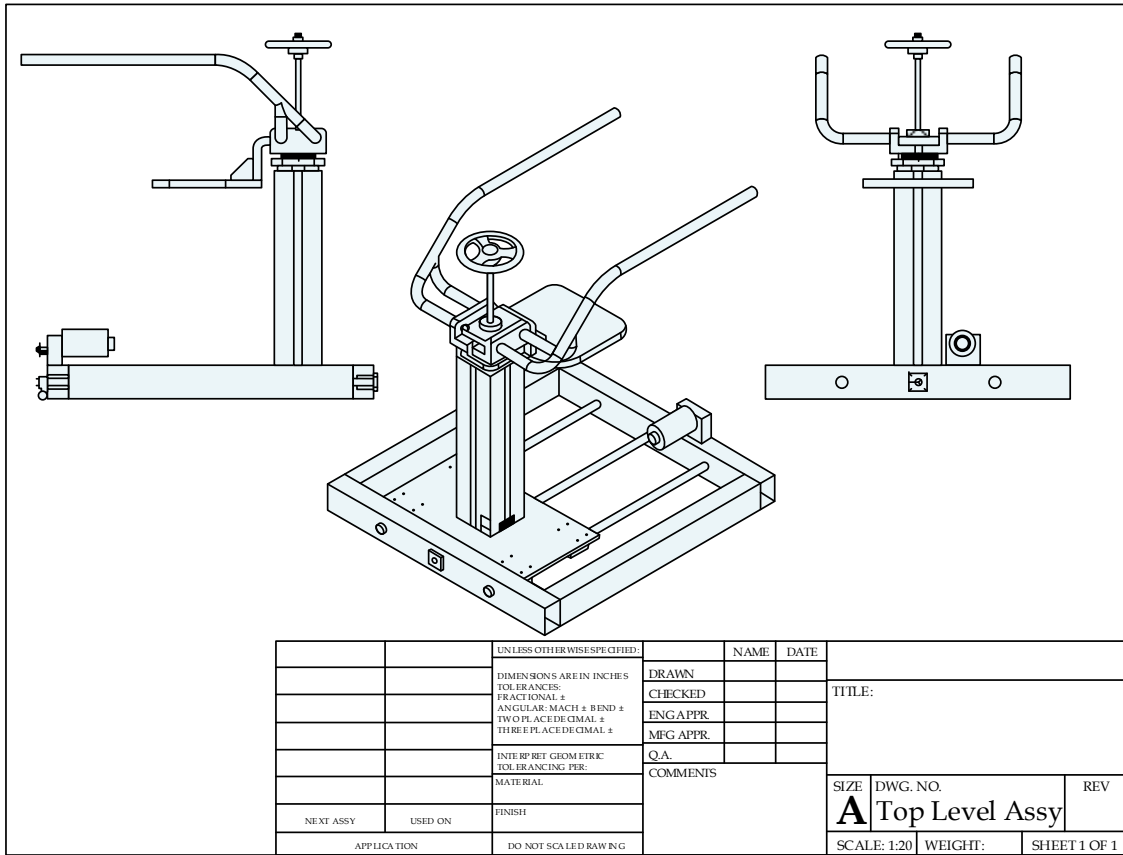


Fig. 18.3. The Deployable Base Attached to a Wheelchair.

THE UPLIFTER: HOTEL BED TRANSFER DEVICE

*Designers: Stephen Hoback, Antonio De Armas, and Iris Boci
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
Department of Mechanical Engineering
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Tampa, Florida 33620-5350*

INTRODUCTION

The purpose of this device is to provide a portable hotel bed transfer device to make it easier for people with disabilities to transfer to and from bed. A slide board is often difficult to use due to the large difference in height from wheelchair to bed. This device incorporates a four bar mechanism upon which a user can easily sit and be raised to the needed height.

SUMMARY OF IMPACT

This device allows the individual to transfer from a wheelchair to a hotel bed.

TECHNICAL DESCRIPTION

The Uplifter device uses an electrical actuator to efficiently raise and lower the user. The 24 VDC actuator is an enclosed worm gear that drives a rod to a predetermined stroke length. The actuator runs from a converted 120 VAC via an AC/DC converter to provide the necessary torque for the maximum load of 250 lbs. The actuator coupled with a four bar mechanism gives the Uplifter the needed variation in height. To operate the device, the user pushes a limit switch that has two buttons for up and down. This device allows the user to transfer from a standard 19 inch high wheelchair seat to a 30 inch high bed. Fig. 18.4 shows the Uplifter device.

The cost of the parts and materials was about \$1000.

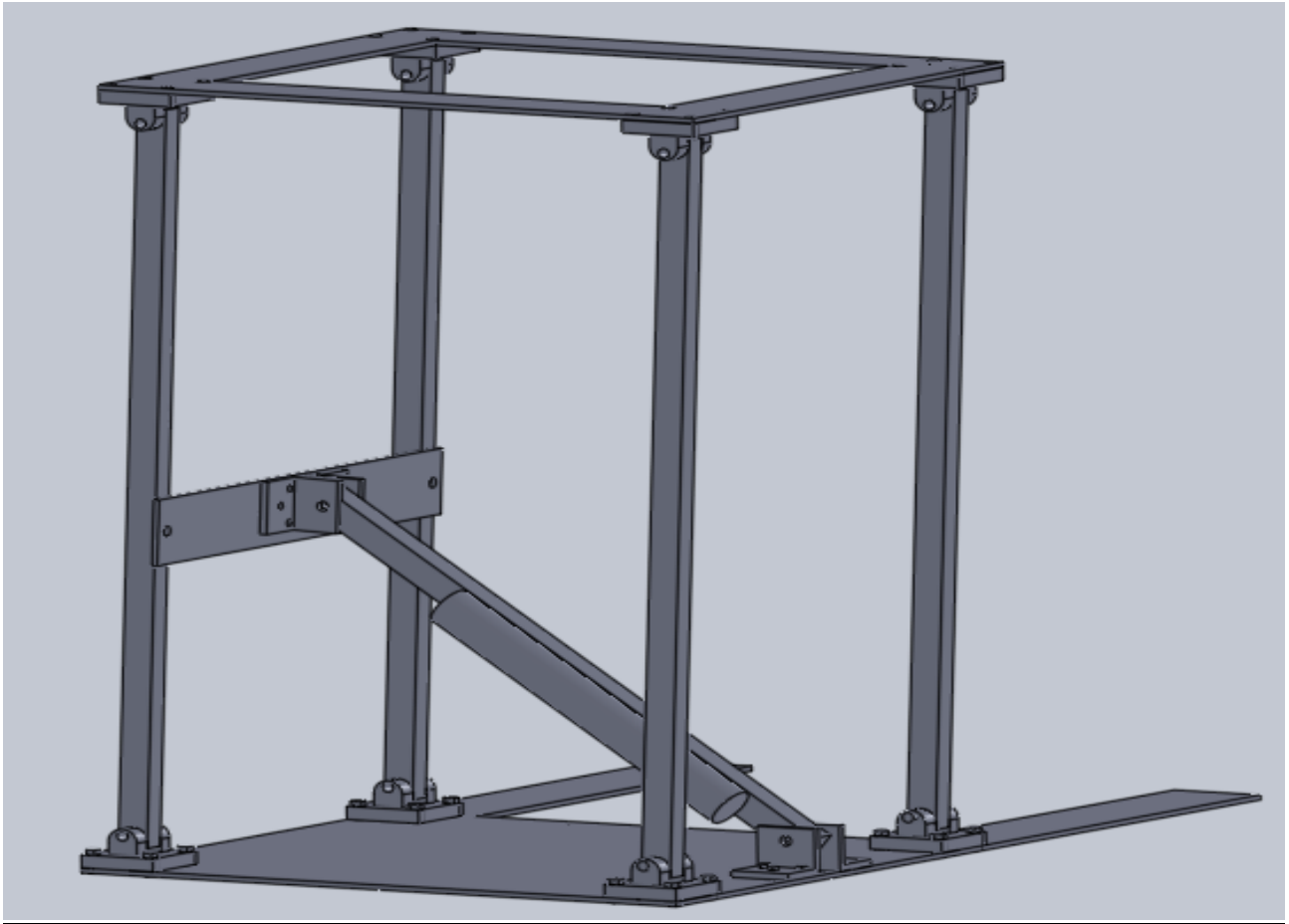


Fig. 18.4. The Uplifter Shown in the Fully Open Height of 30 inches.

PORTABLE WHEELCHAIR LIFTER FOR HOTEL BEDS

*Designers: Alex Berrios, Sean Tancey, and Daniel Perez
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
Department of Mechanical Engineering
University of South Florida
Tampa, Florida 33620-5350*

INTRODUCTION

This objective of this project was to develop a portable transfer device for hotel beds as an alternative to helping people with disabilities move from their wheelchair to the hotel bed.

SUMMARY OF IMPACT

This device allows the individual to transfer safely from a wheelchair to a hotel bed with little or no assistance.

TECHNICAL DESCRIPTION

The device works as a portable wheelchair lifter, using two hydraulic electric jacks to raise a platform.

For transfer, the user drives the wheelchair onto the platform which is then raised until it reaches the correct level.

The lifting plane of the prototype has a width of 30 inches and a length of 48 inches. The device materials used are A36 carbon steel, which gives the prototype a large yield stress (250 MPa) with a minimum amount of deflection. The prototype has a maximum stress of 65 MPa when lifting the user and power chair. The device weighs 335 lbs.

The cost of the parts and materials was about \$1000.

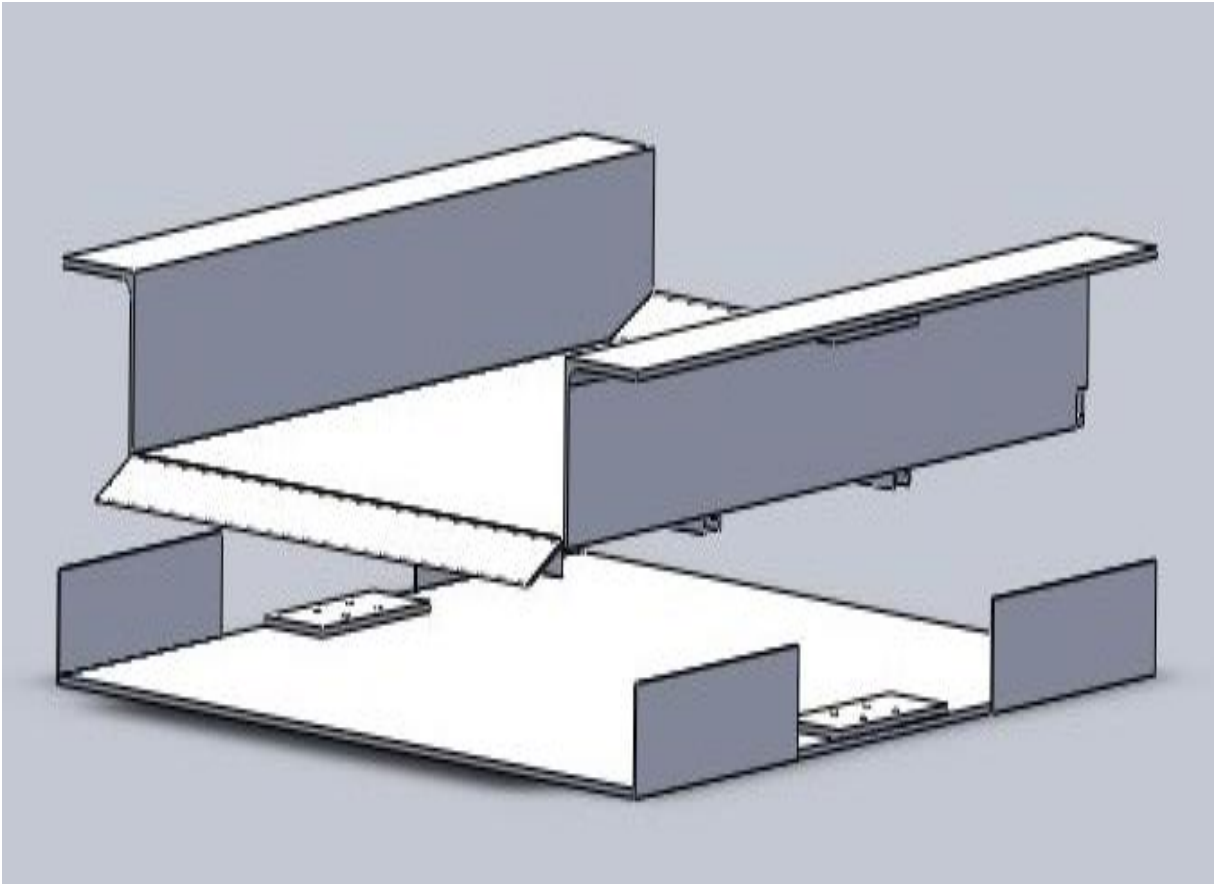


Fig. 18.5. Portable Wheelchair Lifter.

PERSONAL HEATING AND COOLING SYSTEM

Designers: Jay Mckenzie, Rashid Alshatti, Shuen Yasui, and Yanay Pais
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
Department of Mechanical Engineering
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Tampa, Florida 33620-5350

INTRODUCTION

The project goal was to create a personal cooling and heating system that could be integrated into a powered wheelchair. This project is primarily for the use of paraplegics and quadriplegics, who because of spinal injuries, have trouble controlling their own body temperature.

SUMMARY OF IMPACT

By being able to regulate body temperature, the user can enjoy activities that were not possible prior to this device. This device also allows temperature of the user to be monitored and controlled remotely.

TECHNICAL DESCRIPTION

This device uses a thermoelectric cooler as the main component. The 12 v battery on the powered wheelchair, or any external 12 v battery, can be used to power the device. The heating and cooling of the system adjusts automatically based on the user's core temperature utilizing the Peltier effect. The system requires minimal maintenance and is easily adjustable based on the user's environment. Fig 18.6 shows a chart of how the liquid flows throughout the system to cool or heat the user.

The cost of the parts and materials was about \$800.

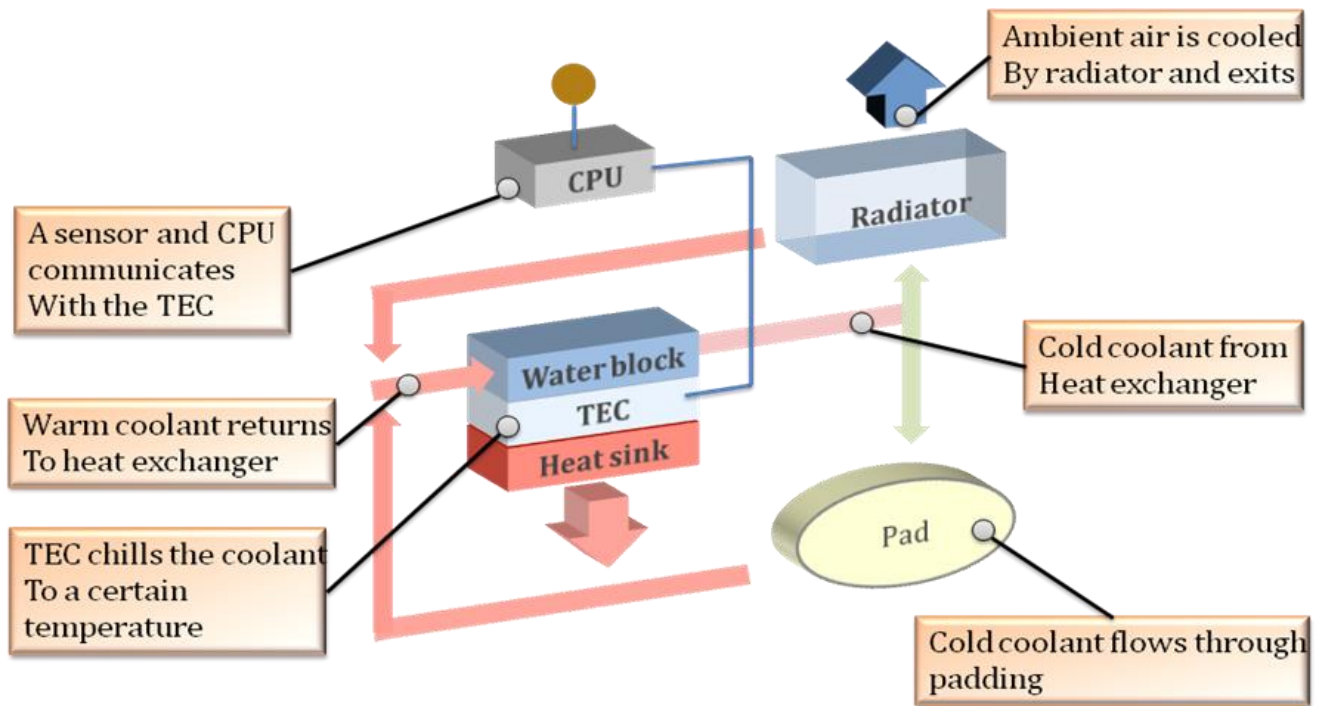


Fig. 18.6. Liquid Flow through the System to Produce Heating or Cooling.

CRUISE SHIP EVACUATION: SPINE BOARD

*Designers: Patricia Arredondo, Danielle Grannis, and Steve Lombardo
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
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INTRODUCTION

This device was developed to decrease the time it takes to evacuate passengers with disabilities from a cruise ship while providing support to the user. Currently a cruise ship has a special team of 30 people who assist passengers with disabilities. In case of an evacuation, at least four members carry the passenger in his or her wheelchair to one of the six master stations located three decks below the rooms equipped for people with disabilities. The life boats hold 140 passengers, 10 crew members, and no wheelchairs. The passenger with the disability is placed unsupported and unsecured on the life boat bench.

SUMMARY OF IMPACT

This design aims to improve the efficiency and safety for all involved in the evacuation of passengers with special needs. This device is a means of carrying the individual and provides seating support in the life boat for the person with disabilities.

TECHNICAL DESCRIPTION

This device is a modified evacuation spine board. It is comprised of three sections: back support, seat, and leg support. Each section is attached with locking hinges which allows the evacuation spine board to be adjusted to various positions to meet the user's needs. The spine board has handles surrounding the perimeter, which provide the safety team with extra grip during transport. The spine board also acts as a flotation device, equipped with an automatic inflatable life vest. In case the lifeboat capsizes, the life vest will automatically inflate once it's submerged in water. This device was developed to be able to minimize the number of physical transitions from personal chair to lifeboat bench, provide comfortable support, offer an alternative independent flotation device, improve evacuation time of the boat, and also possess a maximum of 6 decks.

The cost of the parts and materials was about \$700.

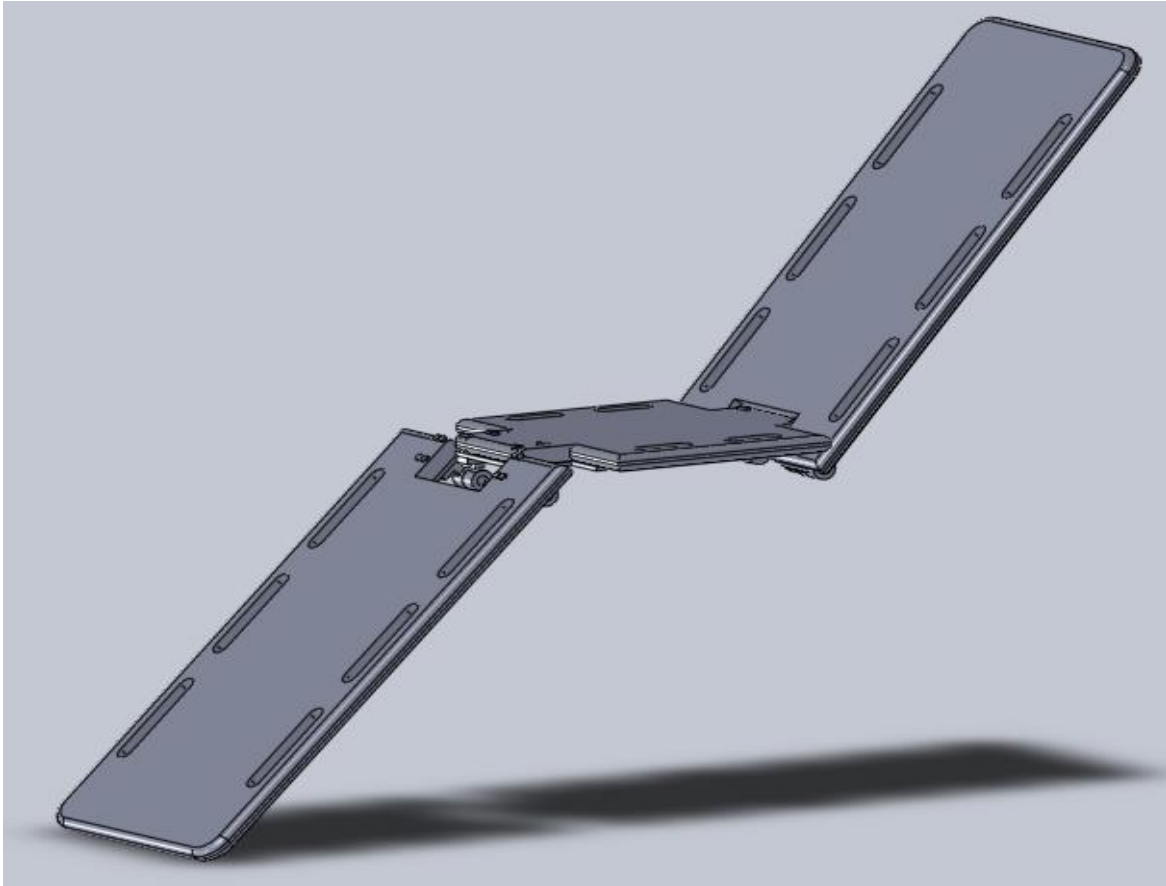


Fig. 18.7. Modified Spine Board for Boat Evacuation.

CRUISE SHIP EVACUATION DEVICE

*Designers: Andrew Knapp, Diego Herrero, and Viktor Skowronek
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
Department of Mechanical Engineering
University of South Florida
Tampa, Florida 33620-5350*

INTRODUCTION

This design is for a mechanical machine to assist in moving people with disabilities up and down cruise ship stairwells. Currently a cruise ship has a special team of 30 people who assist passengers with disabilities. In case of an evacuation at least four members carry the passenger in his or her wheelchair to one of the six master stations located three decks below the rooms equipped for people with disabilities. The life boats hold 140 passengers, 10 crew members, and no wheelchairs. The passenger with the disability is placed unsupported and unsecured on the life boat bench.

SUMMARY OF IMPACT

This design aims to improve the efficiency and safety for all involved in the evacuation of passengers with special needs. This device is a means of carrying the individual and provides

seating support in the life boat for the person with disabilities.

TECHNICAL DESCRIPTION

The Vertical Evacuation Rail Transport System (V.E.R.T.S.) consisted of a track similar to that of a rollercoaster, motor actuated wheel system, and a worm gear assembly. The track was a smooth piece of machined steel alloy that followed the interior of the stairwell. A U-Grooved wheel and a motor actuated system were attached to a platform. The actuator and worm gear assembly assist in moving the device and act as a brake. The user can sit on the composite material platform or chair and be moved down the stairs. The prototype was made to fold up to allow for easier storage and quick deployment in an emergency. Fig. 18.8 shows this chair design.

The cost of the parts and materials was about \$350.

