

**NATIONAL SCIENCE FOUNDATION
2005
ENGINEERING SENIOR DESIGN
PROJECTS TO AID PERSONS WITH
DISABILITIES**



**Edited By
John D. Enderle
Brooke Hallowell**

NATIONAL SCIENCE FOUNDATION

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Creative Learning Press, Inc.
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FOREWORD

Welcome to the seventeenth 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 Disabled (BRAD) program of the Emerging Engineering Technologies Division of NSF¹, 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 describing these projects, entitled NSF 1990 Engineering Senior Design Projects to Aid the Disabled, was published.

North Dakota State University (NDSU) Press published the following three issues. In NSF 1991 Engineering Senior Design Projects to Aid the Disabled almost 150 projects by students at 20 universities across the United States during the academic year 1990-91 were described. 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.

Creative Learning Press, Inc. has published the succeeding volumes. 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. 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. 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.

This book, funded by the NSF, describes and documents the NSF-supported senior design projects during the seventeenth year of this effort, 2004-2005. Each chapter, except for the first five, describes activity at a single university, and was

¹ In January of 1994, the Directorate for Engineering (ENG) was restructured. This program is now in the Division of Bioengineering and Environmental Systems, Biomedical Engineering & Research Aiding Persons with Disabilities Program.

written by the principal investigator(s) at that university and revised by the editors of this publication. Individuals wishing 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.

It is hoped that this book will enhance the overall quality of future senior design projects directed toward persons with disabilities by providing examples of previous projects, and by motivating 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 and Gil Devey, 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.

We acknowledge and thank Samuel Enderle for technical illustrations, and Alexandra Enderle, Nicholas Linn, Rachel Poling, Annie Puntillo, Heather Williams, and Imogene Preisch for editorial assistance. We also acknowledge and 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 editors 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 John Enderle 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, Enderle 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 is Associate Dean for Research and Sponsored Programs in the College of Health and Human Services and Director of the School of Hearing, Speech and Language Sciences at Ohio University. Hallowell's primary area of expertise is in neurogenic communication disorders. She has a long history of collaboration with colleagues in biomedical engineering, in research, curriculum development, teaching, and assessment.

The editors welcome any suggestions as to how this review may be made more useful for subsequent yearly issues. 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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NATIONAL SCIENCE FOUNDATION

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

CHAPTER 1

INTRODUCTION

John Enderle and Brooke Hallowell

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 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) has enhanced educational opportunities for students and improved the quality of life for individuals with disabilities. Students and university faculty members 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 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 emphases of the program are 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 with a similar need. 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 2003-2004.

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 effectively address the needs of persons with disabilities.

Thirdly, through its initial four 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, 15 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.^{2,3,4} Many call this the capstone course. Engineering 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

² Accrediting Board for Engineering and Technology (1999). Accreditation Policy and Procedure Manual Effective for Evaluations for the 2000-2001 Accreditation Cycle. ABET: Baltimore, MD.

³ Accrediting Board for Engineering and Technology (2000). Criteria for Accrediting Engineering Programs. ABET: Baltimore, MD.

⁴ 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

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 to help 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, and 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 that often require a multidisciplinary system or holistic approach for a successful and useful product. This stage of the design process is typically the most challenging because of the creative aspect to generating problem 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, PSpice, a circuit analysis program, easily analyzes circuit problems. 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 then the project is given to the client. Ideally, the project in use by the client should be periodically evaluated for performance and usefulness after the project is complete. Evaluation typically occurs, however, when the device no longer performs adequately for the client, and 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, such as OrCAD or AutoCAD.

The two-page reports within this publication are not representative of the final reports submitted for design course credit, and in fact, 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. Usually, photographs of the device are not included in the final report since mechanical and electrical diagrams are more useful to the engineer to document 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 work on many small design projects during the two-semester senior design course sequence. At North Dakota State University, students work on a single project during the two-semester senior design course sequence. At the University of Connecticut, students are 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 a grant from the National Science Foundation, and is offered each fall. The course size 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 insure 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 of 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/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 want 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. Texas A&M has participated in the NSF program for seven years. 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 adds to the overall design experience. The meetings take place at the beginning of each semester, and periodically thereafter as projects are completed and new ones 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 their project reports.

Throughout each phase of the project, a faculty member supervises the work, as well as the teaching assistants assigned to the rehabilitation engineering laboratory. These teaching assistants are paid with university funds. 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 "opinionnaire" 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

North Dakota State University (NDSU) has participated in this program for ten years. All senior electrical engineering students at 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 disabled individual within 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 consists of 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 show. 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/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, waveform generator, oscilloscope, breadboard, and a collection of hand tools.

The second laboratory contains Intel 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 implementation stage. Analysis software supported includes Microsoft EXCEL and Lotus 123 spreadsheets, PSpice, MATLAB, MATHCAD, and VisSim. Desktop publishing supported includes Microsoft Word for Windows, Aldus PageMaker, and technical illustration software via AutoCAD and OrCAD. 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 were many projects constructed at NDSU (and probably at many other universities) that proved 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 Dept. in this effort.

To provide effective communication between the sponsor and the student teams, a web-based approach was implemented.⁵ 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

⁵ 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.

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

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 a disabled individual after interviewing a person 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://design.bme.uconn.edu/>.

The first phase of the on-campus projects involves creating a database of persons with disabilities and then linking the student with a person who has a disability. The A.J. Pappanikou Center provided 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 the speech-language pathologists, 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/or 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 involve 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^{6,7}. There is

⁶ 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.

strong empirical evidence in numerous disciplines suggesting that students may benefit from explicit training to compensate for or enhance the cognitive style with which they enter an educational experience, such as a senior design course.^{8,9,10}

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,^{11,12} the two most essential determiners for success in teamwork are positive interdependence and individual accountability.

⁷ Witkin, H.A., & Goodenough, D.R. (1981). *Cognitive Styles: Essence and Origins*. International Universities Press, Inc., NY.

⁸ Deming, W. (1986). *Out of the crisis: quality, productivity, and competitive position*. Cambridge, Massachusetts: Cambridge University Press.

⁹ Katzenbach, J. & Smith, D. (1993). *The wisdom of teams: creating the high-performance organization*. Boston, Massachusetts: Harvard Business School Press.

¹⁰ Larson, C. & LaFasto, F. (1989). *Teamwork: what must go right, what can go wrong*. Newbury Park, California: SAGE Publications.

¹¹ 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.

¹² Jaques, D. (1991). *Learning in groups*, 2nd edition. Guilford, Surrey, England: Society for Research into Higher Education.

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 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 10 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. 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 far too difficult, scheduling of team meetings was too challenging, they did not have the proper background, 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, completing a project according to specifications and on time, this approach lacked the important and enriching multidisciplinary team experience that is desired by industry.

NSF Projects Year 2

During the second year of the NSF senior design program, seven students worked in 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 would have three students working on individual projects, projects that required integration in the same way a music system requires integration of speakers, a receiver, an amplifier, 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 student is required to update the timeline 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

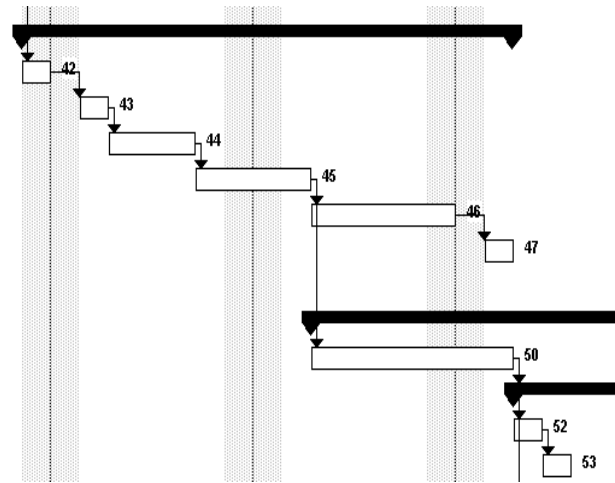


Figure 2.1. Shown above is a section of a typical timeline. The rectangular boxes represent certain tasks to be completed. These singular tasks are grouped into larger tasks, represented by thick black lines. The tasks are numbered to correspond to a task list that is not shown. The thin lines that descend 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.

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 via the web on a weekly basis project progress. Included in this report are sections of their timeline that focus on the week just past and on the week ahead. During these meetings the instructor can discuss progress or the lack thereof, but more importantly the instructor can take mental note of how the student is proceeding on a week-by-week basis.

Theory

The Senior Design Lab utilizes what is perhaps the most easily understood project-planning tool: the timeline. The timeline, or Gantt chart (see Figure 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 then 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 should a task require more time than expected or if a design methodology turns out to be unsatisfactory with the result of new tasks being 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 out of 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 – higher detail allowing the project manager to follow the plan with greater 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 followed 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 then publish his/her timeline and proceed to follow their 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/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/or client coordinator uses 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 WEB 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 was 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

During the past ten years, the Accrediting Board for Engineering and Technology (ABET)¹³ 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: (a) improvements in the learning of engineering students, especially those engaged in design projects to aid persons with disabilities, and consequently, (b) 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,

¹³ Accrediting Board for Engineering and Technology (2000). Criteria for Accrediting Engineering Programs. ABET: Baltimore, MD.

candidates for accreditation are required to demonstrate plans for assessing educational outcomes, and 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.¹⁴

"Meaningful" Assessment Practices

Because much of the demand for outcomes assessment effort is perceived, at the level of instructors, as a bureaucratic chore thrust upon them by administrators and requiring detailed and time-consuming documentation, 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

¹⁴ 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.

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 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.¹⁵

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

¹⁵ 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.

might use to talk about assessment issues. Still, 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.¹⁶ 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

¹⁶ Angelo, T. A., & Cross, K. P. (1993). *Classroom assessment techniques: A handbook for college teachers*. San Francisco: Jossey-Bass.

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 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 experiences¹⁷ 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).

¹⁷ Accrediting Board for Engineering and Technology. Criteria for Accrediting Engineering Programs. ABET: Baltimore, MD.

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.

We welcome contributions of relevant formative and summative assessment instruments, reports on assessment results, and descriptions of assessment programs and pedagogical innovations that appear

to be effective in enhancing design projects to aid persons with disabilities.

Please send queries or submissions for consideration to:

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APPENDIX: Desired Educational Outcomes as Articulated in ABET's New "Engineering Criteria 2000" (Criterion 3, Program Outcomes and Assessment)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
- (d) An ability to function on multi-disciplinary 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 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 Accrediting Board for Engineering and Technology (2000). Criteria for Accrediting Engineering Programs. ABET: Baltimore, MD (p. 38-39).

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 accreditation¹⁹. 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.

¹⁹ Engineering Criteria 2000 (Criterion 3, Program Outcomes and Assessment)

Accrediting Board for Engineering and Technology (2000). Criteria for Accrediting Engineering Programs. ABET: Baltimore, MD (p. 38-39).

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 probably varies widely 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: A) form and formatting, B) accompanying images, C) grammar, spelling, punctuation, and style, D) overall content, and E) 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 and 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 revision²⁰. 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 to 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.

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 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.

It is the profound hope of the editors of this book that future improvements in reports submitted for NSF-sponsored publications will reflect instructors' increasingly greater attention to the quality of student-generated writing. With continuously enhanced attention to the development of engineering students' writing through improved foci on writing skills and strategic assessment of written work, all with interest in design projects for persons with disabilities will benefit.

²⁰ Ohio University Center for Writing Excellence Teaching Handouts [on-line] (2002). Available at: http://www.ohiou.edu/writing/3_Ls_of_Revisio n.htm

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 size type 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. One classification scheme proposed by the WHO, the International Classification of Impairments, Disabilities and Handicaps (ICIDH) employs the general terms "impairment", "disability", and "handicap", while a more recent scheme, the ICIDH-2, employs the terms "impairment", "activity", and "participation", to refer to the various contextual aspects of disabling conditions one might experience.²¹ 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.²² 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

²¹ World Health Organization (1999). ICIDH-2: International Classification of Impairments, Activities and Participation: A manual of dimensions of disablement and health [on-line]. Available: <http://www.who.int/msa/mnh/ems/icidh/introduction.htm>

²² 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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²³ 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 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, who holds the onus, and the ways that 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 phenomena 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 and/or family carry 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 and a variety of factors are assessed in terms of barriers and or 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 their 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 very powerful and 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 they are, not for what they do or do 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 general guidelines on person first language, a keyword internet search will reveal many resources. For 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, and can include off the shelf items as well as special design. 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).

Assistive Technology 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 replacement of 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, and cognition including memory. 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, we assigned specific duties 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/her family members, caregivers, 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 Figure 5.1. Overall, an individual with a disability was linked with a student engineering team to provide a prototype custom designed assistive device specific to his/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 their 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:

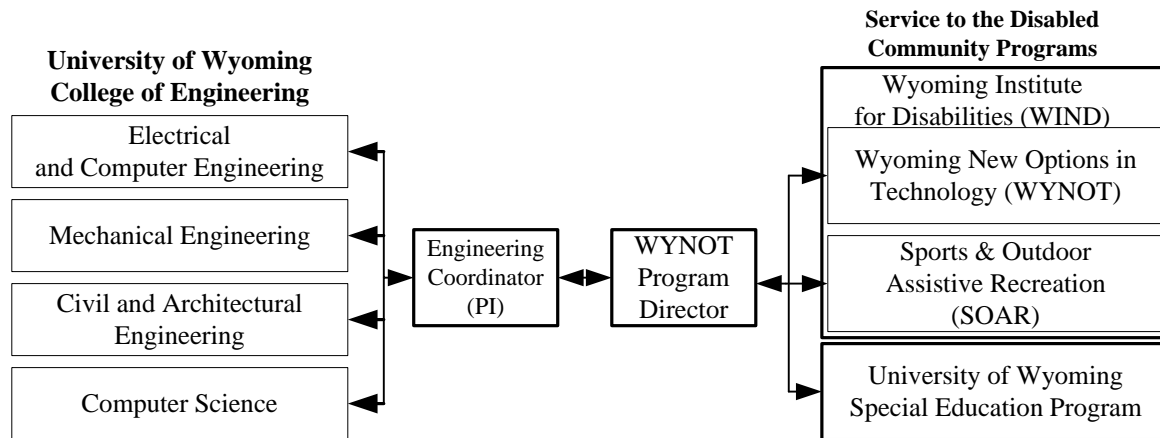


Figure 5.1. Program Flow for Undergraduate Design Projects to Aid Wyoming Persons with Disabilities [Barrett, 2003].

- 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.html>

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 then locate all of the state assistive technology projects and obtain contact information for their 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

ARIZONA STATE UNIVERSITY

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THERAPEUTIC WRIST AND FOREARM BRACE

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INTRODUCTION

The purpose of this therapeutic design is to develop an effective, easy-to-use extension to improve hand function for an individual with contracted wrists due to cerebral palsy. The design criteria for the brace were defined by the client's needs, which include frequent trips to clinics to receive physical

and occupational therapy. The new therapy brace will help the individual independently accomplish frequent extension exercises. The design is composed of a wrist and forearm brace with polyester elastics for extension.



Figure 6.1. Therapeutic Brace with Elastic Strips

SUMMARY OF IMPACT

This therapeutic brace (shown in Figures 6.1 and 6.2) has removable extension tools as well as a safe attachment tool. Consistent use of the device will increase range of motion and soft tissue integrity, which is essential in the maintenance of proper positioning. The device also provides rigid, consistent support of the client's wrist. Furthermore, the device is adjustable over time, so that the amount of extension can be progressively increased as the client's tolerance improves.

TECHNICAL DESCRIPTION

The device is composed of a commercial wrist and forearm brace, Velcro, and double stranded strips of polyester elastics. Three strips of Velcro were attached by a seamstress along the brace and on the area between the wrist and fingers. Two double strands of five, seven and nine centimeter-long polyester elastics were attached, with Velcro hooks sewn onto both ends. Force of extension, produced

by the elastics at four different increasing positions on the brace, was measured using a force meter. The values were approximately 9.2, 12.1, 15.6, and 18.6N. The strongest elastic strip was found to have the ability to provide the client with full wrist extension while the other strips provide varying degrees of extension. Other technical aspects include a means of securing the device that will not hinder or compromise the blood circulation in the client's hand or cause a pooling of fluid in the distal extremity. As a therapeutic device, it is able to take slow, constant stretching to provide the best results on the soft tissues. Also, the positioning of the device is comfortable enough to allow the client to sleep with it on. This provides increased benefits to the client at night because the muscles are more relaxed during sleep and, therefore, would be more susceptible to the stretching effects.

The overall cost of materials for the therapeutic brace was \$46.



Figure 6.2. Client Using Therapeutic Brace

ADAPTOR FOR EXERCISE BICYCLE PEDAL

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INTRODUCTION

An individual with Parkinson's disease firmly believes in the use of continued exercise to slow the progression of the disease. He first discovered he had Parkinson's ten years ago and his main symptom was tremor in his left hand. Today his disease has progressed to other areas of his body, including his legs. He has trouble using his favorite piece of exercise equipment, the recumbent exercise bicycle, because his legs are unable to maintain a constant rhythm with the bike. With one leg cycling faster than the other, his feet often slip off the pedals, having the potential to cause injury. He requested to have his exercise bike modified to adapt to his needs. The exercise bicycle pedal adaptor has been designed to allow him to exercise with the recumbent exercise bicycle, even when he is experiencing symptoms of reduced leg muscle control. This device allows the client to easily secure his feet to the bike, and provides him with the freedom to use his bike at home, as well as the bikes at the gym.

SUMMARY OF IMPACT

The device, shown in Figures 6.3 and 6.4, allows the client to resume his exercise schedule. This, in turn, will provide him with a better quality of life and possibly slow the progression of Parkinson's disease.

TECHNICAL DESCRIPTION

This device was designed with two components, which simplify attachment and removal for the client. The two components, the pedal attachment and the foot attachment, are connected through an inter-device connection. The pedal attachment required a design that would not damage the existing pedal. Therefore the final design is a thin aluminum platform with rubber stoppers attached to its base, along with nylon straps and plastic clips for attachment to the existing pedal. This design allows the device to fit easily over the existing pedal

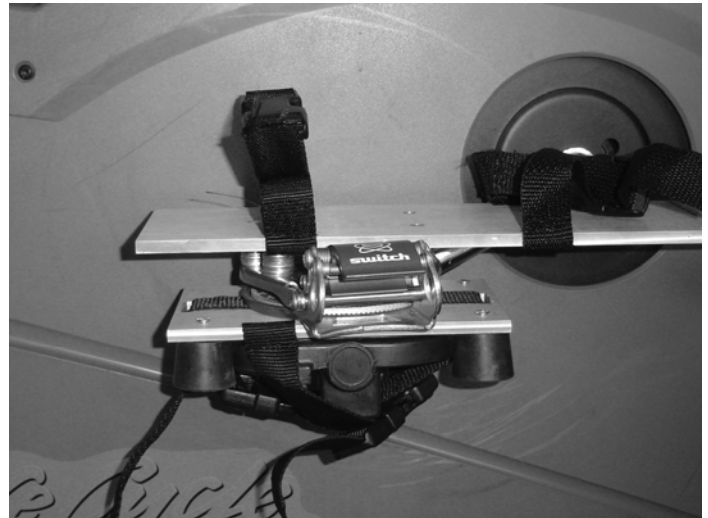


Figure 6.3. Adaptor for Exercise Bicycle Pedal

and then be secured using the clips and tightened with the nylon straps. Based on the dimensions of the pedal, the platform is a rectangle of 6.75" by 4". The rubber stoppers are secured to the platform using 6-32 flat-head machine screws. These screw from the top of the platform into coupling nuts that were previously glued into the center of the rubber stoppers. The base of the inter-device attachment then screws into the top center of the pedal attachment platform using 1/4- inch flat head machine screws.

The foot attachment component of the design utilizes aluminum pieces, 1/4 in. washers, 1/4 in. (1 in. long) screws, 6-32 (1 in. long) screws, plastic clips, and nylon straps to secure the client's foot to the pedal connection portion of the device. The main base plate is made of a 12x4x1/4 inch sheet of aluminum which has sections milled for the attachment of: the nylon straps, five 1/4 in. (1 in. long) screws, and two 6-32 (1 in. long) screws. The back plate, a 1/2x4x1 inch block of aluminum, has sections milled for two 6-32 screws. The foot attachment portion of the device is constructed in three major steps: (1) The main base plate and the back plate are

connected using two 6-32 (1 in. long) screws. (2) The foot attachment portion of the inter-device connection is attached to the main base plate in the following manner: each of the five $\frac{1}{4}$ in. (1 in. long) screws is slid through the corresponding hole on the inter-device connection, through nine $\frac{1}{4}$ in. washers, and finally screwed into the main base plate. (3) The nylon straps are slid through the milled holes on the main base plate and sewn to the plastic clips.

The inter-device attachment is a clip-in snowboard binding. This binding allows the two components to remain separate during attachment, yet to be easily

attached together just before beginning the exercise activity. Once exercise is completed, a pull on the lever on the outer end of the binding is the only action required to separate the two device components. This action allows the client to detach the pedal attachment from the pedal, and the foot attachment from the foot.

The total of cost of parts and materials for the adaptor was approximately \$50.



Figure 6.4. Adaptor for Exercise Bicycle Pedal, Attached to Existing Pedal

DEVICE FOR STRETCHING LEG MUSCLES

Designer: Vivien T. Lau

Supervising Professors: Jiping He, Ph.D., and Brian Glaister

Ira A. Fulton School of Engineering

Harrington Department of Bioengineering

Mail Code: 9709

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INTRODUCTION

The purpose of this design project is to build an exercise device to help a client with Becker Muscular Dystrophy to stretch his leg muscles. The individual uses a motorized scooter for locomotion most of the day, and his legs receive limited exercise. The device was designed to enable him to perform leg extension while remaining seated in his motorized scooter.

SUMMARY OF IMPACT

The device (see Figure 6.5) allows the client to stretch his legs while remaining in his scooter. This is also likely to provide him some upper extremity exercise benefit as well. The simple nature of the

device allows the client to maintain independence while exercising.

TECHNICAL DESCRIPTION

The overall structure of the Leg Stretch Exercise device was made with two-by-four pieces of wood. Wood screws, bolts, and T-brackets were used for assembly. Two pulleys were attached to the arms of the device through which cords were passed. On one end of the cords, custom foot rests were attached while handles were attached to the other ends. The foot rests were made with polyester cloth and cotton.

The cost of parts/material was approximately \$200.



Figure 6.5. Device for Stretching Leg Muscles

MOBILITY AID PROTECTIVE DEVICE

*Designers: Kurt S. Allen, and Othman Mjahed
Supervising Professor: Dr. Thomas Sugar
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INTRODUCTION

The Mobility Aid Protective Device (see Figure 6.6) was designed to offer lightweight, easily-removable environmental protection for an electric mobility aid while being carried on an existing car carrier lift. The Mobility Aid Protective Device is essentially a lightweight, aluminum frame covered with a waterproof, UV- resistant material. The device mounts on an existing car carrier lift and utilizes a collapsible fabric door that is retractable by the use of a mechanical pulley system. This enables the owner to drive the mobility aid into the device and close the cover while the lift is lowered, then raise the lift. It was designed to offer environmental protection for a specific model of mobility aid and lift, but could easily be adapted to many models of mobility aids and lifts, with slight modifications from the original design.

SUMMARY OF IMPACT

The Hover Round Activa is an electrically-operated personal mobility device used by people with physical disabilities who would otherwise be using a conventional wheelchair. The owners must transport them when they drive and travel. As a result, these machines are often very susceptible to premature degradation caused by exposure to the sun and other environmental elements. These mobility aids are costly pieces of equipment, and consequently increasing the device's usable life is of great interest to those who purchase them. The Mobility Aid Protective Device provides a moderate level of environmental and travel protection while being transported or stored on the car carrier (see Figure 6.7). The final device is simple and easy to use. It is also relatively lightweight and easily removable from the lift assembly. It will extend the useful life of the scooter for its owner.

TECHNICAL DESCRIPTION

The structure of the device is made from welded 1"x 0.5"x 0.125" rectangular box aluminum type 6063. The design requires 42' of this material at a total

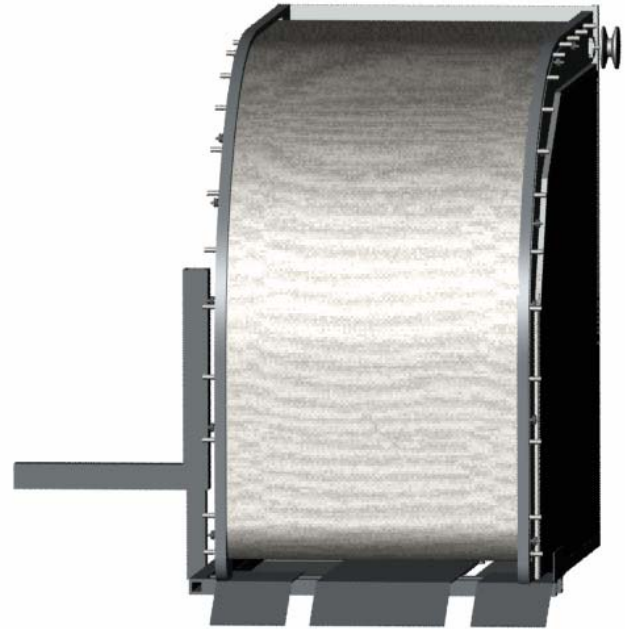


Figure 6.6. Mobility Aid Protective Device

weight of 15 lbs. Also, there is a complete floor made from 0.09" aluminum (6061) plate and welded to the lower edge of the frame. This floor has been machined to allow the design to fit directly on the existing lift. The floor is drilled to accommodate four 0.25" bolts with which to secure the device to the lift. Pre-existing holes in the lift's floor allowed the design to mount to the lift without any modifications to the lift itself.

The design has an easy and dependable way to raise and lower the cloth roll top cover. It has a cable and pulley system driven by a 12 VDC reversible motor that will operate cables on both sides of the frame in order to assure that the cover will raise and lower dependably without binding. The 12 VDC reversible gear-motor will provide up to 15 Watts of output power at 44 RPM, which gives the retractable cover a speed of approximately one foot per second. The gear-motor connects directly to the existing 12 VDC line used for the lift mechanism and is fused at 15 amps. A two-pole double throw rocker switch and

limiting switches control direction and movement of the cover. This design allows the operator to open the cover by simply throwing a switch, and close the cover by throwing the switch in the opposite direction.

The motor, which is externally mounted on this version, turns a 0.5" diameter steel shaft through means of a flexible coupling. The shaft is supported by two sealed ball bearing assemblies and has two 3" diameter drive sheaves mounted externally at each end. These sheaves motivate two 1/16" diameter stainless steel cables. The retractable fabric cover has eight 0.3" diameter plastic dowels that are sewn into the cover to provide stiffness. These dowels project out the side of the retractable cover and ride in a machined groove in the frame. The cables are guided through holes at the ends of each successive dowel. The cables are then secured only to the dowel furthest from the driven sheaves on

each side, and operate in a looped arrangement to raise and lower the flexible cover. This arrangement controls the direction of the cover's movement as well as securing the cover to the frame. The cable's tension is controlled by the use of spring-loaded tensioning pulleys. Six smaller, intermediate pulleys are located along the path of the cables and control the direction of the cables. These pulleys are also equipped with ball bearings to enhance durability.

All of the mechanical components weigh approximately six pounds. This gives a total weight of 45 pounds, including the cloth required to cover the device. At a total of 45 lbs, the mobility aid is well within the weight capacity of the mechanical lift.

The total cost of parts and materials was approximately \$550.00.



Figure 6.7. Mobility Aid Protective Device, Mounted on a Car

SENSORY BOX

Designer: Vern Wolfley

Client Coordinator: Mary Jo Oechslin, Dysart Unified School District, El Mirage, AZ

Supervising Professor: Brian Glaister

Ira A. Fulton School of Engineering, Harrington Department of Bioengineering

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INTRODUCTION

The sensory box (shown in Figure 6.8) was designed to provide sensory stimulation for children with varied neurological disorders. The sensory box is simply two boxes joined together, that allow for multiple positioning of the children as a therapist works with them. The sensory box is used to help capture the children's attention and allow them to explore different textures, sounds, and skills at random or with the therapist's direction. This device will be used in classrooms K-8 for children with various neurological disorders. The sensory box will allow therapists to customize an environment specifically tailored for the needs of each child to better help them learn and aid in development.

SUMMARY OF IMPACT

The design specifications for the sensory box were defined according to the needs of the children and the therapists. The therapists needed a device capable of being adaptable to each child. The sensory box was designed to be sturdy and safe, which allows both self-exploration and therapist-guided exploration of the different sensory devices.

TECHNICAL DESCRIPTION

The overall design includes panels to create the sides and tops of the box, which were made from HDPE, a material similar to that used in school playground equipment. This material was selected because of its structural integrity, durability, and machinability. It was available in a variety of colors that added to the

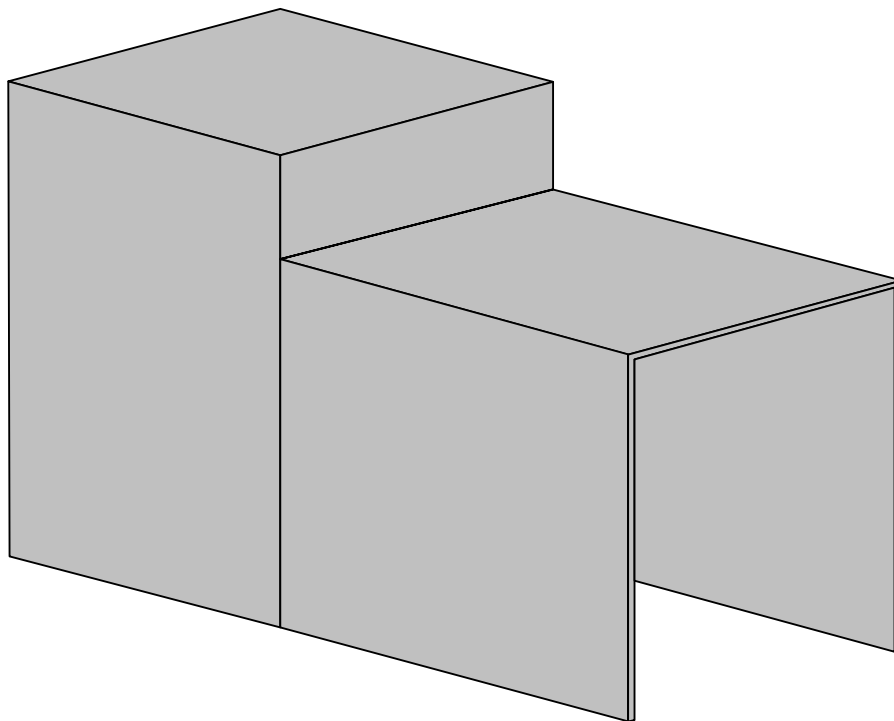


Figure 6.8. Sketch of Sensory Box

sensory appeal of the sensory box. The panels were cut using an ordinary table saw with a blade designed for cutting plastics. After the panels were cut, the sharp angles on the sides of each panel were removed with a 3/16" round over bit. This treatment was applied to every surface that was cut, to ensure that no sharp edges were exposed.

Each panel was connected to the others with 1-1/2" double wide corner braces. Cutouts for these braces were machined out using a router and a 3/4" straight bit. A cutout guide was manufactured to help in the exact placement and size of each cutout. The cutouts allowed the braces to be recessed into the material, reducing the exposure to sharp angles.

The panels and braces were all fastened together using 10-32 x 1/2" button head socket cap screws with matching nylon insert locknuts. These were again chosen to reduce exposure to any sharp angles as well as ensure that the connections stayed tight and secure. The holes for these screws were drilled out using a 13/64" bit.

With the sensory box being closely related to the design of playground equipment, ASTM standards regulating the design of playground equipment were utilized to ensure that the sensory box was designed using tested and accepted safety standards. The ASTM standard regulating the design of playground equipment is ASTM F1487-01.

The sensory box was designed so that off-the-shelf sensory items could be used. Therapists selected different toys and devices from various toy stores for their ability to provide sensory learning experiences for children. The toys were attached to the box using industrial strength Velcro. Velcro was chosen because of its versatility and because it also provided sensory stimulation when the student came in contact with it. An added bonus of using Velcro is that as toys wear out and break, the therapists can easily replace them and add new toys they feel would provide a different sensory experience.

The total cost of materials and sensory items was approximately \$950.

CLUTCH REACHING AND GRIPPING DEVICE

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Supervising Professors: Brian Glaister
Ira A. Fulton School of Engineering
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INTRODUCTION

The CLUTCH Reaching and Gripping (CRG) device (see Figure 6.9) is for an individual with muscular dystrophy. He uses a motorized scooter for mobility and needs the assistance of such a device to grasp and collect items that are out of his reach.

SUMMARY OF IMPACT

The design criteria for the CRG were based on the client's own specifications. He currently uses a similar device, which needs improvements. The individual stated that he often has pain in his forearms due to the fact that he must continually compress the trigger to keep the prongs of the current device closed. Also, he stated that the short length of the device restricted him from utilizing the device for the purpose of getting dressed. The CRG eliminates these problems by providing the client with a device that is normally closed (i.e. he only has

to squeeze the trigger to open the prongs, after which it closes automatically), and is additionally longer in length.

TECHNICAL DESCRIPTION

The CRG is made of steel machine screws, steel picture wire, acetyl copolymer and rubber bands. The gripping prongs trigger and trigger attachment pieces were all custom-machined out of a block of acetyl copolymer. An acetyl copolymer tube was also utilized in the design. Holes were cut in the tube and steel wire was passed through to either end. The wire was attached to both the trigger and the gripping prongs. Rubber bands were fitted around the prongs to keep them closed.

The cost of parts/material for the CLUTCH Reaching and Gripping prototype was approximately \$200.

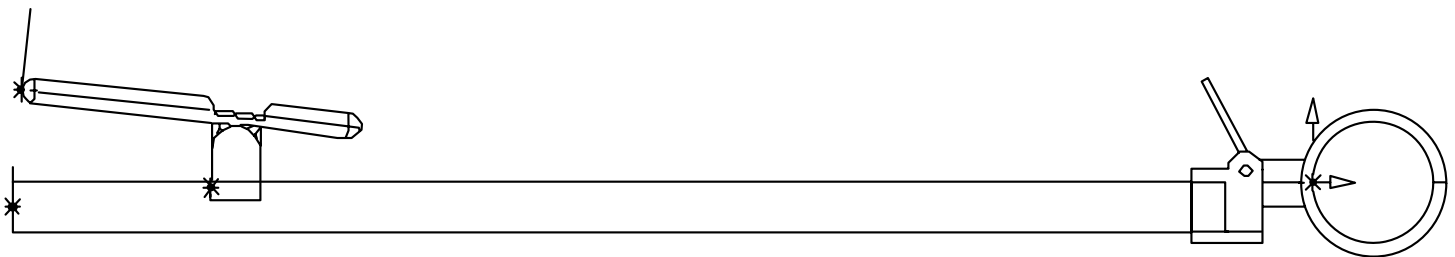


Figure 6.9. Schematic of CLUTCH Reaching and Gripping Device

CHAPTER 7

DUKE UNIVERSITY

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FOOT-OPERATED CAMERA SYSTEM

*Designers: Eric Lai, Anthony Lau, and Tom Rose
Client Coordinator: Luanne Holland, Durham County Schools
Supervising Professor: Larry Bohs
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INTRODUCTION

A wheelchair-mounted, foot-controlled camera system was developed to allow a client to take digital photos unassisted. The client was an eight-year-old boy with cerebral palsy, who had limited fine motor control in his upper extremities, but good control of his feet. The system consists of a digital camera with a panning mechanism, an external LCD display, and foot pedal controls for shutter release and panning. The completed system is removable and easy to operate, and gives the client the ability to take digital pictures independently.

SUMMARY OF IMPACT

The device will allow the client to take pictures unassisted. His mother commented that she liked "how it's got a large range of motion" and that the client "can take pictures of just about anything he wants." The system's portability will allow the client to use it in classrooms and on field trips, thereby increasing his level of interaction with classmates and family members.

TECHNICAL DESCRIPTION

The Foot-Operated Camera System (Figure 7.1) consists of a commercial digital camera (Olympus Stylus 300) with shutter remote, a 5" LCD screen, a commercial tilting mechanism with remote (Bescor MP-101), and a custom mounting apparatus for attaching the devices to the client's power wheelchair.

The camera's remote control was replaced with a large switch shaped like a dog's paw (Radio Shack), which was attached to the left footrest of the client's wheelchair with Velcro. The camera's 1.5" LCD screen was too small for the client to use effectively, so a 5" LCD screen and associated battery compartment were attached in easy view, using a gooseneck attachment clip from a microphone boom stand.



Figure 7.1. Foot-Operated Camera System, with Camera and Screen Rotated Out

The camera was attached to the top of the tilting mechanism, which was attached to a custom mounting arm using a tripod mount. The tilting mechanism allowed the camera to rotate $\pm 90^\circ$ horizontally and $\pm 15^\circ$ vertically, and its remote control was attached to the right footrest using Velcro.

A mounting arm was constructed from $5/8$ " diameter copper tubing, painted black. A custom clamp was machined to connect one end of the copper tubing to the horizontal side bar of the

wheelchair. This clamp functioned like a sandwich, with two recessed openings for clamping the wheelchair side bar and the copper tubing together. A hole was drilled through the clamp and copper tubing, through which a quick release pin was inserted, to secure the support structure while allowing for easy removal. After testing, a series of holes were drilled in the copper tubing to allow the camera and LCD to be placed farther from the client as he grows.

Removing the system from the wheelchair involves removing the spring pin from the mounting clamp, sliding the mounting arm from the clamp, and removing the foot controls from their Velcro pads. The client's parents can mount or remove the system in less than two minutes. Figure 7.2 shows the client using the device.

Cost of parts for the Foot-Operated Camera System was approximately \$700.



Figure 7.2. Client Using Foot Operated Camera, with LCD Screen Rotated 180 degrees

RECREATIONAL SWING AID

*Designers: Mike Holliday, Eric Lai, and Mike Scott
Supervising Professor: Larry Bohs
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INTRODUCTION

The client, a seven-year-old boy with TAR syndrome, lacks radius bones and, therefore, has short arms and weak hands, which limit his reach and strength. The client had difficulty participating with his peers and siblings in many of his favorite recreational activities, including the use of a playground swing. The goal of this project was to create a device that allowed the client to swing independently and reach greater heights than before. A swing aid was designed with front and back safety pads, a durable nylon safety strap, easy-grip handles attached to the swing chain, and a clip used by the client to secure or remove the front safety pad.

SUMMARY OF IMPACT

The client has quickly become comfortable with the Recreational Swing Aid, and now can go “super high” without parental assistance. The swing aid will provide him with greater independence and confidence at home and school by allowing him to participate with his peers in this common recreational activity. The client’s mother commented that the “swing has enabled him to enjoy going outside again with the rest of the family. It is great to see him wanting to do things most ‘normal’ kids do, and enjoying the fun of childhood.”

TECHNICAL DESCRIPTION

The completed Recreational Swing Aid is shown in Figure 7.3. The primary components of the aid were constructed from a child’s water life vest. After removing the two arm flaps, the life vest was cut horizontally, forming the back safety pad from the lower two-thirds of the vest and the front safety pad from the remaining piece. 1” nylon straps were attached to the clips of the back pad with brass grommets.

Two metal clips connected a 2” nylon safety strap above the back safety pad. To prevent the strap from



Figure 7.3. Recreational Swing Aid

sliding between the client’s back and the back pad, the strap was placed through a nylon loop extending from the top of the back pad. The remaining slack of the 2” nylon loop was sewn vertically into the back pad and secured under the swing seat by a large brass grommet. This prevented the client from sliding off the swing in the open area between the back pad and the seat.

On each swing chain, a 1” nylon strap extended through a plastic fastener and looped through a rubber bicycle grip. This allowed the client to easily and securely lean forward and backward in the natural swinging motion.

Two ¾” nylon straps were sewn into the front pad and fixed to the left swing chain at two separate plastic fasteners. At the opposite side of the front pad, these straps were sewn together and ended at one piece of a clip, which is used by the client to securely attach the front pad between the swing chains. A plastic fastener rigidly connected the alternate end of this clip to the swing chain so that the client could use both hands to direct the

alternate free end of the clip into the locked position. Figure 7.4 shows the client using the device.

The cost of parts for the recreational swing aid was \$75, not including the original swing seat and chains.



Figure 7.4. Client Using Recreational Swing Aid

OVEN HELPER

Designers: Roni Prucz, Justin Brower, and William Hong
Client Coordinator: Annette Lauber, North Carolina Assistive Technology Project
Supervising Professor: Larry Bohs
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INTRODUCTION

The Oven Helper was designed for a client who loves to cook, but has difficulty using large baking and casserole dishes due to her cerebral palsy and use of a wheelchair. The device assists her with the lifting and lowering of heavy pans into and out of an oven. The device utilizes a gas spring mechanism to help her move pans between the stovetop and middle oven rack. Pans are vertically displaced through single-hand pushing or pulling actions. The device is mobile, easy to operate, and suitable for use by individuals with back pain or who use wheelchairs.

SUMMARY OF IMPACT

Providing the client with this device allows her to cook items previously not possible. Besides enhancing self-reliance, the device allows the client to cook larger portions of food for storing or serving to guests, and increases the diversity of dishes that can be made, such as large casseroles. The client commented, "The oven helper can help me in so many ways in the kitchen. It feels as though it was made to be there. I could not be happier with the result."

TECHNICAL DESCRIPTION

The Oven Helper (Figure 7.5) was built by modifying a commercial height-adjustable rolling table. The L-shaped frame was modified to obtain the desired minimum level of 22" and the maximum height of 36," which corresponded to the client's middle oven rack and stovetop respectively. After substantial research, a gas spring was chosen as the lifting mechanism. Testing revealed that commercial springs did not possess the proper extension and force, so a custom spring was ordered from Easy Lift Springs (Melbourne, FL), with a stroke of 15," a compressed length of 18," and a 21.5 lb force at full extension. This spring also featured a locking system controlled by a Bowden wire.



Figure 7.5. Oven Helper

The spring was mounted inside the square telescoping tubing of the original rolling table, which required careful modification to allow the spring to recess into the tabletop and the release head to sit below the frame of the device. A small notch was also cut in the frame to accommodate the Bowden wire.

When the prototype was tested with the client, several problems became apparent. At full extension, the inner and outer telescoping shafts overlapped by only 1." The weight of the table thus caused the inner shaft to sag toward the cantilevered end of the table, and the client could not lower the device due to the resulting friction between the telescoping shafts. Additionally, the client could not comfortably reach the top of the table. These problems were resolved by attaching two linear drawer glides, one inside and one outside the shaft.

Custom clamps secured the external linear glide to the shaft. A padded handle was mounted below the tabletop, with the spring release lever attached for easy operation by the client.

To hold the Oven Helper in place while in use, a soft rubber keyboard wrist pad was affixed horizontally to the lower frame, which provided substantial friction against the opened oven door. Raised lips

were added to two sides of the tabletop to prevent dishes from sliding off of the device.

Figure 7.6 and Figure 7.7 show the client using the device.

Cost of parts for the Oven Helper was approximately \$550.



Figure 7.6. Client using Oven Helper to Remove Item from Oven



Figure 7.7. Client Using Oven Helper to Put Item on Stovetop

PENCIL DISPENSER AND COUNTER

Designers: Leahthan Domeshek, Kelly Fong, and Evan Harrell

Client Coordinator: Judy Stroupe, Orange Enterprises

Supervising Professor: Larry Bohs

Department of Biomedical Engineering

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INTRODUCTION

The Pencil Dispenser and Counter helps workers at a vocational rehabilitation facility count a specific number of pencils. The device is first loaded with pencils and set to a specific goal count by a supervisor. Once the set-up is complete, the worker pulls a lever to dispense and count one pencil, which falls into a bottom hopper with a folding wall. Each time the worker pulls the lever, another pencil is dispensed and the count is incremented on a large digital display. An audible signal sounds when the worker reaches the goal count. The device is inexpensive, portable, easy to operate and suitable for use by individuals who lack fine motor control.

SUMMARY OF IMPACT

In the past, employees had difficulty handling and counting pencils. An assistant oversaw and helped with pencil sorting at all times. The Pencil Dispenser and Counter will help make employees more independent and efficient in this task, while still allowing them to be an important part of the process. A supervisor commented, "The employees used to count eight to ten pencils in an hour and then need a break, now they can count that many in five minutes."

TECHNICAL DESCRIPTION

The Pencil Dispenser and Counter (Figure 7.8) uses a rotating cylinder with a slot big enough to hold one pencil. When the user pulls a lever, the cylinder rotates and the pencil falls into a bottom hopper. A torsion spring helps return the lever and cylinder to the loading position. A stopper, padded for protection and shock absorption, stops the lever in the correct position to allow another pencil to fall into the slot in the cylinder. The cylinder shaft is supported on flange bearings to make it durable and easy to rotate. The pencil container is V-shaped and holds at least 150 pencils in a compact space while also allowing easy loading of the cylinder.

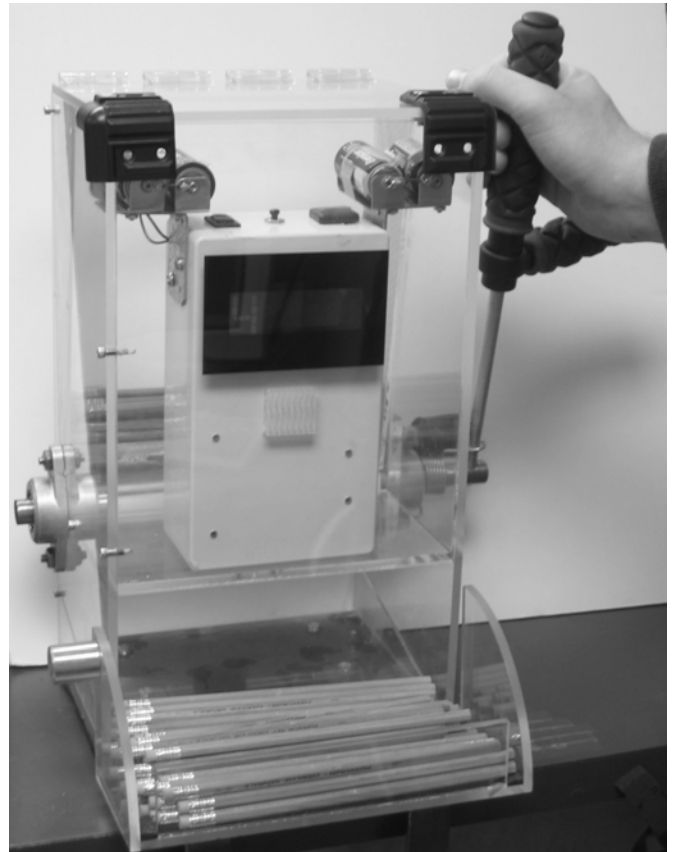


Figure 7.8. Pencil Dispenser and Counter

The count is actuated using a momentary toggle switch, which resides in a circumferential groove in the cylinder. The switch is activated when a pencil rotates past the switch as the lever is pulled down. The switch is connected to a BASIC Stamp II microprocessor, which tallies the count and controls the system. An up/down rocker switch sets the goal count from 0-100 in increments of five, and a buzzer beeps four times once the goal count is reached. An LCD with large character display and a continuous backlight shows the number of pencils dispensed. Four C batteries power the device for over 100 hours, and are easily replaced.

The pencils fall out of the cylinder into a bottom hopper, which has a slanted floor so the pencils roll down to the front of the device. The flap of the hopper is mounted to the main frame of the device using a hinge, and the flap can be folded for storage. Quarter-circle walls attached to the sides of the bottom flap prevent pencils from spilling out during retrieval. Two integral clamps and rubber padding stabilize the device to a work table. Figure 7.9 shows the device in use.

The device was evaluated to assess durability, ease of use, effectiveness, and safety. Durability was

assessed throughout the design stages of the device and was the main reason for using the clamps, rubber bottom, and bearings. Jamming was minimized to below one percent in a 500-pencil trial. After testing the device with employees, we determined that they could operate the lever and unload the pencils from the bottom hopper.

Cost of parts for the Pencil Dispenser and Counter was approximately \$400.



Figure 7.9. Employee Using Pencil Counter

MODIFIED ELECTRIC SCOOTER

Designers: Kevin Ko, Aya Eguchi, and Eric Schwartz

Client Coordinator: Jodi Petry, Lenox Baker Hospital

Supervising Professor: Larry Bohs

Department of Biomedical Engineering

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INTRODUCTION

A Schwinn S180 electric scooter was modified for safe and comfortable use by an 11-year-old boy with right-side hemiplegia. The modifications aid with balance, steering, and comfort, as well as limiting the maximum speed. As a result, the client can safely and comfortably ride the scooter, which he was unable to do previously.

SUMMARY OF IMPACT

The modified scooter allows the client to use his electric scooter comfortably, independently, and safely. He can now ride with family and friends during trips to the beach, thereby fostering self-confidence. In a letter, the client said, "Thank you very much for all the hard work you all did on my scooter. I will be able to ride with my brothers and sister and not be left sitting out watching them have all the fun. I won't have to work as hard as them! I'll be the coolest kid in the neighborhood with the coolest ride! Thank you."

TECHNICAL DESCRIPTION

The modified scooter (Figure 7.10) includes: 1) a foot guard to prevent the right foot from falling off the scooter; 2) modified handlebars to facilitate left-handed control; 3) a stabilizing mechanism for help with balance; 4) a modified seat and right arm support to maintain the client's posture while riding; and 5) a speed governor to maintain a safe operating speed.

The foot guard was made from aluminum sheet metal, which was molded to the contour of the floorboard's right, outer edge. The metal wraps around the underside of the floorboard and is attached by four countersunk 3/16" flat headed bolts. The top edge of the foot guard extends 1.5" from the bottom edge, which is sufficient to block a foot from sliding off that side of the scooter.



Figure 7.10. Modified Scooter

The handlebars were modified to reside closer to the client's body and facilitate steering with the left hand. Two sections of aluminum tubing, 8" long, were attached to provide an L-shaped extension to the original bar. The throttle and hand brake were attached to this extension, bringing the scooter controls 8" closer to the user's body.

A robust pair of training wheels (Fat wheels, Mechanical Innovations, Inc, Charlotte, NC) was attached to aid the client's balance. One-inch axle extenders were added to properly attach the Fat wheels. During testing of this mechanism, excessive stress on the training wheels caused the mounting bracket to bend. Therefore, an additional triangular plate was welded to the bracket, and a larger-diameter axle extender was created and attached.

Because the client found it difficult to maintain his posture with the original seat, an 18" high-back seat (Freedom Concepts, Inc., Winnipeg, MB), which included side-supports, was purchased and mounted. A custom armrest was fabricated from a sheet of aluminum, slightly curved to an arm's contour, lined with an adhesive foam and Poly-Fil,

and covered with black vinyl. The armrest was supported by two aluminum shafts, one attached to the backrest, and one attached to the bottom of the seat. A ball was attached to the end of the armrest to provide a gripping surface for the right hand.

A mechanical speed governor was implemented to limit the maximum speed of the scooter, which was initially too high for use. Three holes were drilled in the throttle mechanism to accept setscrews, such that three different maximum speeds could be

selected. In this way, the client's parents can gradually increase the maximum speed of the scooter as the client becomes more skilled and comfortable. Figure 7.11 shows the client using the scooter.

Cost of parts for the scooter modifications was approximately \$500.



Figure 7.11. Client Using Modified Scooter

ALL TERRAIN WALKER

Designers: Dan Choi, Stephanie Chi, and Fong Ming Hooi
Client Coordinator: Barbara Howard, Duke University Hospital
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
Duke University,
Durham, NC 27708

INTRODUCTION

The All Terrain Walker was developed to help the client, a 12-year-old girl with cerebral palsy, travel more efficiently on rough surfaces. An Otto Bock Busy Bee frame was modified by adding large front wheels, swivel rear wheels with shock absorption, an additional frame member for stability, and padded handlebar grips. These modifications yield a responsive and stable all-terrain walker that allows the user to travel on rough surfaces such as trails and grass, as well as on pavement and other smooth surfaces.

SUMMARY OF IMPACT

The All Terrain Walker will enable the client to participate in more outdoor activities with her family. Her mother commented that, "Mobility devices for [the client] equal freedom; freedom to get where she wants, when she wants, at a relatively normal rate of speed (or better!). This 'all-terrain walker' will expand the geography of her world, since we otherwise could not go to the places it will get her to. I think the whole process of building it for her, with her input, also offered her more evidence that she has value as a human being. Otherwise, why would everyone bother?"

TECHNICAL DESCRIPTION

The All Terrain Walker (Figure 7.12) was created by modifying a commercial walker frame (Busy Bee; Otto Bock, Minneapolis, MN). The modifications included large front wheels to allow the client to negotiate rocks, roots, and other bumps, swivel rear wheels, frame stabilization, and padded handlebar grips.

The front swivel wheels of the Busy Bee were removed. 20" alloy wheels (Baby Jogger, Richmond, VA) were mounted to the front of the frame by welding on steel cylinders that accepted the quick release axles of the commercial wheels. The



Figure 7.12. All Terrain Walker

cylinders were welded at the proper height to keep the frame level with these large wheels.

The fixed rear wheels of the original frame were replaced with two shock-absorbing swivel wheels (Frog Legs, Inc., Vinton, IA). The swivel wheels were attached using standard caster housings built for wheelchairs, which were bolted to a steel plate welded to the legs of the walker frame. The walker frame was shortened in this area to account for the larger size of the Frog Legs casters compared to the original wheels.

The walker frame was stabilized by adding a 3/4" steel tube, bent to allow more rear clearance for the client's feet. It was welded to the walker frame at the bottom of the rear legs. The grips on the handrails of the original frame were replaced with tennis grip tape, which the client found more comfortable.

The client tested the All Terrain Walker on rough grass and found the walker to be easier to roll on such surfaces. One disadvantage is that the large

front wheels also made it somewhat more difficult to control speed when going down a steep paved hill. Because the walker is designed for off-road travel, it will require supervision until the user learns how to control its response. Figure 7.13 shows the client using the walker.

Cost of parts for the All Terrain Walker was approximately \$470.



Figure 7.13. Client Using All Terrain Walker

ROTATIONAL WORKSTATION

*Designers: Dan Southam, Brian Goldberg, and Mike Scott
Client Coordinator: Barbara Howard, Duke University Hospital
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
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INTRODUCTION

A six-year-old client previously had difficulty completing his homework and working on the computer without adult assistance because he was born with TAR syndrome, a condition resulting in short arms and weakened hands. A custom computer workstation was built that allows him to work independently at his desk. The design consists of a rotating surface that provides easy access to a magnetic writing stand and a wireless keyboard, both with adjustable incline. The client presses and releases a foot pedal to lock the rotating surface in the desired position, while a commercial desk chair with a back pad provides appropriate support. Using this device, the client can complete his work and operate the computer independently and comfortably.

SUMMARY OF IMPACT

The Rotational Workstation (see Figure 7.14) will enable the client to complete his homework, paint or draw pictures, and use a computer without adult assistance. The client's mother commented, "He loves it! He is using it to make all kinds of stuff, and feels so important having his own desk. There is nothing on the desk he can't operate, and it works very well."

TECHNICAL DESCRIPTION

The Rotational Workstation includes a rotating surface, adjustable writing stand, wireless keyboard, an adjustable-height desk, and a desk chair.

The rotating surface was made from a circular piece of $\frac{3}{4}$ " pine, 2' in diameter, to which a commercial Lazy Susan bearing was attached. A series of holes were drilled near the outer edge of one sector of the desk to accommodate the client's pens, pencils, and markers.

A commercial adjustable easel was attached to the rotating surface, and a clipboard attached to the



Figure 7.14. Rotational Workstation

easel. A magnetic writing surface was glued to the clipboard, and a foam-padded lever was built to make the clip easy for the client to use. Magnets with small handles and a check memo rail were provided so that the client could secure his writing paper to the clipboard using the clip on the top and magnets on the sides, thus allowing him to draw and erase without tearing the paper.

The rotating surface was attached via the Lazy Susan bearing to a commercial adjustable-height desk. Thick foam weather-stripping was secured to the edge of the desk to improve the client's comfort as he leaned over to use the writing stand or keyboard. A commercial desk chair with low ground-to-seat height was found appropriate for the client, after adding a back pad and extra foam cushioning at the rear of the backrest to support his torso while reaching the workstation components.

Finally, a locking mechanism was implemented to prevent the Lazy Susan from rotating while one of the two stations was in use. A spring pin was positioned under the desk, and two holes drilled into the bottom surface of the Lazy Susan, according to the desired positions of the keyboard and writing

surface. The client could depress a drum pedal, connected to the pin by a bike cable, to disengage the pin while he rotated the surface to an alternate position.

Figure 7.15 shows the client using the Rotational Workstation. Cost of parts for the device was approximately \$550.



Figure 7.15. Client Using Workstation

PAPER MANAGEMENT SYSTEM

Designers: Clayton Eiswirth, Megan Hanson, and Sean Huffman

Client Coordinator: Judy Stroupe, Orange Enterprises

Supervising Professors: Richard Goldberg, Kevin Caves

Department of Biomedical Engineering

Duke University,

Durham, NC 27708

INTRODUCTION

The client is a middle-aged man with cerebral palsy. His place of employment is an organization that employs adults with disabilities, helps them develop job skills, and works at placing them in jobs within the community. The client and his employer requested a device that would help the client collate two pieces of paper and fold them in a tri-fold, using only coarse movements with his left hand. The design included three components: a folding mechanism, a clipping mechanism, and a collating mechanism.

SUMMARY OF IMPACT

The Paper Management System allows the client and others to collate and fold up to three pieces of paper at a time, a task not previously possible. The client's supervisor commented, "He would have had so much difficulty trying to do something like this before. By just using these handles the task is greatly simplified."

TECHNICAL DESCRIPTION

The overall design (as shown in use, in Figure 7.16) incorporates three components for folding, holding, and collating the paper. The folding surface is comprised of three 1/4" polycarbonate panels that are connected by custom hinges, which attach on the bottom of the panels, creating a smooth surface. A standard tri-fold is achieved by using the two levers to first fold one panel, open it, then fold the second panel and open it. A wooden L-corner with attached rubber provides an edge for the client to

push the paper against. The holding component descends from the rear of the device to clip the paper in place while folding. A square aluminum bar is attached to a piece of steel sheet metal, the clip. The sheet metal has a 4" track cut lengthwise out of its center. The bar is fitted through the guide tracks of two sets of polycarbonate. The outer set prevents rotation with vertical guide tracks and is attached to a 10" drawer slide. The inner set is fixed in place with angled tracks bored into the sides, allowing the bar to raise and lower as the outer set is moved back and forth with an attached copper lever. This action causes the clip to slide onto the center panel of the folding component. Magnets inlaid in the polycarbonate keep the clip from moving once it reaches the folding surface. After a paper is folded, moving the lever back raises the clip, and a vertical rod pushes the folded paper from the clip.

A commercial product was used so that several sheets of paper could be collated and folded simultaneously. This collator had a right-handed lever to move a set of pages out of stationary trays. However, the client needed a left-handed lever. We fixed the lever arm in place, put the collation trays on 10" drawer slides, and added a left-handed lever arm. When the client slides this lever arm, it moves the trays along the drawer slides, and the collated sheets of paper are pushed out toward the paper-folding surface.

Cost of parts for the Paper Handling System was approximately \$330.



Figure 7.16. The Paper Management System, Shown Starting the First Fold

3-D SOUND STATION

Designers: Jonathan Weiss, George Crowell, and Mike Chu
Client Coordinator: Luanne Holland and Susan Parker, Durham Public Schools
Supervising Professors: Kevin Caves and Richard Goldberg
Department of Biomedical Engineering
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Durham, NC 27708

INTRODUCTION

The goal of the project was to provide a versatile stimulation and entertainment system, activated by switch presses. The client is a ten-year-old boy with multiple disabilities, including limited vision as well as cognitive and developmental delays. The 3-D Sound Station includes speakers, large pushbutton switches, an LED tube, music keyboard, and an MP3 player, all mounted on an adjustable stand. Several modes, selectable by the therapist, allow the station to provide different types of cognitive training and feedback for the client.

SUMMARY OF IMPACT

The client is often unable to independently participate in class activities and has had limited success with commercially available technologies. The 3-D Sound Station will aid in therapy and provide the client with entertainment. The client was intrigued by the device from the first interactions. The supervisor, who is also the client's speech-language therapist said, "The device looks great and [the client] seems to enjoy it."

TECHNICAL DESCRIPTION

The 3-D Sound Station (Figure 7.17) includes five main components: an MP3 player, speakers, user input switches, an LED tube, and a detachable musical keyboard. In addition, a teacher interface box allows the teacher to switch between different operating modes of the device. The MP3 player (Rogue Robotics, Toronto, Ontario) is controlled via RS232 serial commands from a PIC microcontroller. Because it uses an SD flash card, the audio files can easily be updated by the client's teachers, using any computer.

Four powered speakers provide audio feedback; one pair acts as the left channel, and the other pair acts as the right. The two high-contrast interactive switches (Enabling Devices, Hastings-on-Hudson, NY) provide light and vibration feedback when

pressed. The LED tube (purchased at crazypc.com) provides bright colorful light for visual feedback, as well as encouragement for the client to look up and sit up straight. The musical keyboard (purchased at Radio Shack) connects directly to the speakers via a headphone jack.

The 3-D Sound Station has six operating modes. The first three modes are programmed to teach the user cause and effect. Mode 1 outputs the same auditory reward upon activation, regardless of which switch is pressed, while Mode 2 outputs a different reward sound for the left and right switches. Mode 3 chooses a random song from Folder A when the left switch is activated, and chooses a different random song from Folder B when the right switch is activated. Currently, Folder A contains music files while Folder B contains voice clips of the client's father. However, these folders can be reprogrammed to contain any desired audio files.

Mode 4 encourages the user to follow directional auditory cues. A five-second sample of a file randomly selected from Folder A is played out of the left speakers only, and consequently, a five second sample of a file randomly selected from Folder B is played out of the right speakers only. The user is then allowed ten seconds to choose by activating the respective switch. Once selected, the file is played through all four speakers. This mode stimulates a cognitive response from the user and allows him to make decisions. Mode 5 can be programmed to allow the client to respond to simple questions. Currently, pressing the left switch produces a recorded "No," while the right switch produces "Yes".

The first five modes can be programmed via the teacher interface, which uses two six-position knobs, to determine how long the audio response will play: 5, 15, 30, and 60 seconds, momentary, or full-length. In all six modes, the LED tube lights during the audio response.

In Mode 6, the switches are deactivated and a musical keyboard, which has been placed on the tabletop by a teacher, is powered on. The keyboard sounds play through the four speakers of the device.

The components are mounted on a sturdy music stand, to which a sheet of polycarbonate is attached. The music stand allows for adjustment in both height and tilt angle. A wooden disk, attached to

the bottom of the stand, provides good stability. A PIC16F876 controls the system and power is supplied by a 16V, 500 mA wall transformer.

Cost of parts for the 3-D Sound Station was approximately \$520.

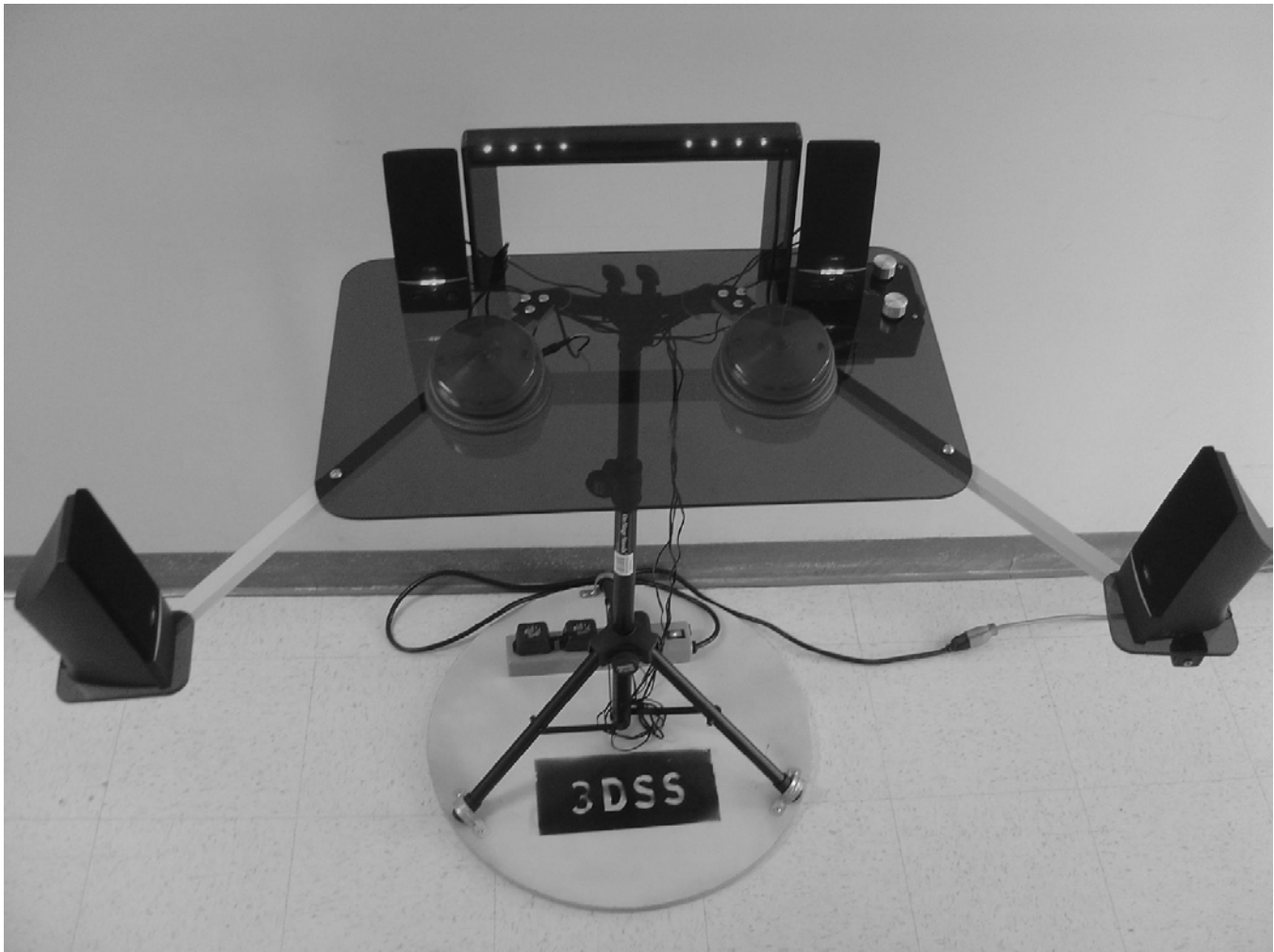


Figure 7.17. 3-D Sound Station

READER'S ASSISTIVE DEVICE

Designers: Tina Chang, Xander Chen, and Michele Nguyen
Client Coordinator: Leslie Lerea, Director, UNC SPIRE program
Supervising Professors: Richard Goldberg, Kevin Caves
Department of Biomedical Engineering
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INTRODUCTION

The client is a post-doctoral researcher with Friedrich's Ataxia. She has a tendency to skip lines when she reads and has difficulty turning pages. The goal of this project was to assist her in making reading more comfortable. This goal was achieved by constructing a device with an adjustable bookstand, an electronic masking device, and a manual page turner. The device shows only three lines of text while blocking out the rest, helping the client focus on what she is reading. It also makes turning pages less strenuous. Overall, this novel device gives the client the ability to read more quickly and comfortably.

SUMMARY OF IMPACT

The Reader's Assistive Device allows the client to read more comfortably and efficiently, enhancing the progress of her research and allowing her to teach a class with less assistance. The client was excited that she could easily control the up and down movements of the masking device simply by pushing or pulling the joystick.

TECHNICAL DESCRIPTION

The Reader's Assistive Device (Figure 7.18) includes a bookstand, masking device, and page turner. The bookstand was built from 1/2" thick oak, with rubber grips added to the base. It provides easy angle adjustment and folds for storage. An accessory LED light provides even illumination of the text with no glare.

The masking device uses a clear Lexan sheet, which lays over the page to weigh down the paper and acts as the support and foundation for the mask. The slotted mask was fashioned from black Lexan, with vertical movement regulated by metal guides attached to the edges of the clear sheet. A DC gear motor with rack and pinion mechanism moves the mask vertically, controlled by a two-way joystick.



Figure 7.18. Reader's Assistive Device.

Six D-type batteries power the 9V motor. The masking device is attached to the bookstand using a drawer slide, which enables the masking device to be moved laterally to cover both pages.

The manual page turner consists of a spring with a sponge end, mounted to the masking device. The spring is covered with black Tygon tubing for safety and aesthetics. Post-it adhesive is applied onto the sponge using the roller applicator, enabling about 30 successful cycles of turning per application. To turn a page, the client presses down on the page turner spring, then grips the double handlebar and slides the masking device laterally. At the end of the lateral movement, the pressure on the spring is released and the page flips over. Terminal rollers at the ends of the bookstand ensure that the masking device does not slide off the bookstand, and facilitate sliding back in the other direction. Figure 7.19 shows the client using the Reader's Assistive Device.

Cost of parts was approximately \$330.



Figure 7.19. Client Using Device

ASSISTIVE FOOT CARE DEVICE

*Designers: Avery Capone, Shaun Noonan, and Connie Siang
Client Coordinator: Annette Lauber, NC Assistive Technology Project
Supervising Professors: Kevin Caves, Richard Goldberg
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INTRODUCTION

A foot care device was designed and constructed for a middle-aged woman with cerebral palsy, who had difficulty bending over and reaching to cut her toenails. She had previously used a conventional toenail clipper, which had often taken her up to 20 minutes per foot. The constructed device allows her to clip her toenails while sitting comfortably in her wheelchair, significantly reducing the time and energy that it takes her to perform the task.

SUMMARY OF IMPACT

The Assistive Foot Care Device will improve the client's ability to trim her toenails quickly and effectively. According to the client, "You have no idea what an improvement this is over the past."

TECHNICAL DESCRIPTION

The Assistive Foot Care Device (Figure 7.20) is modeled after commercial reaching devices, which provide a grasping mechanism at the end of a rod, controlled by a trigger grip. The device consists of five main components: the trigger/handle, chassis, force transmission system, vision enhancement mechanism, and trimmer.

A handle with a plastic handgrip was removed from a commercial hand-held reacher (Featherlight). The plastic trigger lever was replaced with a custom aluminum lever for stability and strength. The handle and trigger were dipped in Plasti-Dip to create a softer finish. The chassis was constructed from aluminum u-bar, chosen for its durability and light weight. The u-bar allowed a protective housing for the internal components of the device while allowing easy accessibility.

The chassis provides a 134-degree angle, selected as optimal for the client while seated in her wheelchair, which was created by making angled cuts in the u-bar and fixing them with aluminum binding posts. The upper part of the chassis was dipped in Plasti-



Figure 7.20. Assistive Foot Care Device

Dip, while the lower half of the chassis was coated in heat-shrink wrap to enclose the force transmission system. The force transmission system used high-strength kite string, which was attached to a hole in the trigger at one end, run down the chassis through a retaining eyebolt, and to a hole in the clipper lever at the other end.

To improve precision, a small magnifying sheet was mounted to the chassis with alligator clips attached together by pliant wire, so that it is adjustable. The alligator clips allow the magnifying sheet to be removed if the client so chooses. The trimmer uses high-quality large commercial clippers (Brookstone), with a hole drilled for the string. A steel L-bracket mounts the trimmer to the chassis.

In evaluations, the client estimated that this device will reduce the amount of time that it previously took her to perform foot care maintenance by 80% and that the device will reduce the amount of exertion required to trim her toenails by 90%. Figure 7.21 shows the client with the Assistive Foot Care Device.

Cost of parts was approximately \$100.



Figure 7.21. Client Using Assistive Footcare Device

ACCESSIBLE BALL MAZE

Designers: Twinkle Gupta, Julianna Swanson, and Amanda Zimmerman

Client Coordinator: Beth Leiro, Physical Therapist

Supervising Professors: Richard Goldberg, Kevin Caves

Department of Biomedical Engineering

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INTRODUCTION

The client, a two-year-old with arthrogryposis, has multiple joint limitations and uses a wheelchair for mobility. To enhance his interaction with peers and increase his opportunity to engage in outdoor activities, his caregivers sought to create a new playground activity at his school. The goal was to design a wheelchair-accessible outdoor ball maze that allows the client to maneuver the entry of the balls and to play simultaneously with his peers outdoors.

SUMMARY OF IMPACT

The client, his peers, and the staff at the preschool were immediately captivated by the ball maze. One teacher commented, "It's great that the pattern isn't the same every time, that the pattern is not predictable. It keeps the kids entertained for a while." On its first day in use, the ball maze increased the client's outdoor interaction with his peers, with up to five children playing at once. The client's physical therapist stated, "It's important for [the client] to be able to have appropriate activities on the playground that have appeal to both him and his classmates."

TECHNICAL DESCRIPTION

The Accessible Ball Maze (Fig 7.22) uses golf balls enclosed in a clear housing. Three focal areas of the design include the entry mechanism, the internal components of the maze, and the exit mechanism.

Because of the client's limited range of motion and strength, the device was designed so that caregivers can load a large hopper in the top of the device with golf balls. Fifty colored golf balls were provided for

use with the device. The client or his classmates can release one ball at a time by pulling on a rope. This lowers a long lever with a spring-loaded hinge to guide a ball into the maze. Sometimes the golf balls can get jammed in this hopper. To break this jam, they can pull on a "jiggler," an "L"-shaped wooden rod that was added to one end at the top of the maze. To make the jiggler and rope accessible to the client and other individuals with fine motor impairments, the rope has knots tied in the end and the jiggler rod has multiple drilled holes, in which to grab or stick a finger. Also, the jiggler was purposefully long to minimize the force required for operation.

Once released, a ball travels through the maze along ramps, a double staircase, spiral staircase, ringing pipes, and other components. These components were chosen to provide a fun auditory and visual experience. The ball travels randomly down one of two separate paths through the maze. At the bottom of the maze, the ball lands on an inclined piece of sheet metal and rolls to a locked collection bin in the bottom corner. The bin is an easily removable drawer that the caregiver can unlock to move the balls back to the top of the maze. Holes in the bottom of the bin allow for water drainage.

The maze is permanently installed in the playground of an early intervention center, where the client attends pre-school. It is located under a pavilion for protection from the weather. The frame of the maze is made of pressure treated wood and the sides are made from Plexiglas.

Cost of parts for the Accessible Ball Maze was approximately \$440.



Figure 7.22. Accessible Ball Maze.

MODIFIED SCOOTER

Designers: Jeremy Kim, Miao Wang and Charles Tao
Client Coordinator: Lisa Mangino, Physical Therapist
Supervising Professors: Kevin Caves, and Richard Goldberg
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INTRODUCTION

The client is an active seven-year-old boy with TAR syndrome, which causes very short arms, and reduced dexterity in his legs. His peers enjoy using scooters to ride around his neighborhood, an activity that requires balancing on one foot while propelling with the other. Because of his disability, the client cannot use a commercial scooter. A commercial scooter was modified by adding forward outriggers, a side platform and wheel, a braking mechanism, handle bar extensions and pads, and a vertically adjustable seat. The client can use the scooter on his neighborhood streets, allowing him to participate with his siblings and peers.

SUMMARY OF IMPACT

The modified scooter gives the client another means of riding a self-propelled device outdoors. The client's mother commented that the scooter "has really increased his inclusion in family activities outside. He always had to be put in a wagon, or helped greatly if we were going to walk around the block. Now, with his scooter, he can completely independently go around the block and require no assistance from the rest of the family. It gives him a great sense of pride to keep up with his siblings as we walk or ride bikes and scooters around the block."

TECHNICAL DESCRIPTION

The Modified Scooter (Figure 7.23) was constructed from a Razor brand scooter. Modifications included forward outriggers, a seat, a foot platform with side wheel, a steering mechanism, and brakes.

The outrigger frame was made from three pieces of 1" square, 1/8" thick aluminum tubing. The wheels, made from commercial casters, were bolted to this frame. To reduce rolling resistance, the plastic

wheels that were originally mounted on the casters were replaced with low-friction skateboard wheels.

The seat mount was created by bolting the handlebar mount of a spare Razor scooter to the rear of the modified scooter frame. A standard bicycle seat and seat post were secured in the handlebar mount shaft.

The quick release mechanism of the handlebar mount allows for simple and quick adjustments of the seat height.

To provide more surface for the client's feet on the scooter, a platform was shaped from a 24-inch square piece of 1/8" thick aluminum sheet, and bolted to the scooter's frame. A rollerblade wheel was attached to the rear side of the plate, and a guard was attached to the top of the plate to prevent the client's foot from contacting the wheel.

The steering mechanism of the original scooter was modified using two pairs of mountain bike handlebar extensions on each side. Each pair of extensions was first linked together in an "L" shape, and then attached to each end of the original handlebars. Cushioned pads were constructed from rounded wooden blocks covered with soft sponge, and bolted into the extensions.

A braking mechanism was created from a bicycle U-brake system, attached to the rear scooter wheel. The rubber brake pads were replaced with metal pads, to give a smoother braking operation. The hand lever from the bike brake was cut short and mounted on the scooter body, just in front of the foot platform, for accessibility with the right foot. A bicycle brake cable was connected between the lever and the U-brake at the rear wheel.

Cost of parts for the Modified Scooter was approximately \$400.



Figure 7.23. Client with Modified Scooter



CHAPTER 8
MICHIGAN TECHNOLOGICAL
UNIVERSITY

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ACCESSIBILITY SYSTEM FOR A SCHOOL STAGE

Designers: Melissa Collins, Jason Prudom, Amanda Smith, and Jessica VanRiper
Client Coordinator: Norman McKindles, North Central Area High School, Powers, Michigan
Supervising Professor: David A. Nelson, Ph.D.
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INTRODUCTION

A student with cerebral palsy who uses a wheelchair is unable to access the stage in her high school. This limits her ability to participate in band, graduation and other stage activities. It is estimated that the student will use the stage no more than ten times per year. The stage does not meet the regulations of the American with Disabilities Act (ADA) which requires that public buildings have handicapped access to all areas of the building. The stairways to the stage are also less than the ADA minimum width of 36 inches.

The school needs a means to allow the student, and those with similar disabilities, to gain access to the stage. One possibility is to use an existing door to the rear of the stage, which opens to the school's parking lot. This was as unacceptable option, as it would require the student to go outside during inclement or cold weather. Existing products that could meet this need include: 1) a ramp; 2) a portable lift that can be stored when not in use; or 3) a permanent lift that would attach to the stairway railing. A ramp is not practical, as it would require a run in excess of 30 feet, and require at least one landing, to meet ADA requirements. Portable lifts cost \$8,000 to \$20,000, exceeding the school's budget. Purchasing a permanent lift would require substantial building modifications for ADA compliant installation. Building alterations could be done by volunteers, but the cost of purchasing the lift is prohibitive.

The problem was solved using a van lift which was donated for this project, shown in Fig. 8.1. The lift will be installed in a stairwell that separates the stage from a storage room. This will require significant, but not extensive, modifications to the storage room and stairwell. These modifications will preserve existing stairways and exit doors and ensure the school will be in compliance with local fire codes. This solution was chosen because of its



Figure 8.1. Modified Van Lift with Box Containing Hydraulic Motor and Battery

low cost and its minimal impact on the appearance and continued use of the stage.

SUMMARY OF IMPACT

The lift will provide accessibility to the raised stage for all individuals and will make the school compliant with current ADA regulations. The student will now be able to access the stage and participate in the band with her fellow classmates. Traditionally, the band has always played on the stage for athletic events, but the band relocated to the bleachers to allow this student to participate. The graduation ceremony has also always been held on the stage. By having access to the stage, this

student will be able to participate equally in school traditions and will no longer be the reason for changes to these traditions.

TECHNICAL DESCRIPTION

A van lift was modified and designed to be in a stairwell between the gym and the stage. The lift folds downward into the stairwell and lowers a platform to the ground level. The student drives her wheelchair onto the platform, which lifts her to the stage. As the lift platform is too small to allow a wheelchair to turn, it was necessary to locate the lift such that she exits the platform on the side opposite the entrance. To install the lift, the stage area will need to be remodeled. A doorway will be cut into the wall that separates the storage room from the stairwell. This route will allow easy access to the lift, hide the lift to maintain the gym and stage appearance, and provide an emergency exit route for the student via the exit doors outside of the storage room. All modifications to the stage and building for this design will be performed by volunteers to minimize the budget impact on the school. The cost for these building renovations was estimated to be \$12,000 to \$15,000.

Modifications were also required for the lift. A hydraulic pump and motor were donated by Blizzard Corporation (Calumet, MI) to power the lift. A 12V car battery is used to power the motor. The use of a DC power system eliminates the need to provide an AC power connection for the lift,

which minimizes building modification costs. The original lift had a hydraulic cylinder capable of lifting the platform 33 inches, but this application required a vertical rise of 36 inches. To obtain the maximum vertical travel possible for the lift, a hydraulic cylinder was purchased with a 36 inches stroke length. To install the longer cylinder, the crossbar of the lift was raised to allow for full extension and head clearance for the student when the lift is in the raised position. The lift is capable of 36 inches of vertical travel, but the stage is 38 inches from the ground level. To solve this problem, the lift will sit two inches deep into the stage and a two-foot long ADA compliant ramp will be built, as shown in Fig. 8.2.

A pulley system connects the hydraulic piston and lift platform. A new roller chain and connection system for the pulleys was also installed. To make maintenance easier, a removable side panel was added and a storage box was created to hold the battery, pump and motor. The lift was made more aesthetically-pleasing by using black paint and Michigan Tech graphics.

The approximate cost for this project is \$985 (\$560 for materials and \$425 for labor). The van lift (value undetermined) and the hydraulic motor and pump (approximately \$1000) were donated by Blizzard Corporation.

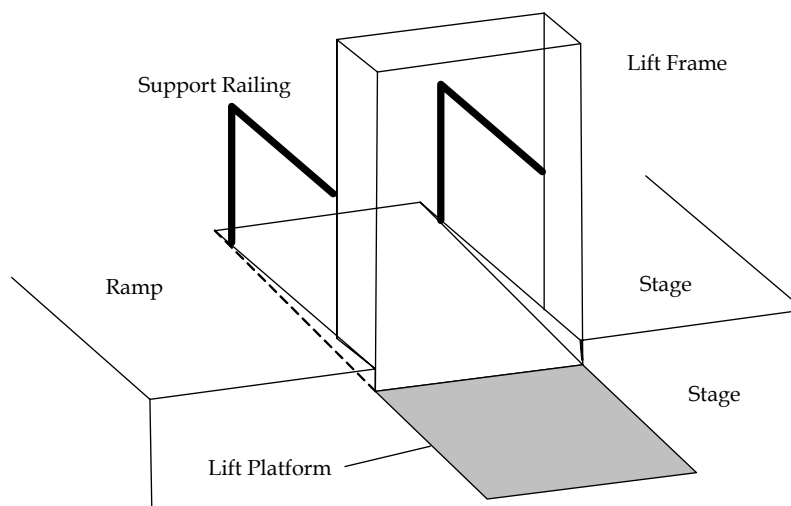


Figure 8.2. Schematic Showing Lift Frame in Extended Position, Installed into Stage.