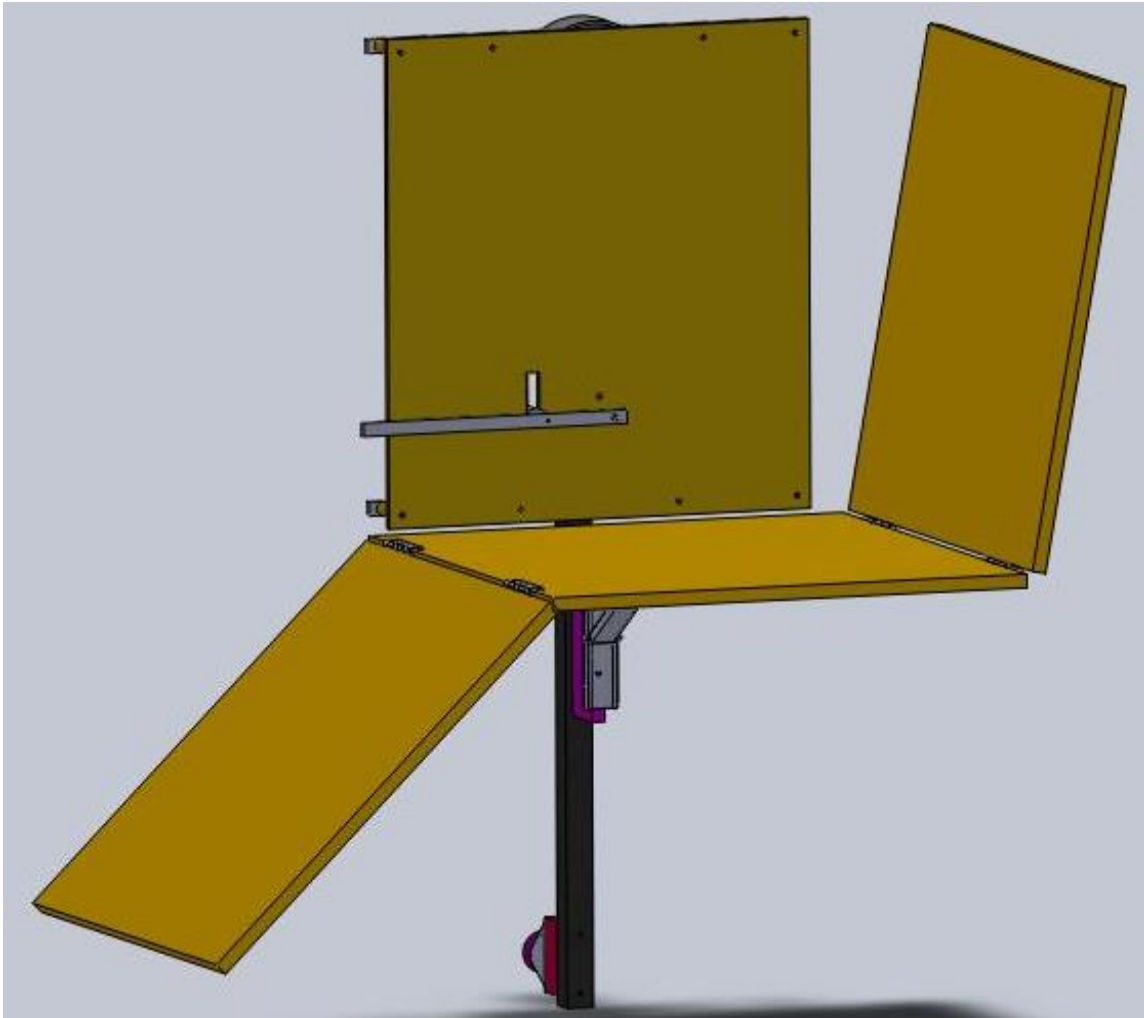


Fig.18.8. The Vertical Evacuation Rail Transport System Boat Evacuation.

CRUISE SHIP EVACUATION CHAIR

*Designers: Joseph Gundel, Justin Barnhart, and Chris Iacono
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
Department of Mechanical Engineering
University of South Florida
Tampa, Florida 33620-5350*

INTRODUCTION

This chair allows the passenger with a disability to be transported to the lifeboats and to be supported appropriately in the lifeboat at sea. Currently a cruise ship has a special team of 30 people who assist passengers with disabilities. In case of an evacuation at least four members carry the passenger in his or her wheelchair to one of the six master stations located three decks below the rooms equipped for people with disabilities. The life boats hold 140 passengers, 10 crew members, and no wheelchairs. The passenger with the disability is placed unsupported and unsecured on the life boat bench.

SUMMARY OF IMPACT

This design aims to improve the efficiency and safety for all involved in the evacuation of passengers with special needs. This device is a means of carrying the individual and provides seating support in the life boat for the person with disabilities.

TECHNICAL DESCRIPTION

The chair frame is made of 6061 aluminum tube. Aluminum is strong, lightweight, and corrosion

resistant - 6061 is commonly used in marine environments. The NPS 3/4 SCH 80 pipe was bent into U-bends, each 18" wide, with one 36" long, and the other 18" long. The seat is 18" x 18", 1/2" aluminum plate with four large triangles removed to help reduce weight. The weight of the frame is less than 25 lbs. and holds a 250 pound load.

A 1" thick mincel foam cushion was sewn around the back, seat, and foot rest, providing support for the evacuee in every location. The mincel foam is lightweight, water resistant, mildew resistance, and buoyant. The foam was covered by a canvas duck cloth material, wrapped and sewn around the frame. Medical grade Velcro straps were used to secure the passenger to the chair.

A three part system was incorporated to secure the chair in the life boat, consisting of four aluminum pegs, a non-slip surface on the bottom of the base plate, and a seat belt attached to the chair. Fig. 18.9 shows the chair design.

The cost of the parts and materials was about \$700.

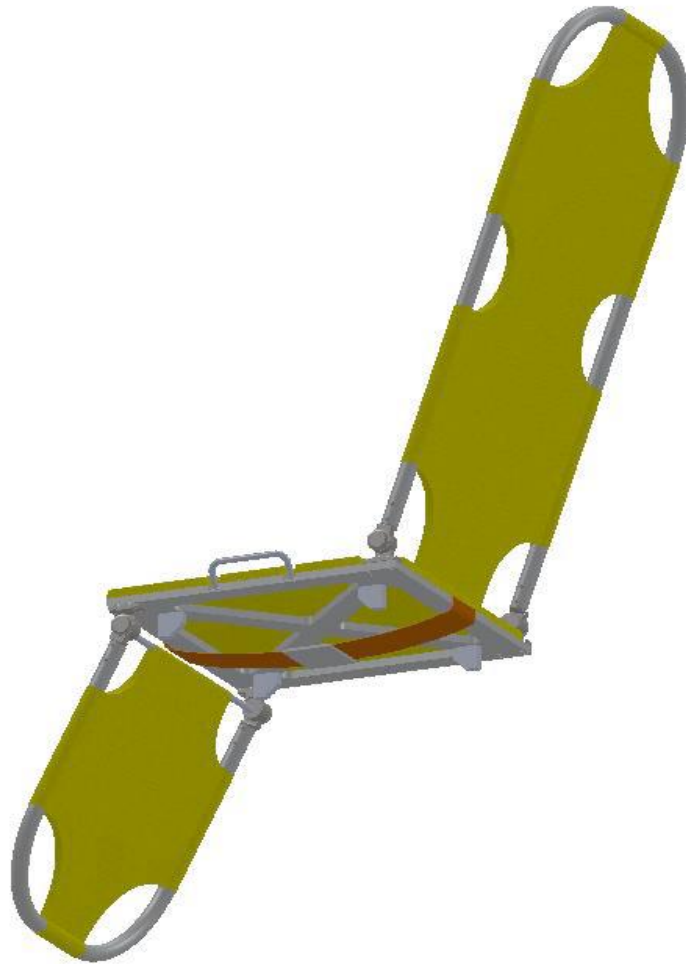


Fig. 18.9. Cruise Ship Evacuation Chair.

WHEELCHAIR LIFT FOR A YACHT

*Designers: Nick Knickerbocker, Blake Palmer, and Tegan Strautmann
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
Department of Mechanical Engineering
University of South Florida
Tampa, Florida 33620-5350*

INTRODUCTION

The objective of this project was to create a vertical lift system for a 46' Carver 444 CPMY, capable of moving an individual with disabilities in a wheelchair safely to the second level of the boat.

SUMMARY OF IMPACT

This lift system allows a person with disabilities to gain access to a boat, that otherwise was not possible. Additionally, this system protects the user from the elements during transport.

TECHNICAL DESCRIPTION

This device is designed for a 46' Carver yacht, which is white with stainless steel trim. The design used conventional elevator techniques, which included a winch and cable system. Due to the shape of the boat, a tract system was incorporated to provide extra stability and safety.

The design includes a winch/pulley system with a custom platform and detachable railings (2" x 2" x 3/16" square stainless steel tubing). The base platform, 48" x 54", was designed to allow a standard power wheelchair to transfer on to it with

ease. The floor of the platform was diamond plate aluminum, fortified with a steel foundation (2" x 2" x 3/16") to withstand a load of up to 1000 lbs. All components were made of stainless steel, with the exception of the aluminum base plate, which was coated in order to resist the corrosive effects of salt water. The foundation of the base plate has a protective rubber coating to prevent damage to the fiberglass hull.

Two custom made roller brackets allowed for connectivity of the carriage to the wall of the boat. The brackets were stainless steel with a 2" in diameter nylon roller. The nylon rollers were chosen for their low coefficient of friction and high modulus of elasticity, and were designed to encompass two ball bearings (5/16" x 11/12") rated for loadings higher than 1000 lbs. The winch that drives the system was rated for loads up to 3000 lbs.

The cost of the parts and materials was about \$1700, and with boat modifications, the cost approximates \$6700.

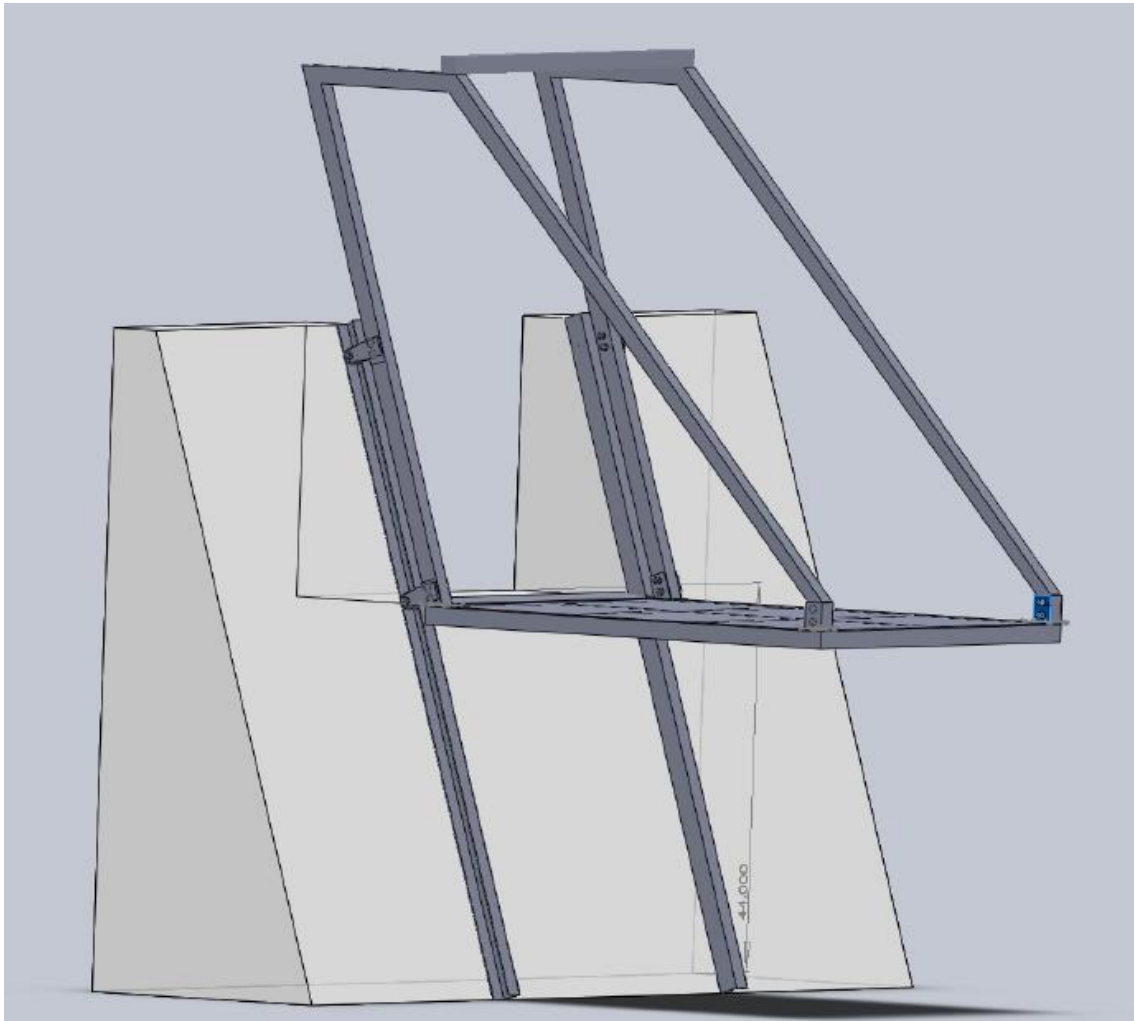


Fig. 18.10. Cruise Ship Evacuation Chair.

HYBRID VEHICLE RETROFIT: A FEASIBILITY STUDY AND DESIGN REVIEW

*Designers: Robert Cole, Scott Fregeau, and Jason Ramsay
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
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University of South Florida
Tampa, Florida 33620-5350*

INTRODUCTION

The goal of this study was to determine the feasibility of converting current gas automobiles into hybrids for energy savings.

SUMMARY OF IMPACT

This device has the potential for minimizing the energy lost by automobiles under braking.

TECHNICAL DESCRIPTION

The device from this project is different from the Regenerative Braking in electric and hybrid cars and the Kinetic Energy Recovery Systems (KERS) in Formula 1 cars, which are used to capture braking energy and store it in a usable form for powering the vehicle.

This device utilizes existing technology for the generative motor system:

The energy is captured through a generator/motor:

1. It is mounted in a cavity next to the front of the motor

2. There is an overflow reservoir where the radiator normally mounts
3. It is powered via a belt with a modified pulley

The batteries have a large storage capacity for proper cycling

A controller is used to manage:

1. The drag of the generator on the belt
2. The power supply to the motor
3. The generator/motor engagement
4. The amount of power to and from the batteries

The only component to be constructed from raw materials was the vehicle-specific mounting bracket.

The cost of the parts and materials was about \$3400.



ROCKING WHEELCHAIR

*Designers: Chris West, Juan Guartatanga, & Momo Kajiwara
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
Department of Mechanical Engineering
University of South Florida
Tampa, Florida 33620-5350*

INTRODUCTION

This design was inspired by a 15 year-old girl who was not able to breathe on her own due to a trachea disorder. In order for her to breathe without a ventilator, she needed to be in a constant rocking motion. There are not many wheelchairs currently available that can transport a person and rock at the same time. In addition, the user for this device tried a wheelchair that is on the market now, but it required a large force to rock and was not practical for her.

SUMMARY OF IMPACT

This device provided a viable rocker to assist this young woman's breathing.

TECHNICAL DESCRIPTION

This design begins by modifying a manual wheelchair. The cross braces were replaced by a four bar mechanism to provide the rocking motion.

The range of the rocking motion is +20 degrees from the horizontal plane. The chair can be locked in any position within the full range of motion.

The device specifics include a frame to hold the four bar mechanism fabricated out of 3/4" square steel tubing, hung between the two halves of the chair by a linkage system. The attachment of the links to the frame was with a self-locking 5/16 shoulder bolt. The four bar links were made out of 6061 Aluminum with PTFE (Polytetrafluoroethylene) plain bearing were pressed into the links for smooth movement. A seat was mounted to the top of the frame. See Fig. 18.11 for the final design.

The cost of the parts and materials was about \$1000.

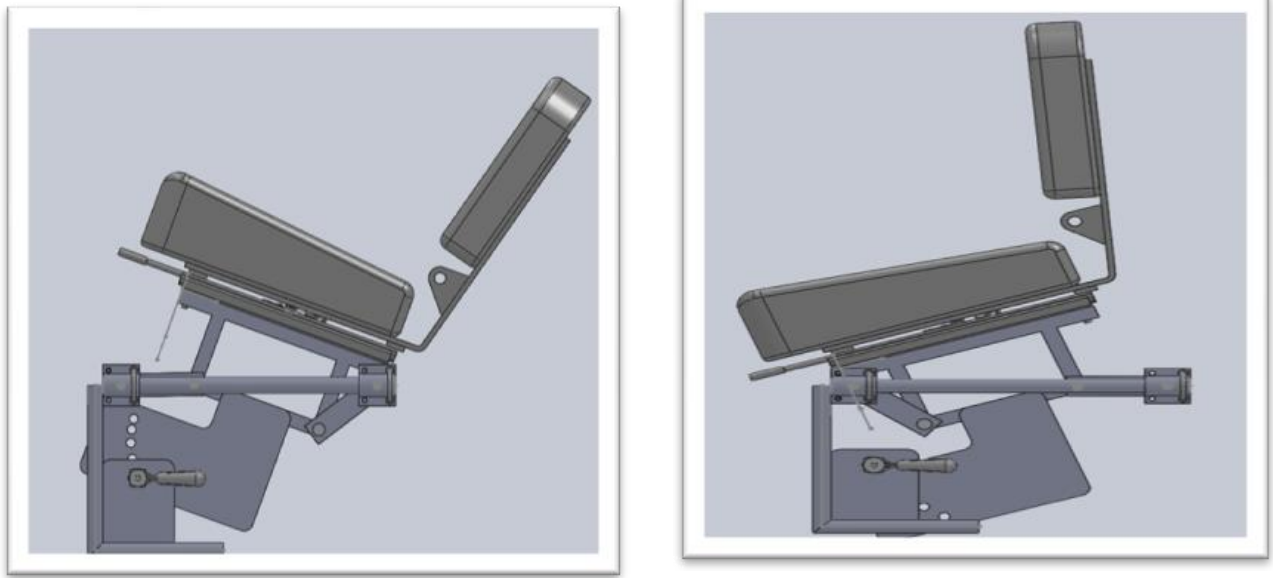


Fig. 18.11. The New Wheelchair Design: a) at -20° (left) and b) at $+20^\circ$ (right).

NON-INVASIVE LAPROSCOPIC SURGICAL DEVICE

Designers: James Doulgeris, Ben Nelson, Brandon Kruse, Graham Roach, and Erin Moree
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
Department of Mechanical Engineering
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Tampa, Florida 33620-5350

INTRODUCTION

Laparoscopic, also known as abdominal, surgery is one of the most common surgical procedures in the United States. With over 4.7 million surgeries performed annually, it is imperative that this procedure continues to evolve and introduce new technologies as it becomes available. In the past, these procedures were generally performed by making a six to twelve inch incision down the center of the patients' body. The abdominal cavity was then exposed and the surgeon performed the surgery in this fashion. Recovery from these procedures could take anywhere from a few weeks to several months.

At present, there are two forms of laparoscopic surgery, the multiple incision and the single incision surgeries. The multiple incision surgery is the more common technique, where two small incisions, between 5 and 12 millimeters, are made in the abdomen. A third, slightly larger incision is made around the belly button to allow the insertion of a camera to provide visibility within the abdominal cavity. By making two incisions on opposite sides of the abdomen, surgeons are capable of using a technique known as triangulation. Because of triangulation, these surgeries can be finished in about 1.5 hours and only require a week and a half for recovery.

The newest version of laparoscopic surgery, which was first performed in 2007, is known as single incision surgery. A new instrument known as the Single Incision Laparoscopic Surgery, (SILS) port allows the insertion of all cutting tools from this one port. This type of surgery provides surgeons with a minimally invasive surgery that leaves only one hard to notice scar. However, without triangulation, the surgery also takes at least 4.5 hours, a three hour difference between the multiple incision surgeries.

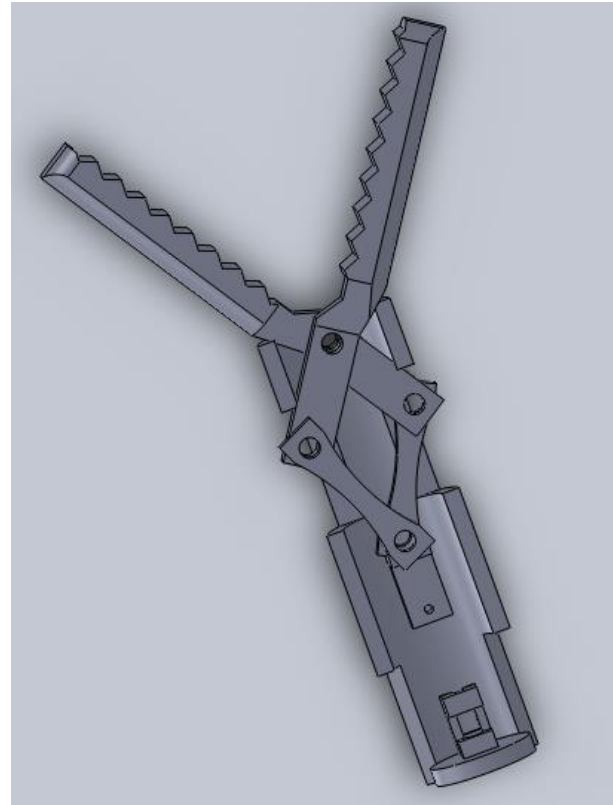


Fig. 18.12. An Internal View of the External Head Including Part of the Delivery Holster.

SUMMARY OF IMPACT

There is an obvious need for improvements to both the multiple and single incision surgeries. As with most medical procedures, the introduction of a scarless surgery would be preferred; however, doctors would be happy with modifications to improve the single incision surgery. During single incision surgeries and the use of the SILS port, the surgeon has limited visibility and without the use of triangulation, the surgery is not only longer but causes harm to the patients' abdominal wall. This device uses triangulation to enhance surgeon visibility and reduce patient scarring.

TECHNICAL DESCRIPTION

The problem of triangulation is resolved by an expanding detachable cutting head tool. This tool is the best representation of a non-invasive surgical tool that, when used in conjunction with the SILS port, provides the surgeon with the triangulation the SILS port prevented. Additionally, two versions of a cable free tool were created: Design 1 is the external cable detachable cutting head tool, and Design 2 which is the cable-free detachable cutting head tool. Both designs were created to closely resemble the current laparoscopic surgical tools on the market today.

Design 1, the external cable, uses a cable system to lock the cutting head to the rod as well as actuate the cutting head when it is in the body. As seen in Fig. 18.12, there is one cable casing running from the handle to the cutting head. This cable casing contains two cables, one used for actuating the cutting head and the other to work the cam used to lock the cutting head onto the rod. When in use, the beveled tip on the handle/rod is used to create a small puncture in the abdomen of the patient. The rod is then slowly inserted further into the abdomen, having the progress viewed on the camera on the SILS port. This tool operates very similarly to those laparoscopic tools in use today. The major benefit of this external cable model is the fact that the rod shaft has been reduced from a 5

millimeters diameter to that of 1.6 millimeters, the same as an 18 gauge needle. With the smaller shaft, no incisions are needed to provide entrance for the tool into the abdomen. This means that no scar will be made by the insertion of the new rod through the abdominal wall.

Design 2, the cable free model, when assembled looks almost exactly the same as the tools being used today. As with the external cable design, the rod diameter is only 1.6 millimeters, again ensuring that no incision must be made to allow the insertion of the rod. However, instead of being actuated by a cable, an inner shaft is used to control the head. As seen in Fig. 18.13, there are two shafts that make up the rod portion, an inner rod measuring 1.2 millimeters and the outer rod measuring 1.6 millimeters in diameter. Each rod has a few notches carved in it; the outer shaft is used to lock the rod to the cutting head while the other actuates the head.

Both designs provide a laparoscopic surgical tool that articulates in the same manner as those on the market today with the added advantage of moving to a single incision surgery with triangulation. Though each tool is slightly more expensive than the current model, because our tools are disassembled, the handle/rod can be re-sterilized and used for multiple surgeries.

The cost of the parts and materials was about \$1500.

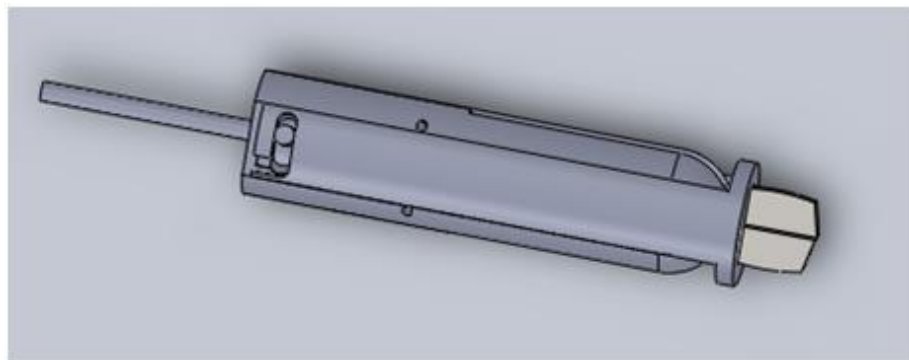


Fig. 18.13. External View of the Cable Free Model Cutting Head.

UNIPOINT: SINGLE-INCISION SURGICAL PORT

*Designers: Kent Wheeler, Danny Segal, and Asad Ahmad
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
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Tampa, Florida 33620-5350*

INTRODUCTION

For many years, surgeons have been exploring minimally invasive techniques to decrease the complications of traditional abdominal hysterectomy. Although two-thirds of all hysterectomies in the United States are performed through a large abdominal incision, a minimally invasive hysterectomy provides a faster recovery, less scarring, less pain, a quicker return to normal activities, and fewer complications. Most minimally invasive gynecologic surgeons view conventional laparoscopic hysterectomy as a great option for patients. Notably, the conventional procedure still requires several small incisions and ports, each of which increases the potential of complications from bleeding, nerve injuries, or port-site hernias and hematomas. The scarring due to the multiple incisions in turn diminishes the cosmetic outcome desired by most women.

SUMMARY OF IMPACT

The next frontier and the next logical step in the development of minimally invasive surgery have recently been realized. This new laparoscopic approach is most commonly referred to as single-incision laparoscopy or laparoendoscopic single-site surgery (LESS). These procedures involve a single umbilical incision and the use of one specialized port through which three to four laparoscopic instruments can be passed. The most significant benefits to patients are the minimization of scarring and complications. Often the incision can be completely hidden within the natural creases of the umbilicus. This is most likely the most attractive benefit to women qualified for single-incision laparoscopy. However the further reduction of potential morbidity associated with the use of multiple laparoscopic trocars may be an even more important advantage to patients.

TECHNICAL DESCRIPTION

The goal was to replicate the triangulation that a doctor is accustomed to with traditional

laparoscopic surgery, which lead to designing a new multi-channel port.

The procedure is still so difficult to perform that surgeons are reluctant to offer the option to any but the best possible candidates. The SILS™ port design that is currently being used at Tampa General Hospital is a great device that makes the benefits of single-incision laparoscopy available to patients. But the design of the SILS™ has its drawbacks as it is a first generation product. The SILS™ port is a solid form with holes from top to bottom. Being a solid form, whenever one instrument is manipulated the entire device is moved – resisting the surgeon’s movements and interfering with the manipulation of other tools in the port.

The design team designed the UniPort. It addresses many issues that the original SILS™ port and other mechanisms of single incision laparoscopy do not address. Once fully assembled, the UniPort has a larger port and tool aperture maximizing the 30mm incision needed for the single incision procedure. Relocating the tool insertion position to the outside of the incision area allows for increased tool motion and a reduction of interference between the tools being utilized. The UniPort’s design features appreciably reduce the high level of stress the SILS™ port produces. Because of the limited range of motion and instrument interference, the surgeon is often forced to bend the port site for a SILS™ port to get better entry angles and easier visibility. To address this disadvantage, the UniPort’s tool pivoting point is located above the incision sight and has a thinner membrane for the tools to move within the incision. In conclusion, the UniPort eliminates some of the issues with the range of motion and the instrument interference thus the UniPort does not need to be manipulated to better suit the surgeon. The goal for the UniPort is to become an all-inclusive product that is the pinnacle of single incision laparoscopic procedures. Fig. 18.14 shows the design.

The cost of the parts and materials was about \$550.

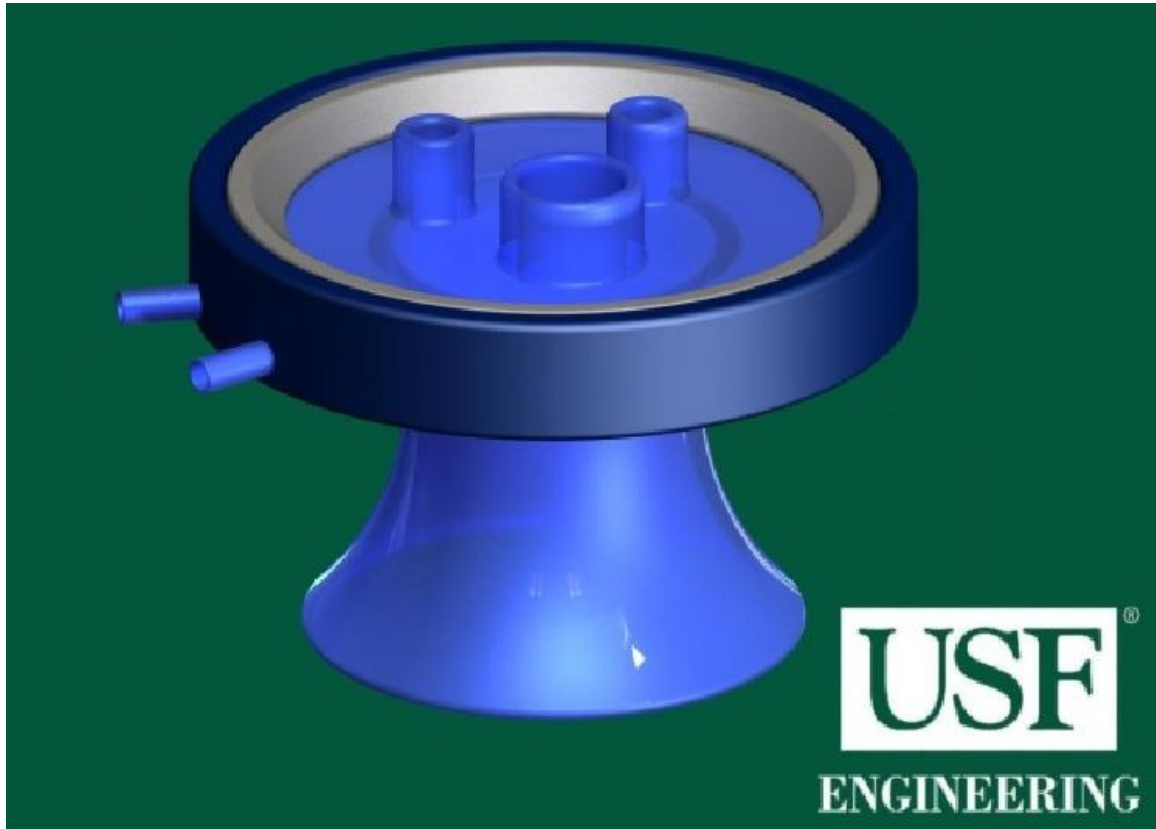


Fig. 18.14. Computer Modeled Picture of the UniPort.

THE DESIGN OF A DOOR OPENING MECHANISM FOR POWERED WHEELCHAIRS

Designers: Matthew Conrad, Steve Gonzalez, Kyle Johns and Patrick Vitello

Supervising Professor: Dr. Don Dekker, Stephen Sundarrao

Department of Mechanical Engineering

University of South Florida

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INTRODUCTION

Wheelchair users are often faced with door entry situations that do not comply with the ADA regulations, these standards can provide information for designing a proof of concept door opening mechanism. The standards of interest within these guidelines are: a 5 pound force maximum for opening doors, a 32 inch minimum door entrance width, and a 24 inch minimum maneuvering clearance on the pull side of a hinged door.

SUMMARY OF IMPACT

The prototype design proved to be a feasible concept for a power wheelchair mount door opening system. The prototype demonstrates the range, motion, and power required to accomplish such a task. This device will allow users of power wheelchairs to open doors and pass through the doors without the assistance of friends.

TECHNICAL DESCRIPTION

The Overall Assembly is composed of five different sub-assemblies. Each Assembly functions to solve an

issue involved with the process of mechanically opening a door. The Utility Shaft serves as a base for mounting these sub-assemblies. The lead screw assembly solves the issue of positioning the system on the door knob while also providing a means of opening the door once the knob of the handle has been turned. Once the lead screw sub-assembly extends out to the door, the gripper assembly is responsible for attaching to and detaching from the door knob. The gripper assembly also applies torque to the door knob in order to solve the issue of turning the handle. Once the handle has been turned by the gripper assembly and the door has been opened by the lead screw assembly, the rail assembly is used to hold the door open while the wheelchair and the system pass through the door. The advantage to splitting up the several functions of opening the door into different sub-assemblies is that each assembly is specialized and can be designed for that single function. Fig. 18.15 shows the design.

The cost of the parts and materials was about \$3100.

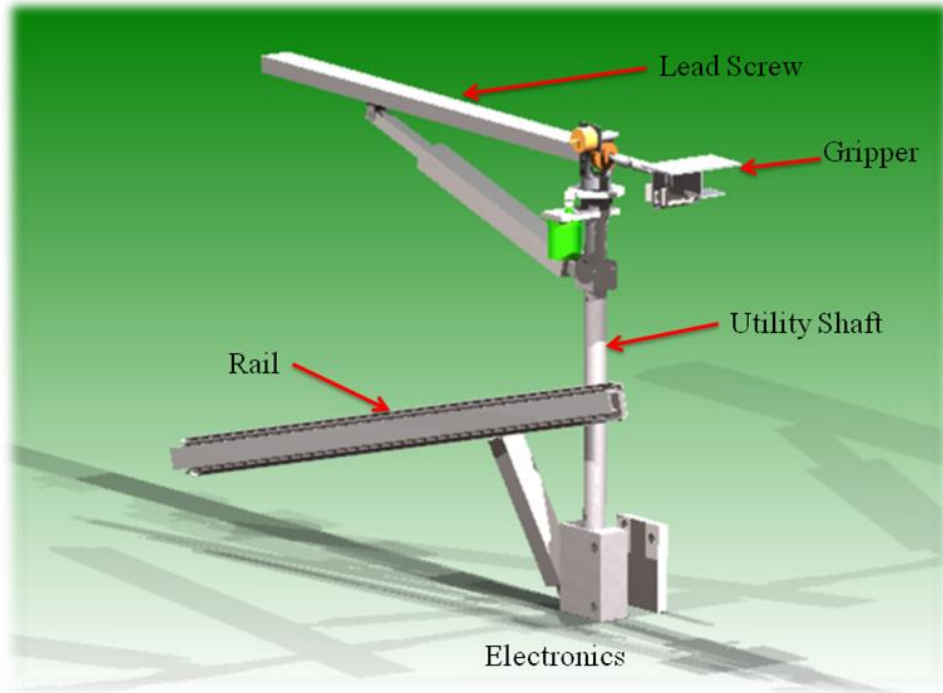


Fig.18.15. Overall Assembly of Prototype.

PORTABLE DOOR OPENER

Designers: Stephen Helms, Lauren Kintner, Jennifer Gilbert, and David Leppert
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
Department of Mechanical Engineering
University of South Florida
Tampa, Florida 33620-5350

INTRODUCTION

In most office or school buildings, the front doors and main entrance doors have handicap access, but many other doors do not. These doors also usually have some sort of damper system to close the door. This closing action presents a problem for wheelchair users trying to go through the door. This device can open these doors without heavy, bulky machinery being attached to the wheelchair, provided the user has enough upper body strength and can partially open one of these doors.

SUMMARY OF IMPACT

This device allows a person in a wheelchair to open heavy doors and go through the door without help. It is lightweight and fits most doors. A person in a powered or manual wheelchair can use it. Little power is needed from the power source of an electric wheel chair with a 12 volt power supply or a portable battery in the case of a manual wheelchair. This design has proven successful in implementing a portable door opener for a door with a damper system.

TECHNICAL DESCRIPTION

This device is constructed of aluminum to reduce the weight of the mechanism. A bar clamp is used to hold the mechanism in place while the door is extending and retracting. A lead screw is used to open and close the scissor mechanism controlled by

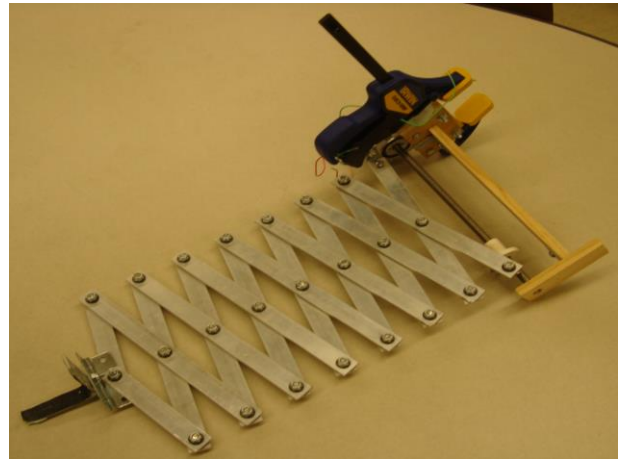


Fig. 18.16. Photo of Completed Assembly: Extended position.

a two-way toggle switch. A controller for the lead screw is connected to the powered wheel chair's battery. It can also be connected to a portable 12 volt battery so that it can be used with a manual wheel chair. The lead screw is supported by a wooden support that is also used as part of the door support. A rubber grip pad is installed at the other end of the scissor mechanism to hold the device to the door without slipping while it is opening and closing. Figs. 18.16 and 18.17 show the device.

The cost of the parts and materials was about \$590.



Fig. 18.17. Photo of Completed Assembly Clamped to Door Frame.

MANUAL WHEELCHAIR DOOR ASSIST DEVICE

Designers: Matt Causin, Matt Kennedy, Paul Mitzlaff, and Kirk Van Portfliet
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
Department of Mechanical Engineering
University of South Florida
Tampa, Florida 33620-5350

INTRODUCTION

The aim of this device is to assist those individuals in a manual wheelchair to pull open any sort of door they would encounter in everyday life. The intended audience is those persons who are capable of normal upper body movement and grip strength. The difficulty comes once the door handle has been grasped and the wheelchair user attempts to back away while holding the door with one hand and maneuvering their wheelchair with the other hand. This device was developed to allow the user to stop several feet in front of the door, apply their brakes, and reach out with the device to grasp and open the door. This allows them to be out of the swinging area of the door while it opens therefore making it much easier for them to navigate through the door. The device consists of a clamping mechanism at one end and a ratcheting handle at the other end of a 3 ½ foot half inch tube. This design will be very useful to anyone in a manual wheelchair that may encounter any type of common door knob in their daily lives and feel comfortable in that fact that they will be able to open it easily.

SUMMARY OF IMPACT

There is a need for a device which can open most types of doors while sitting in a manual wheelchair. One of the challenges, which people in wheelchairs encounter, is trying to pull open a door. The manual wheelchair tends to roll forward when one pulls backwards. This design will help manual

wheelchair users overcome this obstacle. The door opening device will allow users to open a door while staying outside the range of motion of the door. They can then move through the doorway.

TECHNICAL DESCRIPTION

The device can be operated without any motors or batteries to reduce cost, save weight and increase reliability. The device is designed to be collapsible, allow the user to approach a door straight on and stop at a distance of 4 feet from the door, require a gripping force of more than 5 to 8 pounds to actuate most doors, not require the user to lean forward more than 12 inches in order to grip the door handle, be weather resistant and durable, and be aesthetically pleasing. The device should also be able to grip all round door handles, and also operate a variety of lever type door handles.

The design provides a vertical clamping force between two points with a minimum distance of 3 inches between its jaws. This device allows a person to wheel straight up to the door rather than from the side of the door. It is completely made from weather resistant materials. This device has a universal door handle gripper at one end of a 40 inch aluminum tube and a ratcheting handle at the other end. A stainless steel cable connects the gripper to the ratcheting handle after being directed through two holes and around a pulley as shown in Fig. 18.18.

The cost of the parts and materials was about \$1700.



Fig. 18.18. Picture of Prototype.

WHEELCHAIR CLEANER

*Designers: Jose Cruz, Richard Scott, and Johanlis Clintron
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
Department of Mechanical Engineering
University of South Florida
Tampa, Florida 33620-5350*

INTRODUCTION

The goal of this project is to design a wheelchair cleaner that will simplify the task of cleaning one's wheelchair.

SUMMARY OF IMPACT

An issue with wheelchairs is the user's ability to clean the wheelchair properly without reliance on another individual for assistance. Innovative ideas that remove the need of a second person to help the wheelchair user will reaffirm their sense of independence, as well as provide simple solutions to make everyday life easier and more convenient. A simple method to easily clean an individual's wheelchair will allow them the freedom and independence to keep a healthy lifestyle. Wheelchair users will find it more convenient to engage in outdoor activities where the wheelchair will collect dirt and other debris from being outdoors. Users can go indoors without the worry of tracking in dirt and unwanted particles.

TECHNICAL DESCRIPTION

The concept of the design for this wheelchair cleaner was focused primarily on cleaning the wheels. This system uses solely the power of the wheelchair to activate the mechanism. The only outside source of power is the external water supply pumping water through the system. Additional advances could be made to keep a supply of water in a tank for a manual pump. Fig. 18.19 shows the design.

The base of the wheelchair cleaner acts as a support for the wheelchair and the user to comfortably set themselves upon the rollers for cleaning. At the location of each hole, each set of rollers for both the front and rear wheels will be placed to allow the wheel to contact the rollers. The wheel will only contact the rollers during the time of operation. The lengths of the rollers and their corresponding holes on the base will be dimensioned to allow the rear wheels to pass the rollers designated for the front wheels. This will allow for a smoother transition of the user onto the rollers and decrease any unbalancing that may occur when disengaging from the cleaner.

The design of the wheelchair cleaner, in its prototype state, can be implemented in many ways. It would be ideal as nursing homes or other locations where there are many wheelchair users that would need an effective machine to assist in keeping their wheelchairs clean. Daily activities and especially recreational activities will become more prevalent in the lives of individuals restricted to wheelchairs, as the burden of cleaning and maintaining the chair will become extremely quick and simple, and will no longer impede on the individual's lifestyle.

The cost of the parts and materials was about \$900.

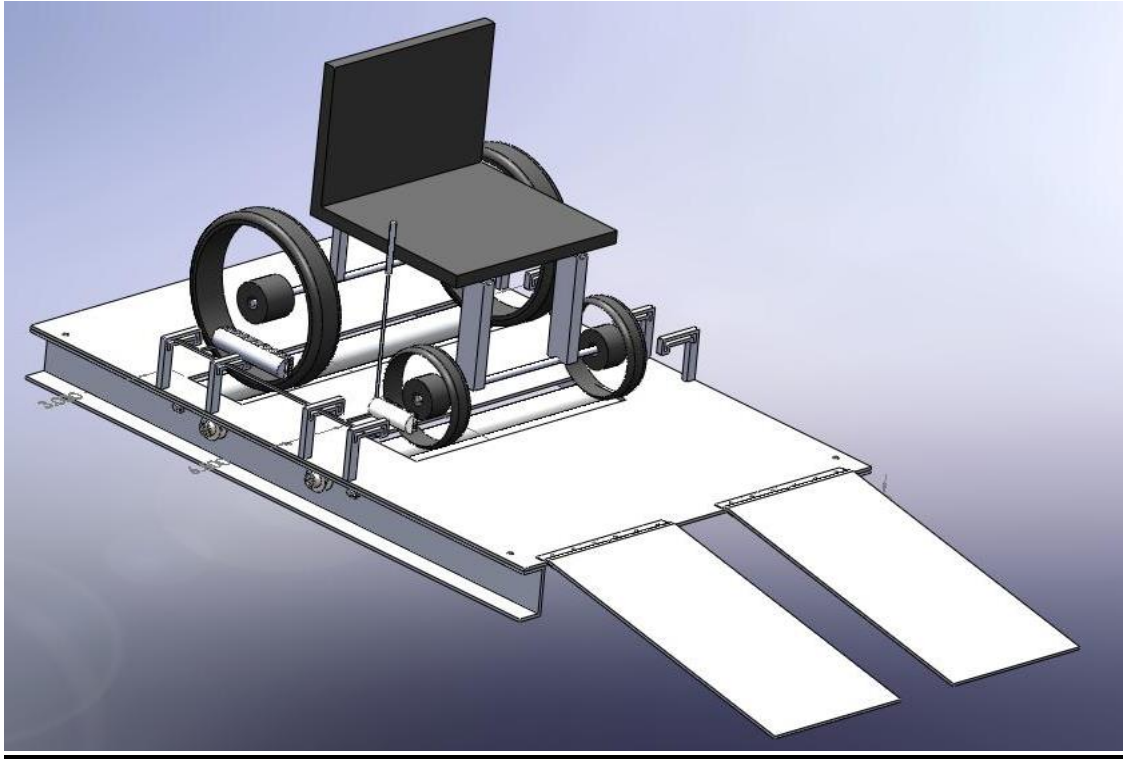


Fig. 18.19. Conceptual View of the Wheelchair Cleaner.

PORTABLE DEPLOYABLE RAMP FOR ATTACHMENT TO A POWERED WHEELCHAIR

Designers: Trenton Jawors, William Krichman, and Brian Scheirer
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
Department of Mechanical Engineering
University of South Florida
Tampa, Florida 33620-5350

INTRODUCTION

The problem was to design a mobile platform that can deploy from a power wheelchair to be utilized by the user to overcome four to five inch curbs.

SUMMARY OF IMPACT

There are many locations where wheelchair ramps are unavailable and the users cannot proceed to their destination without trying to surmount a curb or other obstacle. This ramp will allow the wheelchair user to have the ability to go places that are currently inaccessible.

TECHNICAL DESCRIPTION

The ramp, the RM500, consists of four major components: the ramp, geared motor, fork arm, and controller. Most of these components are commercially available sizes and specs. Since the design has such few components and utilizes aluminum for the main body of the unit; it is also lightweight. The main component is the ramp which is composed of six pieces. There are two U-channels that act as drive paths for the wheels of the wheelchair. They are also nearly stock sized, with the exception of having some of the sides of the channel removed. This means it requires very little machining to get to the final size. These two channels are held together by three hollow

rectangular tube bars. The final component serves multiple purposes; it has a slot that allows the fork to lower and raise the ramp and it also helps keep the ramp rigid. All six pieces are welded together.

The overall length of 36 inches keeps the angle of incline below eight degrees. A finite element analysis in SolidWorks, using the Von Mises criteria, indicates that the ramp can support 500lb static loads. The total weight is 20.82lbs and not expected to slow the wheelchair while towing the ramp on the back. The overall width is designed not to exceed the width of the powered wheelchair, as to not interfere with the user's ability to navigate through narrow walkways.

The ramp is lowered and raised using a fork connected to the driveshaft. The fork is composed of aluminum and the shaft is made out of steel. The shaft features a slotted and key design for easy assembly as well as safe operation. The fork design was inspired by commercially available forklifts and how they lift palettes. However, the RM500 only has one fork located in the center of the wheelchair and lifts the ramp from its center. This was meant to aid in use, because lining up two forks required much more precision from the operator. Fig. 18.20 shows the design.

The cost of the parts and materials was about \$880.

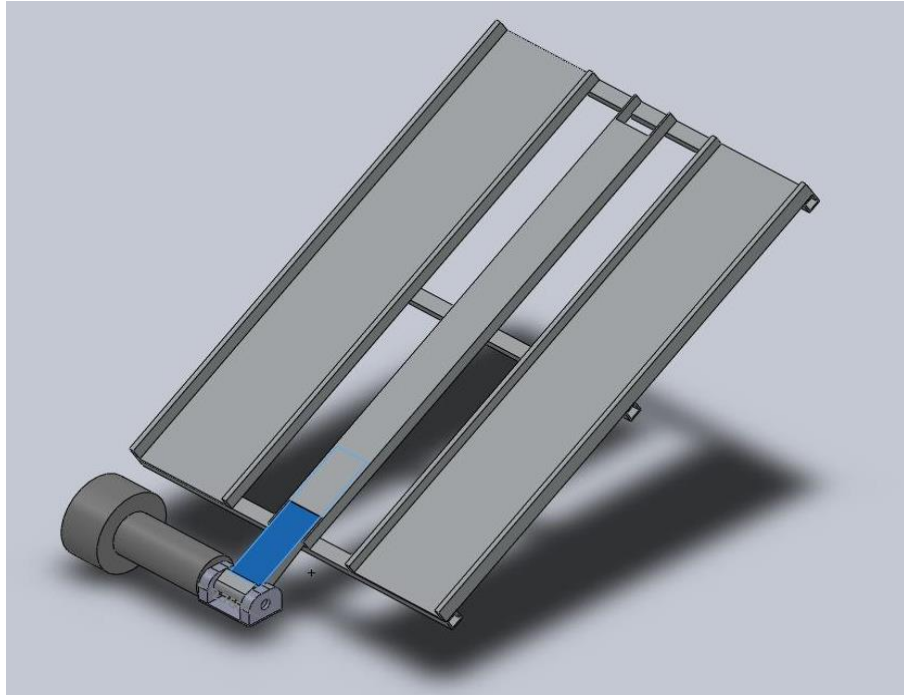


Fig. 18.20. Ramp Master 500 CAD (top) and Prototype Attached to a Wheelchair (bottom).