LIFT AND TRANSPORT SYSTEM

Designers: Alisha Brinkman, Meghan McGee, and Joshua Stegmeyer
Client Coordinator: Sara Menzel, UP AT Center, Marquette, Michigan
Supervising Professor: Debra D. Charlesworth, Ph.D.
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INTRODUCTION

People who rely on assistive devices such as canes, walkers, and wheelchairs often experience difficulty moving objects around their home. Physical therapists and home visitors have noted that elderly clients, in particular, are unable to move and empty a bedside commode bucket unassisted. This results in an unhygienic home environment and a loss of independence. The client requested a device capable of allowing people with ambulatory impairments to move objects, weighing up to 20 pounds, around the home unassisted. The team was unable to find any device on the market that directly met all of the client's needs.

After meeting with the client and conducting preliminary research, the team decided that the most versatile device would be one that is free standing and self powered. The team decided to include a remote control mechanism to allow for the widest range of users, including people in wheelchairs. The device that was developed, shown in Figure 8.3, has a lifting mechanism that moves from the ground to countertop height, and a remote-controlled base that allows the user to drive the device around the house.

SUMMARY OF IMPACT

The inability of a person to move everyday objects around the home represents a significant loss of independence. The client was required to ask for assistance for tasks such as carrying groceries into the house, doing laundry, or emptying the bedside commode buckets. When that assistance was not available, these tasks were either left undone or were performed inadequately. Home health professionals visiting the client would often find delivered groceries spoiling in the doorway, laundry piling out of its hamper, and trails of waste between the bedside commode and the bathroom from when the patients attempted to empty the buckets



Figure 8.3. Final Lift and Transport System

themselves. Using this device will allow people with mobility impairments to function independently in their homes.

TECHNICAL DESCRIPTION

From discussions with the client, it was determined that the device must: 1) adequately perform its function; 2) be statically stable when fully loaded; 3) be maneuverable in small spaces; 4) be easy to operate; and 5) be non-threatening in appearance.

For stability, the device was designed with a steel two-foot by two-foot base and a lighter aluminum lifting frame that reaches 42 inches in height. This height was chosen based on the dimensions of standard kitchen countertops. The electronic components for the base were purchased from

suppliers that traditionally sell parts for remote control vehicles. The majority of these were purchased from Tower Hobbies. The base had four rubber tires, each 3.5 inches in diameter. An electric motor (Monster Maxx PRO 19 turn Motor) was attached to a drive train that spun the rear wheels while an electric servo (Hitec HS-5945MG Coreless High Torque 2BB MG Servo) was used to control the front two wheels. Both the motor and servo were controlled by a standard remote-control vehicle transmitter and receiver set (Futaba 2DR 2-Channel AM transmitter and receiver). The remote control has one stick to control the forward velocity of the device, and one to control the steering of the front wheels. The motor and servo are powered by a 7.2 volt, 3000mAh nickel metal hydride battery.

The lift mechanism consists of a ball screw assembly that angles backward so that the load is situated over the wheel base when fully lifted. Attached to the ball screw assembly is an aluminum scoop with a beveled edge that rode via linear bearings on two precision ground steel rods running parallel to the screw. The ball screw is turned by an electric motor of the same make as the drive motor. The lift motor is controlled by a large toggle switch that is attached to the back of the device and powered by the same type of battery as mentioned above. The batteries and control circuit are wired through a switch and battery charger so that the device can be plugged into any 110-volt power source to recharge. A schematic of this circuit can be seen in Figure 8.4. A painted polycarbonate shell was placed around the

device to hide the electronics inside, and provide an appealing appearance.

To evaluate the effectiveness of the device in meeting the design objectives, the team developed a series of tests. First, the device was loaded to the maximum amount, dictated by the parameters of the project, and the force needed to cause the rear wheels to leave the ground was measured. A small obstacle course was built to simulate a “worst case scenario” in which the device would be used. This course included a right-angle corner, a half-inch threshold, a wheel-chair ramp following ADA specifications, and a transition from linoleum floor to carpet. Lastly, senior citizen volunteers operated the device and were asked to complete a questionnaire concerning its ease of control and its appearance.

The device passed every test. The input from the senior citizen volunteers was positive. Two areas of suggested improvement were noted: the first was that the lift mechanism was noisy, and the second was that the device appeared too large. The complaint of noise from the users arises from excessive vibrations in the lifting assembly during use. A larger ball screw or a dampening box around the metal gears may lessen the noise. To make the device appear smaller, the lifting frame could be modified to taper at the top.

The total cost of materials placed directly in the device was approximately \$1790.

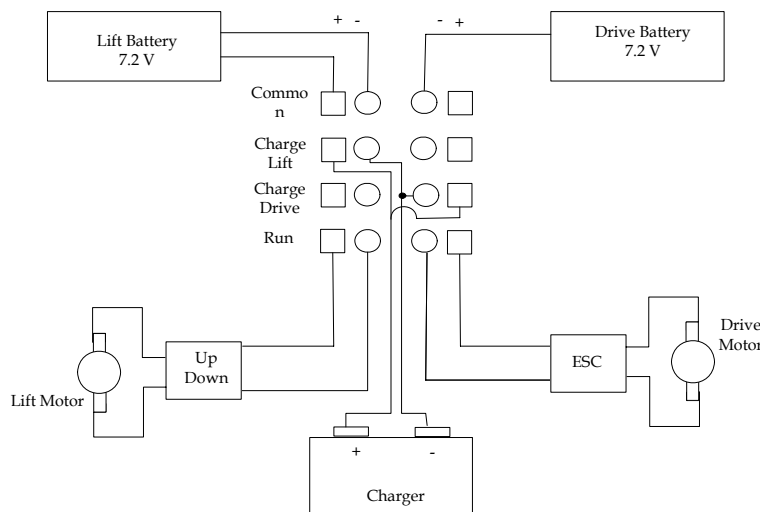


Figure 8.4. A Circuit Schematic of the Device's Charging and Power Wiring

MILK CARTON OPENER

Designers: Justinian Broughton, and Kristen Karnowski
Client Coordinator: Sara Menzel, UP AT Center, Marquette, Michigan
Supervising Professors: Debra D. Charlesworth, Ph.D., and David A. Nelson, Ph.D.
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INTRODUCTION

Elderly people and people with disabilities often have meals delivered to their homes. During home visits, it became apparent that some people do not consume the milk that is delivered with the meals because they are unable to open the cardboard milk container. The milk carton opener was designed to assist in opening single-portion cardboard cartons. The client for whom this device was designed specified several design constraints for the device. These included that the final product could be easily manufactured at a low cost, and be easily cleaned. The top view of the milk carton opener is illustrated in Fig. 8.5. This view shows the two projections that puncture the milk carton as well as the opening where the milk drains.

SUMMARY OF IMPACT

The milk carton opener will allow people with limited mobility and dexterity to maintain their independence. This device will stop unnecessary waste of milk and allow an important part of a healthy diet to be reinstated.

TECHNICAL DESCRIPTION

A three-dimensional model of the device was created using solid modeling software (Ideas Version 10). The three-dimensional model was then used to create a plaster prototype of the device. The prototype lacked the durability of a production unit, but was useful for testing. The prototype maker first lays down very thin sheets of plaster. Then, a printer head goes over the plaster and lays glue over the solid areas of the device on that plane. This process of laying down layers of plaster and then gluing is repeated until the prototype is complete. When the prototype is complete, the plaster milk carton opener is sifted out of the loose plaster. The plaster device was coated with an epoxy to strengthen the walls and increase the durability for testing. The device is a single piece that could be molded easily out of plastic. This will reduce the

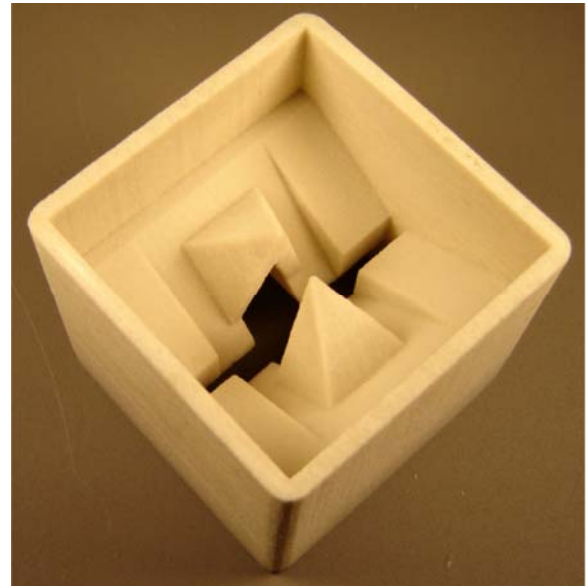


Figure 8.5. Top View of Finished Milk Carton Opener

manufacturing costs of the device and, additionally, will make it easier to clean and maintain.

To use the device, the milk carton is inserted upside-down into the top of the device. The milk carton will be punctured by the two pyramid-shaped projections at the base of the rib found on cardboard cartons. As pressure is applied to the top of the milk carton the projections will open up the milk carton allowing the milk to flow out into a cup below the device as the milk carton is pulled back. The final wall thickness was .125 inches. A cut-away view of the three dimensional model can be seen in Figure 8.6. This figure highlights the internal design and the lip designed to connect to the adjoining cup.

A cup was designed to snap onto the bottom of the opener to provide a sturdy base and allow a seal to be created so that no milk will spill. The device could also be used with the milk carton placed upright and the opener pushed down on top of it.

The milk could then be poured into any ordinary container. As the milk carton is pushed into the opener, the walls of the carton expand slightly. The dimensions of the device were chosen to allow for expansion of the milk carton while it is being compressed.

During meetings with healthcare professionals, it was determined that the people who would be using this device can generate at least ten pounds of force with their hands. To determine the force necessary to puncture a milk carton using the device, the

device was placed on a load cell. A milk carton was filled with sand to simulate the milk, and the carton was inserted into the device. A computer data acquisition system collected the force placed on the device as a function of time. The average maximum force was 13 pounds, which is higher than the design objective. The roughness of the plaster may contribute to this force, and it could be lowered by using a smoother material.

The cost of this device is approximately \$50.

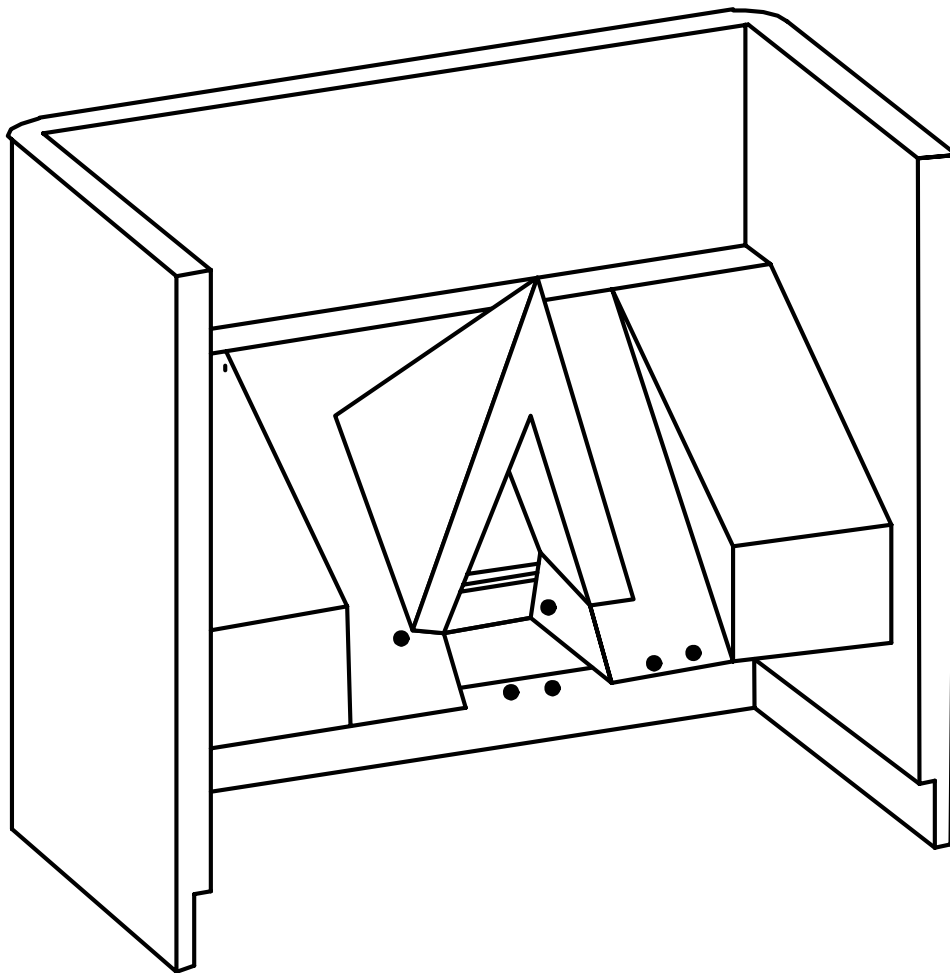


Figure 8.6. Cut-Away Line Drawing of Interior of the Milk Carton Opener

TOOTHBRUSH ASSIST DEVICE

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INTRODUCTION

People with limited or no mobility in their wrists or hands have difficulty maintaining proper oral hygiene. Current assist devices allow an individual to hold the toothbrush, but still require rotation of the toothbrush to clean all surfaces of the teeth. Since these individuals are not able to rotate their hands or wrists, this requires an assistant to turn the toothbrush. The prototype has bristles on all sides of the brush, as shown in Figure 8.7.

SUMMARY OF IMPACT

This device will allow individuals with limited mobility the ability to brush their teeth without assistance. This will improve their oral hygiene, level of independence, and quality of life. In addition to impacting the user, the device will also affect the individual's assistant by allowing him to perform other tasks during this time.

TECHNICAL DESCRIPTION

During initial conversations with the client, two design constraints were identified. First, the device must be able to clean all tooth surfaces. Secondly, the device must interface with existing assistive technology to grip a toothbrush. Due to these constraints, it was decided early in the design phase to maintain the toothbrush handle and only modify

the head. Two designs were considered. The first would resemble an oversized pipe cleaner, with bristles oriented 360° around a central shaft. The second design would utilize four toothbrush heads each at a 90° angle to each other. For each of these designs, it is vital that the characteristics of commercial toothbrush bristles be maintained. Bristles are produced so that they optimally clean tooth surfaces and do not damage the enamel. Both of these designs were approved by the clients, as they met their design constraints.

A supplier for toothbrush bristles could not be found, therefore the second design was chosen. The heads of three toothbrushes were removed from their handles, and they were glued to the head of a fourth toothbrush with an adhesive suitable for plastics. Since this created a wide toothbrush, a prototype was also created with child sized toothbrush heads. A concern with this design is damage to the soft tissue on the inside of the cheek. To ensure that this damage is not detrimental to oral hygiene, future work will examine the effects of brushing on oral soft tissues.

The cost of this device is approximately \$15.



Figure 8.7. Photograph of Two Modified Toothbrush Prototypes (Adult-Sized Toothbrush Heads on Left, Child-Sized Heads on Right)



CHAPTER 9

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INTRODUCTION

A digital communications assistant device (shown in Figure 9.1) helps people with speech disabilities communicate with others. The device that was designed is a second-generation of the project, and aims to overcome deficiencies of the first version. The device is required to be portable, programmable, easy to use, reasonably priced, reliable, versatile in its recording ability, and easy to understand. The interface consists of eight interchangeable cards that will each contain eight pictures. Each picture represents a phrase that the device will play when that picture is touched. In most cases, the phrases are arranged by context. For example, cards are organized for home, work and mealtimes. This system allows for versatility while also keeping the interface simple.

While there are commercially-available products that offer similar functions, they are typically expensive, difficult to operate, and not easily portable. This device overcomes these issues and offers significant advantages over existing products.

SUMMARY OF IMPACT

The digital communications assistant can help a user compensate for communication difficulties. The new design keeps the small size and portability of the original device. The dimensions are approximately 7" x 4" x 1¾," about the size of an engineering calculator. The device is powered by a regular 9V battery for portable use, or it can be plugged in during those times when portability is not required. The simple interface requires very little from the user, so clients with a broad range of abilities are able to operate the device. The device is also easy to program and needs no additional equipment to do so. This allows for the device to be easily customized for any client or situation. The

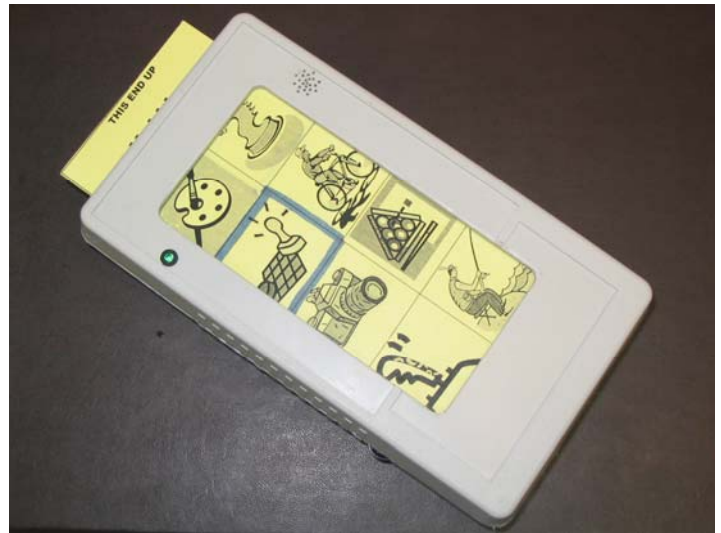


Figure 9.1. Portable Digital Communications Assistant

completed device, shown in Fig. 9.1, is currently in use.

TECHNICAL DESCRIPTION

The digital communications assistant is composed of four primary blocks: 1) a card detector; 2) a user interface; 3) a controller; and 4) a record and playback unit.

At any given time, the Portable Digital Communications Assistant stores up to eight phrases for up to eight cards, for a total of 64 phrases. To distinguish which card is present in the device, the user must press a button designated on the card. The device uses an optical switch to determine when a card is inserted into the device. Once this happens, the device waits for the user to press a button on the card indicating which card is present. This is similar to popular commercial reading toys for children.

Once the card is inserted, the user selects a phrase by touching one of the eight pictures displayed. The touch is registered by a sensor matrix created on a printed circuit board. When contact is made, one of two four-button touch-sensing chips produced by QProx (QT60040) interprets the signal. The QT60040 digital outputs are then inverted and encoded by an eight-to-three line priority encoder before being sent to the microcontroller.

The microcontroller interprets the input from the encoder, and determines which button is being pressed. It then initiates either a play or record operation. The specific operation is set by a toggle switch on the left side of the device. For the “play” and “record” operations, the microcontroller controls the memory locations that are used. This is necessary because the audio is divided into two-second chunks, which allow for dynamic memory allocation during both recording and playback. The device can have at most 64 messages and record up to eight and a half minutes total. The memory needed for these operations are stored in the microcontroller’s EEPROM.

Recording and playback are achieved using the Winbond Electronics ISD5116, a specialized audio storage chip. The audio is stored at a sampling rate of eight kilohertz, the maximum available on the chip. The input to the audio chip is a biased electret microphone circuit that uses a noise-canceling

microphone, which helps eliminate some of the background noise. The audio output is fed through an LM 386 differential audio amplifier prior to being routed to an eight-ohm speaker. Volume control is achieved by adding a 50 kilo-ohm variable resistor thumbwheel between the two inputs of the amplifier. The operation of the ISD5116 is controlled via the I2C interface on the microcontroller.

A 9-volt source powers the device. This can be either a 9-volt battery or 9-volt wall transformer that plugs into a port on the side of the device. When the device is not in use, it can be powered off using the switch on the right side of the device. A reset switch is located inside the battery compartment, which allows the user to erase all messages from the memory and reset the device in the case of a malfunction.

The device can be produced for around \$130 per unit for a small run, a price significantly lower than similar commercially-available devices.

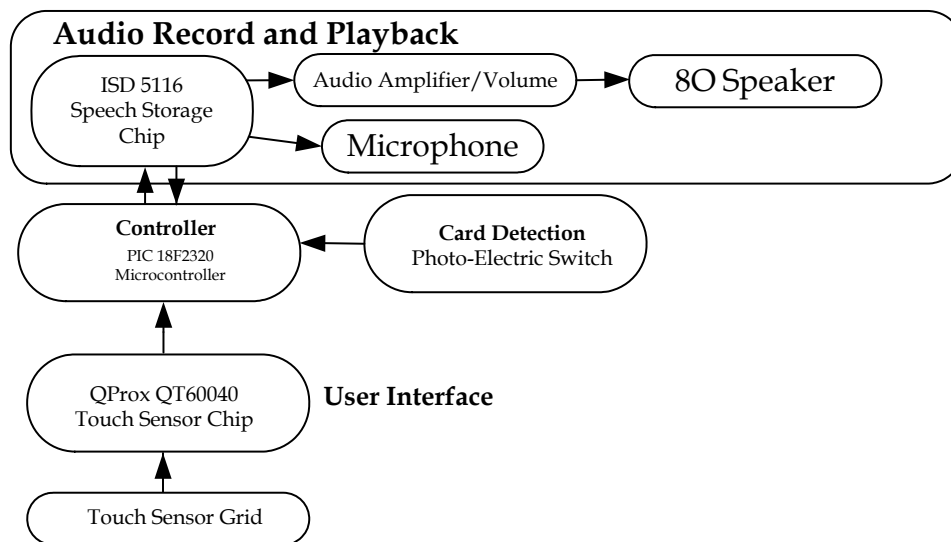


Figure 9.2. System Block Diagram

The heart of the conversational speech assistant is the SOLA algorithm. Figure 9.4 depicts the algorithm graphically. The SOLA algorithm segments the input signal into overlapping frames of 30ms length, the start of the n^{th} frame being positioned at $10n$ milliseconds from the start. The time-scaled output is created by overlapping these successive input frames with the start of the n^{th} frame now positioned at $(20n + K)$ milliseconds, where K is a deviation allowance ensuring that successive frames overlap in a synchronous manner. The value K is determined for each frame using a correlation function that compares the overlapping segments and finds the overlapping position where the waveforms are most similar. The overlapping waveforms are weighted linearly before recombination so that the n^{th} waveform's amplitude goes from 100% to 0% while the $(n+1)^{\text{th}}$ waveform's amplitude goes from 0% to 100%. Dissimilarities in overlapping frames are characterized by soft clicking or popping sounds in the output. The completed product is shown in Figure 9.5.

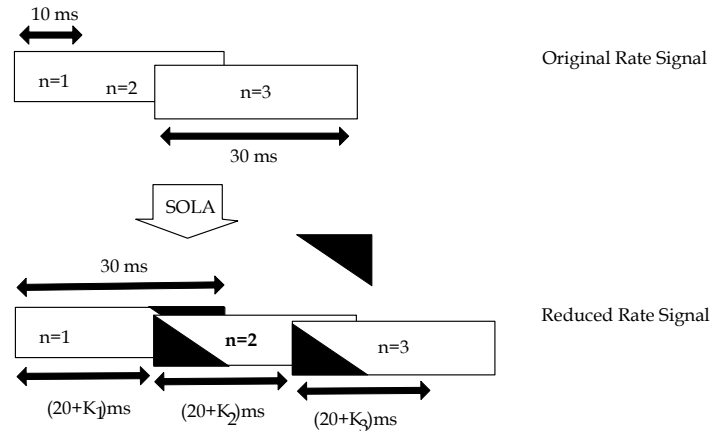


Figure 9.4. Graphical Depiction of the SOLA Algorithm

The cost of design and construction of the Conversational Speech Assistant is approximately \$500. This cost can be drastically reduced if large-scale production is employed.



Figure 9.5. Conversational Speech Assistant

THERAPEUTIC HEATING ZONE SYSTEM

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Supervising Professors: Dr. V.V.B. Rao, and Dr. Roger Green
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INTRODUCTION

The therapeutic heating zone system is intended to provide targeted heat therapy for individuals with rheumatoid arthritis or other chronic aches and pains. The system is designed to fit into a wheelchair and is comprised of six heat zones, each independently controlled by the user. The system is designed to be: easy to use, small, operable on standard AC wall voltages, and machine-washable. It also includes independent zone controls.

The completed system, shown in Figure 9.6, contains four heat zones in the wheelchair pad and is capable of powering two auxiliary zones for external use. The system includes a simple remote control, which displays the current state of the zones and allows the user to change the heat applied to each zone. Bar graph displays are used to show the amount of heat applied to each zone. Pushbuttons are used to increase or decrease the heat applied to each zone. This approach maximizes simplicity and limits the range of motion needed to operate the device. The system also utilizes a number of Velcro straps to ensure a secure attachment to the wheelchair. This guarantees that the system remains in place and can continue to offer targeted heat therapy even if the individual is moving in the chair.

SUMMARY OF IMPACT

This system aids in the relief of chronic pains associated with rheumatoid arthritis or other similar conditions. This relief provides the user with a more comfortable environment when participating in normal daily activities. The system targets the afflicted areas to ease the pain experienced by the client.

TECHNICAL DESCRIPTION

The system block diagram is shown in Figure 9.7. As the figure shows, the system is comprised of four primary units, including: 1) power source, 2) user interface, 3) control, and 4) heating zones.



Figure 9.6. Assembled Therapeutic Zone System

The power source for the system is a standard AC wall outlet.

The user interface utilizes a bar of eight LEDs and two pushbuttons for each zone. The bar of LEDs displays the current level of heat applied to the zone. One pushbutton is used to increase the temperature, while the other pushbutton is used to decrease the temperature. There are a total of six LED bars and 12 pushbuttons on the user interface.

The control unit contains a microcontroller and supporting circuitry. This unit accepts input from the pushbuttons on the user interface and provides the output to the LEDs on the user interface. The

control unit also has six outputs to the power unit to control the power to the heating zones. The microcontroller controls the amount of power applied to the heating zones through a method known as burst mode. Also known as proportional control, "burst mode" allows single cycles of AC to pass either completely or not at all. Thus, for 50% burst mode, half of the cycles are let through and half are not. Using this method, the microcontroller can efficiently scale the output power of each zone independently from 100% down to 0%. By using burst mode to scale power, the system retains nearly 99% efficiency in the power control process. Also, the microcontroller is synchronized with the 60 Hertz AC line voltage in order to switch the line voltage at the zero crossing points and thus avoid unwanted switching characteristics.

The power unit is responsible for regulating and rectifying the AC input voltage to provide DC power to the control unit and user interface. The power unit executes the actual switching of the AC

voltage as determined by the control unit. This switching effectively controls the output from each of the heating zones. Six modified AC waveforms are produced in the power unit and are sent out to the six heating zones.

Figure 9.6 shows the user interface and the heating zone system. The small plastic enclosure houses the user interface and the control unit. The large fabric enclosure houses four of the six heating units. The other two heating zones are provided as auxiliary zones to be used with external heating pads. The power unit is located behind the fabric enclosure. All connections from the power unit to the heating zones are made through standard wall outlet connectors. This allows for any commercially available heating pad to be used for auxiliary zones.

The development cost of the therapeutic heating zone system was approximately \$750. The cost would be less if it were produced in mass quantities.

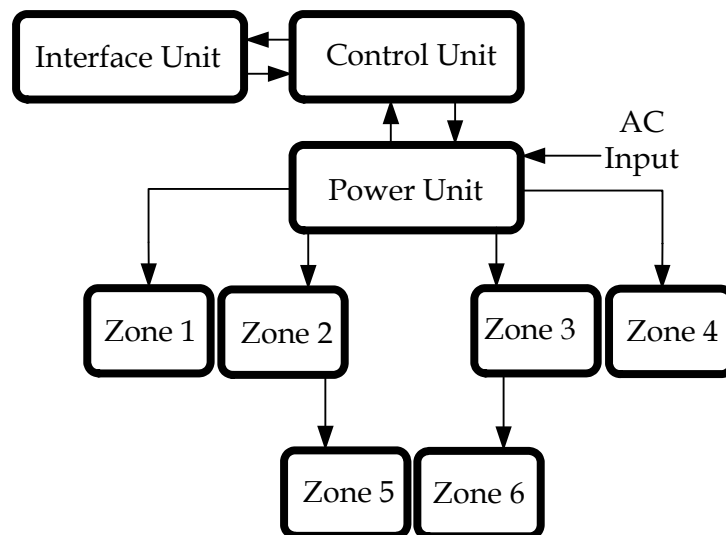


Figure 9.7. Block diagram

REMOTE DOOR ALARM

*Designers: Jon Hanson, and Adrian Freidel
Client Coordinator: David Hoverson, SVEE Home
Supervising Professor: Dr. Roger Green
Department of Electrical and Computer Engineering
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INTRODUCTION

Some individuals in a home for adults with developmental disabilities are on restricted diets, such that it is necessary for the staff to monitor what they eat. The staff members requested an alarm system to alert them when someone opens the pantry door. They wanted this alarm system to be discrete so that only the staff would be aware of the alarm. To fulfill this need, an alarm system was designed and built consisting of two units: a door-mounted sensor and a pager that alerts staff when the door is opened. Both completed units are shown in Figure 9.8.

SUMMARY OF IMPACT

Since staff members are immediately aware of pantry access, they can address any problems of inappropriate access. This obviates the need for a more intrusive access control method, such as keeping the pantry under lock and key at all times.

TECHNICAL DESCRIPTION

For the pager to respond to the sensor, a signal must be transmitted between the units. This transmission is achieved with a Chipcon CC1010 RF transceiver/microprocessor on each unit, as shown in Figure 9.9. The small footprint of this chip (64 pin quad flat pack) necessitated that the printed circuit board (PCB) be professionally manufactured.

The pager and sensor have similar hardware requirements. Therefore, a single PCB design was used for both units. A header on the PCB allows access to the serial programming interface (SPI) as well as power, ground, reset, and one 8-bit microprocessor port. The PCB also has a flexible printed circuit (FPC) connector in order to attach a liquid crystal display (LCD) to the pager. The sensor unit has a magnetic switch that is triggered by a magnet on the door. Other features, such as the LCD circuitry, remain unpopulated on the sensor unit PCB.



Figure 9.8. Completed Pager and Door Sensor

The pager features a vibrating motor in addition to the LCD display. An Optrex C-51496 LCD was chosen because it has a controller chip embedded in the LCD's packaging, enabling the LCD to be very compact. This LCD also contains internal voltage boosting circuitry, which allows the pager to operate exclusively on +3VDC.

The system's software is designed with system expansion in mind. If the SVEE Home should wish to monitor additional doors in the future, those doors could be monitored with the original pager. Rather than using an addressing scheme that maps a door's unique address to a text string, each sensor directly transmits the message that is displayed on the LCD. With this design strategy, adding another door to be monitored is accomplished simply by programming each new sensor with a unique message.

Since both of the units are designed with portability in mind, battery life is another concern. To maximize battery life, the design includes some important power-saving strategies. First, the sensor remains in shutdown mode while the door in question is

closed. This allows it to consume virtually no power for the majority of the time. When the door is opened, it transmits its alarm message a series of times and shuts down once again.

The pager also has a power-saving strategy, slightly different from the sensor. The pager's microprocessor periodically wakes up from sleep mode, checks for an incoming RF signal, and returns to sleep mode if there is no signal present. Since the pager is turned on for long periods of time, this method decreases power consumption without affecting the reliability of the system. If there is an incoming signal when the pager checks, it writes the received message to the LCD and pulses a vibrator motor three times to notify the staff. The LCD

displays the message for approximately 20 seconds and then powers off. Additionally, once the pager receives the sensor's message, it responds by sending the same message back to the sensor. When the sensor receives this confirmation signal, it immediately stops transmitting and shuts down.

The majority of costs involved in the project are due to the professionally manufactured revisions of the PCB. The costs of individual capacitors, resistors, etc., are comparatively insignificant.

The project cost was approximately \$600. Units could be produced for a much lower cost (approximately \$25 per unit) in volume.

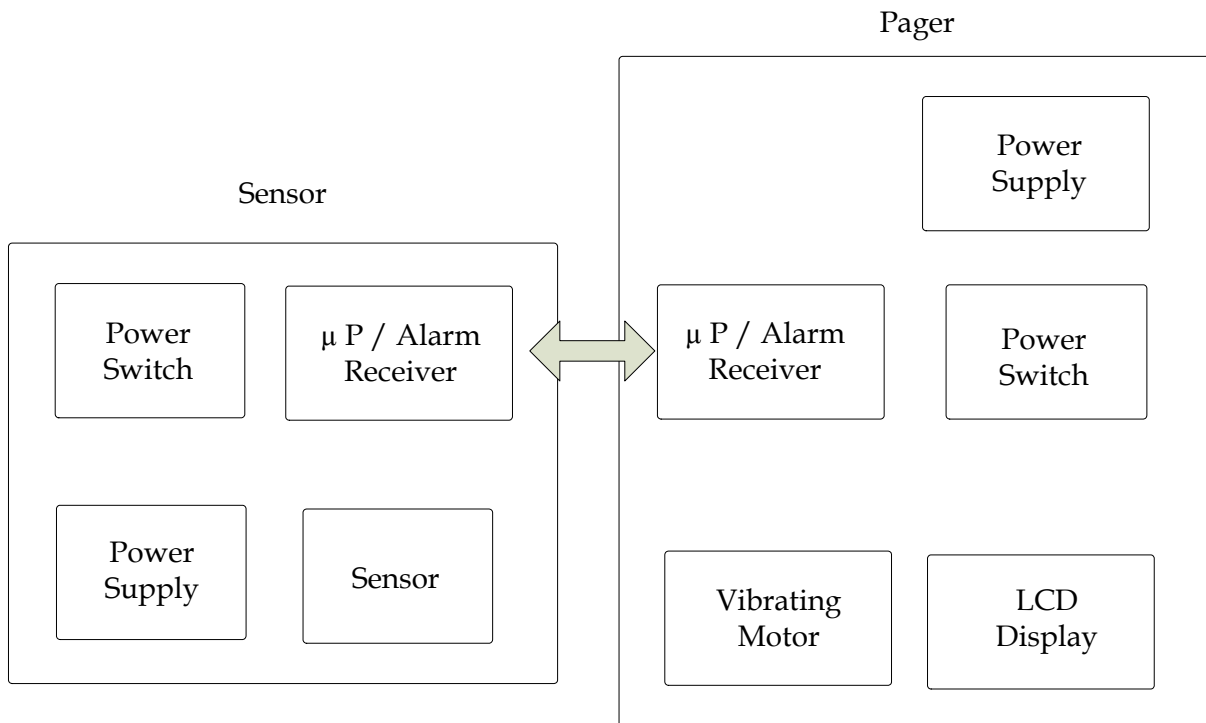


Figure 9.9. Block Diagram of System

NURSE ALERT SYSTEM

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INTRODUCTION

The nurse alert system is a nighttime incontinence monitor. The objective of this project was to develop a moisture detection system to indicate to caregivers if it is necessary to wake the user and change his or her bedding. Prior to the nurse alert system, the user was awoken by the caregiver several times during the night to determine if care was needed. This device is designed to allow the user a restful night while still being monitored.

There are several similar commercially-developed

products on the market. The main difference is that these devices are designed to aid children in potty training. When moisture is detected, an audible alarm is activated to wake the user. The nurse alert system is designed to be unobtrusive to the user while alerting the caregiver.

SUMMARY OF IMPACT

By being able to detect when care is needed, the user may sleep more during the night and receive care as needed. This system also gives the caregiver more flexibility to carry out his or her nightly tasks and

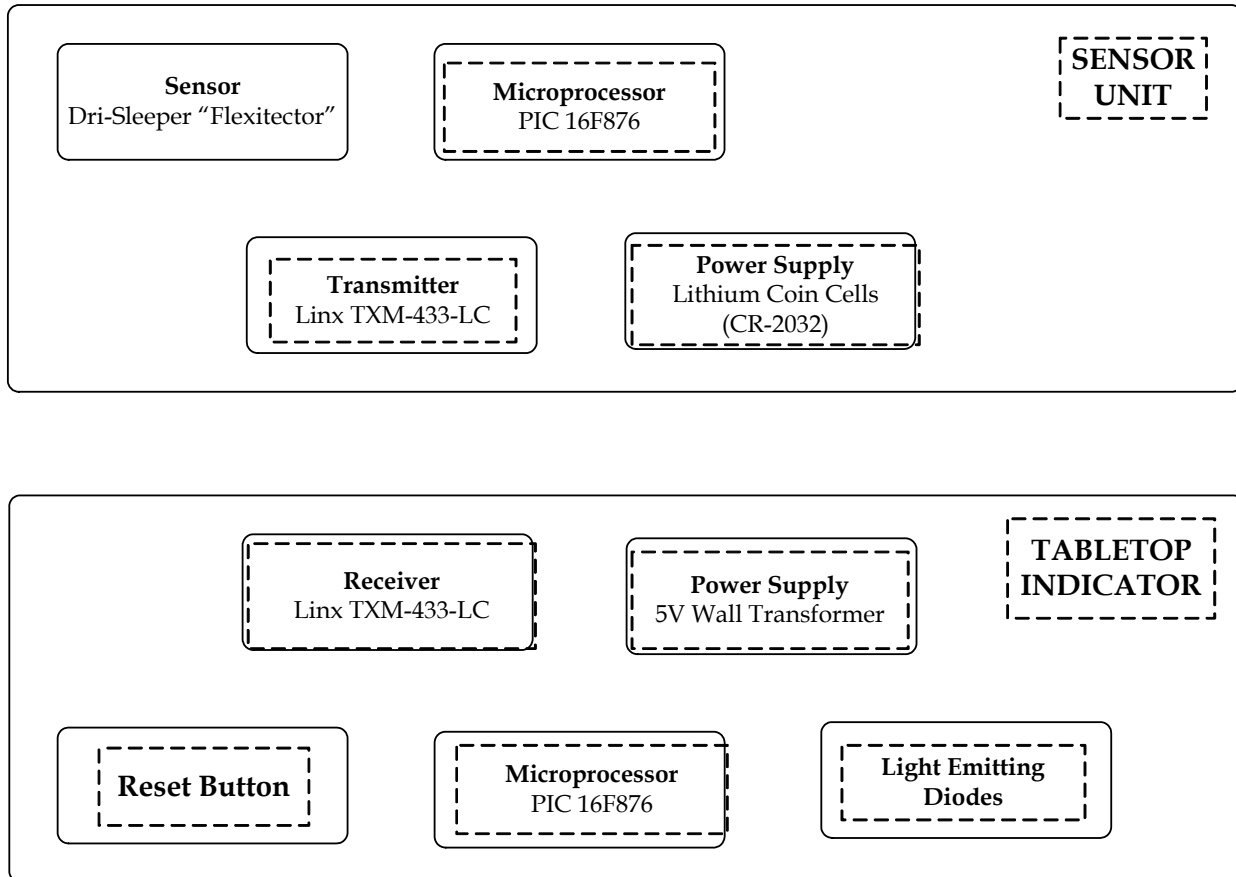


Figure 9.10. Block Diagram

only periodically check the status of the sensing unit.

TECHNICAL DESCRIPTION

The nurse alert system is comprised of two units: a sensing unit and a tabletop indicator. Figure 9.10 shows a block diagram for each device. The final product is shown in Figure 9.11.

The sensing unit is composed of a resistive-type sensor, a microprocessor, and a wireless transmitter. The resistance of the sensor decreases as it becomes exposed to moisture. This change in resistance is detected using an analog-to-digital converter on the microprocessor. The microprocessor compares the raw data against a set of predetermined values. It then determines the degree of wetness present at the sensor. Wetness is categorized as dry, moist, or wet. If the sensor becomes disconnected from the sensing unit, the microprocessor will detect this. A voltage regulator is used to maintain a constant operating voltage. If the operating voltage falls out of tolerance, the voltage regulator relays this error to the microprocessor. The microprocessor sends the appropriate serial communication to the transmitter. The transmitter then sends this information wirelessly to the tabletop indicator.

The tabletop indicator is composed of a microprocessor, LEDs, a reset button, and a wireless receiver. The wireless receiver relays the signal sent from the sensing unit to the microprocessor. The microprocessor decodes the signal and lights the corresponding sensor status. The tabletop indicator is updated by the sensing unit every 15 seconds. If a dry signal is received from the sensing unit, a green LED is illuminated. If a moist or wet signal is received, the LED will flash amber or red, respectively. If the sensor determines a wet condition, the red LED will remain flashing until the caregiver acknowledges this state. The reset button is used when the indicating unit gets locked into this wet state or if an error has occurred. If a valid signal has not been received within two minutes, a communication error LED is illuminated. The transmitted signals are coded with a unit identification number so multiple units can be used in the same environment.

The overall cost for this project is \$93.50. This includes all of the components that are required for manufacturing. This cost does not include expenses associated with manufacturing a printed circuit board. In quantity, each professionally manufactured circuit board would cost approximately \$35.

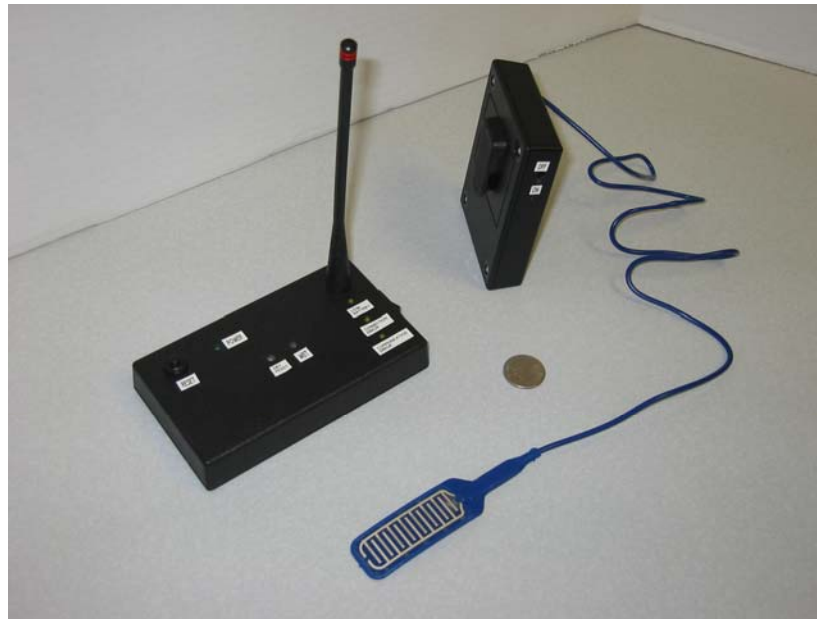


Figure 9.11. Completed Nurse Alert System

PAGE-TURNING SYSTEM

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Supervising Professor: Dr. David Rogers
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Fargo, North Dakota 58105*

INTRODUCTION

With limited upper body mobility, a task such as turning the pages in a book can be difficult. A device has been developed to aid in turning the pages of a book or magazine. There are very few models on the market today which perform such a task. These models have various drawbacks, including high prices and limited warranties. The intention for this project is to design a reliable low-cost solution that will compete with current models. The completed product is shown in Figure 9.12.

SUMMARY OF IMPACT

The system allows the user to turn pages both forward and backward by using a joystick. Precise control allows for the turning of one to several pages at a time. With minimal practice, the user can manipulate these functions easily.

TECHNICAL DESCRIPTION

As shown in Figure 9.13, the page-turner is composed of nine blocks: 1) AC/DC power supply, 2) PIC micro-controller, 3) sway arm motor controller circuit, 4) roller motor controller circuit, 5) sway arm motor, 6) roller motor, 7) input joystick, 8) roller, and 9) sway arm.

The page-turning device has a wooden, wedge shaped enclosure similar to that of a desktop podium. The enclosure is covered in black felt with a hinged top for easy repair and maintenance. An on/off switch is located on the front panel next to a joystick. Power is provided by 120V AC which, in turn, is converted to +3.3V and +5V DC. The +5V DC is supplied to a PIC16F876A microcontroller, which controls motor speed and direction. The +3.3V DC powers four CMOS ICs, which convert signals from the microcontroller into pulses for the specified motor.

A four pole joystick gives the user four different operations. Pushing the joystick right or left will move the sway arm position in the corresponding



Figure 9.12. Completed Page-Turning System

direction. Up and down joystick motions will control the rubber covered roller. Up rotates the roller clockwise for advancing pages in a book; down rotates the roller counterclockwise for turning pages in the reverse direction.

The joystick's four poles (normally open switches) are fed into four pins on the PIC. Depending on the input, the PIC determines motor selection and direction. The PIC will then output a set frequency square wave to the corresponding motor control circuit. The controller circuit steps the motor once (1.8 degrees) for each pulse of the square wave. The PIC also sets the direction of the motor by toggling an appropriate output pin.

Page-turning is accomplished with two stepper motors. The first motor controls a sway arm which rotates across the face of the book, in a motion similar to turning a page. The sway arm is composed of hollow metal tubing which allows the flexible shaft a pathway to the rubber covered roller. This roller is controlled by the second stepper motor. The roller's main use is to spin slowly, causing the desired page to flip over the sway arm.

The caregiver first must slide the book's cover under the elastic straps provided. The power switch is located next to the joystick along with a power indicator light. To advance one page in the book, the user needs to manipulate the joystick. The user starts by pressing the joystick to the right until the roller rests on the page. The joystick is then pressed up to start the rubber covered roller in motion. The roller will rotate clockwise, gradually causing the page to buckle up near the center of the book. The page will

then flip over the sway arm. By pressing the joystick to the left, the user will complete turning the page. The sway arm may be adjusted as required to aid in turning or reading the pages of the printed media. Turning in the opposite direction requires a similar procedure.

The total production cost of the page-turning system was approximately \$297.

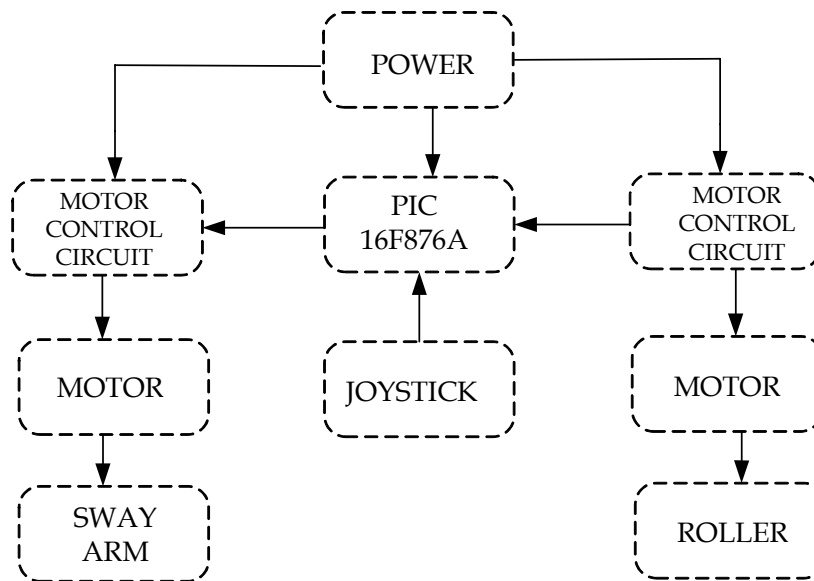


Figure 9.13. Block Diagram of Page-Turning Device

VIBROTACTILE STIMULATION PAD

Designers: Betty Wey, Jennifer Wilken, and Rebecca Barrows
Client Coordinator: Connie Lillejord, Anne Carlson Center for Children
Supervising Professor: Dr. Ivan T. Lima
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INTRODUCTION

The vibrotactile stimulation device is designed for a center for children with disabilities. The vibrotactile stimulation pad is designed to be: 1) portable, 2) durable, and 3) able to provide different stimulation patterns. For portability, the device pad and its controls easily mount on the back of a chair with no exterior connections. To avoid external connections, the device is powered by batteries, which can be recharged whenever the vibration pad is inactive. Mounting the pad and its controls on a chair also helps maintain durability by keeping the device behind the chair back and out of reach. Finally, by designing separate control and driver circuits, the vibrating motors can output different patterns at different intensities, based on user-controlled settings.

The vibrotactile stimulation pad also serves as the first step in a series of projects to develop an aid for the visually impaired. The goal of the future aid is to guide individuals through their environment using vibrotactile stimulations to the head.

SUMMARY OF IMPACT

The vibrotactile stimulation pad, shown in Figure 9.14, allows clients to use vibrotactile sensations in different situations. The device serves its intended purpose: it is portable, robust, and outputs different patterns and intensities. Some of the center's clients find input to the touch receptors on the skin to be soothing. Before the device can be used in future vision applications, improvements are needed, including motor control improvements and size reductions.

TECHNICAL DESCRIPTION

As seen in Figure 9.15, the vibrotactile stimulation pad includes five main components: 1) a power circuit, 2) driver circuits, 3) control circuits, 4) switches, and 5) a vibrating motor array. Each of the



Figure 9.14. Completed Vibrotactile Stimulation Pad

components, excluding the power circuit, is divided evenly among two printed circuit boards.

The power circuit consists of a battery source, an on-off switch, and a power jack. When the vibrating device is turned on, the batteries provide power to the device. However, when the switch is placed in the charge position, an AC adapter can be attached to the device to recharge the batteries. In the off position, the device is neither operating nor charging.

Eight driver circuits are created using 555 timers, resistors, and capacitors. All the drivers receive input from a variable resistor, which is accessible by the user. Based on the resistance selected by the user, the drivers output a variable duty-cycle square wave. The change in duty cycle increases or decreases the intensity at which the motors vibrate. Each of the driver circuits is responsible for providing input to one of the eight motors.

Each control circuit is implemented using a PIC microcontroller and a 16-bit I/O Expander, which

communicate via an I2C bus. Four different vibration patterns are supported by the PIC software: 1) all motors on; 2) a puddle wave; 3) a vertical wave; and 4) a horizontal wave. Using the pushbutton, the user can cycle through the different patterns of the device.

Sixteen chips, containing four switches each, are used to control which motors receive input from the driver circuits. Each of the switches consists of an input, an output, and an enable. The input to the switches is supplied by the driver circuits.

The vibrating motors are arranged in an 8 x 8 array, yielding a total of 64 motors. A grid of this size is

used to allow motors to be spaced evenly at approximately an inch apart and cover most of the chair back. Also, the array needs to provide adequate resolution to output different shapes, which will be used for the physiological studies for future aids. In the final device, the motors are attached to a pad with Velcro and covered with a thin fabric case. Velcro attachments are used for mounting the device onto the back of a chair. The vibrotactile stimulation pad rests on the front of the chair back, while the box containing the electronics is attached to the back.

The cost of this project, including all parts for the vibrotactile device, is approximately \$490.00.

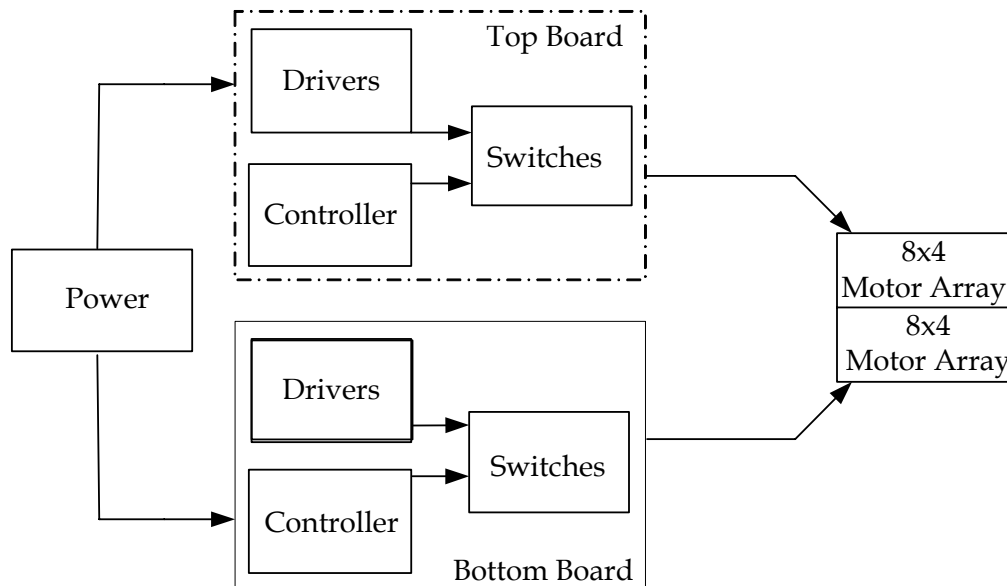


Figure 9.15. Block Diagram of Vibrotactile Device

SHOULDER TILT INDICATOR

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Supervising Professor: Dr. Roger Green
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INTRODUCTION

The shoulder tilt indicator is designed for a client who recently had a stroke and is sometimes unable to determine if his shoulders are level. The shoulder tilt indicator system monitors the angle of the user's shoulders and notifies him or her when they exceed a threshold from level. The device is designed to be lightweight, portable, comfortable, and easy to use. Comfort is important so that the client is able to wear the shoulder tilt indicator for extended periods

of time.

The user wears the shoulder tilt indicator system as a vest. When the device detects that the user's shoulders are not level, the device sends an output to the user. The LCD shows the angle of the user's shoulder and is continuously updated by the controller. The client can choose the alert output mode: a buzzer or a vibrating motor.



Figure 9.16. Completed Shoulder Tilt Indicator

SUMMARY OF IMPACT

The client is able to wear the shoulder tilt indicator during his daily routines with minimal limitations from the device. He does not have to constantly monitor whether his shoulders are level because the device alerts him when they are not. The completed device is shown in Figure 9.16.

TECHNICAL DESCRIPTION

The shoulder tilt indicator consists of a sensor, an LCD, a microcontroller box, and a button box, as shown in the system's block diagram in Figure 9.17. The shoulder tilt indicator is attached to a vest, which allows the client a comfortable way to wear the device. The main component of the shoulder tilt indicator is the sensor, which is an AccuStar electronic clinometer. The sensor is a capacitance-based tilt sensor. When tilted, the capacitance of the sensor is changed. The capacitance is then converted to a voltage that is proportional to the angle. When the sensor is at zero degrees, the output of the sensor is one-half the supply voltage to the sensor. The sensor output is linear for plus or minus 60 degrees of angle. Additionally, the sensor has low power consumption.

The microprocessor receives the output from the sensor and determines when the user should be alerted. Since the device is to be worn by the user, the power supply is a six volt rechargeable battery. A rechargeable battery supplies the power for the entire device.

The shoulder tilt indicator consists of two printed circuit boards (PCBs) enclosed in two separate enclosures. One of the PCBs is the battery and the microcontroller, and the other consists of the user's

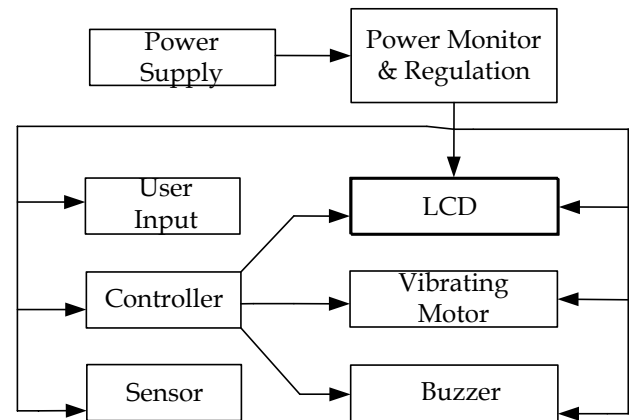


Figure 9.17. System Block Diagram

buttons to control the device. The user's buttons consist of: 1) the power button, 2) sensitivity up, 3) sensitivity down, 4) output mode, and 5) calibrate. The sensitivity buttons let the client adjust the threshold used to activate the alarm. For example, the sensitivity level while the user is taking a vigorous walk is less than when the user is sitting in a chair.

The output mode button changes the mode of output for the client. The buzzer and vibrating motor are positioned on the shoulder straps of the vest to maximize the user's ability to hear and feel the output. The vibrating motor mode can be used while the client is wearing the device in public. The calibrate button allows the sensor of the shoulder tilt indicator to be calibrated to zero degrees. Such calibration would enable the device to work accurately even if the sensor were not mounted onto the vest properly.

The device costs approximately \$300.

AMBULATORY BRAIN COMPUTER INTERFACE

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 Supervising Professor: Dr. Mark Schroeder
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 Fargo ND 58105*

INTRODUCTION

A brain computer interface (BCI) system allows a person with paraplegia or other immobilizing disabilities to control a device with his or her thoughts. Normally, BCI systems have two phases: pre-training and training. The pre-training phase determines parameters necessary for thought classification. This project deals specifically with the training phase. Typical BCI systems require a long training process in a lab environment. The lab environment is neither conducive for actual use, nor desirable for most users. The ambulatory brain computer interface (ABCI) system (shown in Fig. 9.18) is designed to allow an individual to train outside of the lab environment while engaged in a variety of activities. This gives the user more freedom and flexibility in training, thus making the training process more efficient. The system works by first collecting electroencephalogram (EEG) signals, via electrodes placed on the head, and then conditioning and processing the signal. The signal is then classified by the PDA program as left or right. The PDA provides the user with audio and visual feedback while recording the training results.

SUMMARY OF IMPACT

This lightweight, portable, and easy-to-use system gives researchers a new tool for studying the potential of portable training. Long-term training is the key to controlling a device using thoughts. With this portable system users are able to train throughout the day. This gives individuals with immobilizing disabilities a tool to interact with their everyday environment.

TECHNICAL DISCRIPTION

The ABCI system is comprised of three distinct parts: 1) electrodes and instrumentation, 2) microcontroller, and 3) PDA. The instrumentation and microcontroller printed circuit boards along with the power supply are all enclosed in a small box. Controls on the box allow the user to turn the device on or off, adjust channel gains, plug in



Figure 9.18. Completed ABCI system

electrodes, and connect serially to the PDA. Figure 9.19 shows a system block diagram.

The main function of the instrumentation stage is to collect the EEG from the user and output that signal to the microcontroller. There are two channels, each comprised of two electrodes placed on the head, and a reference earpiece. A series of filters and user-adjustable amplifiers limit the EEG signal to a range of 1 to 25 Hz, and a peak-to-peak amplitude of 5

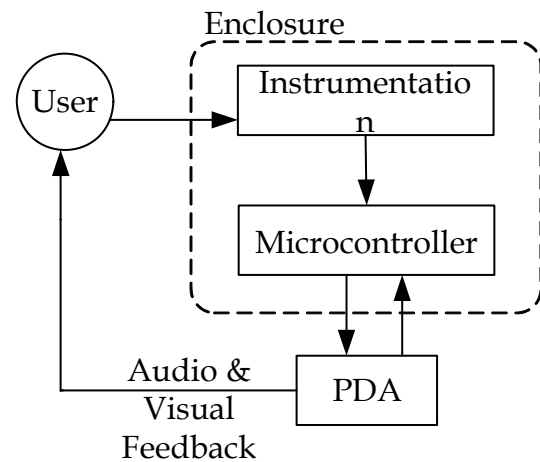


Figure 9.19. ABCI System's Block Diagram

volts, suitable for the microcontroller.

The microcontroller operates in two modes: 1) raw signal, and 2) train. The raw signal mode samples one channel of the EEG signal and sends that signal directly to the PDA to be viewed for signal verification. In train mode, the microcontroller samples both channels of the EEG signal, performs user-defined digital filtering, calculates RMS power for each channel, and then sends the power calculations to the PDA using serial communication. The sampling rate is 128 samples per second. The digital filter is an eighth-order bandpass elliptical filter implemented using second-order sections. It is adjustable to capture specific brain wave frequency ranges. RMS power is calculated every one-half second and sent to the PDA for classification.

The PDA uses two programs written using LabVIEW PDA module. The first program is used to view one channel of the EEG signal in real time. The program allows the user to choose which channel to view, which also lets the user to verify the signal and proper electrode connections. The second program is the ABCI training program. This program has four modes: 1) start, 2) input test, 3) train, and 4) settings (as shown in Fig. 9.20). In "start," the user enters his or her name and training session number. This information is used to generate a file to save the training results. "Test" puts the microcontroller into train mode and allows the user to view and verify the input power signal.

"Train" is the major component of the program. The user enters in the number of trials and classification parameters. At this point, the user presses the start button to begin the training process. The user controls the audio and visual feedback using only his or her thoughts. The phrases, "think right," "think left," "correct," and "wrong" are given

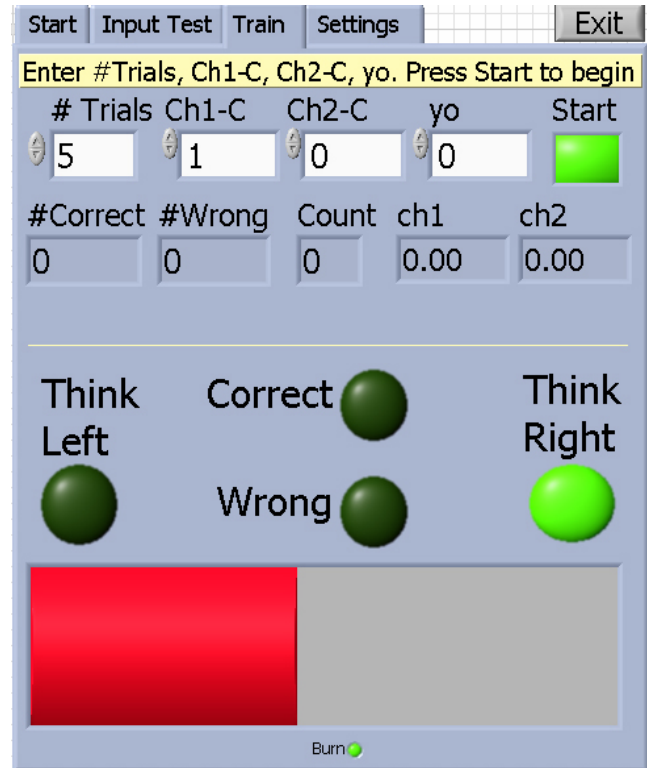


Figure 9.20. Lab VIEW Training Program

audibly and visually. For the command "think right" the user tries to move the LabVIEW bar (Fig. 9.20, bottom) to the right. The user also hears a tick in his or her right ear, which gets louder as the bar progresses to the right. The "think left" command operates in a similar manner. The final mode is for advanced settings. This gives engineers access to main program settings and provides troubleshooting information. These settings are generally not to be adjusted by the user.

The project cost was approximately \$750, the majority of which was associated with the purchase of the PDA and LabVIEW software.

PRODUCTION REPORT ASSISTANT

Designers: Kristin Schroeder, and Josh Shones

Client Coordinator: Dianne Wanner, Supervisor, Developmental Work Activity Center (DWAC)

Supervising Professor: Prof. Val Tareski

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INTRODUCTION

A center provides services for approximately 50 adults with developmental disabilities. It allows these individuals to perform meaningful work and earn money. Throughout a full day of work, individuals receive training in socialization and adaptive living skills. Additional programs to help them attain supportive or competitive employment are also offered. The individuals are paid on a piece rate basis for the work they do correctly, requiring staff members to keep accurate and detailed records. The current record system consists of a half sheet of paper for each individual. At the end of each day, information is recorded on the paper to indicate production results, supervision levels, doctor's visits, and appearance. The paper system is cumbersome, especially when information is needed from a previous day and staff members have to sort through piles of papers. Furthermore, mistakes are likely when sorting and tallying information by hand. The new electronic system provides a paperless solution that is accurate and fast, thereby allowing staff to dedicate more time to work with clients.

SUMMARY OF IMPACT

The electronic system allows staff members to monitor each individual's production more efficiently, eliminate bulky paper stacks, and streamline the storage of data for audits and year-end reports. With the paper system, an hour or more of the day is set aside to organize and tally the data for an administrative assistant. Over the course of one year, the system can save staff up to 250 hours. A supervisor said, "I am so excited about the possibilities this could bring to our program...I can't tell you how much staff time will be saved for our program."

TECHNICAL DESCRIPTION

Two Dell Axim X30 PDAs were purchased with Pocket Excel preinstalled, for proof of concept, as seen in Figure 9.21. Microsoft Excel and Pocket Excel spreadsheets are custom formulated. The spreadsheets include: 1) names of individual workers; 2) four tasks for each individual; 3) level of supervision needed; 4) appearance/hygiene for the day (the staff refer to this as "presentability"); and 5) the number correct out of the total number attempted at each task. These spreadsheets are made to work on Pocket Excel, which requires only simple formulas. Figure 9.21 shows an example of everyday recordings in the spreadsheet.

Each PDA supports every client, which allows staff members the flexibility to check on any individual. Due to limitations in Excel, a separate spreadsheet is used for 25 individuals; thus, two sheets are needed for the 50 DWAC clients. When the administrative assistant receives all of the PDAs at the end of the day, data from all spreadsheets are automatically combined into the master spreadsheet. The master spreadsheet includes Excel functions and formulas that search for each individual's name in every spreadsheet and then locate and tally the corresponding data. The administrative assistant copies the organized results from the master spreadsheet into customized software. The spreadsheets can be transferred to the computer via three methods: USB, IR, and Bluetooth.

The staff participated in the design effort, creating a true collaboration between the design team and client. During mid-design, the staff field tested the system for three weeks and provided valuable feedback, which was incorporated into the final design to ensure product quality and usefulness.

The approximate cost of the project is \$570.

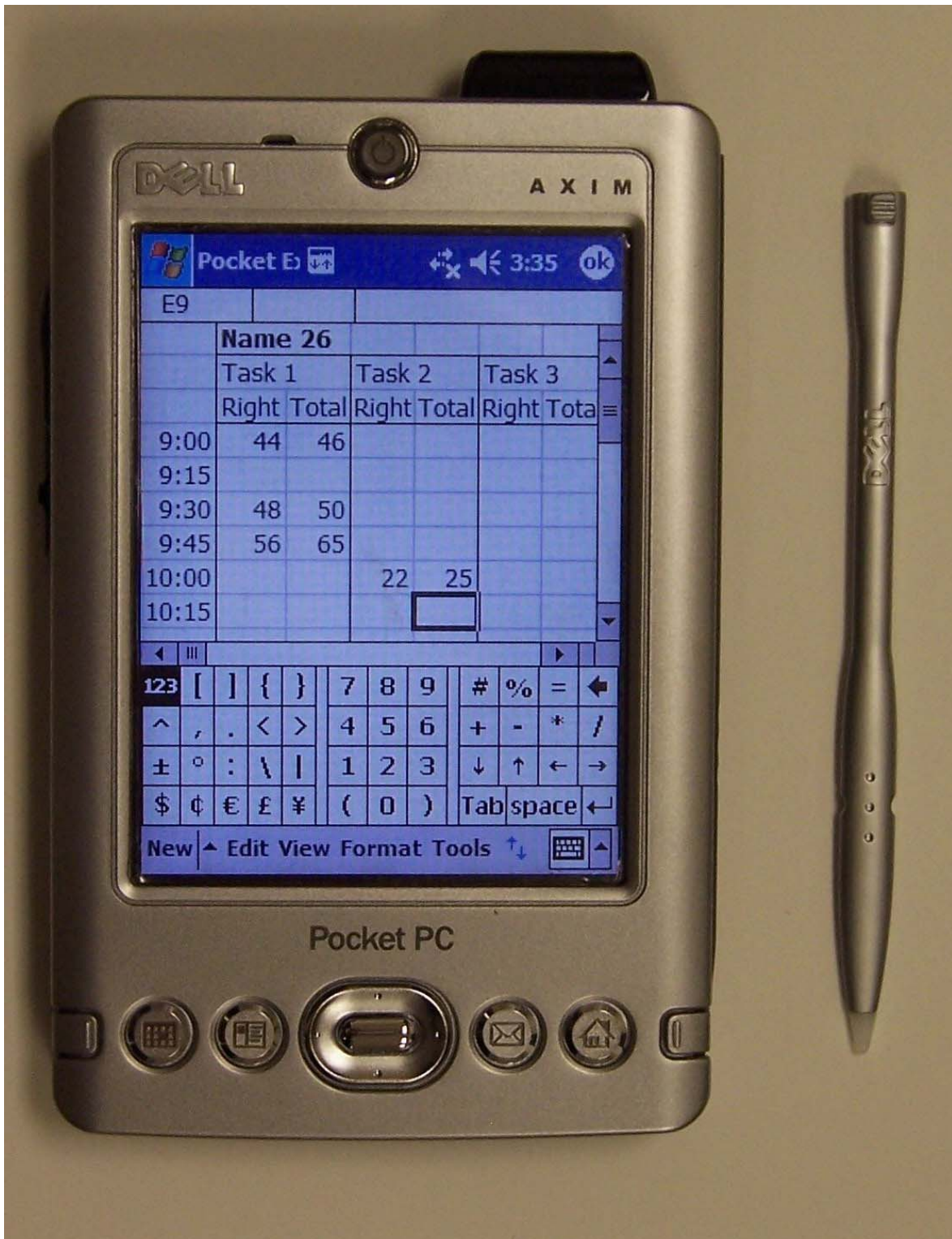


Figure 9.21. Dell Axim PDA Displaying Production Spreadsheet

BOCCE BALL SCORING SYSTEM II

*Designers: Russell Cook, Shaun Schmeig, and Phil Stich
Client Coordinator: Shelly Woodcock
Supervising Professor: Dr. Jacob Glower
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North Dakota State University
Fargo North Dakota, 58105*

INTRODUCTION

A device was designed to provide Special Olympics officials a bocce ball coring system that is fast, accurate, and easy to use. Bocce ball is played by two teams consisting of two players each. The object of the game is for each team to alternate turns throwing the bocce balls, with the intent of having the team's balls rest closest to the target ball, known as the pallino. This system helps judges determine the closest (winning) ball. The completed prototype system is shown in Figure 9.22.

SUMMARY OF IMPACT

The Bocce Ball Scoring System II makes the judging process much more efficient. The design accomplishes this by accelerating the scoring process, increasing precision, and reducing the number of judges needed. Only one judge is needed for this system, and the scoring process can be completed in just 10 seconds over the amount of time it takes to set the units on each of the bocce balls.

The newest design is superior to the previous bocce ball scoring system, which was located inside of the bocce balls. Upon encasement, the audio signals are almost completely absorbed by the material of the bocce balls, preventing proper operation of the system. This problem is avoided in the new design by using external circuitry, which is placed on the bocce balls after they have been thrown. The current design is an improvement over the previous design in several other ways as well. First, the current system is more practical to implement physically. Any bocce ball set can be used. It is also much easier to replace one of the ball locators than to have to replace a whole bocce ball with the electronics inside. Second, the current system is able to operate correctly in a noisy environment. The previous design required a quiet environment for the system to work properly. Third, the current design uses an audio signal that does not need to be filtered. The



Figure 9.22. Bocce Ball Scoring System II

audio signal on the previous design, created by a buzzer and received with a microphone, needed to be filtered and modified into a usable signal. Any variable delay added by the filters could greatly affect the precision of the measurements. The signal created by the ultrasonic sensors in the current design only requires a gain stage before it is used. Therefore, the current design has higher precision than the previous design.

TECHNICAL DESCRIPTION

As shown in Figure 9.23, this system is comprised of a hub unit, which sets over the pallino, and three bocce ball locator units, which are placed on the bocce balls. The system determines the winning balls using a combination of radio frequency (RF) and audio signals to calculate the distance to each ball. The hub first sends out an RF signal to start and synchronize timers in the ball locators. Then the hub sends out an audio signal using ultrasonic sensors to stop the timers in each of the ball locators. Because of the relatively slow propagation of the audio signal, the timers in the closer locators will be stopped before the timers of the locators that are farther away.

Once the timers in the ball locator units are stopped, each unit sends its timer value back to the hub using the RF transceivers. The microprocessor in the hub uses these values to calculate the winning ball or balls. The hub then transmits the winning ball information back to the ball locators, commanding the winning ball or balls to flash their LEDs.

Power is supplied to each unit using alkaline nine-volt batteries. Using standard batteries, the system operates continuously for six to seven hours. By turning units off between rounds, the system is able to operate for approximately 200 scorings.

This system is controlled by a PIC16F876 microprocessor. The RF transceivers in the design are RFM DR3000 modules. The audio transmission and detection is performed by 40 kHz ultrasonic sensor pairs made by Panasonic. For a complete eight-ball system, there is one sensor in each of the ball locator units and 10 sensors on the hub unit. Each sensor on the hub covers a 36 degree interval around the hub in order to achieve line of sight to

each ball on the playing field. The user interface of the system consists of a reset switch on each unit and an extra switch on the hub that starts the scoring process. The display on each ball locator unit consists of LEDs that display the system status and information on the winning ball or balls.

The Bocce Ball Scoring System II detects the closest ball with a theoretical precision of approximately .06 mm per count of the timer. During testing, however, the system consistently determined the winning ball between two locators that were placed approximately one millimeter apart.

The cost for a complete eight ball system is approximately \$950.00. The hub unit alone costs \$150.00 to manufacture, and each ball locator unit costs \$100.00.

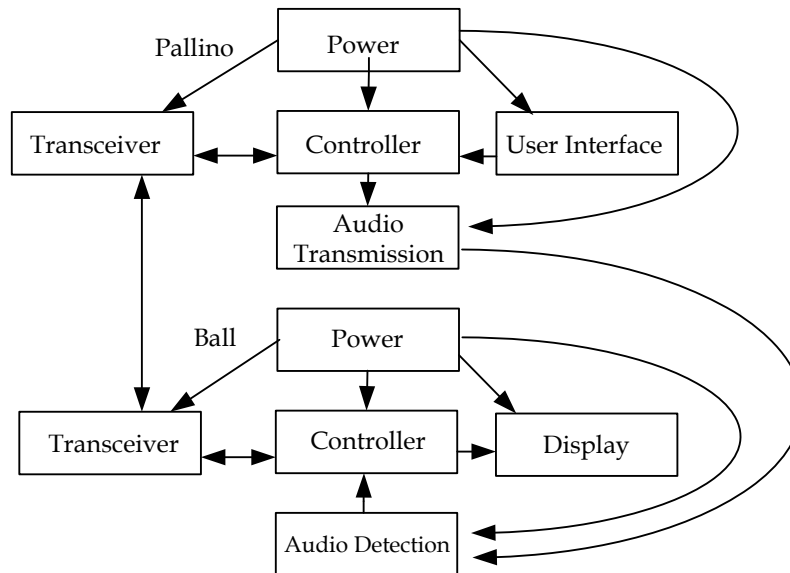


Figure 9.23. Block Diagram of Bocce Ball Scoring System II



CHAPTER 10

SAN DIEGO STATE UNIVERSITY

Department of Mechanical Engineering
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Principal Investigators:

Michael A. Lambert, Ph.D., Asst. Prof.

Karen May-Newman, Ph.D., Assoc. Prof. and Chair

CENTER PEDESTAL GRINDER WITH PIVOTING BASE FOR RACING SAILBOAT

Designers: Guillermo Navarro, Israel Valero and Miguel Santoyo

Supervisors: Peter C. Newman, and Dr. Karen May-Newman

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INTRODUCTION

Winches are used on sailboats for hauling in and tensioning a variety of sail handling and control lines. Traditional winches have a crank handle mounted directly to the vertical axis of the drum. This configuration requires substantial trunk and lower body strength to power the lateral motions required of the handle. This motion can pose ergonomic challenges for able-bodied sailors and can be impossible for individuals with physical disabilities or limitations in lower body strength.

An improved device provides a pair of cranks rotating about a horizontal axis, using an opposing motion characteristic of bicycle pedaling. This configuration, referred to as a pedestal or "coffee grinder," is commonly found on larger sailboats. Larger sails lead to higher control line tensions, and larger crews allow some crew members to be dedicated primarily to winch grinding. Gearboxes mounted under the deck provide multiple speeds, and allow the power to be directed to different winch drums.

The goal of this project was to design a mechanical interface with a commercially available pedestal winch that could be rotated for use by a crew member sitting on either the port or starboard side of the cockpit of a 40' racing boat. The pedestal mates with a commercially available gearbox and drive shaft components mounted below the deck.

SUMMARY OF IMPACT

The center pedestal grinder provides a method for crew members with limited lower or upper body strength and mobility to raise and adjust the sails of a boat. The center pedestal allows crew members seated in specially designed seats on the track and trolley system (designed by a different student team) to work a variety of winches from a single position.

TECHNICAL DESCRIPTION

The center pedestal winch grinder employs the coffee grinding mechanism, which is mounted in the center of the boat's cockpit and connected to winches on either side of the boat. The pedestal grinder is a common device in larger racing sailboats, and is typically operated with both hands while the user is in a standing or crouching position. The new design enables crew members in a seated position to effectively grind with a powerful, bicycle-like hand motion at chest level (see Figure 10.1).

Several design alternatives were considered before the team decided to adapt an existing commercial pedestal system. A belt drive pedestal from Harken served as the starting point, with the company's representatives providing much help in securing the proper drive elements. Stock parts were chosen for the upper portion of the pedestal, including the hand crank assembly, bearings, pulleys, and toothed drive belt.

A pivoting base assembly was designed to support the modified pedestal at the desired position and interface with the standard below-deck drive components. This assembly transfers the drive power from the pivot to the output shaft. This base includes a quick-release position lock accessible to the user, and also holds a flange to mount the device to the deck. Prototype assembly as well as patent disclosure filings are currently in progress.

The total cost was \$3500, including \$2844 for the pedestal winch and \$656 for materials and supplies.

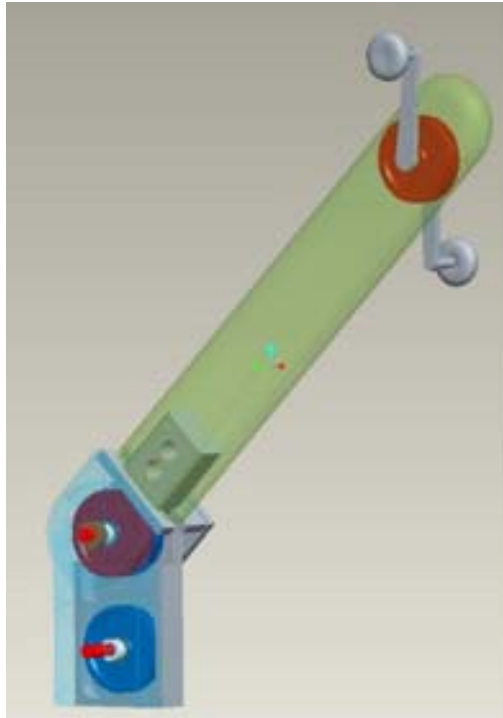


Figure 10.1. Diagram of Center Pedestal Grinder with Pivoting Base

TRACK AND TROLLEY FOR RACING SAILBOAT COCKPIT CREW SEATS

Designers: Michael Romano, Fervin Callo, Philip Yoakem, Chris Aramburo, and Jonny Lam

Supervisors: Peter C. Newman and Dr. Karen May-Newman

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INTRODUCTION

A system was designed to shuttle racing team crew members with quadriplegia or paraplegia around a circuit to each watch station in the cockpit. The stations include the port and starboard jib sheeting winches, the port and starboard mainsheet trimmers, the navigator station, and the helm position. The existing will be mounted onto rolling trolleys seats (see Figure 10.2 A and B). A full-scale mock-up of the cockpit and aft decking has been constructed to test, evaluate, and modify the device before installation on the racing boat. The mock-up is capable of being tilted to simulate maximum expected "heel," or roll angle, while sailing "close hauled" (as far into the wind as possible). The goal of the new design was to reduce the weight, profile, and obstruction of the track and trolley system developed last year.

SUMMARY OF IMPACT

The design will improve the safety and mobility of crew members with limited leg and lower trunk strength. The complete track and trolley system will allow individuals who have paraplegia and quadriplegia to move from one watch station to another without leaving their seats. This innovation will increase safety and comfort for the crew.

During rough weather, there is the possibility that a crewman will be injured or even hurled overboard while changing positions. The new system will reduce this possibility. The only time a crew member will be out of his or her seat will be when he or she is moving from the cabin to the companionway and into a seat immediately adjacent to the companionway, or returning to the cabin.

TECHNICAL DESCRIPTION

The new design represents a different approach from last year's design. The team combined commercially-available components from Bishop

Wisecarver (Aurora, CA) with parts the team designed to create a single-track, dual-trolley system. The track is made from stainless steel with hardened edges that fit to v-groove wheels on the trolley. The track is capable of making a 90-degree turn with a radius of curvature of 9 inches, which is sufficient to provide clearance from the hardware on the boat. The single rail system provides less interference and the low profile reduces the risk of a tripping hazard, enabling an ambulatory crew member to sit on the adjacent deck. The aluminum trolley has four independent v-groove wheels that roll smoothly on the track, handle substantial vertical and horizontal loads, and can turn corners easily without the use of bogeys. The trolley profile is more than one cm lower than the previous design. Torques about the guide are supported by wheels mounted to the seat base plate.

The seat plates are attached to the trolley with a carriage plate and a 5/16" hex bolt with an aluminum spacer to create clearance between the carriages. Two spherical bearings are used to distribute the coupling loads on the carriage and are housed by retainers that attach under the bottom seat plate. The seat plates can rotate about the vertical axis on a pivot and have support wheels in front and back. Three new seats were made following a previous design that incorporated a backpack-style frame with padded waist and shoulder belts and a sling-bottom seat positioned over the seat plates and attached with stainless fasteners. The entire assembly rolls smoothly over the deck surface and will allow a crew member to sit comfortably for several hours.

The new design for the track and trolley system is a single-track, dual-trolley system that is light and has a low profile allowing both ambulatory and non-ambulatory crew members to work side-by-side on the boat deck. Total cost was \$6280.

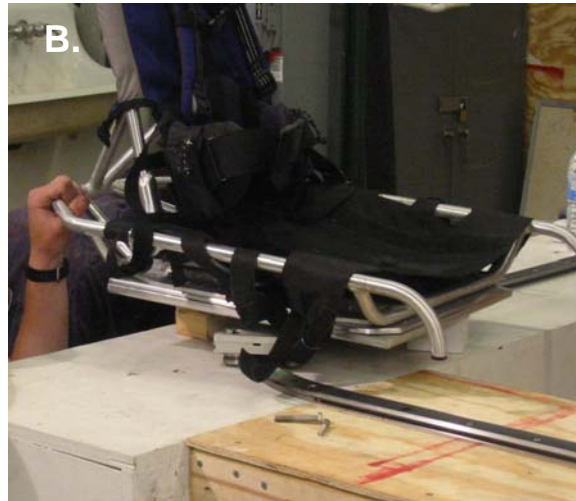
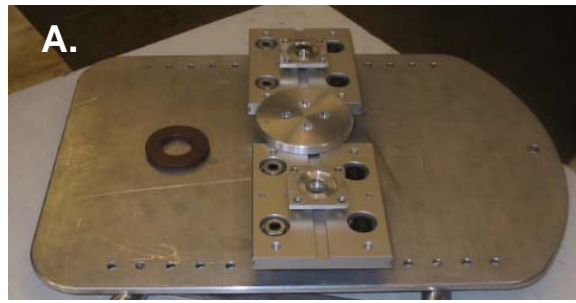


Figure 10.2. A. Seat Plate and Trolley Sliding along Curved Track Section. B. Seat Assembled to Trolley.



CHAPTER 11
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WALKER WITH A SLING/SADDLE SEAT

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INTRODUCTION

The walker shown in Figure 11.1 enables people with limited leg strength to walk. It was designed to be used in a physical therapy setting to fit people of heights from 4'5" to 7' tall, and it will accommodate up to 300 pounds. The walker's width allows a standard wheelchair to be rolled into the entrance of the walker, as shown in Figure 11.2. This allows for an easier and safer transition between wheelchair and walker. Two handles have been placed at the rear of the walker for a therapist to use during transition and to help guide the walker during operation. An adjustable sling supports the majority of the person's body weight. The mechanism that the sling hangs from has a large range of adjustments in three directions. All four wheels have brakes and can be locked in various positions, as shown in Figure 11.3. This allows for three modes of operation: 1) straight line walking (all wheels locked in one direction), 2) limited turn range (front two or rear two locked in one direction) for practicing turns, and 3) fully articulated motion (all wheels unlocked). The straight line mode is used for people that tend to veer right or left. This forces the person to walk in a straight line, and decreases the possibility of the person bumping into anything. The arm supports are fully adjustable and removable to suit the user's individual needs.

SUMMARY OF THE IMPACT

This walker may help the user regain leg strength and motion. The comfortable sling allows for lengthened physical therapy sessions. The arm supports allow the user to steady himself. Most importantly, this device allows the user to be in a standing position and walk. He may wish to use this walker primarily outdoors if space inside his residence is limited.

TECHNICAL DESCRIPTION

The walker has two main assemblies: a frame and an adjustment platform. The walker frame is made from 1/8-inch-thick tube steel with an outer



Figure 11.1. The Walker with a Sling/Saddle Style Seat

diameter of one inch. The frame has three sides: front, left and right. The back is open to allow the patient to get in and out of the walker. The front cross bar is bent to be out of the way of the user's legs.

All wheels are bolted to welded plates attached to the frame and have non-marring surface castors. They are capable of carrying 500 pounds each. The multi-surface wheels have the ability to lock in two directions, and all four wheels have brakes. This allows for a limited straight line motion or for fully articulated motion. The wheels have two grease fittings: one for the upper bearing, and the other for the axle bearings.

The arm supports were purchased. The original clamping and attachment system was awkward to use and adjust. To compensate, the team designed a more efficient system with a single-turn handle that tightens around the arm support's shaft. A follower tube, shown in Figure 11.4, is used to keep the shaft

from rocking. The arm support can be removed and installed by loosening and pulling up and out, or by pulling in and tightening. This one adjustment point allows for left-to-right rotations and for up-and-down adjustments. The arm support pad has a wide range of adjustments built in by the manufacturer. It also has a Velcro strap to secure the person's arm.

The adjustment platform assembly is fairly complex; it adjusts for side-to-side width, front-to-back width, and height. The side-to-side and front-to-back adjustments each have two incremented sliding aluminum bars with a pushbutton release and lock. A back bar must be taken out by sliding two locks towards the outside of the walker, as shown in Figure 11.2, and then reinserted after the patient enters the walker. The hinge includes an offset pin so that a maximum opening angle can be obtained. The bar has a simple rotating slide lock that has grooves for security.

The torso adjustment is made from crew tube steel that has a one-inch outer diameter and is 1/8 inch thick. It has spring buttons inside. The tubes have welded inserts that are threaded and are secured with bolts. An outer aluminum tube, which contains one-inch graduated holes, slides over the steel tube for front-to-back and side-to-side adjustments. The aluminum tubes are from the bottoms of standard walkers.

Height adjustments are made via four pipe clamps. The height adjustment mechanism is a spring-loaded rotating lock that fits into a moving bar with incremental indentations that serve as stoppers. There are two on the left side and two on the right. There is no resistance to lift upwards; however, to lower the assembly, a bar on each side of the walker must be pushed down to unlock the mechanism. This can be done one side at a time or simultaneously. A safety lock was placed over the push bar to stop accidental release. The pipe clamps



Figure 11.2. Walker Entrance Figure 11.3. Locking Wheels



Figure 11.4. Close-Up of Connections and Adjustment Bars

have a straight line ratchet pawl arrangement for one-inch adjustments and stops. To go up, swing locks open and pull up on the torso adjustment bars. To go down, swing locks open and push the bars that connect the pipe clamp mechanism. The steel parts are coated with metallic silver and clear powder to ensure a durable finish. The aluminum parts were anodized for corrosion resistance. The sling can be purchased or custom made by a qualified person.

The total cost of this design was approximately \$600.

ADJUSTABLE SHOE GRIPPER/HELPER

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INTRODUCTION

The daily task of putting on shoes is a challenge for some individuals with chronic lower back pain or arthritis. A device was designed to allow the user to grip and position a shoe and then slip his or her foot into it without interference (as associated with a shoe horn). The Adjustable Shoe Gripper/Helper, shown in Figure 11.5, allows the user to adjust the length of the shoe gripper relative to his or her height, and to adjust the gripper for other purposes. The shoe gripper requires only a small amount of force to manipulate the gripping action.

SUMMARY OF IMPACT

The adjustable gripper arm, combined with the adjustable-length tubes, provide for multiple uses, easy storage, and portability.

TECHNICAL DESCRIPTION

The main body of the Adjustable Shoe Gripper/Helper is comprised of two telescoping corrugated aluminum tubes. One end is attached to a spring-loaded handle enclosed in housing from a reacher device, as shown in Figure 11.6. The other end is attached to an adjustable aluminum arm enclosed in plastic housing, which is connected to

the bottom portion of the aluminum tube from the reacher device. The reacher device includes the jaws of the gripper, shown in Figure 11.7, and its arms for cable attachment. A compression spring was added to maintain the open position of the jaws when not in use.

The cable mechanism consists of 65-pound fishing line (with 15-pound cross-sectional capacity) attached at one end to the gripper mechanism. It extends externally from the lower telescoping tube to the upper telescoping tube. It passes through a rod attached to another rod extending from the handle, and loops around a pulley mounted externally on the lower end of the upper tube. The cable ends at a screw that can be turned to increase tension as needed.

A groove with three slots in the lower tube allows the user to adjust the height of the shoe gripper by pulling the screw, attached to the pulley, to the desired position. With the arm at a 90-degree position, the device can be extended from 26.5 to 30.5 inches. The maximum length of the device, when the arm is straight, is 40 inches.

An earlier, fixed-length prototype consisted of a



Figure 11.5. Adjustable Shoe Gripper/Helper

section of 0.625 inch diameter aluminum tube, a bicycle handle, and a gripping mechanism from a child's toy. It demonstrated the viability of a horizontal gripper mounted on a vertical shaft. A brake cable with housing was connected at one end

to the gripper and at the other end to a brake lever. The total length of this device is 33.5 inches.

The cost of this project was \$119.



Figure 11.6. Spring-Loaded Handle



Figure 11.7. Gripper Jaws

AUTOMATIC PILL DISPENSER

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INTRODUCTION

A device was designed to help individuals to take their medications without forgetting or struggling to open a pill bottle. It dispenses pills at a specified time every day.

SUMMARY OF IMPACT

The simplicity of the design makes it a practical and user-friendly device. The pill dispenser can be used in any home without the use of batteries. The device shown in Figure 11.8

TECHNICAL DESCRIPTION

The pill box dispenser was made by adapting a circular acrylic disk to an existing 125-volt AC, 60-Hz heavy duty daily timer. The acrylic disk was

split up into 24 equal sections and marked off for each hour of the day. Certain times of the day were marked and drilled out to put pill containers in the appropriate slots. The remainder of the pill box was constructed out of wood with appropriate cut-outs for the pre-existing timer to sit. The electrical wiring needed little modification, as shown in Figure 11.9.

The dispenser can be used by first rotating the acrylic disk clockwise to the current time and then filling the containers with medication. As time goes on, the disk rotates clockwise and the pills drop out of a cut-out slot in the pill box at the appropriate times. This process is repeated daily.

The total cost of the project was \$43.



Figure 11.8. Automatic Pill Dispenser



Figure 11.9. Wiring of Timing Component

SELF-RISING SUPPORT CANE

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INTRODUCTION

Normal canes have a fixed length and require the user to use the arm and back to rise from a seat. The self-rising support cane, shown in Figure 11.10, allows the user to adjust the length of the cane with a switch. The length of the cane can be adjusted 12 inches from the lowest to the highest position, permitting the user to adjust the cane while getting up, helping him or her to stand.

SUMMARY OF IMPACT

This device addresses the challenge faced by people who require assistance to rise from a chair. It also easily adjusts to accommodate climbing and descending stairs.

TECHNICAL DESCRIPTION

The origin of the assembly is a standard quad-cane. The base and handle were retained, while the shaft was replaced with a 12-volt, 250-pound linear electro-mechanical actuator with limit switches. The actuator extends a full 12 inches. A 3/4-inch hole was drilled through the center of the cane base to encase the bottom of the actuator, which was then welded on.

The shaft on the outside of the actuator is made of 2.5-inch and three-inch PVC pipe. It was cut to length and fitted with Velcro bushings. A PVC cap was added to the entire extendable shaft and a 29/32-inch hole was drilled through the center to accommodate the handle shaft.

Figure 11.11 shows the wiring of this device. The actuator is powered with 10 Ni-MH rechargeable batteries wired in series with an On-Off-On momentary switch on the handle. This is all wired in parallel with a recharging circuit. This circuit includes a 33 ohm resistor and a female end to accept the male end of the AC to DC power adapter. The batteries are expected to provide one hour of full usage, or about 180 cycles of the cane.



Figure 11.10. Self-Rising Support Cane

To operate this cane, the switch on top must be activated. Pushing towards the body increases the

length and pushing away from the body decreases the length of the shaft. Figure 11.10 shows the cane at minimum shaft length and Figure 11.12 shows the cane at maximum shaft length. When recharging the batteries, the plug will fit directly into the front of the battery box and into a 15-volt wall outlet. A full charge takes 14 hours. The cane is fairly heavy and requires some upper body strength.

The entire assembly weighs approximately 9 pounds.

The total cost of this project was \$420.



Figure 11.11. Wiring of Device



Figure 11.12. Self-Rising Support Cane at Maximum Length

LEVER-OPERATED DISHWASHER OPENER

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INTRODUCTION

The goal of this project was to create a device that will allow people with limited use of their hands to easily open the door of a dishwasher. The existing release handle used on dishwashers requires significant clamping force applied by the hand, which people with arthritis, Parkinson's disease, or those who use prosthetic devices, may have trouble producing.

SUMMARY OF IMPACT

This device will allow people who have disabilities

that affect grip strength to take advantage of the convenience of a dishwasher.

TECHNICAL DESCRIPTION

Typically, the mechanism used to release the door of a dishwasher is activated by squeezing the release handle against the top of the unit. The lever that is employed drives an axle. This axle turns a cam, which rotates and displaces the release handle in the same manner that one's hand would. The benefit of using this lever is that much less effort is required to depress this lever than would be required by a



Figure 11.13. Lever-Operated Dishwasher Opener in Use

person's hand to operate the release mechanism without it. In fact, the handle need not be grasped at all.

The device is mounted onto the dishwasher by a hanger and suction cup, as shown in Figure 11.13. The hanger keeps the unit in place when the lever is being pulled, while the suction cup keeps the device from falling off of the door when the door is open.

Construction of this device is simple. The device has a few moving parts. The base is constructed of wood

for this proof-of-concept model, shown below in Figure 11.14. In actual use, the device base would likely be made of plastic with a stainless steel shaft to accommodate usage in the kitchen.

As an added feature, the handle disengages from the shaft and can be rotated to lie flat against the dishwasher, keeping it out of the way when not in use. The handle is spring-loaded so it will re-engage when rotated into the operational position.

The total cost of this project was \$54.



Figure 11.14. Concept Model

EZ-SPLIT PILL CUTTING MACHINE

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INTRODUCTION

It is common for people to take medication in half-pill doses. With the rising costs of prescription drugs, some patients are choosing to save money through prescriptions for pills that are twice as strong as necessary, and then cutting the pills in half. Since there is typically little price variation between strengths of the same medication, these prescriptions last twice as long as ones for smaller, more appropriately-sized pills, at a similar price. A device was designed to cut a pill in half quickly, easily and consistently. Current methods of pill splitting include using a razor blade to cut a pill by hand on a counter top, or purchasing a device to complete the task, which is little more than a razor blade mounted to a small plastic lever. These methods are both unreliable and depend highly on the user's motor skills. The EZ-Split Pill Cutting Machine, shown in Figure 11.15, automates the pill-cutting process.

SUMMARY OF IMPACT

This device fills a need for an easy and consistent way to cut a pill. With this device, it is possible for pills to be aligned and cut cleanly. Pills are aligned by dropping them into a similarly shaped hole on a rotating disk, and rotating the disk until the pill is under a blade. Pill-splitting requires only the push of a button. The device ensures precision alignment and drives a blade through the pill, making pill-splitting a process that does not rely heavily on motor skill or strength.

TECHNICAL DESCRIPTION

The initial system requirements for this device consisted of simplifying the pill alignment process, providing a consistent cutting force, maintaining a budget of under \$100, and ensuring that the device is small enough to fit on a countertop.

The simplest and most effective way to align pills of different shapes is to use a round disk with different shaped cutouts set at around the perimeter. A detent



Figure 11.15. EZ-Split Pill Cutting Machine

system allows for each shape to be clicked into place and only allows for rotation in one direction. The user simply puts the pill into a cutout of similar shape, and rotates the disk until it clicks into place under the blade. A close-up of the disk and blade can be seen in Figure 11.16.

Cutting force is provided by a magnetic solenoid. After the pill has been aligned under the blade, the user presses a normally open momentary switch,

which closes the circuit, providing power to the solenoid. When the solenoid is powered, its pushrod (to which the blade is attached) fires downward, driving the blade through the pill. When the user releases the button, springs force the pushrod back up to its resting position. This provides for an identical cutting force for every cut. After the pill

has been cut, the user rotates the disk in the only direction the detent system allows, and the cut halves fall through a hole onto the counter for easy retrieval.

The total cost of the materials in the final prototype was \$40.

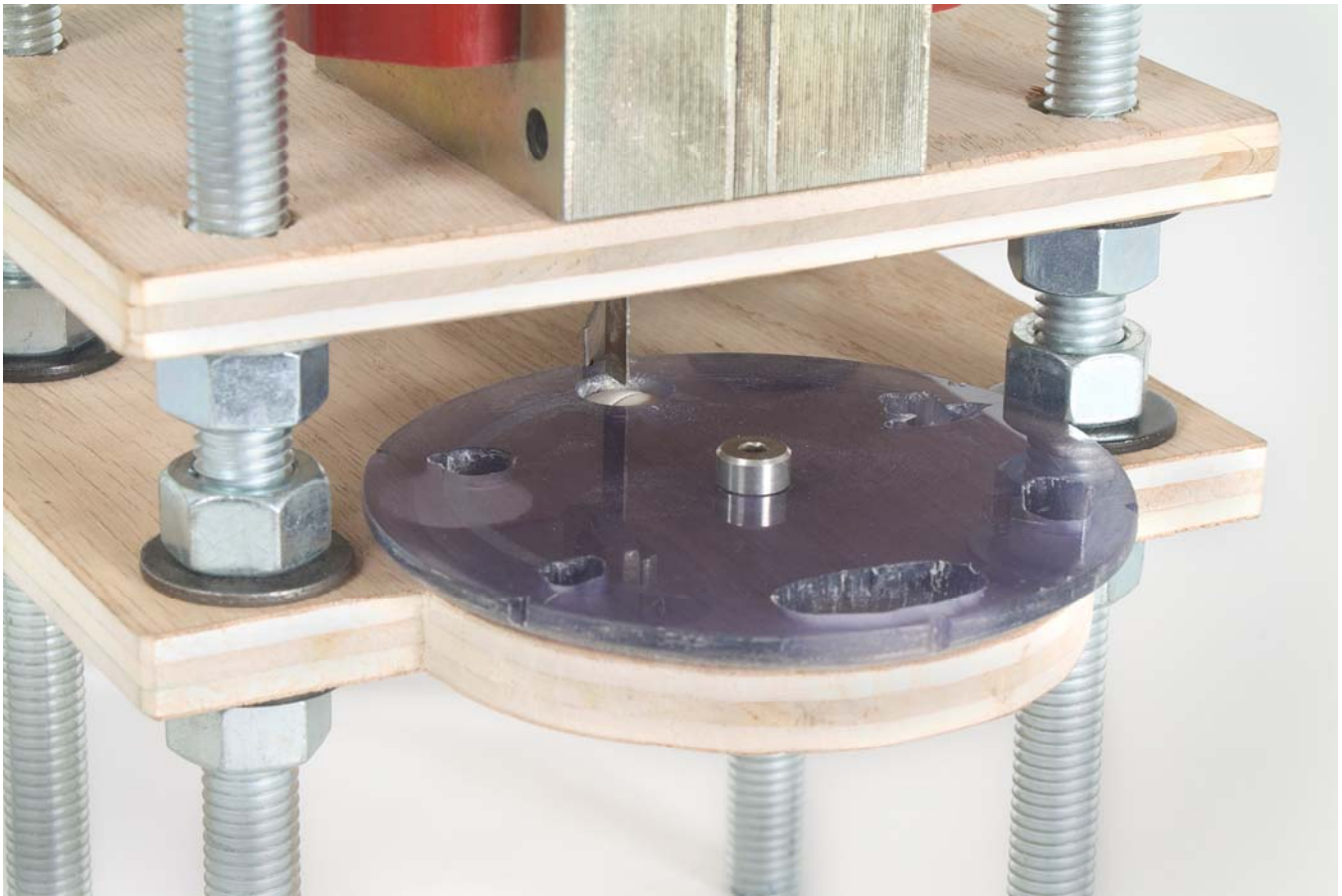


Figure 11.16. Pill Alignment Disk and Cutting Blade

MOTORIZED WEAK GRIP BED HOIST

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INTRODUCTION

A device was designed to enable a client with paraplegia to sit up in bed. He is not able to achieve a sitting position independently.

SUMMARY OF IMPACT

With this device, shown in Figure 11.17, the client's need to rely on others is considerably reduced.

TECHNICAL DESCRIPTION

The client has reduced upper body strength and a weak grip. At the client's request, the device should be easily removable when it is not in use.

The motorized hoist is attached to the foot of a hospital bed and is held in place by a clamping mechanism, as shown in Figure 11.18. A Warn 1500AC Powerwinch provides the power, and is mounted on a 3/8 inch thick aluminum plate. This plate forms the base to which all other components are attached. The use of Bosch aluminum framing enables the device to be easily mounted to the bed frame.

The hoist was designed to clamp over the end of the bed. The top of the clamp hangs on the top rail of the foot of the bed. The bottom of the clamp is removable, and is attached once the device is positioned on the bed. All screws and fasteners were



Figure 11.17. Motorized Weak Grip Bed Hoist

selected such that a 3/16-inch Allen wrench would be the only tool required for installation and adjustment.

A length of the Bosch framing extends vertically from the mounting plate; this is to provide the leverage needed for lifting. The angle of the extension is adjustable to suit the height and needs of the user.

Two-inch-wide nylon webbing is attached to the spindle of the winch. This webbing passes through an adapted seatbelt guide. The guide is secured to a short horizontal member bolted to the upright framing. The benefit of using the seatbelt guide is that it completely surrounds the webbing. This makes it impossible to become detached, which would render the device inoperable.

The other end of the webbing is attached to a 21-inch-long wooden T-bar, which is used to raise the client to a sitting position. Two loops of two-inch wide webbing are attached to the bar, one at each end. These loops are for the client to insert his arms until the loops are located in the crease of the elbow. This allows him to perform the lifting. When his arms are fully inserted through the loops his hands

naturally meet in the middle. The controls for the winch are attached to the bar using a carabiner for easy removal. These controls fall within easy reach of the client's hands. The controls consist of two buttons, one for raising, and one for lowering the patient. Figure 11.19 shows the T-bar assembly.

The control mechanism of the winch is such that when the buttons are released, the T-bar remains at its current height, ensuring that the client is supported at all times. The linear speed of the winch is eight feet per minute, which raises and lowers the patient at a comfortable rate. This winch has a high load capacity. It utilizes 110-volt AC power and so can be used in any hospital or domestic environment. The winch is fully self-contained, requiring no modification to be used in this application.

For finishing touches, plastic end caps were inserted into the framing. Black plastic inserts were also purchased to improve overall appearance.

The total cost for this device was \$475.



Figure 11.18. Hoist Attached to a Hospital Bed



Figure 11.19. T-bar Assembly

WHEELCHAIR-MOUNTED SUCTION SYSTEM FOR RETRIEVAL OF SMALL ITEMS

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INTRODUCTION

A suction system, shown in Figure 11.20, was designed to help people who use wheelchairs or people who are otherwise unable to bend over easily to retrieve items from the ground.

SUMMARY OF IMPACT

The wheelchair-mounted system will allow a user that is unable to leave his or her wheelchair, or to bend over, to retrieve a variety of items from the ground.

TECHNICAL DESCRIPTION

The device has three main pieces: a plunger with an o-ring seal, a hollow vacuum tube, and a hose and suction cup. The base is a piece of plastic tubing two inches in diameter and approximately six inches long. The tube has a $\frac{3}{4}$ inch opening with a hose and suction cup attached. The plunger system operates inside the tube, and is sealed with a two-inch o-ring.

The user places the suction cup onto the item he or she wants to retrieve and pulls the plunger up, which produces a vacuum, and a strong seal is formed on the object. The user can then use his or her arms to pull the item up into the seat. Once the user has pulled the object up, he or she can release the pressure by pushing the plunger back down the tube.

The system can be easily mounted to a wheelchair. Its mounting can be changed for user comfort, to fit different wheelchairs, and is adaptable for left-handed users. The system can pick up any item that weighs less than about four pounds, is nonporous, and has a flat surface equal to or greater than the diameter of the suction cup. To increase the versatility of the system it is easy to replace the suction cup with a larger diameter cup for larger, heavier items or a smaller diameter cup for lighter items with smaller surfaces. This system has three



Figure 11.20. Wheelchair-Mounted Suction System

suction cups: 0.79 inch, 1.63 inches and 3.25 inches in diameter.

The total cost of this project was approximately \$175.



Figure 11.21. Main Components of Device

BATTERY-OPERATED AUTOMATIC TOOTHPASTE DISPENSER

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INTRODUCTION

A dispenser device was created to assist people who have poor mobility or strength in their hands, causing them to have trouble squeezing a tube of toothpaste. This design reduces the physical force this task requires.

SUMMARY OF IMPACT

With this dispenser, people with hand injuries, arthritis or amputation will have an easier time brushing their teeth.

TECHNICAL DESCRIPTION

The dispenser, shown in Figure 11.22, is designed to sit on a bathroom countertop and dispense toothpaste without occupying much space. The tube of toothpaste is loaded from the front and then rolled out from the back forward. A portion of the front panel is hinged such that the tube can be replaced easily.

A one-inch diameter thin-walled acrylic tube was used to make a roller to empty the toothpaste. The tube has chamfered ends that hang over a platform such that the roller makes contact with the platform. The roller has two holes on either end in which a steel 3/16-inch diameter shaft is inserted. There are also two miniature bearings on either side, allowing it to spin freely on the shaft. The shaft is connected to an aluminum bracket on both ends. The bracket comes up and across the top of the roller. In the middle of the roller, the bracket is threaded with 20 1/4-inch threads. Figure 11.23 provides a close-up view.

A lead screw is used to move the bracket and roller assembly forward or backwards, as well to hold it down on the tube. One end of the lead screw is inserted into a flanged end bearing at the front of the dispenser, just above the opening of the toothpaste tube. The other end of the screw is attached to a



Figure 11.22. Battery Operated Automatic Toothpaste Dispenser

small geared motor. The motor is roughly one inch in length and outputs 20.4 inch-ounces of torque. The six-volt DC motor is driven by four AA batteries located directly beneath it. The back of the dispenser, shown in Figure 11.24, is hinged to allow easy access to the batteries and motor.

There are two micro switches attached to the side wall of the dispenser, located at the front and back of the tube. These switches are used to limit the forward and backward motion of the bracket and roller assembly. These small, lever-actuated switches cut power to the motor when they are activated. This ensures that the bracket cannot be overextended. There is one momentary pushbutton and one toggle switch located on the top of the dispenser. The toggle switch, normally off in one position, retracts the roller. In the other position, the toggle switch activates the pushbutton for dispensing. There is also a small LED located in the front middle of the dispenser that blinks when the roller has reached its forward most position, indicating that the tube is empty.

The cost of this project was \$57.

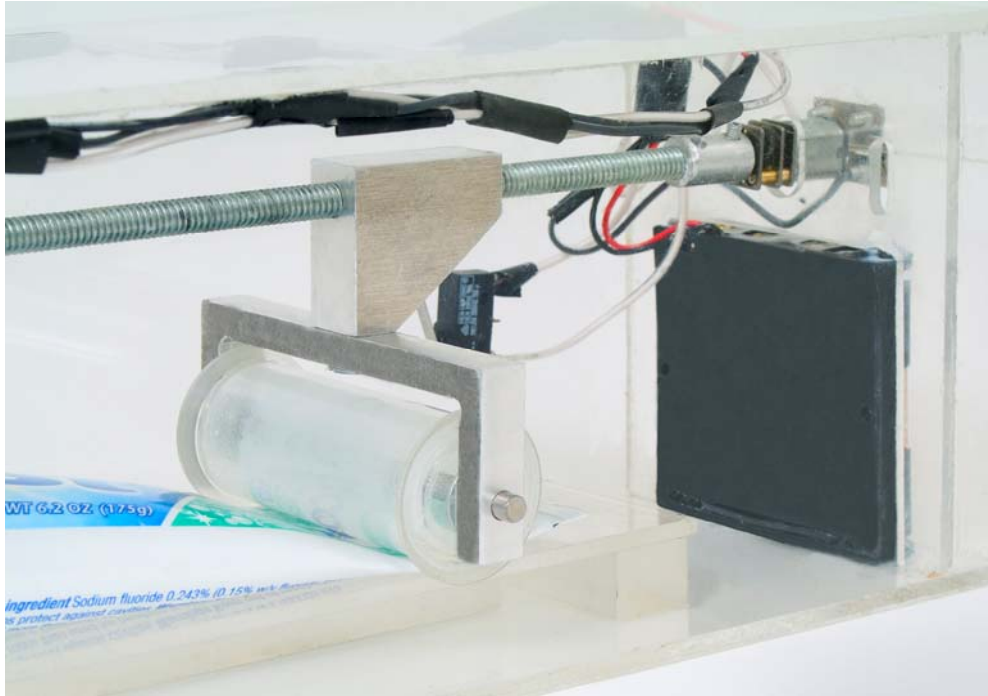


Figure 11.23. Close-up of Roller and Bracket Assembly



Figure 11.24. Hinged Access Door to Batteries and Motor

REMOTE CONTROL ENTRY DOOR

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INTRODUCTION

This device allows for hands-free entry to a home or office via a remote controlled unlocking system. This system also allows the option of using a key for entry if necessary, since only one remote is included in the current design.

SUMMARY OF IMPACT

This device provides keyless entry into a home or office.

TECHNICAL DESCRIPTION

A model of the Remote Control Entry Door is shown in Figure 11.25. A remote control device, similar to that of a garage door opener, activates the system. This triggers a time-off delay relay component, which the user can set to a predetermined time frame. When the timer is active it completes the loop connected to the other electrical components. When a person enters within the range of the motion sensor, the electric strike lock, as seen in Figure 11.26, is unlocked. Once the time has expired the door will re-lock and entry is no longer possible.

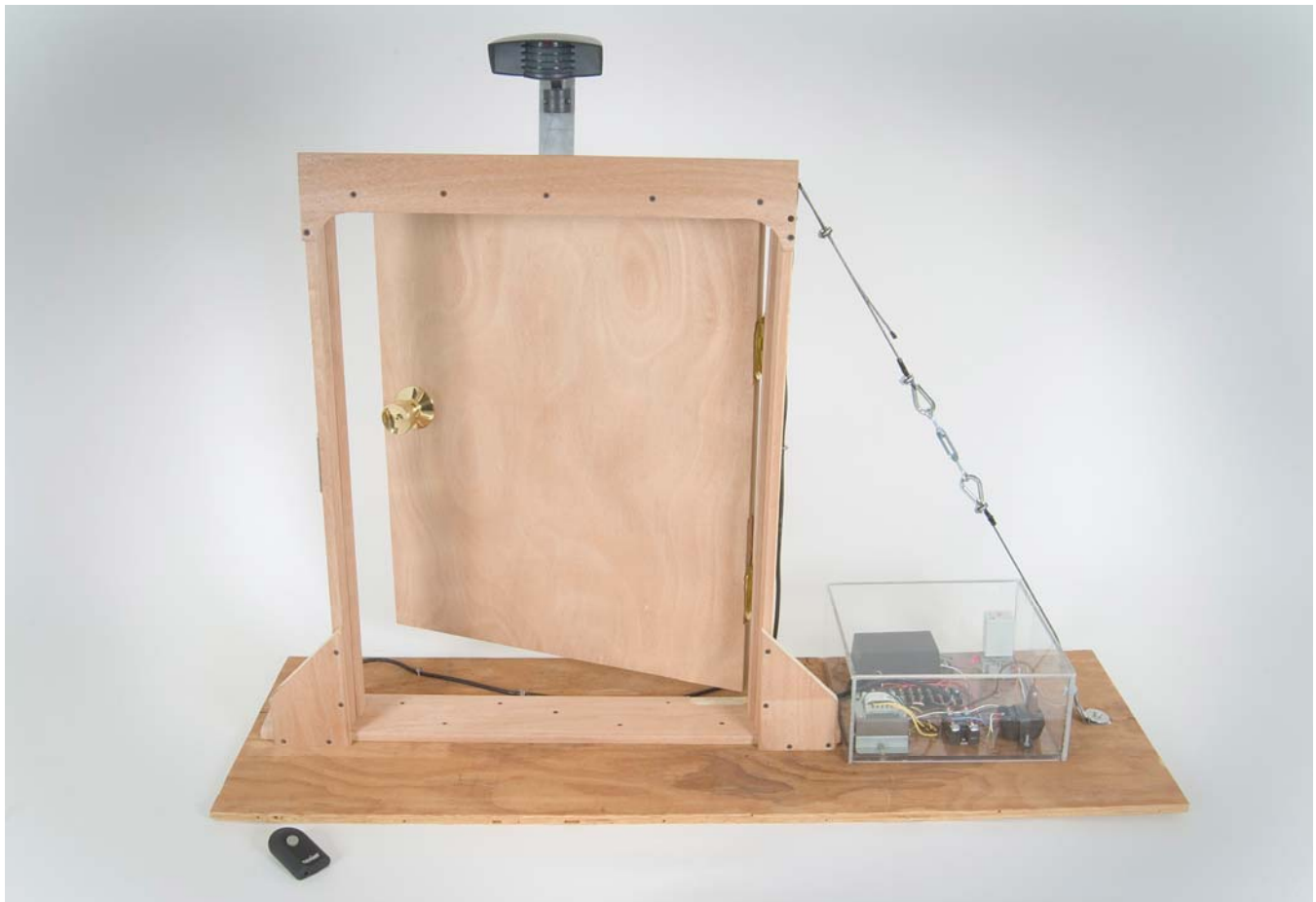


Figure 11.25. Remote Control Entry Door

Most readily available motion sensors run on 120 volts, but the electric strike deadbolt should not be used at a voltage greater than 12 volts, so a compatible model motion sensor was used. The device is timed by an 11-pin octal off-delay relay timer. This timer can be set to range from 0.1 seconds to 10 hours. This timer is the heart of the circuit; it is used to regulate the time and duration of system activation. The 11-pin octal timer plugs into an 11-pin receiving wire harness, in which specific outputs can be achieved by wiring to certain pins. Other components that were used are: 1) a 120-volt to 13- volt transformer to convert the voltage being used by the remote control relay of a garage door opener, and 2) the 11-pin timer in conjunction with a steady-state relay to be able to power the electric strike device and the new 12VAC/DC motion sensor. Figure 11.27 shows a close-up view of the electrical components.

The remote control device works in conjunction with a garage door opener kit and is powered by its own 120-volt transformer. The transformer is tied into an extension cord that allows for one plug to be plugged in, as opposed to the two usually required. The garage door opener transformer is linked to the exterior plug as well as the timer device and other components of the circuit. The timer then runs into a steady-state relay that allows for a switch connection to be made once the motion sensor is triggered. The motion sensor can be put into different operating modes: a test mode, and an operation mode. In the application, the designers found that it was difficult to achieve the desired setting. Through testing, the designers found that one must plug and unplug the device three times or until there is a steady red light from the motion sensor, indicating that it is not sensing. If the red light is off, then it is sensing. During this step, it is advised not to stand within the range of the motion sensor.

The system has not been optimized for commercial use. The electric strike is a noisy device that makes a continuous buzzing sound as long as the motion sensor is activated. The designers suggest that additional research be conducted to minimize or eliminate this. In conjunction with the motion sensor, the designers recommend that a flood-light device be installed that would also activate as the user approaches the door and remain active for the duration of the relay time, providing additional



Figure 11.26. Electric Strike Lock

safety and security. Another possible security risk exists in the ability to open and reopen the door as many times as the user desires within the predetermined relay time. The designers believe that adding a touch sensor to the system would solve this. Upon closing the door, the sensor would send a cut-off signal to the system, thereby locking the door.

The total cost of this project was \$300.

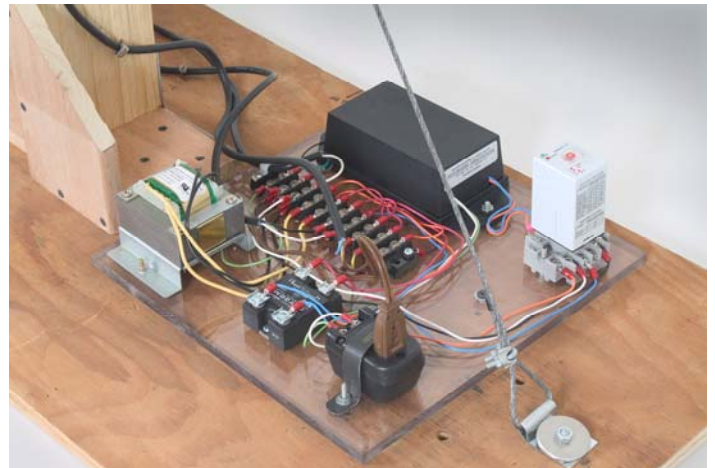


Figure 11.27. Electrical Components

POWERED DESKTOP LETTER OPENER

Designer: Adam Bienas

Client Coordinator: Elizabeth Cuzzacrea

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INTRODUCTION

The Powered Desktop Letter Opener addresses problems people may have in opening their mail. Some people have difficulty holding the thin envelopes to tear them open. Others may not want to use the potentially dangerous knife-style letter openers. The device designed, shown in Figure 11.28, could be of assistance and may also prove useful to any workers who encounter high volumes of mail to be opened.

SUMMARY OF IMPACT

This device makes easier the everyday task of opening the mail.

TECHNICAL DESCRIPTION

The design is intended to be set up on a desktop or counter. The body of the letter opener was constructed out of 20-gauge steel. A pattern was cut, and the appropriate corners were bent at 90° angles to form the base. Another piece was cut out and shaped to form the top of the battery and cutter compartment and two pieces were cut to form the side walls. Two more pieces were cut to form a divider between the battery area and the cutting motor area, and also to act as a cover for the back of the device. All of the pieces were welded together and the back piece was attached with two hinges, as shown in Figure 11.29. The internal pieces of the device were found at a local hobby store. A six-volt motor is used to drive a set of gears that are attached to two circular razors, which were taken from a



Figure 11.28. Powered Desktop Letter Opener

paper shredder. The motor is powered by four AA batteries, and is activated by a small contact switch.

Figure 11.30 shows the device in use. An envelope is inserted into the machine from the right side and slid left until a micro-switch is activated. Upon activation the envelope is pulled through a set of two rotating blades and pushed out of the left side of the device with approximately 1/16 inch cut off of the top. The top of the envelope is also expelled from the left side of the opener as a cover for the back of the device. The battery compartment and two pieces were cut to form the side wall. The letter opener weighs approximately one half pound and measures 8 x 4.25 x 1.75 inches.

The total cost of this project was \$30.



Figure 11.29. Hinged Door of Battery Compartment



Figure 11.30. Close-Up of Micro-Switch and Circular Razors

POCKET-SIZED CHANGE SORTER

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INTRODUCTION

A device was designed to help users, especially those with arthritis, grab coins in deep pockets.

SUMMARY OF IMPACT

By using this device, shown in Figure 11.31, coins become more readily accessible and are presorted for when they are needed. This allows a person with dexterity problems to be able to access their coins independently.

TECHNICAL DESCRIPTION

The design of this device is simple. Coins are placed in a flip-up hopper at one end of the sorter. They then slide down a path and fall into the appropriate

hole. Figure 11.32 shows the device in use. At the bottom of the coin hopper is a thin slot that allows only one coin through at a time, preventing binding. Once the coin has gone through the hopper, it can only follow the linear path cut into a rectangular block of material. Holes are placed according to increasing size, beginning at the end of the sorter, closest to the hopper. The smallest coins fall into the first hole while the larger ones slide easily over it. At each subsequent hole, the same process of the next smallest coin falling and the larger coins sliding over, is repeated until all coins are sorted. The designer made a simple cover to prevent the coins from falling out of the sorter once they have been sorted.

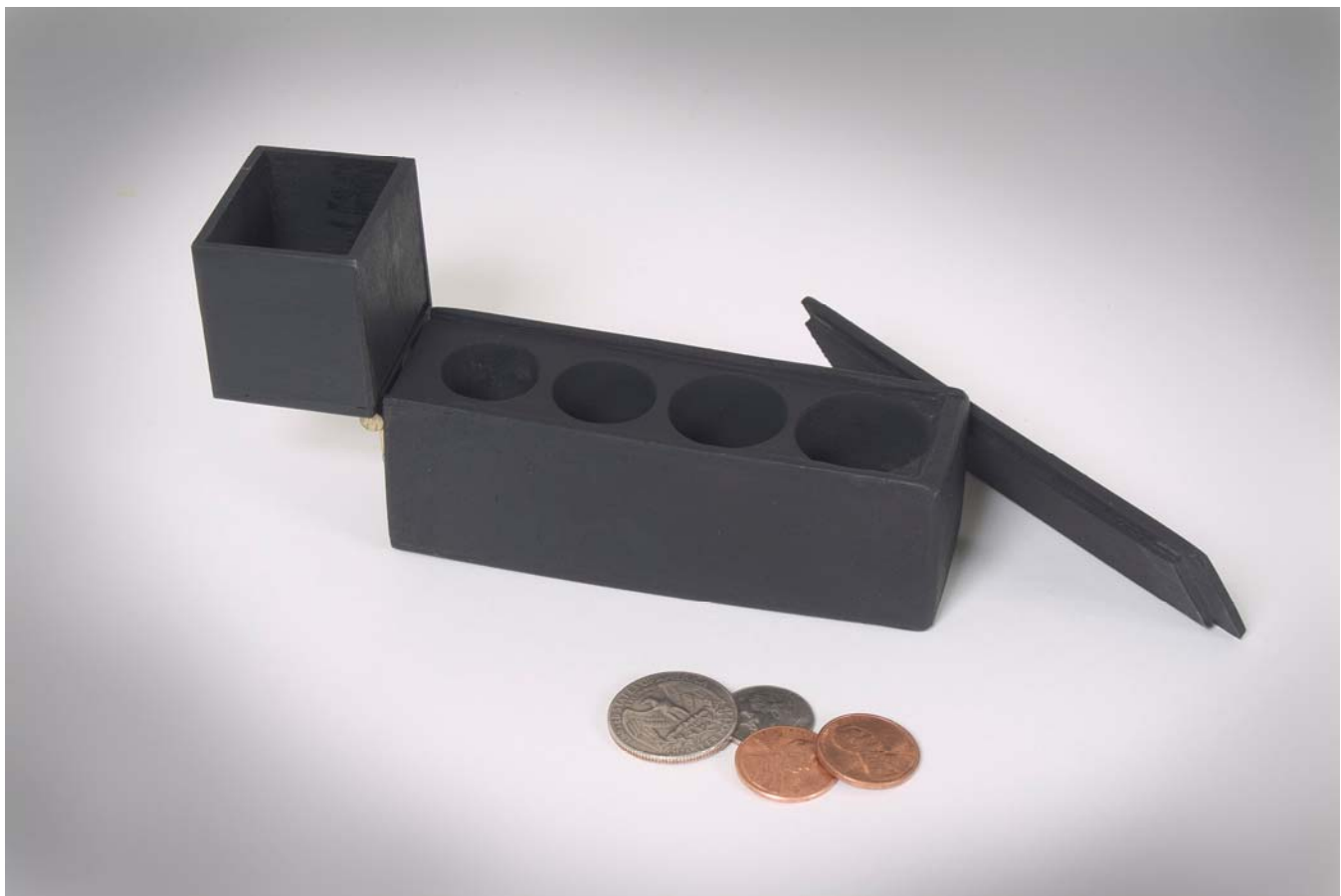


Figure 11.31. Pocket Sized Change Sorter

The sort order is as follows: dimes first, pennies second, nickels third, and quarters last. This device does not sort half dollars, silver dollars, or the new golden dollar coin. The reason is twofold: first, these coins are not often used for purchasing purposes, and secondly, while adding the ability to sort these coins is quite easy, they are large coins and will nearly double the size of the sorter if they are included in the design. The second limitation of the device is that it is designed only to sort coins from the United States. For example, it cannot discern between a Canadian penny and an American penny.



The designer chose wood for this design because of its light weight, ease of shaping, and the fact the coins do not clink against the side. Plastics were considered and are viable, but they are not readily available, nor as easily shapeable for prototype purposes.

Use of this device is as simple as placing a handful of coins into the hopper and shaking it slightly. It works best when held at a slight angle to promote the sliding of the coins. It works for both left- and right-handed people. The hopper is spring-loaded so as to fold out of the way when not in use and hold itself up when in use, as shown in Figure 11.33.

The total cost of this project was \$10.

Figur



Figure 11.33. Hopper in Storage Position

BATHTUB TRANSFER BENCH WITH ROTARY SEAT

Designer: Pek Hao Koh, Sze Chung, Andrew Wong, and Sue Guan Lim
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INTRODUCTION

Individuals who have trouble walking face particular challenges when taking a shower in a bathtub. The Bathtub Transfer Bench with Rotary Seat, shown in Figure 11.34, makes taking a shower in a standard bathtub easy for people with disabilities that affect walking and standing, without the need for costly remodeling. With this product, users will be able to take a shower directly with the volume control from the faucet.

SUMMARY OF IMPACT

With this device, clients take a warm shower directly from the shower spray.

TECHNICAL DESCRIPTION

For this project, the goal was to shorten the process and make the user able to take a shower directly from the existing spray without renovating the bathroom. This design is based on the Deluxe Transfer Bench with Back, by Nova, which is a simple transfer bench. The Nova design is a rigid frame without a rotary system. Once properly set up, the user fills the bathtub with water and takes a shower using a scoop. There are many similar products on the market, but the current design requires multiple steps for use and too much time.

In this project, the Nova device was redesigned to address its shortfalls. To keep this device safe for use and maximize the angle of rotation, the existing frame was bent downward. This gives the bench a wider range of movement, maximizes the use of the limited bathtub space, and allows the original height-adjustable system to be used without modification.

In order to make the rotary system work well, the original frame was cut and redesigned to connect the two stands from the bottom. For the rotary system, the bearing was pressed into the bearing



Figure 11.34. Bathtub Transfer Bench with Rotary Seat

seat, which was machined from the tubing. The end of the bearing seat was welded to the frame. Then, the shaft was pressed into the inner bearing, where



Figure 11.35. Seat in Upright Position

the other end of the shaft is connected to the seat. For this device, the bearing used is one inch; however, a bearing of greater length is suggested to create stable rotating motion. The rotating motion sinks to the other end of the side, due to an imbalance in the length of the two sides; however, this is solved by using the plywood to help the shaft rotate properly.

The original Nova seat is two inches thick. Manufacturing difficulties and impracticality associated with this thickness provoked a design change to $\frac{3}{4}$ -inch thick plywood screwed onto a $\frac{1}{4}$ -inch thick steel or aluminum plate. The purpose of the $\frac{1}{4}$ -inch steel plate is to increase the strength of the plywood. The reduction of the thickness for the seat affects the pin that holds the right angle position of the end at the outside of the bathtub because the size of the pin must fit into the seat. It is designed to have a pin with a $\frac{1}{2}$ -inch diameter. The

seat is rectangular and has a 90-degree folding end. In the straight position shown in Figure 11.34, the folding end is on the outside of the bathtub to allow the user to transfer from a wheelchair. In the other position, the folded end is used as a handle, as shown in Figures 11.35 and 11.36.

At the point where the hinge is placed on the board, there is a piece of plywood to increase the support of the downward force when a person is transferring into the bench. This is for conceptual purposes; an improvement on this would be a conveyer path to increase smoothness while rotating. The foam that covers the frame to avoid damage to the tub is also for the proof of concept. The design intended for manufacturing includes rubber or vinyl due to the water contact while showering.

The total cost of this project was \$200.



Figure 11.36. Seat in Upright Position and Rotated

TURN-EASE MOTORIZED REFRIGERATOR LAZY SUSAN

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INTRODUCTION

Many people rely on crutches, walkers, or wheelchairs to get around the house. One challenge that they encounter on a daily basis is accessing items stored in a refrigerator. The Turn-Ease Motorized Refrigerator Lazy Susan, shown in Figure 11.37, addresses these difficulties.

SUMMARY OF IMPACT

This device allows anyone to easily rotate items stored on a refrigerator shelf with the touch of a button. It is simple to install in almost any refrigerator.

TECHNICAL DESCRIPTION

The goals for this project were to adapt an existing Lazy Susan to be turned by an AC gear motor, to



Figure 11.37. Turn-Ease Motorized Refrigerator Lazy Susan

power the motor using a refrigerator's light socket, and to operate the device safely using a single pushbutton. Off-the-shelf parts were incorporated wherever possible to reduce cost. For size and weight considerations, an 18-inch Lazy Susan with a 150- pound capacity was chosen. The base is a stainless steel plate that turns, has rustproof ball bearings and features a one-inch lip to prevent items from sliding off.

Next, a 50 rpm shaded pole motor was selected to provide rotation. The model utilized is designed for the type of intermittent use this device requires, and includes a magnetic brake. When combined with a three-inch rubber wheel contacting the Lazy Susan on its outer edge, a rotational speed of just over eight rpm is obtained. The wheel is tapered to best interface with the Lazy Susan, and is made of styrene butadiene rubber (Shore A40 hardness), which will resist deformation and hardening in a refrigerated environment.

For operation, a simple on-off pushbutton switch is employed. Safety is ensured by the switch's

connection across a 120 volt to 12.6 volt transformer. In the unlikely event that the user receives an electric shock, the transformer ensures that he or she will not be injured.

The base was constructed out of 1/8-inch acrylic measuring 18 x 19 inches. An acrylic ring, also 1/8 inch thick and 1/4 inch wide, is glued in its center. This ring holds the stationary bottom of the Lazy Susan in place. The rear corners of the base provide a location to mount the motor and transformer, as shown in Figure 11.38.

To power the device, a two-outlet light socket adapter, was modified as necessary. This solution offers many advantages. It utilizes electricity already available inside the refrigerator and requires no modifications. The device is only powered when the refrigerator door is open. Once the device is installed, the refrigerator light operates normally.

The total cost of this project was \$125.



Figure 11.38. Close-up of Motor and Transformer

EASY-STORE EASY-USE CRUTCHES

Designer: Phillip Palma

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INTRODUCTION

People who use crutches often have difficulty storing them. The Easy-Store Easy-Use Crutches, shown in Figure 11.39, were developed to relieve this problem. The crutches were designed to be collapsible into three separate parts using bungee cords. They are also foldable. The reduction in the overall size of the crutches makes it easier for the user to store them where space is limited.

SUMMARY OF IMPACT

This device eliminates storage problems associated with traditional crutches. The design also makes it easier to carry the crutches. The crutches can be assembled quickly and easily. Furthermore, the Easy-Store Easy-Use Crutches are strong, lightweight, comfortable, affordable, and safe.

TECHNICAL DESCRIPTION

A pair of height adjustable aluminum crutches was each cut into three separate pieces. The top segment is 14 inches, the middle is 12.25 inches, and the bottom is 16 inches. These specific lengths were chosen so that upon folding, all three pieces of each crutch would align at one end.

The next step was to build the inserts that would be welded to the proximal ends of the bottom and middle segments. These inserts would then slide into the distal ends of the middle and top segments. The inserts were made from a 3/4 inch diameter aluminum rod. Eight pieces were cut from the rod, each with a length of two inches. Each piece was then designed to have step cuts 1/4 inch from the bottom and 3/4 inch from the top. Both steps have a diameter of 13/20 inches. A 3/8 inch hole was then drilled into each piece in order for the bungee cords to pass through.

Once the aluminum inserts were welded, the last step was to insert the bungee cord starting from the bottom and passing all the way through to the top segment of each crutch, where it was then wrapped and tightened by a metal wire. The result is a pair of crutches that can be folded into a more compact size using bungee cords. Figure 11.40 shows the collapsed state of the crutches. The combined weight of the crutches is 6.0 lbs.

The total cost of this project is \$45.



Figure 11.39. Easy Store Easy Use Crutches



Figure 11.40. Crutches in Folded Position

ROTATIONAL SHOWER SCALD SAFE VALVE

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INTRODUCTION

This project addresses the devastating injuries that can occur when a person comes into contact with unsafe water temperatures while showering. People who are elderly or have mental or visual impairments are especially vulnerable to accidental exposure to scalding water. Scalding leads to additional injuries such as heart attack, shock, and fall-related injuries such as broken bones. This device is designed to sense the possibility of scalding and block water flow before the user is harmed.

SUMMARY OF IMPACT

This device can extend the freedom of those in need by allowing them to shower in privacy without the risk of scald injuries. By protecting them from unexpected temperature shocks and scalds it will increase the users' confidence, comfort, and safety while showering.

TECHNICAL DESCRIPTION

The device, shown in Figure 11.41, consists of two 3.25 inch diameter, 0.25 inch thick discs that are machined from a ceramic material. Each disc has eight 0.25 inch diameter holes drilled around its center on a 2.125 inch bolt pattern. When placed together, the holes' alignment can be rotated to allow or block water flow. The discs are held on a shoulder screw with a nut and washer; the front disc is fitted with a bearing allowing its rotation in front of the rear disc.

The rotational force is created by using a passive actuator, requiring no power source other than the water itself. The actuator is a 0.015-inch-diameter,



Figure 11.41. Rotational Shower Scald Safe Valve

8.5-inch long Nitinol (Nickel/Titanium alloy) wire that contracts five percent of its total length upon being heated to a specified scald temperature.

The wire is housed in a 0.125 inch groove inside the front disc with small water passages drilled into it (See Figure 11.42). Each end of the wire is secured by a metal pin. One pin is fitted through both discs but is given a passage for movement only in the front disc. The other end is in a pin secured only in the front disc, allowing movement. When water passes through these passages it transfers its heat to the wire. When the wire reaches the desired activation temperature it pulls the pin embedded in the front disc, which has a bearing in its center, and rotates. This rotation blocks the holes in the back disc and prevents water flow through the valve.

The cost of this project was \$100.



Figure 11.42: Valve Open Showing Wire and Groove

APPARATUS FOR REMOVAL AND TRANSPORTATION OF GARBAGE

*Designers: Robert T. Giza, and Valerie M. Ringler
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INTRODUCTION

This project addresses the problem many people face when attempting to remove garbage from their homes. The device, shown in Figure 11.43, while designed to lift the garbage bag out of the can, also allows for the transport of the garbage bag with minimum effort, further decreasing the work required.

SUMMARY OF IMPACT

This device will ease the everyday frustrations many people encounter when attempting garbage removal in their homes.

TECHNICAL DESCRIPTION

The Apparatus for Removal and Transportation of Garbage is an assistive device that uses a hydraulic hand pump to aid in the removal of garbage bags from garbage cans. The device is a mechanical hoist with caster wheels at its base for ease of mobility. The rear caster wheels have locking mechanisms to allow for the 65-pound device to remain stationary when required. The user maneuvers the lifting arm over the garbage can and attaches the bag as necessary. Then the user strokes the pump, which forces the arm to rise, lifting the bag out of the can, as shown in Figure 11.44. The user can then move the bag to a desired location by simply rolling the device. Once at the desired location, the pump's pressure relief allows the arm to drop down to a more convenient height, as shown in Figure 11.45.

Mild Carbon A 500 1.5 inch steel square tubing with a 1/8 inch thickness was used for the frame, along with a three ton hydraulic hand pump. Recommendations for a final prototype include moving the location of the back wheels roughly 4 inches back, using a smaller hydraulic pump requiring fewer strokes, using large caster wheels, and using thinner steel. Moving the wheels back improves the center of gravity of the lift, decreasing



Figure 11.43. Apparatus for Removal and Transportation of Garbage

the possibility of an accidental tip. The hydraulic pump was designed and could easily be replaced with a less powerful model that produces a force of roughly 400 pounds. Increasing wheel size will make the device appropriate for use across a greater variety of surfaces. A wall thickness of 0.025 inches for the tubing would safely handle the maximum moment occurring through the pivot arm. The total cost of this project was \$160.



Figure 11.44. Arm in Lifted Position



Figure 11.45. Arm in Lowered Position

TANGLE-FREE CPAP MASK

Designers: Matthew Davis, and Angelo La Greca

Client Coordinator: Alfonso La Greca

Supervising Professor: Dr. Joseph C. Mollendorf

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INTRODUCTION

Some persons with sleep apnea wear a mask while sleeping to ensure adequate air supply to their lungs. The mask design, shown in Figure 11.46, is more comfortable than current models and eliminates strangulation hazard to the user by relocating the air supply hose away from the user's extremities. It also increases the user's range of motion of by adding rotational flexibility to the air supply hose.

SUMMARY OF IMPACT

As a side effect of sleep apnea, persons with this condition are typically restless sleepers, causing them to toss, turn, and get tangled in the air supply hose. The Tangle-Free CPAP Mask eliminates the strangulation hazard posed by standard CPAP masks, making the product safer and less restrictive.

TECHNICAL DESCRIPTION

This design utilizes the advantages of current mask designs, while providing more safety and comfort to the user. Typical CPAP mask designs have the air supply hose leaving the mask at the user's face, so that they are left free to drape across the bed and bedroom. This puts the hose in a prime location to become wrapped around the user's neck. To eliminate this problem, the air supply hose on the Tangle-Free CPAP Mask is guided to the crown of the user's head where it is connected to the semi-rigid headgear, as shown in Figure 11.47.

The semi-rigid connection between the mask and headgear allows the hose to be fixed in a position away from the user's extremities where it does not pose a threat to the user. The semi-rigid construction also allows some compliance for greater comfort. For added convenience, the plastic headgear is connected to the adjustable fabric and elastic straps by Velcro hook and loop fasteners, which allows the plastic and fabric components to be easily separated for cleaning.



Figure 11.46. Tangle-Free CPAP Mask

A continuous, steady flow of air to the user is the mask's main function. This design employs a swivel elbow, capable of unlimited rotation, at the connection between the air supply hose and the headgear. The added joint prevents kinking in the hose and compromised air supply when the user rolls in his or her sleep. This keeps an unobstructed air supply flowing to the mask and allows the user more freedom of movement than current designs.

Another feature that differentiates this mask from others that are currently on the market is the tensioner, shown in Figure 11.48. To keep the excess air supply hose away from the user, the tensioner utilizes a constant force spring and retractable cord mechanism that is similar to the retractable power cord on many vacuum cleaners. The tension cord is attached to the hose between the headgear swivel elbow and the air pump, where it applies enough force to pick up the excess hose and hold it in the air, away from the user's extremities. By utilizing a low stiffness constant force spring, the user is still able to use the excess hose. As the user pulls on the air supply hose, additional cord is released from the tensioner to allow the excess hose to straighten out

and the user to move further away from the air pump without adding tension to the hose.

The client had only two negative comments: The air flowing out of the overflow vent made his spouse cold; and he had to sleep further down in his bed to prevent the swivel elbows from contacting his headboard. To address the first issue, a diffuser mask was added to diffuse the air leaving the overflow vent. Unfortunately, the second issue is inherent to this design. Given that it is necessary to have the hose and connections at the top of the head, the user will have to sleep further down in the bed. However, this problem will not be as pronounced in production versions, because the size of the mechanism at the top of the head will be minimized.

The total cost of this project was \$148.



Figure 11.47. CPAP Mask in Use

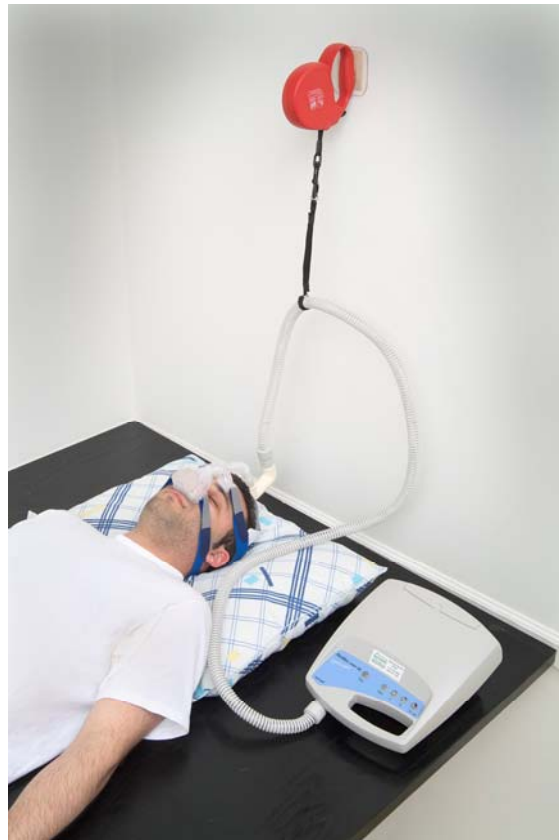


Figure 11.48. Mask, Hose, and Air Pump System in Use

CANE SEAT

*Designers: Darren K. Leskiw, Benjamin T. Miller, and David M. Wollaber
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INTRODUCTION

Roughly the same weight as a conventional wooden cane, the Cane Seat provides the same support with the added dimension of becoming a stool, as seen in Figure 11.49. This is an important aspect of the design because similar products are heavier than conventional canes. The innovative design combines cane and seat functionality into one sleek device.

SUMMARY OF IMPACT

With the Cane Seat, a person can rest at any location, eliminating the need to seek out available benches and chairs along their paths. The one-size-fits-all design enables a wide range of users to take full advantage of the Cane Seat.

TECHNICAL DESCRIPTION

The Cane Seat's collar and legs are made of 6060 Aluminum, and thus are lightweight and strong. While in cane mode, the three legs are collapsed, forming a conventional cane. The $\frac{3}{4}$ -inch-diameter legs are bound together using a Velcro strap, as seen in Figure 11.50, to restrict the legs from opening.

The legs are attached to the circular collar approximately 14 inches from the ground-ends. The collar was machined so that all the legs open counter-clockwise tangentially to the collar, as shown in Figure 11.51. When opened completely in seat mode, the legs form a 60-degree angle to the ground.

The triangular canvas seat is riveted to the top ends of the two 22 inch legs and eight inches down from the 30-inch handle leg. The $\frac{7}{8}$ inch diameter handle is inserted over the $\frac{3}{4}$ inch diameter leg and secured using an adjustable spring clip. The handle has two height adjustment settings.

For future designs, the canvas seat could be made from a stronger, more weather-resistant material.



Figure 11.49. Cane Seat in Stool Mode

Also, by increasing leg diameter, the cane seat could accommodate larger loads.

The cost of parts and materials for this project was approximately \$75.



Figure 11.50. Cane Seat in Cane Mode



Figure 11.51. Close-up of Machine Collar that Restricts Legs from Opening Improperly

PAPER CURRENCY IDENTIFIER

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INTRODUCTION

By using the Paper Currency Identifier, shown in Figure 11.52, people with visual impairments can verify that the money they are given is valid United States paper currency. Once the money is identified as authentic, the value of the money is determined and made known via an audio output.

SUMMARY OF IMPACT

The design contributes to the independence of people with visual impairments through automatic verification and identification of authentic paper currency and its value.

TECHNICAL DESCRIPTION

This design incorporates and adapts an off-the-shelf bill validator and a microcontroller. The bill validator is a model BL-700-USDI type made by International Currency Technologies. This is similar to others which are commonly used in vending machines. The validator accepts paper money (specifically \$1, \$5, \$10, and \$20 bills), authenticates them, and then returns a pulse output signal indicating the denomination of the bill. The microcontroller, built by Axiom Manufacturing, is a model CME-11E9-EVBU board. This is used to hold the non-volatile memory chips which contain the computer codes for the conversion of digital pulse signals to analog audio responses. The inner components can be seen in Figure 11.53.

A digital-to-analog converter is built adjacent to the microcontroller. This uses eight resistors in parallel ranging from 680 to 150k ohms. Each resistor is approximately double that of the previous resistor. An ideal digital-to-analog converter would have exactly double the resistance from one resistor to the next. These can be purchased rather than built, and would result in a much clearer analog representation of the audio file. Because of the inexactness of these resistance steps, the clarity of the output is diminished. The audio file is contained on an eight-bit memory chip. By using an eight-bit



Figure 11.52. Paper Currency Identifier

device there was a need to perform a considerable amount of editing to the sound wave forms. If, for example, a 16-bit chip were to be utilized, the quality of the audio response could be enhanced further.

The unit is housed in a 4 x 6 x 10 inch sheet metal box. The money is returned via the front of the unit, below the validator intake slot. In order to achieve this, the validator was modified to return the bill through its bottom, instead of through the rear, and

a return chute was added inside the housing to steer the money toward the front. Access panels are located on the rear and the underside of the unit. The rear panel has a three-inch speaker mounted to it, which faces the back. A series of small holes were drilled here to allow the sound to escape freely. Brackets inside the unit allow the microcontroller to slide in and out for maintenance or repair. A bolt through the circuit board and bracket secure it. Above the rear panel is a female type "M" jack which brings power to the internal components. This allows for a wall adaptor with a male type "M" jack to supply power to the unit. The adaptor converts a 120-volt power supply to 12 volts at 1.5 amperes of current.

For convenience, a handle was mounted to the top of the unit. Four padded feet are located under the bottom access panel. A Braille plaque is located below the intake slot on the validator. This reads "Accepts \$1, 5, 10, 20."

Recommended improvements are: a Plastic housing, increased memory, an ideal digital-to-analog converter, an inexpensive validator to lower costs, and a smaller size (preferably similar to a standard checkbook or wallet).

The total cost of this project is \$450.

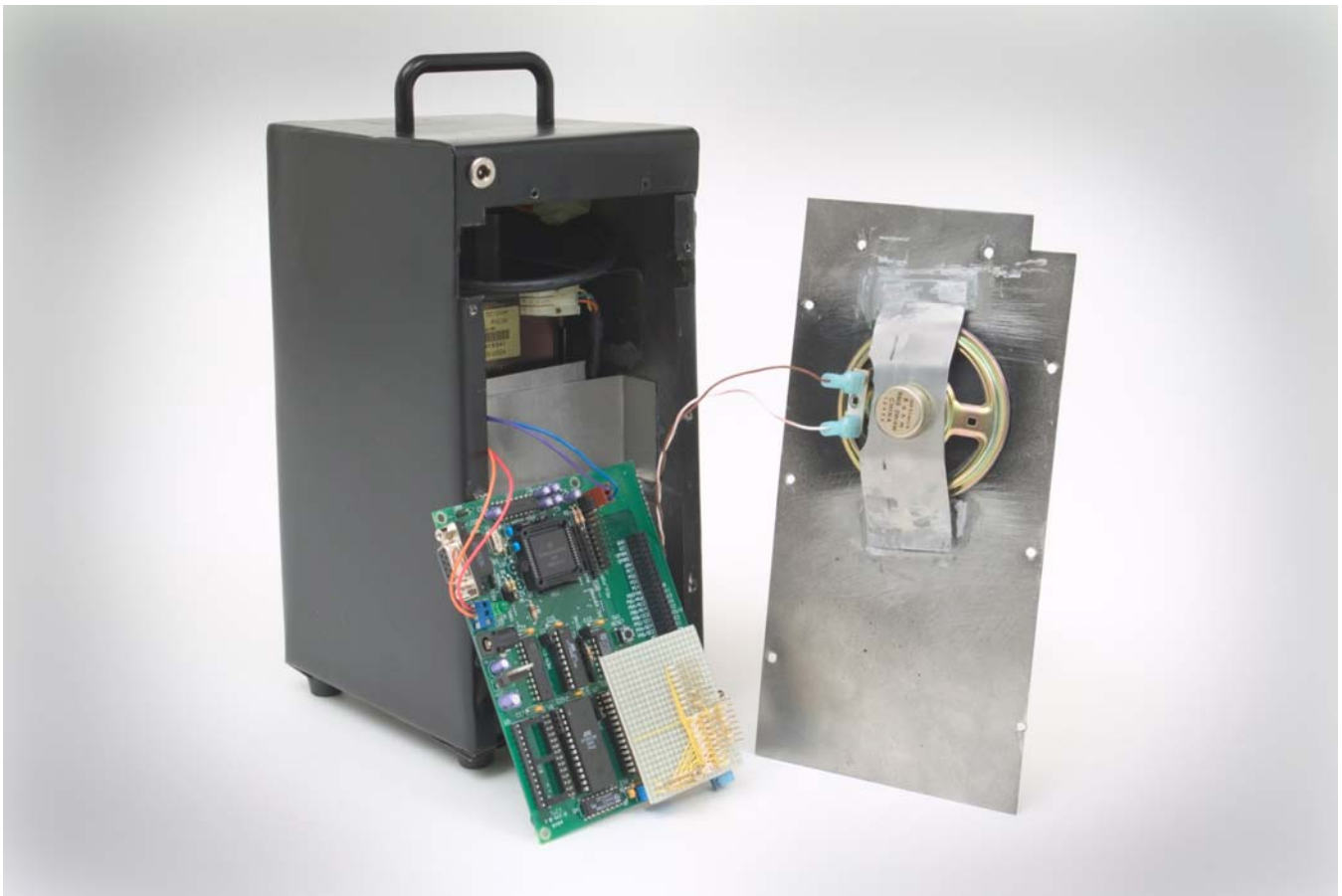


Figure 11.53. Inner Components

ADJUSTABLE MECHANICAL REACHER

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INTRODUCTION

Many people with limited mobility have difficulty reaching items on the floor, high shelves, and other remote places. Mechanical reaching devices are available to assist these individuals in retrieving items in hard to reach places, however most commercially available devices have a fixed length ranging from approximately 15 to 36 inches. This design, shown in Figure 11.54, is a mechanical reacher that allows the user to adjust the length via a telescoping mechanism.

SUMMARY OF IMPACT

The device is a significant improvement over existing mechanical reachers because its length can be adjusted to best suit the user's needs. The design is simple and reliable.

TECHNICAL DESCRIPTION

The Adjustable Length Mechanical Reacher has several parts, including a frame, hand grip, trigger, sliding arm, fixed arm, two-prong collar, and object

grasping paddles. The frame consists of two parallel PVC tubes that are bound together. The frame's PVC tubes contain the fixed arm and the sliding arm. The fixed arm is rigidly bound to the frame. The sliding arm can move about 1.5 inches longitudinally within the frame.

A hand grip is rigidly bound to the frame rearward of the sliding arm. The hand grip is made of plastic and is designed to function similar to the hand grip on a pistol, as shown in Figure 11.55. A trigger is rigidly fixed to the sliding arm so that the user can move the sliding arm within the frame. A compression spring is located in the frame between the hand grip and the trigger and sliding arm. When the trigger is released, the compression spring forces the sliding arm to move away from the hand grip.

Both the fixed arm and sliding arm consist of two aluminum tubes. The two aluminum tubes make up the telescoping mechanism for the mechanical reacher. They have inner and outer diameters that allow one tube to slide within the other. Both tubes



Figure 11.54. Adjustable Length Mechanical Reacher Extended to Full Length

are fitted with plastic bushings that allow the smaller diameter tube to slide within the larger diameter tube without the aluminum tubes making contact (i.e., only the plastic bushings make contact with the aluminum tubes). This design prevents galling of the aluminum tube surfaces. The smaller diameter tube contains a push-button mechanism. The larger diameter tube contains holes that the push-button mechanism goes through. The larger diameter tube position remains fixed until the push-button mechanism is pushed through the hole.

Object-grasping paddles are connected to the sliding arm by a dowel. The dowel is placed through a hole in the paddles and acts as a hinge. A two-prong plastic collar is rigidly attached to the fixed arm. The second prong of the two-prong collar allows the sliding arm to slide within it. The two-prong collar acts as a pivot point for the grasping paddles. A compression spring is located between the object grasping paddles to force the paddles apart when the object is released, as shown in Figure 11.56.

The sliding arm moves longitudinally within the frame by squeezing the hand grip and trigger together. As the sliding arm moves rearward, the object grasping paddles are forced together by the two-prong collar. When the trigger is released the sliding arm moves longitudinally forward and the object grasping paddles move apart.

The Adjustable Mechanical Reacher's length is adjustable from 33 to 39 inches. This device is recommended for moving objects up to one pound.

Thin-wall (~0.020 inch) aluminum tubing is recommended for the sliding arm, fixed arm, and frame to reduce the overall weight. Also, the object grasping paddles should be made of a slightly thicker (~0.080 inch) steel to increase their strength.

The total cost of materials was approximately \$45.



Figure 11.55. Close-up of Hand Grip



Figure 11.56. Close-up of Object Grasping Paddles

ADJUSTABLE SCISSOR LIFT TO MOVE A PERSON BETWEEN A WHEELCHAIR AND THE FLOOR

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Client Coordinator: Ray Carter

Supervising Professor: Dr. Joseph C. Mollendorf

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INTRODUCTION

For people who use a wheelchair, it is often difficult to access objects that are at ground level. Some use the strategy of lowering themselves from their wheelchair and then attempting to climb back up to a height of 20 inches or more. This puts a strain on the arms, shoulders and back. The goal of this project is to alleviate this problem by designing a lift that can be raised and lowered by the user to allow for transfer to the floor.

SUMMARY OF IMPACT

By allowing a person who uses a wheelchair to lower him- or herself with little trouble, the device, shown in Figure 11.57, will provide greater independence. The only outside assistance necessary will be to move the lift into position; after this point, the user can move freely between the floor and the wheelchair as the task requires.

TECHNICAL DESCRIPTION

This device utilizes a scissor mechanism to raise and lower the lift. The scissors allow for a fully collapsible lift, so that at the lowest height the users will be able easily to slide themselves onto the floor. It also provides for a stable up and down motion that supports the weight of the user evenly throughout the structure.

The basic frame of the lift is made up primarily of 1 x 1-inch 4130 steel square tubing, with a 0.049-inch wall thickness. This material provides strength while adding less weight compared with similarly strong materials. The tracks that support the movement of the scissor arms are standard steel angle irons, which give the base and the top rigidity and a sturdy track to move along. The arms are powered by a threaded rod with a 0.5-inch outer diameter, which is turned by manually cranking a ratchet attached on one end, as shown in Figure



Figure 11.57. Adjustable Scissor Lift in Raised Position

11.58. A plastic chair is mounted on top of the lift to provide back support and comfort.

Plastic casters are mounted onto the side of the base of the lift to allow for easy transport, while not increasing the minimum height of the lift, as shown in Figure 11.58. The lift can be moved in a fashion similar to that of a wheelbarrow. The handle of the ratchet is extendable to a length of 1.25 feet, which lowers the force needed to turn the threaded rod. The ratchet can also be folded over, which allows the ratchet to be kept safely attached to the lift while in storage or during movement.

The maximum height of the lift is over 36 inches, but there is a safety mechanism inserted to limit the height to only 25 inches to ensure stability and a proper center of gravity. The lowest height possible is seven inches, as shown in Figure 11.59. This is a much more manageable height from which to lower

oneself than the usual wheelchair height of about 20 inches. The total weight of the lift is roughly 55 pounds.

The total cost was \$253.

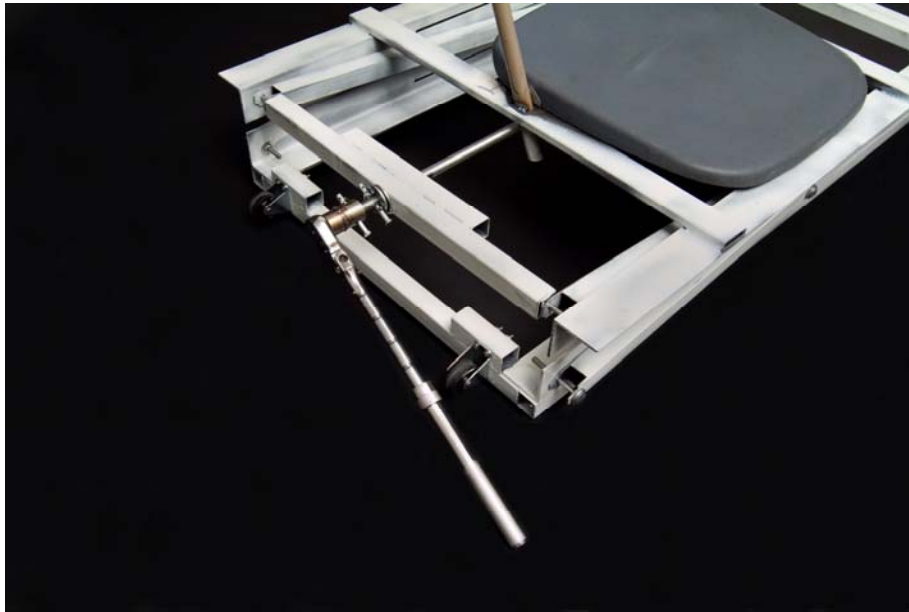


Figure 11.58. Ratchet and Wheels

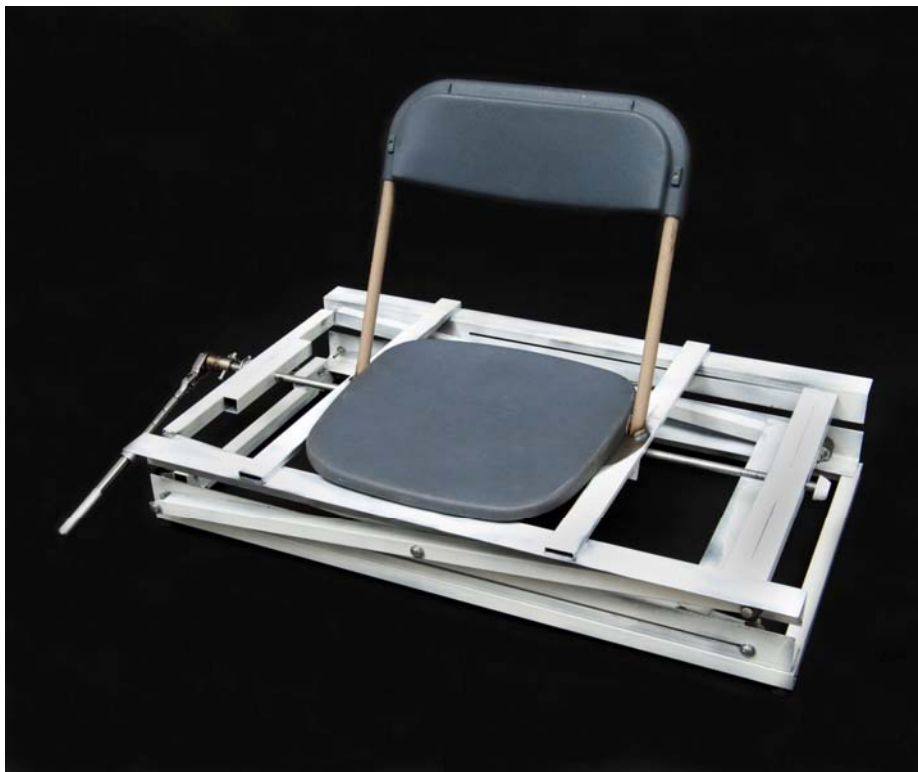


Figure 11.59. Lift in Lowered Position

ONE-BUTTON INFRARED REMOTE CONTROL

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Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

Remote controls for modern electronic media products such as televisions, VCRs, and DVD players have become increasingly complex, with the number of buttons on a single remote often exceeding 30. For children, the elderly, and people with cognitive disabilities, these controls can be confusing and difficult to use. To address this problem, an infrared remote control was developed to be capable of performing a sequence of functions for any infrared-controlled electronic device with a

push of a single button, as shown in Figure 11.60. Using the program coded into the remote, a portable DVD player will play when the button is pushed.

SUMMARY OF IMPACT

This device will simplify the use of any infrared electronic device for which it is programmed. The remote holds 8 kb of total memory, which enables a preprogrammed sequence of functions to be stored and then carried out at a push of a single button. For example, if the remote is programmed for a child's



Figure 11.60. One-Button Infrared Remote Control

television, pushing the button once could turn the television on, turn to half maximum volume, and turn to a specific channel.

TECHNICAL DESCRIPTION

The remote consists of a normally open pushbutton, a 40 kilohertz clock oscillator, a 12-bit counter, an 8 kb reprogrammable memory chip, and an infrared LED. It is powered by a nine-volt battery. Holes were drilled in the outer casing for the button, LED, and mounts for the circuit board. All of the components on the circuit board, shown in Figure 11.61, were connected using wire wrapping.

A portable DVD player was selected as the programmed remote prototype as it was easy to transport for exhibitions. The designers programmed the remote to make a DVD play once it was inside the player and the remote button was pushed. In order to accomplish this, the infrared impulses coming out of the new remote must match those coming out of the DVD player's original remote. The original remote was directed at a phototransistor and the "play" button was pushed. The data stream was recorded and saved into the computer for analysis. The sequence of pulses was found to last for 500 microseconds each. Computer code was written to match the pattern and it was saved to the memory chip.

When the user pushbutton is pressed, the set/reset flip-flop is set and latched. Its output enables the 40 kilohertz clock oscillator, brings the 12-bit counter out of reset, and pulls the CE and OE of the memory chip LOW to enable it for reading.

The 12-bit counter generates a binary sequence, which is applied to the reprogrammable memory chip. This causes the circuit to access each memory address in an ascending sequence. Data output bit zero of the memory chip is connected to the infrared LED driver circuit. Depending on the data programmed in the chip, each address can turn the LED on or off as desired. Data output bit seven is connected to the "reset" side of the set/reset flip-



Figure 11.61. Internal Remote Components

flop and is used to end the sequence when desired. Data output bits one through six are not currently used, although they could be used for future expansion. The data coming from output bit zero is programmed to both pulse settings, the infrared LED at a nominal 40 kilohertz and also to generate the code sequences necessary to control the remote device. The data output bit seven is programmed to allow the flip-flop to remain enabled until the sequence is complete. At that time, data output bit seven sends a reset signal to the flip-flop and ends the sequence.

At the end of the sequence, the 40 kilohertz clock oscillator is disabled, the 12-bit counter is reset to binary zero, and the CE and OE of the memory chip are set HIGH to disable reading and place the chip in low power "standby" mode. At this point, the sequence may be repeated by again pressing the user pushbutton.

The total cost of this project was \$110.

TABLETOP PILL REMINDER

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INTRODUCTION

The goal of the Tabletop Pill Reminder design, shown in Figure 11.62, was to create a system that could assist people in taking their daily prescriptions. This product is a conventional daily pill case incorporated with electronic components. The device tells the user when to take his or her medicine and, specifically, what pills need to be taken at that time. This product would be suitable for anyone who needs to take medications but would be especially helpful for those who must take multiple pills throughout the day. Also incorporated into the design is a pill splitter, commonly a separate tool.

SUMMARY OF IMPACT

Through the use of light and sound, this product not only reminds the consumer when to take pills, but also shows which ones to take.

TECHNICAL DESCRIPTION

The design of this product consists of 14 LEDs and a buzzer connected to a programmed microcontroller. The controller is programmed so that at user-defined increments the system will activate, causing the light for the corresponding pill compartment to turn on and the buzzer to sound. To operate this product, the user would be taken through a few simple commands, similar to setting a regular alarm clock, which would set an alarm for each particular compartment that the patient wants to use. Once the alarm goes off, the buzzer will sound and the LED will light for the compartment that corresponds to the alarm that was set. The system will then be reset through the use of the switches.

This prototype consists of an LCD screen and two toggle switches used to set the alarms. The casing has two rows of pill compartments, each with seven compartments. The user can utilize these spaces in



Figure 11.62. Tabletop Pill Reminder

the most convenient pattern for their needs, for example, using one compartment per day and having it last for two weeks or using two compartments for each day and having it last for one week. Down the center are two rows of LED lights, 14 in total, with one LED corresponding to each compartment. At the end of the casing is the pill splitter. Internally, the wiring was organized using a wiring harness made to connect the switches, LEDs, and buzzer to the microcontroller, as shown in Figure 11.63.

The conceptual design of this product was originally for a portable system to carry in the patient's pocket. Due to limited manufacturing process, the prototype is designed as a tabletop model. The pocket size model that this prototype represents would have the same basic features with the addition of a vibration mechanism to assist in notifying the patient. The pocket size would also need to be fitted with batteries instead of being powered by an outlet.

The total cost of this project was \$365.