CURB TACKLER: WHEELCHAIR RAMP

Designers: John A. Bruegger, Carlos E. Carballo, James R. Ritter III, and Nick J. Vukelja
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
Department of Mechanical Engineering
University of South Florida
Tampa, Florida 33620-5350

INTRODUCTION

This project focuses in the design of a mechanical ramp that allows a power, rear wheel drive wheelchair, to overcome a curb of at least 5 inches tall. Other basic design requirements that were taken into consideration were: the width of the wheelchair should not be altered, access to the wheelchair should not be impeded and lastly, the length of the ramp should allow an angle of attack not larger than 10 degrees.

SUMMARY OF IMPACT

The ramp will enable the user to overcome curbs, steps, and other obstacles at least four inches in height.

TECHNICAL DESCRIPTION

This particular design consists of two eight-inch wide ramps for the wheels to travel on. They are hinged at the middle with an off center pin for strength and to allow for clearance between the frame rails of the ramp when it's closed. This clearance was essential to the prototype to allow room for the connecting links to be screwed to the frame rails being that it is initially going to be made out of wood.

With the connecting links neatly folded between the ramp's faces all of the connecting link pins will align within the clearance we created from the offset pin. As you can see, we initially over designed the hinge in the middle of the ramp face. After running

strength equations we determined the hinge could be greatly reduced.

First Prototype: Although rough in design, the first prototype was beneficial. After deciding on one particular design concept we proceeded to create the first prototype. It was difficult to determine if it was even possible to design the hinges to retain the proper axis of rotation to enable rotation about the vertical axis. It was also difficult to determine an acceptable range of motion without contacting any other surfaces. Modeling the CT1 design and physically building the small scale model provided additional ideas on how to improve the joints and reduce the overall dimensions of the future device. For example, instead of the joints being mounted on the surface of the connecting links with PVC, which were easily dislodged and bulky, we decided to incorporate the joints into the links themselves. This design allowed for greater control, tighter tolerances, and prevents the occurrence of pins slipping out. It also makes the pins concentric with reference to one another in the center of the device, ensuring the same rotation in both directions, which CT-1 did not exhibit.

Second Prototype: The new pin design, within the connecting links, greatly reduced the bulky appearance of CT-2 and reduced the dimensions, however the materials used for the model still limited certain design aspects. Fig. 18.21 shows the CT-2 design.

The cost of the parts and materials was about \$1500.

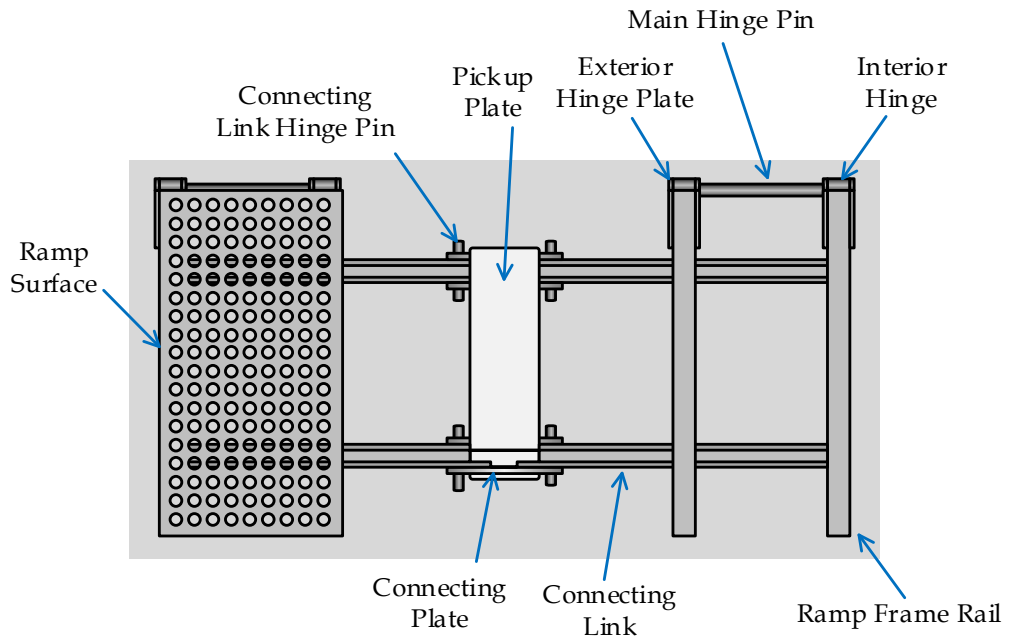


Fig. 18.21. Drawing of the CT-2 Ramp.

DEPLOYABLE WHEELCHAIR RAMP

Designers: Eric Tridas, Hamad Alosaimi, Kenji Music, and Victor A. Macias

Supervising Professors: Dr. Don Dekker, Stephen Sundarrao

Department of Mechanical Engineering

University of South Florida

Tampa, Florida 33620-5350

INTRODUCTION

The objective is to build a ramp that can be deployed from a power wheelchair to be utilized by the user to overcome four to six inch curbs. This design consists of motorized ramps attached to a shaft with linear bearings to ease the rotation of the shafts. The shafts, with the ramps attached, will be rotated by heavy duty DC motors with gears, sprockets, and chains. This overall design is effective and simple for its task with the capability of adapting to different wheelchairs. In addition, it will be user friendly since it will be easy to maintain.

SUMMARY OF IMPACT

There are many locations where wheelchair ramps are unavailable and the users cannot proceed to their destination without trying to surmount a curb or other obstacle. This ramp will allow the wheelchair user to have the ability to go places that are currently inaccessible.

TECHNICAL DESCRIPTION

The ultimate design chosen was the variable length ramp arm design. There are three main parts of the system: the ramp/joint assembly, the member/linear bearing assembly, and the drive train system. The ramp/joint assembly consisted of the ramps and the joint that controls the motion of the ramps. The ramp required two degrees of freedom, one to allow for the chair to ride over it and the other to fold the ramps up. This folding motion is controlled by a DC motor. The member/bearing assembly consisted of an aluminum rod and a linear bearing. This bearing would be mounted on a plate and connected to the final component of the system, the drive train. The drive train consisted of a DC motor and several gearing and chain components.

This design employed beams that have the ramps attached to their ends. These members are supported by linear bearings mounted to a drive train on each side of the wheelchair. The motors powering the drive train allow the members to be moved to any angular position by rotating the linear bearings they were mounted to. When in use, the ramps would be lowered into position onto the curb. As the wheelchair moves forward friction prevents the ramps from sliding further so it remains in position. The members attached to the ramps are able to slide freely, allowing for the length between the pivot point on the gearbox and the end supporting the ramps to change in length. An elastic band is used to keep the members fully extended with respect to the linear bearings. This prevents unwanted sliding motion as the members are rotated.

As the wheelchair rides over the ramps the motors are deactivated and the angular position of these members changes due to the linear motion of the wheelchair. This motion allows the ramps to remain attached to the wheelchair yet still allow for the wheelchair to ride over the ramps. After the wheelchair finishes climbing the ramp the ramps are rotated 90°, leaving their final position perpendicular to the ground allowing for space conservation. When this is complete the members rotate until they too are perpendicular to the ground. The motors used to control the angular position of the members as well as the motors to control the tilt of the ramps are controlled by momentary switches.

Fig. 18.22 shows the device in action.

The cost of the parts and materials was about \$1000.

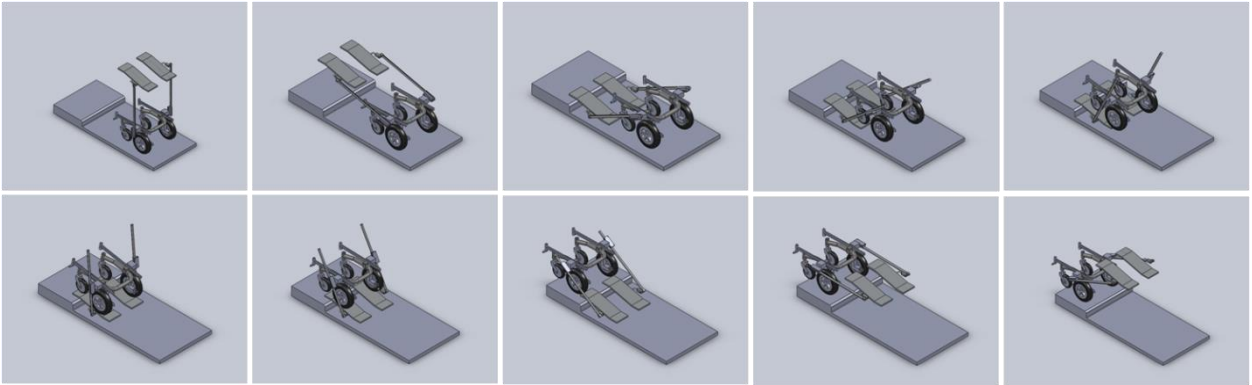


Fig. 18.22. Function of the Proposed Ramp System.

THE DELEVATOR: BOAT WHEELCHAIR LIFT

Designers: Michael Bair, Adriana Chacon, Mario Kikic, and Evgeny Shakurov
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
Department of Mechanical Engineering
University of South Florida
Tampa, Florida 33620-5350

INTRODUCTION

This team went to the Tampa Florida Aquarium to look at the current design of the ramp being used to board the Ecotour boat. The currently used device operates and completes the task of enabling people to get on the boat however it does not allow persons in wheelchairs to get on the boat because the current ramp is not wheelchair accessible (it is very steep and narrow).

The purpose of this project is to design a device that would allow wheelchair users and other mobility impaired individuals to board a tour boat at the Florida Aquarium. This design would be an improvement over an existing solution, which does not accommodate people with mobility impairments. The design would provide a stable mechanism and a familiar environment for the users. Moreover, safety features, environmental corrosion, and other key elements such as material and component selection were addressed.

SUMMARY OF IMPACT

This device provides access to a tour boat for persons with disabilities. This design solution employs a familiar system which is essentially an elevator that lowers the person down to the level of the boat and allows them to drive onto the boat with ample maneuvering space.

TECHNICAL DESCRIPTION

The design has a platform within an enclosed space that can go up and down with a winch through a railing system attached to the dock. This enclosed space is composed of hand rails to provide safety and comfort to the user. The platform would sit perpendicular to the dock until the mechanism is needed. When functioning, the platform would rotate so that it levels with the dock's surface and then descends until it reaches the boat. Rising motion would occur in a similar way. Fig. 18.23 shows the elevator and winch systems. Fig. 18.24 shows the device.

The cost of the parts and materials was about \$5000.

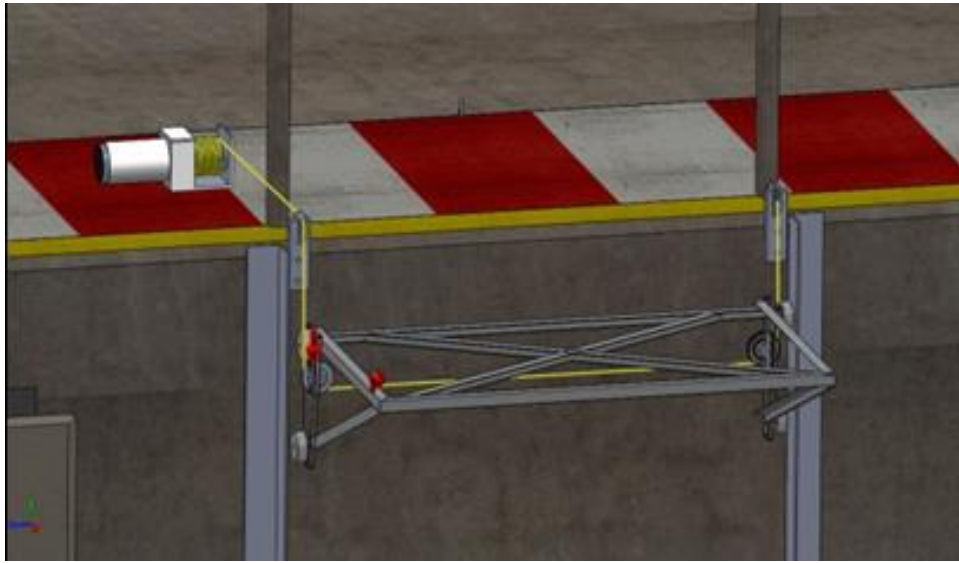


Fig. 18.23. Winch and Elevator Mechanisms.

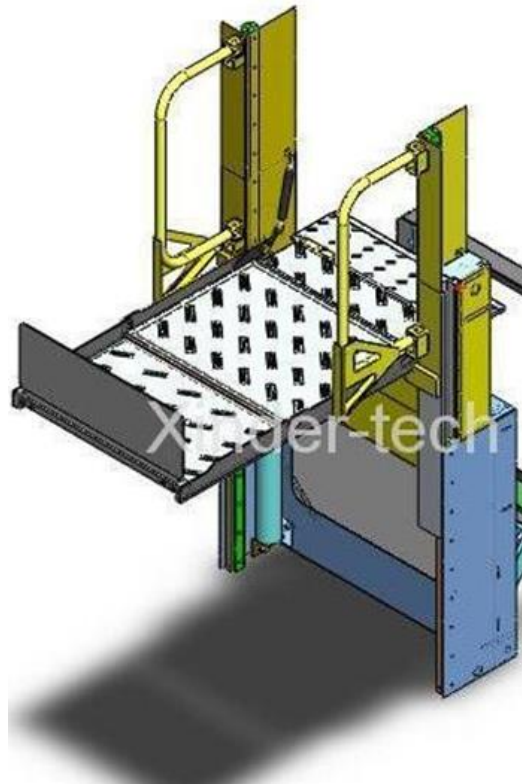


Fig. 18.24. The Concept of a Delevator Mechanism.

ECOTOUR BOAT ACCESS FOR PASSENGERS WITH DISABILITIES

Designers: Mycah Jewell, Jantzen Maynard, Jeremy Reedy, and Shane Worsham
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
Department of Mechanical Engineering
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INTRODUCTION

The Tampa Aquarium has gone to great lengths to make their entire facility accessible to people with disabilities. However, passengers must navigate metal stairs in order to board the aquarium's tour boat. A solution to the limited access to the Ecotour Boat would allow people, who have limited mobility, to explore the environment of Tampa Bay on the boat (See Fig. 18.25).

A site visit to the Tampa Aquarium's tour boat clarified the accessibility issues of the tour boat. Several constraints were noted during the site visit such as space confinements, range of motion, and stability of the device. The design should allow wheelchair users to safely transfer from the dock to the boat deck or vice versa without having to disembark from the wheelchair. It also needs to have a range of motion that can work with varying tide levels. All of these issues have been addressed with the chosen design.

SUMMARY OF IMPACT

This device provides access to a tour boat for persons with disabilities. This design solution allows a person to drive a wheelchair onto the boat with ample maneuvering space.

TECHNICAL DESCRIPTION

This design uses rotary motion to accomplish the transfer of the passenger from the dock to the boat desk. The device uses a single degree of freedom to rotate the passenger platform from the loading position to the unloading position. The device is designed for long life and a high lifting capacity. Cost of the device and safety of the passenger were also key considerations in the design. Fig. 18.26 shows the device.

The design is simple as it uses a single motion to lift and extend. The passenger is transferred to or from



Fig. 18.25. Ecotour Boat Access.

the boat in one single fluid motion. The transfer time is less than one minute. This time includes loading the passenger, transferring to the boat, and unloading the passenger. The device is also easy to use. The passenger rolls on to the platform and the ramp closes behind. Once the passenger is on board, the device moves to the desired location, the opposing ramp is lowered, and the wheelchair can roll off onto the boat deck. A single controller will be implemented to operate the device.

In order to keep the platform stable during operation, a gearing system was added to the lifting arms that extend out to the basket. The gearing system keeps the basket floor parallel to the ground at all times which ensures that the basket will not tilt under any loading condition. When the model was tested, it was shown that if a person was located offset from the center of the basket, the basket could tilt as much as fifteen degrees. This was a major hazard that needed to be resolved and thus the gear system was implemented.

The device will be rated at a 600 pound capacity. With the safety factor load of 900 pounds, the device should be able to last for approximately 100 million cycles. This is anticipated to be vastly more cycles than the device will ever see. Aluminum was used throughout since it is lightweight and corrosion resistant. The sprockets are stainless steel and the pillow block bearings, that support the shafts, are a plastic material with excellent corrosion resistance.

The motor is a 5 hp unit. It is geared down approximately 320:1 in order to get the output torque needed to operate the device. The drive train also includes a worm drive gearbox. This was added to keep the motion of the basket controlled at all times. If power is lost, the basket will stop where it is and not be dropped.

The cost of the parts and materials was about \$6000.

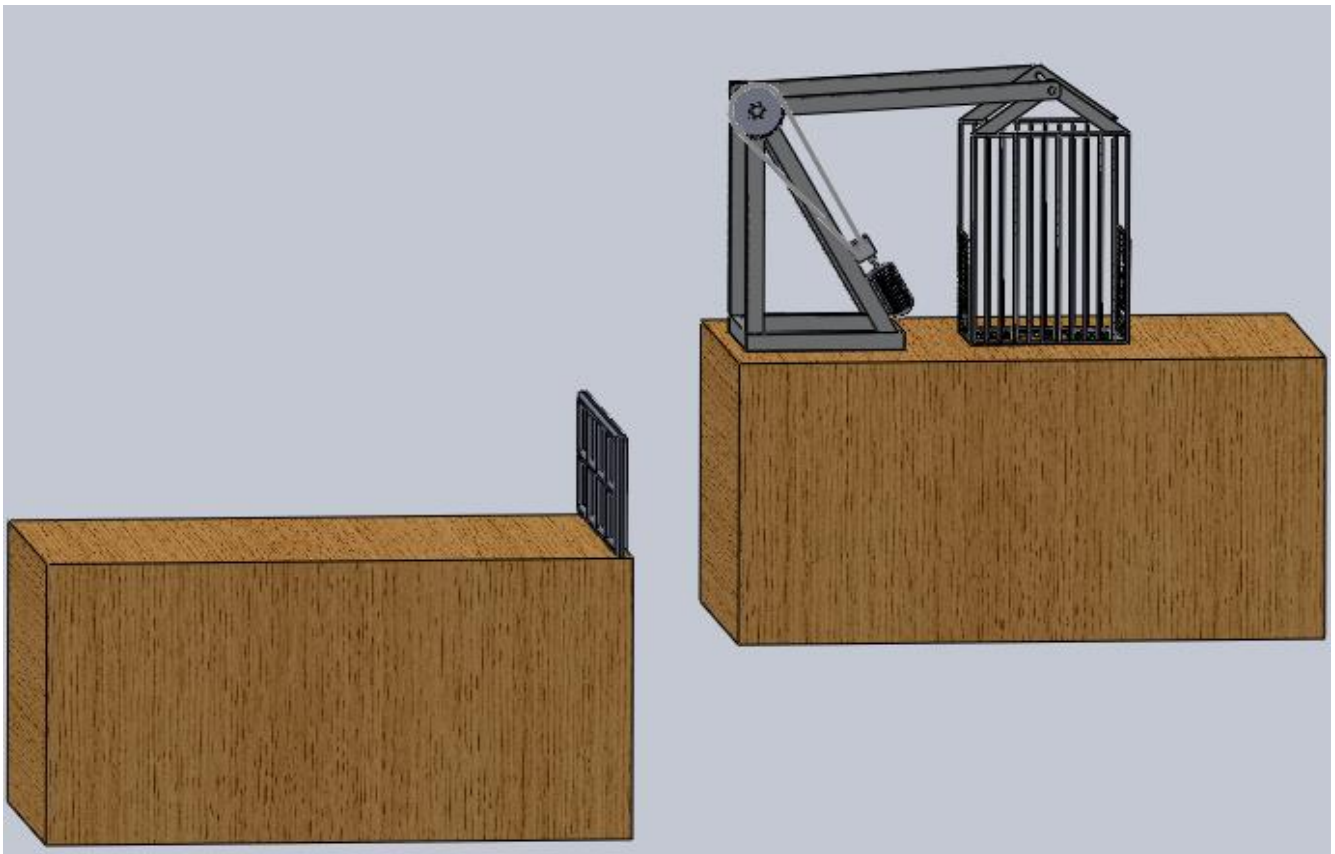


Fig. 18.26. Rotary Lifting system for the Ecotour Boat.

SUNBRELLA: UMBRELLA HOLDER FOR MANUAL WHEELCHAIR

Designers: Ivan Espinosa, Christopher Jones, Kevin Lotero, Jeremy Stano and Lenny Valles
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
Department of Mechanical Engineering
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INTRODUCTION

The project that was chosen was the umbrella holder for a manual wheelchair user. This project involves designing a lightweight, detachable accessory that is capable of holding an umbrella for a disabled person who uses a manual wheelchair. This person must use their arms to propel the chair forward, thus rendering them incapable of holding anything for any sustained period of time.

SUMMARY OF IMPACT

This project came to us from a young lady at USF named Shauna Bisson, who has been having trouble going to and from class in the rain. She needs both hands to power her wheelchair, and has no way to hold an umbrella. She carries her books and homework in her lap, and they all became soaked anytime it rained. Most people take for granted the fact that they can just walk outside with an umbrella and be covered, whereas Shauna doesn't have this option. Something as simple as an umbrella holder can make the lives of many disabled individuals much easier. Since Shauna and her schoolwork both need to be covered by the umbrella, the umbrella holder needs to be widely adjustable so it can cover any part of the chair.

TECHNICAL DESCRIPTION

The design needed something sleek, attractive, and simple. Our first challenge was to determine how our prototype could be attached to any wheelchair. The solution was a slip that went over the back of the chair which is kept in place by the weight of the user. We were worried about wind being a factor in our design, and the slip basically eliminated that concern. Another problem that Shauna mentioned to us was the fact that when she was getting in and out of her chair, she would need the umbrella to be higher. This would make it much easier for her to move around, and the heightened umbrella would keep a greater area dry. This problem was solved by

adding an extendable rod to the back of the seat attachment. When the rod is lowered, the umbrella sits directly above the user, however when it is extended, it sits well above the user, allowing more freedom of movement. Finally, we needed a way to attach the umbrella. After doing some research, we found an umbrella holder for a golf bag. This part was able to be adjusted in every direction, which is what is desirable our prototype. The umbrella holder is mounted directly to the end of the extending rod.

There are many benefits to the design of our prototype. Most notable however, are the size, style, and ease of use. We basically wanted our prototype to be an "accessory" to the wheelchair, so that the person using it doesn't feel like they have a giant weight on their back. The small size and style both contribute greatly to this factor. It's easy to use since one only needs to pull up on the holder to extend it, and then turn the handle to adjust it in any direction. Also, the umbrella sits right in the holder, so there is no need to clamp or fit the umbrella perfectly. The holder fits a wide variety of umbrellas as well, so the user can have their own personal style incorporated with the holder. Another benefit to our design is the fact that it can fit any size chair. The seat slip is adjustable to fit a wide variety of chairs, so the user need not worry about if the holder will fit their wheelchair. Another major benefit to our design is the fact that the umbrella holder is easily transportable. The user can decide when to attach the holder, and not have to worry about bolting anything. The seat slip takes a few seconds or less to fit over the chair and it's attached. The user's body weight actually holds the umbrella holder in place, so it won't come loose in the wind or on rough terrain. Since the seat slip is comfortable, the user won't even notice the holder is attached. Fig. 18.27 shows the device.

The cost of the parts and materials was about \$175.