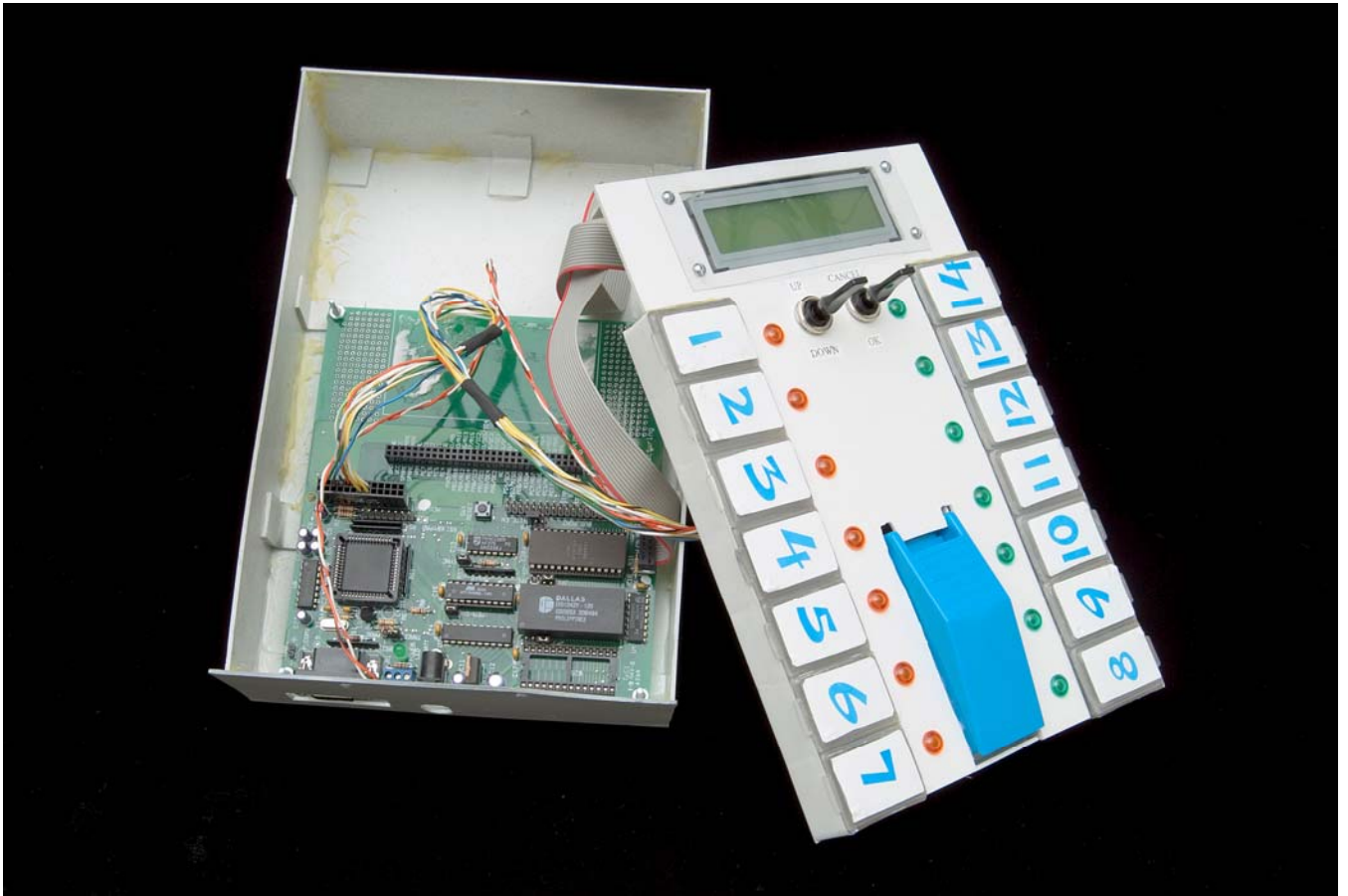


Figure 11.63. Internal Components and Wiring

PORTABLE DEVICE TO LIFT A PERSON INTO A VEHICLE

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INTRODUCTION

One challenge that individuals who use wheelchairs face on a routine basis is the task of entering and exiting a vehicle. To provide assistance, many lifting systems have been developed to safely lift the user out of his or her wheelchair, and safely into the passenger or rear seat of the vehicle. Current lifting systems are non-portable and are designed to be used exclusively in conjunction with a large vehicle that has a considerable amount of interior space, such as a van or mini-van. These units have to be permanently installed into vehicles, thereby altering the vehicle from its original condition. While still maintaining the structural integrity of larger existing devices, this design, shown in Figure 11.64, is an easily transportable and versatile solution. The flexibility of this device allows for it to be stored in the user's trunk and used with a variety of standard wheelchairs and vehicles.

SUMMARY OF IMPACT

The major advantages of this device over existing lifting devices are that it is portable and can function without permanent modifications to the wheelchair or vehicle. Through lightweight, strong materials and a collapsible design, it allows users to transfer a family member or friend from his or her wheelchair to a vehicle and to transport the device itself easily. The design could be developed to address a significant untapped market for a portable device that accomplishes the same function as permanent wheelchair lifts.

TECHNICAL DESCRIPTION

The lifting system uses a forklift-style lifting device and is constructed of lightweight high-yield-strength materials. The device is composed of three main components, which the user will assemble before each use, as shown in Figure 11.65.



Figure 11.64. Portable, Collapsible Device for Transfer to a Vehicle

The first assembly component is the lifting base, which is comprised of the hydraulic pump, the lift housing, and the legs. The lift housing, which is constructed of lightweight aluminum, is designed to exhibit a high moment of inertia to absorb high stresses due to bending moment and rigidly encompass the hydraulic pump. The aluminum support legs are collapsible and can easily be folded up against the lift housing after use to make the unit

more compact. Hard rubberized plastic casters are attached to the table legs with locks, allowing the unit to be rolled on the ground.

The second assembly component is the fork-bar, which is constructed of high-strength alloy steel. Once the lifting base is assembled, the fork-bar is inserted through two holes on the Lift Housing. Once inserted, two metal valco snaps allow the fork-bar to snap in place.

The third component is the seat assembly. The seat is constructed of heavy-duty canvas material, which covers a wood base and composite wood board backing. It also has a hinged back to allow for easy storage. The seat assembly is to be placed into the wheelchair before the user enters the wheelchair.

Once the user is placed into the wheelchair, the seat assembly latches on to the fork-bar and hoists the person into the passenger seat of the vehicle. The seat is equipped with seatbelt straps that secure the user and prevent injury from falling.

The working prototype is designed to be used by a person of 125 pounds or less. If the device were designed for a person greater than 125 pounds, additional modifications would be required. The legs would have to be constructed of a stronger material and the tolerances between the housings would have to be tightened.

The cost of this project was \$304.



Figure 11.65. Lift System Components

QUICK AND EASY HEIGHT-ADJUSTABLE WALKER ATTACHMENT FOR FOREARM SUPPORT

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INTRODUCTION

An individual using a walker often requires additional support due to weakness and limited motor skills in the upper body. The device in Figure 11.66 is primarily a height-adjustable walker attachment that provides necessary support to the forearm and gives additional stability to the user with the aid of a hand grip. Such attachments are usually cumbersome to operate, requiring the manipulation of four screws for mounting, removal, and height adjustment. This attachment design can be quickly and easily mounted, removed, and adjusted for height, making it ideal for use in nursing homes, hospitals and other facilities for people with disabilities.

SUMMARY OF IMPACT

This design provides necessary support to the user while being safe and easy to use, with lockable settings. These features will enable some users to make adjustments on their own and thus will enhance independence and save time and effort of caregivers.

TECHNICAL DESCRIPTION

Two Guardian Walker Platform Attachments were used. The vertical bar on each was shortened to a length of 28.5 inches to remove the unnecessary length and weight, making the system more stable.

The two design aspects are the mounting and removal of the platform attachment and height adjustment. The main design component employed for both these issues was the quick-release clamp. Quick-release bicycle seat post clamps were used. They are ideal because of their low cost, light weight, high strength, locking ability, adjustability, and ease of use. Both the attachment and the height adjustment were incorporated into a single block for each of the four walker bars, on which the platform attachments were mounted, as shown in Figure



Figure 11.66. Quick and Easy Height-Adjustable Walker Attachment

11.67. For each platform attachment on either side of the walker, two 2 x 2 x 4 inch blocks of 6061 grade aluminum were used. Each of these blocks was machined with two holes (one horizontal on the horizontal walker bar for mounting and the other vertical on the vertical platform attachment bar for height adjustment), .87 inches in diameter. These holes were lined with PVC with slits along the lengths to prevent scratches and to allow for tightening when required.



Figure 11.67. Platform Attachment Blocks

For attachment, a small section on the outer side of the horizontal cylindrical cavity on the block was cut. Then the metal was replaced with a small hinged piece, into which the screw bolt of the bicycle clamp was screwed. This mechanism allows for the cavity to have an opening when the bicycle clamp is released and moved out of the way using the hinge. The bar of the walker would then be inserted into the cavity and the bicycle clamp would be moved via the hinge and placed with its length across the opening. The clamp would then be pressed down on the other end of the block to close the cavity onto the bar, locking the bar into the attachment block, as shown in Figures 11.68 and 11.69. Each block of aluminum was designed with this mechanism for attachment onto the bars of the walker (two on each side). An additional feature was added to these

cavities to accommodate any bends that the walker bars might have.

For height adjustment, the second (vertical) cavity on the block is used. On the block that goes on the top bar of the walker, a bicycle clamp was used across a small section of the circumference of the cylindrical cavity. Due to the use of the bicycle clamp, the cavity can be tightened and loosened as desired. The vertical bar of the platform attachment, when passed through this cavity, can be held in place or the grip can be loosened to adjust for the height. On the block that goes on the bottom bar of the walker, the second (vertical) cavity is used as a "guide" for the platform attachment to add stability rather than for height adjustment.



Figure 11.68. Bicycle Clamps Open



Figure 11.69. Bicycle Clamps Closed

The total cost of the project was approximately \$250.

E-Z REACH VERTICAL SPACE SAVER STORAGE SYSTEM

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INTRODUCTION

The E-Z Reach System addresses the challenge of utilizing vertical storage spaces. In environments ranging in size from the home to large warehouses, vertical spaces are plentiful while horizontal spaces are limited. This results in excess vertical spaces that can be difficult to utilize. In one particular case, an individual who uses a wheelchair may not be able to use a high cupboard space without the assistance of another person or a reaching arm, neither of which are practical to the individual. This design will specifically address the problem of high cupboard spaces and provide proof of concept for varied scales of application.

SUMMARY OF IMPACT

By creating a storage system that is similar to that of a lazy susan, with a vertical application, high vertical spaces may be accessed. The device, shown in Figure 11.70, operates via a switch in a manner similar to that of a Ferris wheel. Carriage-like boxes serve as individual storage spaces which follow a track, moving the carriages from front to back and top to bottom of the cupboard space. This allows the user to bring any desired storage carriage to an accessible height and to better utilize otherwise inaccessible cupboard volume.

TECHNICAL DESCRIPTION

Large kitchen cupboards for which this model was made typically have a top shelf at a height of approximately seven feet. The main goal is to take what would be the storage space of the top shelf and make it mobile to reach the lower level of the cupboard while moving the bottom shelf space to the top.

The first step was to eliminate the standard shelves so the space was open and storage carriages and tracks could be installed. The carriages that serve as the new storage spaces were constructed to be 10



Figure 11.70. E-Z Reach Level Rite Vertical Space Saver Storage System

inches high, 20 inches wide and 6 inches deep. The front face of the carriage was left open with the exception of a small lip at the bottom to prohibit items from easily sliding or rolling out. Three carriages were used.

The tracks, which guide and propel the storage carriages, were placed on each side of the cupboard. (See Figure 11.71) Each track was constructed from four sprockets with a $\frac{1}{2}$ -inch pitch, 12-teeth design. One of the sprockets in each track is a double sprocket with two sets of 12 teeth parallel to one another. The sprockets were mounted on $\frac{3}{4}$ -inch-diameter shafts, which, in turn, were connected to the $\frac{3}{4}$ -inch bore flange bushings. The flange

bushings were mounted on the sides of the cupboard space. Two individual chains were used to loop all four of the sprockets on each side.

Three small rods were used to connect the tracks to the storage carriages. The rods run the width of the device from track to track, where they were welded to the chain at each end. The carriages were hung from the rods with free rotation. This ensures that as the carriages run the course of the track, gravity maintains a level carriage orientation, and carriage contents remain in place.

The final aspect of the design was the propelling device. A permanent magnet DC motor is used to drive the system and is operated via an on/off switch. The motor's shaft was connected to a rod running the width of the cupboard space. On the rod are two additional sprockets, which were connected to the double sprockets of each track via two small looped chains. The motor drives the rod and upper sprockets, which drive the tracks and carriages.

The total cost of this project is \$343.



Figure 11.71. Close-up of Tracks

VIBRATING BRACELET

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Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

The purpose of this project was to address the fact that individuals with hearing impairments require adaptive alarms to alert them to potential dangers such as fire, smoke and carbon monoxide, especially while they are sleeping.

SUMMARY OF IMPACT

The Vibrating Bracelet, shown in Figure 11.72, will vibrate when an alarm sounds and alert a sleeping person with a hearing impairment or hearing loss, giving him or her ample time to respond to a dangerous situation. The device requires no added

features to be placed in the consumer's household. It is easily transportable and could be used during travel.

TECHNICAL DESCRIPTION

The concept device is enclosed in a 6 x 3 x 2 inch box. It weighs 257 grams, and can be placed on the arm or the leg using the Velcro straps to secure it. The bracelet works with any existing house or building fire alarm without any enhancements. It is triggered by the sound of the alarm, vibrates to alert the user, shuts itself off after one second of time has expired, and then resets itself for use again.



Figure 11.72. Vibrating Bracelet

The circuit consists of a two 741 op-amps, one 386 audio amplifier, and one ECG-253 transducer, which acts as the switch for the device. A motor that spins at 9700 rpm causes the vibration; a small clip-on microphone receives the signal, causing the resistors and capacitors to receive the required power, as shown in Figure 11.73. The microphone detects the sound and converts the sound into an electrical current to power the circuit. The first op-amp is then used as a filter so that sounds that occur commonly do not activate the bracelet prematurely. The next

two op-amps are used as amplifiers to make the sound's power increase so that it is strong enough to power the vibrating motor. The bracelet will then shut itself off and reset by using the CD-4093 Digital Logic chip. This will have gates with which to determine when the device is allowed to vibrate, alerting the user of danger. The system currently activates for only one second. By adjusting the capacitor located parallel to the CD-4093, the length of activation time can be extended.

The total cost of the vibrating bracelet was \$60.

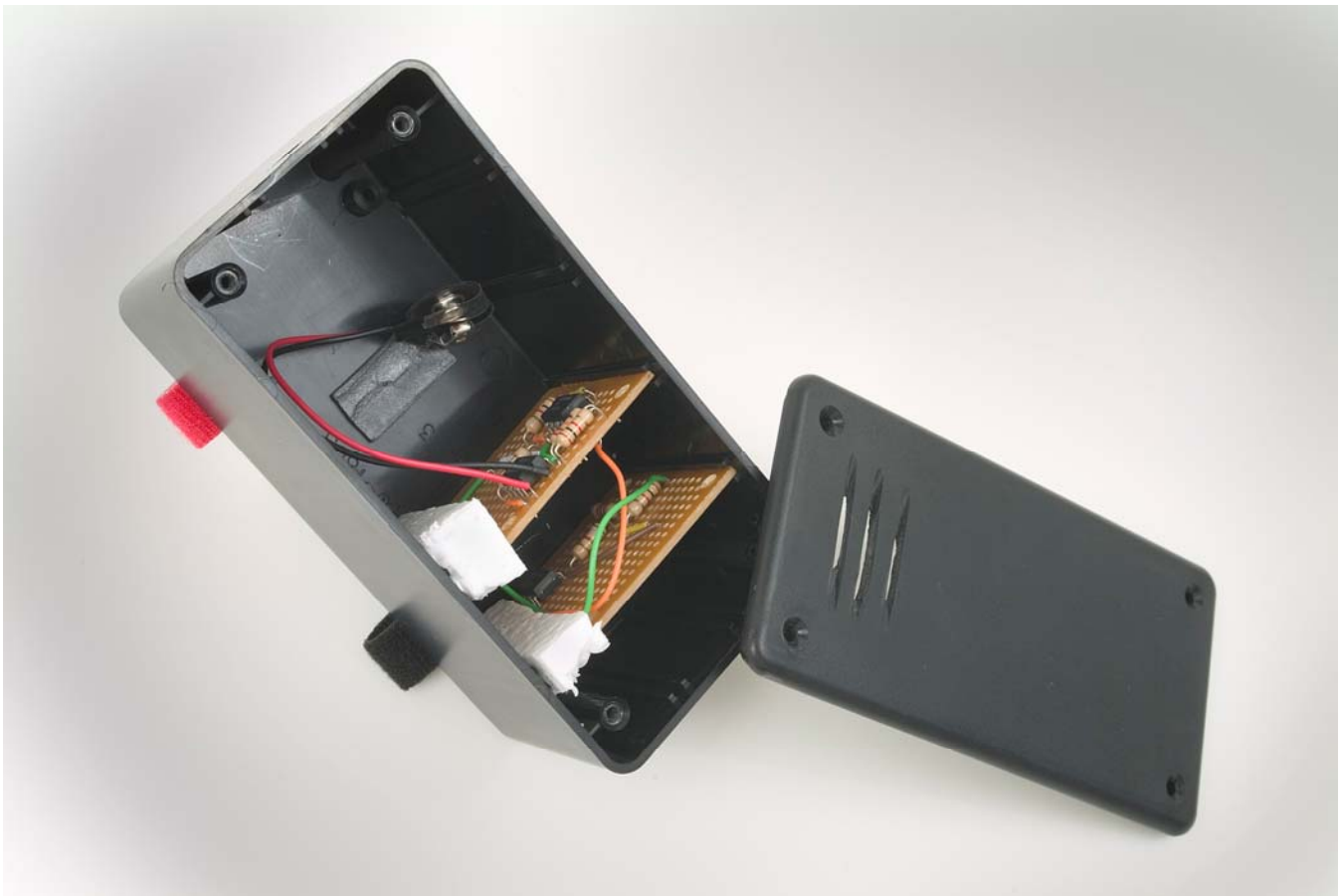


Figure 11.73. Internal Bracelet Components

TACTILE FEEDBACK PRESSURE SENSOR WALKING DEVICE

*Designer: Laura Koehler
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INTRODUCTION

People who have nerve damage in their feet have difficulty walking if they cannot feel when their feet hit the ground or how much weight their feet are supporting. This device translates the amount of weight supported by the foot into a vibrating sensation that can be applied to another area of the body, such as the arm, that maintains greater nerve sensitivity.

SUMMARY OF IMPACT

The Tactile Feedback Pressure Sensor Device, shown in Figure 11.74, gives people with nerve damage feedback that may help them walk. This device is inconspicuous, lightweight, and easier to carry than a cane or walker. The components are inexpensive,

especially when bought in bulk, which could make the device only slightly higher in price than an ordinary pair of sneakers. No similar product is currently on the market.

TECHNICAL DESCRIPTION

This device consists of: a 1.5 KGF pushbutton pressure sensor, a thick miniature enclosed vibrating motor that has a 0.55 inch diameter and is 0.135 inches thick, a three-volt battery, Velcro hook and loop fasteners, a transistor, wires, a 68-ohm resistor, and a generic sandal. The pressure sensor is set in the shoe near the metatarsal region, over which the majority of a person's weight is normally balanced. The pressure sensor used in the prototype is a push-button type with a linear resistive response. The

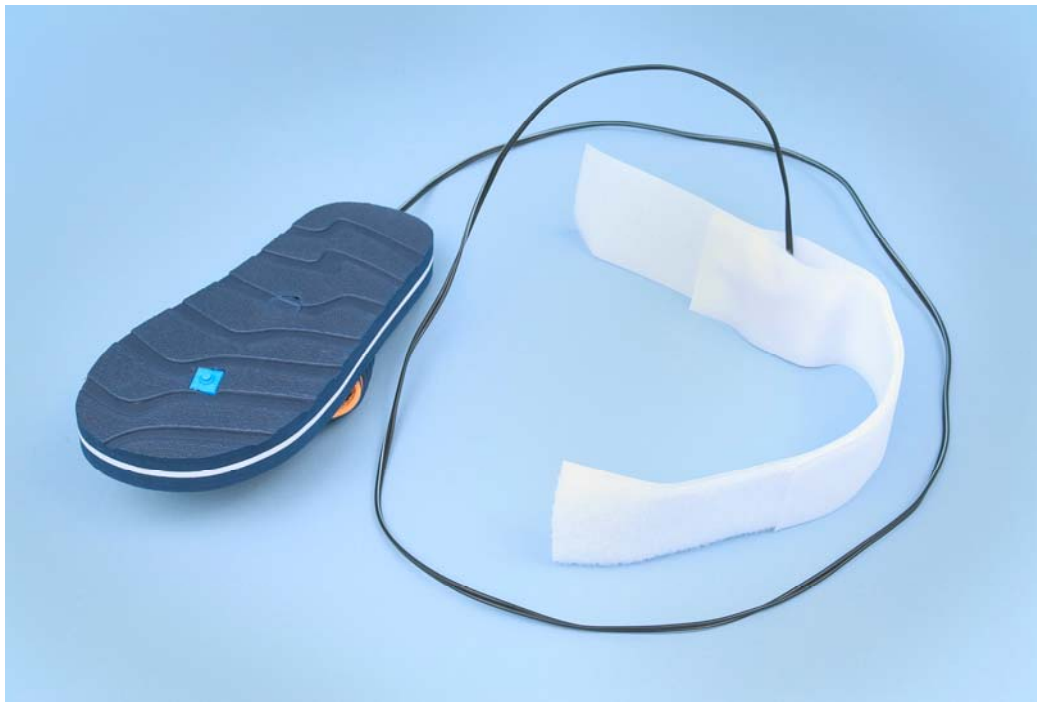


Figure 11.74. Tactile Feedback Pressure Sensor Device to Aid in Walking

linear response is important in that it gives the user proportional feedback as to the amount of weight being supported. In a working model, this pressure sensor should be replaced by a more durable and flexible sensor imbedded in a shoe or sneaker. The FlexiForce A201 Sensor, available from Tekscan, Inc., would be a good candidate for this purpose. A transistor is used to amplify the signal from the sensor. This amplified signal is sent to the vibrator

motor. A three-volt battery supplies the power to the device. The transistor, battery, and vibrator motor are all held in a Velcro band that is to be worn against another part of the body, such as the arm or upper leg. When necessary, the Velcro band layers can be easily separated to change the battery, which can be seen in Figure 11.75.

The total cost for this project was approximately \$50.



Figure 11.75. Arm Band Inner Components

AUTOMATIC CORD RETRACTOR FOR PORTABLE VENTILATORS

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Buffalo, NY 14260-4400*

INTRODUCTION

The objective of this project was to design a device which would help store the cords from a portable ventilator and make it easier to plug in the ventilator. Many people who require the use of a ventilator have trouble plugging and unplugging it, as well as storing its cords when it is not in use. This device, shown in Figure 11.76, was designed to be adaptable to most types of ventilators to alleviate these problems.

SUMMARY OF IMPACT

By developing a place to store the cords and an automatic cord retractor to easily retract the power cable, it became much easier for the client, whose movement is limited, to use a portable ventilator. This device allows the two cords coming out of the ventilator to be securely stored, and out of the way. This device has also made it easier to plug in the ventilator.

TECHNICAL DESCRIPTION

The design of this device was based on the conversion of the two cumbersome cords coming out of the ventilator into one cable that is on an automatic cord retractor. The way cord retractors work is that the cord will come in from the top to an electrode which is in contact with copper rings. These rings are attached to another cable, which is the actual cable used in the retractor. For this device, a 14 AWG 5-wire cable was made. This cable had to be light enough so the automatic cord retractor's spring was strong enough to retract it. Also, the cable had to be flexible enough to wrap around the retractor spool. Normal cord retractors only have two copper rings to carry the charge. For this design, two additional copper rings were manufactured. These rings had to be almost perfectly circular, as well as precisely mounted, to guarantee uninterrupted power flow. Di-electric grease was



Figure 11.76. Automatic Cord Retractor for Portable Ventilators

applied to the rings to lower the friction between the electrode and the copper rings.

Another key part of the design is storage space for the two cords that come out of the portable ventilator. This was accomplished by making a T-bracket that the cords can wrap around. Once the cords are wrapped, they are plugged into the top of the device. The cord coming out of the device is forked. One plug is a 110-volt AC plug to power the

ventilator inside, and the other plug is a 12-volt DC plug to power the ventilator in a vehicle. The whole device is mounted on an aluminum base that can be easily mounted onto the back of the portable ventilator. This device conveniently stores all cords out of the way and facilitates plugging in of the ventilator. Figure 11.77 shows the inner components of this device.

Overall, the design is functional, but some improvements could be made. Ideally, the base and cover would be molded out of plastic. This would greatly reduce weight and improve durability. Another improvement to the design would be to

lower the friction between the copper rings and the electrodes. The higher the friction between these two parts, the more work it takes for the spring to retract the cord after it has been extended. This could be accomplished by precisely mounting the electrodes so that a minimum amount of force is put on the rings. One final design improvement would be to use a smaller and stronger spring that powers the retractor. This would enable the device to be much smaller and thus reduce weight and improve ease of use.

The total cost of this device is \$70.



Figure 11.77. Cord Retractor's Inner Components



CHAPTER 12

STATE UNIVERSITY OF NEW YORK AT STONY BROOK

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BIKE EXERCISER

Designers: Li Ching Chin, Jessie Li, and Yen Sze Yuen
Client Coordinator: Thomas Rosati, Premm Learning Center, Oakdale, NY
Supervising Professor: Dr. Jeff Ge
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INTRODUCTION

The Bike Exerciser (see Figures 12.1, 12.2 and 12.3) was designed to provide a piece of fitness equipment that is enjoyable and motivating for the client with learning disabilities who is overweight. It will allow him to participate more actively in physical therapy.

SUMMARY OF IMPACT

The Bike Exerciser was made for a child who does not exercise often. Ideally, the child's arm and leg muscles and cardiovascular system will be strengthened over time.

TECHNICAL DESCRIPTION

The operating mechanisms of the Bike Exerciser are two four-bar linkages with a crank rocker: one on the left side and one on the right. The four-bar linkage consists of three moving links, one fixed link and four pin joints. The handles, pedals, and cranks are moving links, while the body frame is fixed. When a force is exerted on the pedal link, it causes the cranks to revolve and the handles to rock within a certain distance simultaneously. The motions of the four-bar linkage on the left and the right sides are opposed since both sides are connected through a shaft attaching the oppositely aligned cranks. When the user starts to pedal with his feet, with his hands on the handles, his arms start to move. The motion on one side of the linkage triggers the other side to move at the same time.

The bicycle seat is designed to slide on a seat rail, which is tilted and allows for horizontal and vertical adjustments.



Figure 12.1. Designers with Bike Exerciser

The body frame and linkages of the Bike Exerciser are constructed of steel tubing, except for the two footrest plates in which aluminum thread plate is used instead. The maximum weight the Bike Exerciser can support is 200 lbs.

The total cost of the prototype is approximately \$685.



Figure 12.2. Bike Exerciser Prototype

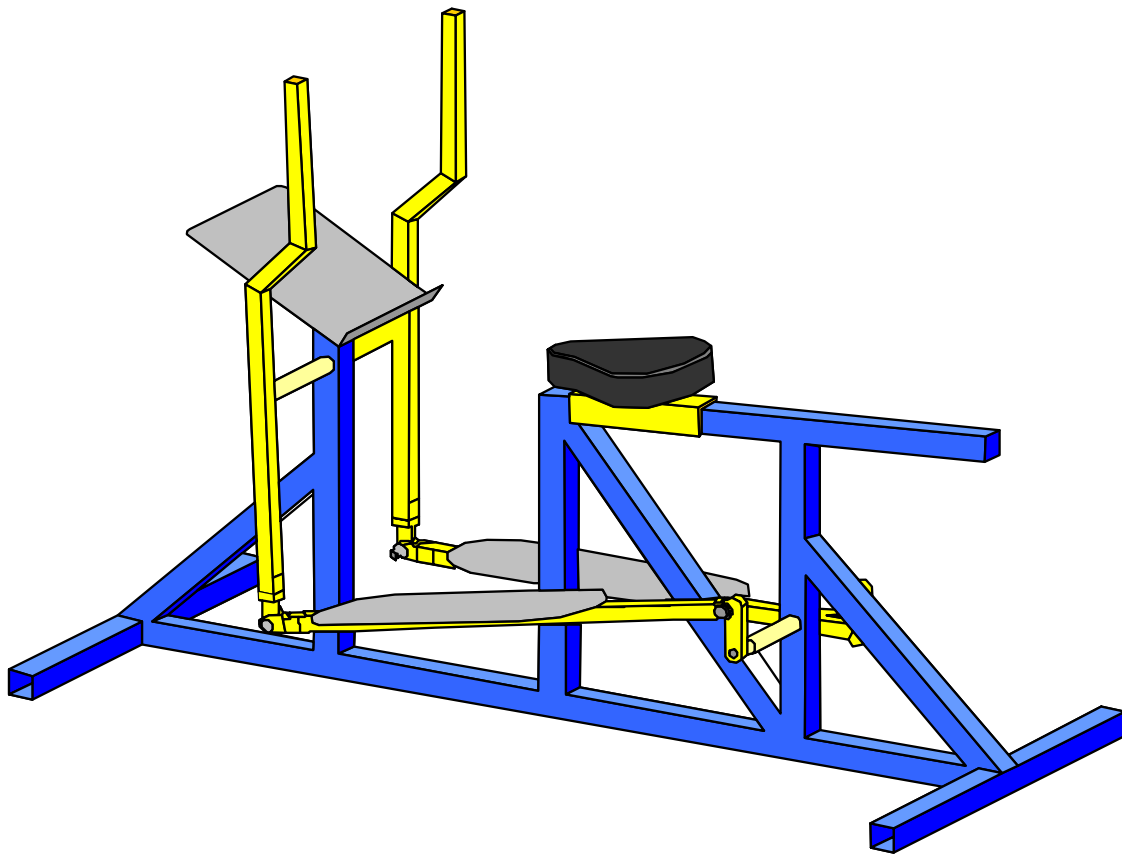


Figure 12.3. CAD Drawing of Bike Exerciser

CLEANING ASSISTANT

Designers: Un Long Chio, Gregory Koumoullous, and George Toumoumis
Client Coordinator: Thomas Rosati, Premm Learning Center, Oakdale, NY
Supervising Professor: Dr. Raman Singh
Department of Mechanical Engineering
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INTRODUCTION

The Cleaning Assistant was designed to clean the underbody of a person after a bowel movement. It is for use by a person with physical and cognitive disabilities. A major problem that caretakers face every day is to find an efficient and convenient way of cleaning the underbody of the person they care for, particularly when that person's condition requires the use of a diaper. A bidet can be used only to rinse the underbody of an individual. This design incorporates soap spray and temperature-controlled and pressure-regulated water to achieve complete cleaning of an individual after a bowel movement, in a typical residential bathroom.

SUMMARY OF IMPACT

The client has severe cognitive disabilities due to tuberous sclerosis (TS), a genetic disorder resulting in many small tumors in the brain. Due to TS, this individual has minimal communication skills and is not able to communicate when he has to use the bathroom, so he is required to wear diapers. It is often difficult to clean him after he has a bowel movement in his diaper. The use of ordinary sanitary wipes is often not strong enough to clean the remaining feces and his caretaker must give him a shower with pressurized water. The Cleaning Assistant allows the client's caretaker to clean him easily and quickly after he soils his diaper.

TECHNICAL DESCRIPTION

After extensive background research and brainstorming, a toilet-mounted device was selected as the best solution. The detailed design was drawn using AutoCAD (Fig. 12.13). The system consists of four nozzles for pressurized water spray and two nozzles for soap spray.

The water system is supplied by the existing hot and cold water supply that goes to the bathroom sink. This allows all permanent plumbing connections to



Figure 12.4. Water Temperature Control



Figure 12.5. Reducing Fitting And Shutoff Valve



Figure 12.6. Assembly of Special Seat



Figure 12.7. Water Spray Nozzles



Figure 12.8. Soap System Control Switch



Figure 12.9. 12V Soap Pump

be made under the sink. Small-diameter plastic tubing is used because it is flexible and inexpensive. The mixing valve ensures that the temperature of the water is appropriate and consistent. A manual hand shut-off valve enables simple control. Small water jets will spray a "v" shape stream to cover a maximized surface area. Four jets ensure that the entire surface is cleaned. Major components of the system are shown in Figures 12.4 through Figure 12.12.



Figure 12.10. Female Power Adapter for Soap Pump



Figure 12.11. One-Gallon Soap Tank



Figure 12.12. Seat with Nozzles in Action

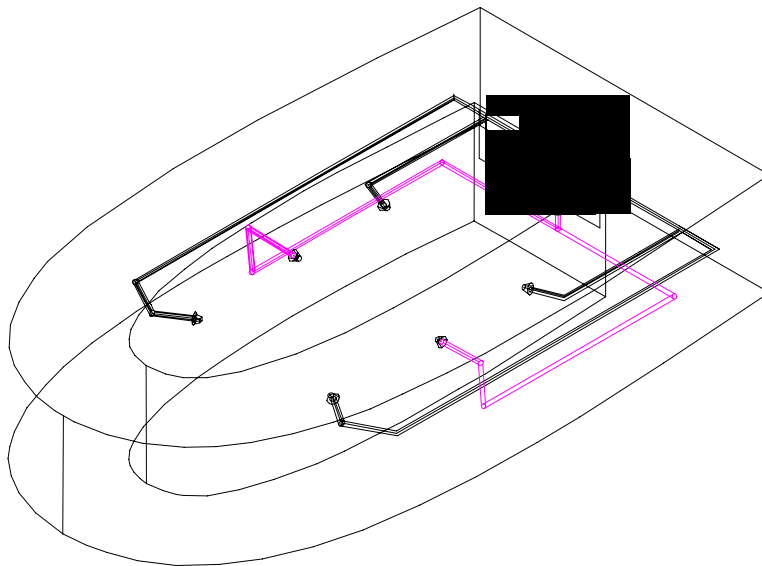


Figure 12.13. CAD Design for Toilet-Mounted Nozzle System

ALTERNATELY-PROPELLED MECHANICAL WHEELCHAIR

Designers: Troy Azimi, Derek Tynan, and Christopher Yang
Client Coordinator: Thomas Rosati, Premm Learning Center, Oakdale, NY
Supervising Professor: Robert Kukta
Department of Mechanical Engineering
State University of New York at Stony Brook
Stony Brook, New York 11794-2300

INTRODUCTION

The Alternately-Propelled Mechanical Wheelchair is a modified wheelchair that incorporates a superior braking system and eliminates complete hand-to-rail contact when moving forward. By incorporating a clutch system engaged by air cylinders, the user can apply a relatively small amount of force to travel further than a traditional wheelchair.

SUMMARY OF IMPACT

The Alternately-Propelled Mechanical Wheelchair is designed for a range of users, including children of eight years or older, people of diminished upper body capacity, and individuals seeking an easier mode of transportation. The drive mechanism reduces the amount of force the user exerts to propel the wheelchair forward.

TECHNICAL DESCRIPTION

The Alternately-Propelled Mechanical Wheelchair (see Figures 12.14 through 12.19) consists of a drive system similar to that seen on a mountain bike. It incorporates a main drive gear that is connected to a bicycle chassis by means of a chain. The chassis is attached to the drive shaft, which consists of a male gear on each side. Two handles are mounted on a guide rail on each side of the user. The right handlebar consists of a brake lever and a twist-shifter. When the handles are moved in a forward motion, a main air cylinder pumps oil along a tube and allows two secondary cylinders to engage the female gear into the male gear. As a result of this engagement, the rotating shaft rotates the wheels. Each wheelchair wheel consists of a clutch bearing,

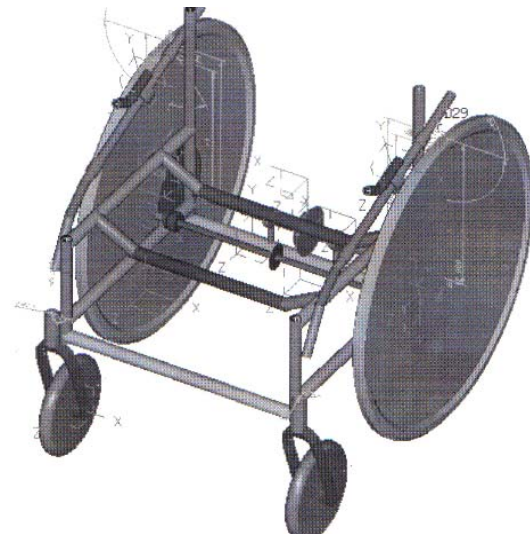


Figure 12.14. CAD Drawing, Solid Isometric View

which is a one-way bearing that allows for free-wheel motion when the clutch is not engaged. As a result, the user no longer has to use his hands to propel and stop the wheelchair.

The total cost for parts and supplies of the project is approximately \$ 827.

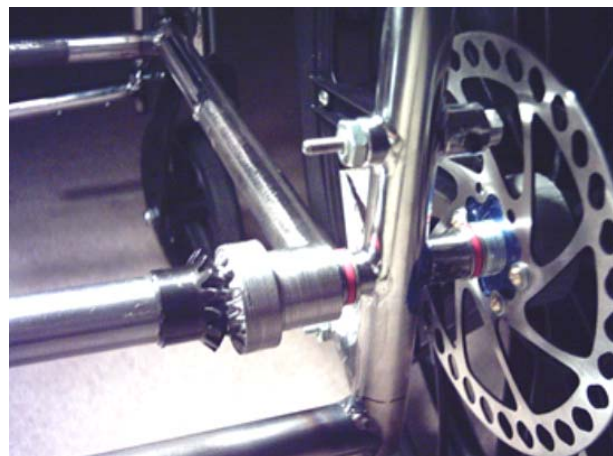


Figure 12.15. Engaged Clutch System and Disc Brakes

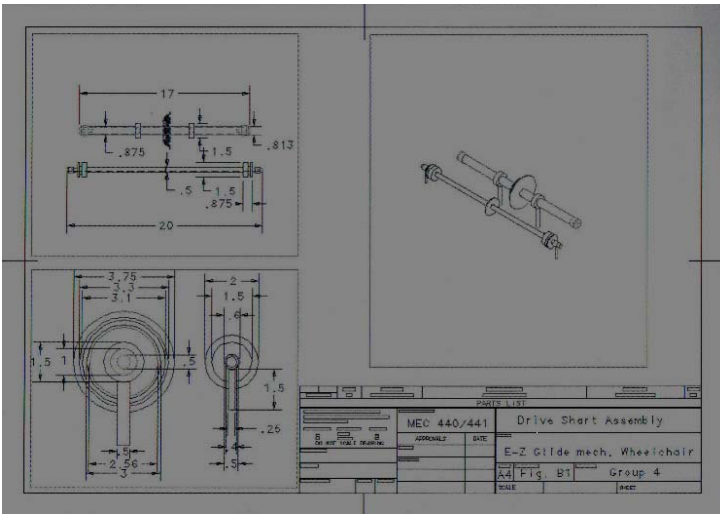


Figure 12.16. CAD Draft of Drive System Assembly

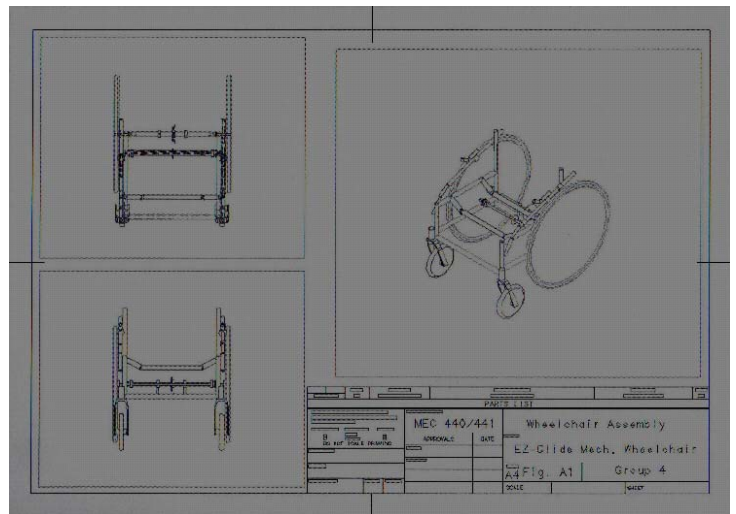


Figure 12.17. CAD Draft of Entire Wheelchair Assembly

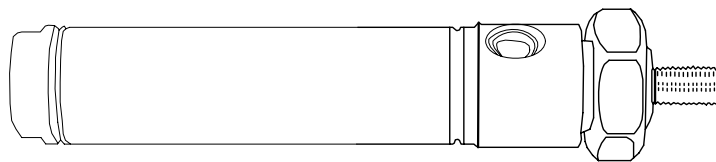


Figure 12.18. Illustration of Air Cylinders

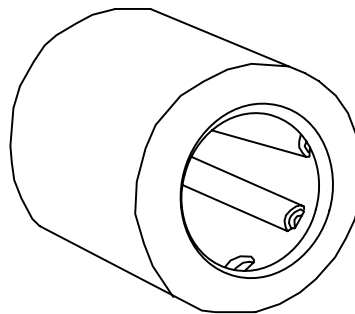


Figure 12.19. Illustration of Clutch Bearings

TRICYCLE-BASED HAND-POWERED WHEELCHAIR

Designers: Byung-Chul Yoo, Cheng Yang, and Ji Yin Yang

Client Coordinator: Thomas Rosati, Premm Learning Center, Oakdale NY 11769

Faculty Advisor: Professor Sheng Chang

Department of Mechanical Engineering

State University of New York at Stony Brook

Stony Brook, NY 11794-2300

INTRODUCTION

A tricycle-based wheelchair was designed to enable the user to exert less energy than required by a standard wheelchair while ensuring safety and comfort. Additionally, it was also designed to encourage the users to enjoy outdoor activities. It is designed to be used outdoor on level surfaces, and is able to go 15 degrees uphill. The wheelchair is a hand-powered tricycle, so the user must have sufficient upper body strength to power it.

SUMMARY OF IMPACT

This design (see Figures 12.10 through 12.22) allows people with physical disabilities to exert less energy during travel. It also allows them to enjoy outdoor activities, as well as exercise upper body muscles. The seat is adjustable.

TECHNICAL DESCRIPTION

This tricycle-based wheelchair is fully mechanically operated. The chassis of this design originally came from a bicycle. Three 26-inch bicycle wheels, linkages, sprockets, and a chain are incorporated. The seat slides forward and back via a sliding mechanism and also may be adjusted up and down. An electrical jack is attached on the bottom of the chair to operate the seat adjustment.

An important part of the design was calculating the gear ratio, which can help the rider operate the wheelchair while exerting less energy. The lever gear has 15 teeth and the two-speed gear has 30 and 45 teeth. The speed for a 1:2 gear ratio is 2.14 mph and the speed for a 1:3 gear ratio is 1.43 mph. Thus, the 1:3 gear ratios uses less energy but travels one third less than the 1:2 ratio, which is useful for going uphill.



Figure 12.20. Prototype of Tricycle-Based Hand-Powered Wheelchair



Figure 12.21. Designer Operating Wheelchair

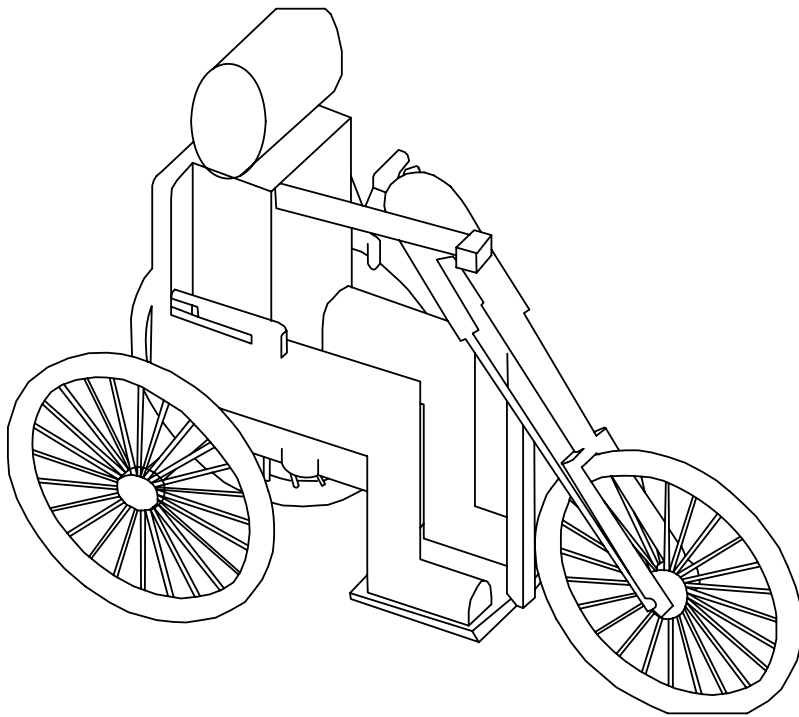


Figure 12.22. 3-D CAD Model of Tricycle-Based Hand-Powered Wheelchair

HILL ASSIST WHEELCHAIR WITH ENHANCED SAFETY

Designers: Roger Cheng, George Chan, and Ricky Venters

Supervising Professor: Jeff Ge

Advisor: Dr. Michelle Nearon

Department of Mechanical Engineering

State University of New York at Stony Brook

Stony Brook, NY 11794-2300

INTRODUCTION

A wheelchair was designed so that the user is able to exert the same amount of energy when moving on either flat or inclined planes. To ensure safety, an anti-rollback system, an anti-tip mechanism and a braking system are incorporated. To allow for increased the speed, a modified driving mechanism has been implemented.

SUMMARY OF IMPACT

This wheelchair is designed with multiple subsystems specifically developed for a user who lives in a hilly or mountainous area.

TECHNICAL DESCRIPTION

The anti-tip system, shown in Figure 12.26, prevents the wheelchair from tipping more than 30 degrees from its normal position. The anti-roll back system, as shown in Figure 12.25, will not slip on a 30-degree

grade. The braking mechanism, shown in Figures 12.24 and 12.25, will stop an uncontrolled descent within an average distance of five feet. No prototype was built for the driver mechanism, Fig. 12.27, because the calculated dimensions were found to be faulty. The allowed width was exceeded, and the placement of the system could not be determined without rebuilding the entire wheelchair.

The total project cost was approximately \$320.



Figure 12.23. Prototype of Hill-Assist Wheelchair



Figure 12.24. Braking System

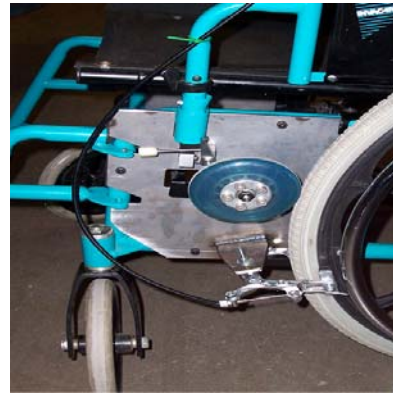


Figure 12.25. Anti-Rollback System



Figure 12.26. Anti-Tipping System

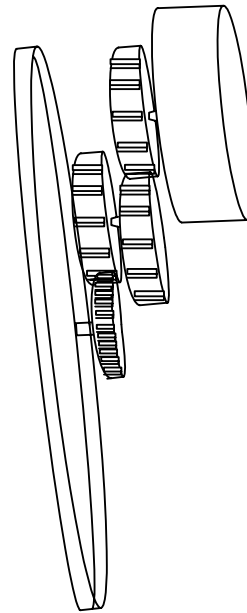


Figure 12.27. Gear System

TIDIS-B: WHEELCHAIR-TO-BED TRANSFER SYSTEM

Designers: Chin Ho Fung, Pierre Benel, and Fowler Tyrone
Client Coordinator: Thomas Rosati, Premm Learning Center, Oakdale, NY
Supervising Professor: Dr. Huang, Peisen S
Department of Mechanical Engineering
State University of New York at Stony Brook
Stony Brook, NY 11790-2300

INTRODUCTION

Tidis-B (Transport of Individuals with Disabilities into Bed) is an assistive device designed to move a

person from a wheelchair to a conventional bed, as well as from a conventional bed to a wheelchair. The device is intended for use in homes and is able to



Figure 12.28. Prototype of Tidis-B



Figure 12.29. Tidis-B in Sliding Motion



Figure 12.30. Tidis-B in Use

transport a person who weights up to 300 lbs. In addition, the device requires minimal physical assistance by caretakers, which can help prevent back injuries. The device is designed so that the person being transported is comfortable and safe.

SUMMARY OF IMPACT

The design of Tidis-B supports individuals who use wheelchairs and lack the ability to transport themselves from the wheelchair to the bed. This device requires the assistance of a second individual who could help operate the device.

TECHNICAL DESCRIPTION

The device is operated by a conveyor system made of a gear motor, a conveyor belt, 15 conveyor rollers, a power supply, and a 12-volt battery. The purpose of the gear motor is to provide a specified amount of torque capable of rotating the conveyor belt and rollers while the individual is seated on it. The ideal and actual designs perform the same task, although they are not completely similar. The ideal design is

the electromechanical design that would be operated with an electric motor and a hydraulic lift table, and the actual design or the prototype is operated mechanically. The prototype was built on the actual design (as shown in Figures 12.28 through 12.32) because the ideal design was too expensive to be made. The materials used in the prototype are carbon steel and aluminum alloy 6061.

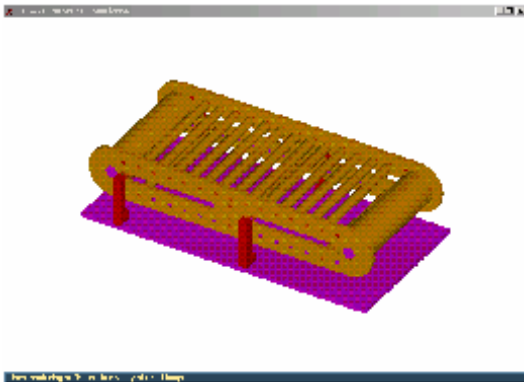


Figure 12.31. Detail Design (Seat Portion)

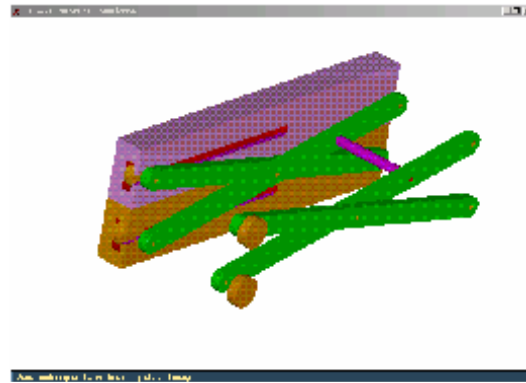


Figure 12.32. Detail Design (Lifting Mechanism)

ELECTRICALLY-ASSISTED HUMAN-POWERED VEHICLE

Designers: Stephen Carrig, Christopher Astefanous, and Daniel Yousefzadeh
Client Coordinator: John Hotmer, ProRhythm, Ronkonkoma, NY
Supervising Professor: Dr. Imin Kao
Department of Mechanical Engineering
State University of New York at Stony Brook
Stony Brook, NY 11794-2300

INTRODUCTION

The objective of this project was to design and construct a four-wheeled two-passenger electrically-assisted human-powered vehicle (EHPV) (see Figures 12.33 and 12.34). The EHPV can be used by people with physical disabilities, such as a person who does not have full strength in his or her legs. The EHPV can also be used as a rehabilitation device, where an instructor can aid in pedaling the vehicle. The EHPV can also function as an alternate form of transportation for the environmentally-conscious consumer, and is suitable as a recreational vehicle.

The electrical assistance in the EHPV is primarily for assistance in uphill climbs, or traversing rough terrain where pedaling may become difficult. The electrical assistance may also be used for aiding an individual who does not have the strength or ability to pedal during normal driving conditions. The electric motors are powered by batteries that can be charged prior to use. The user has the option of engaging or disengaging the electrical assistance depending on riding conditions and preference.

To ensure a comfortable ride, the EHPV is equipped with four-wheel suspension. To prevent loss of braking in wet conditions, enclosed drum brakes are used. For safety, the EHPV is equipped with a brake light, reflectors, lights, and turn signals.

SUMMARY OF IMPACT

The vehicle will function as a recreational vehicle and an alternate form of transportation. The cargo area can be used to store medical equipment needed by the occupant or leisure equipment for the recreational user.

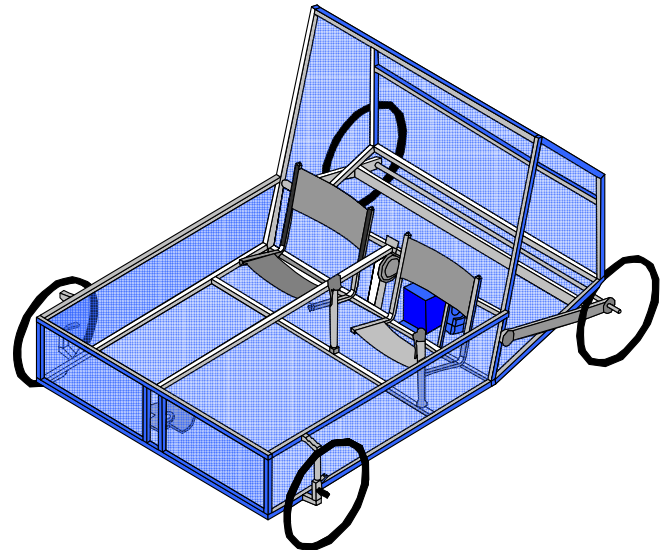


Figure 12.33. Front View of Vehicle Frame

TECHNICAL DESCRIPTION

The power is transmitted from the pedals through an axle to the front wheel axle and then to the rear axle by a drive chain. This prevents the chain from dragging on the ground. The chain is enclosed for safety.

The front suspension (see Figure 12.35) is a single A-

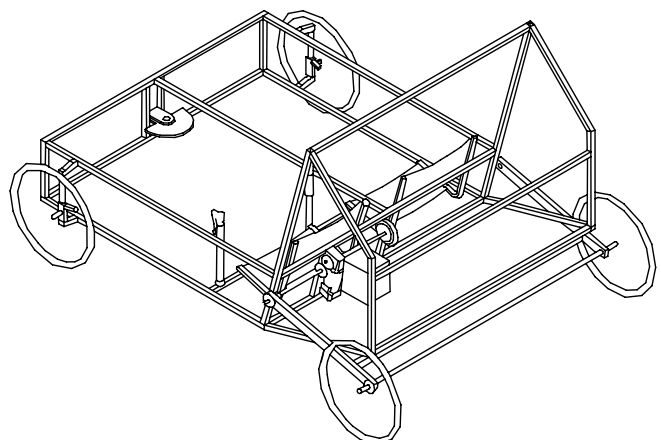


Figure 12.34. Rear-View of Vehicle Frame

arm design with an upper control arm. The A-arm is an independent suspension that uses curved members (wishbones) to control suspension travel. A wishbone suspension offers good axle control, limits undesirable suspension and helps to ensure good handling. The rear suspension is a swing arm design, with the outer arms of the swing arm placed outside of the main body of the chassis. This is important for keeping the design compact while maximizing cargo space.

The vehicle is steered by the left-side passenger using a steering wheel attached to the front axle via linkages that allow a limited range of motion (see Figure 12.36). The rear axle is a powered motor and a direct chain drive. All the motor controls, housed in a console between the two passengers, turn the motor on and off and adjust the motor's speed.

The total prototype cost approximately \$1900.

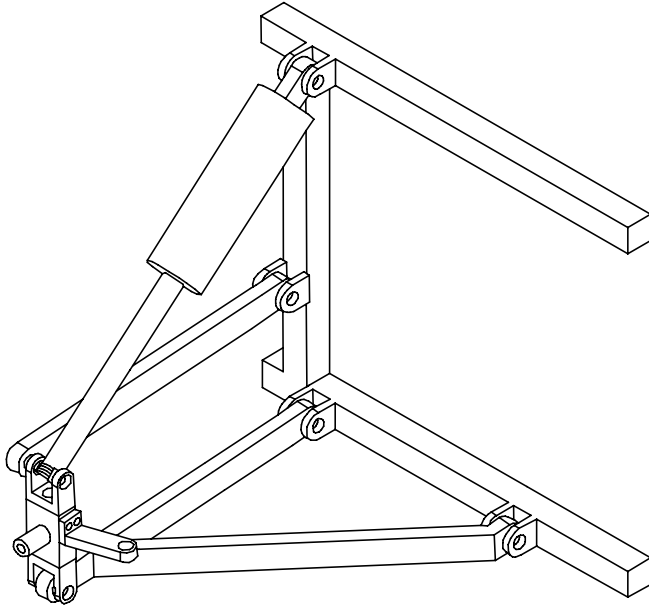


Figure 12.35. Front Suspension

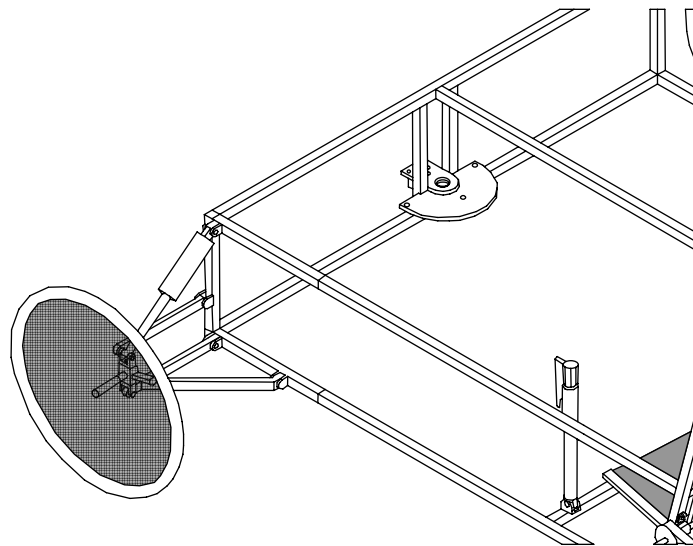


Figure 12.36. Front Wheel and Steering Mechanism

SMART SHOWER

Students: Justin Goldstein, Adam Krause and T. M. Kaikobad
Client Coordinator: Thomas Rosati, Forest Brook Learning Center, St. James, NY
Supervising Professor: Dr. Nearon
Department of Mechanical Engineering
State University of New York at Stony Brook
Stony Brook, NY-11794-2300

INTRODUCTION

A shower device was designed to enable individuals to shower independently with the use of only one hand.

SUMMARY OF IMPACT

The device ensures safety, remaining stable in a fixed position with the help of an antilock system.

TECHNICAL DESCRIPTION

The prototype shower device (see Figures 12.37 and 12.38) consists of 14 major parts. The arc is constructed of $\frac{3}{4}$ " copper tubing bent to create a 180-degree arc with a 30" diameter. At each end, a 360-degree range nozzle is fixed perpendicularly to the arc facing the other nozzle. The arc is then clamped into a custom-made aluminum canister. Inside this canister sits an aircraft engine valve spring, which creates a force perpendicular to the arc, allowing the arc to remain stationary in any position. The force

that this spring creates is not greater than the force needed to change its position. The user can move the arc to any position and it will remain in that position.

The aluminum canister is fixed to a ball joint apparatus, which allows the arc to rotate and swivel. The ball joint is rigidly mounted to the shower wall at mid-chest level. The water feed is located at one end of the arc to allow a full translation. The arc is self-contained so that only one water inlet is needed to supply two outlet nozzles. Due to low water pressure nozzles and $\frac{1}{2}$ " fittings diffused to $\frac{3}{4}$ " tubing, the pressure drop between the two nozzles is negligible. The water feed hose is a 200 psig. safety hose coiled to prevent binding during use.

The total cost of this device is \$408.00.



Figure 12.37. Smart Shower Assembly

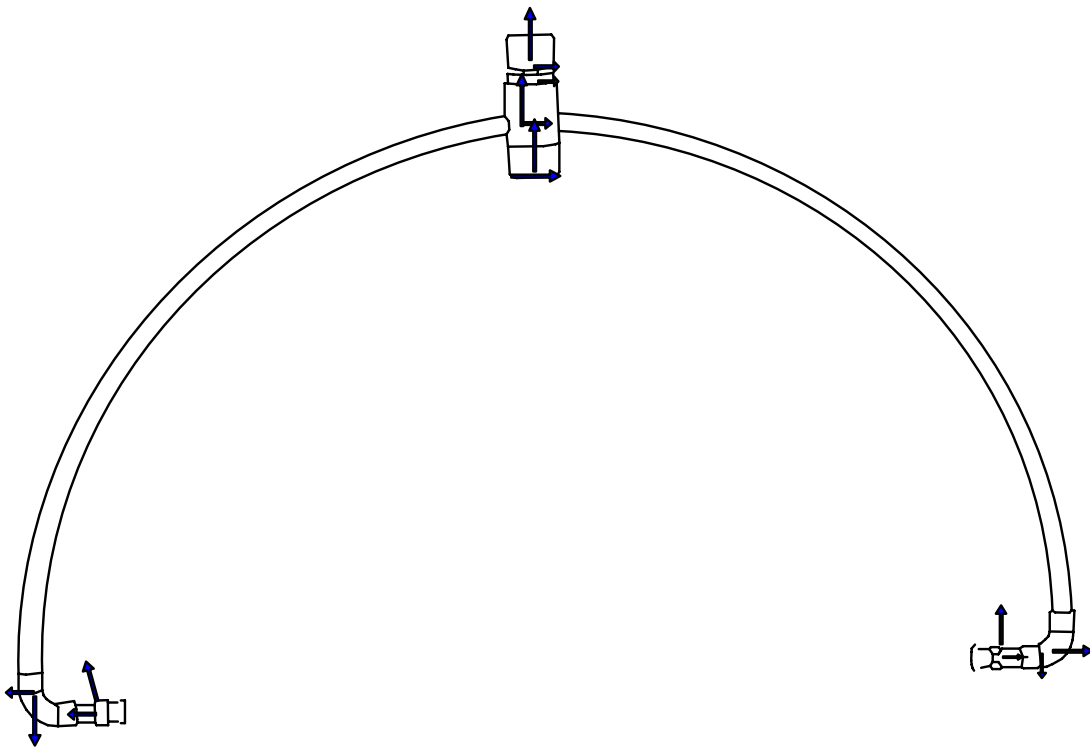


Figure 12.38. CAD Model of Smart Shower



CHAPTER 13
UNIVERSITY OF ALABAMA AT
BIRMINGHAM

Department of Biomedical Engineering
1075 13th St. S.
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Principal Investigator

Alan W. Eberhardt, PhD

(205) 934-8464

CHEETAH WALKER: TRANSITIONAL WALKING DEVICE

Designers: Jonathan Brightwell, Cara Rouse, and Nathan Fife

Client Coordinator: Scott Sall, Children's Hospital of Alabama

Supervising Professor: Alan W. Eberhardt, Department of Biomedical Engineering

University of Alabama at Birmingham

Birmingham, AL 35294

INTRODUCTION

The client coordinator is a physical therapist who specializes in working on motor coordination and balance with children who have cerebral palsy (CP). He has found that many of these children have a difficult time improving their gait with a traditional walker and even more difficulty transitioning from a walker to hand canes. The four-wheel pull-behind walkers that most of these children use are designed for them to hold their upper body rigid, placing all of their weight in their arms and dragging their feet along with them. The coordinator noticed that, after using the walkers for a prolonged length of time, many of the children develop a rigid upper body and are unable to adjust to the upper body movement required to walk with hand canes. The aim of the present project was to develop a transitional walker that permitted arm movement (flexion and extension) as in contrary walking (where the arm that swings forward is on the opposite side of the foot moving back).

The design was subject to several constraints. First, the device must emulate normal walking as closely as possible. If not, the child may be forced to make two transitions instead of one: a transition from walker to device, and a transition from device to hand canes. Second, the device must accommodate children with CP ranging from four to eight years old, up to 100 pounds, and a height range of 32 to 48 inches. Accordingly, the arm canes will need to be adjusted to the proper height for each child (16 to 32 inches). Third, the device must have adjustments for variable widths between the canes. Fourth, the handles of the canes should have a 360-degree adjustable range in the horizontal plane. This will accommodate any abnormal hand position caused by CP. Fifth, because children of different ages move their arms at different distances when walking, the length of forward and backward movement of the canes must also be adjustable. Also, these adjustments must require few tools. Sixth, the

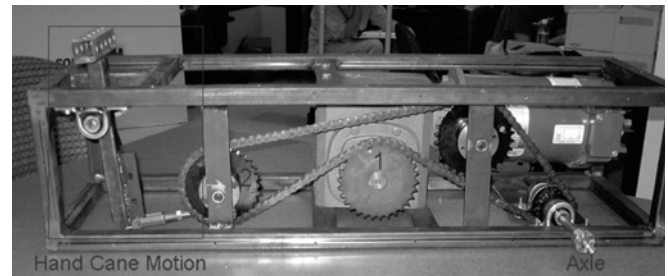


Figure 13.1. Drive Side of Cheetah Walker, Including Sprockets for Hand Cane Motion (Left), and Transfer Rotation to Non-Drive Side via an Axle (Right)

completed device should be transportable within the therapy room from the treadmill to the storage closet. The budget for this project was \$1500 and the time allowed was approximately four months.

SUMMARY OF IMPACT

The walker will serve as a training device for children with mild CP, for use by the client coordinator at a hospital. It will provide a child-friendly device with which they may transition from a traditional, follow-behind walker to hand canes, thereby improving their quality of life and independence. This new walker will help children develop the upper body movement necessary to walk with a cane, while still providing the stability of a four-leg walker.

TECHNICAL DESCRIPTION

The device has two basic components: the drive-side and the non-drive side. Both are contained in rectangular boxes with a tube steel frame and are enclosed by 1/2-inch plywood. Each box is painted with a jungle theme and a cheetah, leading the children at the hospital to name the device the "Cheetah Walker."

The drive-side of the device (shown in Figure 13.1) has a 3/4-horsepower Baylor Industrial DC electric

motor with a gear reducer and runs at a speed of 68 rpm. The motor is attached to the frame using 1/8" steel. Sprocket 1 is attached to the gear reducer and is powered by the electric motor. Sprocket 1 turns the chain, resulting in the turning of three more sprockets that are attached to the chain. A pushrod is attached to sprocket 2, changing the rotational motion into linear motion. Sprocket 2 is bolted to 1/4" steel rod, which is welded to the frame. The other end of the pushrod is attached to a 3/8" steel bar that is welded to a 1" steel tube. The steel tube has a 1/2" steel bar welded 7" above the attachment, which is connected to the frame by two pillow blocks. At the top, and perpendicular to the 1" steel tubing, is welded a 1.5" steel tube that holds the cane width adjustment tube. Sprocket 3 is used to re-route the chain, preventing mechanical rubbing.

The non-drive side of the device is powered by the drive-side by way of an axle that runs underneath the treadmill. The chain on the drive-side turns sprocket 4, which turns the axle. The axle is attached to the frame by two pillow blocks. The axle has two breaks in its length. These breaks are linked together

by mated couplings. The middle length of axle is supported by two pillow blocks that are attached to a separate 4.5" x 29" frame made of 1" steel. The non-drive side has two sprockets, attached by a chain. One sprocket turns with the axle. The cane movement mechanism works in the same way as on the non-drive side. The cane mechanism has a retractable 1" square tube pinned inside the 1.5" steel tube from the drive- and non-drive side. This allows for the 13" to 22" width for cane placement, accommodating different sizes of children. At the end of the retractable bar is a clamp from a percussion stand. The adjustability of this clamp allows for the 360 degree rotation of the canes. Normal adult canes were cut in order to fit into the clamp and to fit the height adjustability specifications. The final design is shown in use by a child with CP in Figure 13.2.

The costs for the project totaled approximately \$1260.



Figure 13.2. Client Using Transitional Walking Device

ELECTRIC ELEVATION ASSIST AND SPASTICITY CONTROL ARM

Designers: Steven Moore, Donald Burke, and Tiffany Borden

Client Coordinator: Linda Pierson, PT, Hueytown Elementary School

Supervising Professors: Alan W. Eberhardt, Department of Biomedical Engineering, Gregg M. Janowski, and J. Barry

Andrews, Department of Materials Science and Engineering

University of Alabama at Birmingham

Birmingham, AL 35294

INTRODUCTION

The purpose of this project was to augment a mechanical arm support for an 11-year old boy who has dystonic cerebral palsy with choreoathetoid movement. The client coordinator had previously purchased an arm support system. This device was intended to provide the client with a more comfortable restraint system than being strapped to his wheelchair arm rest. That system was not comfortable, and movement was restricted to only the horizontal plane, preventing him from performing daily activities such as eating and brushing his teeth. A device was desired that would restrict the client's spasticity, but allow him to raise and lower his arm so that he is able to perform day-to-day tasks.

The device had to be able to be removed and attached to the client's wheelchair easily and quickly. In addition, the device had to restrain posterior abduction of the humerus at a force of 40 to 120 pounds. To accomplish daily tasks that involve hand-to-mouth motion of his right arm, augmentation of the device had to allow for 0°-110° flexion of the elbow, 50°-60° internal rotation of the shoulder, 30°-45° flexion, abduction of the humerus, and a lifting force of 25 pounds. In addition, the device had to restrain his dystonic spasms of 40 to 120 pounds. The device is to be controlled by the user, and any electrical and mechanical components had to be properly installed. A budget of \$1500 was specified and the team had roughly four months to complete the design.

SUMMARY OF IMPACT

The resulting device provides a comfortable restraint system that restricts the user's spasticity, but allows him to control elbow flexion so that he can perform such tasks as eating, brushing his teeth, and other hygienic activities. While testing the

device, the client exclaimed, "I can brush my teeth now." The client's physical therapist has also expressed her satisfaction with the final product.

TECHNICAL DESCRIPTION

The final design incorporated an AC linear actuator to provide the desired range of motion, a foot control for the user to control movement, and a control box to convert AC to DC power (shown in Figure 13.3). These devices were donated by LINAK (Louisville, KY), and were chosen based on size, weight, availability, appearance, and desired performance. The LINAK linear actuator was wired to the control box. Snap-connectors and heat-shrink tubing were added to secure the line. The original distal joint of the arm support was removed, and an aluminum conduit was used to fix the arm support segments into a set position. Locking the arm at this joint functions in spasm control and also provides a stable mounting position for the actuator. This positioning allows the user's arm to be relaxed, hanging slightly anterior to his body, from where the linear actuator can raise his hand to his mouth in a comfortable and natural manner. Steel bushings were placed in the piston rod eyes to accommodate for diameter size differences between the eyes and the mounting brackets. A hole was drilled as close to the proximal joint as possible to allow for full extension of the actuator piston. A conduit hanger was then bolted at the hole's location to allow for attachment of the stationary piston rod eye.

The forearm support was adjusted to allow for the proper pivot angle, and a stainless steel bolt was inserted through a mounting flange to attach the movable piston rod eye. Vinyl bushings were then used to prevent lateral movement and a stop-pinion was removed to prevent overshoot complications. The completed system is shown in Figure 13.3.

The linear actuator, control box and foot switch were donated, resulting in a total cost of \$96.



Figure 13.3. Electric Elevation Assist and Spasticity Control Arm (Top). Foot switch (Bottom Right), Linked to Control Box (Bottom Left).

SAFE FLOORS FOR PREVENTION OF FALLS

Designers: Maile Kruse, Jared Haden, and Jonathan Quick

Client Coordinator: Uday Vaidya, Department of Materials Science and Engineering

Supervising Professors: Alan W. Eberhardt, Department of Biomedical Engineering,

Gregg M. Janowski, and J. Barry Andrews, Department of Materials Science and Engineering

University of Alabama at Birmingham

Birmingham, AL 35294

INTRODUCTION

A flooring system for passive prevention of falls resulting in hip fracture was the goal of this project. The constraints for the floor material were that the floor must withstand normal walking (i.e., the 385 N peak force caused by walking barefoot). Under impact of a 35-kg load at 2.6 impact velocity, the floor must attenuate 2.23 kN from the hip surrogate in order to prevent hip fracture of a woman. Hip padding systems were to be capable of lowering the femoral impact force well below 4 kN, the mean force required to fracture the elderly femur in vitro in a side fall loading configuration at realistic loading rates. Furthermore, all components of the surrogate were to be durable enough to withstand multiple impacts.

SUMMARY OF IMPACT

The most common cause of hip fractures is falls, usually in people over 65 years of age. Due to the prevalence of osteoporosis, women are up to three

times more likely to experience a hip fracture than men. A flooring system to serve as passive prevention of hip fracture was the goal of the present work, to prevent hip fracture in women. Further design work is needed, as the current design was not successful in testing to simulate hip fracture prevention.

TECHNICAL DESCRIPTION

Floor

A layered sandwich composite structure was developed for the floor. A core subsystem is the primary energy absorber. Options for the core included honeycomb, prismatic, and foam/laponite mixture. The honeycomb core was chosen because of its in-plane properties. Honeycomb core made of aramid paper was chosen for its low weight and cost efficiency. The HexWeb HRH-10-1/8(in)-3.0(lb/ft³) absorbs approximately 60 J upon buckling and therefore was considered adequate for the flooring purposes. Epoxy was chosen for the resin

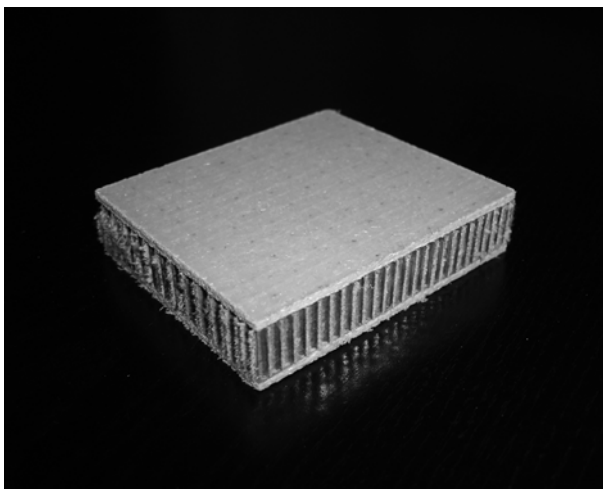


Figure 13.4. Sandwich Composite Floor with Hexweb Honeycomb Core Made of Aramid Paper (Left) Joined to Face Sheets of E-Glass Fiber and Coremat With Epoxy(Right)

subsystem. A series of E-glass fiber and Coremat were chosen for their high affinity to bond to each other. To impart rigidity to the face sheets, the layers were bonded together using Freeman's FMSC 690 epoxy resin followed by vacuum bagging and 24-hour cure. The honeycomb core was sandwiched between the two face sheets with 3M's Scotchweld DP - 125 Grey epoxy adhesive bonding. The floor was put into an oven at 160°F (71 °C) for two hours to attain full cure. The finished floor tile was then cut into 8.9" x 11.4" tiles for testing (Figure 13.4).

Surrogate

A hip surrogate was constructed using wood, springs and an adjustable shock absorber (Figure 13.4). The femoral head of a Sawbones 3rd generation composite femur was glued onto the center of the top plate's superior face. A layer of Sorbothane, .75 cm thick, was attached on top the femoral head by spray adhesive. A hole with a 3.8-cm diameter was drilled into the center of the 25.5 cm x 25.5 cm bottom plate to house the 25 cm tall damper. The damper was placed through this hole and fastened to the plate with two nuts, one on either side. Four 8.5 cm x 8.5 cm x 12.5 cm blocks of wood were attached to the bottom plate to provide clearance for the height of the damper. Then a hole with a 1.5 cm diameter (the diameter of the springs) was drilled into the center of eight 8.5 cm x 7.5 cm x 3.7 cm blocks of wood. Four of these blocks were screwed into the corners of the superior face of the bottom wooden plate. The other four blocks were screwed into the corners of the inferior face of the top plate. Furthermore, a block of wood with a 3 cm diameter hole in the center was screwed into the center of the inferior face of the top plate, to enclose the head of the damper. The springs were placed into each hole of the bottom plate. The top plate was placed on top of the springs and damper to unite all three subsystems. Two screws were tightened through the housing of the damper head to ensure that the three subsystems act as one system under impact.

Floor testing

After construction of the composite flooring, compression and point load tests were performed on

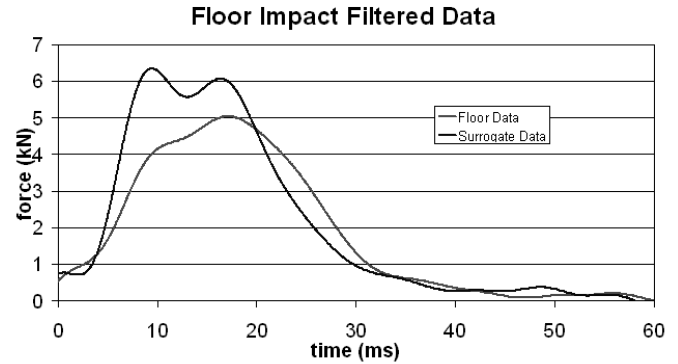


Figure 13.5. Impact Force Data for Hip Surrogate (6.3 kN peak force [dark line], with sandwich composite flooring [gray line], reducing peak force to roughly 5 kN)

the tile to determine whether the floor would be able to withstand everyday forces such as a typical walking. The floor stiffness was found to be independent of the loading rate. Point load testing was conducted to better understand the floor's response in situations such as a woman walking in high heels and someone sitting down in a chair. As expected, the floor failed at a lower force with the small indenters versus the large indenters, but none at levels below 400 N. The surrogate was then impacted with 35 kg raised 32 cm from the impact surface to generate a 2.6 m/s impact velocity. The data were filtered by a fast Fourier transform using a low-pass filter with a cut-off frequency of 140 Hz. The surrogate underwent a peak force of 6.4 kN within a response duration of 60 msec. Although the force peaked earlier than expected, the surrogate was used to validate the flooring system for hip fracture prevention. In floor evaluations, a 8.9 cm x 11.4 cm floor tile was attached to the 7.62 cm x 10.16 cm impact plate by spray adhesive and dropped onto the hip surrogate under the same mass and velocity conditions. The data were filtered, and the floor decreased the peak force experienced by the hip surrogate by 1.4 kN, which did not decrease the peak force to the target 4.1 kN. The flooring system, therefore, was not successful in the prevention of hip fracture.

Total cost for materials was approximately \$820.

STAIR TRAINER FOR CHILDREN WITH CEREBRAL PALSY

Designers: Harleen Khanijoun, Dina Halwani, and Monalisa Ghosh

Client Coordinator: Marliese Delgado, UCP Hand in Hand

Supervising Professors: Alan W. Eberhardt, Department of Biomedical Engineering

University of Alabama at Birmingham

Birmingham, AL 35294

INTRODUCTION

A stair trainer device was built to promote gross motor function in children with cerebral palsy (CP), aged two to five years old. The ascending and descending of stairs employs an increase in the lower-limb movement and more intense muscular activity than walking (Figure 13.6). Currently, stairs on the administrative side of a CP program's building are being used to train the children. A previous stair trainer designed by a previous senior design team was abandoned due to safety concerns. A modification of the previous stair trainer was requested, differing from the previous in size, material, and appearance.

An isolated stair trainer that provides an incentive for children to repeatedly climb a set of stairs was the goal. The stair trainer had to allow for easy adult supervision, and be easily disassembled and stored when needed. Based on the safety standards for playground equipment, the railings were to have an appropriate height of 24" for toddlers and were designed to be 24" apart to disallow holding of both railings during climbing. A height of three feet was designated for the platform with a minimum of 24" of railings, as dictated by safety standards. Additionally, wood was the material preferred by the client, and the use of metal was to be avoided due to its hospital-like appearance.

The space for use of the stair trainer was a corner of a room with an area of 18' x 18'. The minimum final structure height as instructed by representatives at the UCP was designated as 36". The design was to be disassembled into large modular components, each of which could be moved by two adults who could lift a combined weight of 150 pounds. The components had to fit into a storage area with a single door entryway. The maximum number of children expected on the set of stairs was three per stair and five on the platform, and a safety factor of two was employed. The following dimensions for

the stairs were prescribed: a height of 8", a width of 10" and a length of 24".

The smallest child on the stair trainer would be 19" tall, weighing 20 pounds, while the largest would be 46" tall, weighing 68 pounds. Appropriate fall zones had to be taken into account at a minimum of 6' in each direction. To avoid head entrapments, openings could not exceed 9" and could not be smaller than 3.5". Additionally, the structure could not have any sharp edges or corners, the supports had to be sturdy, and the device stable. According to the Safety Standards for Playground Equipment produced by the Consumer Product Safety Commission, the angle of the stairs could not exceed 35 degrees. The angle of the slide could not exceed 50 degrees at any portion and had to maintain an average angle of 30 degrees. The ideal slide would re-orient the child to a sitting position at the exit. The project had to be completed within four months and within a \$1,500 budget.

SUMMARY OF IMPACT

Through treatment, muscle coordination in CP can be improved, and secondary conditions can be avoided. Children of various levels of ability will be able to practice stair climbing, and receive the reward of a ride down the slide. The staff commented that the concentration of children playing on the stair trainer will allow for easier supervision of larger numbers of children. The trainer has not yet been delivered.

TECHNICAL DESCRIPTION

The final design consists of the three following subsystems: one set of stairs, one platform, and a slide (Figure 13.6). Wood comprised the primary material because of its well-known properties, low cost, and ability to be machined. The team used a lightweight commercial polyethylene slide component as an incentive to climb the stairs.

The density of $\frac{3}{4}$ " birch plywood (0.01987 lbs/cu in) was used in the calculations. To reduce bulkiness, a small platform of 26" x 26" was designed. The completed weight of the structure was 200 pounds. The slide was lightweight, at approximately 20 pounds. The final structure was carpeted, per the client's request, and to reduce noise created. As dictated by the design criteria, the stair trainer was built as an isolated structure. Given its 90-degree angle against the corner of a wall, it allows for easy adult supervision. It is of the requested 36" height

with additional 36" railings on the platform, promoting safety. There are no places where children might crawl through and no sharp edges. The device is stable, and the railings are placed for safety and supervision. The project met all safety standards with the stairs and slide angle.

Due to higher-than-expected cost of labor, the project exceeded the \$1500 budget by \$260.

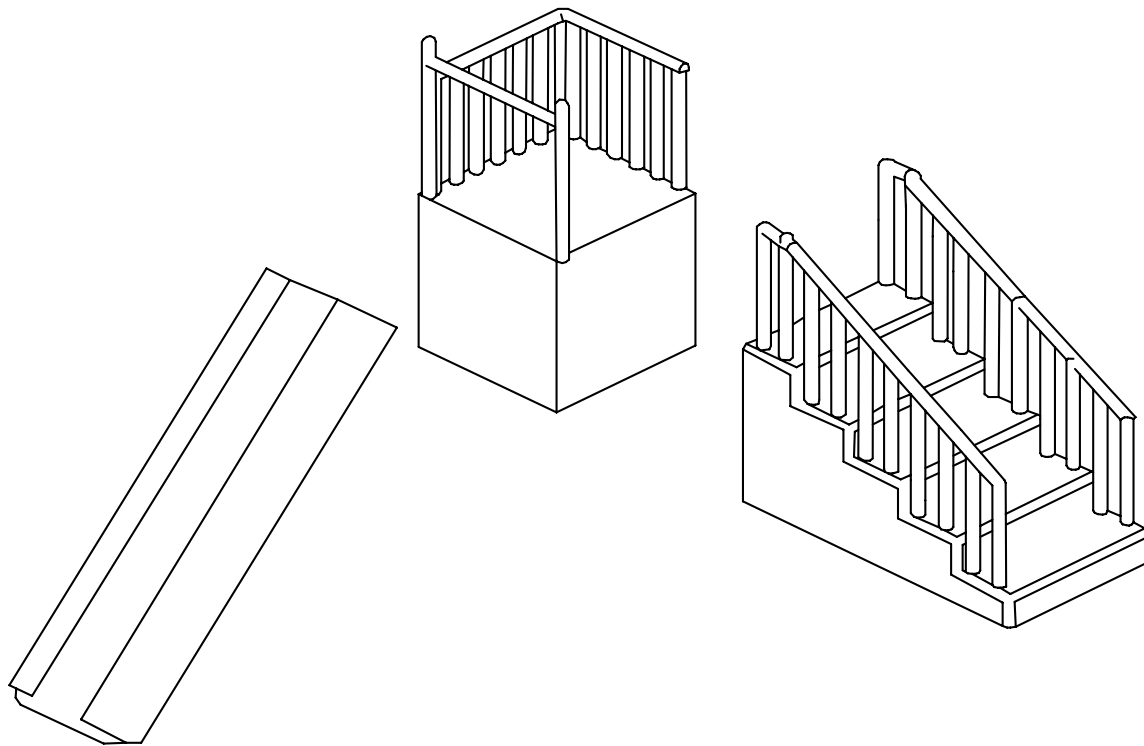
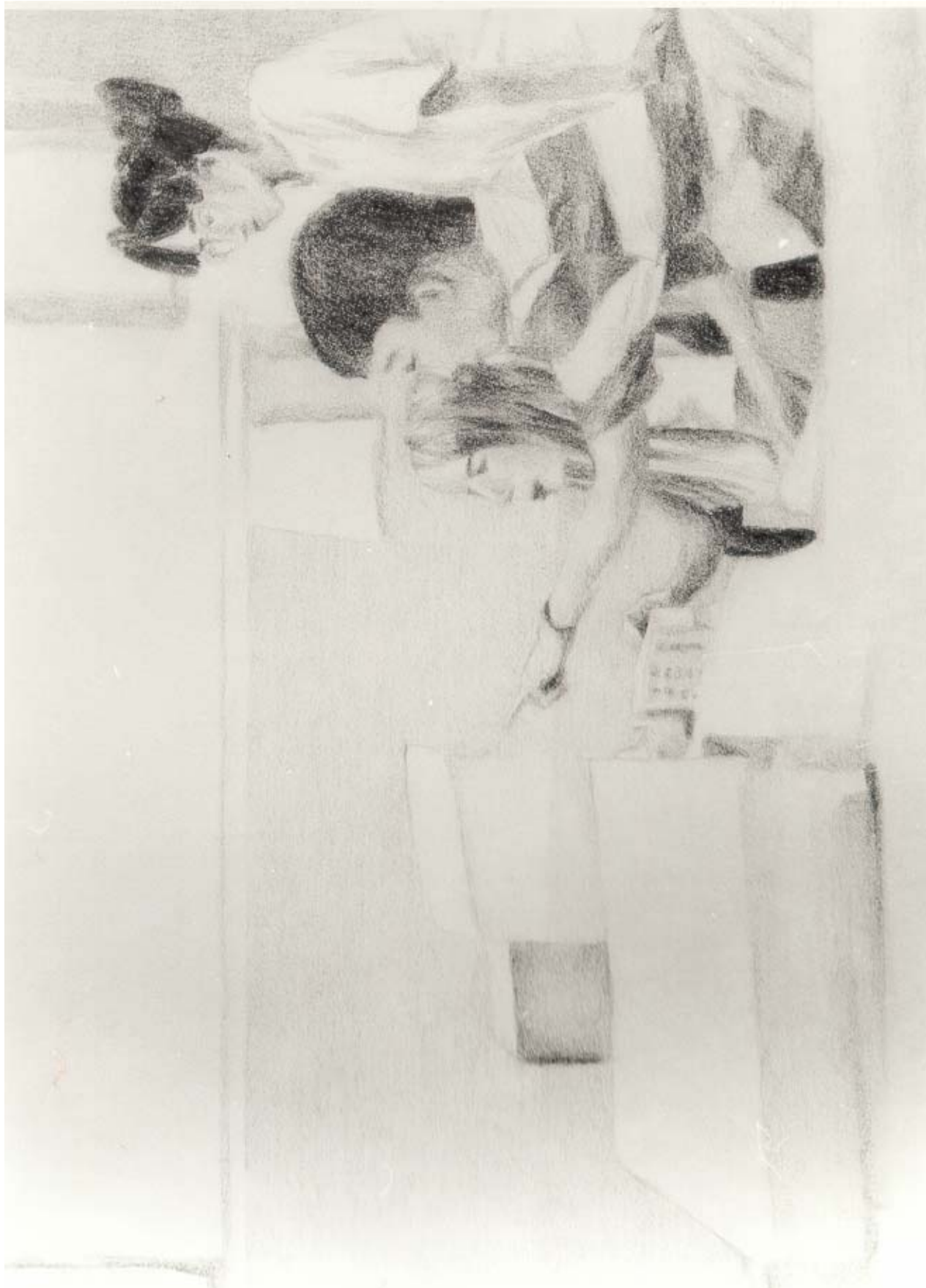


Figure 13.6. Schematic of Stair Trainer (Slide, Platform and Stairs)



CHAPTER 14

UNIVERSITY OF MASSACHUSETTS AT AMHERST

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SPATIAL RESOLUTION ENHANCEMENT IN ULTRASONIC RANGING FOR A SMART CANE

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INTRODUCTION

Ultrasonic ranging has been applied to obstacle detection in many assistive technology applications, including collision avoidance in electric wheelchairs, preventing automatic doors from closing on slow pedestrians, and electronic travel aids (ETA) for individuals with visual impairments. For ETA applications, high spatial resolution information is needed to be able to identify obstacles that must be avoided to reduce the risk of injuries. This design project describes a method to digitally focus ultrasonic ranging data in a constraint environment of a microcontroller, for structural integration into the thin shaft of a sensor-embedded smart long cane.

SUMMARY OF IMPACT

Obstacle identification with ultrasonic ranging is dependent on determining the spatial position of an object in at least two dimensions: distance and height. This capability is critical for a sensor-embedded long cane to distinguish overhanging obstacles from other obstacles detectable by the cane. The technique presented here can be implemented in an 8-bit microcontroller with limited memory to fit the size constraints of integration into a long cane and will make travel safer for the user.

TECHNICAL DESCRIPTION

The spatial position of an obstacle can be measured using ultrasonic echo location by transmitting an ultrasonic pulse and measuring the time of flight (TOF) for echoes that are reflected off the obstacles. The ability to detect a reflected ultrasonic pulse is governed by the energy content, E , of the transmitted pulse.

For most ultrasonic transducers, the operating frequency is fixed and the amplitude is limited. Thus, only the pulse length can be varied to increase

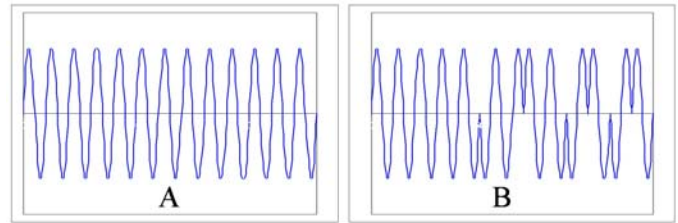


Figure 14.1. Waveforms of the carrier: A - Unmodulated, B - Phase-modulated with a 13-bit Barker Code

the energy content of a pulse for improved pulse detection. However, such an approach results in a proportional loss in the spatial resolution. For example, a pulse length of 52 cycles at 40 kHz is 0.45 meters long, meaning that the spatial resolution of the obstacle detected is measured as being less than half a meter, due to the difficulty in determining accurately the beginning of an unmodulated sound wave. This is especially true when the level of weak echoes is undistinguishable from the ambient noise level.

Pulse compression using cross correlation can overcome this drawback. Cross correlation is a measure of the similarity of two signals and shows the relative position of one signal in the other. Cross correlation is often referred to as matched filter, or the sliding dot product. Mathematically, it is the sum of the product of the elements of the signal vector, with the elements of the search pattern vector or correlation vector for successive positions

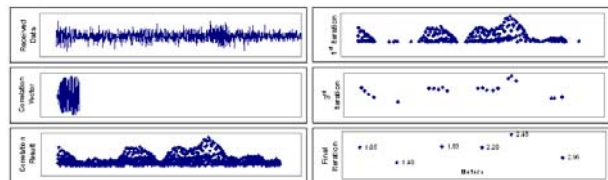


Figure 14.2. Iterative Process for Ultrasound Peak Detection

along the signal vector of length.

An ultrasonic pulse is modulated to create a pattern that can be easily correlated. Figure 14.1 shows the waveform of an unmodulated carrier and a phase-modulated carrier. The phase of the carrier is shifted 180 degrees to encode ones and zeroes. A pattern that gives a high correlation value when it is aligned with itself and low correlation values for all other positions of partial alignment is applied, by means of the Barker codes, which create binary patterns. In this project, a 40 kHz pulse was encoded with a 13 bit Barker Code (1111100110101) using phase modulation and 4 cycles per bit, resulting in a 52-cycle pulse. The waveform of the excitation signal (to a piezoelectric transmitter) is shown in Figure 14.1B. Subsequently, the piezoelectric transmitter converts this excitation signal into a sound pressure wave, and transmits it into the air, in the form of an ultrasonic pulse train. The pulse train is reflected by a control surface, which serves as a calibration object, and is converted back to an electric signal by means of a piezoelectric receiver. The received signal serves as a correlation vector. As shown in Figure 14.2, the correlation vector is aligned with the beginning of the received signal, with a time lag of zero. The result of the cross correlation operation is a vector of values representing the strength of the correlation, or match, between the ultrasound signal and the correlation vector.

The correlation peaks, shown in Figure 14.2, correspond to the time or position in the vector of the received echoes to the resolution of the sampling frequency, effectively compressing a pulse length of 52 cycles to one sample, which is less than one cycle. This solves the resolution problem for a pulse with a large enough length to be easily detected. Locating a peak is accomplished by a pulse detection operation, for which an iterative process is performed, as shown in Figure 14.2. The process considers the minimum spacing between adjacent peaks, determined experimentally, to eliminate weaker correlations, called sidelobes, without losing real matches. The process is repeated until only peaks that are further apart than the sidelobe spacing remain. The result in Figure 14.2 shows the output

of the cross correlation for the received ultrasonic signal, where the peaks represent the location of pulse echoes in the received data. The timing of the peaks represents the time of flight (TOF) of the echoes at the speed of sound and therefore the range to the obstacles.

The Y-axis position of the peaks represents the relative strength of the correlation, and it is used to locate the peaks. The positions along the X-axis represent the range of an obstacle, and are measured in meters. Each dot on the graphs represents one data sample or reading of the analog-to-digital converter within a microcontroller. The final values shown in the bottom graph of Figure 14.2 are the location of the start of the detected pulse echoes converted to time, obtained by multiplying the sample number by the sampling period. This gives the TOF of all detected echoes with a precision of one sampling period. The TOF information from two receivers is combined to calculate the spatial position of the obstacle that reflected the transmitted pulse. This spatial information can then be used to categorize the obstacle. The photo in Figure 14.3 shows the experimental setup for ultrasonic signal correlation.

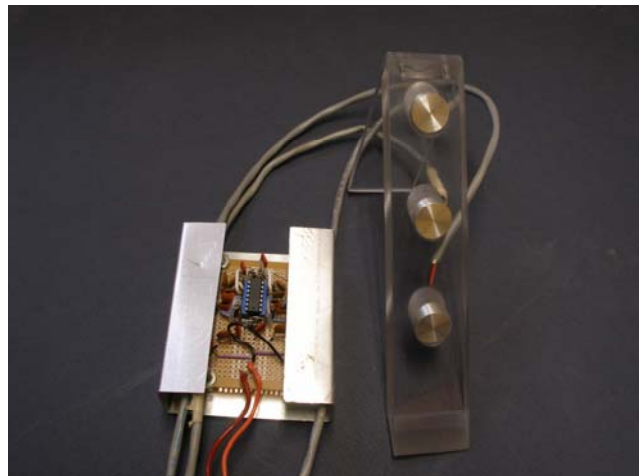


Figure 14.3. Experimental Setup, with Ultrasound Transmitter Holder and Prototype Electronics

SMART CANE MODIFICATIONS

*Designers: Brett Laviolette, Michael Resca, and Alicia Lemieux
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INTRODUCTION

The Smart Cane utilizes specific sensors, modules, and electronics that will alert a person who has a visual impairment of the exact distance and height of an obstruction in his or her path. The objective was to design a hollow shaft for the cane that will house the miniature ultrasonic ranging module and microelectronics while maintaining the same vibration frequency as a standard cane. The current design for the cane has all the electronics mounted on the cane shaft with a bulky aluminum casing. To achieve the design goal, different design concepts were produced and evaluated based on the design criteria. Figure 14.4 shows the final design, which is a tapered hollow oak shaft with an inside diameter being large enough to accommodate the largest existing computer chip. This design was selected for its low cost, low weight and its ability to match the

natural frequency of a standard cane.

SUMMARY OF IMPACT

Standard canes for people who have visual impairments only aid in detection of obstacles below the waist. The Smart Cane reveals obstacles not only below the waist but also above by utilizing signals that locate the hindrances and notify the user accordingly. The additional features of the Smart Cane require electronics to be added to a standard cane, which might alter the characteristics of the cane. Redesigning the shaft of the Smart Cane to mimic the characteristics of a standard cane will allow people who currently use a cane to transition easily from the current standard to the Smart Cane. The redesign also provides a protective housing unit for the sensitive electronics.

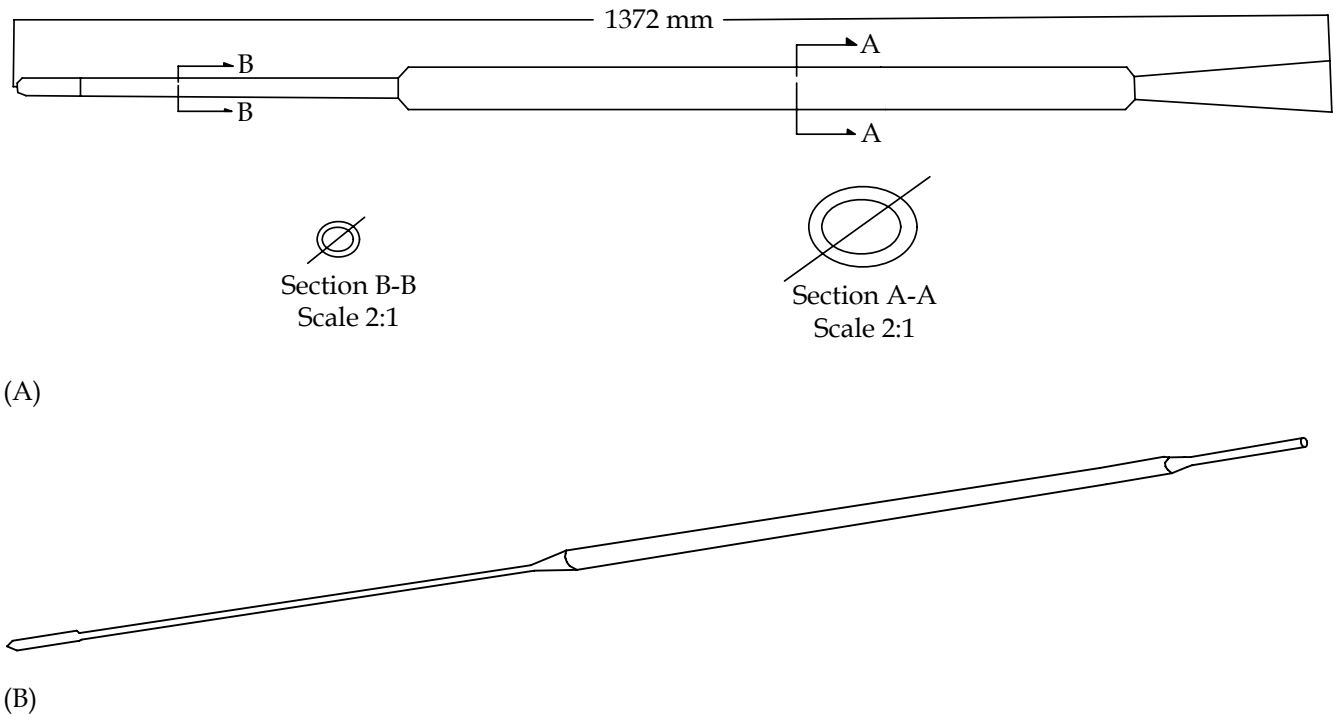


Figure 14.4. A: Engineering Drawing for the Redesigned Cane; B: Pro/Engineering Drawing.

TECHNICAL DESCRIPTION

The concept that was chosen for the design of the Smart Cane's shaft has an outer diameter of 56 mm. This diameter is large enough to house the largest computer chips needed for the ultrasound detection of objects and is located toward the top of the cane. Approximately 2/3 of the length of the cane will be filled with the electronics. At the end of the electronics housing section of the shaft, the larger diameter will be tapered in the remaining section of the cane. The remaining 1/3 of the cane will have a diameter of 24 mm, which is the current standard diameter of a cane. The material selected for both sections of the cane was oak. Oak was selected

because the first four modes of its natural frequency match almost exactly the frequency of the standard cane made from aluminum. Also, the oak cane only weighs 0.0297 kg more than the standard cane. The small differences between the standard cane and the oak cane mean that there will be almost no difference in feel to the user. Another advantage of using oak is its low cost (\$3.00/kg for perpendicular oak), which results in a cost of only \$0.335 for the cane material (not including any electronics). A perpendicular grain orientation on the upper shaft was used to reduce cost. A parallel grain orientation on the lower shaft was used to provide superior strength.

DAMPER DEVICE TO PROTECT SMART CANE ELECTRONICS

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INTRODUCTION

A means of protecting the sensitive electronics housed inside the shaft of a smart cane is needed. One solution is to make a mold of visco-elastic foam. The visco-elastic foam chosen for this design is light and inexpensive, and excellent for damping vibrations. To maximize damping and minimize weight, conical bumps will be molded to create stress concentrations and increase the damping of the protective sleeve that will surround the electronics (see Figure 14.5).

SUMMARY OF IMPACT

The electronics for a cane with the capability to detect objects above the waist are expensive and delicate. By creating proper protection for these sensors the cane will be able to handle the rigors of everyday use. Additionally, this new technology will increase the safety of Smart Cane users.

TECHNICAL DESCRIPTION

Visco-elastic foam is molded to have coned-shaped protrusions on the outer surface and a groove on the

inner surface, as seen in Figure 14.6.

The cones on the surface create stress concentrators, which allow for higher damping. Once the flat mold is created, it is then wrapped around the housing of the cane to make a cylinder. Next, the chip is inserted into the molded grooves on the inside surface and then inserted into the cane (See Figure 14.7).

It was determined that this configuration will be able to protect the sensitive electronics from impact if the tip of the cane on the ground has a speed up to 21mph. This is based on the average cane length and arm length to give a sweeping radius of 59," while sweeping a 45 degree arc every 0.25 seconds. This is thought to be an extreme case and would cause large vibrations along the cane shaft. Using these assumptions the design group is confident that the solution presented will affectively protect the electronics in the cane even in extreme impacts at the tip of the cane.

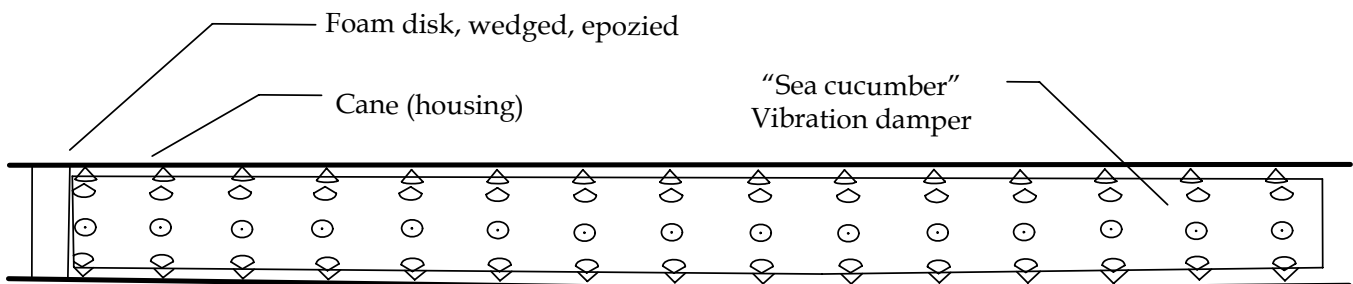


Figure 14.5. Final Geometric Design of Protective Visco-Elastic Foam

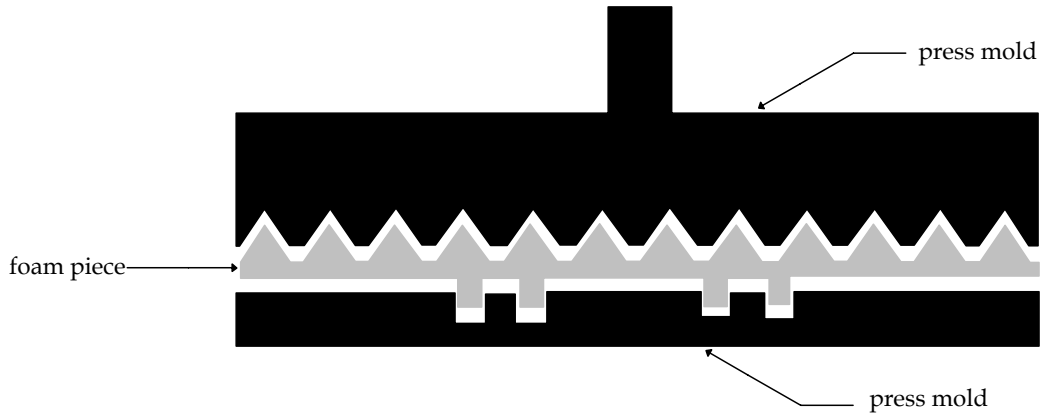


Figure 14.6. Mold for Creating the Inner Geometry of the Shaft

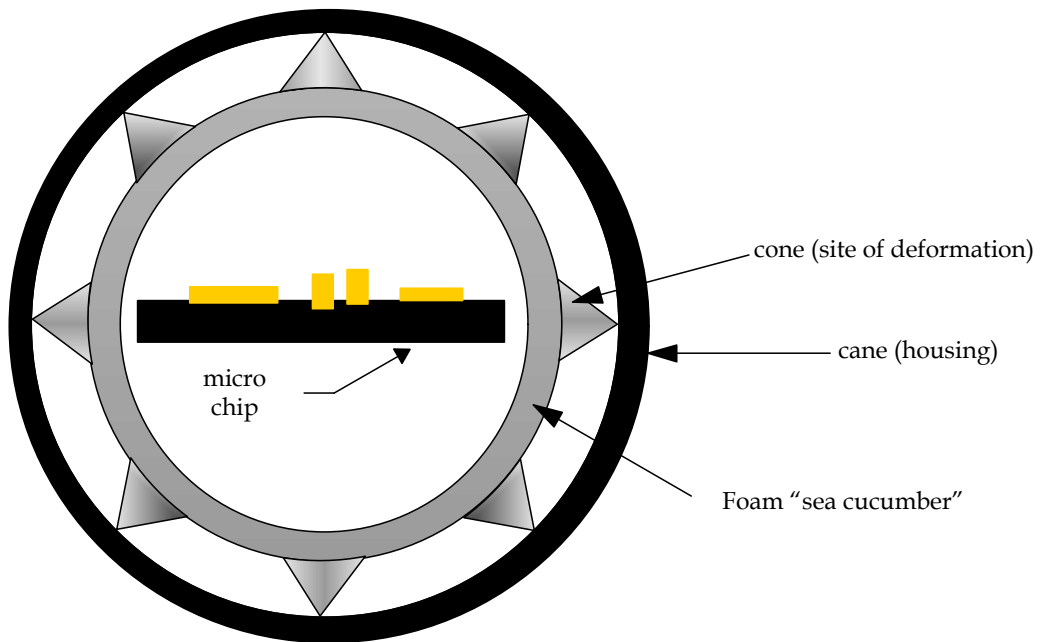


Figure 14.7. Cross Section of the Cane, Sensor and Damper

BOTTLE CAP REMOVAL ASSISTANT

*Designers: Marc Attar, Steven Baj, and Andrew Werther
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INTRODUCTION

The goal of this project was to design a bottle cap opener that requires the use of only one hand and is portable. Currently there are simple solutions for opening bottles with metal caps. One is a wall-mounted bottle cap opener. Another option, which is more common in the average household, is the portable bottle opener that has a hole into which the metal cap fits at an angle. By lifting the handle upward, the cap comes off. However, the portable bottle opener requires the use of two hands, one to stabilize the bottle and the other to use the handle or lever that gives the user a mechanical advantage. This easy-to-use lightweight portable bottle opener (Figure 14.8) grips the neck of the bottle and then lifts off the bottle cap when the handles are squeezed together.

SUMMARY OF IMPACT

People who have limited use of one hand will benefit from a portable bottle cap opener that requires only one hand to use. This new design will enhance independence. Its portability will enable

users to remove bottle caps when wall-mounted devices are not available, such as during outdoor activities.

TECHNICAL DESCRIPTION

The design is shown in Figure 14.8. It uses a lever, which gives a mechanical advantage to the user, reducing the force needed to pry the metal cap off of the bottle. The same basic shaped head or cap removal arm is used as the standard bottle opener, which interfaces with the bottle cap (Figure 14.9). The lever arm and the cap removal arm are linked, allowing for the proper motion to remove the cap and force transfer. The design has a claw mechanism that grips the bottle, obviating the need for a second hand. The lever mechanism removes the bottle cap (as shown in Figure 14.10).

Future redesigning and testing are required to guarantee that the grip arms and lever arm will comfortably fit in the user's hand and to ensure that the three arms are within comfortable grip capacities of a wide variety of potential users' hands.

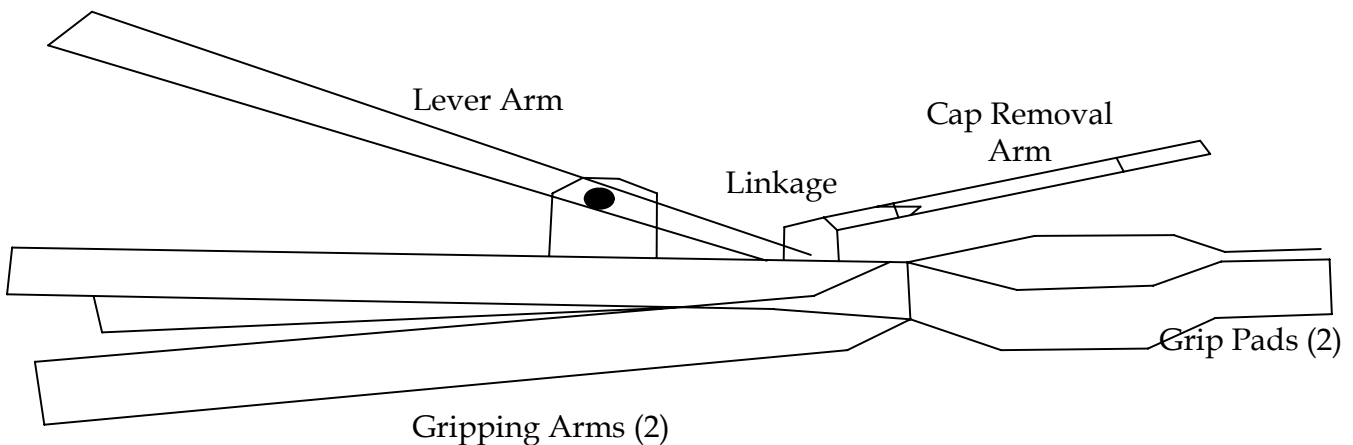


Figure 14.8. Bottle Cap Removal Assistant Design

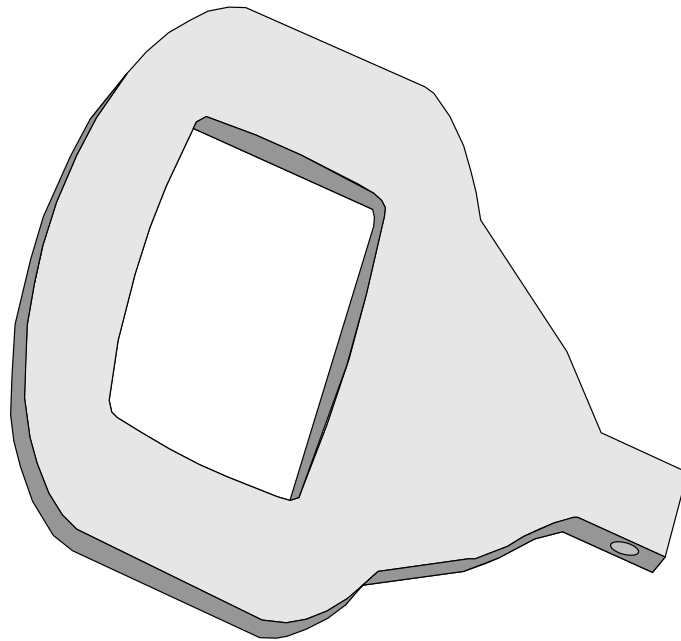


Figure 14.9. Cap Removal Feature

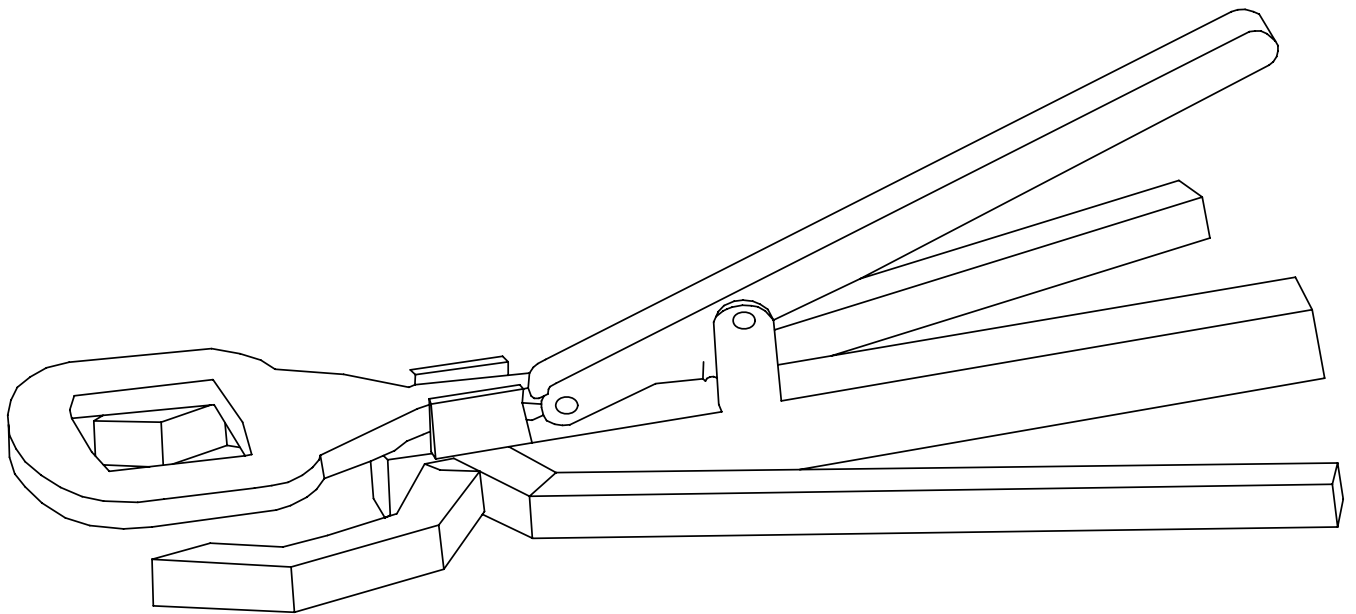


Figure 14.10. Claw and Lever Used to Grip Bottle's Neck

ASSISTIVE REACH MECHANISM

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INTRODUCTION

An assistive reach mechanism for individuals with lower back problems was redesigned. A telescoped arm was designed, which makes the product easier to carry and store. The final design has a gripping claw that can pick up objects as small as a needle and as large as a can or jar. The arm brace, shown in Figure 14.11, aids in lifting the maximum five-pound load.

SUMMARY OF IMPACT

The design can help with grabbing objects that are up to four feet away and weigh as much as five pounds. People who may benefit include those with risk of falling from stools or ladders, people who use wheelchairs, people with back pain and injuries, and people who are short.

The claw allows for picking up a wide range of objects without damaging them. The shaft is strong and telescopes for easy storage. The trigger handle allows for full closing of the claw with only one full pull, and the ratchet mechanism locks the claw in place so constant force is not required. The handle trigger and ratchet will be helpful for people with hand pain or weakness. Finally, the addition of the arm support distributes the load over the arm and reduces the load on the wrist.

TECHNICAL DESCRIPTION

The functional components of the reach mechanism consist of: 1) the interface with person (handle), 2) the interface with object (claw), 3) the support mechanism (shafts), 4) the control mechanism (cable), and 5) mechanical advantage (gearing). Each of these functions were looked at individually, and the best design for each component was selected. Next, modifications were made to assure that all of the components fit and work together.

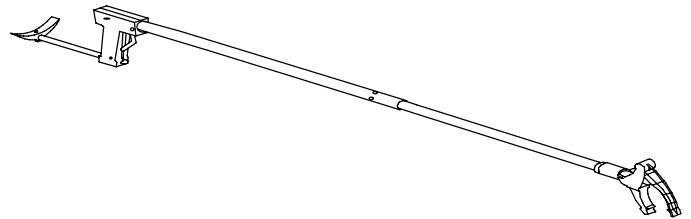


Figure 14.11. Assistive Reach Mechanism

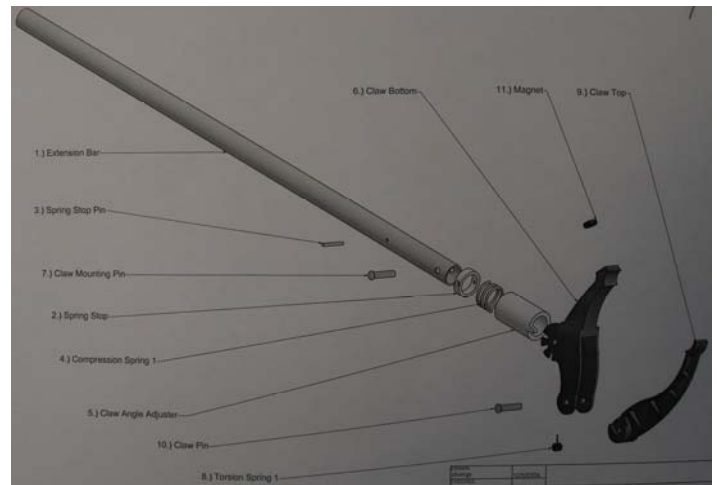


Figure 14.12: Exploded View of Claw

The claw assembly, as seen in Figure 14.12, has a lobster claw design. The claw is hinge-pinned at the top, and uses a torsion spring at the hinge to hold the claw open. The closure is controlled by a cable, which connects to the handle. The claw has two different gripping areas: 1) a larger area near the hinge joint for gripping glasses and jars, and 2) the rubber tips on the ends of the claws, which allow for grabbing objects such as needles and pins. The claw is made of cast aluminum for strength, and has a vinyl coating so the metal will not damage any of the objects being picked up, such as glasses.

The handle, which is made of ABS, plastic and gearing, uses a ratchet mechanism and a trigger handle. This configuration was used because it

allows the user to close the gripping mechanism in one pull of the trigger (see Figure 14.13). The key feature of the ratchet is that it allows the user to lock the claw into place around an object.

There are two shafts in the design: one that connects the handle to the claw, and another that connects to the handle and gives support to the wrist when lifting. Figure 14.14 shows the overall design and the shafts. The shaft that connects the handle to the

claw is comprised of two pieces that telescope, one inside the other. This is held in place with a c-type button when fully extended. Both shafts are made of wrought aluminum alloy with a 1-inch outer diameter and 1/16-inch inner diameter for the shaft and a 0.5-inch outer diameter and 3/32-inch inner diameter for the arm support.

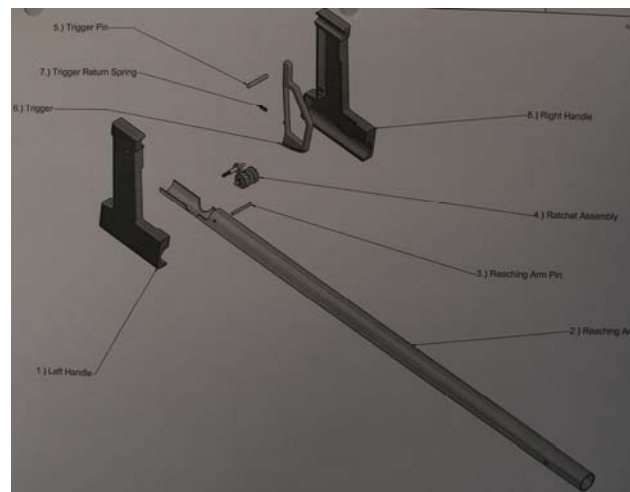


Figure 14.13. Exploded View of Handle

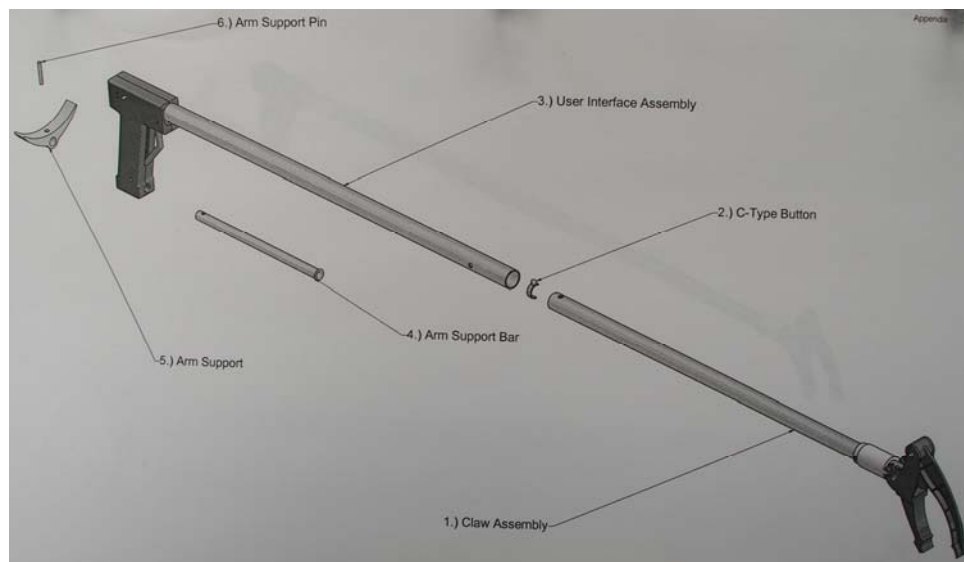


Figure 14.14. Exploded View of Telescoped Shafts

ASSISTIVE STAIR CLIMBER

Designers: Brian O'Connell, Luck Asselin, and Nathan Labarge

Supervising Professor: Robert Hyers

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INTRODUCTION

A device was designed to assist in the moving of heavy loads up a set of stairs. There are many homeowners who cannot carry or move loads up a staircase. Some individuals have trouble making the ascent even without carrying anything. Although there are wheelchair and lift systems to aid in moving loads up stairs, there are no low-cost

personal assistive devices to help in these situations.

The design, shown in Figure 14.15, is a low-cost device that will transport as much as a 40-pound load up a flight of steps.

SUMMARY OF IMPACT

The device is a tread-driven vehicle with a removable self-leveling basket that is capable of

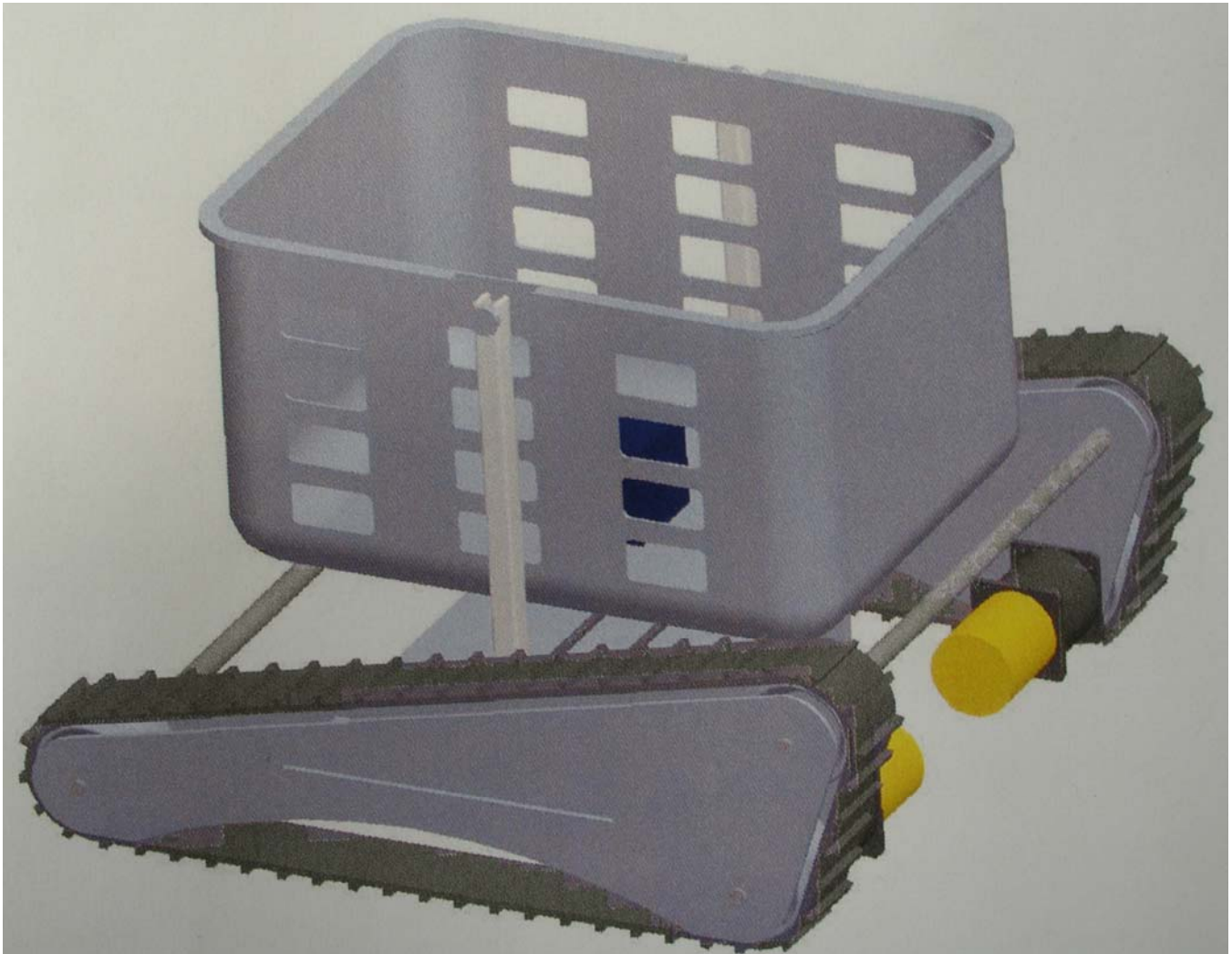


Figure 14.15. Assistive Stair Climber

running along flat ground, as well as up to a 45-degree incline. It will ascend a flight of steps in just over one minute. The device has few parts and was designed for easy manufacturing and assembly. This design will aid people in bringing groceries up and down their front steps, supplies from their basement, or even laundry to their bedroom.

TECHNICAL DESCRIPTION

The proposed design is a basket that is mounted to two arms and attached to the central mounting platform. The central mounting platform connects the two motorized tracks, the motor, battery, and the arms. The arms pivot to keep the carrying basket level while it goes up and down the stairs. The low height of the assembly and the shape keeps the center of gravity far forward and low. The location of the center of gravity keeps the basket from falling back while going up an incline.

The material indices of the plates, shafts and wheels were determined by a simple calculation, maximizing the strength against relative cost and density. PVC was chosen for the plate, while maximizing modulus against relative cost led to the selection of aluminum for the wheels and the shafts. All of the PVC parts will be joined using PVC welding, which creates a bond stronger than the PVC itself.

The belt that propels the assistive carrier and climbs the steps allows for a maximum loading weight of 100 pounds directly in the center of the bottom track, with a pretension of one inch. This allows for a maximum strain of 1.9% and causes an elastic spring force of 8.7 lbs per inch throughout the track. The Saint-Gobian Chemfab TCN 1590 Leno Weave Nomex/Fiberglass Belting Material, which has a max elongation of 2% at a loading of 40 pounds per inch, was the best match for this design.

It was determined that, for the motor, a torque of 15 ft*lb was necessary to drive the device while carrying a 40-pound load up a 45-degree angle at approximately 0.5 ft/sec. The motor selected was by HIT, and runs on a 12V DC battery at 2850 rpm and supplies 0.1562 ft*lb of torque. A spur gear head by Bayside Motion Group was chosen due to its 100:1 gear ratio with 98% efficiency and low backlash. It will provide the necessary force and speed.

The battery supply for the motor is based on the discharge time of 1.1 hours because the motor requires 1 ampere. A sealed lead acid battery was chosen based on the principle that it is able to discharge at any rate. The total weight of the battery is three pounds; it has a low-profile design, making it easy to attach to the support plate.

The expected cost for all parts (not including the belt) is approximately \$200.

STOW AND GO: JOHN DEERE GATOR WHEELCHAIR STORAGE SYSTEM

Designers: Tim Smith, Sean Pringle, and Brian Swearengin

Collaborators: John Deere, PTC, Georgia Institute of Technology, University of Illinois-Urbana Champaign

Supervising Professors: Sundar Krishnamuty and James Rinderle

Department of Mechanical and Industrial Engineering

University of Massachusetts

Amherst, MA 01003-3662

INTRODUCTION

This project is the continuation of the designing and building of a prototype add-on for a John Deere 6x4 Gator (Figure 14.16). Throughout the project stages, the University of Massachusetts collaborated with Georgia Tech and University of Illinois-Urbana Champaign. The design is specific to people who use a wheelchair but wish to transport the chair easily when they are using the Gator. The UMass team's task was to design a device able to stow and retrieve a folded wheelchair on the 6'x4' vehicle. The final design (Figures 14.17 and 14.18) is easy for the user to control by using simple on and off switches. Also, the design minimally impedes on the usefulness of the Gator as a utility vehicle, by having the wheelchair be stored on the device itself. Low cost and robustness were also priorities of this project.

SUMMARY OF IMPACT

John Deere has determined that there is a market for a Gator that can be used by people who use wheelchairs due to a disability affecting the lower body. This design will enable users to remain active outdoors and to be able to do some of their own yard and garden maintenance, increasing independence and quality of life.

TECHNICAL DESCRIPTION

The "Stow and Go" is designed to be durable through the use of lightweight and strong 1/8"-thick 6063 aluminum square tubing for the frame and all the hinges. A 12-volt electric linear actuator provides the motion. This low-voltage actuator allows the device to be powered by the Gator battery and obviates the need for expensive and complicated hydraulics. The wheelchair attaches to the lift via an adjustable clamp where it is securely held by an easy-to-use cam lever (as shown in Figure 14.19).



Figure 14.16. John Deere 6'x4' Gator

This clamp holds the wheelchair handles during lifting, retrieval, and when the Gator is in use. Operation is controlled by two simple toggle switches. One controls the direction of the motor while the other controls the power. Safety cut-off switches are fully integrated into the electrical



Figure 14.17. Partially Extended Prototype

system.

This design allows for a customer to buy the product as an after-market add-on, since it is fully self-contained and only interfaces with the Gator for the power supply. The design would be easy and inexpensive to install at the factory because it can be

fully assembled independently from the assembly of the Gator.

The final cost for this project is approximately \$500.



Figure 14.18. Fully Retracted Prototype



Figure 14.19. Clamping Mechanism to Hold Wheelchair



CHAPTER 15

UNIVERSITY OF MASSACHUSETTS AT LOWELL

**Department of Electrical and Computer Engineering
University of Massachusetts Lowell,
Lowell, MA 01854**

Principal Investigator:

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NINE-BUTTON TALKING BOX

Designer: Demis John

Client Coordinator: Karen Kane, James F. Sullivan Middle School, Lowell, MA

Supervising Professor: Walter McGuire

Electrical and Computer Engineering Department

University of Massachusetts, Lowell

Lowell, MA 01854

INTRODUCTION

The client for whom this project was designed is a non-verbal 11-year-old girl with learning disabilities. These include poor auditory comprehension, as well as trouble understanding words and concepts represented by pictures. The teacher has been teaching the client to point to small picture squares as a form of communication. Often, the client points

to a picture conveying a message, such as the need to use the bathroom or desire to use the computer. It took the teacher one year to help the client understand the connection between a picture of a computer and the computer workstation itself.

The teacher requested a device linking the pictures that the client already uses to corresponding audio messages. The device consists of nine square



Figure 15.1. Nine-Button Talking Box

buttons intended for the display of the client's picture cards, each button triggering a separate re-recordable audio message.

SUMMARY OF IMPACT

The Talking Box (Figure 15.1) serves as a learning tool to reinforce associations among pictures, concepts and words and also serves as an augmentative communication device. The teacher commented that the simplicity of the device is helpful; there are only the nine buttons, one power switch, a volume knob and a recessed play/record switch. Additionally, after only two hours, the client had already begun to understand that this device was hers only, and that the pictures were meant for her to communicate ideas. The teacher then presented new concepts to teach the client, and commands or comments she could express using the device. The teacher anticipates that the client will become more independent as she becomes more proficient with her Talking Box.

TECHNICAL DESCRIPTION

The device consists of nine large 1.75" square arcade buttons (with the back-lighting capability disabled)

on the front face of a rectangular box. On one side of the device is a three-position volume control, chosen over a variable volume control to prevent accidental alteration of the setting. On this side also lays a recessed play/record switch and a battery compartment containing four AA batteries. On the opposite side are speaker holes and a microphone for recording. Attached to the rear, flat side of the device are two Velcro straps, for strapping the device to the user's waist.

Only three ICs were needed to implement the audio capabilities. Winbond Electronic Corp.'s ISD2560 provided 60 seconds of addressable audio recording and playback. To control the playback of audio, Parallax Inc.'s Basic Stamp (model BSII) provided 16 I/O pins able to be programmed with a variant of the BASIC language. An LM386 Power Amplifier was used to boost the output volume to a two-inch speaker. The buttons were simple three-terminal momentary pushbuttons, typical in arcade machines.

The cost of parts and material was approximately \$160.

DROP FOOT SOCK

*Designer: Karl P. Metzemaekers
Supervising Instructor: Alan Rux
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Lowell, MA 01854*

INTRODUCTION

The Drop Foot Sock (DFS) (Figure 15.2) was designed for a client who has a neuromuscular disorder known as drop foot, which affects his ability to raise his foot at the ankle. He wears a brace that pivots his ankle for him so that his heel always plants first before his toes. If the heel is not planted first, a stumble or fall is likely. The purpose of the design is to alert the user if his foot is not bent back enough to make a proper heel plant to take a step. The device is simply a sensor attached to an ACE bandage. As the foot drops more and more, a vibrating motor intensifies, alerting the user to concentrate more on pivoting the foot so that the heel plants first. Upon completion, the DFS was

presented to the client.

SUMMARY OF IMPACT

The client has some control over his compromised foot, but does not have much feeling in it. The DFS was designed to replace the brace and let the client work on getting full control over his left foot. The DFS is a feedback device that alerts the client if his foot is not in a proper position to take a step. If the client feels an intensifying vibration, he knows to concentrate more on pivoting his ankle to plant his heel first.

TECHNICAL DESCRIPTION

The DFS has two parts: a traditional sock with Velcro on the bottom to secure the pressure mat, and



Figure 15.2. Drop Foot Sock

an Ace bandage that goes over the sock and secures the flex resistor (drop sensor) tight to the user's foot. On either side, the bandage holds the battery pack and project enclosure that stores the circuitry with plastic fasteners. Four cords extend out from the box: one goes to the battery pack, another to the flex resistor (drop sensor), and another to the pressure mat. The last cord is small and is connected to the DC motor. This motor gets tucked into the bandage when the user puts on the sock, which allows the user to get the full effect of the vibration.

A schematic diagram is provided in Figure 15.3. The device is powered by four AA rechargeable Ni-MH batteries. This 6-volt supply must be regulated to 5 volts for the logic circuitry. The voltage regulator is made of a zener diode and a series resistance of 110 ohms. The device draws less than a 200 milliamps and should run at full load for approximately 10 hours.

The pressure switch is made with a cut-out section of a footpad with two thin metal discs as contacts. The two discs are set on either side of the footpad; when the footpad is compressed the two pieces of metal make contact. Wires were soldered to each disc to serve as the two leads of the switch. The

contacts are covered on either side using a clothing patch. The pressure mat opens and closes a ground path for input 1 of a Quad 2-input XOR (7486) logic chip. Input 2 was tied directly to the 5-volt from the regulator. In order for the system to be on when the switch is open and off when the switch is closed, an inverter (7404) was used. The output of the inverter goes to the resistor bridge. The bridge was designed so that when variable resistance (flex resistor) is increased the output voltage decreases. The bridge is made up of three 750-ohm resistors and the flex resistor that varies from 12.3k to 34k ohms. When the flex resistor is completely straight (the lowest varied resistance), the bridge outputs 110 mV, which is then amplified. Because the output of the bridge was only 110 mV, it had to be amplified to activate the DC motor. An LM 358 was used in conjunction with a 1k ohm input resistor and a 22k ohm feedback resistor to give the 2.5 V needed to operate the motor. This dual low-power operational amplifier was chosen due to the 6V supply.

The cost of parts and material was approximately \$75.

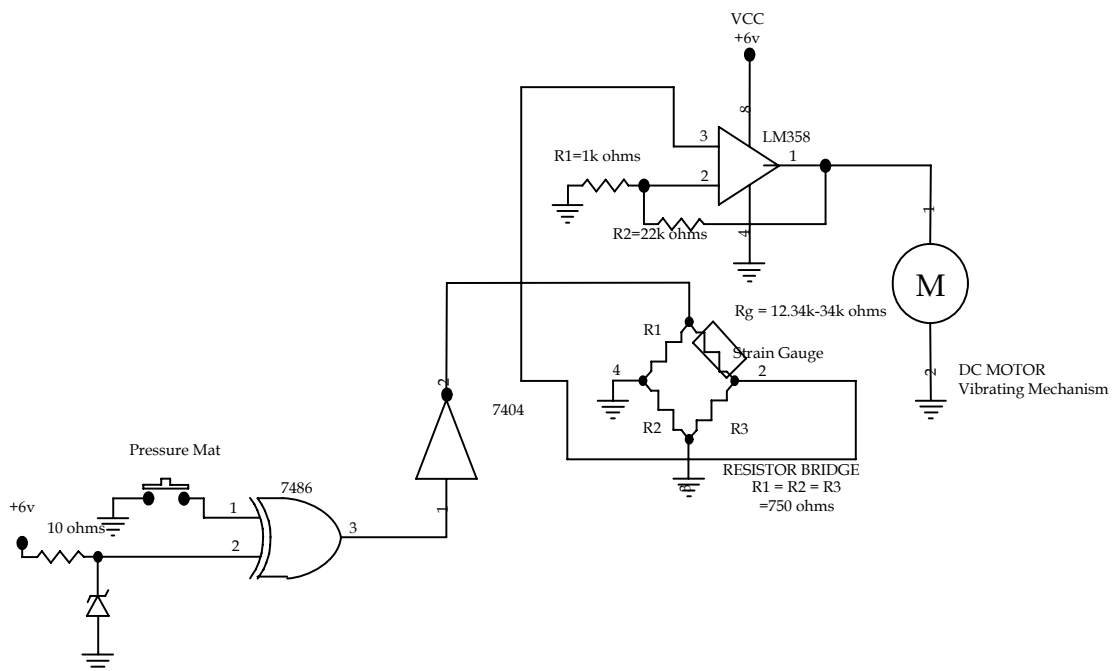


Figure 15.3. Design Schematic of Drop Foot Sock

SNOEZELLEN SWITCH

Designer: Keith Griffis

Client Coordinator: Deborah Webster, Lowell Schools, Lowell, MA

Supervising Instructors: Walter McGuire and Alan Rux

Electrical and Computer Engineering Department

University of Massachusetts, Lowell

Lowell, MA 01854

INTRODUCTION

The Snoezelen Switch was designed to create interactive sensory experiences for a child with physical and cognitive disabilities. The child is legally blind, has limited motor skills, and cannot speak. The device contains a series of four pull switches, adapted from the child's environment, that hang approximately 12 inches above the child when he is lying on an activity mat. Three of the pull switches activate music of different types. Each of these three switches is recordable. The fourth switch activates a vibrating motor, which runs through a DC plug on the base of the unit (as shown in Figure 15.4). Upon completion, the project was presented to

the client's school.

SUMMARY OF IMPACT

Left unattended, the child would simply lie on his back, pulling and chewing a tube attached to a key-chain coil. Utilizing the coil-tube, the client's response to auditory stimulation, and his preferred physical position, the Snoezelen Switch allows for advancement in both his motor skills and his intellectual capacity while maintaining familiarity with his environment.

TECHNICAL DESCRIPTION

The outer housing of the Snoezelen Switch was



Figure 15.4. Completed Snoezelen Switch.

constructed of lightweight aluminum sheet metal, attached by plastic corner bracing. Aluminum provides a rigid frame resisting deformation when the child produces downward force on the body of the device. This was essential due to the length required for spacing of pull switches. The plastic bracing provides the level of safety required given the environment in which the device is to be operated. The housing was mounted using three L-shaped brackets without cross braces. This was done so that no part of the mount would be accessible to the child.

The pull switches were designed to mimic the child's existing toy. A keychain-style plastic coil was attached to semi-rigid plastic tubing mounted through a grommet-fitted $\frac{1}{2}$ " hole in the housing (see Figure 15.5). Each coil was spaced 10" apart, accommodating the client's visual impairment and his motor skills. The tube and coils are removable from the exterior of the housing for cleaning or replacement.

The internal electronics of the device consist of a BS2 micro-controller, ISD 2560 Voice Record Chip, LM386 Audio Driver, and all necessary switches and wiring. Audio for the device was stored on the

modified ISD 2560 Voice record chip. By altering the cutoff frequency of the chip, it was able to record music with minimal distortion. Additionally, the chip has the ability to store several segments of audio on one source, without A/D conversion or memory, while still having audio that is addressable and re-recordable. The chip also had differential speaker outputs, which improve noise rejection. A BS2 Micro-controller was used to accept the switch inputs, and control the ISD 2560 and vibrating motor circuit. In order to drive the vibrating motor, an IRF510 Power Mosfet was used for switching. The mosfet was used due to the inability of the BS2 to provide sufficient current to the DC vibrating motor. The BS2 sends logic one to the gate of the mosfet, allowing 10 Volts DC to pass through the motor. This was wired to a DC power jack to provide modularity.

The cost of parts and material was approximately \$150.



Figure 15.5. Switch Tube and Coil

HEAD-ACTIVATED WHEELCHAIR

*Designer: Lewis R. Perez
Client Coordinator: Alan Rux
Supervising Professor: Walter McGuire
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INTRODUCTION

The Head-Activated Wheelchair (HAW) was designed to provide the client a means of improved control of his electric wheelchair. The client can move his head but has limited movement in his arms. He has difficulty using his electric wheelchair because it has three 10 mm proximity switches with only three sensors that are hard to use while also adjusting the direction of travel. As a result, the client's parents were trying to find a better way for him to use his chair and provided the specifications for this project.

This device replaces expensive components of electric wheelchair systems with a system that is more affordable and easier to use. The device will allow any user to control a wheelchair with more accuracy and considerably less physical effort. The device is placed over the head of the user and connected to a digital box on the wheel chair. Once the wheelchair is turned on, it is ready for use. The client uses his head to control the direction that the chair travels (see Figure 15.6).

SUMMARY OF IMPACT

The newly designed system has a set of six sensors made of conductive and non-conductive fabrics that when pressed, behave as a sensitive switch. The client uses his head to control forward traveling motion and his right arm to reverse direction. As a result, he is able to use his wheelchair more efficiently, allowing him to be more involved in interactions with his environment.

TECHNICAL DESCRIPTION

The system consists of a head array and a digital interface that communicates with the original wheelchair's digital box and controller. The head array is made of multiple pads located in a support bar around the user's head. Each pad is made of multiple layers of fabric enclosed in six different 4" x 3" zipped bags. In total, eight layers of materials



Figure 15.6. Head-Activated Wheelchair

were used to construct the pads or sensors that are located inside the bags (see Figure 15.7). The outermost layers (the bottom and top layers) are composed of fabric. The next two layers are made of Peltex fabric, which does not conduct voltage and acts as insulation for the conductive inside layers. The next two layers consist of a highly conductive material, metallic silk organza, which distribute the voltages along one side and collect voltages on the other side. Next is a layer of Peltex fabric, which has a square concentric hole to insulate the wires coming out of the conductive layers so that they do not touch one another. The next layer is a resistive foam that, when pressed, will allow the current from one conductive layer, the input, to flow to the other conductive layer, the output. The input receives 5

volts coming from the LP interface and sends voltages in the range of 0 to 5 volts to the LP digital interface as outputs.

Once the signals from the head array arrive to the LP digital interface, the set of signals must be processed so that the correct instruction is given to the wheelchair's controller. Enclosed in a 6" x 4" x 2" Project Enclosure, which is easily attached to the back of the wheelchair, is the circuitry that will process the DC signals (see Figure 15.8).

The circuit consists of a set of NPN transistors that work as digital switches, only allowing voltages to be sent when the pads are pressed hard enough to transmit 2.75 volts to the LP interface. From the transistors the signals go to a micro-controller, Basic Stamp 2 (BS2-IC), which sends the correct set of signals to the digital interface so that the wheelchair's controller allows the chair to be moved in the proper direction.

Programming in the BS2-IC controls the logical low signals that are sent to the digital box of the wheelchair, which activates movement in a certain direction. When no voltages are transmitted from the head array to the LP interface, the BS2-IC sends all high signals to the wheelchair's digital box, setting the HAW to its rest position. When a particular pad is pressed, the chair will travel in the direction that the pad is located, no matter how long it is pressed. If two pads are pressed at the same time, the wheelchair will travel on the most forward direction and the travel direction will not change until that particular pad is released and another pad is pressed.

The LP interface is powered by the wheelchair's 24DC battery and has an integrated voltage regulator to produce the 5 DC volts required by the internal circuit. The LP digital interface has an on/off switch, an LED that indicates when it is being powered, and a fuse. The LP digital interface can be easily mounted in the back of the wheelchair by screwing it onto a platform with a bracket attached to the wheelchair structure.

Total cost for parts and materials was \$236.



Figure 15.7. Sensor Layers



Figure 15.8. LP Digital Interface and Mounting Platform

TRANSITIONAL TIMER

Designer: Noel A. Zenga

Client Coordinator: Janet Stafford, KidzPlay Therapy Center, Londonderry, NH

Supervising Professor: Walter McGuire

Electrical and Computer Engineering Department

University of Massachusetts, Lowell

Lowell, MA 01854

INTRODUCTION

The Transitional Timer is designed to assist therapists in guiding children with autism and related developmental disabilities from one activity to another. It is a 60-minute timer designed to provide sensory feedback for timed activities. Once the timer is set, it provides visual cues corresponding to the amount of time left before activity completion (see Figure 15.9). The device was presented to a center for children with disabilities.

SUMMARY OF IMPACT

The occupational and physical therapists and the speech-language pathologist at the center have difficulty getting children to switch from a play activity to a work activity or vice-versa. They requested a timer to provide visual feedback regarding the amount of time left for a timed activity and a separate display for the therapists to track the amount of time left. They specified that the device should operate quietly, and they wished to be able to set, reset, start, and stop the timer. The therapists had been using a single egg timer in a large therapy room to help signal transition times. However, that timer was difficult to see and hear. The Transitional Timer is intended to provide greater control and offer greater visibility.

TECHNICAL DESCRIPTION

The Transitional Timer was mounted on a 2' x 2' section of plywood. The mount had to be large enough for easy view across a large room and strong enough to support its own weight. The circuit diagram is given in Figure 15.10. A Microchip PIC microcontroller maintained the timer and controlled a 12-volt stepper motor, 120 LEDs, a 4 by 4 matrix keypad, and a 16-character by 2-line LCD. Additional "glue" logic was used to provide an interface between the PIC and the LEDs. Darlington transistors were used as an interface between the low current PIC and the higher current stepper

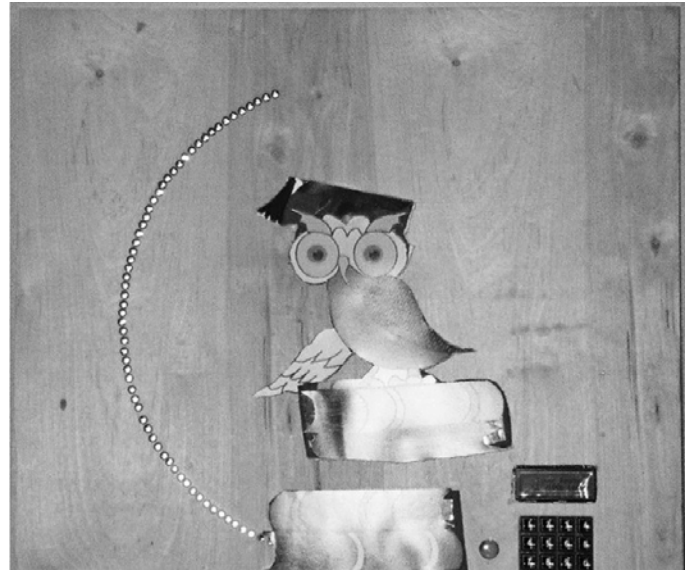


Figure 15.9. Transitional Timer

motor. Power was provided by a retail power supply offering two 5-volt sources at 2-1/2 amperes and one 12-volt source at 1 ampere.

The PIC microcontroller was selected for its ease of programming, versatility and packaging. It has three 8-bit ports, one 7-bit port, and one 3-bit port, most of which were used for digital input or output (see Figure 5.10). The PIC was programmed in C to trigger an interrupt every 10 milliseconds before determining if any attached devices required service. Lengthy service requests were separated into smaller tasks that were subsequently handled. This algorithm allowed the microcontroller to maintain rigid timing requirements within the system.

A stepper motor was selected for its ability to operate quieter than conventional quartz movements found in existing timers. The motor provided more than enough torque to actuate a large timer hand through its full range of motion. A 162-degree range of motion was selected to provide

sufficient resolution of each minute as it expires and without the need for additional gearing.

The cost of parts and material was approximately \$150

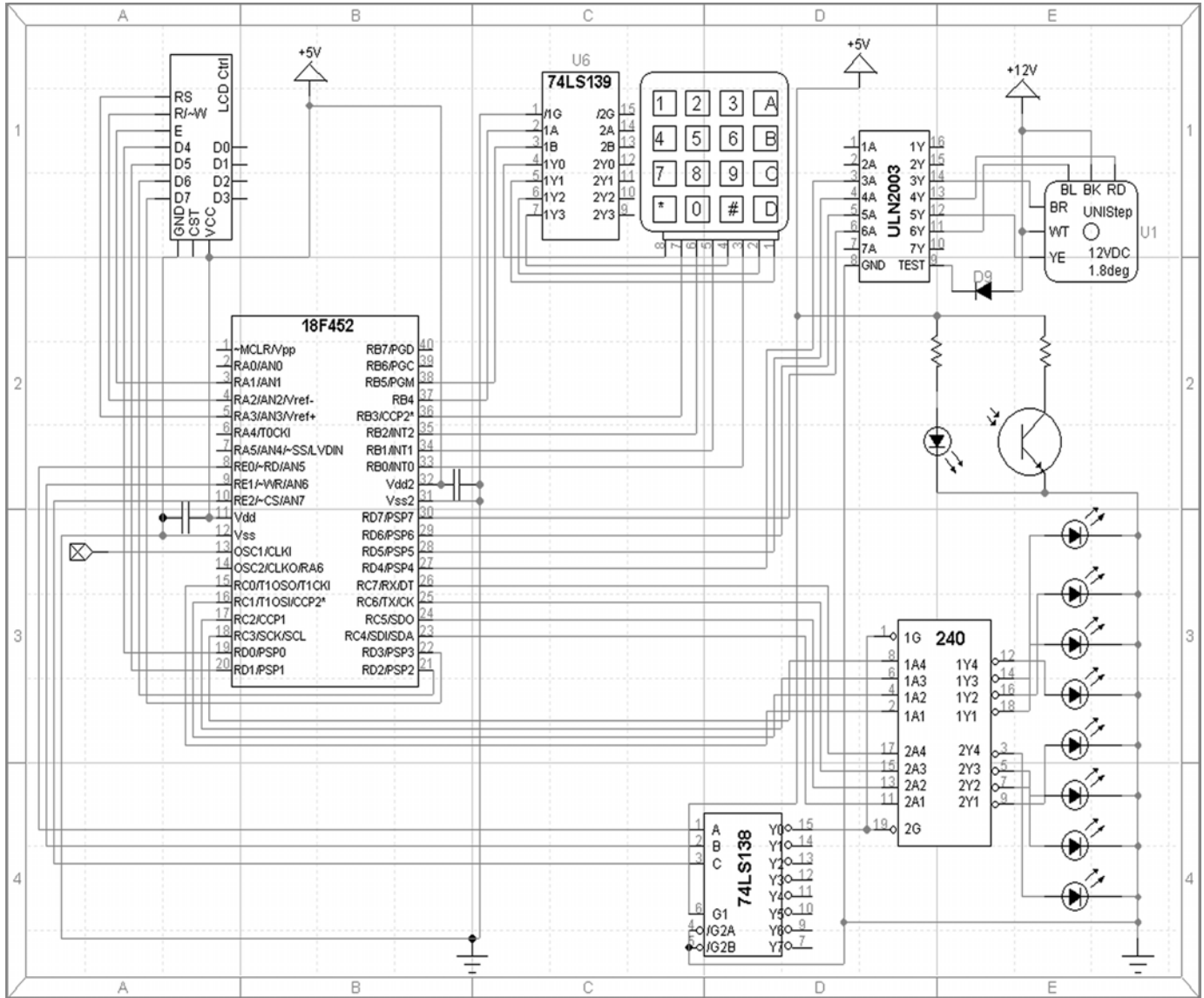


Figure 15.10. Transitional Timer Circuit

NO TOUCH SWITCH

Designer: Victor M. Rodriguez

Client Coordinator: Mary Haggerty, Henry Owens School at Shore Educational Collaborative, Chelsea, MA

Supervising Professor: Walter McGuire and Alan Rux

Electrical Engineering Department

University of Massachusetts, Lowell

Lowell, MA 01854

INTRODUCTION

The No Touch Switch (Figures 15.11 and 15.12) was designed to upgrade a client's Jelly Bean Talking Switches to a system that would be implemented under a table. This will help the client use table space more easily and comfortably. The system uses commercially available proximity sensors, which are triggered by hand motion.

SUMMARY OF IMPACT

The client and guardian both said that the new

design will make things easier for them. Now that the jelly bean switches are replaced by the No Touch Switch system there will be no need for tape on the table and the client is not likely to accidentally knock objects off the table while reaching for switches.

TECHNICAL DESCRIPTION

A 12V DC power adapter is used to power the capacitive proximity sensors under a table. The sensors are triggered by hand motion, stimulating a voltage signal. Voltage dividers then decrease the



Figure 15.11. No Touch Switch Components

voltage and the logic 1 signal (5 volts) is obtained. Logic 1 signal is then sent to Basic Stamp 2, which recognizes this voltage and analyzes it through a program. After running through the program this signal is sent to an input pin of the ISD 2560 chip, which then determines whether the system is in the recording or play mode. The signal is then amplified using an LM-386 Driver Amplifier, which goes out through a speaker so that an audio output is received.

When the system is in the record mode, a stereo microphone is used to record audible data. To record, the sensor must be triggered by hand and the above cycle of signal going through the Basic Stamp and the ISD 2560 chip is followed.

The cost of parts and materials was approximately \$100.

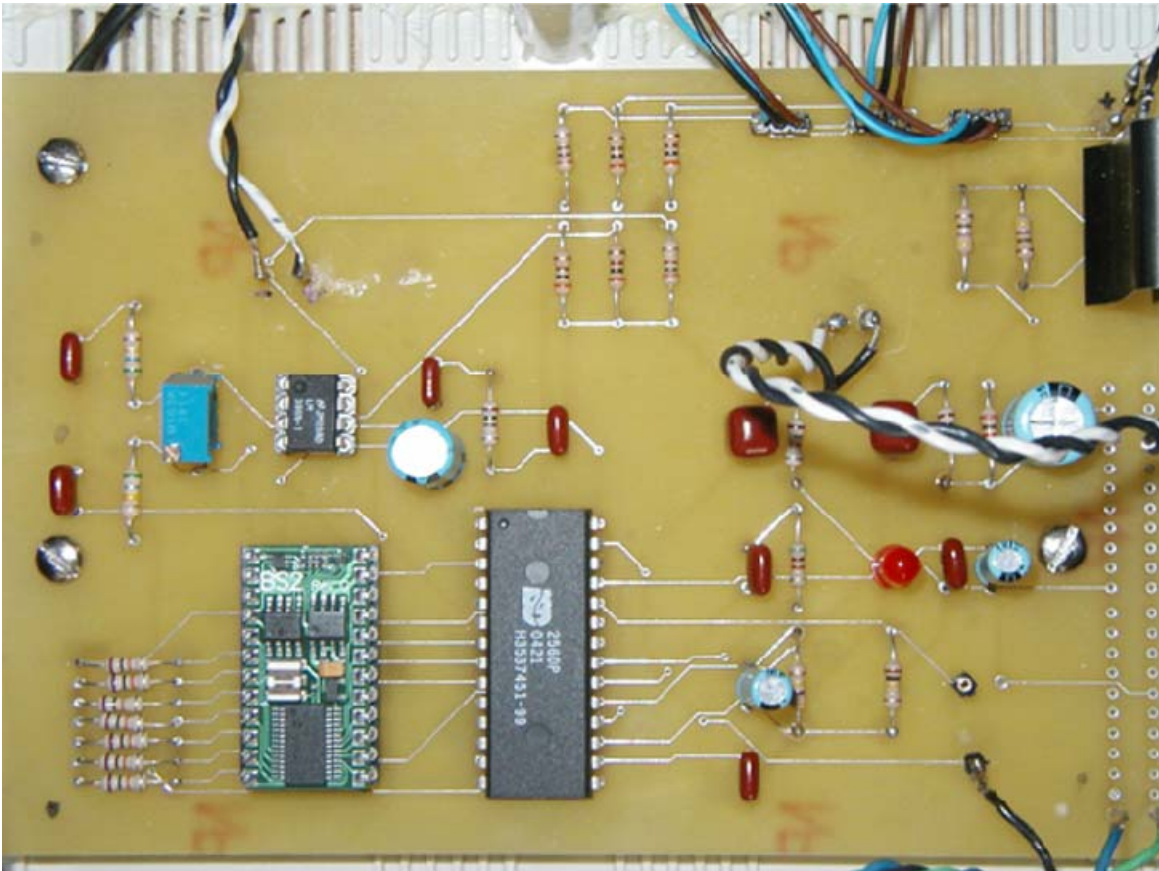


Figure 15.12. Internal Components of No Touch Switch

WIRELESS BASE SIGNAL FOR BEEP BASEBALL

*Designer: Thomas A. Wilbur
Supervising Professor: Alan Rux
Electrical and Computer Engineering Department
University of Massachusetts, Lowell
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INTRODUCTION

This product was designed to be used in “Beep Baseball” games. It consists of one transmitter and two receivers. The transmitter can be used to select either one of the two receivers at one time. When a signal is sent to a receiver, a loud buzzer is sounded. The two receivers are kept inside the first and third bases. The transmitter is typically kept behind home plate. A buzzer is sounded at first or third base whenever a ball is hit. This tells an individual who is blind which base to run to. The custom product was soldered directly to PC Board and enclosed in standard plastic enclosures. While many wireless switching products are already readily available, none were found to have the correct combination of range, size, volume, and durability.

SUMMARY OF IMPACT

The sport of beep baseball is a great way for individuals who are blind to participate in baseball. This product will change the way that beep baseball games are set up. Usually there are wires running along the ground from home plate to the bases. The

wires are cumbersome and can be dangerous tripping hazards. Having a wireless system in place of the cable system is an improvement that will enhance safety and aesthetics.

TECHNICAL DESCRIPTION

This product is enclosed in three standard plastic project enclosures. The transmitter enclosure is significantly smaller than the two receiver enclosures due to the nature of the electronics. The electronics were soldered directly onto three standard PC boards. The batteries and electronics are completely enclosed and protected. Only the switches and buzzers are mounted on the exterior of the enclosures. Generic standoffs, screws and nuts were used in mounting and securing the project. Necessary holes were made in the plastic enclosure with a simple drill and standard bits.

Both the receivers and the transmitter are each powered by a single 9V battery. The transmitter accepts an input range of 5-12 Volts. For this reason, voltage regulation was not necessary and the battery was connected directly to the electronics and ICs.

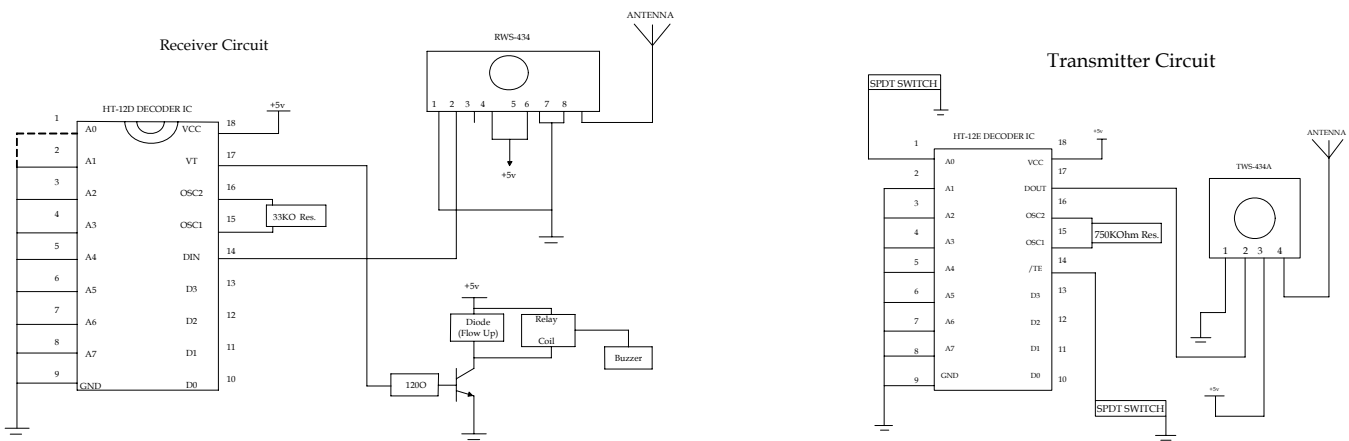


Figure 15.13. Circuit Diagram of Wireless Base Signal

Given that the receivers are sensitive to voltage, a voltage regulator was used. The buzzers were connected directly to the battery while the voltage regulator provided +5Vdc to the sensitive electronics. Voltage regulators like the LM7805 introduce large amounts of power loss. This usually means that standard 9V batteries will not last very long. In this situation however, very little current is needed from the regulator, and it is only fully operational for very short periods of time.

The device operates at a frequency of 433 MHz. The outdoor range is approximately 400 feet. This is more than double what is needed in this application.

Wire antennas of approximately 13.8" were attached and loosely wound within each enclosure. The only difference between receivers was the grounding of the address pin 'A0' in the second receiver. Simple schematics of the electrical design are shown in Figure 15.13. The power circuit is shown in Figure 15.14.

The cost of parts and material was approximately \$135.

Power Circuit (Receivers Only)

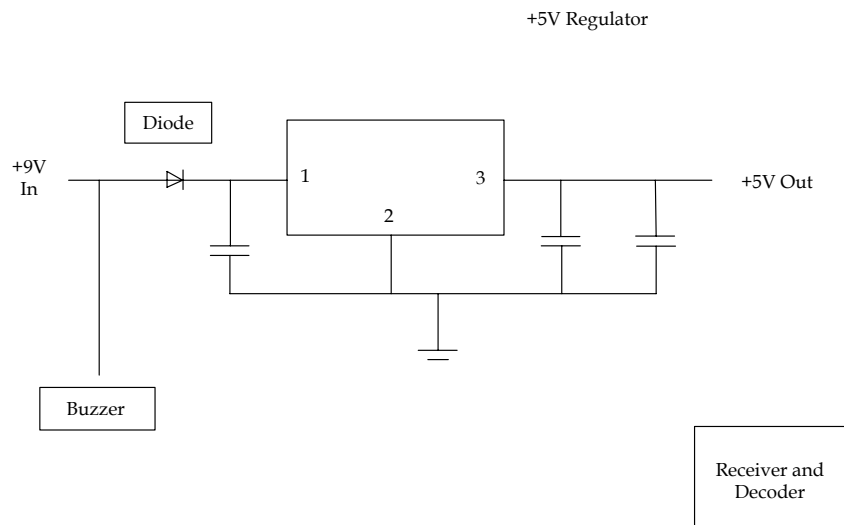


Figure 15.14. Power Circuit for Wireless Base Signal

VOICE ACTIVATED ALARM CLOCK SYSTEM

Designer: Tan Pham

Supervising Professor: Jay Fu

Computer and Electrical Engineering Department

University of Massachusetts, Lowell

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INTRODUCTION

The Voice Activated Alarm Clock System (VAACS) was designed to help a child with physical disabilities control an alarm clock independently and in the dark. To operate the VAACS, the user simply makes sound, such as a hand clap or vocalization, near the microphone. The signal output can activate the relay which can turn on the projector of the alarm clock (see Figure 15.15).

SUMMARY OF IMPACT

The design criteria were defined according to the user's capabilities. The child wants to see the time at night, but she has difficulty turning on the light. Now she will be able to see the time without need for extra lighting. The device is safe and portable.

Voice activated technology can be a fun motivational tool for practicing environmental control and learning cause and effect relationships.

TECHNICAL DESCRIPTION

The system has an on/off switch. The electret microphone is ready to pick up the signal from the user. One red LED is designed to confirm the working system. The relay activates the alarm clock about three seconds after the sound is received. All additional electronic components of the VAACS are soldered in one prototype board and secured to the frame with bolts.

Figure 15.16 shows the complete circuit board installed inside the box. The system has a sound sensitivity control with a Koa 200k adjustable



Figure 15.15. Voice-Activated Alarm Clock System

trimpot. The voice activated switch entails a combined analog and digital circuit. The LM358 is a National Semiconductor inverting negative feedback operational amplifier. The IC will capture the voice signal and amplify the amplitude. The input signal is doubled by two diode signal rectifiers. It is then compared with a comparator amplifier to determine whether the digital signal is high (logic 1) or low (logic 0). This controls the relay that turns the alarm clock on and off.

First, the microphone will pick an input signal from any audio signal. That is amplified by IC LM358 as a non-inverting amplifier. One capacitor is coupled with frequencies above 10 kHz to avoid noises from the microphone. The voltage at the negative feedback resistor is calculated by a voltage divider. Another resistor is used for the DC supply to the electret microphone with a built-in amplifier. It serves as a load resistor for the amplifier. The output at pin 1 of the op-amp feeds two diodes, which

function as a half-wave voltage doubled by using a signal diode. Additionally, a capacitor and diode serve as a DC restorer (clamped capacitor). Because of the polarity with which the diode is connected, the capacitor charges to a voltage equal to the magnitude of the most negative peak of the signal. This rectifies the audio signal to produce a DC voltage across the capacitor with value of 2.2 microfarad. Two resistors are connected to adjust the off delay time. The DC signal is fed to a second stage op amp. This amplifier is constructed as a comparator. A resistive voltage is set to about 2V at pin 6. When the DC voltage is greater than 2V, this turns on transistor Q1, which activates the relay and turns on the LED.