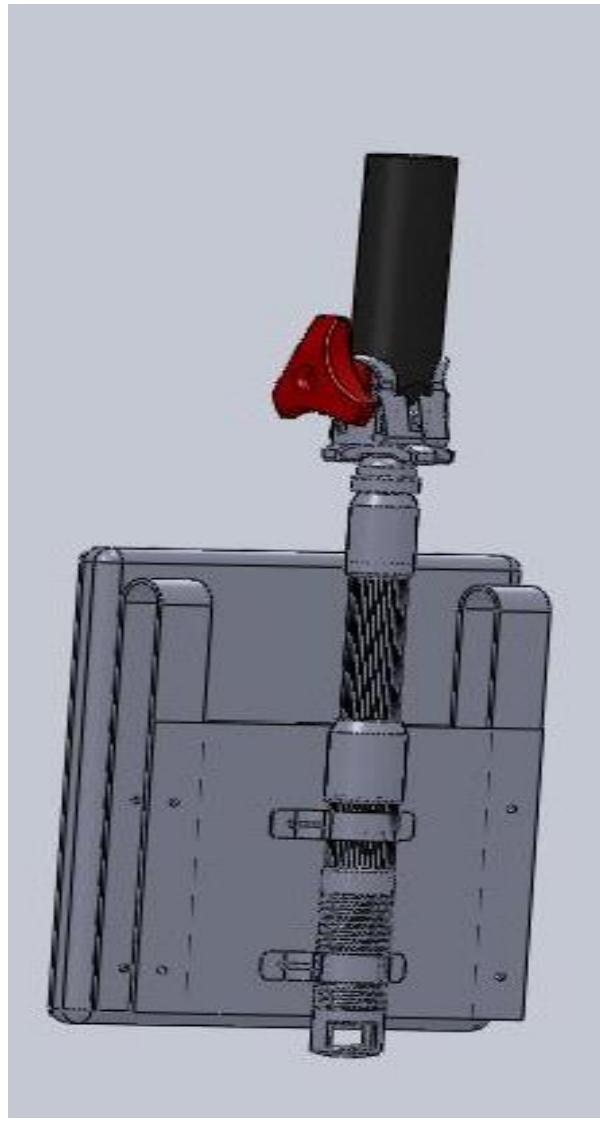


Fig. 27. View of the Wheelchair Umbrella Holder.

WHEELCHAIR UMBRELLA HOLDER

*Designers: Craig Honeycutt, Anthony Ippolito, Jacob Moberg, and John Sushko
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
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INTRODUCTION

To assist in making an umbrella more accommodating to a manual wheelchair user, the design pursued was an umbrella holder. This device is made possible through the use of a utility arm specifically designed for manual wheelchairs. This non-powered robotic arm easily unfolds from the back of the wheelchair when needed and folds back to be stored away when not in use. This utility arm is not limited to holding an umbrella, but also beverages, a table tray, or similar items. This addition permits the user to access items such as food, books, or even a laptop.

SUMMARY OF IMPACT

Since the use of a manual wheelchair requires the use of two hands, other tasks become limited, difficult, or impossible to perform such as holding an umbrella or drink, using a laptop, or other similar task. Therefore, a utility arm is of great benefit, to those using a wheelchair, by allowing these once nearly impossible tasks to become an option. This aims to promote even greater freedom and versatility for the user.

The initial task was to develop a utility arm that could hold an umbrella; however, the idea expanded when additional uses of the utility arm became apparent. This structure was designed for non-powered wheelchairs. The benefits of the utility arm

design include its light weight, slender, non-corrosive, structure that does not impede on the user's ability to maneuver the wheelchair. Furthermore, the utility arm is easily accessible and easy to use.

TECHNICAL DESCRIPTION

The first design consideration was to create a device which required no power supply. This consideration reduces the overall cost of the device while also adding no additional weight. Since rainstorms can be unpredictable, the focus was on creating a device which could be stored on the wheelchair at all times, while also being easily deployed. Specifically with manual wheelchairs weight factors are often of significant concern as additional weight adds more work for the user, thus creating a lightweight device was of high importance.

The final design is lightweight, compact, easily deployable, non-powered and versatile, made of aluminum box beams and c-channels. One end of arm has an adjustable locking hub, rated to support more than one hundred pounds. This joint allows the device to easily move and lock into position. The prototype is very compact and glides easily in varying positions. Figs. 18.28 and 18.29 show the device.

The cost of the parts and materials was about \$335.

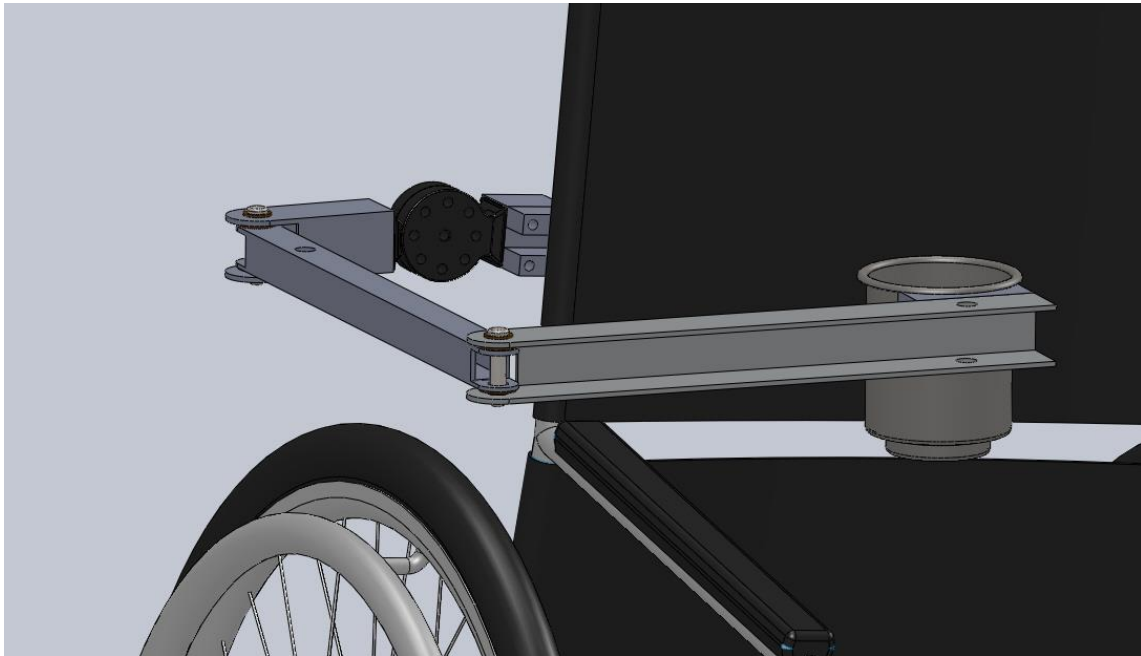


Fig.18.28. Conceptual View of the Utility Arm.



Fig. 18.29. Photograph of the Utility Arm.

PORTABLE CUPHOLDER SYSTEM

Designers: Rafael Alvarez, Cesar Carbonell, Hernando Gonzalez, Ricardo Gutierrez, and Alberto Striedinger
Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
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INTRODUCTION

This report addresses the design process of a device that could assist people who suffer from quadriplegia to pick up a drink from a table and tip it, since they are not able to do this by their own means. Instead, they need to rely on the assistance of somebody else. The proposed design focused mainly on facilitating the lifting motion of the person and the improvement of his or her range of motion in a natural manner. The design consists of two separate systems: one that allows 3 degrees of freedom of movement and other that permits holding the cup in a mechanical hand. This design is highly versatile, adaptable and simple. It provides a smooth and natural motion of the arm, but at the same time it provides enough force to assist the user when lifting the cup. It is important to consider that this design still has room for improvement, looking forward to enhancing the quality of life of people who suffer from quadriplegia. The main goal is to offer them a stylish innovative solution that fulfills their expectations.

SUMMARY OF IMPACT

According to the University of Alabama National Spinal Cord Injury Statistical Center every 41 minutes a person in the United States sustains a spinal cord injury. There are about 11,000 new cases of spinal cord injury reported in the United States each year. The total number of people with spinal cord injuries in the United States is estimated to be between 250,000 to 285,000. 52% of spinal cord injured individuals are considered paraplegic and 47% quadriplegic. Finally, the average age of a spinal cord injured person is 31. These people are quite young, and want to move on with their lives and be able to do activities without having to depend so much on other people. This project can help them improve the quality of their lives and provide them the chance to live their lives as comfortably as they can. This device offers a simple, practical and innovative means for the user to pick up and tip a cup in a smooth and natural manner. In

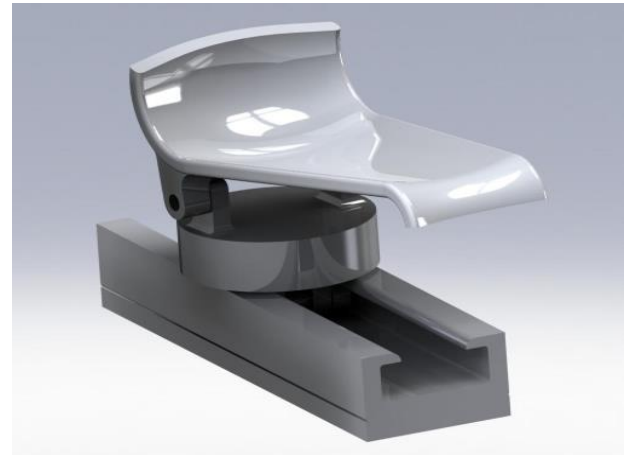


Fig. 18.30. Part of the Prototype that Allows the User to Reach the Cup.

addition, this product ensures a stylish (not too bulky) look, comfort and a user-friendly mechanism.

TECHNICAL DESCRIPTION

The system's functions were established, taking into account the previous requirements, and they are defined as follows, (1) Reach the Cup, (2) Grab the Cup, (3) Take the Cup to the Mouth and tilt the Cup, and (4) Take the Cup Back

(1) To perform this function the device has a support base that allows three degrees of freedom. The base lets the person move his/her arm forward and backward, rotate it and lift it, guaranteeing the range of motion necessary to reach the cup. The base moves along a rail through two bearings in order to produce the linear motion needed. Fig. 18.30 shows the device.

(2) The mechanism employed to grab the cup consists on an arm pad that is attached to the person's forearm, and a T-shape beam that moves along a rail. The beam pulls a thumb finger backward to let the mechanical hand grab the cup. The user must employ his or her left hand to actuate

the mechanism by pressing a lever that pushes the beam backward, and releasing the lever to allow the finger to return to its position and press the cup firmly towards the mechanical hand.

(3) Once the person is holding the cup in the mechanical arm, they need to take the cup to his or her mouth. In order to perform this step, the person has to move his/her arm backward along the base's rail. At this point, a torsion spring will provide most of the force to assist the person to lift the cup without much effort. The person will be able to control the velocity of the lifting movement and the cup's position. These features ensure a smooth simple and natural motion of the arm. Fig. 18.31 shows this mechanism.

Finally, after taking a sip the person can slowly put his arm down in a movement analogous to the lifting motion, but employing less effort.

The device is highly adaptable; since it consists of two separate modules. The user has the choice to use only the elbow support module, giving him or her more freedom to maneuver by his or her own means. The prototype can lead to an attractive and affordable commercial rehabilitation device that could help thousands of people with disabilities to perform a very common yet difficult task for them.

The cost of the parts and materials was about \$1030.

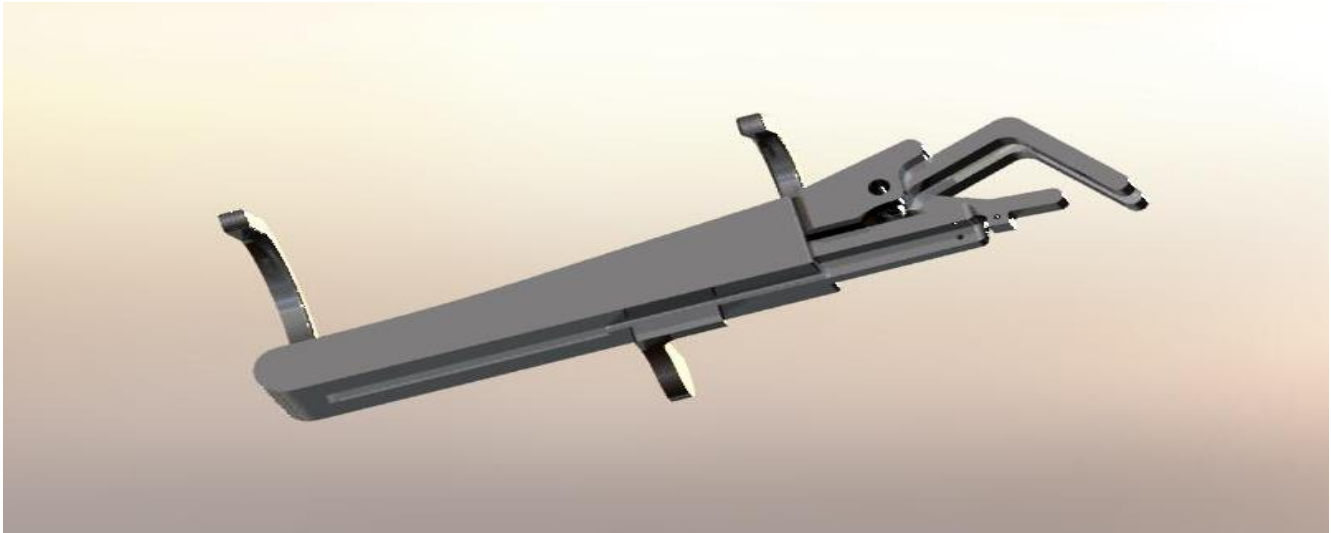


Fig. 18. 31. Part of the Prototype that Allows the User to Take to Cup to the Mouth.

DRINKING AIDE

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Supervising Professors: Dr. Don Dekker, Stephen Sundarrao
Department of Mechanical Engineering
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INTRODUCTION

The drink aid aims to mimic the drinking capability of a human arm. The device can pick up a drink cup from a table and lift the drink to the individual's mouth, in a well-controlled manner. The drink aid accommodates as many individuals as possible, can be attach to most powered wheelchairs, and does not hinder the comfort of the user or the functions of the wheelchair.

SUMMARY OF IMPACT

Currently a person with quadriplegia has to drink out of a straw or requires the assistance of others to be able to drink. This is awkward and difficult for some drinks such as coffee or beer. Over all, the drink aid device aims to empower the user and offer a better quality of life.

TECHNICAL DESCRIPTION

When taking a drink from a cup, the hand provides grip, which secures the cup, and the wrist provides control over the cup's fine motions, tilt and rotation. Therefore, the drink aid design incorporates a robotic claw and pan-tilt device that mimic these biological functions in a simplified manner. In addition to fine motions, a drink cup must experience a large displacement from the table to the user's mouth. The human elbow and shoulder provide a pivot point and support, respectively, for the drinking motion. However, a gear-motor supplies power and a range of motion similar to that of an elbow. Structural tubing provides extended support for mounting the gear-motor, which is attached to the back post of the wheelchair. Therefore, the design fixes the elbow joint as a source of rotation. Overall, the final design simulates a natural drinking motion while providing simple control and function. Acting like a hand, the robotic claw in Fig. 18.32 provides grip during the drinking process. A servomotor attached to the claw allows for control over opening and closing motions.



Fig. 18.32. Robotic Claw.

The motion of a person's wrist is represented by a pan and tilt mechanism in the design. Because of the anatomy of the human wrist, mechanically copying the wrist's exact motion and control is unrealistic for the short time period of this project. However, two motions exhibited by the wrist were chosen for application in this robotic arm. The vertical up and down motion and the side to side motions provide control over the tipping of a drink container. With the use of the controls of the pan and tilt, the user is able to drink from an open cup, and not solely from a cup with a lid or through a straw, as was done previously. Fig. 18.33 shows the pan and tilt device and its location on the arm.

The hand and wrist provide fine control over drinking motion, but the elbow joint provides the strength and large range of motion that brings a beverage to a person's mouth. Because the elbow requires the most force, when compared to the hand

and wrist, the mechanism to replace the elbow needs to be powerful. In addition, the elbow is a compact joint that does not allow much room for an effective moment arm. Therefore, selecting an appropriate mechanism to substitute for the elbow provided a challenge. However, a readily available component was available for use, an electric motor with a gearbox. (Fig. 18.34 shows the motor and its location on the arm.) The gearbox's transmission ratio can be selected for a particular torque and speed. When drinking, one does not want the cup to fly towards the person's face at high speed; therefore, a high gear ratio was chosen to reduce the maximum operation speed. Low speed is also required for ease of control and smoothing the motor's motion.

The design includes two "arm" pieces. These arms connect the electromechanical devices and create a

more natural looking device. These arms mimic the human arm (forearm and upper arm). They are made of aluminum tubing, which is light weight and strong. The forearm is made of square tubing and acts as a connector from the motor to the wrist device. It will add the needed height to make the drink device reach the user's mouth. The upper arm is made of tubing bent at a 90° angle. This will enable the device to be attached below the arm of the wheelchair and then be routed around the user. This bar is used on the rear mounting bracket to attach to the wheelchair. The upper arm adds stability to the design, and allows the design to be more versatile for different body types.

The cost of the parts and materials was about \$300.

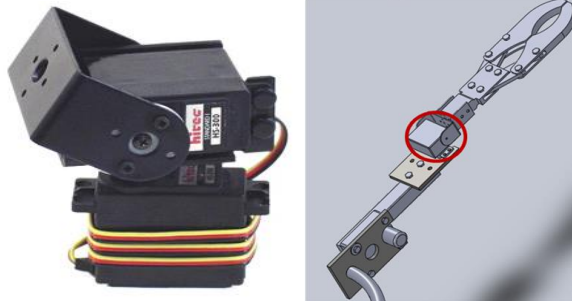


Fig. 18.33. Pan and Tilt Device, and Location.

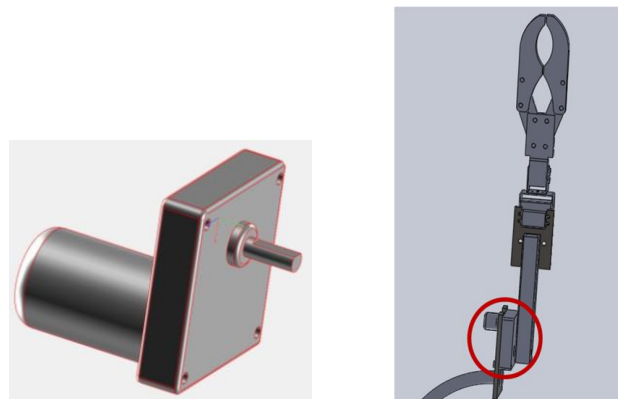


Fig. 18.34. DC Gearmotor, and Location.



CHAPTER 19

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COLLAPSIBLE WHEELCHAIR WITH DETACHABLE COMPONENTS

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Mechanical Engineering Students
Client Coordinator: Ms. Jill Caruso, Employment Specialist
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Supervising Professor: Dr. Mohamed Samir Hefzy and Dr. Mehdi Pourazady
Biomechanics and Assistive Technology Laboratory
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INTRODUCTION

Wheelchair users must take their wheelchairs with them when they travel. Airlines have limited or no space available for storing standard folding wheelchairs in the cabin of the airplane. The closet, in which the wheelchairs are stored, is filled on a first come first serve basis. If the closet is filled or no closet space is available, the wheelchair is then considered as checked luggage. In the baggage hold, it is unprotected from falling items, can be thrown or dropped, or sustain damage that may arise from carelessness of airline employees. If extensive damage to the wheelchair occurs, it may become inoperable. The wheelchair can also become lost luggage and not arrive at the correct final destination. A lost or inoperable wheelchair is an extreme inconvenience to the wheelchair user.

There are a few existing wheelchair designs on the market that are considered to be collapsible. These designs collapse smaller than standard folding wheelchairs but are not small enough to fit in carry-on luggage. Some of the designs are heavy and bulky and none of the existing designs feature collapsing wheels. Other collapsible designs collapse to a small dimension but require someone to push the wheelchair from behind because the wheelchair utilizes four very small caster wheels, which does not allow the user to independently propel it. This requires the wheelchair user to depend on someone else to assist in their mobility.

The purpose of this project is to develop a collapsible wheelchair, with detachable wheels, backrest and seat. When detached and collapsed, all components of the wheelchair fit in carry-on luggage with dimensions of 22" x 14" x 9". The developed unit is constructed using a standard folding manual wheelchair frame that was modified



Fig.19.1. Final assembled prototype.

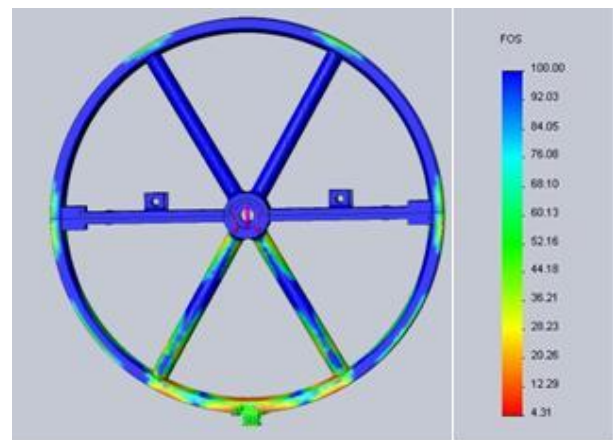


Fig.19.2. Factor of safety was calculated as 4.31.

to make the backrest and seat detachable from the frame. The unit includes two 20 inch wheels; each one is detached into two semi-circular parts. The

foot rest and the two front caster assemblies are modified to allow them to fold up into the wheelchair frame. The unit is assembled and disassembled with minimal time and effort. Fig. 19.1 shows the prototype assembled, and Fig. 19.3 shows all the components when detached.

SUMMARY OF IMPACT

A collapsible wheelchair with detachable components is developed to allow a wheelchair user to store it in the overhead carry-on luggage compartment when traveling by airplane. This design saves space, prevents damage to the wheelchair by the airlines, and enables wheelchair users to travel with greater ease. The developed unit can be disassembled and reassembled quickly and easily yet it is still durable and reliable enough for everyday use. The developed unit thus provides wheelchair users with greater independence as they can independently disassemble the unit, store it in a carry-on luggage compartment, and reassemble it when they arrive at destination. Also, the small collapsed size of the wheelchair makes storing it in a vehicle easier.

The developed prototype was evaluated by a wheelchair user as shown in Fig. 19.4. The Quebec User Evaluation of Satisfaction with assistive Technology (QUEST 2.0) tool was used as an outcome measurement instrument to measure satisfaction with the unit. The eight QUEST items that are assessed include a) comfort, b) dimensions, c) simplicity of use, d) effectiveness, e) durability, f) ease in adjusting, g) safety, and h) weight. Each item scored with a 5-point satisfaction scale ranging from a score of 1 denoting "not satisfied at all" to a 5 indicating "very satisfied". A score of 4 was obtained for simplicity of use, ease of adjusting, and weight, and a score of 5 was obtained for each of the other five items.

TECHNICAL DESCRIPTION

Design requirements include 1) a wheelchair that fits within a 22" x 14" x 9" suitcase, 2) a wheelchair that is durable, 3) a wheelchair that can be assembled and disassembled easily and quickly, and 4) a wheelchair that allows independence in mobility when assembled.

The greatest challenge to overcome was to design the largest diameter wheel to fit into the desired dimensions. Carry-on luggage allows a maximum solid wheel diameter of 14 inches, which is 10 inches

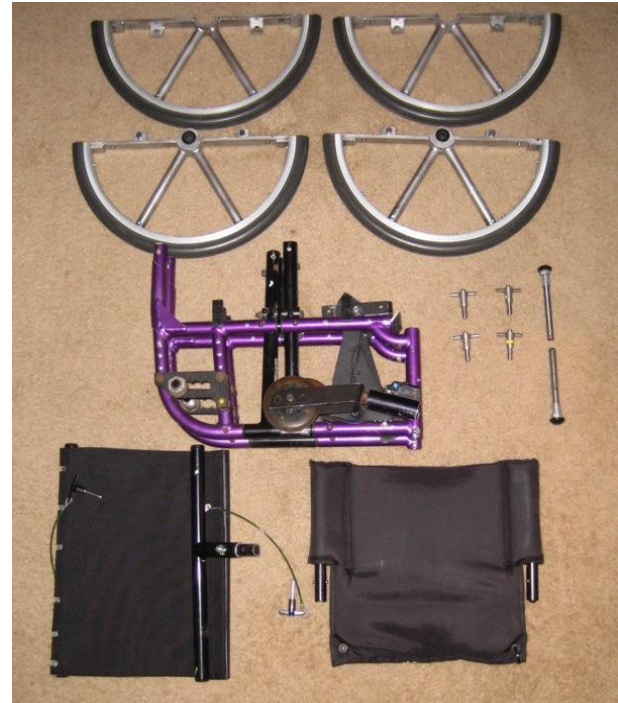


Fig. 19.3. Components of the wheelchair when disassembled.