The cost of parts and materials was approximately \$50.

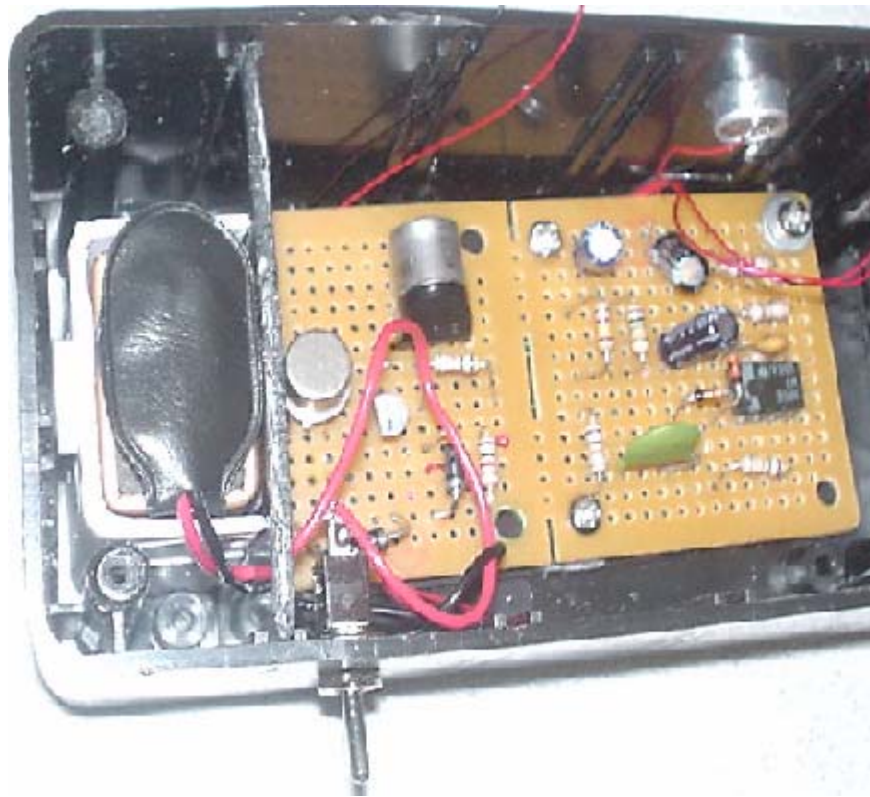


Figure 15.16. Voice Activated Relay Switch

FOOT-CONTROLLABLE TEXT PROCESSOR

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Supervising Professor: Walter McGuire
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INTRODUCTION

The client for whom this project was completed has severe lack of motor control and unintelligible speech due to complications of cerebral palsy. For the past several years he has made use of a system consisting of an Apple computer and a single pushbutton switch to form text messages so that others may read and hear them. He must wait for the cursor to reach his desired option before he may make that selection. Although the basic requirement of message formation is met with this system, it is extremely slow and lacks several basic features found in basic word processing applications. The objective of this project was to create an entirely new system that would solve the deficiencies the client currently faces with the old method of text processing.

SUMMARY OF IMPACT

The Foot-Controllable Text Processor (Figure 15.17) greatly enhances the client's communication experience. The most significant benefits are that words and sentences may be formed more quickly, messages tend to have a more sophisticated structure, and records may be kept of any text created. The client's father, who has for decades volunteered in the care of many adults with disabilities, firmly believes that using the new system will be an enjoyable and enriching experience for his son as well as for others with severely limited mobility.

TECHNICAL DESCRIPTION

The system is composed of a specially developed program and a controller to perform program operation. It is easy for the client to use. The most significant difference from the old system is that it allows the client to move the cursor in any direction and at his own pace. The controller casing is a durable plastic box with dimensions 8" L × 6 3/16" W × 2 1/2" H. Mounted onto the front of this box (8" × 2 1/2" side) are the pushbutton, horizontal toggle, and vertical toggle switches from left to right. The



Figure 15.17. Controller with Mounting Bracket

controller box is mounted securely to the footrest of the client's wheelchair using a 1/2" thick piece of wood and a metal bracket. The interior of the controller houses the circuit board for switch debouncing and the USB interface module. Switches are debounced with series RC circuits with time constant equal to approximately 0.1 seconds. The DeVasys USBI2C/IO interface board provides connectivity between the controller and host computer. Any standard USB cable with A and B connectors may be used. Included with the module are a device driver, firmware, and application programming interface (API) for interfacing with the hardware in C-based applications.

The custom designed "TextMaker" program (Figure 15.18) was coded and built with the Microsoft Visual C++ 6.0 integrated development environment. While there are some graphical improvements to the user interface, its structure has been kept essentially the same. In the top left pane of the program window is the main menu, and to its right is the sub-menu for the current operation being performed. The bottom half of the window displays the text. When the program is started, the stored vocabulary is loaded into memory from a set of files, one for

each letter of the alphabet and another for multi-word phrases. Each file is loaded into a binary tree structure for faster searching. All program objects are based on the Microsoft Foundation Classes (MFC), a library of classes that encapsulates many portions of the Windows API. Moving the toggle switches in a certain direction will change the position of the cursor within the current menu. Pressing the large pushbutton switch will execute the exact same code as if the item were clicked (if a button) or double-clicked (if a list box item).

Many features have been included in the TextMaker program to provide the client with a more streamlined and sophisticated text processing system. He may enter words and phrases much in the same way as before, and he may now insert numeric and punctuation characters, including all numbers for writing dates. Another option made available is the addition of new words by spelling them letter by letter from an array of characters. When the user finishes spelling a word, it is automatically added into its corresponding word

tree and saved to the appropriate vocabulary file. Any word in the stored vocabulary may be removed by selecting it in the same way as it is selected for insertion into the text window. To perform audio output, the application passes the text window contents to an instance of the Microsoft Speech API's ISpVoice class. The client then has the option of restarting, pausing, or stopping audio output of the text.

Another newly available feature is file input and output. The client may save his work into a text file with a name of his choosing and open it at a later time. File input and output is accomplished with the C++ ifstream and ofstream objects, respectively. Clear options include erasing only the last word entered, or the entire contents of the text window. If the user wishes to quit the program, he has the option of saving his work before exiting.

The total cost of all components was approximately \$540.

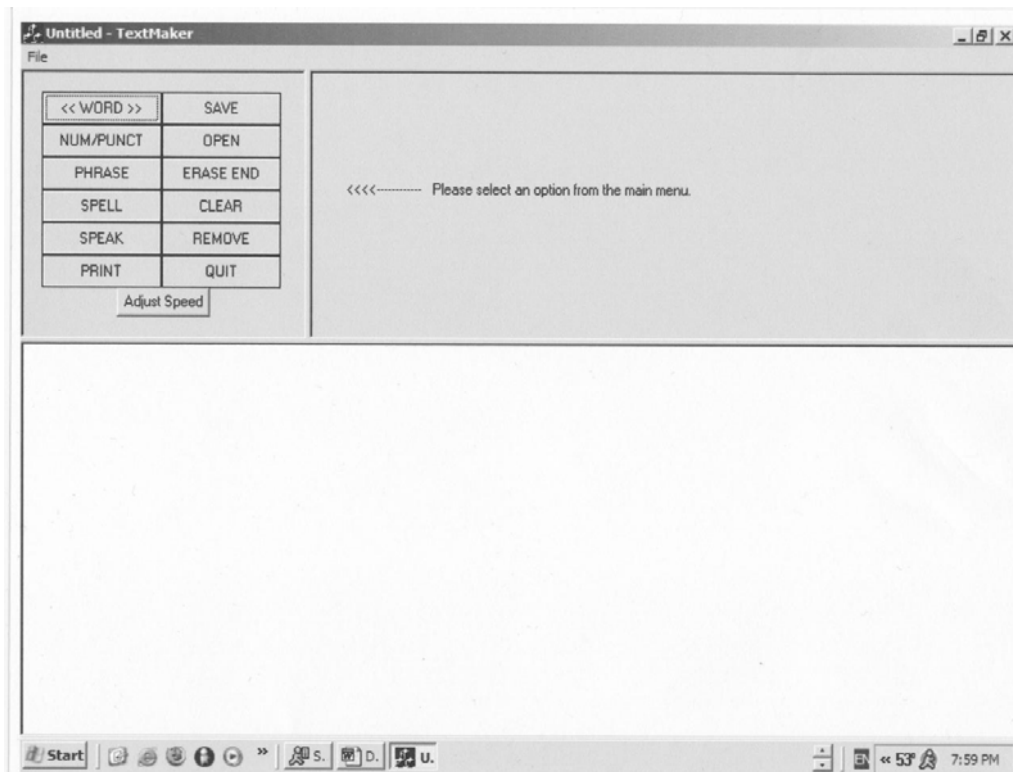


Figure 15.18. TextMaker Program User Interface

KEYLESSBOARD

*Designer: Richard J. Acosta
Supervising Professor: Alan Rux
Electrical Engineering Department
University of Massachusetts, Lowell
Lowell, MA 01852*

INTRODUCTION

The Keylessboard was designed to give active audio feedback to children with reduced motor skills. It functions as a normal musical keyboard, but the keys have been removed and replaced with sensors (see Figure 15.19). When an object is placed over the sensors, notes sound.

SUMMARY OF IMPACT

Some students at a school for children with disabilities had motor control problems that made it impossible for them to control keys on a typical musical keyboard. They now have a way to enjoy making music.



Figure 15.19. Keylessboard

TECHNICAL DESCRIPTION

The Keylessboard is simply a modified keyboard. The keys were removed from it and replaced with a sheet of high-pressure laminate dry erase board. Holes were drilled into the board and cut to the appropriate size and shape using a jigsaw. Sensors were inserted into these holes and hot glued in place. The circuit was mounted inside the keyboard by using existing screw holes and by using wire to securely fasten the board to the cover of the keyboard.

The circuit itself starts with the sensors. The sensors utilize an IR LED. When an obstruction gets in its path the IR light is reflected back and turns on a phototransistor. The amount of current drawn by the phototransistor is dependent on how close the obstruction is to the sensor. This output voltage is then sent to a comparator.

The comparator compares the input voltage from the sensor with a voltage from a trimpot. The trimpot is used to adjust how close the user's hand must be to the sensor in order to sound the key. The comparator is set up in such a way that a low signal is output when the two voltages compare. Otherwise it is always outputting a high signal.

The output signal from the comparator is attached to the enable pin of the buffer. The buffer's enable pin is active low, hence the reason for the comparator outputting low voltage when the two compare. Once the buffer is active a Vcc signal is able to go through the buffer to the relay.

The relay receives the signal from the buffer and turns on. When the relay turns on, it connects the two ends of the key circuit on the keyboard. A schematic of the circuit is shown in Figure 15.20.

The total cost of this project is approximately \$65.

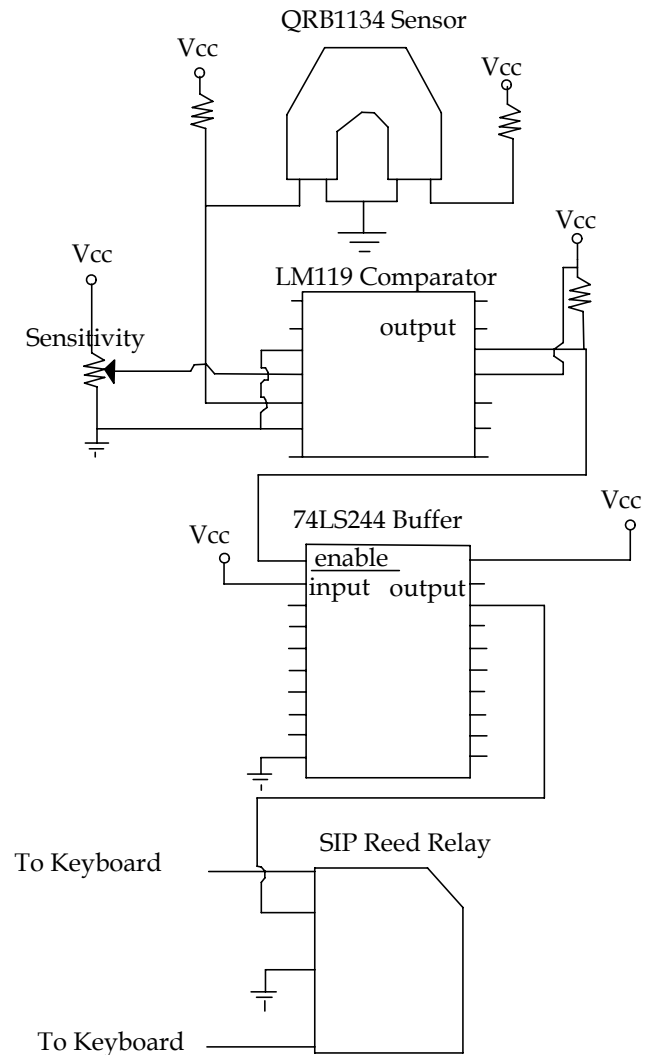


Figure 15.20. Circuit Schematic

CIRCLE TIME APPARATUS

Designer: Lawrence Poitier

Client Coordinator: Marie Haggerty, Shore Educational Collaborative

Supervising Professor: Alan Rux

Department of Electrical and Computer Engineering

University of Massachusetts, Lowell

Lowell, MA 01854

INTRODUCTION

The Circle Time Apparatus is a device to enhance the environmental awareness and independence of children in a special needs classroom. "Circle time" is when four children, with limited mobility and under the supervision of an instructor, come together and perform tasks, such as preparing a meal. The Circle Time Apparatus, shown in Figure 15.21 is a wireless system that senses when jellybean switches are pushed, and then broadcasts sensory data. Subsequently, the broadcast data are used to control any electronic device plugged into the system.

SUMMARY OF IMPACT

The client coordinator stated that, "any device that gives the children a cause and effect and allows them to do things on their own increases their self-esteem and confidence in a tremendous way." An instructor, with the aid of the administrative control system shown in Figure 15.22, has the children push a sequence of buttons that control kitchen appliances to prepare a meal. As a result they accomplish tasks that previously required the assistance of others.

TECHNICAL DESCRIPTION

The device utilizes the HT-12E encoder, HT-12D decoder, TWS 434A RF transmitter, RWS 434 RF receiver, Basic Stamp 2 and solid state relays. The data inputs D0-D3 of the HT-12E encoder receive on/off voltage signals from the four jellybean switches mounted on the circle time desks. The binary signals are encoded based on the HT-12E preprogrammed settings, which are assimilated by the address settings A0-A9. After the data are amalgamated in the encoder, they are communicated to the data input of the TWS 434A RF transmitter by means of a square wave. The square wave is then interpreted by the TWS 434A RF transmitter, and converted to an amplitude modulated radio frequency, operating at 433.92MHz. Subsequently, the radio wave is



Figure 15.21. Circle Time Apparatus

broadcasted to the RWS 434 RF receiver via antennas. The RWS 434 RF receiver translates the radio wave into a square wave and sends the wave from its digital data output to the serial data input of the HT-12D Decoder. However, the information is not processed until the decoder receives a transmission validation by way of a valid transmit circuit.

The valid transmit circuit is comprised of a light emitting diode, a transistor and two resistors. When a current is dispatched from the linear output of the RWS-434 receiver it passes through a 470 resistor. The current passes through the light emitting diode and enters the collector of the transistor. The emitter of the transistor is grounded; hence the current emerges from the base of the transistor into the 10k resistor and commences the transmission validation. After obtaining validation, the square wave is deciphered by the HT-12D decoder and converted to binary impulses, which are transmitted to the administrative control system. There are two essential selection knobs in the administrative control system; these are used to ascertain which

data setting will drive the system. The first knob gives a student authorization to control a selected appliance. This means that the students obtain the ability to control the appliances only when the instructor sanctions the task by turning the knob on the number associated with that particular student. The second knob selects which appliance is to be controlled. The selection knobs perform these tasks by incorporating rotary switches. When the knobs are positioned at a number, the terminal associated with that number on the rotary switch becomes Vcc; otherwise the terminal is ground. The administrative control system is mainly comprised in the Basic Stamp 2 microcontroller. The components of the administrative control system are connected to the Basic Stamp 2 as follows: the first selection knob is connected at pins 1 through 4, the outputs of the HT 12D decoder are connected at pins 5 through 8, the teacher lockout switch is connected at pin 9, and the second selection knob is connected at pins 10 through 12. These inputs are processed by the Basic Stamp 2, and accordingly send 5V to the solid state relay circuitry.

The Basic Stamp 2 program operates under three pivotal principles. The first principle is that Basic Stamp 2 will only conduct a task when the teacher lock switch input is Vcc; otherwise it will remain dormant. This principle was implemented to ensure that instructors are not injured when students accidentally push a switch. The second principle is that the voltage output to the solid state relay circuitry replicates the voltage input from the selected HT 12D Decoder outputs. The third principle is that the parameters instantaneously transfer when the settings of the selection knobs are changed.



Figure 15.22. Circle Time Administrative Control System

The solid state relay circuitry consists of a 2N3904 transistor, a 10k resistor and an ECE solid state relay. The solid state relays have four nodes. The first node was connected to the high wire of a power line that supplies 120V, and the second node was attached to a socket. The third node was directly wired to 5V Vcc, and the fourth node was connected to the collector side of a transistor. The emitters of the transistors were grounded and the base was connected to 10k resistors. When the Basic Stamp 2 determines to power an appliance, it dispatches 5V to the 10k resistor coupled with the solid state relay via a transistor. When the 5V is placed at the 10k resistor connected to the base, the transistor grounds its collector, which in return sets the fourth node of the solid state relay to 0V. Once the fourth node has been set to 0V, the circuit is completed. Therefore, nodes three and four are connected, 120V is sent to the socket, and power is supplied to the appliance.

WIRELESSLY CONTROLLED HEATED GLOVES AND SOCKS

*Designer: John P. Garvin
Supervising Professor: Walter McGuire and Alan Rux
Electrical and Computer Engineering Department
University of Massachusetts, Lowell
Lowell, MA 01854*

INTRODUCTION

The heated gloves and socks were designed for a client with Charcot-Marie-Tooth (CMT), a form of muscular dystrophy. CMT is a neurological disease that causes muscular degeneration of the extremities, namely the hands and feet. The lack of muscle mass in the hands and feet leave them extremely prone to cold weather. When the hands of a CMT patient become cold, they lose mobility and all existing strength. When the client's feet get cold it becomes incredibly difficult to walk. Heated gloves and socks provide an active source of heat to prevent his hands and feet from becoming cold, and also can warm them if they are cold to begin with.

SUMMARY OF IMPACT

The extremities of a CMT patient are very sensitive to heat as well as cold. Battery heated socks or gloves that are already on the market can become uncomfortably hot. At other times they are not

warm enough. These socks and gloves provide the ability to adjust the heat level of each unit separately. They also obviate the need to run wires throughout the client's clothes. Given that the client has difficulty with mechanical knobs, this project uses easy pushbuttons for heat control. This project allows the client to enjoy outdoor winter leisure activities in comfort.

TECHNICAL DESCRIPTION

The components of the device are shown in Figure 15.23. The project consists of five casings; each is 2" by 3", and 1.5" deep. One of the casings is the transmitter and control box. This box contains a Basic Stamp 2 microcontroller, with four momentary switches as inputs. There are two red switches and two black switches. One red switch is to increase the heat of the gloves, the black one to decrease the heat. The other red and black switches control the heat level for the socks. The Basic Stamp controls the inputs to the Holtek HT-12E encoder. This chip



Figure 15.23. Socks and Gloves with Devices Attached, with Batteries and Control Box

encodes a 4-bit parallel input to a serial stream output. The inputs of the encoder are pulled high by the Stamp chip, and the Stamp controller sends a specific number of active low pulses to the encoder. The encoder continuously sends the data to the LINX TXM transmitter modules. The 315 MHz modules control the gloves' heat, while the 433 MHz transmitter controls the socks' heat.

The heat-controlling device is a pulse width modulation circuit. The pulse width is adjusted by the DS1669 digital potentiometer. The digital pot adjusts the pulse width of the square wave generated by op-amps, which is sent to the gate of the IRF510 power MOSFET. This MOSFET turns on the nickel-chromium heating wire based on the setting of the digital pot. The DS1669 has two active low controls for increasing or decreasing the resistance. These inputs are connected to the Holtek HT-12D decoder. The LINX RXM receiver modules accept the serial stream sent by the transmitter, and send it to the HT-12D decoder. These data are

decoded into a four-bit parallel output. The first two pins are used for the gloves, and the bottom two pins are used for the socks. As a stamp output pin goes low, the corresponding output pin on the receivers go low, and adjusts the digital potentiometer accordingly.

The two enclosures for the gloves fit directly inside prefabricated Velcro pouches sewn onto the wrist area of the glove. The existing wires were prototyped to a DC power plug, with the corresponding socket on one end of the enclosure. The battery packs have a pouch with Velcro straps sewn on to secure to the forearm area.

The two enclosures for the socks have specially made pouches that are sewn onto the top of the socks. The battery packs also have their own pouches made with Velcro straps to secure to the calf area.

The cost of parts and materials was approximately \$443.

PERFECT WORKSTATION

Designer: Jeremy Shean

Client Coordinator: Jim Magiera, VA Hospital, Bedford Ma

Supervising Professor: Alan Rux

Electrical and Computer Engineering Department

University of Massachusetts, Lowell

Lowell, MA 01854

INTRODUCTION

A computer workstation was designed for patients with a variety of physical disabilities in a hospital. The hospital had available only simple computer systems that are difficult for some patients to use because of problems with mouse or keyboard control. The new workstation incorporates voice recognition software paired with a wireless Bluetooth microphone. This allows users to move around without getting caught on any wires. It is ergonomically designed to be used for long periods of time.

SUMMARY OF IMPACT

The device, shown in Figure 15.24, will allow patients to use the computer without help from others, at the same level of functioning as anyone who has the capability of using a keyboard and mouse. Checking email will be as easy as saying a few words.

TECHNICAL DESCRIPTION

This project consists of three major parts: the software, the wireless microphone and the hardware system. The software that was selected is Dragon Naturally Speaking 8.0. This software was chosen because of its ease of use and how well it will work for someone who is unable to use a keyboard and mouse.

The second part of the project is the microphone. The software came with a microphone but it was insufficient for the application because it had a wire

and could possibly fall off if the person using it moved around too much. To fix this problem a Bluetooth microphone was used instead of the wired one. This microphone has a range of over 30 feet, so moving around is easy. The implementation of this software requires a system with a Pentium 3 of 700 MHz or greater and at least 512 MB of RAM. This is actually not sufficient; it ran slowly when the software was tested on a Pentium 4 system with 512 MB of RAM. To solve this problem, a dual AMD MP Processor machine running at 1.4 GHz each and 768 MB of RAM was used instead. This configuration allowed the software to run at an almost real time speed which is imperative to using this software properly. The final hardware configuration used for this system started with a Tyan Thunder K7 motherboard. This board supports two processors so it is equipped with AMD 1600+ MP processors. The memory is PC2100 DDR RAM and has a GeForce 3 Video card to meet the needs of any graphic configuration. The other important part of this system is the power supply, which requires an ATX-GES standard. These power supplies are difficult to find, so an EPS12V 550 watt supply with an adapter was used instead. This design was used in case the power supply broke so that the hospital staff would have an easier time replacing it and it would be less expensive to replace. The rest of the computer is fairly standard, including the case, sound card, hard drive and CD writer.

The cost of parts and materials was approximately \$2370.



Figure 15.24. Perfect Workstation

WHEELCHAIR SCALE

*Designer: Edward Avery
Client Coordinator: Walter Farrington, Bedford, NH
Supervising Professor: Walter McGuire
Department of Electrical Engineering
University of Massachusetts, Lowell
Lowell, MA 01854*

INTRODUCTION

The wheelchair scale (shown in Figure 15.25) was designed so that a user can get onto a scale in a wheelchair and determine his or her body weight. The user approaches the scale and turns it on. The digital output produced by the scale is entered into a computer program. The user can see the total weight

minus the weight of the wheelchair.

SUMMARY OF IMPACT

This scale will enable a wheelchair user the freedom to weigh himself or herself.

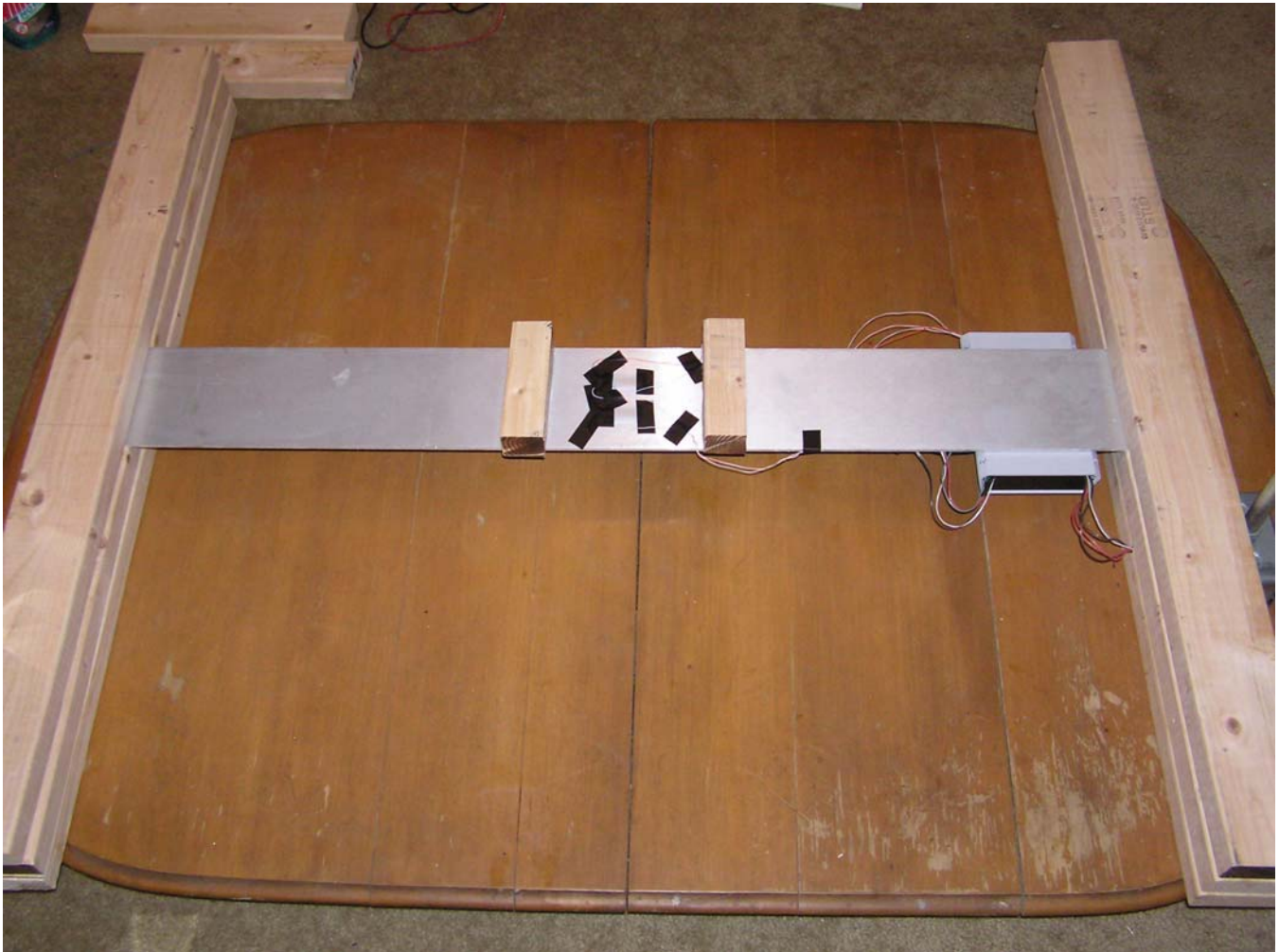


Figure 15.25. Wheelchair Scale

TECHNICAL DESCRIPTION

The scale's operation is based on a very simple concept: the more weight that is put on the scale, the more the aluminum platform bends toward the ground. As this aluminum is strained, the resistance of the strain gages changes slightly. The gages are arranged such that the amount of weight on the scale correlates to an amount of voltage drop across the gages. An amplifier amplifies that voltage so that it can be accurately measured by a voltmeter. This value is then entered into a Visual Basic program, where the voltmeter reading is converted into a weight.

The circuitry is simple. The four strain gages are placed on the lower piece of metal and their lead wires enter the circuit to form a Wheatstone bridge. The voltage drop across the bridge is sent to an amplifier so that the signal can be read. The voltage across a load resistor of 1 k Ω is read by the digital voltmeter. Both the voltmeter and the strain gage circuit are turned on and off by the DPST switch. All of the resistors, connections to strain gages, and the op-amp are placed into sockets on the circuit board.

The strain gages are placed, two on the top, and two on the bottom, on the lower piece of aluminum. In order to place the strain gages on the metal, the surface had to be thoroughly cleaned and the gages had to be handled with tweezers to avoid damage. A thin coat of the SG401 adhesive was placed on the back of each gage and each gage was pressed into place as smoothly as possible. Their efficiency is determined by how well they are attached to the aluminum. They are all 350 Ω resistors at rest. When the scale has no load upon it the voltage drop across the bridge should be close to zero. As the metal begins to bend the top and bottom gages have an opposite change in resistance. This causes the voltage drop to change linearly as the weight is applied. After this the voltage is amplified and the resulting value is displayed on a voltmeter for the user to see. This value is entered into a Visual Basic program where it is entered into a calculation to determine the weight of the client.

The cost of parts and material was approximately \$310.

NUMBER ACTIVITY BOARD

Designer: Eduardo Vargas

Client Coordinator: Pam Fraser, Lawrence High School, Lawrence, MA

Supervising Professor: Walter McGuire and Alan Rux

Electrical and Computer Engineering Department

University of Massachusetts, Lowell

Lowell, MA 01852

INTRODUCTION

A learning board (see Figure 15.26) was designed to help children with learning disabilities learn about numbers. Light emitting diodes (LEDs) are connected to a stamp chip and programmed to generate numbers from one through eight randomly. To identify an answer, the child must press a number on the box. When the answer is correct, a chime rings and when incorrect a buzzer goes off.

SUMMARY OF IMPACT

The Number Activity Board will help children to use their senses to recognize numbers and build counting abilities.

TECHNICAL DESCRIPTION

The durable casing of the Number Activity Board was made out of wood 24 inches long and 9 inches wide. The pushbuttons are mounted in the bottom front of the box, and the LEDs are mounted on the top front of the box. On each side of each LED a hole was drilled for the buzzer and the chime.

The project operates in the following manner. First, the user turns on the Number Activity Board. The Stamp chip then begins to randomize between zero and 64k. Each of eight cases signifies a number to be displayed by LEDs. Using the random function syntax of the Basic language for the BS2p40-IC, the cases are randomized.

Once the Stamp chip selects a case, the corresponding LEDs turn on. The user is to count how many LEDs are on and then press the button that corresponds to the correct answer. If the user selects a correct answer, then the Stamp Chip goes

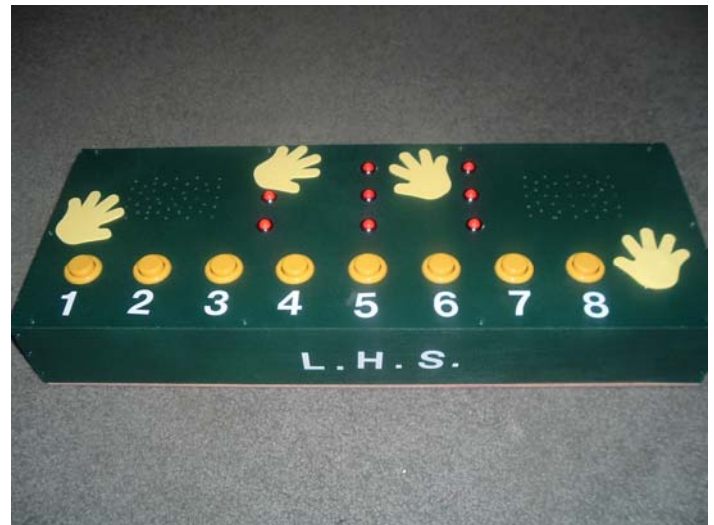


Figure 15.26. Number Activity Board

through an "if-then" loop through eight cases to select the desirable case. This algorithm selects the right answer by going through each of the cases. The right answer sends a "1" to the Stamp chip, causing six volts to be sent to the pin to which the chime is connected to denote a correct answer. A wrong sends a "0" to the Stamp chip. As a result, six volts are sent to the pin associated with the buzzer.

The buzzer and the chime are connected from the output of the Stamp chip to the positive side of the device and respectively, its negative sides are connected directly to the ground. The Stamp chip itself is being powered up by a 6-volt power supply provided by Radio Shack. The circuit diagram is shown in Figure 15.27.

The cost of parts and material was approximately \$96.

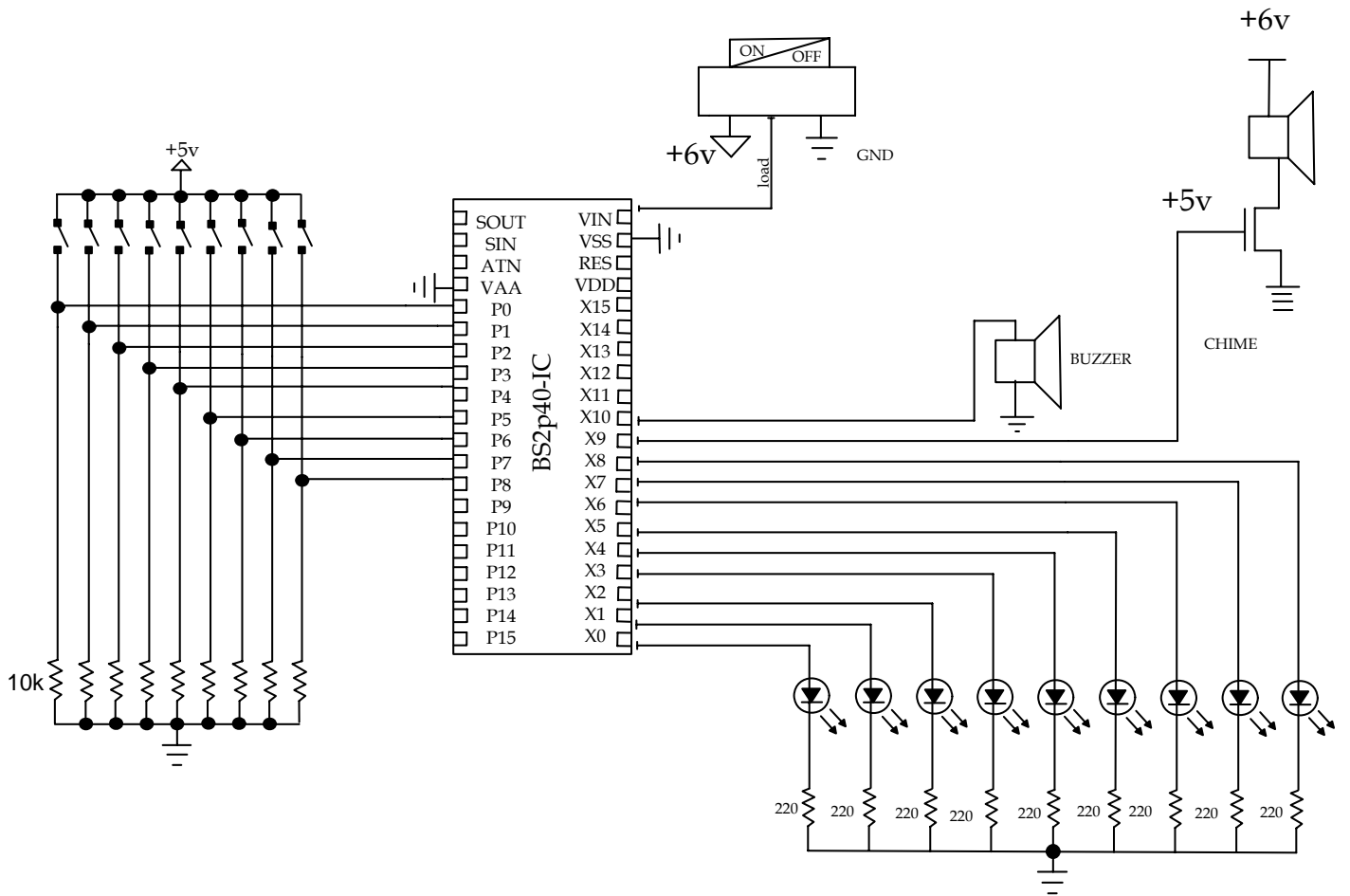


Figure 15.27. LED and Pushbutton Circuit

SNOOZELLEN SWITCH

Designers: Dana J. Greenlay

Client Coordinator: Susan Stanton, Amesbury Schools, Amesbury, MA

Supervising Professor: Jay Fu and Alan Rux

Electrical and Computer Engineering Department

University of Massachusetts, Lowell

Lowell, MA 01852

INTRODUCTION

The Snoozellen Device was designed to appeal to multiple senses of students with a variety of physical and cognitive disabilities. It plays three 20-second segments of music and also vibrates as the music plays. The device has one large jellybean switch mounted on the center for easy access for students with limited motor skills (see Figure 15.28). The jellybean switch is connected to a three-pole switch that controls each one of the segments. On all three settings the vibrating motors run for the length of each song.

SUMMARY OF IMPACT

The completed device was presented to the special education department of an elementary school. This project helps this wide range of students understand cause and effect. The recordable aspect of the design enables the teacher to personalize the device to the

likings of each student.

TECHNICAL DESCRIPTION

Given that the special education teacher travels among different school buildings, it was important to make the device as compact and portable as possible. The casing of the Snoozellen Device was a preformed plastic box approximately 8 inches wide by 10 inches long. The reason for choosing a preformed box was the strength from the internal supports and the size constraints. The button is mounted in the center of the box, and there needed to be enough support to withstand the weight of the children pressing on it. The box has a depth of approximately 3 inches with removable aluminum sides to prevent it from collapsing. The controls on the side panel are a volume control, the three-pole switch, the power button, the playback/record button, and the microphone jack. The reason that these are all mounted on the side is so that the entire device can be put inside a foam pillow to protect the



Figure 15.28. Snoozellen Device

device from the students and to protect the students from the edges. This also gives the teacher the ability to control the volume and the content of the recordings.

The ICs in this device consist of the Basic Stamp 2 micro-controller, the ISD 2560 audio chip, the Lm386 audio driver, and IRF 510 power mosfet. The audio is recorded onto the ISD2560. This chip can hold up to 60 seconds of audio at an 8.4 KHz sample rate, or can hold a number of shorter segments using the controls of the address pins. This is the main purpose for using the micro-controller. Using a series of inputs and outputs, the stamp controls the

addresses and the amount of time it plays back if the entire 20-second segment is not used. The entire circuit runs off a 9.6-volt rechargeable battery, so an important aspect of the design was conserving power. For this reason the Stamp was used to control the power down pin of the ISD as well as the IRF 510 power mosfet controlling the two motors. The stamp sends a logic one to the gate of the mosfet allowing the 9.6 volts to run directly to the motor when the ISD is in playback mode.

The cost of parts and material was approximately \$180.

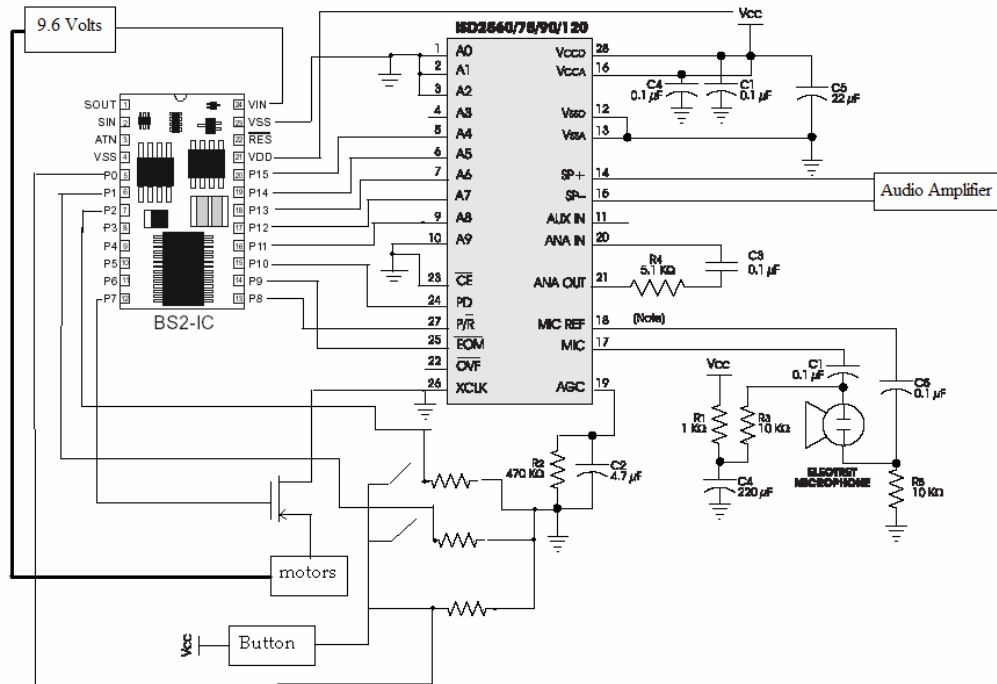


Figure 15.29. Voice Recording Circuit

VOCAL TRAINER

Designer: Chung Chan

Client Coordinator: Ms. Webster, Lowell High School, Lowell, MA

Supervising Professor: Jay Fu

Department of Computer and Electrical Engineering

University of Massachusetts, Lowell

Lowell, MA 01854

INTRODCUTION

The Vocal Trainer (Figure 15.30) was designed for a special needs student in a high school. Its purpose is to provide encouragement and promote self confidence when the client says a word. When the user speaks the device plays back his words to him. An LED display provides visual feedback corresponding to his loudness. The louder his voice, the more light he sees. If the client vocalizes at a mid-range volume, music plays.

SUMMARY OF IMPACT

The device helps the user to develop his speaking skills while engaging in something that is fun. Also, it encourages the user to speak more loudly.

TECHNICAL DESCRIPTION

The headset-microphone combination filters out much of the background noise so that the voice of the user is isolated. The microphone had to be directional and take in only voice signals. The input from the microphone goes to the audio amplifier. The analog sign goes directly to the LED drivers. The LEDs depend on the amplitude of the sign to light up. Also, music will play as the LED lights up to a particular point. A 9 V DC adaptor is incorporated.

The cost of parts and material was approximately \$50.



Figure 15.30. Vocal Trainer

LIGHT, MUSIC AND TOY BOX

Designer: Chun-Tung Woo

Client Coordinator: Ms. Webster, Lowell High School, Lowell, MA

Supervising Professor: Jay Fu

Department of Computer and Electrical Engineering

State University of Massachusetts

Lowell, MA 01854

INTRODUCTION

The Light, Music and Toy Box (Figure 15.31) was designed to promote physical and intellectual stimulation. It uses a remote radio frequency device to control light, music and a toy. Inside the toy box is a series of light tracks with lights that light up to follow a foam ball as it rolls down the light tracks. At the bottom of the light track, a motorized swing projects the ball back up to the top of the light track.

SUMMARY OF IMPACT

The device is entertaining and promotes learning of cause and effect and use of the hands to manipulate button controls. Soft music and soft blinking lights may be soothing to some users.

TECHNICAL DESCRIPTION

The size of the plastic rectangular transmitter box is 6" x 9" x 3". The receiver device is 14" x 11" x 1". The front side of the box is covered with a transparent plastic sheet, and rest of the sides are covered with a plastic sheet painted black. All sides are held together with a hot glue gun. Five 5" x 1" transparent strip tracks were glued inside the box. The back of the box has 16 drilled holes for the LEDs.

The main components of this RF device are the transmitter, receiver, encoder, and decoder. Data input into the encoder are transferred to the transmitter, via a radio frequency signal. The signal received by the receiver is transferred to the decoder for output. The output is on when active high and off when active low.

For the blinking light effect, four LM555 timers were used. To change the timing of the blinking, each of the timers has a different value capacitor. The values of the capacitors range from 10F to 1F. These allow each of the timers to have a different frequency, and, therefore, to blink differently.

The music is sent from a preprogrammed microprocessor chip. The microprocessor was built into a circuit such that it only had to connect to the 5-volt relay to operate. A motor was connected to the 5-volt relay because additional voltage was needed. The wiring is shown in Figure 15.32.

The cost of parts and material was approximately \$80.



Figure 15.31. Light, Music and Toy Box

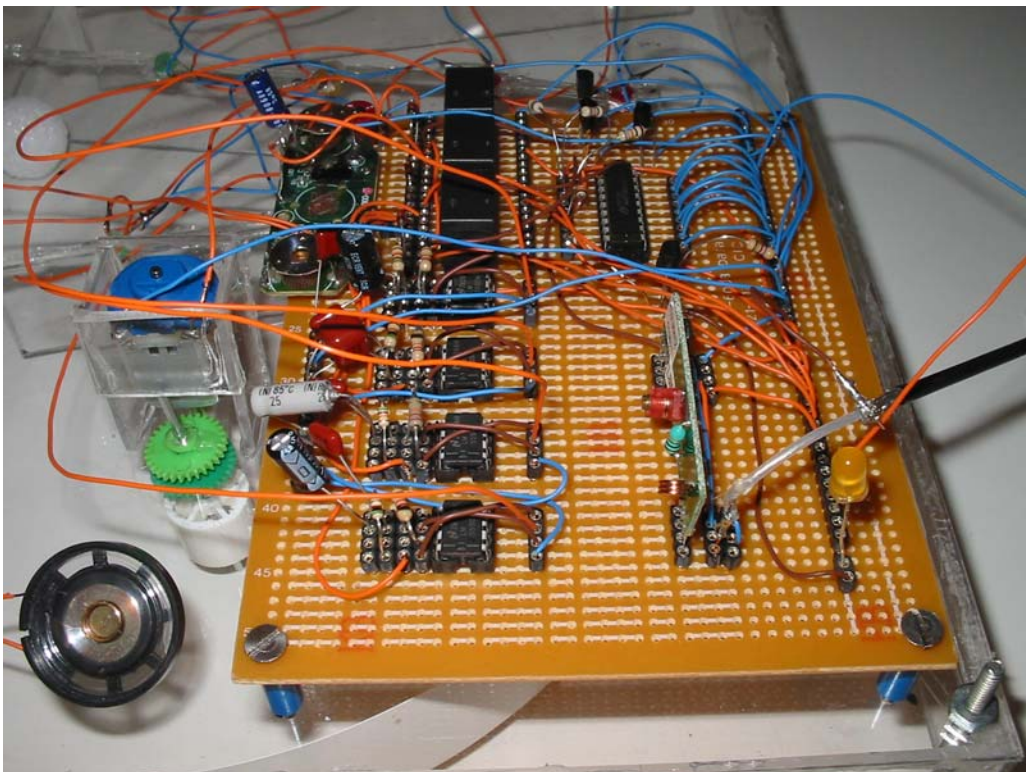


Figure 15.32. Wiring for Light, Music and Toy Box

JOYSTICK-CONTROLLED TILTING MIRROR

*Designer: Alfredo I. Barriga
Client Coordinator: Bonnie Paulino, Kennedy Day School, Brighton, MA
Supervising Professor: Jay Fu
University of Massachusetts, Lowell
Electrical Engineering Department
Lowell MA, 01854*

INTRODUCTION

The joystick-controlled tilting mirror (JCTM) is an educational device that provides children with many tools to enhance their visual and motor skills. It is intended to allow children to interact easily with it and to encourage their visual and cause-and-effect exploration. This device is well suited for children with sensory processing, perceptual, and physical disabilities and is also intended to be an attractive and enjoyable educational toy.

SUMMARY OF IMPACT

The JCTM, shown in Figure 15.33, provides visual and motor learning opportunities as well as entertainment. It also encourages curiosity, as the user can see the entire device, including its internal mechanisms and circuits. Also, users are challenged to enhance self-image and discovery, as they visualize different perspectives in the room, including their own reflections. The device will serve as part of a classroom-learning device for students in a special needs classroom. The product was designed for a group of approximately 80 students with ages ranging from 3 to 21 years, with varying cognitive, speech, language, mobility, and visual disabilities.

The JCTM reinforces visual-motor perception as the user observes the mirror's movements in all directions. The mirror moves up, down, right, and left as well as in combinations of those movements. In addition, moving colored lights turn on in correspondence with the direction of the device's rotation. This feature allows the children to associate the direction of the lights with that of the mirror. Cause and effect associations are promoted as students control the mirror and observe that it moves in any direction.

TECHNICAL DESCRIPTION

The JCTM is a solid structure that contains a moving frame holding a polycarbonate-based mirror. The



Figure 15.33. Joystick-Controlled Tilting Mirror

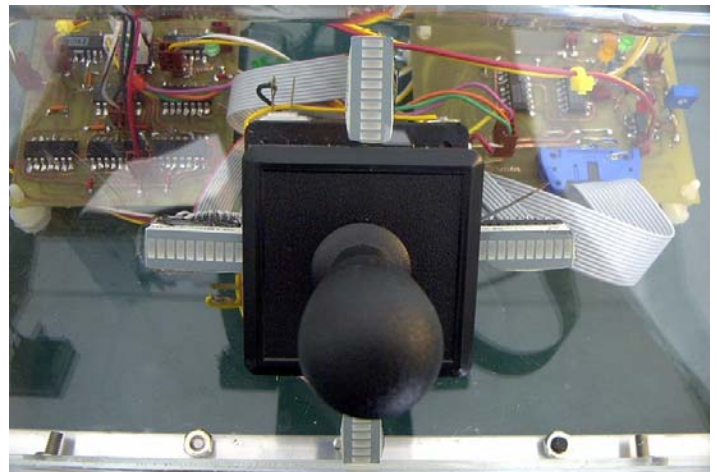


Figure 15.34. Front Control Panel of Joystick-Controlled Tilting Mirror

frame performs horizontal movements in the right and left directions. Also, the frame contains a geared stepper motor attached to a shaft to perform

the vertical rotation simulating the up-down direction.

A bipolar stepper motor powers the device's moving frame. This is joined to a speed-reduction mechanism by a ribbed belt. The system will be controlled by a logic control circuit, which receives signals from the joystick as well as from two switches called limit-of-travel sensors. These sensors are intended to provide a limited range of movement along the horizontal axis. These sensors are used because there are cables connected from the main circuit to the moving frame, preventing a 360° rotation. The logic control circuit generates signals to control the vertical and horizontal motor drivers (UCN 5804), which provide the power output for the stepper motors. Stepper motors were chosen because they offer high resolution, high torque, and more control flexibility. The control logic circuit will also be responsible for generating signals to control the LEDs arrays depending on the direction of the device's movement.

The JCTM was designed to be a robust and safe device. Its main component is a transparent enclosure containing the circuitry, wiring, moving parts, and joystick. These parts are fully enclosed and protected so that the user will not have any contact with any parts that may be hazardous. The

material selected for the enclosure is clear acrylic because of its aesthetics as well as the fact that it also offers durability, flexibility, and is relatively low cost. The enclosure's corners are protected by aluminum angles to keep the acrylic from breaking or shattering if the device accidentally falls.

Another important component of the device is the moving frame. This is an aluminum-based structure that holds a geared stepper motor that moves the mirror in the up-down direction. The geared stepper motor is attached to a shaft that holds a light and flexible 8"x10" polycarbonate mirror. The polycarbonate mirror was selected over any other material because of its safety, durability, and elasticity. This type of mirror is safe and virtually indestructible under normal use.

A stepper motor attached to a speed reduction assembly is used to drive the moving frame. This configuration provides higher resolution and sufficient torque to move the entire structure without any problems. A block diagram of the components is shown in Figure 15.35. The approximate cost of the project was \$250.

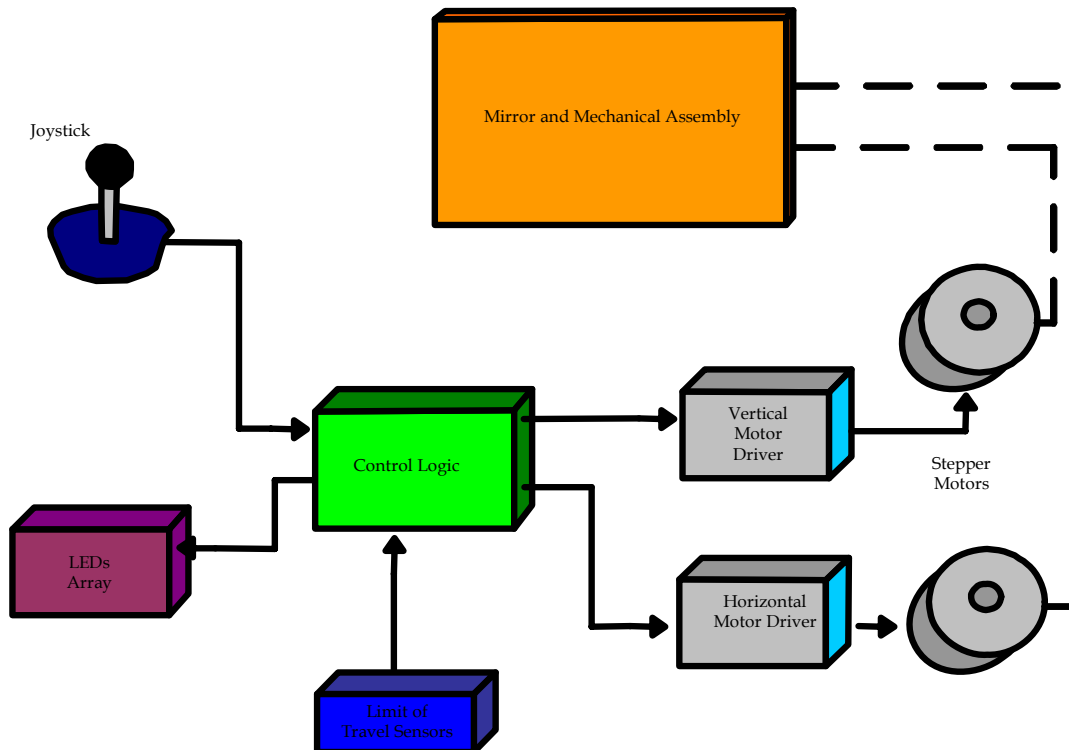


Figure 15.35. Block Diagram of Joystick-Controlled Tilting Mirror

MOTION-ACTIVATED CD PLAYER

Designer: Amir T. Tabrizi

Client Coordinator: Marie Haggerty, Shore Educational Collaborative, Chelsea, MA

Supervising Professor: Alan Rux

Electrical Engineering Department

University of Massachusetts, Lowell

Lowell, MA 01854

INTRODUCTION:

The Motion-Activated CD Player (MACDP) was designed as part of a Snoezelen room at a school for children with special needs. It was intended for students with physical disabilities that prevent them from using their fingers, hands or feet to activate switches and press buttons.

SUMMARY OF IMPACT

The MACDP enables the users to listen to music without having a parent, guardian, or a teacher assist them in controlling the CD player.

TECHNICAL DESCRIPTION

The core of this product was the GP2D15 motion sensor chip manufactured by Sharp. The way the GPD215 operates is that it has two lenses mounted

on it: one is the transmitter and the other is the receiver. The transmitter is constantly sending IR beams out, and if the receiver doesn't receive any IR beam, it means that there is no object in front of the device; therefore there is no reflection. A relay was used to act as a switch for the play/pause button of the CD player. The signal from the motion sensor is sent to the play/pause button, and the CD player plays music.

The cost of this product was approximately \$65.



Figure 15.36. Motion-Activated CD Player

INTERACTIVE BUBBLE TUBE

Designer: Christopher A. Magnell

Client Coordinator: Marie Haggerty, Shore Educational Collaborative, Chelsea, MA

Supervising Professor: Alan Rux

Electrical and Computer Engineering Department

University of Massachusetts, Lowell

Lowell, MA 01854

INTRODUCTION

The Interactive Bubble Tube was designed to provide sensory stimulation for children with multiple disabilities. The device (as seen in the concept drawings in Figures 15.37 and 15.38) is basically a tube of water with an air pump that sends whirling bubbles rising up the tube and lights that illuminate the entire tube in vibrant color. When turned on, the bubble tube rotates through combinations of red, blue, green, and yellow light, creating soothing visual stimulation. The tube also includes a control unit with colored buttons that, when pressed, stop the patterned display and illuminate the tube with the corresponding color. The ability to control the color of the tube is intended to give children the opportunity to control their sensory stimulation. Ultimately the bubble tube serves a dual purpose as a relaxation aid as well as a learning activity device. Upon completion of the final design, three bubble tubes were fabricated for three different classrooms.

SUMMARY OF IMPACT

The design criteria for the bubble tube were defined by the capabilities and needs of the children who will use it. Teachers requested a device that would be portable, entertaining and educational. The tube is fully self-contained and requires only an available electrical socket. Also, the tube weighs less than 20 lbs when filled with approximately 2 gallons of water. The tube's control unit is removable so it can function as a stand-alone relaxation aid. When the control is connected, a single user can play with the buttons, which promotes learning of cause and effect and experience with colors and color mixing.

The control unit has ports to plug in additional remote switches so that multiple children may use the tube together and learn sharing and teamwork.

When the tube was presented, the children in the classroom immediately turned their attention to the device and appeared mesmerized and excited by it. The children's aides commented how the bubble tube's presentation "made their day."

TECHNICAL DESCRIPTION

The Interactive Bubble Tube consists of two separate devices: the bubble tube, and the control unit, as seen in the block diagram in Figure 15.37. The bubble tube houses the primary circuitry, including the air pump, microcontroller, and LEDs. The control unit is connected to the tube via a standard PS/2 keyboard or mouse cable, and houses the buttons and jacks for external switches. These are wired in parallel so that either the button on the unit or a remote switch will work to send a signal to the bubble tube when activated.

As can be seen in the block diagram, the Basic Stamp 2 state machine is at the heart of the bubble tube's operation. The state machine has two states, an idle state and an interactive state. When idling, the microcontroller counts through a series of LED bit-patterns stored in memory and outputs that pattern to the LEDs. There are 20 patterns stored, with each subsequent pattern only changing one bit to create a gradient of changing color in the tube. While displaying the light pattern, the microcontroller constantly monitors the inputs from the buttons. If any of the buttons are pressed, the system immediately jumps into the interactive state and transfers control of the LEDs to the control unit and doesn't return to the idle state until after a few seconds of inactivity on the control lines.

The cost of the three interactive bubble tubes totaled around \$400, which is approximately \$100 less than a single commercially available comparably featured device.

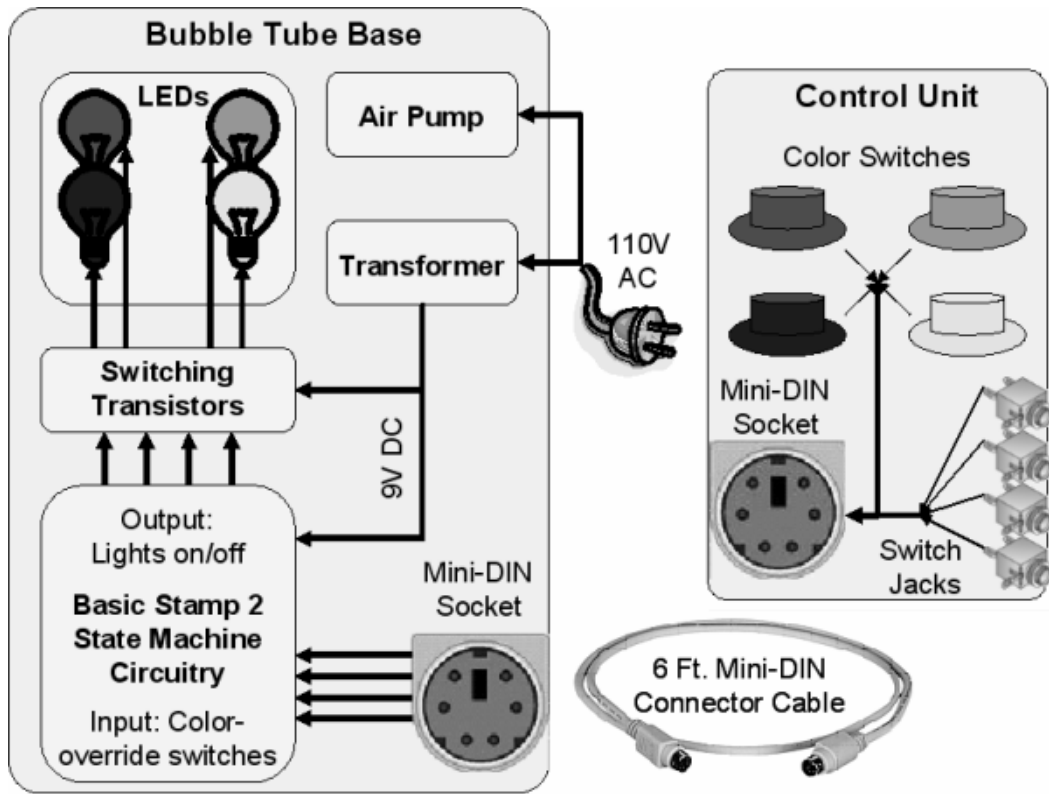


Figure 15.37. Interactive Bubble Tube Block Diagram

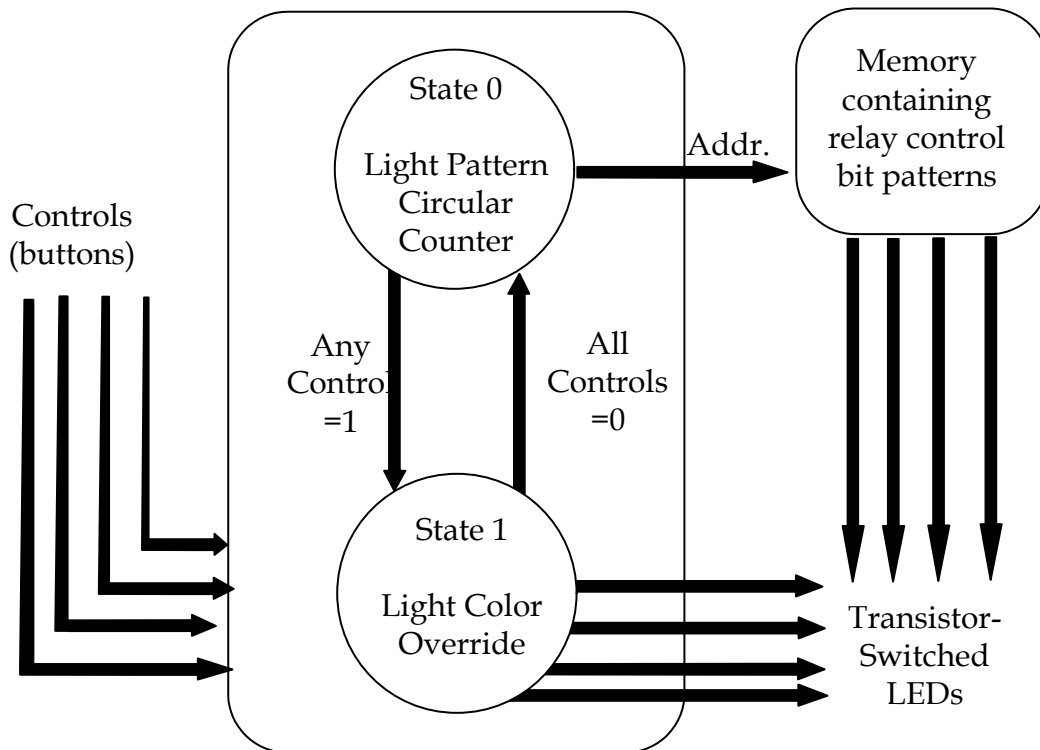


Figure 15.38. Detail of Interactive Bubble Tube State Machine

SMART PILLBOX

*Supervising Professor: Walter McGuire
University of Massachusetts, Lowell
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INTRODUCTION

The Smart Pillbox (Figure 15.39) is a box with timed alerts corresponding to multiple compartments. It is meant to help people who take many medications keep track of their intake. The Smart Pillbox combines features of existing products to provide prescription medication users with an organized and reliable medication tracking method. At the beginning of the day, the patient sets times for each compartment of the device using buttons and a display screen. When it is time to take a particular medication, a light corresponding to the medication's compartment goes on, and stays on until the patient pushes a button to indicate that he or she has taken the medication.

SUMMARY OF IMPACT

The client for whom the Smart Pillbox was designed (shown in Figure 15.40) needs to manage medications for several conditions. In the past, she has had difficulty taking her pills in a timely fashion on a daily basis. Since receiving the device, the client reports that she has achieved almost flawless administration of her medications. She simply sets aside a few minutes in the morning to set the device. Then, she does not have to worry about her medications any further throughout the course of the day. In her own words, "I feel like a weight has been lifted from me, because I don't spend half of my day worrying about whether or not I've taken my medications correctly. I would definitely recommend this to anyone who has to keep track of more than a couple of medications." The client indicates that setting the device is fairly self-explanatory and user friendly, and she likes that she has the option of plugging the device in or using batteries and taking it with her. The client did note however, that the one improvement she would make on the device would be to make it smaller, and therefore less conspicuous and more portable.

TECHNICAL DESCRIPTION

There are five components to the Smart Pillbox device: 1) the microcontroller BS2-IC, 2) the time-keeping chip DS1302, 3) the LCD BPI-216, 4) four



Figure 15.39. Smart Pillbox

pushbuttons, and 5) six LEDs (see Figure 15.41). The project operates in the following manner. First, the user turns the device on and uses the pushbuttons to set the clock. The user then uses the buttons to select and set the time for each medication. The Basic Stamp program stores these times and compares them to the clock to check whether it is time for one of the medications. When it is time for one of the medications, the corresponding LED lights up. Once the medication has been taken, the



Figure 15.40. Client with Smart Pillbox

user pushes a button to turn off the LED. The user has the ability to reset the clock as well as check and reset the compartment times at any point. Also, the user may choose between plugging in the device and using a 9V battery.

The microcontroller communicates with and interprets data from the other components. The BS2-IC has 16 I/O pins and programs are written in PBASIC to the 2KB EEPROM. Other industrial versions of the Stamp chip are available with more I/O pins and extra memory, which could be used for adding more features and messages to make the operation of the device more user-friendly or to simply include additional compartments. Any such changes can be incorporated through some lines of code to the same program. The device could be constructed using a keypad instead of pushbuttons, except that a keypad connects to the microcontroller in parallel and takes up too many I/O pins. On the other hand, the pushbutton method uses program code to perform a specific function when the user pushes a button. For instance, the buttons allow the user to select, scroll, display, and reset. This method

assigns various functionalities to each button at different stages of the program. This method requires lengthier program code, but conserves physical and electrical space.

Connecting the pushbuttons to a ground would conserve power, but a true ground is nearly impossible to achieve with all the interference from the rest of the circuit. By connecting the pushbuttons to +5V, the interference problem is solved. The time-keeping chip has the option of 24-hour time, but 12-hour time is used in the interest of shorter program code and will suffice for the client's needs. The times set for each compartment are lost when power is turned off. Volatile memory is not a concern for this client because she prefers to set the time each day since her schedule and medications are changing regularly. The device packaging is bulky, but durable and safe. There is a flap door for the user to access and change the 9V battery without being exposed to the circuit.

The cost of parts and materials was approximately \$300.

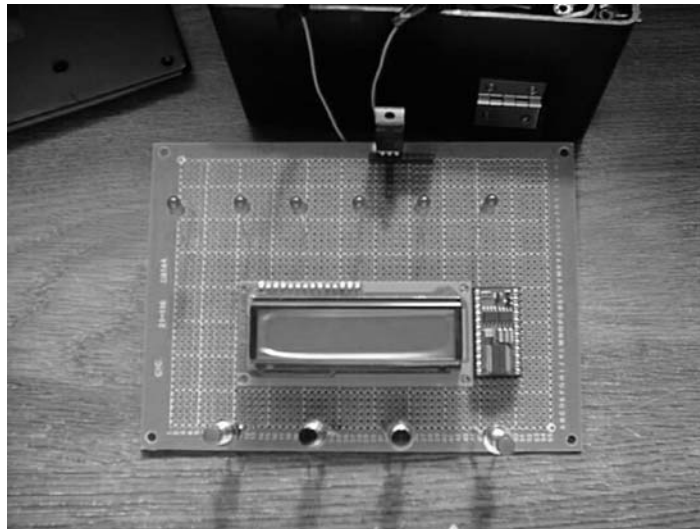


Figure 15.41. Circuit Components

PROGRAM TIMER

*Designer: William C. Muldoon
Supervising Professor: Jay Fu
Electrical and Computer Engineering Department
University of Massachusetts, Lowell
Lowell, MA 01853*

INTRODUCTION

The Program Timer is a wireless environmental control system to enable a client to turn on or off the appliances and lights in her home.

SUMMARY OF IMPACT

The design criteria for the Program Timer were defined by the capabilities of the client and her needs at home. The device enhances her independence and quality of life.

TECHNICAL DESCRIPTION

The project integrates the client's appliances and lights via a hand-held device or through commands on a computer.

It incorporates a Visual Basic Program that runs by X-10 modules. X-10 is a language that allows devices to talk to one another using electrical wiring in the home. The transmission of a message occurs close to the zero crossing of a 60 Hz power line.

There is a binary one that is represented by a one millisecond burst of 120 kHz at the zero crossing point. There is a binary zero in the absence of a 120 kHz burst. The complete code transmission lasts for 11 cycles of the power line. The first two cycles represent a start code. The next four cycles represent the house code. The last five cycles represent the number code (1 through 16) or a function code (on or off). The appliances and lights accept the X-10 signal and decode it and the microcontroller decides whether to turn off or on.

The total cost, including labor, was \$1006.

ALARM SYSTEM FOR AN AUTISTIC CHILD

Designer: John P. Garvin

Supervising Professors: Walter McGuire and Alan Rux

Electrical and Computer Engineering Department

University of Massachusetts, Lowell

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INTRODUCTION

Parents of a child with autism were finding it hard to keep constant watch over their child, especially at night when he should have been sleeping, but instead was often trying to sneak out of his room. Also, he was frequently falling out of bed without their knowing about it until they would find him on the floor the next morning. This project was devised to address both of these problems. An alarm system notifies the parents when their child has fallen out of bed or if he tries to leave his bedroom.

SUMMARY OF IMPACT

This project will provide the parents with the reassurance of their child's safety while they sleep. If the child triggers the pressure sensitive mat by falling out of bed, or triggers the motion sensor by leaving the room, and the parents are notified through a receiver.

TECHNICAL DESCRIPTION

The device includes a mat to detect when the child has fallen out of bed and motion sensors to detect when he is leaving his room. When the mat is triggered it sends a signal to a Basic Stamp chip, which identifies that the mat was the object

triggered. Then the Basic Stamp chip sends a signal to a transmitter, which sends a signal to a receiver, causing a buzzer to sound.

Motion sensors are mounted in the doorway of the child's bedroom. Triggering these sensors also sends a signal to the Basic Stamp chip, which transmits the signal to the receiver and triggers a ringer. The ringer is distinct from the buzzer sound so that the parents will know which of the devices has been triggered. An ISD chip could be incorporated to provide the parents a voice recording to alert them as to which of the devices has been triggered.

The cost of parts and materials was approximately \$217.



CHAPTER 16
UNIVERSITY OF NORTH CAROLINA AT
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Principal Investigator:

Richard Goldberg (919) 966-5768

ELECTRONICALLY-ACTUATED LAZY SUSAN

Designers: Jacob McPherson, and Jeffrey Whittaker

Client Coordinator: Luanne Holland, Speech-Language Pathologist, Durham Public Schools.

Supervising Professor: Dr. Richard Goldberg

Department of Biomedical Engineering

University of North Carolina, Chapel Hill

Chapel Hill, NC 27599-7575

INTRODUCTION

The goal of this project was to develop a device that elementary school children with severe and profound disabilities could use to select one of four different toys while remaining seated or standing. The device was also to provide audio and visual feedback. An electronically-actuated lazy susan (shown in Figure 16.1) was designed. It presents the user with a single toy at a time. A partition blocks the view of other toys on the device, so that the user is not distracted. When the student presses a button, the device starts to rotate, and it stops when the next toy is presented to the user.

SUMMARY OF IMPACT

According to the speech-language pathologist, the device succeeded in increasing the user's independence by providing direct access to desired items and decreasing the amount of teacher intervention necessary. It eliminates the need to navigate the classroom to obtain an object, and prevents confusion associated with choosing from among a group of items.

TECHNICAL DESCRIPTION

The device consists of a 36"-diameter top disc, a similarly-shaped base, and a thin sheet that is wrapped around its perimeter. All items are made of Plexiglas. A DC motor, located inside the device, rotates the top disc. The disc rests on a bed of ten casters that allow for smooth rotation while holding up the weight of the disc and toys (see Figure 16.2). The teacher can connect up to three external, commercial switches via standard audio jacks. When one of these switches is pressed, the device turns the motor on, initiates the first audio feedback message, "go," and turns on the LEDs that are around the perimeter of the device. The device continues to rotate, with the LEDs on, until the next toy is positioned in front of the user.



Figure 16.1. Client Using Lazy Susan

The partitions on the top of the device allow the lazy susan to be sectioned into halves or quadrants, and the device automatically senses which mode it is in and rotates either a half or quarter turn accordingly. There is a tab on the bottom of each partition; the device detects when the tab passes in front of a photo-interrupter, and stops the motor. Then, it plays the final audio feedback message, "stop," and the LEDs are turned off. The device then resets itself, and is ready for the next trigger.

All circuitry is housed within the device itself, and the microprocessor, speaker, other ICs, and the PCB are all contained within an internal project box (see Figure 16.2). User controls for power, volume, and LED on/off are contained in an external box, accessible to teachers but not to students.

The device is battery-powered and therefore does not need to be tethered to a wall, thus increasing its mobility. The low profile of the device allows it to be placed on the floor or on a table, depending on the child's needs, while the bottom of the device is covered with non-slip neoprene to prevent unwarranted movement. The neon colors of the partitions help to retain children's interest.

The cost of the project is approximately \$370.

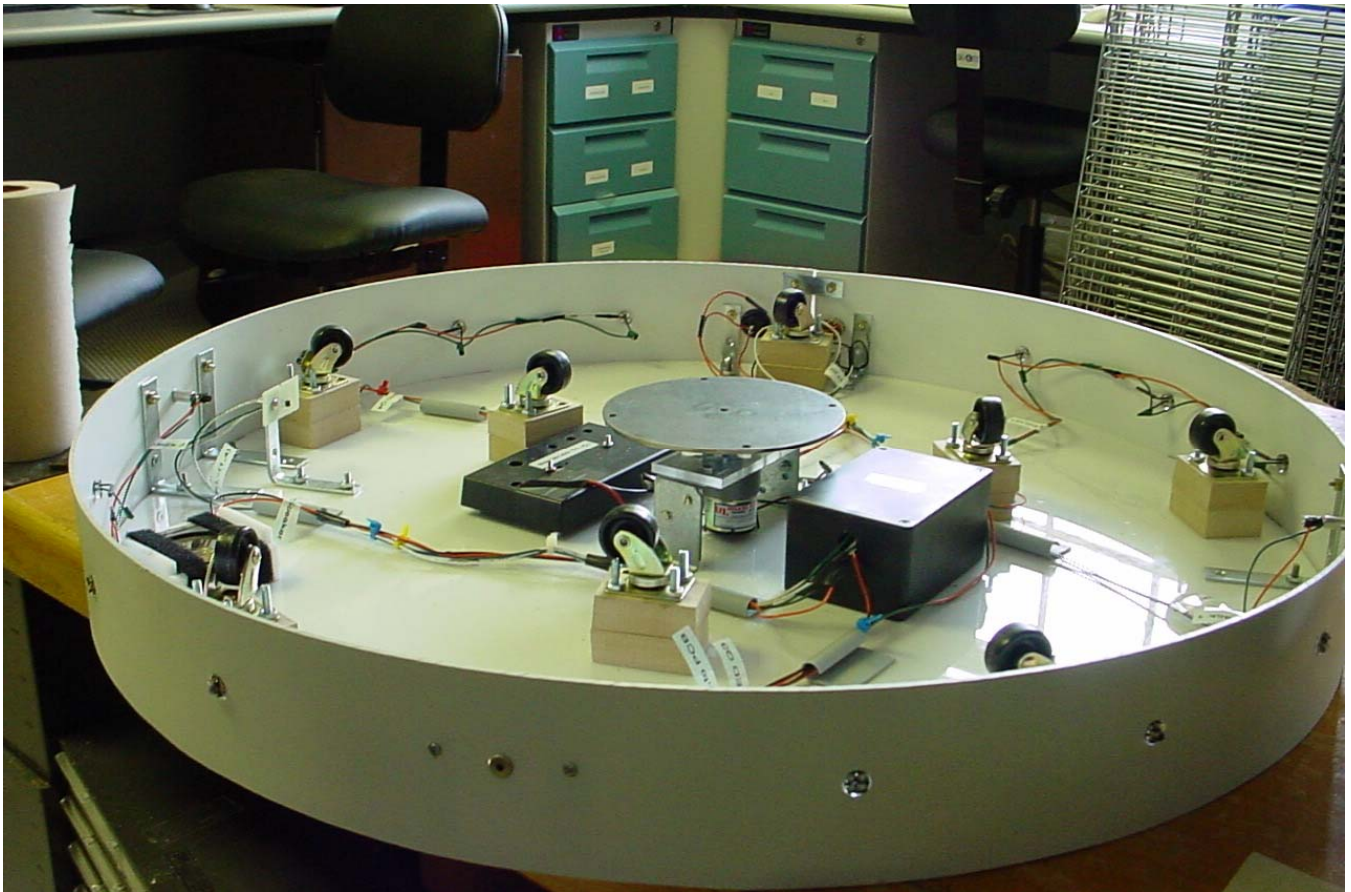


Figure 16.2. Lazy Susan with Top Disc Removed, Showing DC Motor, Electronic Circuitry Box, Casters, and LEDs

FLOW-CONTROLLED SPORTS BOTTLE

*Designer: Vidya Goli
Supervising Professor: Dr. Richard L. Goldberg
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INTRODUCTION

A client who had a traumatic brain injury at a young age occasionally develops high muscle tone. If this occurs while she is drinking, she cannot stop taking in fluid and she chokes. Currently, a caregiver needs to monitor her closely to prevent choking. The goal of this project was to build a flow-controlled sports bottle that limits the amount of fluid that the

user can drink at one time. This will prevent choking and give the client more independence when drinking.

The design uses a two-cup system, in which one cup fits inside the other. A caregiver fills the inner cup with fluid, and the client can dispense a small amount of fluid into an outer cup. The client then



Figure 16.3. Client with Flow-Controlled Sports Bottle

drinks from the outer cup through a straw. After drinking, the user can then dispense more fluid from the inner cup into the outer cup. This limits the amount of fluid the user can drink at one time.

SUMMARY OF IMPACT

The flow-controlled sports bottle will have a large impact on the client's independence. While using a regular bottle and straw, the client would require assistance in pinching her straw to prevent excess fluid intake and choking. With this sports bottle, she will not require assistance. The flow-controlled sports bottle will help her to drink without fear of choking. The client's mother commented that the bottle "works great" and it was easy for the client to use.

TECHNICAL DESCRIPTION

The device uses a two-container design in which the client releases fluid from an inner storage bottle, through a valve, into an outer drinking container. The design uses the Nalgene GoCup, which consists of a Lexan polycarbonate sports bottle that snaps into a Lexan outer measuring cup. When the user presses down on the sports bottle, the fluid flows from the inner bottle through a valve into the outer cup. The user then drinks from a straw that is placed in the outer cup. The Lexan is durable and temperature-resistant from -135°C to 135°C . The bottom diameter of the outer cup is 6.0 cm, allowing it to fit easily into cup holders of 6.5 cm diameter.

The bottle design allows the client to easily refill the inner bottle. To activate flow release, the client simply places her hand above the bottle and presses the bottle downward. The flow rate from the inner bottle into the outer cup is 5.0 ml/sec when the bottle is half-full (240 ml or 8 oz). When the client stops pressing, the bottle springs back up and the valve closes. If the inner bottle is half-full, then up to 110 ml or 3.7 oz can be dispensed into the outer cup. However, the straw does not reach the bottom, so the maximum fluid that the client can drink is about 2.7 oz.

The valve consists of non-toxic commercial parts easily found in the faucet repair section of a hardware store. A nylon screw is placed through a

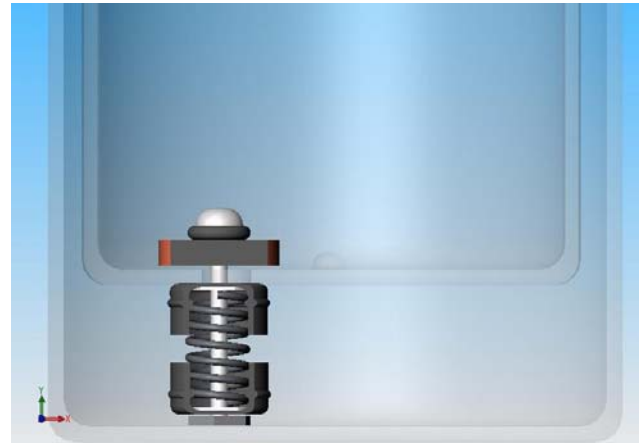


Figure 16.4a. CAD Drawing of Closed Valve

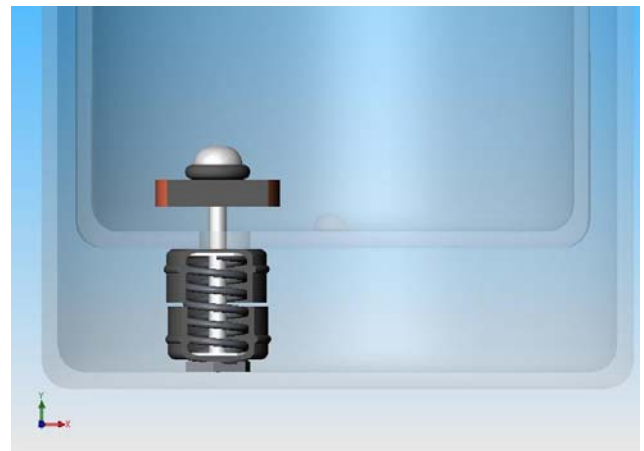


Figure 16.4b. CAD Drawing of Open Valve

hole in the bottom of the inner bottle. An o-ring and gasket are mounted below the head of the screw to seal the hole from above. Below the hole are gaskets, a spring, and a nut (see Figure 16.4a). The force of the spring causes the hole to be blocked under normal conditions. When the client presses down on the inner cup, the spring is compressed, opening up the hole and letting fluid flow into the outer cup (see Figure 16.4b).