Fig. 19.4. Prototype being tested and evaluated by a wheelchair user

smaller than a standard wheelchair wheel (24"), the wheelchair remained easy for its user to independently propel.

Several frame design areas were also considered and it was decided to modify a donated wheelchair frame for this project. In order to make the collapsed frame fit within the desired dimensions, the back rest and seat sections of the frame are removed and the front casters needed to fold into the frame. The front casters are modified to swivel upwards towards the chair for storage. Replacing the lower caster mounting bolt with a quick disconnect pin allows the caster to swivel up and into the frame for storage yet remain locked in place when assembled. The seat support bars and the back rest support bars are modified to become removable as well. Quick disconnect pins are used for this purpose.

SolidWorks® 2009 finite element analysis software is used to conduct a structural analysis on the wheelchair wheels and a factor of safety of 4.31 was

calculated with a one hundred pound load applied at the center hub of each assembled wheel as illustrated by Fig. 19.2.

The cost of the parts is \$400.00. The time for machining and welding of the wheel was donated to the team by the University of Toledo machine shop. The students working on this project posted a detailed description of their design and analysis in the World Wide Web at the following address:

<http://www.mime.eng.utoledo.edu/design/clinics/2009/Fall/sites/2009-04-02/>

This work was also presented at the 2010 Rehabilitation Engineering Society of North America annual conference and was one of five winners of the student scientific paper competition.



EXTENDABLE “EASY REACHER”

*Student Designers: Adam Lewis, Russell Fleetwood, Andrew Webber, Robert West
Mechanical Engineering Students*

*Client Coordinator: Ms. Angie Hiser, Employment Specialist
The Ability Center of Greater Toledo, Sylvania, Ohio 43560*

*Supervising Professor: Dr. Mohamed Samir Hefzy and Dr. Mehdi Pourazady
Biomechanics and Assistive Technology Laboratory
Department of Mechanical, Industrial, and Manufacturing Engineering
The University of Toledo, Toledo, Ohio 43606*

INTRODUCTION

Our client was born with Ehlers-Danlos Syndrome, a group of inherited disorders that affect connective tissue. As a result, she has lost strength in her joints and uses a wheelchair for mobility. In order to grab everyday items from in and out of reach places she uses two types of reachers: a low-grade suction cup reacher, offering a hard-to-squeeze gripping mechanism, and a low profile jaw reacher for around the office. However, she is not satisfied with these commercially available reachers because of the manual grip controls and the lack of an extension mechanism. The purpose of this project is to develop a reacher that can be extended to a comfortable distance and with a more versatile gripping mechanism to allow someone with limited range of motion to reach items are inconvenient distances. There are no similar devices presently available on the market. The unit that was developed can extend up to 5 feet in length and easily grip a two pound object up to 4.5” in diameter. Power screws are used to control the extending and gripping mechanisms. Fig. 19.5 shows the developed prototype next to the commercially available “Easy Reacher”. Fig. 19.6 depicts the client holding the developed prototype.

SUMMARY OF IMPACT

Our client was born with Ehlers-Danlos Syndrome and is confined to a wheelchair. She enjoys cooking and other household activities, but usually has to rely on her husband or someone else to help her. The newly designed device allows her to reach items that were still out of reach with her original “Easy Reacher”. Additionally, the motor-controlled gripper makes it easier for her to grasp heavier objects. This lightweight prototype provides her more independence in her daily living activities. Although this device is designed for one person in



Fig. 19.5. Developed prototype (to the left) next to commercially available Easy Reacher (right).

particular, it could be beneficial to many wheelchair users.

TECHNICAL DESCRIPTION

The design process started with evaluating multiple ideas for extending mechanisms and gripping mechanisms. The first extending mechanism idea utilized a tube with several holes along it. As the device extended or retracted, a spring-loaded button on a second internal tube would snap into one of the holes on the external tube, holding the reacher at a specific length. Depressing the button and sliding the internal tube until the button locked in another position would allow for length adjustment. The second extending mechanism design used a similar concept to that of a camera tripod. To change the length of the device, a knob attached to a set screw on outer tube is loosened, allowing the inner tube to slide easily within the outer tube. The knob is tightened at the desired position to fix the length. However, the first two extending ideas were too labor intensive to operate. The third and final design utilizes a power screw driven by a small electric motor to adjust the length of the two telescoping tubes.

The first gripping mechanism idea consisted of a rod connecting the trigger to two parallel jaws using linkages. Squeezing the trigger would cause the rod to move and close the jaws to clasp an object. This design was unacceptable because it could grasp only

a limited number of object shapes. The second gripping mechanism idea featured scissor-hinged jaws that were spring-loaded to keep them closed. Two cables attached the jaws to a trigger on the handle. When squeezed, the handle opened the jaws to grab around an object. Releasing the trigger allowed the jaws to firmly grasp the object. This design required too much grip strength to open the jaws deeming it unacceptable. In the final gripping mechanism design concept, a second power screw and motor are used to control the gripper. The power screw threads through a nut fixed to a scissor-like mechanism. The jaws open or close depending on the direction of rotation of the screw.

The final prototype was thus developed using two power screws and motors. The extending mechanism consists of two square aluminum tubes that slide within each other controlled by a 6-32" threaded rod attached to a small motor and gearbox mounted in the tubing near the plastic handle. When the power screw turns, a nut fixed to the extending section forces the tube to extend or retract depending on the direction of rotation. The power screw is self-locking allowing the device to maintain a specific length even under load. The gripper mechanism consists of two two-bar linkages

attached to a 2-56" threaded rod. This second power screw is actuated via a small gearbox and motor mounted in the inner extender tube. Memory foam on the grippers allows for improved gripping of a variety of different objects. A plastic handle houses batteries and two switches to actuate the motors controlling gripping and extension. The gripper motor is connected to its control switch and battery by an insulated self-retracting cord.

The developed prototype was tested by the client who was pleased and found the device to be suitably light at just over two pounds and fully functional with the ability to extend up to 5 ½ feet and grip a two pound object up to 4 ½ inches in diameter. Motors were selected to allow for approximately 7 to 10 seconds for a time to full extension and have the gripper close in about two to three seconds.

The total cost of the parts is about \$200. The students working on this project posted a detailed description of their design and analysis on the internet at the following URL address:
<http://www.mime.eng.utoledo.edu/design/clinics/2010/Spring/sites/2010-01-02/>



Fig. 19.6. Client holding the developed prototype.

A WALKER TO ASSIST BARIATRIC PERSONS WITH WALKING

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*Client Coordinator: Dr. Chris Beins, Client Advisor
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INTRODUCTION

Currently, our bariatric client uses a commercially available four wheeled walker as an assistive device as depicted in Fig. 19.7. However, this unit is not suited to his needs. This is because a seat for resting is located directly in the center of the walker's frame. The location of the seat forces the user to stand behind the walker. When the user applies a force to the handles while moving, the walker can become extremely unstable and possibly tilt on either side, as well as falling completely backwards. The purpose of this project is to develop a safe walker to assist this individual with walking, as well as exercising. The new design is a three-wheeled walker that includes two front wheels and a rotating caster rear wheel as shown in Fig. 19.8. The walker has a tee-shaped frame that trails between the legs of the user and the handlebars closer to the front of the unit. Since a bariatric person has a wider stance, the trailing rear wheel, located behind the user's feet, will not only centralize his weight, but make the model less of a tripping hazard when making turns. Also, at the front of the walker, a tray is mounted into the frame to support the user's abdomen. This tray will support a large portion of the user's weight and make it much easier to walk longer distances. Also, the model is constricted to an overall width of 30 inches which is the standard width for most doors.

SUMMARY OF IMPACT

Our client is a bariatric person who uses a commercially available four-wheeled walker. Even though it is one of the best walkers on the market, the client finds it difficult to control and does not feel safe using it because it is unstable. The developed unit was tested by the client and found to serve his needs and to provide a comfortable and



Fig. 19.7. Client using the old walker.



Fig. 19.8. Developed three wheeled walk.

functional walker that can be used on a consistent

basis. It makes walking for him much easier while still functioning as any other walker would. This is because the design allows centralization of the weight of the user which make the model less of a tripping hazard when making turns. Also, adding a tray to the developed unit alleviates some of the weight carried by the user. This allows the user to walk longer distances, which provides him with additional exercising opportunities.

TECHNICAL DESCRIPTION

Design requirements include developing a walker that keeps the center of gravity of the user closer to the center of the entire walker and allows supporting much of the weight of the user's abdomen. When the client uses his old walker, his center of gravity is located behind the center of gravity of the walker, causing the front wheels to leave the ground when a large force is applied to the handlebar. Several designs were considered including a three wheeled walker, a four wheeled walker with inward bent handlebars and a four-wheeled box frame walker. The three wheeled walker design concept was selected based on a house of quality analyses that include the design considerations of safety, stability, portability, cost, size, weight, and comfort.

The three wheeled walker allows the client's center of gravity to be closer to the walker center of gravity. However, the main concerns with this model are stability and safety. To demonstrate that a three-wheeler is stable, a prototype model of the walker was created. The prototype was tested by use in a similar manner to how the actual final product would be walked around. It exhibited no issues with tipping and the wheels rolled without much difficulty. Although the prototype was a crude model, it provided a proof of concept.

The next step was to develop a frame design that would be able to support the weight of the client or other bariatric persons, as well as being comfortable. Since bicycles have been proven to be strong and still lightweight, a frame made of carbon steel and similar to that of a bike was selected. The front of the frame uses a fork similar to that of a bicycle. However, it is split in a semicircle shape to support two wheels instead of one as shown in Fig. 19.8. This fork cannot rotate to the left or right to steer. This is because if the front wheels were able to

rotate, it would cause a greater risk of the walker falling over. Instead, the trailing wheel, which is located behind the client, is a rotating caster wheel which allows the frame to move left or right. Hand brakes are also attached to each of the front wheels, which assist in turning as well as overall control of the walker. The stem and handlebars are standard bike parts that were purchased separately and attached to the frame. This allows the handlebars to be adjustable in both height and angle to account for different users.

Finally, a series of vertical slots are included along the middle of the steel frame in which a tray or seat, depending on the location and the person, may be added. A tray may be used for the client to place his abdomen on, thus alleviating weight from his legs/feet. In decreasing this weight, the client will be able to walk for a greater length of time. A seat may be used for resting only and may not be used while moving.

Both hand and computer calculations are used to assess the structural integrity of the unit. A model of the walker was created in SolidWorks® and a Finite Element Analysis was performed. The loads include 50 pounds on each handle bar and 100 lbs on the tray. A factor of safety of 2.19 was calculated for the frame for this loading condition which resulted in a maximum stresses of 14,600 psi at the edge of the holes for the tray and a maximum deflection of about 0.05" in the handlebars. In order to simulate a falling situation, loads of 100 pounds were applied at each handle and 150 lbs on the tray, which resulted in a factor of safety of 1.2 for the frame and a deflection at the handlebars of about 0.1 inch. An additional benefit of the walker is the ability to change the position of the tray to put it back on the walker as a seat. In order to simulate this situation, a load of 300 lbs was placed on the tray alone and a factor of safety of 2.8 was calculated at the support by the caster wheel.

The cost of the parts is \$195. The three wheels, the tray and the braking system are donations. Labor for machining and welding is outsourced for \$325, making the overall total cost of the project \$520. The students that completed the work and analysis on this product posted their work at the following URL address:

<http://www.mime.eng.utoledo.edu/design/clinics/2009/Fall/sites/2009-04-04/>

ADAPTATION OF A CAMPING TRAILER TO ALLOW WHEELCHAIR ACCESS

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INTRODUCTION

The objective of this project is to provide a means for our client, a person with limited mobility, to gain easy and independent wheelchair access to and from their camper trailer. The trailer has a large door on the front side that is hinged at the bottom and folds down to be used as a ramp for motorcycles and all-terrain vehicles. When folded down into a ramp, the door is too steep of an incline for the client's electric wheelchair to climb. In order to access the trailer, the client has someone lower the door down onto two wooden blocks, about a foot tall, and place another ramp off the end of the door as depicted in Fig. 19.9. Our client is not able to set this up on her own. The purpose of this project is to adapt the current door with a secondary ramp to make the incline less steep, and to allow our client with independent access. A six foot ramp is hinged to the existing six foot door, and a cable driven system is installed in the camper to raise and lower the door and the attached ramp as shown in Fig. 19.10. The ramp folds out as the camper door lowers. The developed system provides a total of 12 feet of ramp surface and is fully automated as it is deployed by the push of a button.

SUMMARY OF IMPACT

Our client uses an electric wheelchair and was not able to independently set up and take down the ramp system that allowed her access to her trailer. She wanted to keep the ramp system and did not want to use a lift system. The ramp provides a more convenient and less expensive solution to a lift system. However, there is not a ramp system that is readily available for camper trailers that will meet our client's requirements. The developed ramp system provides the user with independent and safe



Fig. 19.9. Previous Trailer Ramp Setup.



Fig. 19.10. New Trailer Ramp Setup.

access to the trailer. Fig. 19.11 depicts the client using the developed ramp system.

TECHNICAL DESCRIPTION

An electric winch and cable lift system is developed to raise and lower the existing 6 foot door and the attached 6 foot ramp. The ramp is hinged to the top

of the door on the outside. This design allows gravity to assist the ramp in deploying and still allows the client to have a ramping surface that is 12 feet long and safe to use. The fold out ramp is a pre-fabricated all-terrain vehicle ramp, made of lightweight aluminum and rated at 1200 pounds. It is designed for loading motorcycles and heavy four-wheeled vehicles in the bed of a pick-up truck.

The lifting system includes a sub-frame that rests inside the camper to support a mounting shaft. The fully welded frame with a height of approximately 74", is made of 1" x 2" x 0.125" rectangular steel tubing. This is bolted inside the trailer to the wall and floor using 4"x 4" x 0.125" flat square foot plates. Three cable drums, each with a diameter of 4.75", are mounted on the shaft. Two of the cable drums have cables attached to the door and the third has a cable attached to an electric winch which is used to turn the shaft. This shaft raises and lowers the door and the attached ramp. Aircraft grade cables are used due to their high strength. Two adjustable support legs, one on each side, are attached to the main camper door. Two more adjustable support legs, one on each side, are attached to the top of the foldable 6 foot ramp. Wheels are mounted on the bottom of the 6 foot ramp to allow it to roll across the ground providing a smooth operation. Each of the two wheels of the 6 ft ramp is mounted on a 4.75" long solid shaft with 0.75" in diameter. Two wheel brackets are mounted to the side of the 6ft ramp, one on each side and cantilevered off the front of the ramp. Each wheel bracket is drilled through and the corresponding wheel mounting shaft is inserted and welded solid. Two small ramps are developed and placed on the ground for the 6 foot ramp to land on. The wheels of the 6 foot ramp land on these smaller ramps which will move it away from the camper. This system is depicted in Fig. 19.10. A full size wooden prototype was first built as a proof of concept.

The winch needs to pull out at least 200 pounds since the weight of the door is estimated at 100 pounds. The winch selected is rated at 3000 pounds, runs on 12 volts DC, and comes with a wireless remote control. This winch is chosen because of its low price of \$75.00. Support leg assemblies made of nestable tubing are bolted to the main door and fold out ramp. Each assembly is composed of upper and lower parts. The upper part of each support leg



Fig. 19.11. Client using the ramp to access her trailer.

assembly consists of 1.5" x 1.5" x 0.11" CRS nestable tubing, 4" x 2" x .19" CRS flat bar and a 1.5" flange x 0.125" pin x 0.5" flange CRS piano hinge. The lower part consists of a 6" x 1.75" x 0.1875" thick CRS plate and a 1.75" x 1.75" x 0.11" CRS nestable tubing. Pins, 0.375" in diameter, are used to secure the nestable tubes to each other. The tubing of the upper part of the fold out ramp leg assembly is cut at an angle.

Finite element analysis using SolidWorks® and hand calculations are used to perform structural analyses on the system and its components. A factor of safety of eleven was calculated for the mounting shaft which was made of cold drawn 1018 steel with a diameter of 1" (solid shaft) and 54" long. Each of the two wheel brackets mounted to the side of the 6 foot ramp is designed to support a weight of 360 pounds and the corresponding critical factor of safety was calculated as 4.5 in the wheel mounting shaft. Each support leg assembly is designed to support a weight of 500 pounds and the corresponding factor of safety was calculated at 12.3.

The cost of the parts is \$965.00. The time for machining and welding of the different components of the system was donated to the team by the College of Engineering machine shop. The students working on this project posted a detailed description of their design and analysis in the World Wide Web at the following address:

<http://www.mime.eng.utoledo.edu/design/clinics/2009/Fall/sites/2009-04-05/>

DEVICE TO LIFT A PERSON FROM THE GROUND TO WHEELCHAIR HEIGHT

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INTRODUCTION

The goal of this project is to develop a device to assist a paraplegic or quadriplegic in moving from the floor to a wheelchair with the assistance of only one person. There are times when an individual using a wheelchair may fall out of the chair, or exit the chair to rest on the ground to enjoy a picnic or to play with a child. When the individual tries to return to the chair it can be very difficult, and requires a great deal of strength from the individual or from an assistant to lift them into the chair. A collapsible and portable device resembling a chair into which the individual can be strapped is developed for this purpose. The device separates into four pieces: the high back, the right leg with an attached foot rest, the left leg with an attached seat, and the top handle. The right and left legs are curved. Two ratcheting rear legs are placed on the back side of the unit for additional support. The device and its components are shown in Figs 19.12 and 19.13, respectively. The unit is collapsible into 40" by 18" as shown in Fig. 19.14. During use, the client lies on their side on the floor with their legs bent as if sitting in an imaginary chair. The unfolded and assembled chair is then placed next to them and safety straps are placed around the client's chest, waist, and shins. The client and chair are then rolled so that the client is lying on their back. Once in this position, the assistant lifts the tall back of the chair to bring the client to an upright sitting position at wheelchair height.

SUMMARY OF IMPACT

It can be difficult, for an individual who is paralyzed below the waist, to return to their wheelchair from a ground position. There is currently no available device to assist in lifting our client aside from a Hoyer lift which is expensive, heavy, and generally



Fig. 19.12. Final prototype.



Fig. 19.13. Components of the prototype.



Fig. 19.14. Prototype in a stacked position.

a stationary device. A light-weight, portable device does not exist. As a result, our client chooses not to exit his chair if it is not necessary, limiting what he is able to do and to enjoy, including playing with his son. The device developed allows our client's wife to assist him in returning to his chair with limited effort. This makes the prospect of sitting on the floor much more appealing and less of a chore. He is also pleased that the chair can be disassembled quickly and easily for compact storage, and is lightweight and easy to carry.

TECHNICAL DESCRIPTION

Design requirements include the development of a device to allow someone to lift and lower a person from the ground to wheelchair height, or vice versa, while expending limited effort. From this height, the individual can easily transfer themselves to the wheelchair. The device needs to be capable of lifting an individual weighing up to 300 pounds, portable and lightweight, and be able to fold down to 40" x 18" in order to easily fit in the trunk of the car. The device also needs to be easily operable, and be able to be assembled and disassembled by the assistant and the individual.

Two designs were explored. The first was a tripod which utilizes a winch to hoist the individual from the floor. This design was not used because it requires a large area in which to set up the device due to the large reach of the tripod legs. Also, it would be difficult to put a wheelchair beneath the tripod due to interference with the tripod legs. The second design was simply a collapsible chair with a tall backrest that could be used for leverage. To use this design, the individual is strapped into the chair while it is lying on its side. The chair is then tipped to its backside and lifted into an upright position. At this point, the individual is sitting in the chair normally. In order to minimize the large force required to lift the chair into the upright position, the bottom of the chair is curved as shown in Fig. 19.12. This curve relocates the location of the fulcrum as the chair is being lifted into its upright position. This reduces the force required to perform this lift by approximately 50%.

The frame of the chair is made using 4130 Chromoly steel round tubing. This through-hardened, chromium-molybdenum alloy tubing is used extensively in the aircraft industry, and anywhere light and strong structural tubing is needed. It also costs less than aluminum and is much easier to

weld. The chair is made to separate into four pieces as shown in Fig. 19.13: the high back, the right leg with an attached foot rest, the left leg with an attached seat, and the top handle. The top handle is used when lifting the chair, and is angled upward at ten degrees. This handle increases the lever arm which reduces the force required to lift the chair by about 10%. The right and left legs are curved. Two ratcheting rear legs are placed on the back side of the unit for additional support.

Assembly and disassembly can be completed easily by one person within a matter of minutes. Four screws are used to attach the seat to the right leg, two pins are used to hold the legs in place and attach each leg to the chair back, and two cotter pins are used to attach the top handle to the chair back.

Finite element analyses using SolidWorks® and hand calculations are used to perform a structural analysis on the chair and its components. Two cases are studied: the chair being lifted and the chair resting on its ratcheting legs. When the chair is lifted, the following four positions of the chair were investigated: 0°, 30°, 60°, and 90° with the ground. When the chair is resting, the following four positions of the chair were investigated: 10°, 30°, 60°, and 90° with the ground. In the case simulating the lifting of the chair, the lifting force is applied perpendicular to the back of the chair. For each of the two cases that were studied, the weight of the person is distributed on the back of the chair and on the seat. This distribution changes with the chair position. When the chair was at 0° with the ground, the total weight of the person (300 pounds) is applied to the back of the chair. At 90°, the total weight is applied to the seat. A minimum factor of safety of 4.0 was calculated. This corresponds to the case simulating the chair being lifted at an angle of 30° with the ground. At this position, the lifting force is at a maximum of 80 pounds and the maximum stresses are located in the pins joining the extension handle to the back piece. When the chair is resting on its ratcheting legs, a minimum factor of safety of 5.0 was calculated when the chair was at 10° with the ground. In this case, the maximum stresses are located in the ratchet handles. The unit when assembled is 71" in height and around 40lbs in weight. When disassembled, the chair takes up a volume of approximately 40"L x 20"W x 4"H as depicted in Fig. 19.14. The total cost of the parts is about \$500.

ADAPTATION OF A LAWN MOWER TRACTOR WITH HAND CONTROLS

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INTRODUCTION

A paraplegic individual has full range of motion and dexterity in his upper body. He currently owns a White Outdoor Hydrostatic Lawn Tractor Model LT 165, but is unable to depress the foot-pedal brake lever. The purpose of this project is to adapt his lawn mower to allow him to control the brake lever via hand controls, while maintaining the original operation of the foot-pedal for other users. The developed system includes a cable drawn device that includes two sheathed cables, a tensioner and a handle. One cable is attached to the brake/clutch foot pedal and the second to the handle. The device allows the user to pull the handle to depress the foot-pedal. The tensioner system consists of a spring loaded piston that is used to absorb slack in the cable allowing for normal operation of foot-pedal, depressing directly by foot. Fig. 19.15 depicts the system in use, and Fig. 19.16 shows the tensioner system mounted under the floor plate.

SUMMARY OF IMPACT

A paraplegic individual uses his riding lawn tractor to mow several acres of land. Since he has no leg movement, he was previously using a shovel handle to depress the brake lever when needed. The device developed in this design is user-friendly and allows the client to depress the brake lever by pulling a handle mounted on the top of the rear fender of the tractor. The client tested the developed unit and found it to be easy to use, un-obstructive to wheelchair transfer, and adaptable to various lawn tractors which use similar brake pedal mechanics. He is also pleased that the unit is capable of accommodating normal foot operation.



Fig. 19.15. Cable drawn device in use.



Fig. 19.16. Tensioner unit installed under floor plate.

TECHNICAL DESCRIPTION

Design considerations include developing a device that does not hinder or prevent normal brake operation by means of foot and requires little or no permanent alterations to the tractor. The client

transfers from his wheelchair to the lawn tractor on the same side that the brake lever is located. Therefore, any device designed to control the brake lever should provide sufficient clearance for transfer and the operator's legs during use. A rigid bar may be bolted directly to the clutch/brake foot pedal. While this design is simple and economic, it presents complications with functionality since it is necessary to keep the hand control device within close reach of the user, while not interfering with transfer on and off the mower. Therefore, a cable drawn system design is selected which consists of two sheathed cables, a piston style spring tensioner, and a handle as illustrated in Fig. 19.17. The piston-style spring tensioner is designed to absorb slack cable for normal operation. The cables are guided via sheaths similar to bicycle brake cables. The system uses two cables. One cable is attached to the brake lever shaft by means of a clamped shaft collar. The other cable is attached to the underside of the handle. Both cables are joined by the tensioner unit. The handle is supported by two bearings that are mounted to a base plate bolted to the mower body. A collar is mounted to the foot-pedal to provide attachment for the cable.