There is a second hole in the bottom of the inner cup to provide an opening for the straw to reach the outer cup. A silicone gasket is used (taken from a child's spill-proof cup) around the straw to prevent fluid from leaking through that hole.

The total cost of the device is approximately \$35.

ONE-HANDED NAILSET AND CHISEL

*Designers: Jordan Hutchinson, and Justin Fender
Supervising Professor: Dr. Richard Goldberg
Department of Biomedical Engineering
University of North Carolina, Chapel Hill
Chapel Hill, NC 27599-7575*

INTRODUCTION

A carpenter who has functional use of just one arm due to a brain tumor is unable to perform finishing carpentry, such as nail setting and chiseling because both of these tasks require the use of two hands – one to hold the hammer, and the other to hold the nail set or chisel. When setting nails, the user strikes the nail set, which then punches the nail head below the wood surface. Chiseling requires similar actions.

The goal of this project was to create devices for nail setting and chiseling that can be operated with just one hand. The client needed devices that were easy to use, comfortable, practical, and portable. Commercial PowerShot staple guns were modified with custom tips to perform the desired functions (see Figures 16.5 and Figure 16.6). The nail set tip has a V shape so that the tip hits the nail only and not the surrounding material (i.e. wood). The chisel has a long beveled tip so that it can chisel into wood.

SUMMARY OF IMPACT

The device effectively drives the heads of nails below the surface of all types of woods tested. It requires minimal coordination and allows the client to work independently with just one hand. The client remarked that the device, “allows me to have the ability to set nails without having someone do it for me. This gives me more independence especially since I don’t have to hire an extra carpenter needed for the job, saving \$16 an hour.”

These devices are safe, lightweight, portable and simple to use. It is easy to activate the staple gun lever that does the mechanical work of driving the nail into wood or chiseling wood. The device includes a safety latch to prevent undesired activation of the device.

TECHNICAL DESCRIPTION

Due to the requirements of functionality, size, weight, reach, and cost of the device, a commercial



Figure 16.5. Custom Tips for Chisel (Foreground) and Nail Set (Background).

staple gun was used (see Figure 16.6). The chisel tip is approximately 2” long. The device is small, with dimensions of 16.50 inches x 1.50 inches x 9.25 inches; it is easily portable and weighs 3.17 pounds. Due to its small size and weight, the device can be used in a wide array of positions, enabling adjustment of torque and leverage. As long as the handle can be depressed, the device will do its job. The custom tips were the most expensive components.

The device is easily made and fixed if broken because only one component of the commercial product is replaced (see Figure 16.7). The client was initially the only intended user of the device, but the universal design aspect of the device allows it to be used by anyone intending to increase productivity, efficiency, and ease of use.

The cost of the project is \$40.



Figure 16.6. Completed Device (Custom Nailset Tip at Bottom Right)



Figure 16.7. Interior Mechanism

JAWS: ZIPLOC BAG MANAGEMENT SYSTEM

Designers: Uranie (Peppi) Browne, and Dorian Miller

Client Coordinators: Ashley Stone and Gena Brown, Goodwill Industries of Eastern North Carolina, Inc.

Supervising Professor: Dr. Richard Goldberg

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INTRODUCTION

A vocational training regimen for high school students with disabilities includes performing repetitive tasks. The students are paid for each completed task. One task is to fill Ziploc bags with a user manual, a set of keys and three spare screws. This is difficult task because the bag is just barely large enough to hold the manual. It is particularly difficult for those students who have limited function in one or both hands. The goal of this project was to create a device that would assist the students in putting items into a Ziploc bag. JAWS, a modular universal device, was designed for two students with limited hand function.

SUMMARY OF IMPACT

The clients can successfully use JAWS to fill Ziploc bags with a four-page manual, three screws, and a pair of keys. JAWS made this task easier because it holds the bag in place, keeps it open, and provides a clear path for inserting the manual into the bag. A supervisor says, "I believe that JAWS will increase the productivity of our interns, level the playing field with their peers, and decrease the level of

frustration that they feel as they work on this kind of job, while increasing their sense of accomplishment. Additionally, it will give them the opportunity to try jobs that they may not have been able to do before, while decreasing the possibility of damaging product materials."

TECHNICAL DESCRIPTION

The main component of the JAWS device is the metal and plastic pyramid, which is on its side (shown on the right side of Figure 16.8). The user places the Ziploc bag over the peak of the pyramid (see Figure 16.9), and inserts items through the opening on the opposite end. The sides of the pyramid are hinged to a metal frame that surrounds the opening, allowing the peak to open wide like a set of jaws, so that items can pass through the pyramid into the bag.

The metal frame is also hinged to the base of the JAWS device. This allows the peak of the pyramid to be raised and lowered relative to the base. The user raises the pyramid before placing the bag over the peak. Then, the user lowers the pyramid before loading items in the bag. The pyramid presses down



Figure 16.8. Side View of JAWS

firmly against the bag and prevents it from sliding. A magnetic touch latch, typically used for opening cabinet doors, was used to move the pyramid between the two positions. When the latch is pressed, it alternately extends and retracts by approximately $\frac{1}{2}$ ". It is located in the base of the JAWS device, below the pyramid (seen in black, directly below the center of the pyramid in Figure 16.8). To raise and lower the pyramid, the user simply presses down on the pyramid to engage the touch latch below it.

The perimeter of the pyramid consists of three plastic isosceles triangular surfaces (6" x 7"), and one 6" equilateral triangular opening through which items are inserted into the bag. Within the triangle is a transparent film that guides items as they are inserted. This curls the manual as it passes through

the opening, and the manual flattens properly in the Ziploc when the bag is removed from JAWS.

The base of JAWS is made of wood, with a surface of stiff foam that includes an embedded metallic layer. This foam is an existing product that is commercially used to post messages with a magnet. A magnet is embedded in the acrylic, near the peak of the pyramid, to provide a strong force between the pyramid and the base. This helps to prevent slippage of the bag during filling.

Finally, there is a separate roller with a handle that is used to close the seal of the bag. The roller is made from a bed frame caster, with a customized ergonomic handle made of wood.

The cost of the project was approximately \$160.



Figure 16.9. Loading Ziploc Bag onto the JAWS Pyramid



CHAPTER 17

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VEHICLE CARRIER FOR A RECUMBENT TRIKE

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INTRODUCTION

The goal of this project was to design and construct a racking system that will allow the family of an individual with a disability to transport easily and safely his recumbent trike using a standard automobile. The client is a teenage male who has undergone numerous surgeries and chemotherapy treatments to treat a malignant tumor in the lower rear portion of his brain. These treatments have resulted in a number of medical side-effects including poor balance, which prevents him from remaining upright on a standard two-wheel bicycle. As a result, he owns and rides a recumbent trike. Although he has no problems riding his trike, his family does have problems transporting it as a result of its awkward geometry and weight. The family currently transports the trike using a trailer attached to the hitch of their van. They feel that the current trailer is difficult to attach to the van, awkward to load with the trike, and difficult to maneuver once it is loaded. A custom aluminum rack was designed and mounted on top of a commercial aluminum cargo carrier. This cargo carrier is mounted to a



Figure 17.1. Client (on left) Testing Trike Racking System

standard, two-inch hitch receiver on the client's van. Aluminum ramps allow the trike to be rolled onto the aluminum frame. The trike is secured in place on the racking system using ratcheting nylon tie-down straps. Figure 17.1 displays the client and his mother with the client's trike, testing the finished

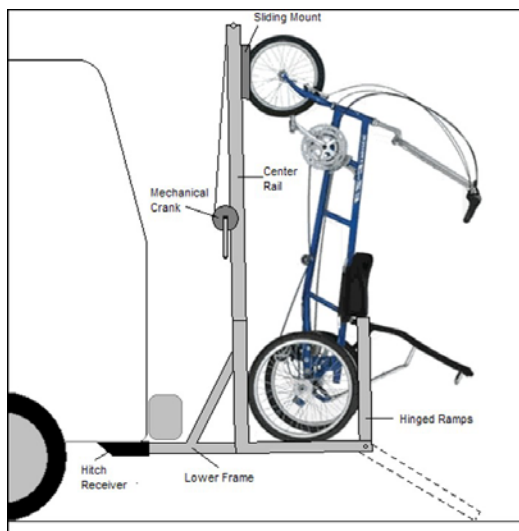


Figure 17.2. Vertical Hitch-Mounted Rack

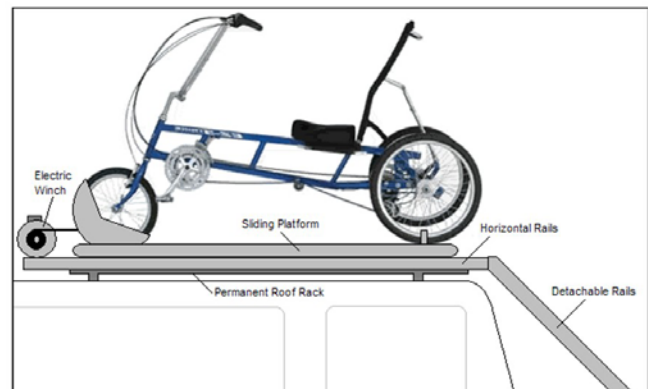


Figure 17.3. Top Mounted Roof Rack

racking system.

SUMMARY OF IMPACT

Due to the client’s medical condition, bicycling is one of the few outdoor activities that he can participate in with his family and friends. He currently lives on a road with a high volume of traffic. As a result, his trike must be transported to local parks or bicycle trails in order for him to use it. Since his mother finds it difficult to load his trike and transport it using the family’s trailer, the client must often wait until his father returns home to use his trike. Providing a racking system that the client’s mother can attach easily and safely to her vehicle, and then load and maneuver, will allow the client to use and enjoy his trike more frequently. This will also reduce stress on the client’s mother, making the process of transporting the trike safer and less physically demanding.

TECHNICAL DESCRIPTION

The trike weighs roughly 60 pounds, is slightly over 6’ in length and nearly 30” wide. The only commercially available racks found were for standard two-wheel bicycles. Such racks cannot accommodate the client’s trike because of size, geometry and weight constraints. Most commercially available products make use of a top-mounted roof rack, a hitch-mounted rack, or interior storage. Because of the large physical dimensions of the trike, interior storage systems were not an option. Three design options for mounting and orienting the trike using either a hitch-mounted system or a roof-mounted system were considered.

The first design option was a hitch-mounted rack that oriented the tricycle vertically on the back of the vehicle, as shown in Figure 17.2. This design would consist of a lower frame that would connect to a standard square two-inch hitch receiver on the automobile. Mounted on top of the lower frame would be two short vertical rails and a long center rail. On the center rail would be a mount for the front wheel of the trike, which would ride up and down the length of the rail. This sliding mount would be connected to a mechanical cranking system. Connected to each of the short vertical rails would be horizontal rails with hinged ramps at the end of each. To load the trike onto the rack, the hinged ramps would be pivoted down, with one end resting on the ground. The front wheel would be lifted into the sliding center mount. Using the

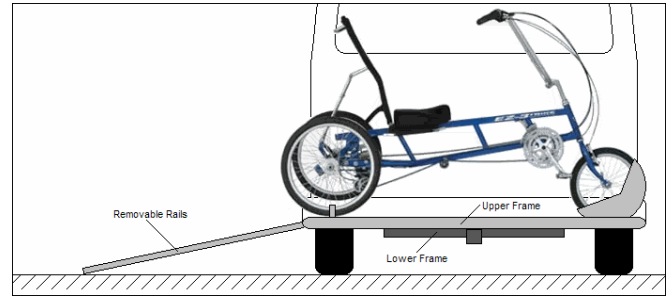


Figure 17.4. Horizontal Hitch-Mounted Rack

mechanical crank, the bike would be pulled into place with the two back wheels riding up the previously lowered, hinged ramps. When the bike is in position, the hinged ramps would be raised against the rear wheels to secure them in place. However, there were several apparent problems with this option. First, the front wheel of the trike would be required to lift a large portion of the tricycle’s weight, which is nearly 60 pounds. It would have to be determined if this small front wheel was capable of holding such a weight. Second, the vertical design would keep the back hatch of the vehicle from being opened as the center rail would extend above the top of the vehicle, whether it was a minivan or SUV.

The second design option was a roof-mounted design, as shown in Figure 17.3. This design would consist of a permanently mounted, commercially-available roof rack that would be mounted onto the top of the automobile. Two horizontally-mounted rails would be attached to the roof rack. At the rear of the vehicle, two detachable rails would connect to the horizontal rails and extend, on an angle, down to the ground. The tricycle would be mounted to a sliding platform by its wheels. Wheels on the platform would allow it to slide up the detachable

Customer Requirements	Rank	Vertical Hitch-Mounted Rack	Top-Mounted Roof Rack	Horizontal Hitch-Mounted Rack
Ease of Installation	8	6	1	9
Loading bike on rack	8	4	8	9
Single person operation	6	4	9	9
Portability b/w vehicles	5	10	7	10
Additional bikes	3	0	7	0
Use of back hatch	3	0	10	8
Aesthetics	3	3	6	7
Total		163	230	293

Figure 17.5. House of Quality for Three Design Alternatives

rails and lock into place on the horizontal rails, on top of the automobile. Because of the weight of the tricycle, an electric winch, mounted on the horizontal rails, would be used to pull the sliding platform up the detachable rails. The roof rack option also had several problems. First, having the entire rack structure and tricycle mounted on the roof could cause significant drag and road noise as the automobile is driving. Second, the design is complicated, requiring an electric winch with a power supply, permanently-mounted components, and a sliding platform with a locking system. Further, this rack could not be easily moved from vehicle to vehicle, as the horizontal rails would be hard-mounted to the top of the vehicle.

The third and final rack orientation that the designers considered was a hitch-mounted rack with the tricycle oriented horizontally along the rear of the automobile. A sketch of such a rack system, with the tricycle in place, can be seen in Figure 17.4. This design consists of a lower frame that would connect into the standard square two-inch hitch receiver of the vehicle. On top of the lower frame would be an upper frame on which the wheels of the trike would rest and onto which the trike would be secured. A set of two removable rails would extend from the upper frame to the ground. Once these were in place, the front wheel would be lifted onto the upper frame and either set into a center rail or a sliding



Figure 17.6. Draw-Tite Aluminum Cargo Carrier [www.draw-tite.com]

mount that would ride along the center of the upper frame. Either of these two options would work to keep the front wheel straight as it moved along the length of the rack. The tricycle would next be pushed such that the rear wheels would ride up the removable rails and onto the upper frame. Finally, the tricycle would be secured to the upper frame using either wheel or frame mounts.

This horizontal hitch-mounted rack did not appear to have the same drawbacks as the other two designs. It was found that the length of the tricycle (73") was only slightly longer than the width of the smallest vehicle this rack would be used on (72"). As a result, very little drag or wind noise would be expected. Also, the height of the rack is fairly low (less than two feet from the ground). Thus, no mechanical or powered devices were thought to be needed to load the trike. Only simple ramps were

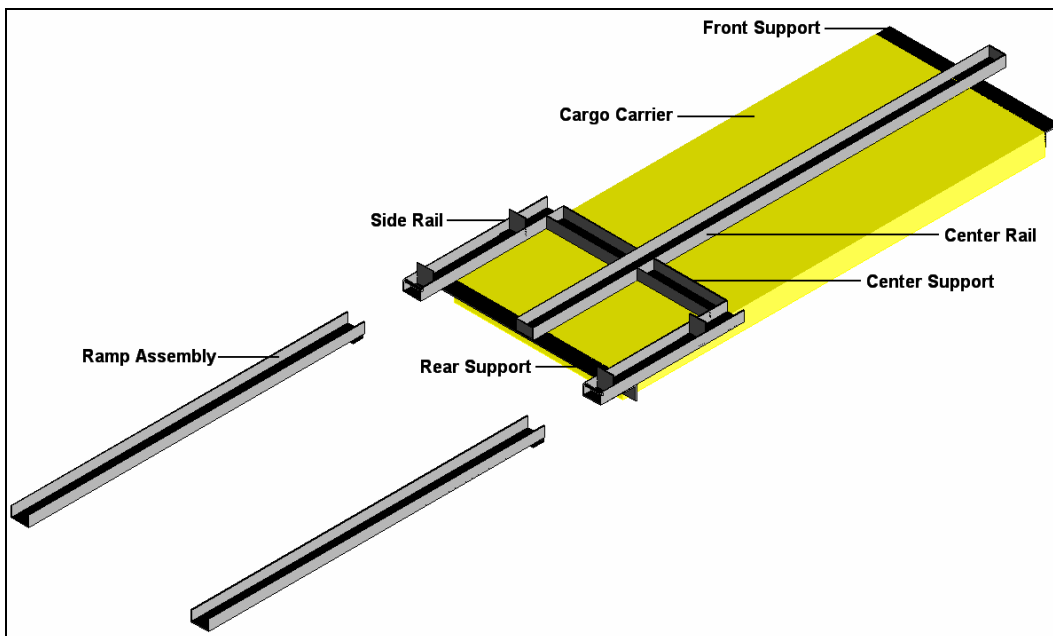


Figure 17.7. Upper Aluminum Frame

expected to be necessary. Overall, this design appeared to be simple with no readily apparent problems.

The three alternatives had to be systematically compared. Through group discussions and client input, a set of customer requirements was established and ranked in order to numerically compare the three design alternatives. The customer requirements included: ease of rack installation, ease of loading the bike on the rack, single person operation, portability between vehicles, allowance for use with additional bicycles, enabling of use of back hatch, and aesthetics.

Using these requirements and a numerical ranking system including values from 1 to 10 (10 being of highest importance, and 1 being of the lowest importance), a house of quality was established to compare the three proposed rack designs (see Figure 17.5). Each design alternative was ranked in terms of how well each met the established customer requirements. The horizontal hitch-mounted rack resulted in the highest total ranking.

After establishing the basic layout of the rack design, further specifics of the design had to be established. A major decision involved choosing the nature of the frame construction for the rack. Four options were taken into consideration. These included an entirely custom built aluminum frame, a custom built steel frame, and a custom built aluminum upper frame that could be attached on top of either a pre-existing steel hitch carrier or a pre-existing

aluminum hitch carrier. These four options were compared using ideal design characteristics, including that it be lightweight, strong, stable, inexpensive, useable for multiple purposes, and corrosion resistant.

A second house of quality was created to compare the alternatives based on these design characteristics. The same method was used. The custom frames were outperformed by the two alternatives using existing cargo carriers, because the latter may be used for multiple purposes and have higher rankings for strength, stability and cost. The custom aluminum frame built on top of an existing aluminum cargo carrier resulted in the highest total ranking because of the option of using an existing steel carrier that is lightweight, corrosion resistant, and compatible in terms of materials.

It was decided that the best alternative for the tricycle rack was a horizontal hitch-mounted layout that consists of a custom aluminum frame constructed on top of an existing aluminum cargo carrier. After establishing the basic design layout and frame construction of the racking system, a conceptual design, including the determination of all components of the rack, was conducted. Draw-Tite's Aluminum Cargo Carrier (Part No. 7501), with overall dimensions of 24" × 60" and a weight capacity of 600 pounds, was selected. The weight capacity was sufficient, as the trike weighs no more than 60 pounds and the weight of the upper aluminum frame would not exceed 20 pounds. This

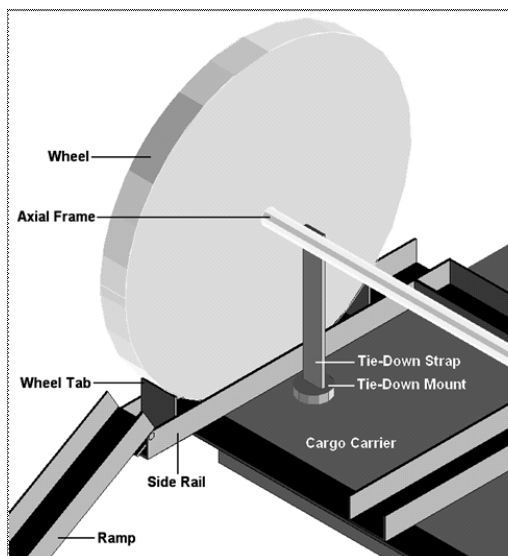


Figure 17.8. Conceptual Mounting of Rear Wheels

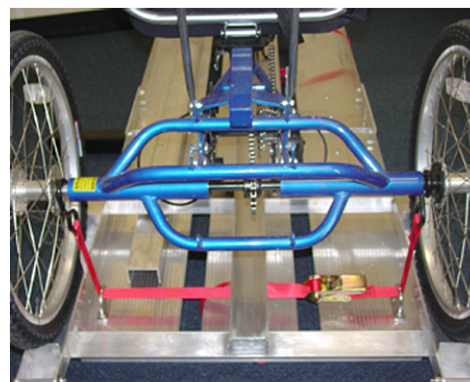


Figure 17.9. Mounting of Rear Wheels

cargo carrier, shown in Figure 17.6, was also selected because of its lower weight of 40 pounds as compared to a comparable steel carrier that would weigh roughly 60 pounds. The client's family reported that 60 pounds would be the maximum weight that they could lift.

The designers then selected the aluminum angle and channel to construct the upper frame of the racking system, shown in Figure 17.7. This would be mounted on top of the aluminum cargo carrier to allow for compatibility with the carrier material and to keep the frame as light as possible. Taking into account the size and geometry of the trike, recommendations from the supplier, and stock availability, the team chose two types of aluminum stock from Tri-State Aluminum (Toledo, Ohio): channel (2.500" × 1.500" × 0.125" (6063-T52 Aluminum)) and angle (2.000" × 2.000" × 0.188" (6061-T6 Aluminum)). Figure 17.7 shows the upper frame mounted on top of the aluminum cargo carrier. The aluminum frame is mounted using the rear and front support rails. Two commercially available zinc-coated steel clevis pins and cotter pins are used to secure each support rail to the cargo carrier.

On top of the support rails are two side rails on which the two rear wheels are mounted. A center rail supports the front wheel and allows the front wheel to ride along it as the trike is loaded. All three of these rails are welded to the support rails. Two center support rails are welded between the center rail and side rails to add rigidity to the frame. Two removable ramp rails are connected to the side rails when loading the trike. These are connected using simple hooks on the ramp rails that hook to two standard 0.313" 18/8 stainless steel bolts, which span the width of the rear side rails.

To load the trike, the ramps are attached to the side rails. Next, the front wheel of the trike is lifted into the center rail. The trike is then pushed from behind, allowing the rear wheels to ride up the ramp into the

side rails. The center rail keeps the front wheel moving in a straight path. Once the trike is in place on the upper frame, it is mounted using several pieces of hardware. Details regarding mounting the rear portion of the trike can be seen in Figure 17.8, where two wheel tabs are welded into the side rails of the upper frame. When loading the trike, the rear wheel rides up the ramp and over the rear wheel tab. The two wheel tabs then keep the wheel from rolling in either direction. To keep the wheel from rolling up over either of the tabs, a tie-down mount is mounted directly on the cargo carrier. A tie-down strap is then attached to both the axial frame of the trike and the tie-down mounts. This applies force straight down on the frame of the trike, keeping the rear wheels from traveling vertically out of the side rail and wheel tabs. This conceptual method of securing the rear of the trike can be seen in Figure 17.9.

U-bolts and a ratcheting tie-down strap are used to secure the rear wheels. Two 18/8 stainless steel u-bolts are mounted on the cargo carrier, under the axial frame of the trike, using stainless steel locknuts. A single commercially available ratcheting tie-down strap is then placed through the two u-bolts, and each end is placed on one side of the axial frame of the trike. The strap capacity of 433 pounds was assumed to far exceed any forces it will be subjected to, while holding the 60-pound trike in place. By ratcheting the strap tight, both wheels are pulled securely down into the rear side rails and between the previously described wheel tabs.

Two standard 0.313" diameter 18/8 stainless steel eye bolts and a ratcheting strap identical to the one used on the rear of the trike were used to secure the front of the trike, as shown in Figure 17.10. The eye bolts were mounted directly to the cargo carrier. The ratcheting strap was then hooked at each end to an eye bolt and tightened around the top tube of the trike. This pulled the front wheel down into the center rail such that it could not move vertically out of the channel.

The last critical component of the design involved the selection of proper hardware to secure the cargo carrier to the automobile. To attach the cargo carrier to the vehicle's hitch receiver, a 0.625" diameter stainless steel locking pin by Reese Heavy Duty was chosen. This pin is rated to withstand the load capacity of the cargo carrier. Also, the locking feature of this pin will keep the racking system and the trike from being stolen from the client's vehicle. The client's current standard bike lock will lock the trike directly to the cargo carrier. Thus, indirectly, the trike will be able to be locked to the automobile.

The rack design in combination with the trike on the back of the client's vehicle was found to result in the taillights being obstructed at certain angles. As a result, a simple turn signal kit was mounted to the cargo carrier to supplement the vehicle's taillights if they are obstructed by the trike. Figures 17.11 and 17.12 show photographs of the final racking system assembly mounted on a vehicle with a standard hitch receiver.

Because the Draw-Tite cargo carrier makes the critical connection between the automobile and the racking system, stress calculations were made to calculate the factor of safety against bending failure in the 2.00" x 2.00" square mild steel tube with 0.125" thick walls that connects the cargo carrier to the automobile. Using the maximum energy distortion theory of failure, a factor of safety of 9.14 was calculated.

The total cost of all parts used to build this unit was \$450.



Figure 17.10. Securing of the Front Wheel



Figure 17.11. Final Trike Racking System (Rear View)



Figure 17.12. Final Trike Racking System (Top View)

ALL-TERRAIN WHEELCHAIR

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INTRODUCTION

Conventional wheelchairs cannot be used to access most park facilities because it is difficult to navigate over terrains other than hard flat surfaces. An all-terrain wheelchair was designed to allow park visitors with disabilities the opportunity to explore park trails. The wheelchair was designed to allow the user to maneuver the chair on his or her own, as well as to allow for assistance if needed. The chair was adjustable to allow for the majority of park visitors with disabilities to explore the park regardless of body size. The design accounted also for the various terrains that would be encountered on the trails, including pavement, stones, sand, snow, hills and tree roots. The all-terrain wheelchair is shown in Figures 17.13 and 17.14.

SUMMARY OF IMPACT

The metropolitan park system operates 11 scenic parks and two recreational trails. The largest attractions are the various trails maintained in each park. The all-terrain wheelchair allows individuals with disabilities independently to access to the trails.

TECHNICAL DESCRIPTION

Design specifications were:

1. The drive tires must have a large width, large diameter, and contain deep tread,

2. The non-drive tires should be larger than normal to allow the chair to climb over obstacles,
3. The chair should be wider and longer than a standard wheelchair to add stability,
4. The chair should be lightweight to allow ease of use and maneuverability in rough terrain,
5. The chair should have the ability to be operated independently or with assistance,
6. The chair should be adjustable to fit the 5th to 95th percentile of users, and
7. The chair should be safe for all users to operate.

Four design concepts were evaluated: a four-wheel rear-wheel-drive chair, a four-wheel front-wheel-drive chair, a three-wheel front-wheel-drive chair, and a three-wheel rear-wheel-drive chair. The four-wheel option was not selected because a fourth wheel represents an additional wheel to get caught on obstacles and would cause added weight to the chair, which would reduce its maneuverability. A front-wheel drive chair was not selected because if the steering wheel were in the rear, it would be awkward for the user to operate, especially if caught on a hidden obstacle. Also, it is easier for a user to sit above the wheels and use his or her weight to drive the chair. A three-wheel rear-wheel-drive design was chosen.

A longer frame and wider base was used in the design to give the chair greater stability, as shown in Figures 17.13 and 17.14. A standard upright wheelchair design would result in a high risk of tipping the chair while out on a park trail. Since the wheelchair of this design has a wider base and longer frame, it is more difficult to tip the wheelchair while operating it on the trails. Even though the wheelchair's frame is larger, the overall weight of the chair was not compromised. The wheelchair's frame was built out of high strength, corrosive-resistant 6061 aluminum. The aluminum stock is 2" x 2" and has a 1/4" wall thickness. This grade of aluminum gives the chair a strong frame,

while also being lightweight. Two 26" x 2.1" mountain bike style tires with a deep tread pattern were used as the rear tires. Each of these two main drive tires is equipped with an inner push rim for independent operation. These tires will supply traction in sand, snow, gravel, and mud. A Roleez balloon style tire with casters was used as the third front tire and was mounted using a yoke, so that it is able to spin independently 360 degrees. The front tire is 7.5" wide and 12.5" in diameter, so it is easy to navigate through dense terrain.

Inner push rims on the rear tires give the user the ability to navigate independently. Push-rods made



Figure 17.13. All-Terrain Wheelchair Frame

from 1" diameter aluminum tubing with a wall thickness of 1/8" were added to the back of the chair to allow an assistant to push the rider and chair through the trails.

Given that a wide range of people will be utilizing the wheelchair, it has the ability to accommodate varying sizes. As shown in Figures 17.13 and 17.14, the front tire of the wheelchair is held on by a single aluminum arm. This was designed so the rider can easily enter and exit the wheelchair from the left side. Also, the seat is mounted on a set of tracks in order to slide forward or backward. It can be positioned where the riders feel most comfortable reaching for the rear tires to push themselves along.

Additional safety components protect the riders from injury. One feature added to the wheelchair was a safety harness for the rider. This personal constraint will prevent the rider from falling out of the wheelchair if the user encounters rough or sloped terrain. Another added component was a braking system similar to that found on a standard wheelchair. By flipping the brake lever, a braking

block is locked against the rear tire to prevent the chair from rolling. The final safety feature added was a wheelie-bar in the back. This bar allows the chair to tip back slightly, but will stop the chair from completely flipping over.

I-DEASTM (Integrated Design Engineering Analysis Software) 10, a finite element analysis (FEA) software package, was used to perform the structural analysis. A three-dimensional model was constructed and used to verify that the chair would withstand impact and wear. It was determined that the maximum stress from impact is 90.8 MPa and the maximum deflection is 13 mm. Both of these were results of a frontal impact load resulting from striking a rigid wall at 15 mph. From all the calculations, the chair has a factor of safety of 3.

The total cost of all parts was \$800.



Figure 17.14. All-Terrain Wheelchair

WALKER WITH REMOVABLE TRAY

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INTRODUCTION

A college student with cerebral palsy uses a Reverse K walker for mobility, as depicted in Figure 17.15. This walker is placed behind the user and is pulled rather than pushed. It also has a fold-down seat so that the user can rest, as seen in Figure 17.16. However, it is difficult to carry items around, such as a book bag or a laptop computer, without assistance. The purpose of this project was to develop a removable tray to be attached to the walker to allow the client to carry his belongings with him. The carrier was designed to keep the walker balanced, to maneuver easily through narrow doorways and hallways, and to carry several everyday items. Aluminum tubing was used to create the frame of the carrier. A pair of casters was mounted to the bottom of the carrier, as shown in Figure 17.17, to enhance mobility. The device is

easily attached and detached from the walker and can be easily folded up for storage or travel, as shown in Figure 17.18. The finished product was tested to ensure it would hold up to 50 pounds.

SUMMARY OF IMPACT

This removable and collapsible tray can be used when needed to carry items, thus enhancing the client's mobility and independence.

TECHNICAL DESCRIPTION

Design criteria include developing a removable tray that is safe, durable, collapsible, detachable, lightweight, and easy for the client to use. To make the tray detachable, it was designed using clamps that attach to the middle and top bars on the back of the walker. Attaching the tray at two different locations ensures that the unit is sturdy. Wheels



Figure 17.15. Client Using Unadapted Walker



Figure 17.16. Unadapted Walker

were mounted on metal poles extending from the bottom of the carrier's tray to the ground, providing stability and mobility.

The device is made collapsible by hinges attached to the tray that allow the tray to fold up and hinges added at the top of the metal poles to allow the poles to fold down. Two additional hinges mounted to the bars that attach to the top bar of the walker make the device completely collapsible, as shown in Figure 17.18.

Aluminum T4 6061 was the material of choice because it is lighter than stainless steel. Locking

devices were added to the construct, as shown in Figure 17.17, to provide additional safety and stability.

DEASTM (Integrated Design Engineering Analysis Software) 10, a finite element analysis software package, was used to perform the structural analysis. A three-dimensional model was constructed and used to calculate the stresses throughout the walker and removable tray. Using a factor of safety of 2, pipes having 1" diameter and 1/4" thickness were used.

The total cost of parts was \$250.



Figure 17.17. Tray Attached to Walker



Figure 17.18. Removable Tray Collapsed

TANDEM ICE HOCKEY SLED

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INTRODUCTION

Sledge or sled hockey is an adapted ice hockey sport that allows a person with limited mobility from the waist down to participate. Players use two-blade sledges that allow the puck to pass underneath them. They control the sled with two sticks approximately one meter long. On one end of the stick is a blade used to maneuver the puck; on the heel of the stick, sharp teeth are used to propel the sled forward. Some individuals with limited arm strength, such as young children or people with quadriplegia, are unable to use the standard skate sled. The purpose of this project was to design and construct an adult tandem hockey sled for two individuals, a driver and a passenger, to participate in ice skating together. No tandem hockey sled is currently available on the market. A computer model of the unit that was developed is shown in Figure 17.19 and the unit itself is shown in Figure 17.20.

SUMMARY OF IMPACT

The unit will allow a seated passenger with limited arm strength (preventing him or her from moving the sled on his or her own) to participate in sled hockey while seated on the same sled with an individual capable of propelling the sled. This is a new design concept because no tandem hockey sled is currently available on the market.

TECHNICAL DESCRIPTION

Design requirements were to develop a sled that is compact, lightweight, easy to maneuver, and has adjustable seats. The sled had also to meet the U.S. Sled Hockey Association (USSHA) standards. Two design concepts were evaluated. The first concept featured two individual sleds that could be combined to form a single tandem sled. This option was cost prohibitive. The second concept was a sled

that would allow a driver and a passenger to ride in close proximity to each other, with the driver's legs resting under and to the sides of the passenger's seat, as shown in Figure 17.20. This sled is wider than a single sled, so that the driver's legs do not cross the boundary of the sled's frame, to minimize the chance of injury.

After consulting with Unique Inventions, Inc., one of the largest manufacturers of hockey sleds in North America, the following overall dimensions were determined: length of frame = 64"; width of frame = 18"; height from bottom of frame to ice = 3.5"; and the weight of the frame should not exceed 45 pounds. The frame and cross members to hold the seats and skate holders were made of tubular 6061 T6 aluminum. The seats, safety restraints, skate holders and skates were purchased from Unique Inventions, Inc.

The team used I-DEASTM (Integrated Design Engineering Analysis Software) 10, a finite element analysis software package, to perform the structural analysis. The stresses and maximum deflections were determined in the seat bracket, skate bracket and sled frame. Maximum stresses of 7980 psi, corresponding to a factor of safety of 4.4, were found to occur in the seat bracket with a concentrated load of 400 pounds in its middle.

After the frame components were fabricated, they were welded together. The seats were then fitted to the seat brackets. Seat restraints were attached to the seats. The seat brackets, skate brackets and frame were primed and painted to make the sled more aesthetically pleasing, and the seat and skate brackets were then bolted to the frame of the sled. The finished unit is shown in Figure 17.20.

The total cost of all parts was \$720.

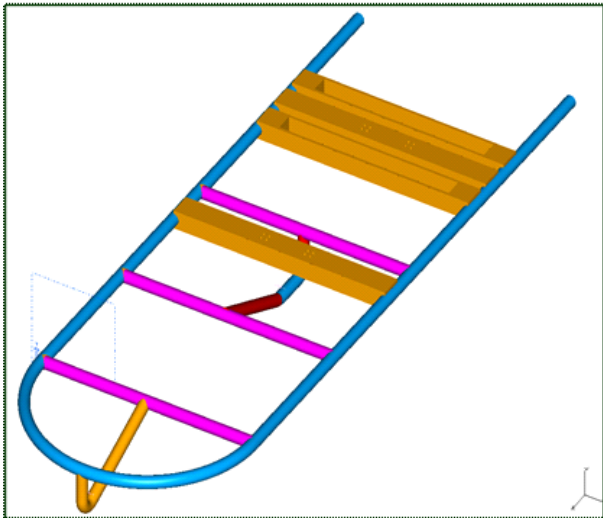


Figure 17.19. Computer model of the unit



Figure 17.20. Finished unit

AIMING DEVICE AND STAND

Designers: Tony Mitchell, Nathan Burns, Thomas Spry, and Aaron Deloenthal

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INTRODUCTION

A previous senior design group designed and constructed a “bite-trigger” mechanism that allows a client with mobility impairments to shoot a rifle with help from an assistant. The client uses a wheelchair. He has the ability to move his head and shoulders, has limited movement in his right arm, and has no fine motor control of his right hand. Requiring the assistant to aim and move the rifle is cumbersome. The client desires to control the movement of the gun, aim, and fire with the least amount of help from an assistant. The purpose of this project was to develop an aiming system that allows the client to accomplish this goal. The existing “bite-trigger” mechanism was incorporated into the design. The system includes three main components: a gun holding mechanism to secure the gun in place, an aiming mechanism to move the gun, and a wheelchair mount to attach the gun holding and aiming mechanisms. A 12V motor was used to power a wheel that allows horizontal motions of the aiming mechanism. A custom-built screw drive linear actuator was used to provide the vertical motions. The aiming mechanism was controlled using a headrest interface to allow movement of the rifle using inputs from the client’s head movements. Figures 17.21 and 17.22 show a computer model and a picture of the entire assembly.

SUMMARY OF IMPACT

The system moves the rifle using inputs from the client’s head movements. The successful completion of this project has enabled this individual to aim and shoot his rifle without assistance from others.

TECHNICAL DESCRIPTION

The design was required to incorporate the following features:

- 1) The rifle must be securely attached to the client’s wheelchair,
- 2) The device must allow the client to control the movement of the rifle, aim, and fire the rifle as independently as possible,
- 3) It must be able to safely withstand the recoil of the rifle and prevent the rifle from moving relative to the device,
- 4) It must allow for an assistant to reload the rifle without removal from the device, and
- 5) The device must allow for the use of the existing “bite trigger” mechanism.

The design team decided that the most effective and efficient way for the client to control the movements of his rifle is to use control inputs from his head motions. The design of the system was broken into four areas: the gun holder, the aiming system, the mounting system, and the user interface.

In the design of the gun holding system, the primary focus was safety. The gun holder consists of a metal arm made of 1” aluminum channel and rubber posts that are attached to the arm. A strap is placed over the rifle between these two posts to secure the rifle to the holder arm. Also, a strap goes around the back of the rifle to prevent the recoil from causing it to fly backwards. At the back of the holder are two triangular plates, made of 0.25” thick aluminum 6061 alloy, to which the strap is attached. These plates also have a pin attachment to the aiming system.

The aiming system consists of two parts: a swing arm and a horizontal aiming frame. The swing arm is made of 1” aluminum channeling and has a pivot connection on two vertical plates (0.25” thick aluminum) that connect to the gun holder pivot point, allowing vertical aiming. A horizontal pivot

at the back of the arm connects to the horizontal aiming frame, allowing horizontal aiming. A three-wheel system at the end of the swing arm holds it firmly to the front of the horizontal frame. Two wheels are mounted under the frame, and a powered wheel is mounted above the frame. All wheels are 1 5/8" in diameter. The horizontal frame is made of 1 1/4" aluminum rods; the front end is bent into an arc, as shown in Figure 17.22, to allow the wheels to travel over it. The arc at the end was made by machining a 1 1/4" thick piece of aluminum. A 12 V motor rated at 50 in-lb of torque with a speed of 1.3 rpm was selected to allow the full range of horizontal motion to be accomplished in roughly 40 seconds. For vertical motion, a custom-built screw drive linear actuator with a pitch of 10 threads per inch was used. The motor is rated at 240 in-lb at 6 rpm, which provides 6 inches of linear travel per minute. The motion from the actuator is transmitted to the gun holder arm via a mechanical linkage.

The mounting system, depicted in Figure 17.21, consists of three parts made of steel tubing: the wheel chair arm mounts, a cross tube, and a vertical mounting post. The arm mounts connect the system to the wheelchair. The armrests on the client's wheelchair have a vertical post and a horizontal post that are used to connect arm mounts. A half tube is placed around these posts, and they are pressed up against the wheelchair arms using the cross tube. A tubular steel frame connects the attachment points to the cross tubes that go over the client's legs.

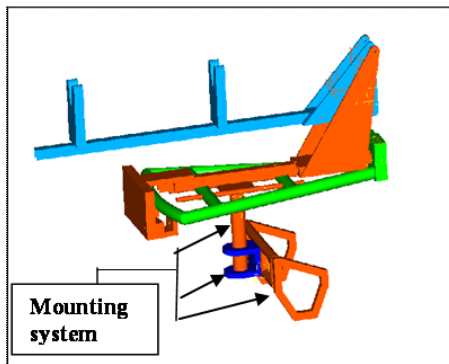


Figure 17.21. Computer Model

Mounting blocks are used to allow the system to be adjustable. Horizontal adjustments of the mounting system take place by pushing the arm posts in and out of the ends of the cross tube. The vertical post is able to slide up and down in the mounting blocks of the cross tube to provide vertical adjustment. Attached at the top of the mounting post are 1/2" steel rods that go through holes in the horizontal aiming frame. They are secured in place by clamping shaft collars rated at 600 lbs.

A wheelchair headrest that had been used to control a wheelchair is the user interface. It will not interfere with the bite trigger, but allows controlling of vertical and horizontal motions independently. The left and right buttons of the headrest aim the gun horizontally. When a switch in the back of the headrest is depressed, the sides of the headrest may be used to aim the gun vertically.

A circuit was developed to allow the signals from the activation of the switches to control the motors. A housing attached to the gun holder contains all of the electronic components. The headrest switches can be plugged into and unplugged from the housing, as can the 12 V battery connectors that power the electronics and motors.

The cost of material and most of the components was \$600. Some components were donated.

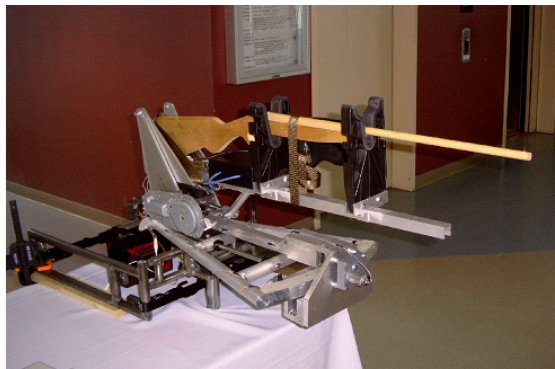


Figure 17.22. Aiming Device and Stand

WHEELCHAIR CAMERA STAND

Designers: Nicholas Bender, Kristin Klosowski, and Khamis Almerii
Client Coordinators: Dr. Gregory Nemunaitis,
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Kim Dittman, High School High Tech Coordinator, Ability Center of Greater Toledo
Calvin Smith, Recreation Inclusion Specialist, Ability Center of Greater Toledo
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INTRODUCTION

The client, who has no use of his legs or left arm and only limited use of his right arm and hand due to cerebral palsy, requested a camera mount that is easy to adjust and align and able to secure either a digital camera or camcorder. Figure 17.23 shows the camera stand, and Figure 17.24 shows the client demonstrating how the unit is used with a digital camera.

SUMMARY OF IMPACT

The client has a passion for photography and is hoping to start his own digital imaging business. The camera stand enables him to take still or video digital images with ease and comfort. The client tested the unit and found it efficient and convenient to use.

TECHNICAL DESCRIPTION

Design requirements included developing a camera stand that is easy to use, and easy to adjust both horizontally and vertically in order to align the pictures. The system must be easily put on and taken off of the wheelchair and should not interfere with the client's movement. The camera stand was also required to hold either a digital camera or camcorder and rest at the client's eye level. To make this system easy to adjust a flexible shaft design was selected. A system was developed that includes a universal camera mount, flexible heavy duty flexible tubing, and a wheelchair mounting bracket.



Figure 17.23. Camera Stand Assembly

A tripod head from a Sony Remote Controlled Tripod (Model # VCT-D68RM) was used. This head, shown in Figure 17.25, was used because it is a standard universal camera mount and it utilizes a remote control. The universal camera mount is an industry standard and can be used with virtually any camera or camcorder. This camera mount also had a quick release function, a feature in which the client had expressed interest. The tripod head also came with a remote controlled handle that could control some of the basic camera functions. Using this handle the client can turn the camera on and off, zoom in and out and start and stop recording. This is ideal because it enables him to use the handle to align the shot, as well as to take the picture or video.



Figure 17.24. Client Using Camera Stand with a Digital Camcorder

A flexible shaft can be bent, twisted and positioned in almost any orientation without requiring the client to adjust any screws or fastening mechanisms. It was thus used to hold the camera on the camera mount and tested to ensure that it was flexible enough for the client to move easily and robust enough to hold the camera in place. The client found that he was able to move it around easily. It was also found that the shaft held rigid with a one pound load but began moving slightly after the load was

increased to one and a half pounds when tested at the weakest position. It was thus decided to use two of these shafts to hold the camera. The system is able to support approximately three pounds, almost twice the average load for both digital cameras and camcorders (which weigh approximately 0.8 lbs and 1.2 lbs, respectively).

The final feature of the camera stand was the wheelchair mount, which attaches the camera stand unit to the wheelchair. A lockable mounting bracket, shown in Figure 17.26, was used to allow the unit to be taken on and off easily. The mount remains fixed on the client's wheelchair, and the camera stand can be taken on and off from the fixed wheelchair mount with a simple turn of a handle. The system will not interfere with the chair.

The system was put together by connecting the two flexible shafts to the camera mount. Each flexible shaft was then connected to a brass pipe. These two pipes were bolted to the opposite sides of an aluminum snap lock adjustable pipe. These pipes run down along the left side of the wheelchair, and the central pipe locks into the wheelchair mount, as shown in Figures 17.23 and 17.24.

The cost of all parts was \$200.

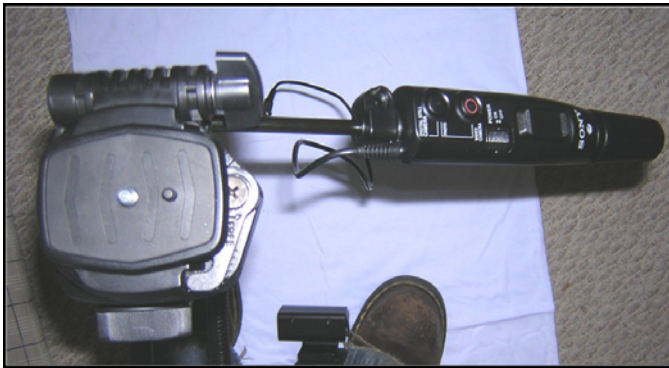


Figure 17.25. Camera Mount with Handle



Figure 17.26. Wheelchair Mounting Bracket

EXTENSION PUSH HANDLES FOR A MANUAL WHEELCHAIR

Designers: Doug Stricker, David Karl, Chad Guthrie, and Douglas Martz
Client Coordinator: Kim Dittman, High School High Tech Coordinator
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INTRODUCTION

The purpose of this project was to design and fabricate adjustable push handles to attach to a manual wheelchair. A person of any height can become fatigued when bending over and pushing a wheelchair for an extended period of time. The final design will be used by a woman with cerebral palsy and her attendant. An attachment, including two adjustable push handles as shown in Figure 17.27, was designed to be used with the client's current wheelchair. Figure 17.28 shows a picture of the push handle system attached to the wheelchair. This attachment can easily adjust to any height and disconnects to ensure that the chair will still collapse for transport. A cup holder is attached to the side of the right adjustable wheelchair handle to allow for easy carrying of a beverage if desired.

SUMMARY OF IMPACT

The client owns an Invacare 9000 XT manual wheelchair, shown in Figure 17.28, that is not ergonomically-friendly to various heights of attendants. Significant effort is required to push the wheelchair. Her attendants occasionally become fatigued when bending over and pushing for an extended period of time. The chair was adapted with a set of adjustable push handles to make it easier for the attendants.

TECHNICAL DESCRIPTION

The height of the handles on the Invacare 9000 XT manual wheelchair is 38 inches from the ground. To ensure that the existing wheelchair remains unchanged, it was decided to keep its existing handles and add adjustable extension push handles. These extension handles can be removed when desired to allow the wheelchair to be folded up and stored in the trunk of a car or in other storage areas.

The push handles were attached to the wheelchair at two locations, the wheelie bar points and the existing handles, as shown in Figures 17.27 and 17.28. The wheelie bar points were identified as support points because the client does not use wheelie bars.

The height of the two extension handles was the most important factor. The handles were made adjustable to accommodate varying heights of attendants. Each extension handle has two parts: the upper part is the extension handle tube, and the lower part is the support tube. Holes were drilled in the support tubes at one-inch increments to create a total of eight holes. They were drilled on the back and on the side of the support tubes so that the handlebars of the extension handle tubes can be positioned straight back or to the side. Titanium tubes were used for the upper parts of the extension handles. Aluminum was used for the lower parts of the extension handles (the support tubes). Aluminum and titanium were used since they are strong, lightweight materials that are aesthetically pleasing. The upper and lower parts of each of the extension handles were attached together using 5/16" aluminum retaining pins with steel springs that allow for quick and easy adjustment.

Holes were drilled on the underside of the existing handles of the wheelchair and also on the underside of the wheelie bar points to attach the extension handles to the wheelchair. The support tubes were attached to the wheelie bars using 5/16" aluminum retaining pins with steel springs. Two spring clamp assemblies were fabricated to attach the support tubes to the handles of the wheelchair, as shown in Figure 17.27.

Each spring clamp assembly includes a small tube and a spring clamp. A retaining pin is inserted into the clamp assembly's small cylindrical tube, which is inserted into one of the wheelchair handles. The spring clamp allows the support tubes of the extension handles to be clamped to the spring clamp assemblies, which are inserted into the wheelchair

handles. The retaining pins are easily compressed during installation and removal of the extension handles.

A removable cup holder is attached to the left support tube.

The cost of all parts was \$300.

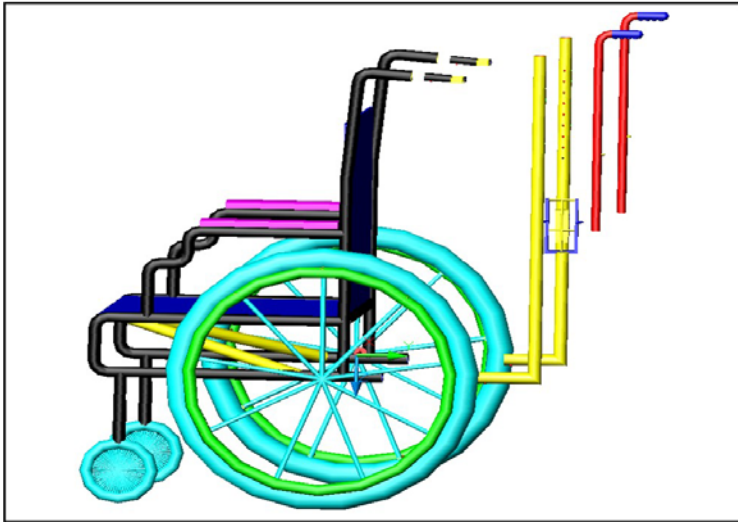


Figure 17.27. Computer 3D Model of Components



Figure 17.28. Extension Handles Mounted on Chair

POOL WHEELCHAIR

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INTRODUCTION

Staff members of a recreation center requested a chair with adjustability to aid in wheelchair transfer and safe operation in a swimming pool. Many of the individuals who will use the chair have limited dexterity and require simple operation so they can use the chair independently. The wheelchair will transport the user independently into the pool using an access ramp. The chair is constructed of furniture-grade 1.25-inch Polyvinyl Chloride (PVC) pipe and fittings to resist corrosion caused by water and chemicals in the pool environment. The seat is adjustable in the horizontal direction, allowing each user the ability to select the ideal distance from the rear wheels. The armrests are adjustable in the vertical direction and drop low enough to be flush with the seat. Two footrests are placed at two different heights from the floor, allowing the user to choose which one is more comfortable. Each footrest is adjustable in the horizontal direction and is fully retractable. Buoyancy problems were alleviated by replacing the standard air inner tubes of the rear wheels with solid rubber inserts. The completed chair is shown in Figures 17.29 and 17.30.

SUMMARY OF IMPACT

The pool wheelchair previously used at the recreation center lacked adjustability, which is a major problem that limits its use by diverse individuals. The newly-constructed wheelchair's adjustability allows for safer wheelchair-to-wheelchair transfer, safer operation, and increased ergonomic comfort for all users.



Figure 17.29 Completed Chair in Use

TECHNICAL DESCRIPTION

The final design has a PVC pipe frame, adjustable armrests, an adjustable footrest, an adjustable seat, low buoyancy tires, and stainless steel hardware.

Furniture-grade PVC was chosen due to its high resistance to decomposition instigated by exposure to UV light. Also, PVC can be bonded together using adhesive and is lightweight while maintaining strength. The pipe measures 1.25" in diameter and has a schedule 40 wall thickness. The frame is a boxed design, with the user sitting on the top of the box. Rear wheels are attached to the bottom rear of the box, and front casters to the bottom front of the box.

Quarter-inch holes were strategically placed in the frame to allow it to quickly fill with water and reduce buoyancy in the pool. The holes and slots also allow for easy drainage to prevent mold

buildup in the frame. Wheelie bars were added to the bottom rear of the frame to provide safety when using the ramp to get in and out of the pool.

Armrests are supported with posts that are dropped into a slide collar mechanism located on the seat platform. Holes were drilled into the slide collar on the seat platform as well as in the posts. A stainless steel pin was inserted into both sets of holes simultaneously to fix the armrest at the desired height. The other end of each armrest is attached to the post behind the seatback with a slide collar, allowing for movement. The armrests can also adjust to a level just above the seat, allowing an individual to transfer independently from a standard wheelchair to the pool wheelchair.

Two footrests were installed. Each is composed of two 90-degree elbows and three sections of pipe. The assembled design is U-shaped. The footrest was placed on the bottom of the box frame. Four slide collars were placed on the vertical members of the box frame. The sides of the U shape have two slide collars per side. These collars are bonded together, allowing for vertical adjustability and translation in and out of the chair.

The seat is a molded seat, the same in construction and appearance as the original chair. Although the seat was the same, the newly designed frame allows for adjustment. The seat was supported by two members running front to back within the box frame. The seat is attached to four slide collars that run along these members using stainless steel hardware. One of the four slide collars has a $3/8$ " hole drilled through it. The member this collar slides along has holes drilled every 2" along it. A stainless steel pin is driven through both sets of holes simultaneously to fix the position of the seat at



Figure 17.30 Completed Chair

a location comfortable to the user. Velcro chest straps and lap belts are integrated into the seat to aid individuals with low abdominal and upper body strength.

The 24" rear wheels are fitted with solid tires. These reduce buoyancy and thus increase safety over the previous design. Stainless steel shafts and hardware were used to attach the wheels into the shaft inserts located at the lower rear corners of the box frame. These $7/16$ " stainless steel shafts are of considerable strength.

The front wheels are stemmed casters. Stem inserts were placed in the bottom of the pipes that composed the front section of the box frame. The $7/16$ " stems from the casters were press fitted into the inserts.

The total cost of the parts used to construct the chair was about \$700.



CHAPTER 18
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ACCESSIBLE WEIGHT SCALE

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INTRODUCTION

A platform weight scale was designed and developed to be universally accessible to people with various types of disabilities. A county department serving elderly people has several health care facilities and a fitness center. Representatives requested a scale to accommodate all of their clients. A picture of the prototype is shown in Figure 18.1.

SUMMARY OF IMPACT

The design criteria were that the weight scale be: convenient in home, long-term care and hospital settings; cost effective; safe; quiet; portable; low maintenance; able to measure weight accurately and reliably to the nearest ½ lb; able to determine weight within 30 seconds; able to provide output in alternative formats; and easy to use with individuals who have varying disabilities. It will be appropriate for users who are sensitive to having others know how much they weigh.

TECHNICAL DESCRIPTION

The scale was designed with a 32" by 32" weighing platform. Universal design features for the ramp and platform include: a high contrast between the ramp and platform so that both can be easily seen; less than a 2" slope on the ramp for ease of maneuverability; tactile grooves to prevent slipping and to alert a person to a change in surface; a platform surface area large enough to hold most standard sized wheelchairs; a platform that raises and lowers through the use of a toggle switch; and automatic shutoff once the platform is raised. To address portability criteria, the device is made of lightweight material, and is set on wheels, and the ramp folds up for easy moving and storage. Audio output and digital display of weight are available, and an adjustable visual display screen is adaptable to persons of varying heights. Controls are

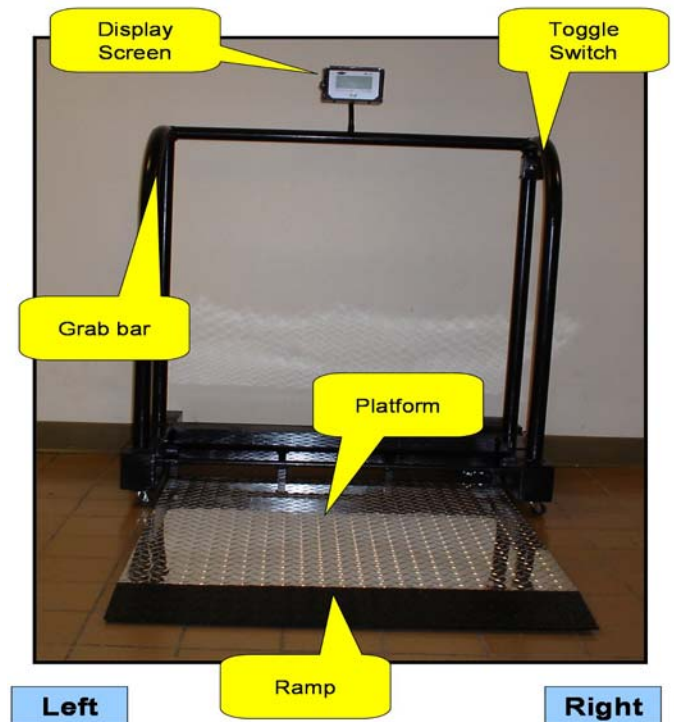


Figure 18.1. Universally-Accessible Weight Scale

accessible to the user. The device runs on DC power. Figure 18.2 shows how to use the weight scale.



A. Approach the scale from the right.



B. Press the button to lower platform.



C. When invited use the ramp in the front.



D. Adjust visual and voice feedback.



E. Back out after at goodbye.



F. Press the button to raise the platform.

Figure 18.2. Steps to use the weight scale A-F.

ACCESSIBLE EXERCISER: HANDGRIP ASSIST

Designers: Daniel McGowan*, Kim JyHun**, Ali Ahmad**, Rochelle Mendonca**, and Amit Sethi**

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INTRODUCTION

The purpose of this project is the design and development of an adaptation to the NUSTEP exerciser, (Figure 18.3) to assist with handgrip during exercise. In some cases, people who have experienced a stroke have limited use of the left or right side of their body. Although the extent of the disabilities caused by stroke varies, the affected side experiences diminished muscular strength. Combined arm and leg cycle exercises using the NUSTEP can help maintain and improve their cardiovascular and muscular systems. Due to diminished muscular capability on the affected side, an individual who has had a stroke may have reduced handgrip on the affected side. This could result in accidental collision of the head with the



Figure 18.3. NUSTEP Exerciser [Adapted from the Manufacturer]

exercise system.

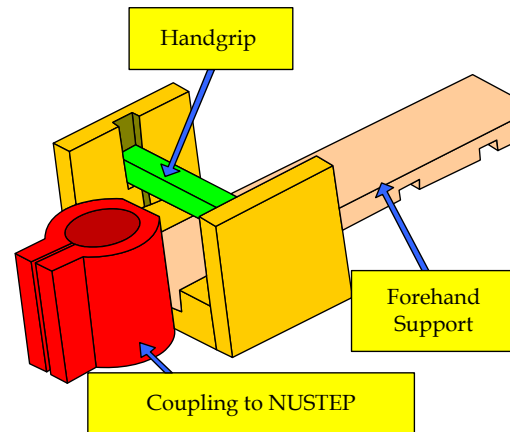


Figure 18.4. Initial Design of Handgrip Assist

SUMMARY OF IMPACT

The new design addresses the potential loss of handgrip and associated safety concerns for NUSTEP users. It also prevents excessive leg adduction so that clients can engage in appropriate and safe exercise.

TECHNICAL DESCRIPTION

Figure 18.4 shows an initial design of the Handgrip Assist.

The device is attached to the NUSTEP handle by means of a tightened screw. The user's grip rotates 90 degrees on the adjustable handle. The user's forearm can rest on the support platform, which is attached by means of straps to minimize slippage and provide force transfer through the forearm. The rotated handle grip is a promising design feature, although only for users with complete inability to maintain grip because of exercise symmetry disruption. Lack of adjustment of the angle of the device relative to the handle could result in injury and discomfort to the user.

Although the device is structurally sound, there were problems with actual use of the assist. The bar for the handgrip turned the grip 90 degrees away and did not adequately support combined arm and leg exercise. As a result, an alternative design was developed, and is shown in Figure 18.5. It was developed to conform to the NUSTEP device handgrip shown in Figure 18.3, and to maintain forearm support. This allows for body symmetry and provides more support for users with physical abilities. This concept features three adjustable rotations between the handle and wrist attachment, which allows the device to adjust to the natural forearm angle of different users. Due to machine shop limitations, the handle connection was modified. As illustrated in Figure 18.6, it consists of an off-center hole that is bored from a short cylinder. A slice is removed to allow for tightening it onto the NUSTEP handle.

To test the new grip connection, design analysis of a finite element model, illustrated in Figure 18.7, was completed in ANSYS.

After establishing functionality and structural integrity, the prototype was developed. To maintain the forearm on the Handgrip Assist device, the forearm was secured with loose Velcro. This allows the forearm to coast if forearm strength is lost. Maintaining the forearm with and without muscle strength is illustrated in Figure 18.9.

The total materials and labor cost of the Handgrip Assist was \$230.

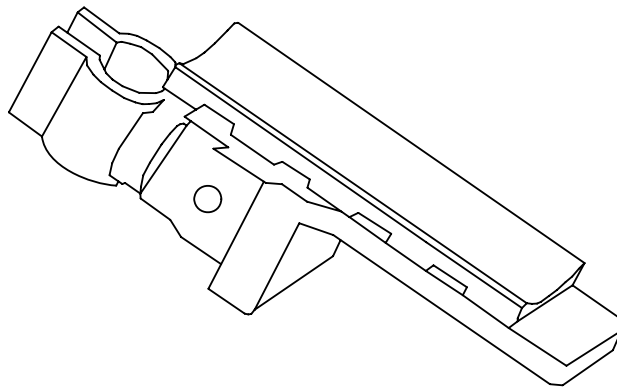


Figure 18.5. Illustration of Alternative Design

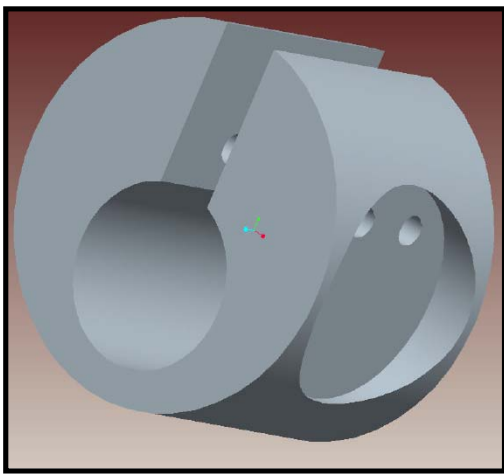


Figure 18.6. Off-Center coupling design

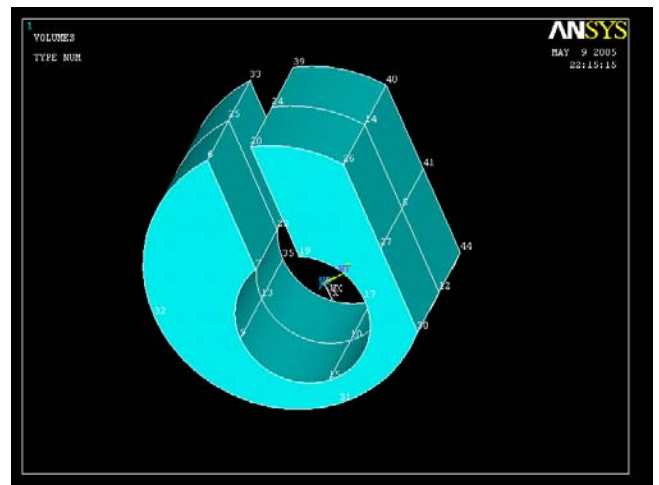


Figure 18.7. Finite Element Model

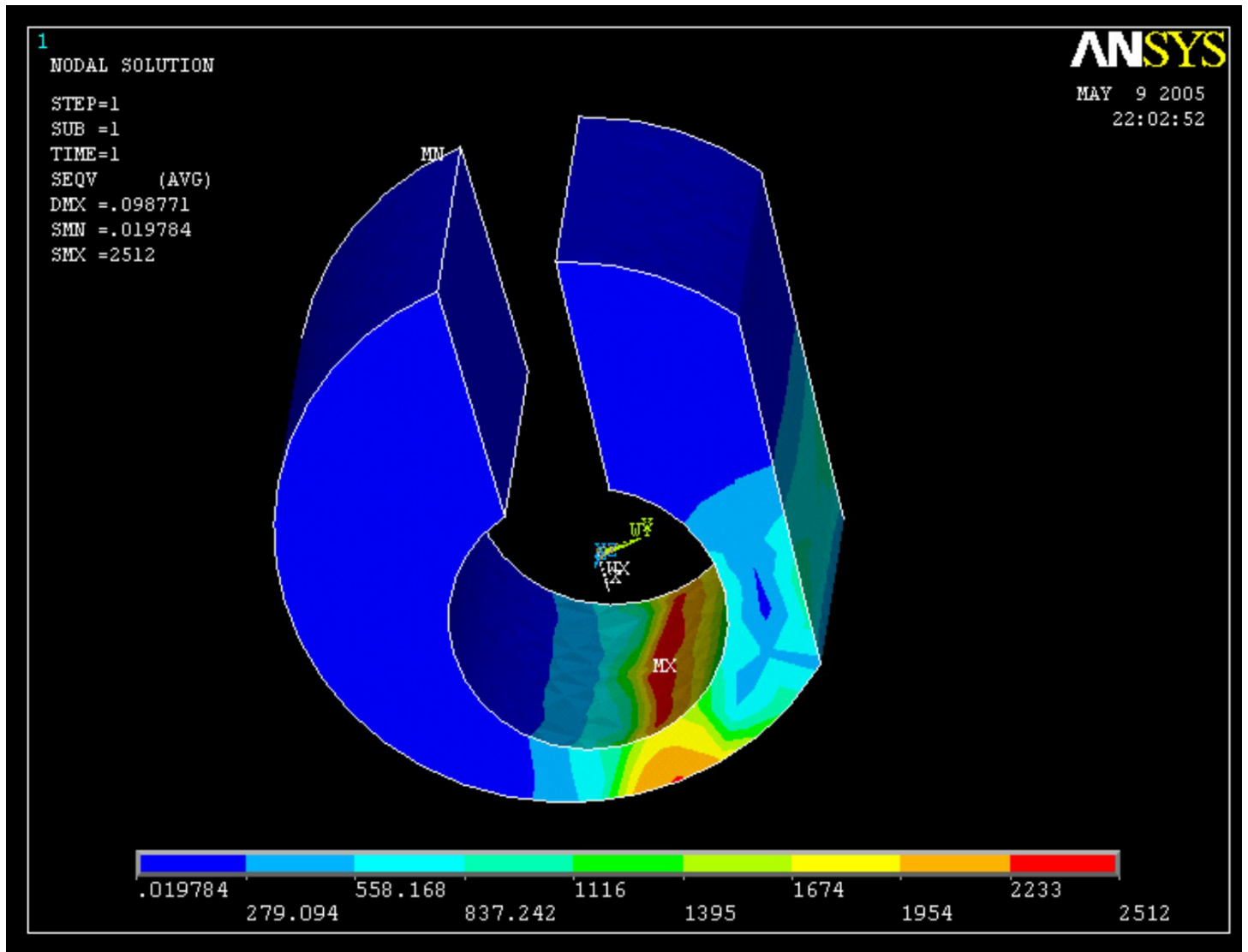


Figure 18.8. Finite Element Results



Figure 18.9. Top: Photo of Handgrip Assist with Hand Engaged; Bottom: Hand Support without Handgrip

ACCESSIBLE EXERCISER: LEG SUPPORT

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INTRODUCTION

Many people who have a stroke experience limited use of the left or right side of their body. Combined arm and leg exercise can help maintain and improve their cardiovascular and muscular systems. The NUSTEP, illustrated in Figure 18.10, is a common exercise system. However, due to diminished muscular capability along the affected side, people who have had a stroke may execute excessive abduction of the affected leg, which may cause dislocation at the hip. The purpose of this project was to design and develop an adaptation to the NUSTEP to support the affected leg so that people who have had a stroke can engage in exercise without causing further injury.

SUMMARY OF IMPACT

Preventing excessive adduction during use of the NUSTEP exerciser will prevent injury to the hip or knee.

TECHNICAL DESCRIPTION

The NUSTEP device as sold on the market has no leg support. The mechanism for the added leg support consists of a slide bearing attached to a swivel, as illustrated in Figure 18.11. This allows the device to adjust through the motion of the user, while providing support against excessive abduction. For the initial mock-up, a linear ball bearing for a drawer was used. Data regarding the life of the bearing suggested 50,000-70,000 cycles and weight capacities in excess of 150 pounds. The expected force on the mechanism based on observation is not expected to exceed 40 pounds. The remainder of the design focused around incorporation of the drawer bearing.

Attachment to the NUSTEP was achieved through two holes on each side of the device matched with two holes under the seat of the NUSTEP. Initial



Figure 18.10. NUSTEP Exercise Machine

calculations regarding the stress of the material suggested that the device should be made from steel. To match the swivel motion of the user's leg, a rotational bearing was selected. The bearing was able to handle forces in excess of 1,100 pounds, which is far beyond the maximum forces expected. The abduction limitation was made by means of a stop-plate, limiting the maximum swivel motion of the device. The maximum abduction for this type of exercise motion is 0° relative to the side of the body. In order to adapt to people of differing hip widths, a series of holes with a removable adjustable pin was added. The prototype of the leg abductor, shown in Figure 18.12, allows for complete uninhibited motion of the leg in every direction while providing restriction on the adduction motion. The weight of the device is supported primarily by the attachment to the machine, and the device is hardly noticeable to users. The linear ball bearing slide allows for people of varying heights to use the device. Although the natural motion of the leg in the

machine requires little need for the extension of the device, active extension is made possible by the bearing.

The material and labor cost was \$200.

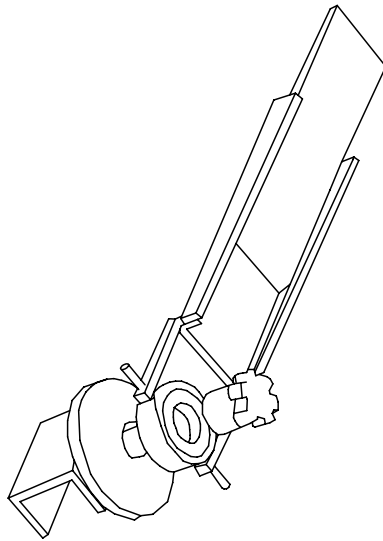


Figure 18.11. Initial Abduction Limiter Leg Support



Figure 18.12. Picture of Leg Support System in Use

TRANSFER LIFT ASSIST FOR PEOPLE WHO USE WHEELCHAIRS

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INTRODUCTION

The Transfer Lift Assist was designed for independent use by people who use wheelchairs. It is light enough to be taken from place to place.

SUMMARY OF IMPACT

The lift transfer assist device is safe, sturdy and portable.

TECHNICAL DESCRIPTION

The platform is capable of continuous height adjustment, uses a quiet DC-driven actuator and has a scissors structural arrangement. Pro/Engineering Wildfire was used to model all the components and assembly of the design concept, illustrated in Figure 18.13. The base and top of the device are rectangular shapes. L-shaped and U-shaped extrusions were used for both the base and top frames. The scissors links are made of U-shaped extrusions because this shape is able to withstand heavier loads compared to a flat piece of aluminum stalk. Aluminum material was selected over steel because it is lighter. Heavy-duty rollers were attached to the scissors' links. The rollers move on the U-shaped base and top channels as the device is raised or lowered. The U-shaped extrusions in base and top hold the rollers in place and protect them as they slide. The electromechanical pillar is attached to the base L-shaped extrusion and to a steel rod that connects the backrest at a halfway point. Mounting brackets were used to secure the fixed ends of the scissors' links and the pillar.

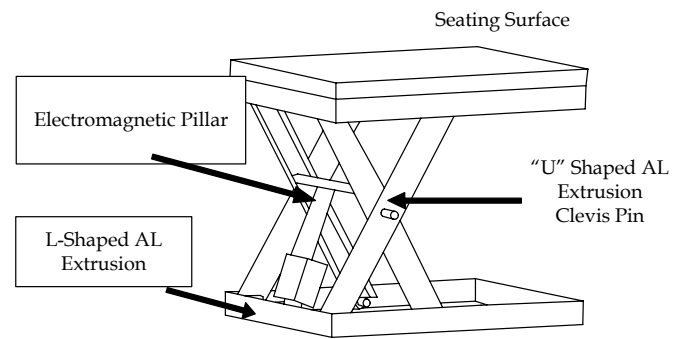


Figure 18.13. Diagram of Lift Assist Device

Pro/Mechanical and Finite Element Analysis (FEA) were used to analyze two critical components of the device: the scissors' links and the mounting brackets, shown in Figures 18.14 and 18.15. When applying a maximum load, the link withstands 3.221×10^4 pounds per square inch maximum principal stress and it deflects by only 4.15×10^{-3} .

When applying a maximum load, the mounting bracket withstands 6100 pounds per square inch maximum principal stress and it deflects by only 1.8×10^{-6} . Overall, the safety factor is greater than 2, which is in accordance with biomedical standards. The prototype is shown in Figure 18.16.

The cost was \$650.

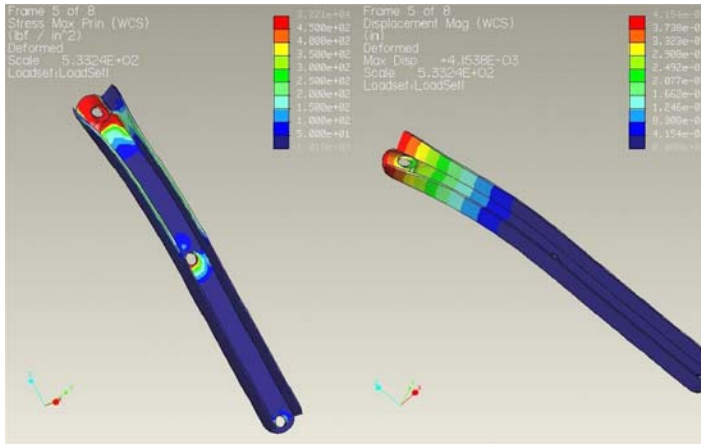


Figure 18.14. Testing of Aluminum Links

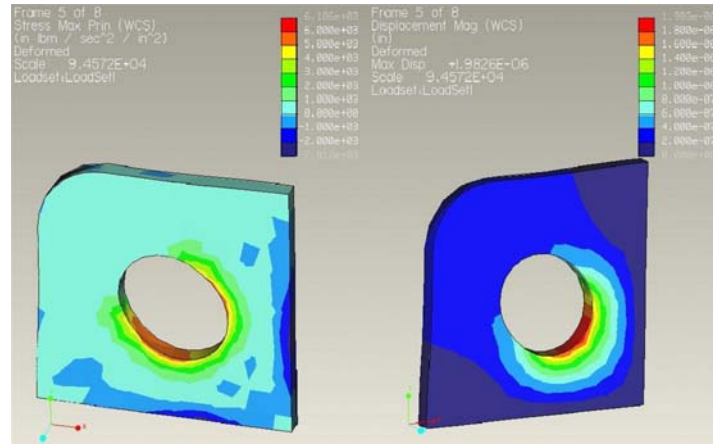


Figure 18.15. Testing of Mounting Aluminum Brackets

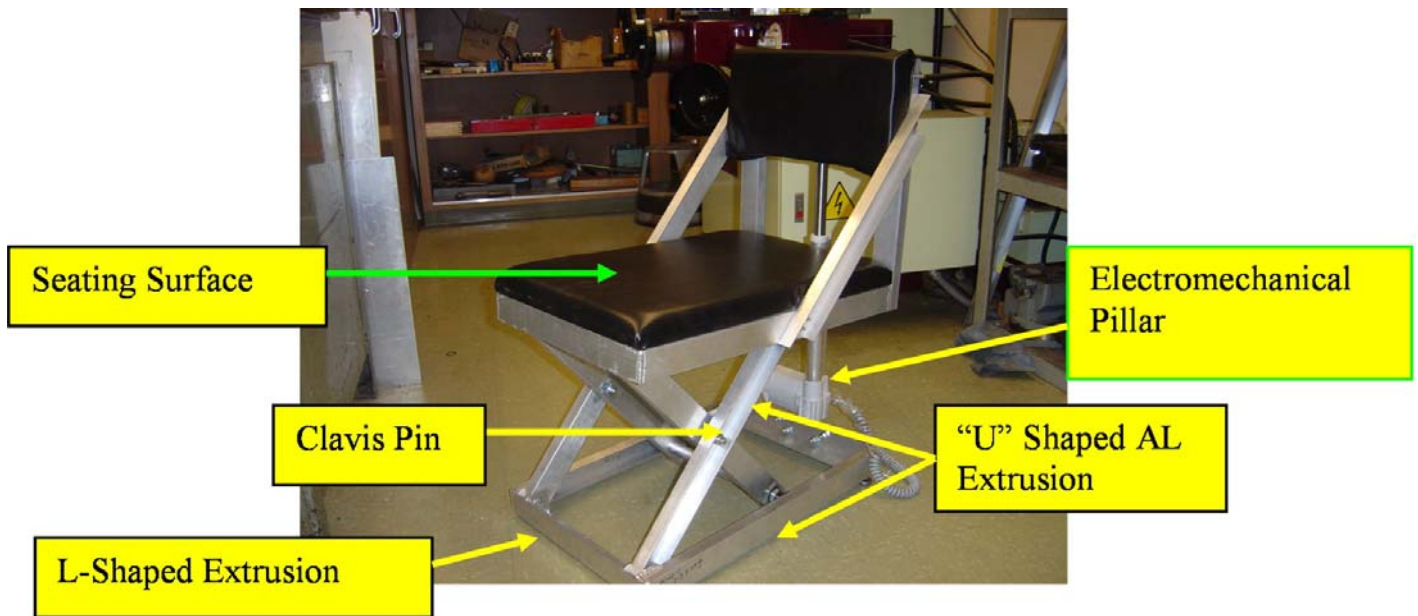


Figure 18.16. Picture of Prototype Transfer Lift Assist System



CHAPTER 19

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ACCESSIBLE SYRINGE DOSING DEVICE

*Student Designers: Travis Anderson, and Christopher Don Cardon
Supervising Professor: Dr. Steven F. Barrett
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INTRODUCTION

A syringe dosing device was designed for people with limited mobility who require injections. Accuracy is critical because small-scale doses of medicine can be extremely important. Safety is essential, as medical applications involving needle use have inherent danger and an incorrect dosage could be harmful and even fatal. The device has an

easy-to-read and user friendly keypad, and a liquid crystal display (LCD) screen.

SUMMARY OF IMPACT

The design is safe, easy to use, and accurate. It will be useful for people with limited mobility who have to take medication requiring injection.

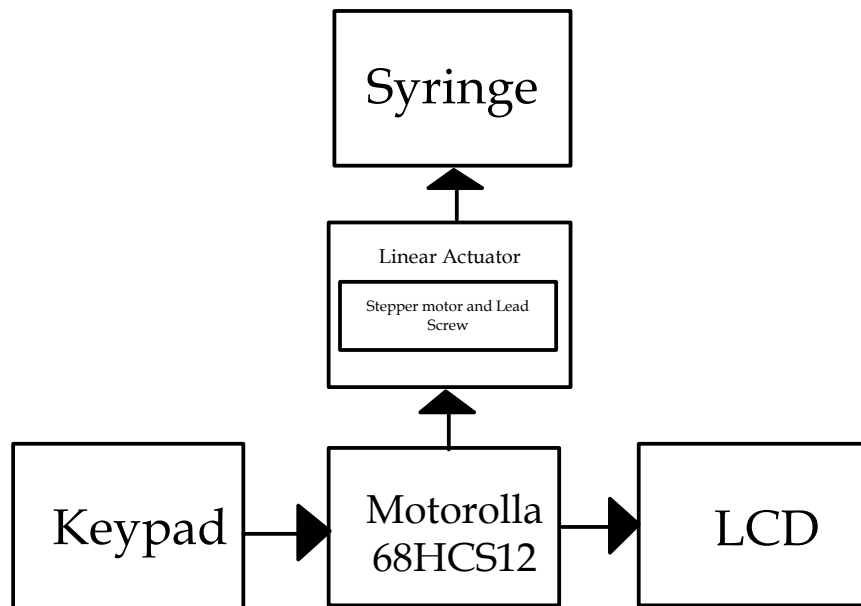


Figure 19.1. Top-Level Diagram of Design

TECHNICAL DESCRIPTION

The mechanical assembly adapts the linear stroke of the linear actuator to draw the syringe plunger. This is done while holding the actuator, syringe barrel, and U-100 vial at a fixed position. Each part in the mechanical assembly is an intricate machined aluminum part. The pieces had to remain rigid to provide the required accuracy and safety.

When powering up the device, the LCD prints "Enter Units:" as an input prompt. The program runs until three correct inputs are given from the keypad. Valid entries are values from 1 to 100 units of fluid. If a non-valid entry is given, the LCD prints "Incorrect Amount" and reprints "Enter Units:" while it waits for a valid input.

When a valid input is given, the program initiates the Bubble Reject function. This function is given to prime the syringe. This is accomplished by drawing out 20 units and thrusting the fluid back into the vial. Thus, when the actual amount of fluid is drawn, it starts with a fluid-filled needle rather than a needle filled with air.

After the Bubble Reject function, the device draws the correct amount of fluid. The device then stops and waits for the user to take the syringe out of the mechanical assembly. At this time, the LCD says, "Press A to Reset." Nothing happens until the user presses A, at which time the actuator goes back to the home position. The device is then ready to be used again, and prompts for another input.