When the handle is pulled, the cable travels through the sheath and completely depresses the foot pedal. In this case, the tensioner acts as a rigid member traveling a distance equivalent to the length of cable drawn. A challenge arises when the foot pedal is operated normally. If the foot-pedal is depressed directly by the foot, tension in the cable is lost allowing the cable to bend and twist upwards. This could potentially allow the cable to get caught on other parts not allowing the pedal to return to its neutral position. The piston-style spring tensioner system is designed to maintain normal brake operation and its mechanism is illustrated in Fig. 19.18. Under normal operating conditions and as the foot pedal is depressed, the compressed spring extends due to the drop in the cable tension, thus raising the slider tube and drawing excess cable into the tensioner. When the pedal is completely depressed, the slider tube is extended to its maximum displacement position (Fig. 19.18 View

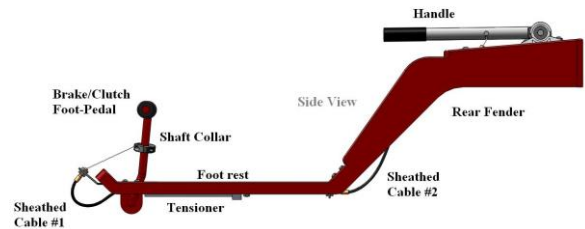


Fig. 19.17. This figure shows the different components of the cable drawn system.

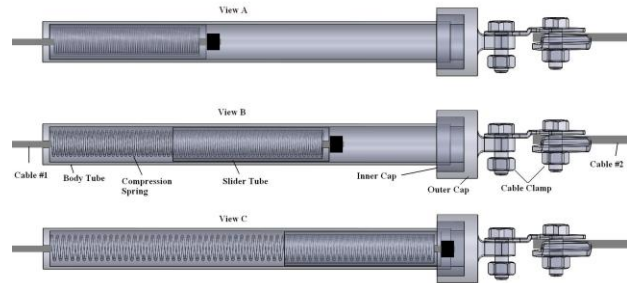


Fig. 19.18. Tensioner assembly.

C). This allows the excess cable to be pulled into the tensioner while maintaining cable tension.

The cable travel is used to select the appropriate compression spring and design the piston and cylinder. The force required to completely depress the pedal is determined experimentally to be from 3.5 - 4.5 pounds and used to estimate the maximum tension in the cable at about 70 pounds. A braided cold-drawn steel cable having 19 strands, each with a diameter of 0.014 in is selected resulting in a factor of safety greater than 2 in the cable. A handle length of 13 inches is used to maximize mechanical advantage and avoid interfering with the client's transfer space. Finite element analysis is used to perform a structural analysis on the different components of the system which are found to have a minimum factor of safety of 2.6. The total cost of the parts is about \$310.00. The students working on this project posted a detailed description of their design and analysis on the internet at the following URL address:

<http://www.mime.eng.utoledo.edu/design/clinics/2010/Spring/sites/2010-01-03/index.htm>

HAND CONTROLS FOR A UTILITY TERRAIN VEHICLE

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INTRODUCTION

The objective of this project is to develop hand controls to allow an individual paralyzed from the waist down to independently operate his Utility Terrain Vehicle's (UTV) accelerator and brake pedals. A device that can be completely operated with the use of one hand is developed for this purpose. The device includes a handle mounted on the right side of the steering wheel. The handle uses a series of linkages to push the brake and throttle pedals down. If the operator pulls the handle back the brake will engage. If he pushes the handle forward it will engage the throttle. Fig. 19.19 shows a schematic of the system and Fig. 19.20 shows the system installed in the UTV.

SUMMARY OF IMPACT

An individual was involved in a hunting accident that left him paralyzed from the waist down. He is still an avid hunter and uses his Kawasaki Mule to travel to various hunting locations. He previously relied on a long object, such as a stick, to push and operate the foot pedals. The developed device allows him to independently and safely operate his UTV. The client tested the device and found it to be easy to use, durable, safe, and comfortable. He is also pleased that the unit has made no permanent alterations to the vehicle, which will help the vehicle retain resale value.

TECHNICAL DESCRIPTION

Several criteria and guidelines are considered when designing a hand control mechanism that allows the client to independently operate his UTV. The device needs to control both pedals using only one hand since the other hand needs to be on the steering wheel to safely operate the Mule. The device cannot be intrusive, and must be within the driver's reach.

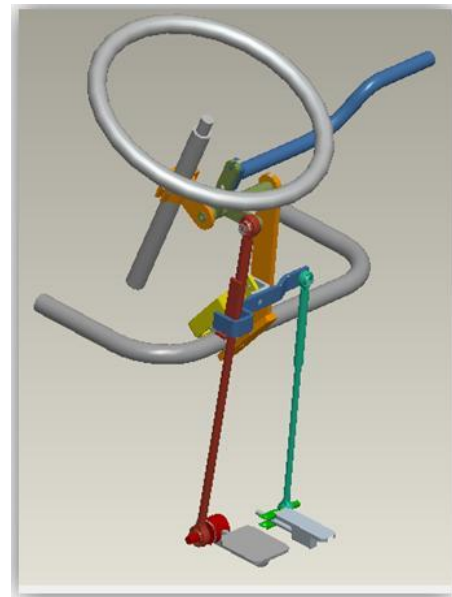


Fig. 19.19. Schematic of the device.

The client requested that the device be located to the right of the steering column for more personal ease of use. Another consideration is that the pedals need to remain functional to someone operating the vehicle with their feet while the device is installed on the Mule. Also, the design needs to be robust and sturdy since the Mule will be driven in fields and on uneven ground which will cause the device to vibrate. All of this needs to be considered while keeping in mind that the device needs to be removable, leaving no permanent alterations to the Kawasaki Mule that would violate the warranty or depreciate the value of the vehicle for future resale. It is also desired that the device be transferrable to another UTV if the client chooses to purchase another model.

SolidWorks® and Professional Engineer® are used to draw a 3D model for the device shown in Fig. 19.21. The existing parts on the SUV that are used to attach the hand control mechanism are clearly shown in Fig. 19.21 and include the steering column and wheel (the top of the figure), the U-Shaped lower UTV frame (in the middle of the figure), and the brake and throttle pedals (at the bottom of the figure).

This design is very simple to operate. It consists of two directions of motion of the hand control located at the upper right of Fig. 19.20. When the operator is facing the steering wheel, the hand control is pushed forward to engage the throttle. Likewise, the operator can pull the handle towards their body to engage the brake.

The forward and backward hand control operations cause the brake and throttle to engage through a series of mechanical linkages. The handle is directly connected to the crank arm with two bolts as shown in Fig. 19.21. This crank arm is supported on both ends so it rotates on an axis that is parallel to the handle. The crank arm is also connected to the brake arm assembly (located at the left of Fig. 19.20) as shown in Fig. 19.21. A pivot arm detailed in Fig. 19.22 connects the brake arm assembly to the throttle arm assembly (located at the bottom right of Fig. 19.20 and at the right of Fig. 19.21). The upper part of the brake arm assembly slides in the upwards direction on its lower part when the handle is pushed in the forward direction. This results in rotating the pivot arm in the clockwise direction, which moves the throttle arm assembly in the downward direction applying a force on the throttle clamp, thus engaging the throttle. With the handle bolted directly to the crank arm, the backwards motion of the handle results in an opposite rotation of the pivot arm pushing down on the brake arm assembly which directly applies a force on the brake clamp, engaging the brake.

Finite element analysis is used to perform a structural analysis on the unit. Calculations are done only for the braking because the accelerator pedal takes only a fraction of what the brake pedal takes to fully compress. It was determined experimentally that an average of 12 pounds force is needed to be applied to the handle to fully compress the brake pedal. AISI 1020 cold rolled steel is used to fabricate the system and a minimum factor of safety of 8.5 was calculated with the maximum



Fig. 19.20. Device installed in the UTV.

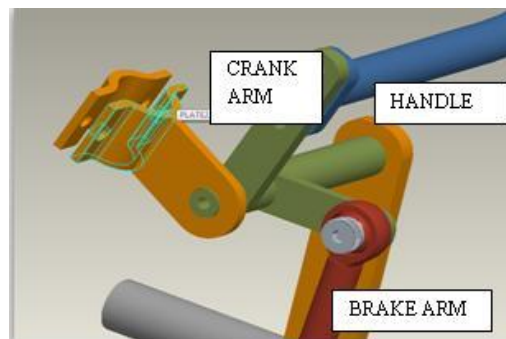


Fig. 19.21. Close-up view of the crank shaft



Fig. 19.22. Close-up view of the pivot arm.

stresses occurring in the crank arm near the bottom hole where the handle attaches. The total cost of the parts is about \$400. The students working on this project posted a detailed description of their design and analysis on the internet at the following URL address:

<http://www.mime.eng.utoledo.edu/design/clinics/2010/Spring/sites/2010-01-0>

ASSISTED FEEDING MECHANISM

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INTRODUCTION

The goal of this project is to develop a mechanism that will help an individual with cerebral palsy eat more independently. A robotic arm is developed in this design for this purpose. The device consists of a base and three arms made of PVC pipe and joined together with sleeve fit joints. The unit includes four motors, one housed inside each of the three joints and one inside the base. A utensil attachment is located at the end of the robotic arm to allow the user to retrieve from his plate. Two motors are controlled via a joystick that is mounted to the table using a clamping fixture. The other two motors are controlled by two foot pedals. When eating, the robotic arm is placed directly on the table to the left of the plate. The joystick is controlled with the chin of the user while the pedals are controlled with his feet. Fig. 19.23 depicts the developed robotic arm.

SUMMARY OF IMPACT

An individual with cerebral palsy would like to be able to eat independently when in a restaurant or at home. Since he has minimal control of his hands and fingers he is not able to pick up a fork or spoon and eat with a utensil. The developed device allows this individual to operate a robotic arm that can pick food up from a plate and place it in his mouth. The unit was tested by the client and he was able to both stab and scoop food when using it. The client has indicated that he was very pleased with its performance. Fig. 19.24 depicts the client using the robotic arm to feed himself. The mechanism could also be used in other applications such as with the elderly.

TECHNICAL DESCRIPTION

The client has a motorized wheelchair that is controlled with a joystick located on a hinged bar under his chin. It is desired to operate the feeding mechanism with controls similar to those of the client's wheelchair. Other design criteria included



Fig. 19.23. Developed Robotic Arm.



Fig. 19.24. Client using the arm.

the ability to pick up a wide variety of food, portability, and ease of use. Several design ideas were considered including an indexing or rotating plate that an arm would scoop food from while fixed to a predetermined track, a design similar to a three axis mill where a central utensil attachment would be able to move in space, and a power screw to move an arm fixed in a horizontal position up and down and radially. These designs were not pursued

because of the client's mobility constraints and because of their inconveniently large sizes. The selected design is a four-degrees-of-freedom robotic arm that is controlled by a joystick and foot pedals. This design is chosen because it allows a wide range of movement, has the ability to stab and scoop food, and is not very distracting when used in a restaurant setting.

The robotic arm consists of three pieces of $\frac{3}{4}$ " Polyvinyl Chloride (PVC) pipe that are joined together with sleeve fit joints. The robotic arm is mounted on a turntable base. Four motors are used, three to control the rotations of each of the three arms and one to control the rotation of the base. A motor is housed inside each of the three sleeve joints, and the fourth one inside the base. Each joint consists of an inner and an outer insert; a motor is mounted inside of the inner sleeve using a custom designed plug and its shaft rotates the outer sleeve.

At the end of the robotic arm is a utensil attachment which is used to stab or scoop the food on the plate. Two motors are controlled via a joystick that is mounted to the table using a clamping assembly. The other two motors are controlled by two foot pedals. The joystick is controlled with the chin of the user while the pedals are controlled with his feet. In order to easily control the device, the joystick needs to be mounted so that the client can easily reach it with his chin. This is accomplished by welding a clamp with a T-handle to an adjustable clamp in which a PVC arm coming off the joystick box attaches.

Four gear boxes are also used since the motors need to be geared down to a slow speed of 3 rpm. Most of the rotations in the eating process will not exceed 120 degrees and take only five to seven seconds to be performed. A 12 volts lead acid battery with 4.5 Amp.hr of energy capacity is used as a power



Fig. 19.25. Robotic arm with controls.

supply. This allows running three motors simultaneously for an hour. A turntable with ball bearings is used to rotate the robotic arm at its base which is used to house the battery and wiring. A junction box is used as the base.

The total cost of the parts is about \$500. The students working on this project posted a detailed description of their design and analysis on the internet at the following URL address: <http://www.mime.eng.utoledo.edu/design/clinics/2010/Spring/sites/2010-01-01/>



CHAPTER 20

VANDERBILT UNIVERSITY

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WHEELCHAIR PROPULSION MONITOR

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Client Coordinator: William Mark Richter, PhD.

Supervising Professor: William Mark Richter, PhD.

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INTRODUCTION

Over half of the manual wheelchair user population has developed an upper limb overuse injury. Wheelchair propulsion is likely one of the contributing factors in the development of these injuries. As such, clinicians are training users to change the way they push their wheelchairs. With users pushing an estimated 2,500 times each day, they are being encouraged to make every push count. By using long, smooth push strokes, users can decrease how often they push and thereby decrease their overall number of pushes taken each day. By providing propulsion biofeedback, the Propulsion monitor project will hopefully reduce the number of users developing shoulder and wrist problems.

SUMMARY OF IMPACT

Understanding the biomechanics of manual wheelchair propulsion is integral to providing accurate, beneficial biofeedback to the users. The focus of the project is to design, prototype, fabricate, and program a sensor and feedback device to record and analyze propulsion data from the wheel. From these data are gleaned the push starts and stops, as well as the speed, distance and acceleration of the wheel. These data, covering both activity and cadence, provide beneficial feedback for propulsion training and research.

TECHNICAL DESCRIPTION

A proof of concept Propulsion monitor was developed which is shown in Fig. 20.1. The prototype is designed to evaluate the ability to detect push starts and stops with an angular rate gyro, as well as to assess the potential of various proposed components. The prototype is a custom printed circuit board with: 1) a high contrast organic LED screen (OLED), 2) a 4-way mini joystick with center click, 3) an ultra-thin 3.7V 3.4Wh Lithium Ion rechargeable battery, 4) an altimeter, 5) a 4GB

removable micro SD memory card, 6) a mini-USB and wireless Bluetooth chipset, 7) a tri-color LED and 8) an ATME161 microcontroller. Code was written in C and uploaded to the microcontroller to integrate the components, identify push starts and stops, calculate propulsion outcomes, display results to the screen, receive input commands from the joystick, write data to the SD card, monitor battery charge, and facilitate wired and wireless data transfer to a laptop. After a series of circuit debugging and re-design iterations, the prototype achieved full functionality. The OLED screen is an excellent display choice with high visibility even in direct sunlight. Use of white text on a black background maximizes visibility as well as minimizes power consumption. The joystick enables menus to be navigated and selections to be made. The tri-color LED changes from green to yellow and finally pulsing red as battery reached a critical level. The prototype is mounted onto an instrumented wheel and used to push through several propulsion environments, including an undulating path around a parking lot, a straight path on low-pile height carpet and on a research treadmill set to a two degree incline. The Propulsion monitor results are found to be very comparable to those from the Instrumented wheel. Total number of pushes identified was the same for the treadmill and carpet but short by one push on the parking lot surface. The unidentified push was a small corrective push with unperceivable wheel acceleration. Push start and stop events are found to be within 10 ms of those identified by the Instrumented wheel. As a result, calculated outcomes of cadence, contact angle and distance travelled per push differ slightly from the Instrumented wheel results. Differences are found to be less than 5% between the two instruments. The high level of agreement between the Propulsion monitor prototype and the Instrumented wheel validates the Propulsion monitor prototype.

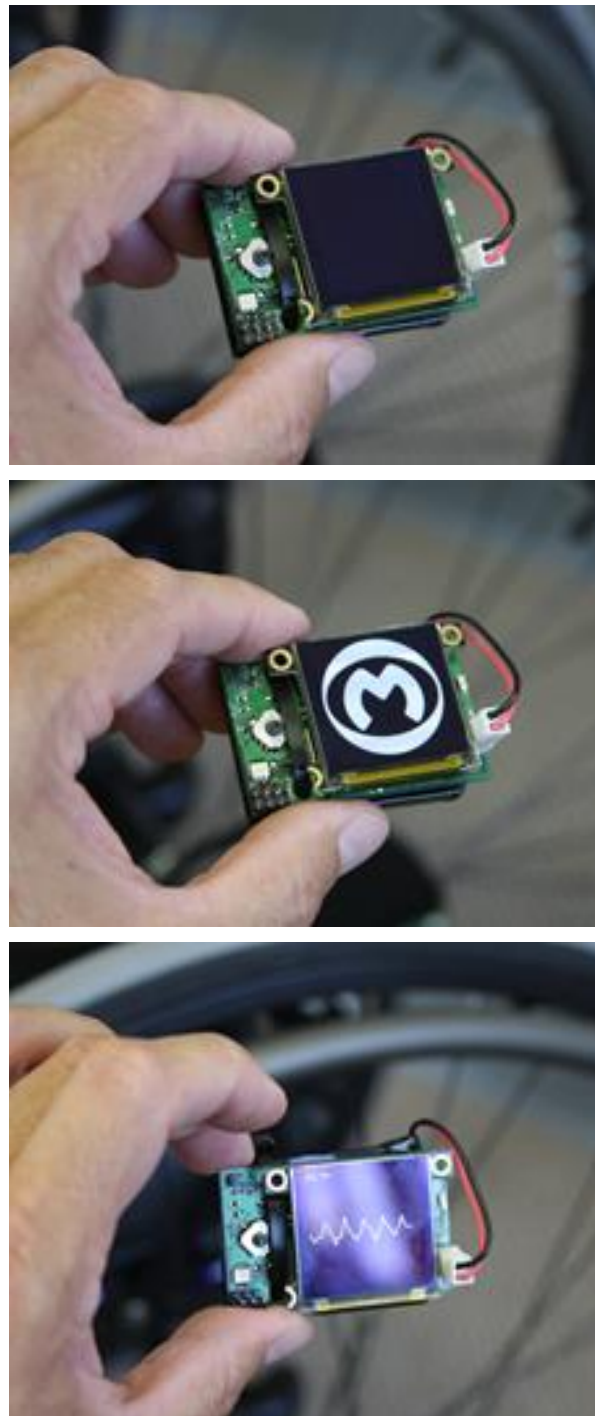


Fig. 20.1. The Propulsion monitor prototype has an OLED screen that is visible even in bright sunlight.

WHEELCHAIR DYNAMIC CENTER OF GRAVITY (D-COG)

*Designers: A. Lossing, K. Mobley, G. Spiegel
Supervising Professors: W. Mark Richter and Paul H. King
Department of Biomedical Engineering
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INTRODUCTION

There are over two million manual wheelchair users in the United States. "Active" manual wheelchairs are used by disabled people who still maintain independence and are seeking products and upgrades that will increase that independence. Over the past decade this push for independence has led to the promotion of "tippiness", which is defined as "a compromise between the risk of rearward instability and the ability to propel and maneuver easily". A wheelchair is tippy when a minimum of 80% of the user's weight rests on the rear wheels. The user accepts additional instability, in the form of higher likelihood of tipping over backwards, in order to gain significant advantages in maneuverability and propulsion. The purpose of this work was to design a wheelchair that allows users to receive all the benefits and independence that accompany the use of a tippy wheelchair while minimizing the disadvantage suffered while traveling up a hill. The design must add as little weight as possible to the wheelchair and be easy for the user to actuate during normal motion.

SUMMARY OF IMPACT

By allowing weight to be shifted forward during the climbing of hills, the user is spared the need to lean forward to minimize the possibility of tip-over during normal hill climbing, and is in a more

comfortable propulsion position. The D-COG wheelchair gives the user a more comfortable and efficient way to climb hills, while allowing all the benefits of a tippy wheelchair, and does not add significant weight to the wheelchair. The final prototype moves the center of gravity from 83% to 64% of weight on the rear wheels by moving the seat 3.18 inches forward.

TECHNICAL DESCRIPTION

The final design is comprised of four main features including a two piece frame, concave wheels and their housing, brakes, and an initiation switch. The upper frame comprises the seat, footrest, and back rest, the lower frame is attached to the standard wheel assembly. The concave wheels link the two sections and allow them to move relative to each other when the brakes are disengaged. There are the two main positions of the wheelchair; the tippy setting for general use and the forward position for climbing hills. The forward position, for climbing hills, is set at a seat position three to four inches in front of the chair's normal position. This hill climbing setting is achieved by releasing the brakes with the initiation switch and "scooting" forward to a stop position and resetting the brakes. Upon reaching a level position, this process is reversed to reset the desired "tippy" setting. Approximate costs include \$1,150 for hardware and \$500 for machining and labor.



Fig. 20.2. The completed prototype in the tippy position.



Fig. 20.3. The completed prototype in the hill climbing position.



CHAPTER 21

WAYNE STATE UNIVERSITY

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GARDEN CAROUSEL

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Client Coordinator: Eileen Whalen, Program Director of ConnectUs

Supervising Professors: Dr. Robert F. Erlandson, Dr. Donna Case

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INTRODUCTION

A mobile, wheelchair accessible, garden carousel was designed for clients of ConnectUs. ConnectUs, a Michigan non-profit 501(c) (3) corporation, was established to fill a need for quality day programming for adults who are severely multiply impaired (SMI). ConnectUs is based on the belief that the needs of one can be an opportunity for another. The Garden Carousel is designed to allow ConnectUs clients the opportunity to experience working with plants and gardening. It will be one component of an accessible garden work area.

SUMMARY OF IMPACT

Ms. Eileen Whalen, Program Director of ConnectUs, envisioned the participants wheeling up to the gardening carousel, and then pressing a switch which would water plants by activating a pump connected to an electric timer. ConnectUs staff or volunteers would rotate the plant trays. Ms. Whalen wanted her son (Michael) and other adults in the ConnectUs program to be exposed to and enjoy the beauty of gardening. The height and placement of the trays holding the potted plants enable participants to remove the plants and work with them.

TECHNICAL DESCRIPTION

The Garden Carousel has four trays that hold potted plants, displayed in Fig. 21.2. The trays are rotated manually by turning a large handle. A motorized tray rotation system was considered but rejected for safety and cost concerns. The basic design would have been much more complicated and expensive considering the error-proofing and safety features necessary for a motorized tray rotation system. A switch operated watering system is on a timer which

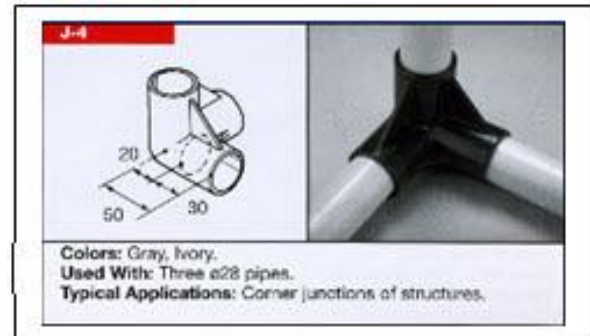


Fig. 21.1. Corner Junctions.

controls the amount of water delivered to the trays. Plant lights can be placed on either side of the carousel. A water tank will be placed below the trays within the base of the carousel frame. The switch used to control the watering process is on a long cable and can be placed to accommodate a variety of users.

The frame of the Garden Carousel is made from Creform a pipe and joint, agile systems technology. Creform is used worldwide for industrial workstations, material handling, and storage systems. The Creform pipe is steel with a bonded plastic coating. The plastic coating comes in a wide variety of colors. The Garden Carousel uses purple and white pipe. There are over 500 standardized components that can be used in conjunction with the basic pipe material. These include a variety of metal and plastic joints (see Fig. 21.1) as well as casters, rollers, brackets, and shelving components. The Garden Carousel uses plastic joints so as to provide a waterproof seal to the steel pipe.

The total cost for the Garden Carousel is \$570.

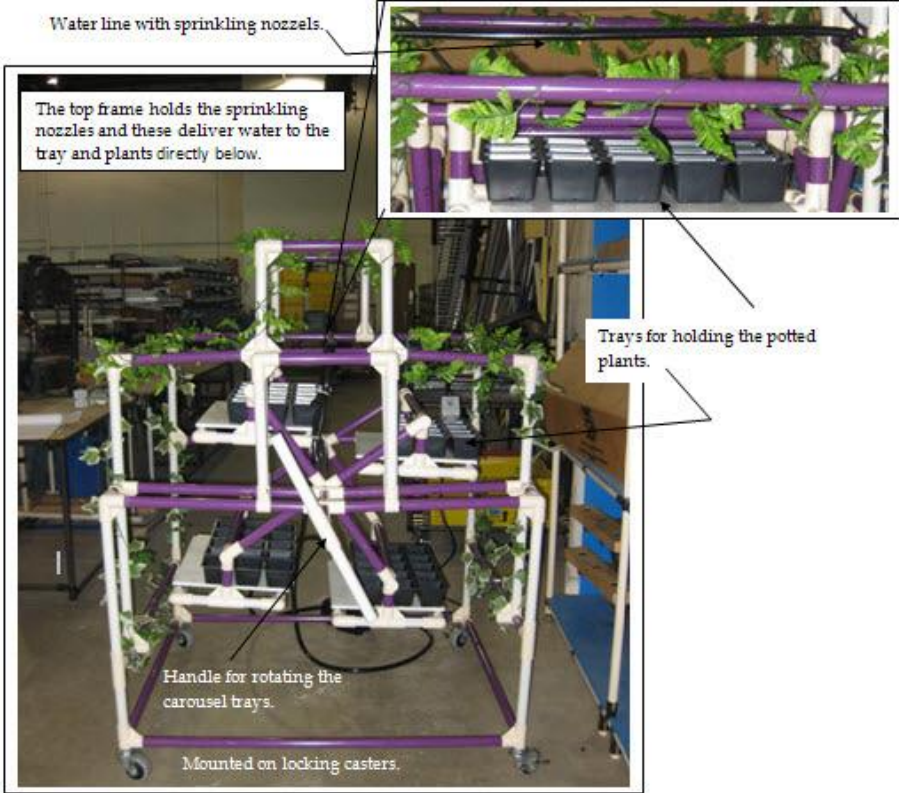


Fig. 21.2. Completed Device.

HANDWRITING ANALYSIS PROGRAM

Designer: Lovepreet Kaur

Client Coordinator: Dr. Gerry Conti, Ph.D., OTR, Director, Human Movement Laboratory, Occupational Therapy Program, Wayne State University

*Supervising Professor: Dr. Robert F. Erlandson
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INTRODUCTION

The goal of this project was to design a software application that can be used for evaluation and analysis. The software application takes data from a Wacom electronic interactive pen and display. A person can write or draw items in free-form or conforming to specific constraints. Fig. 21.3 shows a Wacom tablet.

A data acquisition application collects raw data from the Wacom tablet. Another software application allows post-processing of the collected raw data. Such a system can be used to provide objective baseline and improvement data for people who are recovering from a stroke or traumatic brain injury. Furthermore, the system can be used to evaluate the effectiveness of different treatment protocols for people with diseases such as Huntington's disease, Parkinson's disease and Development Coordination Disorders in children. For example, a current study examines changes in force control and handwriting after treatment with Tetrabenzazine in people with Huntington's disease.

Existing programs typically do not support the rehabilitation process and are focused only on analysis. They are expensive, complex and do not provide the desired analytical tools. This program is easy to use and provides a collection of powerful analysis tools specifically designed to address therapeutic evaluation needs. The program is written in LabView which provides a fast and cost effective development system. Being modular, the program easily allows the addition of new analysis modules.

SUMMARY OF IMPACT

The developed system provides a unique therapeutic and treatment evaluation tool for hand and fine motor control issues. The system uses a familiar task and a commercially available device,



Fig. 21.3. Wacom Tablet.

the Wacom tablet. Clinical trials by Dr. Conti, in the Human Movement Laboratory, Occupational Therapy Program, At Wayne State University, have demonstrated that people very quickly understand what they are to do. The system is being used on a regular basis.

TECHNICAL DESCRIPTION

Both the data acquisition program and the data analysis program are written in LabView. The data analysis program used previously collected raw data. The program allows the therapist to view either the actual letters or drawings created by the client as well as data analysis results and information. The program allows a user to see parameters such as peak velocity and acceleration, total trial time, force inefficiency, and character width on the front panel and also allows saving them in a text file which can then be imported into Excel for further analyses. Four graphs can be displayed on the screen to make the analysis easier to visualize and to confirm that calculated parameters indeed correspond to the graphical outlook. Clicking on different tab buttons allows user to see the four different graphs. Fig. 21.4 provides an example of the display - showing four and a half instances of the written letter "l" and the associated velocity plot.

The application was run on a limited number of samples from different age groups of healthy subjects to see the variation with age. Additionally the healthy subjects were compared against people with Huntington's disease. Average values of force inefficiency, peak velocity and peak accelerations were calculated. The results show that force inefficiency dropped consistently with age and became worse with Huntington's disease. This is consistent with what was expected. Also, it can be observed that peak velocity and peak acceleration increased with age. The increase in peak velocity and acceleration with age was also expected because

movements appear jerkier in older adults compared to youth and adults. When moving from healthy to Huntington disease patients it can be seen that the peak velocity and peak acceleration jumped to very high values which is again what is expected as the jerky movements are even worse in Huntington patients. However, note that all the above statements were based on observation alone; this analysis program now provides objective support for the above statements and an opportunity for quantitative measures of change with intervention. This is especially important as reimbursement for intervention is increasingly scrutinized.

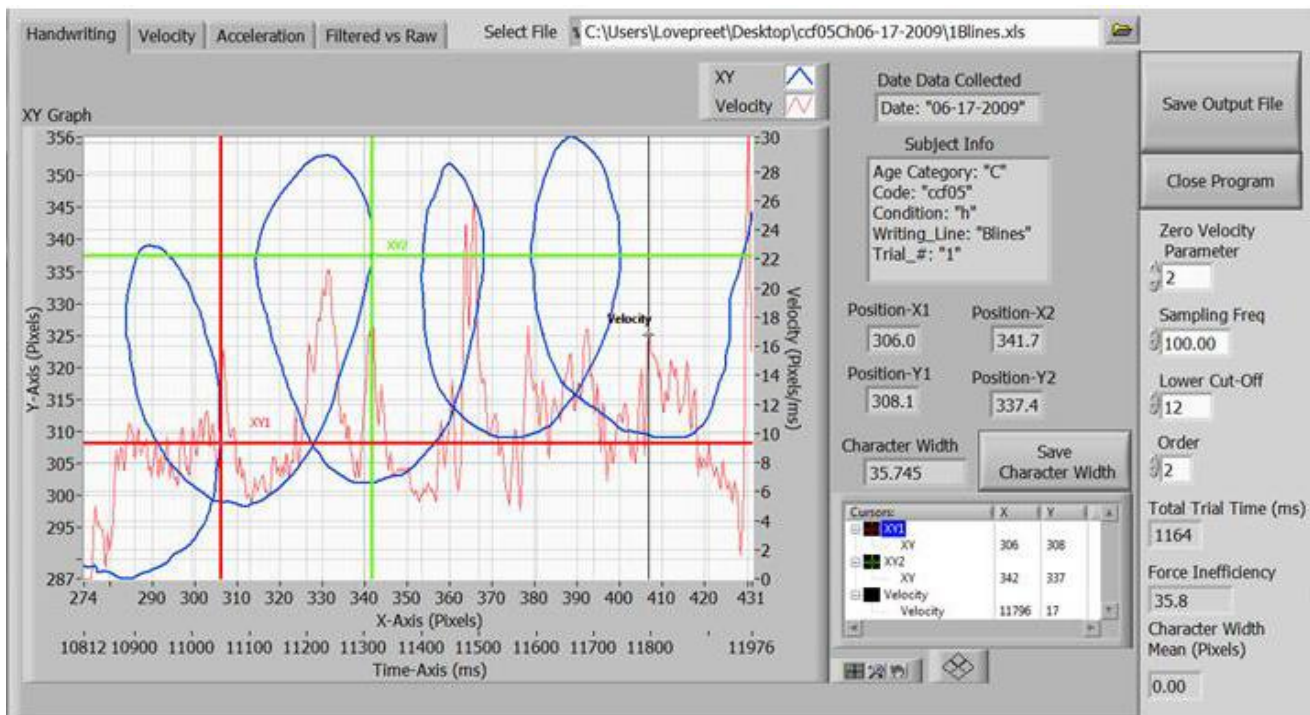


Fig. 21.4. Display of Device.

LOCATION DETECTION ENGINE

Designers: Sahiti Chukkapalli, Jainu Jogani, Kadambari Bhasin, Anuja Vedpathak
Location Detection Engine – Part 2 Jennic: JN5139 and JN5148

Designers: Elizabeth Halash, Lovepreet Kaur

Supervising Professor: Dr. Robert F. Erlandson, Santosh Kodimiyala
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INTRODUCTION

This is the first part of a two phase project dealing with location detection inside a building. Part 1 explores the use of a commercially available location engine, the TI CC2431. Part 2 explores the use of the Jennic system and its signal strength indicator as the basis for a location detection engine. The Enabling Technologies Laboratory (ETL) has a long history of collaboration with Jewish Vocational Services, Goodwill Industries, and special education vocational training centers throughout Michigan. Most of these organizations provide janitorial and custodial vocational training to their respective clients or students. The clients and students have limited cognitive abilities and require significant job coaching and on-the-job support. Over the years ETL has, in conjunction with these agencies, designed and tested a variety of cognitive aids ranging from flipcharts coordinated with talking switches to programmed PDAs. A major problem with all these approaches is knowledge of where the worker is within the facility. ETL experimented with using passive RFID tags placed in the environment. The worker wears a reader which informs the worker of the room he or she is in and the tasks that need to be performed. However, none of these interventions has proven effective in the long run.

SUMMARY OF IMPACT

Recent advances in ZigBee wireless transceiver technology affords the opportunity to use the signal strength indicators associated with these chips to develop location detection engines for inside buildings.

TECHNICAL DESCRIPTION

Part 1

The TI CC2431 location engine development kit was used for the experiments. The kit contains both

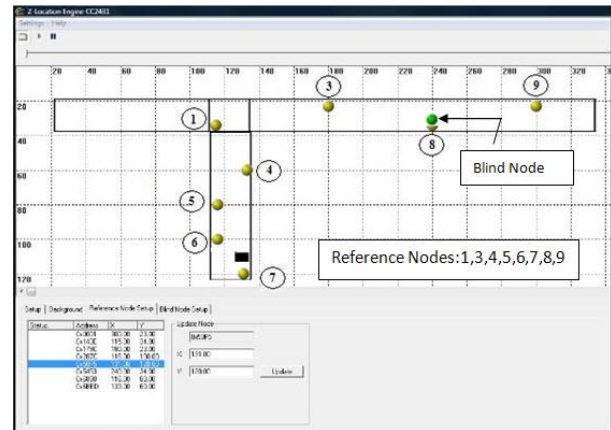


Fig. 21.5. Output of Blind Node Movement Experiment

CC2431 and CC2430 chipsets. The location algorithm uses a form of triangulation from a collection of reference nodes (3 or more up to 6 in this study). A blind node moves within the environment and gathers signal strength information associated with each of reference nodes. The blind node must be CC2431 while the reference nodes can be either the CC2431 or CC2430. The development kit also provides a Dongle which can communicate with the entire network. It can request or configure the position values of all Reference Nodes and the signal strength indicator parameter values of the Blind Nodes via the Z-location Engine PC Application. The Z-location Engine can also configure any Blind Node to automatically make a periodic position calculation and report rather than the default condition wherein the Blind Node waits for a command to perform a position calculation. A variety of CAD or sketching programs can be used to create a scaled map of the interior environment with placement of the Reference Nodes.

Ten experiments were conducted to try and replicate the results reported in the TI technical literature [1-3], with varying degrees of success. Experiments we conducted to empirically determine the values of

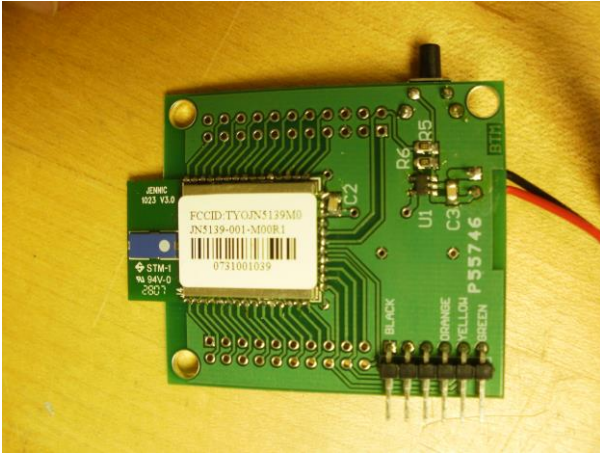


Fig. 21.6. Device.

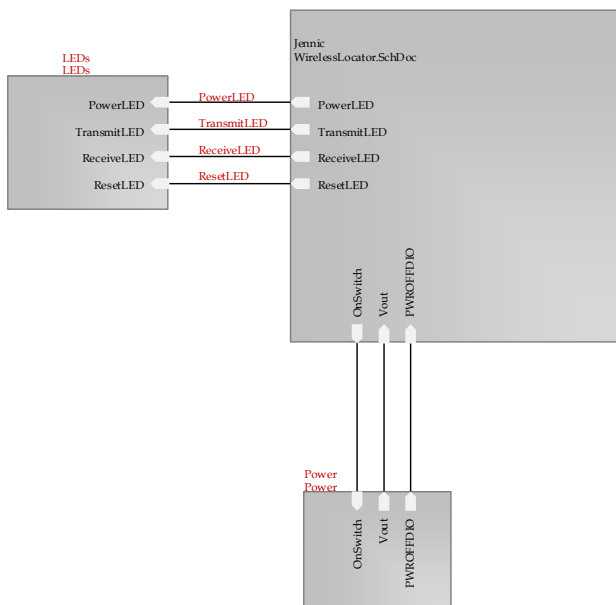


Fig. 21.7. Block Diagram of the Schematic Design in Altium Designer

the parameters in the received signal strength equation. The received signal strength is a function of the transmitted power and the distance between the sender and the receiver. The received signal strength (RSSI) will decrease with increased distance as the equation below shows.

$$RSSI = -(10n \log_{10} d + A)$$

n : Signal propagation constant, also named Propagation exponent.

d : Distance from sender.

A : Received signal strength at a distance of one meter.

The parameters A and n can be estimated empirically by collecting RSSI data (and therefore

path loss data) for which the distances between the transmitting and receiving devices are known. A scatter plot of absolute value of RSSI data versus log (distance in meters) is determined. A least-squares best-fit line was used to acquire the specific values of A and n for the environment in which the data were collected. RSSI values were collected using Daintree SNA network software.

Other experiments used the empirically derived n and A values to observe and plot in real time the movement of a Blind Node through an interior office space. Fig. 21.5 shows the output of one such experiment.

The Blind Node needed to be calibrated prior to each experiment. This was a tedious procedure. The Blind Node's position was highly variable as it moved and tended to stabilize near the correct position when stationary. If the Blind Node was worn by a person the results were too variable for practical applications. These results were similar to those found by other investigators [4-7].

Part 2

Previous experiments to develop an indoor location system used the CC2431 chip developed by Texas Instruments. These experiments did not produce desirable node operation, as the measurement signal strength showed too much variability. This Part of the study used the Jennic JN5139 chip and the newer JN5148. These are low power wireless microcontrollers for the IEEE 802.15.4 and ZigBee applications. Both are 32 bit RISC processors. The units have 192kB ROM and 96kB RAM, 2 UARTS, up to 21 DIO, and a variety of other features. There was no development kit for the Jennic so a PCB had to be designed and built to hold the JN5139 and JN5148 chips and associated components for conducting the experiments. In this project the circuit schematic, foot prints and printed circuit board were designed using Altium Designer. Six PCBs were designed, built and tested; three for the JN5139 and three for the JN5148. One of the JN5139 PCBs had an operational RS-232 serial connector and was designated the coordinator. The Coordinator was attached to the control computer and received RSSI data from all the Reference Nodes (the Coordinator is also a Reference Node).

The Jennic-ICs are programmed in Java. Code is written to control these chips and the transmit/receive process. One board is

programmed to be the blind node, one programmed as the coordinator node as well as a reference node and remaining four boards programmed as reference nodes. A communications protocol is designed and implemented for the RSSI signal and various debug and experiment feedback indicators.

The wireless system has the following operational procedure.

1. PC sends command to the coordinator to start.
2. All reference nodes and the blind node request to associate with the coordinator.
3. Coordinator sends confirmation to nodes, associating with the blind node last. (The blind node is powered on last so that it associates last.)
4. Endless Loop:
 - a. Blind node continually broadcasts a packet to all nodes
 - i. Reference nodes receive the packet, measure the link quality, and send the coordinator a packet containing the measured link quality between the reference node and the blind node as the data.
 - ii. The coordinator also serves as a reference node, receiving the packet broadcast by the blind node and measuring the signal quality as well, and passing that value to the PC.
 - b. The coordinator receives the packets from the reference nodes and automatically passes the measured link quality data to the PC.
5. The PC then takes the packets and reads the measured link quality and the corresponding address of the node it came from.

Knowing the fixed position of the coordinator and reference nodes, the computer has enough information to equate the link quality measurement (RSSI) to a distance value and triangulate the location of the blind node.

A LabView program is designed and implemented to analyze the real time RSSI signals sent by the coordinator node to the PC. The LabView program

makes connection to the coordinator through the RS232 port. Using VISA VI file, the port is opened and bytes are read into the buffer.

Fig. 21.8 shows the signal strength between the second reference node which was placed at the 10m mark and the blind node. The signal strength starts increasing as the blind node moves towards the second reference node and becomes as high as 175 when it's around 10m. It starts dropping again as the blind nodes moves away and becomes as low as 50 at a distance of 36m from origin. These results are typical of the data collected at all the reference nodes.

The Jennic configuration performed better than the TI configuration – more stable and less noise. The data collected thus far suggests that a location engine can be designed for the Jennic system that is more robust than the TI system. The next step will be to design and implement different location detection algorithms and evaluate their performance in a laboratory setting. The best performing location engine will then be applied and tested in real work and office environments.

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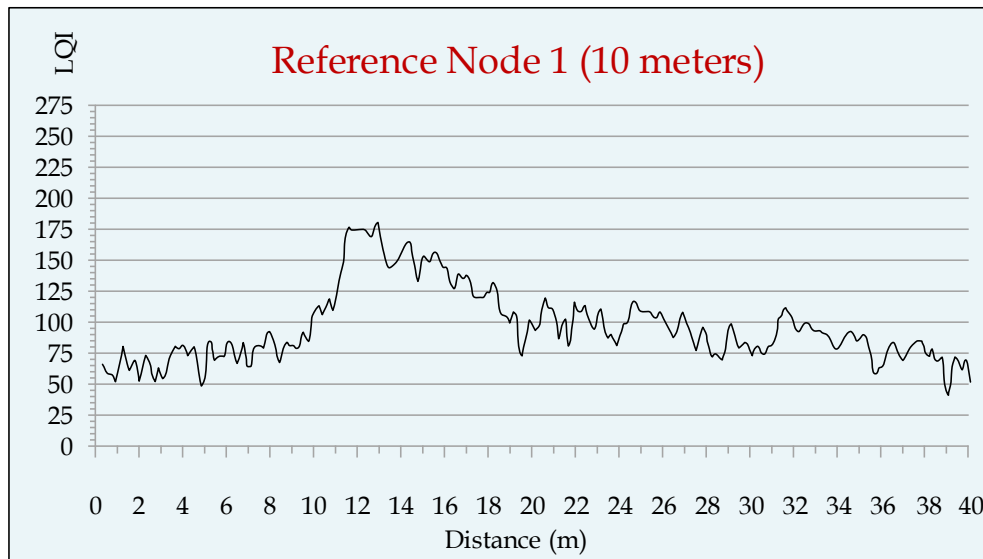


Fig. 21.8. Signal Strength between second and blind nodes

WORKSTATION FOR A MICROENTERPRISE PROJECT

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Client Coordinator: Lisa Knoop-Reed, President, Art For A Cause
Supervising Professor: Dr. Robert F. Erlandson and Dr. Donna Case
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INTRODUCTION

Art For A Cause (AFAC) is a Michigan based small business whose mission includes the employment of people with disabilities. AFAC produces a product line called Cute Tools®. These include kitchen tools, garden tools, hammers, and screw drives. All these tools have a hand painted decorative pattern on wooden handles. AFAC distributes Cute Tools® worldwide through gift stores and as promotional pieces for major corporations.

Michigan Rehabilitation Services (MRS) is part of the Michigan Department of Energy, Labor & Economic Growth and is responsible for helping individuals with disabilities find meaningful employment. Toward this end, MRS staff works with clients as well as Michigan businesses. Art For A Cause submitted a proposal to an MRS solicitation for projects to employ people with disabilities funded by American Recovery and Reinvestment Act of 2009 (ARRA). The project will establish a network of microenterprise operations making and packaging the AFAC Cute Tools® product line.

MRS identifies individuals with disabilities who want to run their own microenterprise. Using ARRA grant money MRS would purchase a Cute Tools® workstation kit from AFAC for the entrepreneur. The Cute Tools® workstation kit contains all the materials necessary for production of a specific tool and pattern. The entrepreneur would be housed at one of many MRS employment centers across Michigan. Anywhere from 8-20 entrepreneurs would be operating out of a given center. Lisa Knoop-Reed, the President of AFAC and several of her associates would train the MRS sponsored entrepreneurs on the steps necessary for creation of specific lines of Cute Tools®. As the entrepreneurs became proficient in the creation of a specific Cute Tools® pattern, they could choose to



Fig. 21.9. Previous Workstation Design.

be trained in the production of additional Cute Tools® products and patterns.

SUMMARY OF IMPACT

A prototype accessible Cute Tools® workstation kit was designed, built, and tested. The process has not yet started so the final impact cannot be assessed. However, MRS and AFAC are moving forward with the planning and training of MRS staff. Under the current plan, a variety of jobs will be created by this MRS/AFAC initiative. MRS clients will, under supervision of AFAC and MRS staff, produce the Cute Tools® workstation kits. The fully supplied kits will be shipped to an MRS center for assembly by MRS clients. AFAC staff will train the entrepreneurs.

AFAC will then subcontract work to these entrepreneurs for specific tools and patterns. The

entrepreneurs will receive all the raw, unfinished, tools and supplies such as sand paper, paint, brushes, etc. for completing the order. Finished packaged tools will be sent to an AFAC distribution facility for shipment to the purchaser.

TECHNICAL DESCRIPTION

The workstation is built from Creform, a pipe and joint technology used worldwide in industrial settings. The pipe is steel with a bonded plastic covering. The pipe is available in a wide variety of colors. There are about 500 standard components available from Creform including; joints, casters, hinges, rollers, and a variety of pipe sizes and shapes. Fig. 21.8 shows an earlier workstation design. Based on several years' experience with this design, a number of design changes are required for the microenterprise workstation. Fig. 21.9 shows the new microenterprise workstation.

The workstations are mobile and mounted on lockable casters. Both designs are wheelchair accessible. Tools can be hung on the slot board back for drying as they are processed. The new design has two sets of slightly narrower drawers. The shelf tops over the drawers are plastic and easily cleaned. The new workstation will be shipped to MRS centers as kits that must be assembled. Therefore the new design incorporates features for error-proofing both the kit creation and packaging operations as well as the workstation assembly at the MRS center. For example, the new design color codes each length of pipe thereby providing an error-proofing feature for both the kit preparation and final workstation assembly.

Fig. 21.10 shows a workstation kit ready for shipping. The front and back slot board provide the top and bottom. The drawers contain supplies and provide separation to hold the pre-cut pipe. Tape holds the packaging together. An assembly instruction manual was prepared, written in a style that is easy to understand. Also visual aid materials are created and included with the directions.



Fig. 21.9. New Workstation.



Fig. 21.10. Workstation Ready for Shipping.

Workstation assembly will be done by different workers than the entrepreneurs.

Total cost of the workstation is \$710.



CHAPTER 22

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