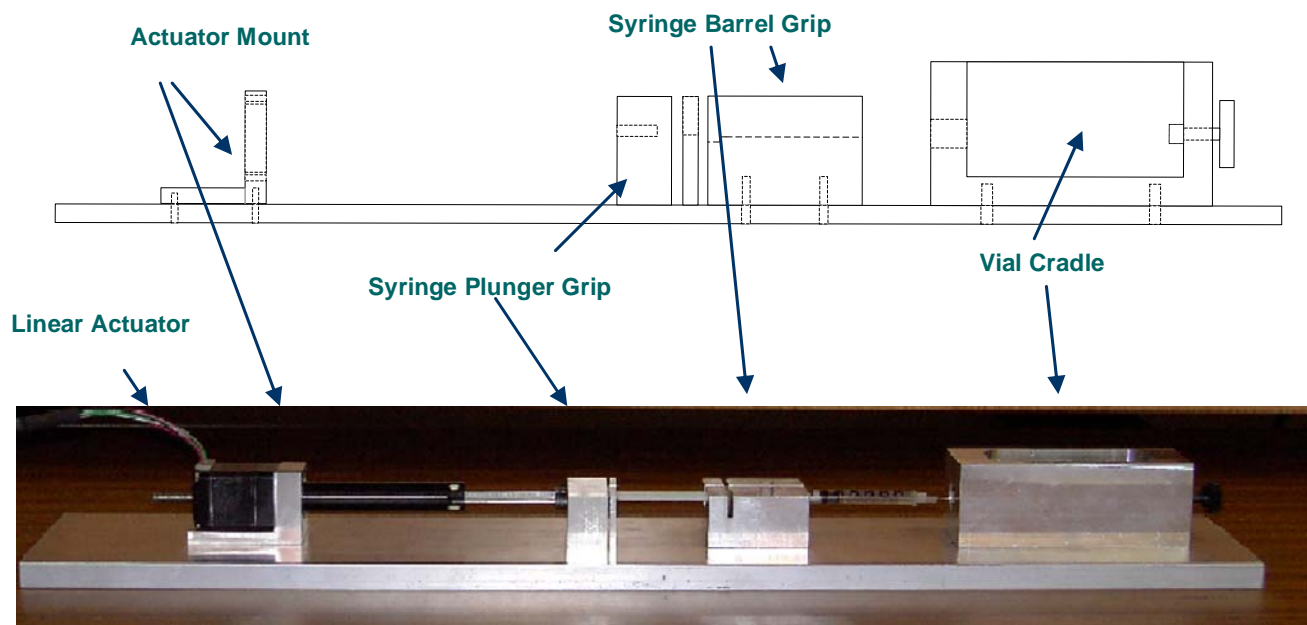


Figure 19.2. Mechanical Assembly of Accessible Syringe Dosing Device

WHEELCHAIR/BICYCLE TANDEM ADAPTER

*Designers: Bryce Brock, Chris Dellit, and Jed Purcell
Supervising Professor: Dr. Nancy Peck
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Laramie, WY 82071*

INTRODUCTION

A wheelchair/bicycle tandem adapter was designed so that the front wheel of a bicycle can be removed and replaced with the adapter, which is then fastened to the frame of a wheelchair. The wheelchair leads the tandem. The adapter is strong enough to function normally, as long as the weights of the two occupants are within the design limits. A design goal was to have the adapter be attached easily to both the wheelchair and the bicycle. To meet this requirement, a desired maximum adapter connection time of 12 minutes was established.

SUMMARY OF IMPACT

The front-mounted wheelchair design option is likely to be more fun and entertaining than an adapter in which the bicycle leads and the wheelchair follows.

TECHNICAL DESCRIPTION

The adapter, shown in Figure 19.3a, 19.3b and 19.4, is composed of a T6-6061 aluminum frame, in combination with several 1018 steel components needed for the braking and steering systems. Aluminum was selected as the frame material to decrease the overall adapter weight. The steering system required a means by which the torque at the bicycle's steering axis could be converted to an axis about which the wheelchair could be turned. The use of a system that allows the bicycle rider to lean from side to side accomplishes this. The steering system was suspended on either side by compression springs, which increased the stability of the tandem.

The braking system consisted of rubber pads used to apply braking forces to the outside of the rear wheelchair wheels. The brake pads are actuated by the bicycle's existing front brake lever.

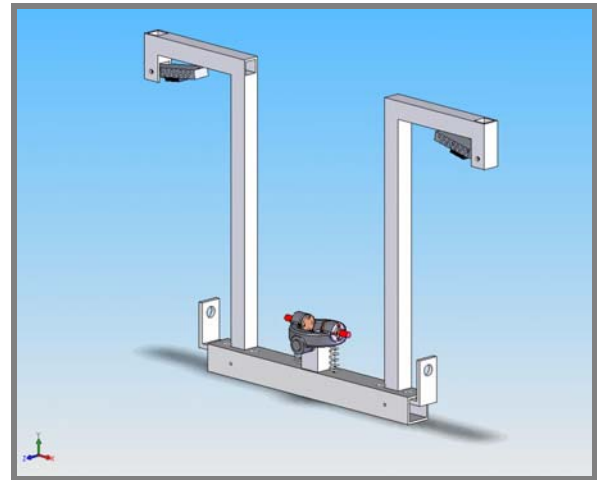


Figure 19.3a. Illustration of Wheelchair/Bicycle Tandem Adapter



Figure 19.3b. Wheelchair/Bicycle Tandem Adapter

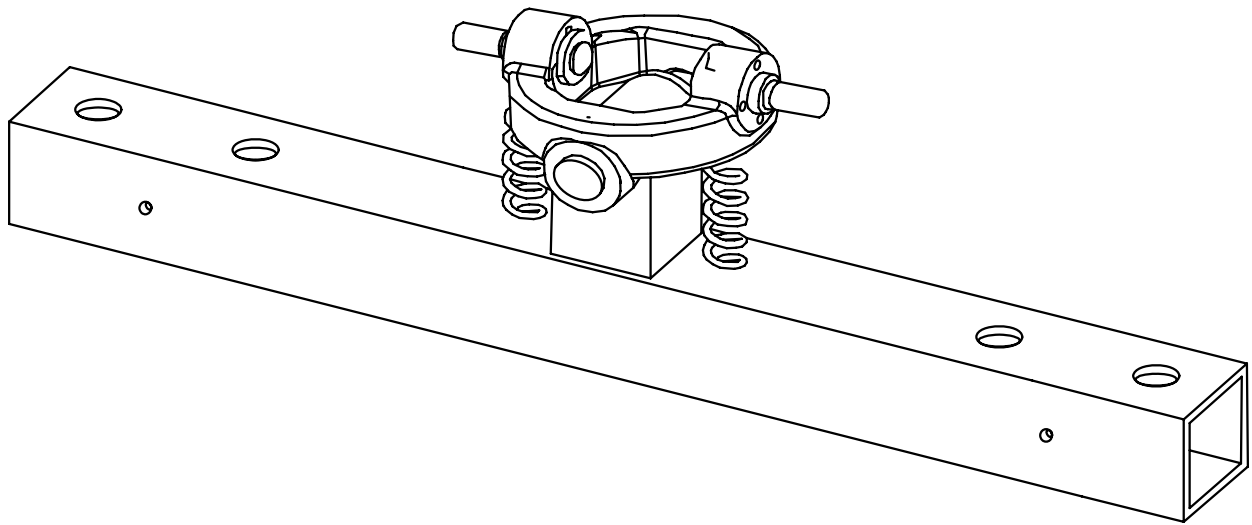


Figure 19.4. Close-Up Illustration of Wheelchair/Bicycle Tandem Adapter

HUNTING BLIND FOR PEOPLE WITH PHYSICAL DISABILITIES

*Designers: Jack Bryson, and Travis Inghram (JTLR Engineering)
Supervising Professor: Mr. Scott Morton
Mechanical Engineering Department
University of Wyoming
Laramie, WY 82071*

INTRODUCTION

A mobile hunting blind (shown in Figures 19.5 a through d) was designed to accommodate hunters who have physical disabilities. The original project description called for a blind that could be pulled by a vehicle or ATV, be equipped with a gun rest and ramp, and have a turret for rotating the wheelchair user.

SUMMARY OF IMPACT

The design is especially suited to hunters who use a wheelchair. A rotating platform allows full 360-degree rotation, an automatic braking system for the platform, a 270-degree shooting arc with three shooting windows, and an adjustable pivoting shooting rest. The interior of the blind is large enough to accommodate two additional hunters who are able-bodied, with three additional shooting windows. The blind is attached to a standard 5'x10' trailer, and can be towed by an automobile or large ATV. A fold-down ramp attaches to the rear to allow easy entry, while jacks mounted at each corner add stabilization to the structure.

TECHNICAL DESCRIPTION

The overall dimensions for the interior of the blind were chosen to allow room to accommodate large wheelchairs while allowing easy access to the windows on both sides. One of the major concerns in the design process was that the blind be able to withstand strong winds. A 60-mph cross wind was chosen as the highest likely wind speed to be encountered.

To minimize noise, the turret was designed to be manually operated. The turret is automatically locked into position to eliminate the possibility of movement when the user shoots his or her weapon. An electro-hydraulic disk brake system that is always engaged unless released by the user accomplishes the automatic locking. An additional benefit of the brake system is safer entry to, and exit from, the turret. The spring tension on the brake caliper allows adjustment for conditions. Rotation of the turret is accomplished with a handrail system that is solidly mounted to the interior of the blind. The handrail wraps 180° around the front of the turret and includes the ribbon switch to release the brake. A gun rest system allows height adjustment, rotation around the vertical axis, and pivots front to back. It is solidly mounted to the turret. To increase the stability of the blind, trailer tongue jacks are mounted at each corner of the trailer. These jacks can be folded for transport.

There were some objectives that were not met, the most notable being the noise level and deflection of the turret. To reduce the noise, a stronger turret assembly must be devised, as the majority of the noise comes from the brake pad sliding on the disk. This is aggravated by the excessive deflection of the turret. The deflection allows the caliper to bind in its bracket and causes the pad to bind on the disk. The electro-hydraulic braking system works as intended. The system is easy to pressurize, provides quick and quiet brake deactivation, and is easy to use. The ribbon switch activates with very little pressure.



Figure 19.5a



Figure 19.5b



Figure 19.5c



Figure 19.5d

Figure 19.5 Multiple Views of Hunting Blind

HIGH/LOW BATH SEAT

Student Designers: Stanley Chua, Scott Lesher, Damian Melder, and Michael Swanson
Supervising Professor: Scott Morton
Mechanical Engineering Department
University of Wyoming
Laramie, WY 82071

INTRODUCTION

The High/Low Bath Seat (see Figure 19.6) is a device that functions as a lift to make bathtubs more accessible for people with disabilities. Specifications for this project were: operation with one assistant; seat loading height of 20 inches; seat rests less than two inches to the bottom of the tub; relatively compact equipment that can be stored after each use; tolerance for user weight up to 200 pounds; and low cost. One commercially available device that met many of the design goals was the Mermaid Bath Hoist. However, the drawbacks are: the lowest position of the seat is 5-½ inches from the bottom of the tub; the equipment requires permanent mounting to the floor; and it retails for \$2561.

SUMMARY OF IMPACT

The motor and battery selected are insufficient to meet performance specifications. Modifications that are required for safe operation include the following: redesign of pinch points, improved power systems, and implementation of limit switches, including torque limiters.

TECHNICAL DESCRIPTION

The design solution is based on a vertical power screw assembly. The main design has four components: the power screw, seat support, seat, and frame. Due to the water environment in which

the lift operates, stainless steel, polymer, and bronze materials were used. The basic components of the power screw assembly require a thrust collar, a source of rotation, a mating coupler, a thrust bearing, and a support column. A ½-10 Acme thread screw offers a compromise of performance and cost. The 12 V DC reversible motor is powered with a rechargeable battery. The motor rotates the power screw, which raises and lowers the seat support and the seat.

The seat support carries the torque and allows free sliding with two polyethylene plain bearings. This configuration places the power screw only in axial tension to minimize thread binding. A non-rotating bronze nut is secured to the base of the support flange to transfer the motion of the power screw into lift. The seat has nylon mesh to ensure submersion and comfort. The seat is pinned to the support arm for easy removal. The support frame clamps to the tub wall using eight leveling mounts. The frame provides stability and support for the bath seat during operation.

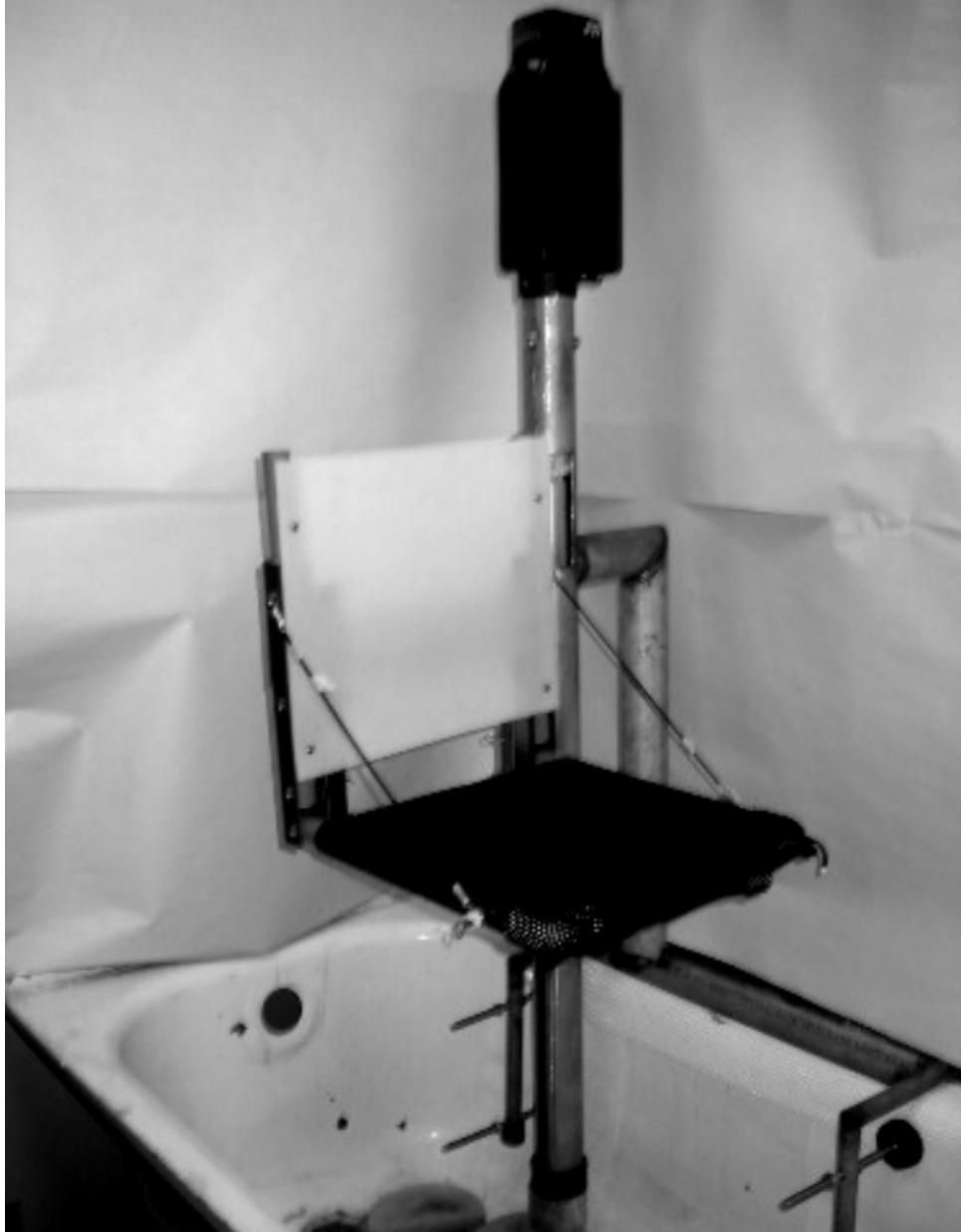


Figure 19.6 High/Low Bath Seat

CHILD MONITORING SYSTEM

*Student Designers: Stuart Fowler, Matthew Jespersen, and Brittany Wheeler
 Supervising Professor: Steven Barrett, Ph.D.
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INTRODUCTION

A monitoring device was designed for use by students to help promote independence while walking through hallways of the school without an accompanying adult. The device allows an occupational therapist to track the children on a computer monitor while they walk alone between two rooms.

The child carries a device that has an RF transmitter. This transmitter sends a signal to three receivers placed throughout the hallways of the school. The receivers, connected to networked microcontrollers, transmit information to the microcontrollers, which then relay the data to a central computer for further processing. The computer manipulates the data received from the receivers and plots the location of the child on a graphical map layout of the school.

SUMMARY OF IMPACT

The transmitter device is wearable, attaching easily to the child's waist via a clip. The microprocessor

has an evaluation board and includes Ethernet capabilities, enabling the system to be hooked up to any computer in the school. The current design allows for only one user at a time, and only tracks the location of the student from the client's office to one specific classroom. This system is not portable.

TECHNICAL DESCRIPTION

The monitoring system consists of the transmitter, receiver, microprocessor, and computer (see Figures 19.7 and 19.8). The transmitter is a wearable device that transmits an input signal to each of the receivers placed in the hallways. Each of the receiver devices in the hallway receive the signal transmitted by the transmitter and then send the signal and the strength of that signal to the microprocessor located by the computer. The receivers receive their "enable" voltage from the microprocessor.

The microprocessor receives the signal and the signal strength reading from the receivers. From the code, the microprocessor translates that signal into usable data for plotting the transmitter's location.

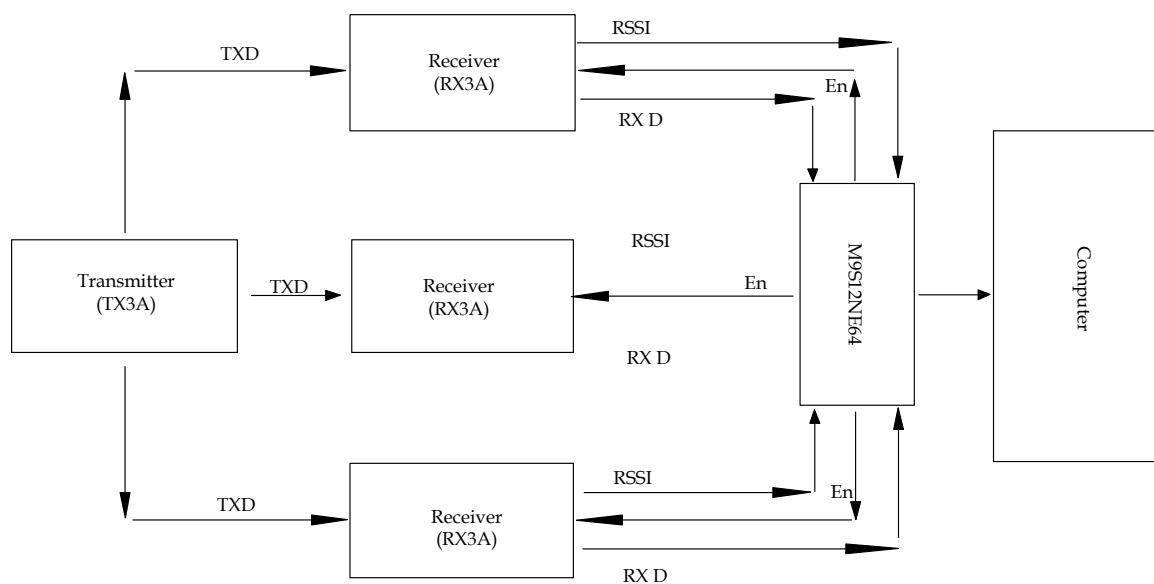


Figure 19.7. Child-Monitoring System Diagram

The microprocessor sends an analog-to-digital conversion of the signal strength measurement to the computer program for distance calculations. A computer program takes the input signal strength

value and calculates the transmitter's location using trilateration.

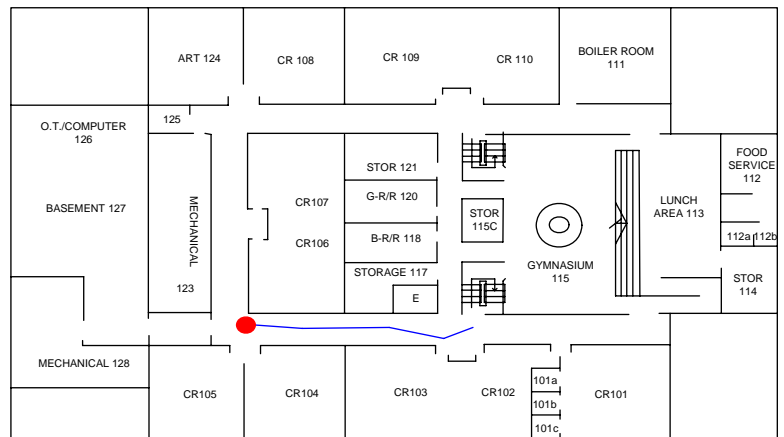
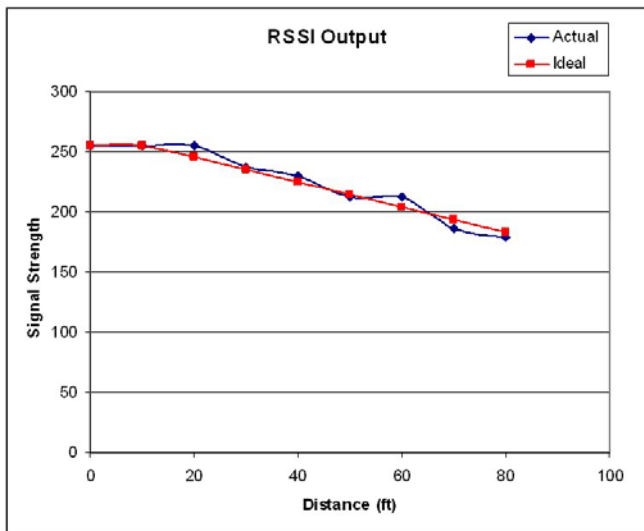


Figure 19.8. Child-Monitoring System Components, Output Display, and Building View for Tracking

POWER-ASSISTED TRICYCLE SAFETY ENHANCEMENT

Student Designer: Matthew Geu, Francis Tuffner, Robert Madsen, and William Harman

Supervising Professor: Dr. Steven Barrett

Electrical and Computer Engineering Department

University of Wyoming

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INTRODUCTION

A customized power-assisted tricycle was developed for a child with Osteogenesis Imperfecta type III, a genetic disorder that limits the physical abilities, size, and strength of the child. This tricycle will ultimately provide the client the opportunity to gain muscle mass, strength, coordination, and confidence. A previous design project did not provide the necessary features to allow him to ride the tricycle safely. For this reason, the tricycle was redesigned to include redundant safety systems.

SUMMARY OF IMPACT

Through the use of redundant systems and sound design practices, the power-assisted tricycle has become more reliable and safer. The power system was redesigned to make it easier for the parents to recharge, and was additionally modified to prevent accidents from occurring during the charging process. A disk brake was added to provide the ability to stop quickly, in the event of malfunction, and to prevent the trike from moving during the charging process. Several more sensors were added throughout the design to provide a check and balance system so that each of the sensors would be able to check to make sure the others were working. An accelerometer was added to detect possible rollover and give the microprocessor a chance to prevent it from occurring. With the new sensors, a new operating system was developed using defensive programming techniques to provide stable and reliable operation. A panic system was installed to provide both the child and the parents with the ability to power down and stop the trike immediately in the event of an emergency.

TECHNICAL DESCRIPTION

The safety system components include power, braking, sensors, software, and general safety devices. By adding several features to the power system, it was possible to make the trike easier for

the parents to charge and also to prevent accidents from occurring during battery charging. A switch was added such that the trike can either charge or run off of the battery but not both at the same time. To accomplish this mutually exclusive operation, a mechanical stop (as shown in Figure 19.9 on the left) was inserted. It causes the switch to be in a particular position when the charger is plugged into the system. When the switch is in this position, the motor and all other subsystems have no power, preventing the trike from being used. When the charger is unplugged from the trike, the stop can be moved upward and the switch turned to the alternate position, enabling the power to the trike. A larger battery was added to expand the duration of operation. A new battery, the Panasonic LC-X1220AP, a sealed lead acid battery that has a 20 Ah capacity, was used to require minimal maintenance and to reduce the likelihood of an acid spill. A power meter was also added to provide the parents with a visual indication of when the battery is fully charged and when it needs to be recharged.

The braking system was added because the trike originally relied solely on the motor and its gear box to provide braking action. The brake was designed such that it requires manual operation by pulling on a lever to set the brake open and electrical power turned on in the tricycle to keep the brakes open. Electric solenoids were used to hold the brake calipers open (as shown in Figure 19.9) so that, in the event that power is lost, the brakes are engaged, preventing the trike from moving. A disk was added to the axle of the trike to provide the necessary surface for the calipers to grip. The disk brake prevents the trike from moving when it is being recharged.

Several sensors were added to provide redundant systems for detecting any sensor errors. The original trike used a single Hall Effect sensor on the front tire to provide feedback to the microprocessor as to the

speed of the tricycle. However, if the sensor would fail or the magnets on the front tire would be misplaced, there would be no backup system to give the necessary feedback indicating that an error had taken place. A proximity sensor was added, which reads the teeth on the sprocket mounted to the motor. By counting the number of teeth that pass by the sensor, it is possible to determine both the RPM of the motor and the overall speed of the trike. The proximity sensor is a NBB2-12GM40-Z0 manufactured by Pepperl-Fuchs. The proximity sensor, combined with the Hall Effect sensor, allow for the microprocessor to compare the data from both of the sensors and to check if the sensors are both working or if there is an error in the system. For example, if the Hall Effect sensor indicates no speed, but the proximity sensor indicates that the motor is running, an error is generated that causes the system to shut down. The second sensor is an accelerometer. This sensor is used to determine if the trike is going to tip over, due to turning a corner at a high speed. The accelerometer is an Analog Devices ADXL202, which has X and Y axes that provide measurement of forces up to 2Gs. This allows for the microprocessor to know if the trike is going to tip over to either side from turning a corner at too great of a speed, or to flip backwards, which can be caused by trying to have the trike climb an incline that is too steep.

The operating system that was originally designed for the trike did not have defensive programming techniques and only had the one Hall Effect sensor for feedback. The operating system was redesigned to include not only defensive programming techniques but to also incorporate all of the new sensors.

Several techniques were implemented using token passing throughout the program and also periodically reinitializing the control registers during program execution. Another programming technique implemented was placing a software interrupt, or SWI, in all the empty space in the read only memory or ROM in the microprocessor. SWI is an assembly command that causes the microprocessor to restart itself. If the microprocessor should jump out of the program into unknown memory, the SWI will cause a restart, preventing any undesired operation.

Several other items were added to the trike to enable a complete shutdown in the event that either the child or the parents need to power down the trike in an emergency. A set of panic buttons was placed on the trike, one in the center of the steering wheel (as shown in Figure 19.9) and one on the side of the seat. The trike's power is shut down completely when a button is pressed. The buttons are Jelly Bean switches manufactured by Ablenet. They are 6.35 cm in diameter and can be pressed from any point on the button. These buttons are attached to a continuous duty power solenoid, purchased from NAPA Auto Parts, which is connected into the power system right after the battery to enable complete power shutdown in the event that the panic system is activated. Components are shown in Figure 19.9. The completed project can be seen in Figure 19.10.

The total cost for the project was approximately \$750.

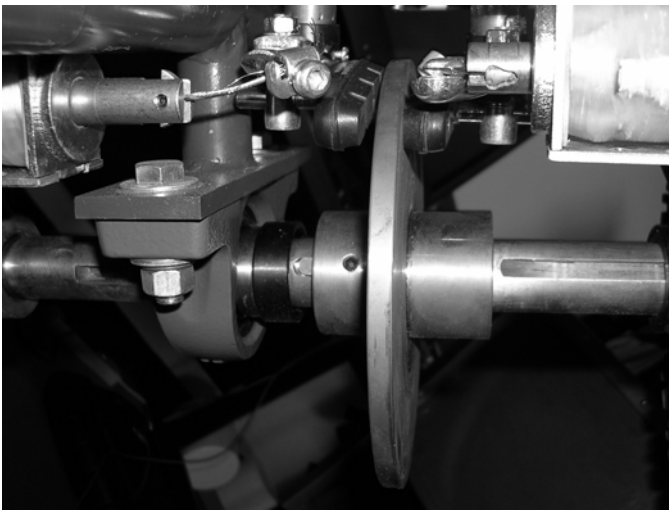


Figure 19.9. Power-Assisted Tricycle Adaptation Components



Figure 19.10. Completed Power-Assisted Tricycle

LEG-POWERED QUADCYCLE BY FOX ENGINEERING

*Designers: Joel Gronvall, Andrew Meissner, Chris Schmit, and Joe Uriarte
Supervising Professor: Dr. Hansen
Mechanical Engineering Department
University of Wyoming
Laramie, WY 82071*

INTRODUCTION

The Leg-Powered Quadcycle accommodates two riders, including a teacher or student on one side, and a student with disabilities on the other. The two will be seated side-by-side and will be able to pedal independently of one another. The frame was constructed of two-inch-square aluminum tubing with quarter-inch wall thickness. The joints were bolted to increase the strength of the assembly. Safety features include a low center of gravity, hand-operated disc brakes, chain guards, seatbelts, and rear fenders. The cycle seats are padded and adjustable to fit different body lengths. The Quadcycle is recommended to be used under speeds of 10 miles per hour with loads not exceeding 400 pounds, with all safety devices used properly.

SUMMARY OF IMPACT

Objectives were to:

Keep the center of gravity low to prevent rollover,

Ensure a vehicle turning radius such that it can turn fully at maximum velocity without tipping or losing control, even if the vehicle contains only one passenger,

Include independent rear drive shafts for improved turning,

Accommodate two passengers seated side by side with a maximum weight of 400 pounds,

Ensure compact size to fit through double doors,

Keep weight light enough for lifting by two people,

Allow the two passengers to pedal independently, each contributing to the motion of the Quadcycle,

Design the gear ratio such that the velocity of the Quadcycle is four miles per hour at 60 revolutions per minute.

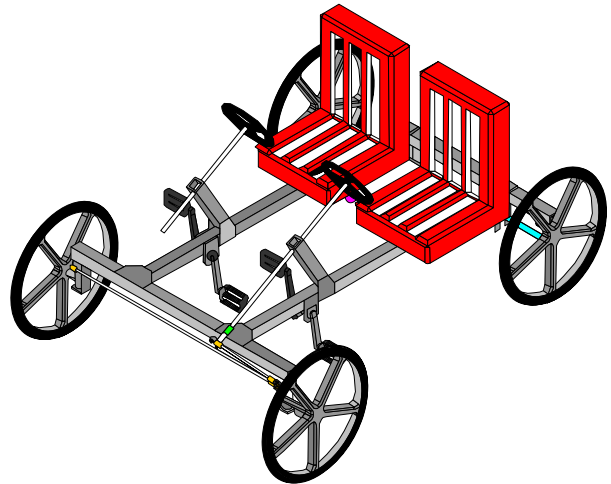


Figure 19.11. Illustration of Leg-Powered Quadcycle

The prototype met all design goals and, therefore, is a success.

TECHNICAL DESCRIPTION

A visual model of the Leg Powered Quadcycle is shown in Figure 19.11. A photo taken during the design process is shown in Figure 19.12. Chain-drive analysis yielded a gear ratio of 0.84 from the drive sprocket to the drive sprocket. This was the closest gear ratio obtainable using standard sprockets to yield the desired ratio of 0.89. The cycle tires used were 20 inches in diameter. As tested by Fox Engineering on exercise equipment, an average pedaling speed of 60 revolutions per minute, or 6.28 radians per second, was reasonable for the design. With the total vehicle/passenger weight of 565 pounds and a velocity of 4 miles per hour at this pedaling speed, the amount of force required to pedal the cycle was calculated. With the gearing combination from above, the force required on the pedals is 20 pounds on a 1:50 slope and 39 pounds on a 1:25 slope. The force required to pedal the cycle at a constant velocity of 4 miles per hour on level

ground is less than 20 pounds. Therefore, a child with disabilities should have no difficulty pedaling the cycle on flat ground. This is appropriate, considering the client wishes to use the cycle on level ground only as a therapeutic device for children with disabilities. The force required to accelerate the cycle 1.5 feet per second squared was calculated for the worse-case scenario with two 200-pound occupants plus the weight of the cycle on a 1:25 slope with a coefficient of friction equal to 1. This pedaling force was 85 pounds on a 1:25 slope and 46 pounds on a 1:50 slope.

Under maximum loading, the maximum deflection in the axle was 0.08 inches. For the worse-case scenario of accelerating at 1.5 feet per second squared, with the back tire fixed on a 1:25 slope, the angle of twist was 1.3 degrees.

The Quadcycle skidding model determined the minimum turning radius before skidding of a tire occurs at various velocities. A worse-case scenario was analyzed with a high coefficient of friction of 1 and a single 200-pound passenger. At a velocity greater than 8 miles per hour, the Quadcycle can no longer negotiate a turning radius of 16 feet. For example, at 10 miles per hour the minimum turning radius without any of the wheels slipping is 24 feet.

The Quadcycle tipping model was used to calculate conditions that would cause the cycle to tip over. The worse-case scenario would be only one passenger weighing the maximum of 200 pounds. With a width of 56 inches, center of gravity height of 27 inches, maximum velocity of 10 miles per hour and total weight of 365 pounds, a maximum turning radius at this maximum velocity was calculated to be 14 feet.

At any velocity, the minimum skidding turning radius is larger than the minimum tipping turning radius. This would result in the cycle skidding before tipping.



Figure 19.12. Construction of Quadcycle

The steering math model allows calculation of the length of the steering arm. It also gives the amount of force required to turn the wheels of the cycle. The length of the pitman arms was 1.5 inches and the resulting steering arm was 2.4 inches in length. The wheel spindles travel 26 degrees to give a turning radius of 16 feet and the steering centerpiece turns through a 45-degree total angle. Assuming a 1-pound force is applied at the outer radius of the 10-inch steering wheel, this will produce a force of 3.3 pounds at the outer radius of the 2.4-inch steering arm. This force will produce a torque on the steering spindle and cause the tire to turn. The torque required to turn the steering wheel under the worse-case scenario when the cycle is stationary with a load of 400 pounds and a coefficient of friction of one, is 47 foot-pounds.

The von Mises stress distribution for the cycle frame gives a maximum stress of 1800 pounds per square inch just in front of where the seats attach. The maximum deflection is .004 inches, which occurs at the location of the seats. The minimum factor of safety using von Mises analysis is 9.8. This factor of safety is greater than the perceived factor of safety, which is 5.8.

HANDS-FREE MOUSE

*Designers: Jeremy Long
Supervising Professor: Dr. Steven Barrett
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Laramie, WY 82071*

INTRODUCTION

The primary goal for this project was to create a device that would offer the equivalent functionality of a standard Personal System 2 (ps2) mouse that does not require the use of the hands to operate. The device was to be easily controlled by head movements and sensitive enough to provide fast cursor movements while still being easily controllable and easy to “center” (to stop the mouse cursor from moving). Also, the mouse was to provide a reasonably fast response time to a user’s directional movements and sip/puff clicks, and be fairly immune to noise.

SUMMARY OF IMPACT

The device leaves both hands free for keyboard, joystick, or other controls. The mouse is easy to control with proper calibration and brief practice. It calibrates itself within about one second upon startup. It approximates the variance of initial readings and adjusts sensitivity for each axis independently, which enables it to be used in a reclined position. The final product is reliable and hot-swappable (can be plugged or unplugged from a PC that is already booted up).

TECHNICAL DESCRIPTION

The device forms a differential capacitor that changes capacitance when tilted one way or the other. Components are shown in Figure 19.13. The accelerometer consists of a square platform mounted on four elastic tethers, one on each corner. When the device is tilted, the platform moves closer to one of the outer walls, which changes its capacitance. Also built into the accelerometer is logic that ‘reads’ the capacitance of both sensors, and outputs a pulse-

width-modulated signal corresponding to the tilt of each axis; if the accelerometer is tilted along one axis in the positive direction, the duty cycle of the corresponding output wave increases.

The sip and puff subsystem is simple. The sip and puff switch can easily be replaced by any type of switch. The sip and puff switch contains two actual switches: one that senses puffs and one that senses sips. A common wire is tied to one of the contacts on each of the switches, and then connected to the ground wire of the ps2 cable. There are two solder points purposefully left open on the circuit board: one for the second contact of each switch. These live contacts are held high via a 10K resistor to the 5-volt supply line, and are tied to input pins on the microprocessor. These inputs will always sense a high signal unless the contacts of a switch are connected (a switch is depressed), which will effectually pull the voltage low at the input pins.

The microcontroller reads the inputs from the accelerometer and the sip and puff switches, and encodes these data into ps2-compatible packets. These packets are sent to the PC as 3-byte movement packets, one byte describes the button states and movement counter directions, one byte serves as a counter indicating the amount of movement in the x direction, and the third serves as a counter indicating the amount of movement in the y direction. The microcontroller also controls the device calibration and sets it up to communicate to the PC.

The mouse fits in a small (1.5” x 1.25” x .8”) box and is lightweight. It could be mounted on a pair of headphones or baseball cap. The sip/puff unit is housed in an independent box.

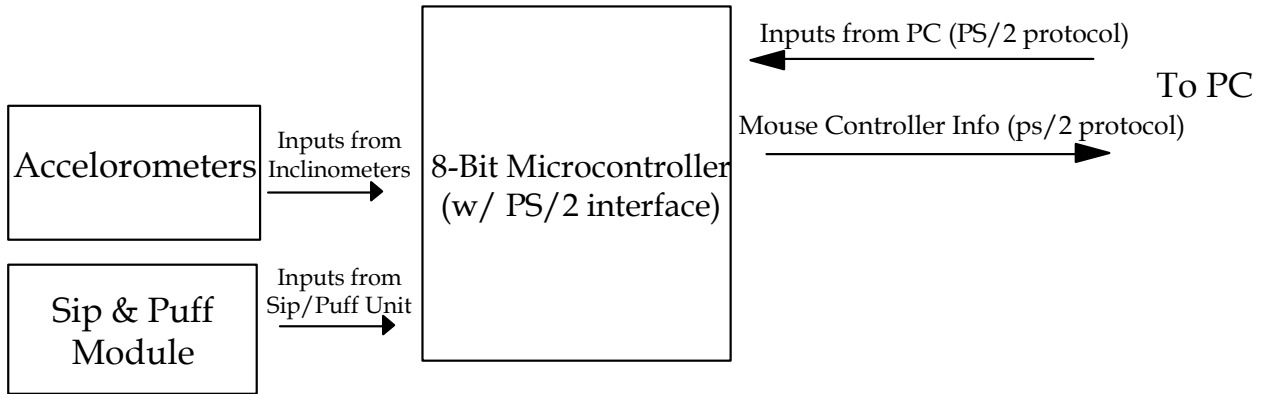


Figure 19.13. Design Components

LUNCHROOM CHAIR

*Designer: Michael Stephens
Supervising Professor: Steven Barrett, PhD, EE
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Laramie, WY 82071*

INTRODUCTION

Representatives of a school requested adaptations to a lunchroom chair for the stabilization of kindergarten children who have weak backs and are not able to balance on their own. The original chair was simply a classroom chair with the legs removed and a bench attachment bracket added on. While these did work, the client requested added leg support.

SUMMARY OF IMPACT

The original chair was deemed uncomfortable and unsafe. A new seat was designed to replace the original seat. Comfort was the first concern to consider. The new chair has a high back, which aids in stabilizing the user and also provides a more comfortable eating position. It has a leg rest and foot rest pads.

TECHNICAL DESCRIPTION

Several designs were considered, but the three most promising designs were to modify a child office chair, build a new seat, or use a car safety seat. While the child office chair would be a well suited chair for this project, it proved hard to find in sizes small enough for a kindergarten student. A child booster seat was chosen as the easiest and most readily available solution.



Figure 19.14. Close-Up of Original Bracket

A car safety seat was selected because it is durable and crash-rated for a child up to 100 pounds. The bracket that attaches to the bench is completely adjustable to accommodate a wide range of lunch benches. Construction simply involved the attachment of the child safety seat to one custom built bracket insert that also provided leg support. Components of the chair and the final design are shown in Figures 19.14 through 19.17.



Figure 19.15. Original Lunchroom Chair

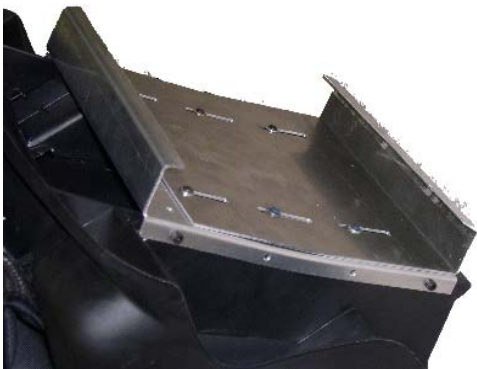


Figure 19.16. Close-Up of Adjustable Bracket



Figure 19.17. Completed Chair

EXTENDABLE REACHER

*Designer: Michael Stephens
Supervising Professor: Steven Barrett, PhD, EE
Electrical and Computer Engineering Department
University of Wyoming
Laramie, WY 82071*

INTRODUCTION

A child who has no arms, with his hands at the level of his shoulders, has difficulty picking up objects and using the bathroom without the aid of a teacher. He would benefit from the functions of a simple store-bought reacher, but these do not come in sizes small enough for him to use. For this reason, reachers were purchased and modified. The main support and the control rod were simply shortened to the appropriate length for the child.

SUMMARY OF IMPACT

The commercially available reacher was made to be shorter and also to be adjustable for continued use as the child grows. The new reacher (see Figures 19.18 and 19.19) remains lightweight despite the additional hardware added to the design.

TECHNICAL DESCRIPTION

Replaceable sections were created to allow for adjustability similar to, but simpler than, a telescoping method. The degree of adjustment is limited because each replaceable center section is made in increments of one to two inches.

Each reacher was modified and had the center sections replaced with rods. Multiple center rods were constructed in increments of one and two inches. The lock nuts tighten against the reacher to set the orientation and the length. The original control rod was replaced with a cable that can easily be lengthened.



Figure 19.18. Extendable Reacher

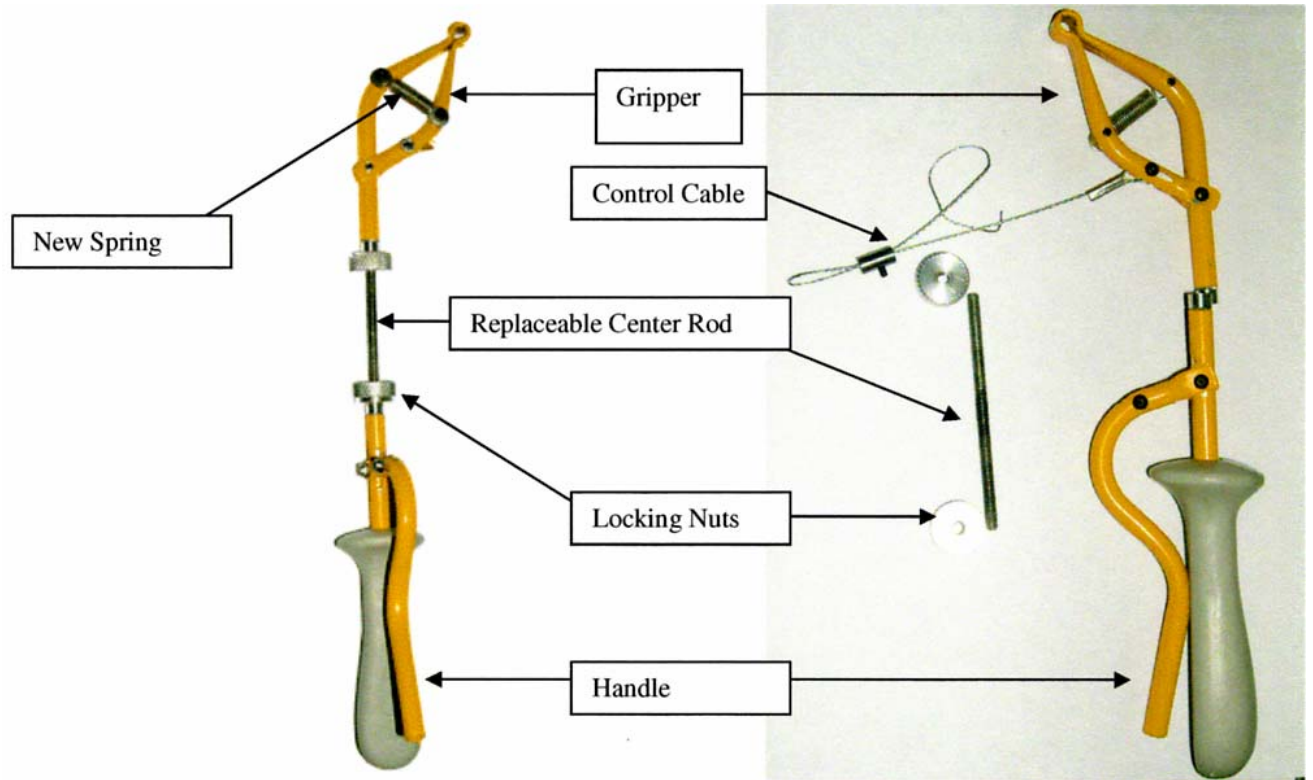


Figure 19.19. Components of Extendable Reacher

WHEELCHAIR PLATFORM FOR MEDICAL DEVICES

Designers: Paul Teini, Katheryn Durkee, and Sandy Shelton
Supervising Professor: Scott Morton
Mechanical Engineering Department
University of Wyoming
Laramie, WY 82071

INTRODUCTION

A wheelchair platform for medical devices was designed. The device had to be portable and lightweight. It also was to be inexpensive, accessible by someone in a wheelchair, and it was to lift the user from a starting height of three inches to a final height of nine inches. Finally, the device was to rotate a full 360 degrees. Both the lifting and the rotation were to be electronically motorized and operable by the user.

SUMMARY OF IMPACT

The wheelchair lift incorporates a car jack to lift a separated top plate that rotates freely from its base assembly. The base assembly is composed of the following:

- Four sets of scissor legs that, when operated in unison, can move the top plate from the desired three inches to the final height of nine inches off of the ground,
- Two sets of base brackets that connect the scissor legs,
- Two plate trusses that connect the base brackets to the car jack and connected the car jack to the scissor legs via cables,
- Three cross-members that enhance the stability of the device, and
- Four top brackets that connect the scissor legs.

The top plate is reinforced with rib stiffeners that allow the thin plate to be strong and lightweight. The top plate is rotated through a gear connected to a geared motor with the use of a timing belt.

During the Fall semester of 2004, the previously-described design was finalized and constructed. Much of Mechcore Designs' time was spent in the University of Wyoming's Engineering Machine

Shop. Many of the materials were purchased from the University of Wyoming, while a few components such as the motors needed to be purchased from outside distributors. Mechcore Designs manufactured the majority of the parts, while the machine shop personnel performed all of the welding on the project. Much of the electronics work was done through the guidance of an electrical engineering graduate student.

Upon completion of the assembly, the device was tested for a number of concerns. From this testing, several modifications have been recommended before the device can be used as intended. First, outboard bearings should be used to add stability to the gearing and the shafts. This will improve the shaft alignment and reduce timing belt slipping while the device is loaded. Second, the cable used to attach the car jack to the scissor legs should be created from a single cable and tension in the cable should be maintained through the use of a yoke. This will allow both sides of the device to be lifted in unison at all times. Third, the plate truss that connects the car jack to the base brackets should be taller to distribute the load created by the car jack evenly. Then, with added reinforcement to the truss extenders, the car jack will not cause any bending to the base. With these essential modifications, Mechcore Designs believes that the wheelchair platform device will be closer to meeting all the design challenges presented at the beginning of this project.

Overall, this project has been an important step in the development of each of the group members' engineering knowledge. Additionally, the final design can hopefully be utilized to help create a wheelchair device that can assist the user at medical facilities and allow for greater independence for the user.



Figure 19.20. Base Assembly And Legs/Lifting Assembly in Fully Down Position

ELECTRONIC BOARD GAME FOR CHILDREN WITH LIMITED MOBILITY

Designers: David L. Werner, and T.J. Colgan
 Supervising Professor: Dr. Steven Barrett
 Electrical and Computer Engineering Department
 University of Wyoming
 Laramie, WY 82071

INTRODUCTION

An off-the-shelf children's board game was adapted for use by children with limited mobility. The game is automated to move player markers, activate a spinner, and move through players in a turn-based manner.

SUMMARY OF IMPACT

The adapted game, shown in Figure 19.22, improves social interaction by allowing the children to play together with minimal help from social workers or instructors. The game could be adapted to more complex gaming systems.

TECHNICAL DESCRIPTION

The microprocessor used to control the different subsystems is an Axiom CML-912SDP256, which is a development and evaluation system from the Motorola MC9S12DP256 family of microcontrollers. This processor was selected due to its memory capacity and low cost. Available memory includes up to 256 K bytes SRAM and 256K bytes flash EEPROM, both of which must be utilized as paged memory in order to access the entire memory allocation. The design utilizes the RS-232 serial port to drive the X-Y plotter. The enhanced 16-bit timer channel is used to drive the stepper motor as part of the spinner assembly. Two address buses allow communication to the drive circuitry and the player buttons.

A mechanical system was required as a vehicle on which to mount the electromagnet, which is energized beneath a ferromagnetic playing piece to move it across the board. A Roland 1300 X-Y Plotter, in conjunction with an electromagnet supplied by Magnetic Sensor Systems, was used as the positioning system for the playing pieces. The X-Y Plotter is controlled through the serial port of the microprocessor and the magnet is controlled

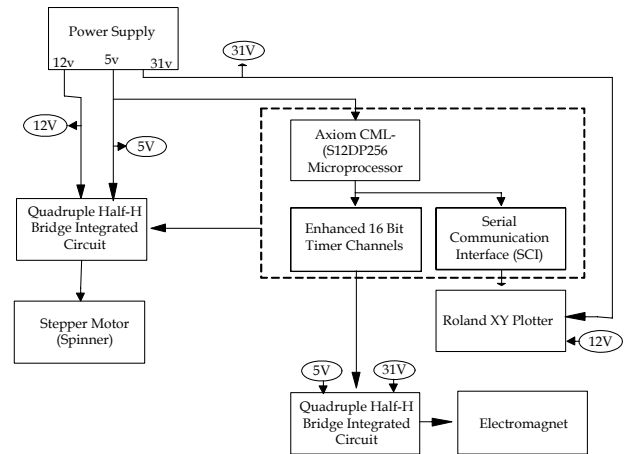


Figure 19.21. Adaptable Board Game Components

using a MOSFET H-Bridge microcircuit in combination with the microprocessor.

A 12 V stepper motor drives the arrow of the spinner through 360° of rotation in 15° steps. The 24 steps are divided between the 18 different cards with 6 steps allotted to regulate game play. The cards are divided into 12 color-coded movement cards and 6 special movement cards. A software random number generator determines which card is drawn and how many rotations the spinner will make prior to selecting the card.

The spinner is activated by one of four buttons that can be plugged into the 1/8" jacks mounted on the chassis. The microprocessor determines the number of players depending upon the number of buttons plugged into the game. Either wireless or hard-wired buttons can be used to play the game. The buttons are manufactured by AbleNet, Inc. and are specifically designed for use by persons with limited mobility. They can be mounted on a table top or to a wheelchair, depending upon the needs of the individual user.

The spinner needle must be initialized before the system starts. Also, the players' pieces must be placed on the board in designated spots and each player's button must be plugged into the chassis.

The players press their buttons to draw a card and move their pieces. The device automatically spins when a player presses the spin button.



Figure 19.22. Completed Electronic Board Game

OFF-ROAD HAND-POWERED TRIKE

Designers: Andrew Downham, Ross Hinschberger, Brian Pischke, and Ashlee Whitman
Supervising Professor: Dr. Andrew Hansen
Mechanical Engineering Department
University of Wyoming
Laramie, WY 82071

INTRODUCTION

An off-road hand-powered cycle was designed to enable a rider to steer and pedal with the same apparatus.

SUMMARY OF IMPACT

The final design is shown in Figures 19.23 and 19.24. The rider now can steer and pedal simultaneously. The internal hub provides a good range of gearing to make going up hills very smooth. The tricycle may be used on rugged terrain and other places in which the client's previous road tricycle would not take him. The client can independently load it into the back of his pickup truck. He puts the front end of the tricycle onto the tailgate and then lifts the rear end and pushes it into the back of the truck.

TECHNICAL DESCRIPTION

Common bike parts were used where possible: tires, wheels, brakes, and chains. This made the design economical and also allows for easy and quick repairs. The front and back tires had to be set far enough apart to enable the client to wheel up to the side and enter the seat.

The main difficulty in the design of the tricycle was giving the rider the ability to steer and pedal simultaneously. This was accomplished by the design and fabrication of the gimbal. The gimbal is a gyroscope-like steering device. It allows the powering sprocket to continue to deliver power while it is rotating off of the vertical plane or plane of dynamic equilibrium (see Figure 19.25).

The tricycle has three sets of Avid disk brakes, a 14 speed Rohloff internal hub, standard tie rod steering, and a custom aluminum fabricated seat. All of these elements function together to enable hand cycling. The hand cranks required a custom fabricated extension in order for the rider's hands to be centered about the initial power chain. This chain connects to the gimbal, which is assembled on the same bottom bracket as a stationary sprocket. The second power transfer chain runs from the stationary sprocket back to the Rohloff Speedhub. The main frame is constructed of an assortment of Chromoly tubing. The tubing was cut at a variety of different angles to facilitate welding.

The three brakes were connected in such a way that the rider only has to push one brake lever to engage



Figure 19.23. Completed Off-Road Hand-Powered Tricycle



Figure 19.24. Tricycle in Use

all three brakes. Safety restraints were placed on the | seat for security.

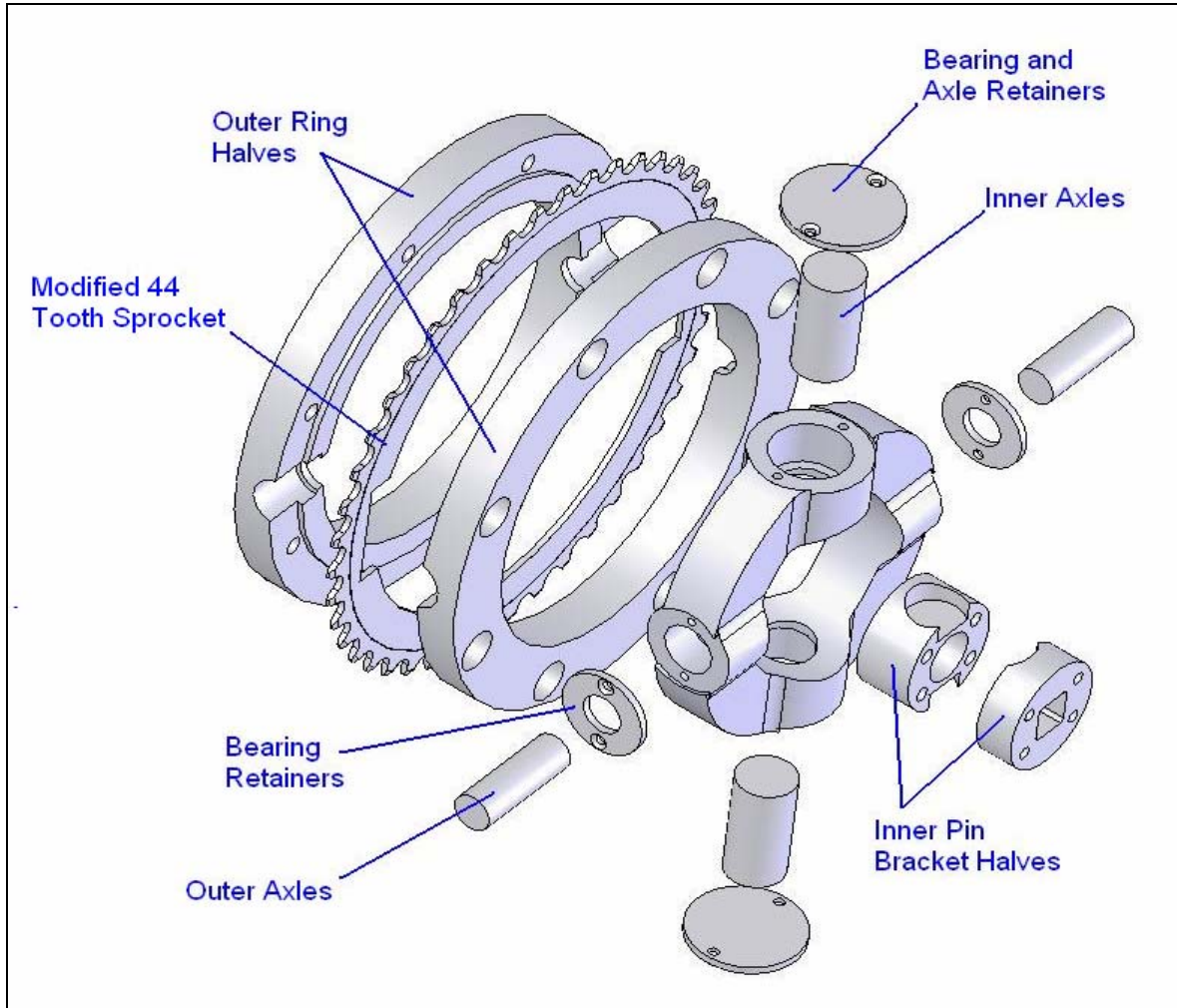


Figure 19.25 Gimbal Schematic



CHAPTER 20

WAYNE STATE UNIVERSITY

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PACKAGING AND ASSEMBLY ENHANCEMENTS

Project 1: Semi-Automatic Wrapping System: Workstation and Turntable

Designers: Nanda K Doddapuneni, and Sivakumar Talla

Client Coordinator: Lisas Knoppe-Reed, President, Art For A Cause, Birmingham, MI

Supervisors: Dr. Robert Erlandson, David Sant, and Santosh Kodimiyala

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Project 2: Semi-Automated Wrapping System: Turntable Controller and User Interface

Designers: Sandeep Jaswal, and Umer Yousuf

Client Coordinator: Lisas Knoppe-Reed, President, Art For A Cause, Birmingham, MI

Supervisors: Dr. Robert Erlandson, David Sant, and Santosh Kodimiyala

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Project 3: Universally-Designed Assembly Fixtures

Designers: Peter Pisarski, Walid Yasin, Rachele Dorsey, Jenn Guanio, and Eunice Osborne

Client Coordinator: Lisas Knoppe-Reed, President, Art For A Cause, Birmingham, MI,

Jane Resutek, Occupational Therapist, Warren Woods High School, Warren, MI

Supervisors: Dr. Robert Erlandson, Mr. David Sant, and Santosh Kodimiyala

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INTRODUCTION

A collection of student design projects was targeted for a business in which artists with disabilities hand paint gardening, kitchen and household tools. The wooden handle of each tool must be sanded and primed several times before an artist applies the decorative layer. A final protective layer is applied before the tools are packaged. Two projects addressed the packaging of tools for shipment, and a third deals with methods for improving the quality and productivity of the employees with disabilities



Figure 20.1. Example of Cute Tool hammer

through improved tool-holding fixtures.

SUMMARY OF IMPACT

The Semi-Automatic Wrapping System was delivered to the client. Workers that were previously unable to perform the wrapping operation are now able to do so at the required productivity levels and with the required level of quality. Both the Semi-Automated Wrapping System and the fixtures employ a universal design philosophy.

TECHNICAL DESCRIPTION

Projects 1 & 2: Semi-Automated Wrapping System

The wrapping process previously in place required two able-bodied workers to wrap a container of tools for shipping with a clear plastic material. The container is a metal flower box unit, about 2 feet long, 10 inches wide and 10 inches deep, with irregular and sloping sides. About 10 to 16 packages (depending on the mix) of tools were placed into the metal container. The metal container has a



Figure 20.2. Display container that must be wrapped - note irregular shape and decorations

decorative ribbon with a bow placed around its base, ready for display, as shown in Figure 20.2.

The design challenges for the wrapping operation included: the irregularly-shaped metal container added variability due to the box configuration; the decorations around the metal container; and the awkwardness of handling sticky shrink-wrap rolls to wrap such an irregularly-shaped package. The goal was to design and build a packaging system that would enable workers with disabilities to do the job at the required production rates with the desired quality.

Figure 20.3 shows the packaging system. The system includes a motorized turntable with a user interface, and two shrink-wrap dispensing units (one for horizontal wrapping and one for vertical wrapping). The system features two student design projects. A mobile Creform workstation was designed and built to hold the components. The workstation design and fabrication (including the two shrink wrap dispensers, bracketing and mechanical attachments of the turntable and motor as well as the design and

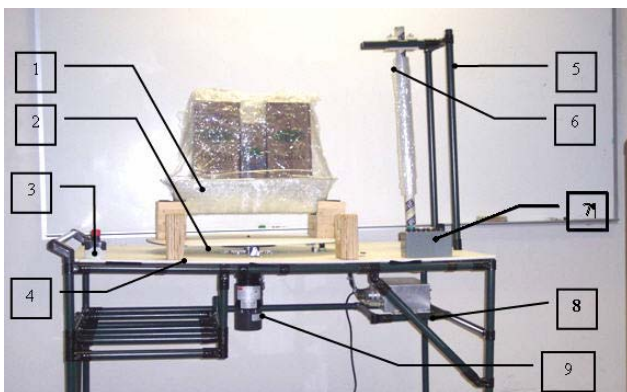


Figure 20.3. Semi-Automated Wrapping System

1. Box to wrap	6. Positioning clamp
2. Turntable	7. Switch Box
3. Emergency switch	8. Control Box
4. Horizontal roller	9. Motor
5. Vertical Roller	

machining of a customized slip clutch) was one project, and the design and fabrication of the electronic motor controller and user interface was the second. The turntable motor controller and user interface were implemented using relay logic.

The work table is made up of Creform, which is a plastic-coated steel pipe joined together with metal clamps. This plastic-coated Creform steel pipe is adaptive, and any desired structure can easily be configured. The worktable is made of white nylon that is .32 inches thick, 55 inches long and 38 inches wide, affixed to the Creform pipes. The turntable consists of a 29-inch nylon (same material as the table top) disc with two blocks of wood to hold the container in place. The turntable rotates on four caster wheels, each with a 2-inch diameter. The disc has a hole in the center and is connected to the Parallel Shaft AC Gear motor. The turntable rotates in a clockwise direction. A custom-designed slip mechanism between the turntable and the motor is used to avoid injury to a worker or damage to the motor in the event that the turntable gets stuck.

Two fixtures hold the rolls of plastic wrapping material: one for the vertical wrap and one for the horizontal wrap. The vertical roller has a pivoting mechanism to enable angled wrapping. This is necessary to accommodate the irregular and slanted shape of the container. The horizontal roller consists of a dispenser lying on two wooden blocks, and is placed between the user and turntable.

The motor control and user interface control box consists of a power supply (24VDC, 60 W), a 3-amp fuse for the user interface circuit and a 10-amp fuse for the motor. The operation logic is realized by using four 24V SPDT relays and one 120V DPDT relay. A timer relay is used to adjust the number of rotations of the turntable. Given the power requirements, the wire harness consists of 22 AWG and 16 AWG wires. There are two toggle switches (SPDT 15A): one for the main power and the other to select the mode of operation (i.e., sequential or express mode). An emergency stop switch is prominently positioned to be used in the case of an emergency.

The Packaging System greatly simplified both the ergonomic and cognitive demands of the job. The system provides two modes of operation: sequential and express. The sequential mode uses prompting lights, built into the workstation, to guide the

workers through the steps required for wrapping. More experienced workers would use the express mode, which does not stop and prompt at each step of the wrapping process.

The Packaging System uses a universal design approach wherein the goal was to design a process that would improve the production rate and quality of the packaging task for all workers and yet render the process more accessible for workers with disabilities. As the ergonomic process was simplified, it yielded a corresponding simplification of the cognitive demands.

Project 3: An assortment of fixtures

The group was charged with the task of designing or adapting existing materials for fixtures to assist workers in the process steps. Figure 20.4 shows some of the fixture concepts. Figure 20.4 (A) shows a fixture that can hold any one of four tools for the sanding, priming, or paint drying steps. The fixture in the foreground of 20.4 (B) was designed solely for the hammer. It has also been replicated and is in use.

In the background of Figure 20.4(B), a simple drying rack for the spatulas, a Styrofoam sheet, is shown. Figure 20.4 (C) shows a folding fixture. All of the tools are packaged individually or in groups of two to four in a cardboard box that has a hard plastic cover slipped over it. The folding fixture was designed to aid in the cardboard folding process. This fixture handles all the cardboard boxes used to package the tools.

Fixture 20.4 (D) is a wedge-shape fixture mounted vertically with the sharp edge of the wedge pointing up. The hard plastic outer covers come flattened and must be opened and shaped. A worker can slip the flattened plastic cover over the sharp end of the wedge and slide the hard plastic cover downward. As it moves downward, the wedge widens into the final shape of the outer cover and forces the flattened plastic to open to the correct configuration. Figure 20.4 (E) shows brushes drying.

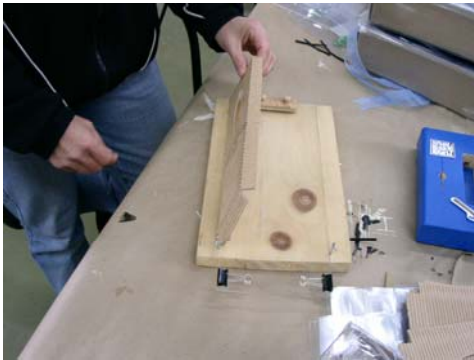
The total cost of projects 1 and 2 was approximately \$860. The cost of the project 3 fixtures varied from a \$3 to \$6 each.



(A)



(B)



(C)



(D)



(E)

Figure 20.4. Fixtures

Disability Advocates and Community Action Using World Health Organization's New International Classification of Functioning, Disability, and Health (ICF)

Designer: Ravindar Koorapati
Client Coordinator: Luke Zelly, Disability Network, Flint, Michigan
Supervisors: Dr. Robert Erlandson, David Sant, and Santosh Kodimiyala
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INTRODUCTION

The WHO ICF is emerging as the internationally-recognized standard framework for describing human functioning. In the U.S., the Center for Disease Control (CDC) has been the leading organization with respect to U.S. involvement. Federal agencies are working to incorporate elements of the ICF into their operations and databases with the long term intent of creating ICF-compliant databases. From a disability community perspective, U.S. providers and third party payers of durable medical equipment are particularly interested in the ICF and have started moving their data collection and client monitoring in that direction. Such applications will have significant implications for people with disabilities.

The WHO ICF conceptual model of disability captures the broader influences of activities and environment in defining disability, in that disability is seen as an interaction of the person, activity and environment. The major components of the ICF model are Body Function, Body Structures, Activities and Participation, and Environmental Factors. These four components are quantified using the same generic scale.

It is important for disability advocacy and service support groups to be knowledgeable of the ICF and its future impact. The ICF also provides a powerful vehicle for organizing information and data and for survey construction and planning activities. This will be particularly true as more and more organizations start using the ICF framework. For this reason, a computer-based process was developed for displaying the ICF framework (over

9000 elements possessing a hierarchical tree structure), and a data management process for creating core groups or core areas of policy concerns from the ICF elements.

SUMMARY OF IMPACT

This system is the front end to what must eventually become a more comprehensive planning and organizational tool for disability rights and advocacy organizations.

TECHNICAL DESCRIPTION

The ICF Analysis and Planning Program is written in Visual Basic 6.0. The program has five main sections. Section 1 provides a view of the ICF taxonomy using a collapsing and expanding tree structure and associated display area. Figure 20.5 (B) provides an example of this section. Section 2 allows a user to define what is called a Category. One important Category is that of people with disabilities that require the use of durable medical equipment. The ICF program allows one to specify, for each major component the ICF, those taxonomy elements that characterize that category. Hence, categories would be established based on Body Structure, Body Function, Activities, and Environment.

The third section allows a user to construct what are called Scenarios. Scenarios are a collection of Categories, one from each of the four major components. For example, a scenario might be for a person with quadriplegia who requires a mobile ventilation device for attending a church service. The ICF components and sub-components used to define the categories and scenarios define people in

their community who have needs as described by the scenarios.

The last two Sections of the program are not implemented. The staff of a client organization wanted to gain experience with the first three sections before taking on more completed procedures.

It should be noted that a collection of professional organizations worldwide have joined together to define what they are calling "ICF Core Sets." These Core Sets will be published in the Journal of Rehabilitation Medicine as they become available. The Core Sets are essentially the same as the Categories and Scenarios structure. The Core Sets define broad demographics, i.e., recovering stroke patients, recovering heart attack patients, and those with senile dementia or Alzheimer's disease. The client's focus is much narrower, concerning itself with community issues and the concerns of local citizens with disabilities.

Being able to clearly specify community members and their needs within the ICF framework will allow organizations to formulate community-based surveys and databases that capture community needs and concerns. They will be able to do this in a language that is commonly shared by insurance companies, Medicaid, other benefactors and care providers.

The ability to communicate in a common language (the ICF framework) will empower community organizations to more clearly understand how policy makers and planners are using the ICF to delivery, monitor, and assess the services they provide.

The cost of this project involved purchase of the CD-based WHO ICF framework, which totaled \$400. Also included in the cost was the cost of preparing CDs with the analysis and planning program for distribution to the client organization, which totaled \$5 per CD.

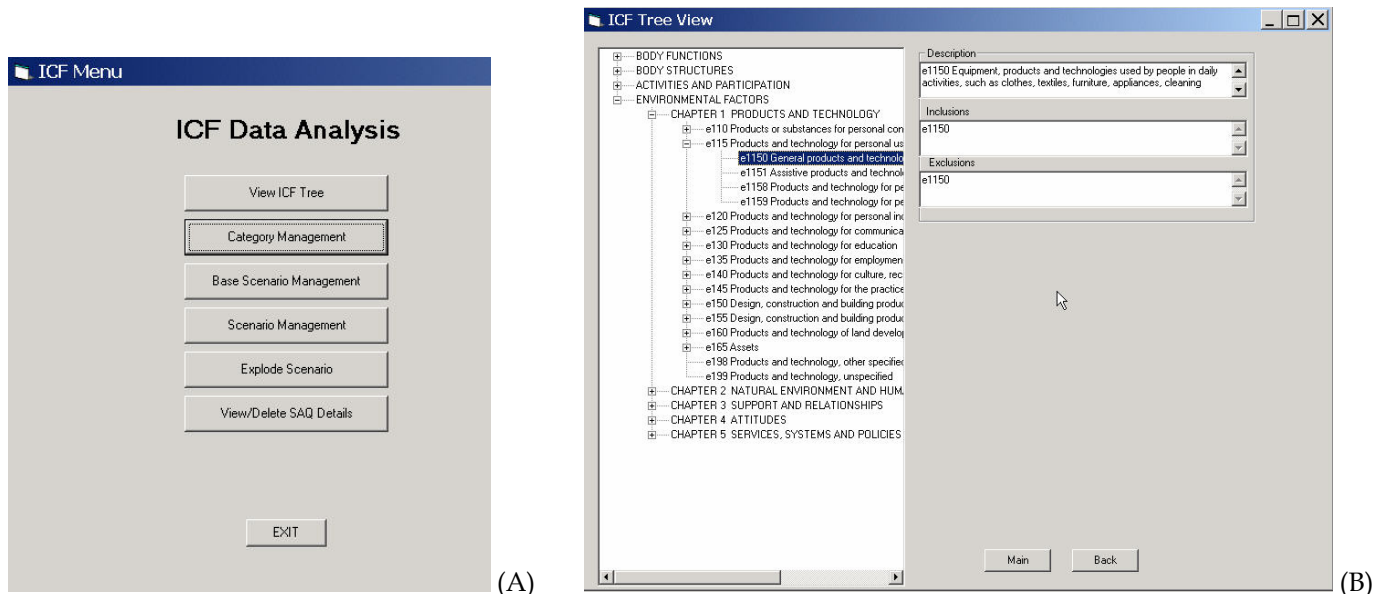


Figure 20.5 (A) Main Screen and Access to Program's Main Functions (B) ICF View Function - Taxonomy Opened to Environment Section

USER INTERFACE AND ACTIVITIES FOR THE RF TAG EDUCATIONAL ACTIVITIES SYSTEM

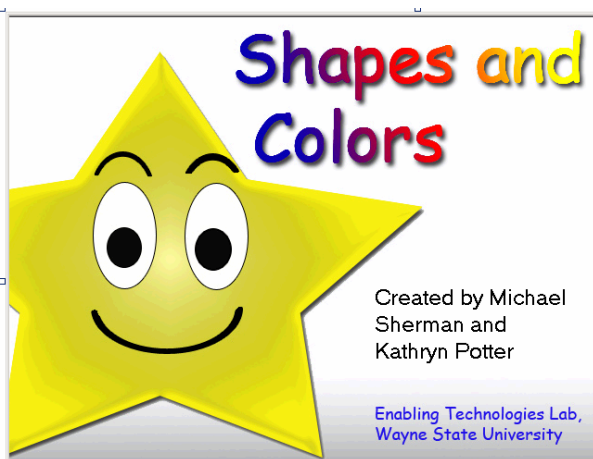
Designers: Kathryn Potter, and Michael Sherman
Client Coordinator: Christine Erlandson, Teacher, Madison Elementary, Wayne-Westland, Michigan
Supervisors: Dr. Robert Erlandson, David Sant, and Santosh Kodimiyala
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INTRODUCTION

An educational activities program was designed for the RF Tag Educational System hardware designed and built by an earlier design team. The aim of the project was to build a system that allows young children with cognitive impairments to develop pre-mathematical skills such as shape recognition, colors, patterning, sequencing and counting skills. The RF Tag Educational System is a multi-semester project, and this project builds on previous ETL student design projects where the following components were designed and built: essential system hardware, a reader/scanner (R/S) for RF tag detection and energizing, and an antenna. RF tags are embedded in a variety of shapes- squares, triangles, and circles. As the tags are placed onto the R/S, it transmits a code that is received by the antenna and the R/S sends the code to the PC and, hence, the game program. Each shape has a unique code. Example activities include identification of

shapes, colors, sequencing tasks, and patterning activities. An experienced first-grade teacher served as a consultant for the activities. She identified four areas and the appropriate levels of complexity for each area. Each activity had three levels of difficulty: very supportive, to moderate support, to no support.

The game includes four activities: color identification, shape identification, a sequencing task, and a patterning task. The first two tasks are very basic in that the students are asked to recognize different colors and geometric shapes. The sequencing and patterning activities also deal with essential pre-math skills. Children need to be able to identify and construct simple sequences. For example, place two red circles on the table. Or place one red circle, one yellow triangle, and two blue squares on the table. Lastly, pattern recognition is an important pre-math skill. The child is presented



(A)

Figure 20.6A. Opening Screen to Shapes and Colors



(B)

Figure 20.6B. Selection Screen to the Four Games

with two examples of a repeating pattern and shown only the first part of the pattern and asked to complete the pattern. For example, the child will see a red circle and a blue square, then another red circle and a blue square, and then the child will be presented with a red circle and asked to place the correct item on the table, i.e., the item that satisfies the preceding pattern. The program provides voice feedback and prompting.

SUMMARY OF IMPACT

The consulting teachers were favorably impressed with the implementation of their recommendations.

TECHNICAL DESCRIPTION

The program is written in Visual Basic 6.0, and communicates with the RF tag R/S hardware using a serial port. Figure 20.7 shows the R/S. A serial connector and power connector are shown at the rear of the device. This unit would sit on a table next to the PC. A collection of shapes (three are shown in Figure 20.7) are put on the table next to the R/S. As the child is prompted, he or she places a shape on top of the R/S. Each shape has an embedded passive RF tag. Each tag has a unique code that identifies the

shape via the program's database.

The final version of the game will use either wooden or plastic shapes with an embedded RF tag. Given that this version of the system is still a prototype, the designers and teacher consultant decided to use a simpler approach. The RF tag is embedded between two layers of thermally sealed heavy plastic. Three different shapes were used: circles, squares, and triangles. There are also three colors: red, blue, and yellow. Each shape additionally has three sizes: small, medium, and large. Such a selection of shapes and colors was deemed sufficient to teach and evaluate the system.

Microchip Inc. donated approximately 50 RF Tags for this project. The RF tags are termed cow tags because they are designed for use with cattle. The tag has a hole through which a pin is used to affix the tag to a cow's ear, which avoids branding. The tag is rugged, designed to withstand considerable temperature variation and mechanical deformations.

The cost of the system, hardware, software, and RF tags was approximately \$1,200.



Figure 20.7. Three Shapes on Reader/Scanner (Quarter to Show Relative Size)

MARK MY WORDS

Designer: Tom Koorapati

Client Coordinator: Carol Kitchen, Occupational Therapist, Special Education Teacher, Bovenschen School, Warren, MI

Supervisors: Dr. Robert Erlandson, David Sant, and Santosh Kodimiyala

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INTRODUCTION

A game was developed to help moderately cognitively-impaired elementary-aged students develop the fine motor coloring and pre-writing skills necessary for writing. To help the students properly grasp and orientate the pencil to the paper, hand-over-hand assistance and utensil grippers are used. The students start by imitating vertical and horizontal lines. Eventually the students are ready to begin tracing vertical and horizontal lines, and shapes. With these emerging tracing skills, it is still difficult for the students to visually attend to the paper and the lines. To increase visual attending, the client coordinator on this project (who is also an occupational therapist and a teacher) developed a word tracing game. The game is based on car racing. A large colored block letter with a dashed line running through it, directional arrows and a start and stop icon. The students can be timed and scored for accuracy as they follow the dashed line tracing the letter. As the student gains proficiency with a single letter one can move to words. The game became so popular among the students that the developer was able to use this method to run pre-writing and handwriting groups. She could work with 10 students at a time with the help of a paraprofessional.

One of the main drawbacks of this pre-writing, tracing program is the time it takes to make up a name sample. The developer has created many shortcuts, but it still takes her about 30 minutes to complete an average name sample. She has a growing list of names and words, but the students are most engaged when they are tracing their names (first and last) and words of items special to them. Even though she has developed a method of word using PowerPoint and its drawing features, it is still a complex time-consuming task.

SUMMARY OF IMPACT

The program has been delivered and is being used by the client coordinator and her students. She and her colleagues are very pleased with program and the capabilities it affords them. The students love the writing games, and are using it more often since it is so easy for the teachers to prepare new material.

TECHNICAL DESCRIPTION

Mark My Words is a software program designed to produce stylized words created by special education teachers. It is written in Visual basic 6.0. These words are to be used by children with disabilities to improve the fine motor skills necessary for writing. The words are big block letters with a dashed line running through them. A green light represents the starting point and arrows placed along the dashed line indicate the direction for tracing. A red light indicates the end of the tracing path. Figure 20.8 shows an example of a stylized word.

The block letter with the desired icons is saved as an image, which is the central point. As an image, it can be scaled to a desired size. It can be inserted into documents. In this way the teacher can recall the word and resize the entire word with the dashes and embedded icons changing size in proportion to the block letters.

While this sounds quite simple this process was technically quite sophisticated and complex. The Mark My Words program will allow many more teachers to construct easily a wide variety of customized words for use by their special education students.

Figure 20.9 shows the startup screen. The user is asked to type in a word. The lower portion of the screen shows the default letter color and the dashed (tracing line) color. The Edit menu in the toolbar allows the user to change font styles, letter color, and tracing line color. To create image with dashes, the user clicks the button "Create image with

dashes” or “Tools”->“Create dashed image.” A customized program using a positioning algorithm then creates the block letter and draws the dashed line in the center of each letter.

Figure 20.8 shows the icon insertion window. After the program creates the block letter and the centered

dashed tracing line, the teacher must add the start, stop and direction tracing icons. A palette of icons is provided and these can be dragged and dropped onto the letter. Once on the letter, the icons can be resized to fit the letter. In this way, the program provides a natural and familiar procedure for block letter creation and marking.



Figure 20.8. Example of a Stylized Word, Shown on a Design Screens

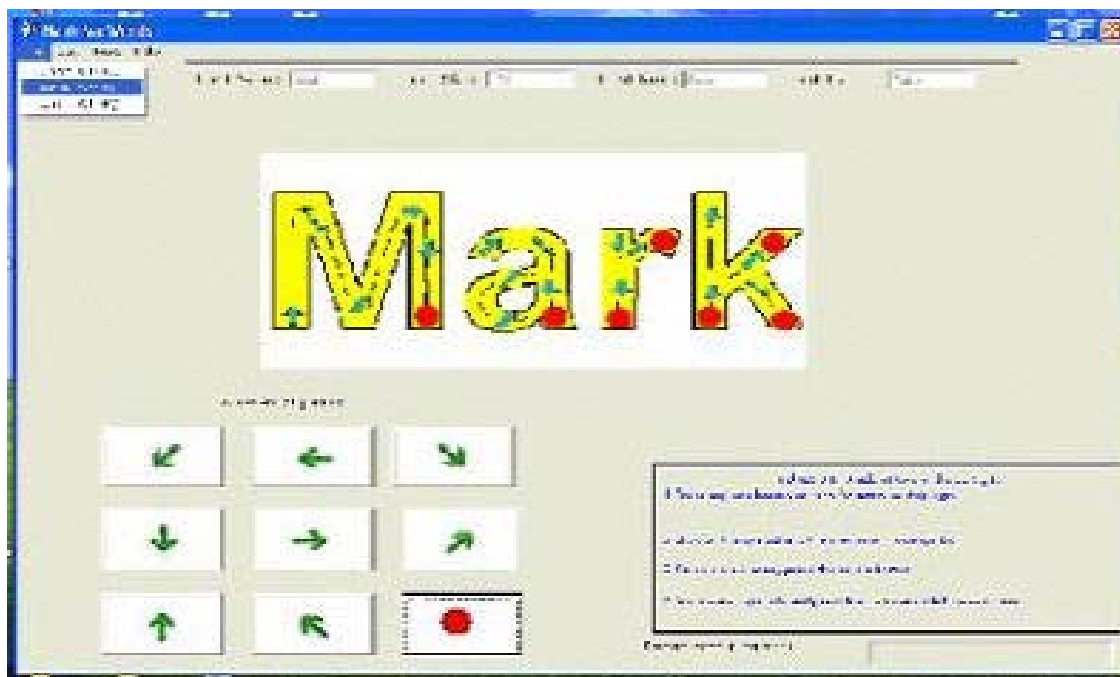


Figure 20.9. Start-Up Screen with Word Typed by a Teacher



CHAPTER 21

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Dayton, OH 45435-0001

INTRODUCTION

Teachers in a middle school disability classroom desired a lighted ceiling for their current “visual room”. The room consists of several visual therapy aids with rotating/flashing lights, including fiber optics. This room is designed to calm children during tantrums or episodes and to provide sensory stimulations.

The room was generally inviting except for its bare ceiling, which looked old and unattractive. The client wanted to give the ceiling a soft “cloudy” look

with lights that run in different patterns for students to follow with their eyes. The client also wanted to have lights that are accessible for easy bulb replacement.

The final design is a set of ceiling panels with embedded rows of lights. The lights may run in different patterns. Fabric panels overlay the ceiling tiles, achieving the desired cloudy appearance.

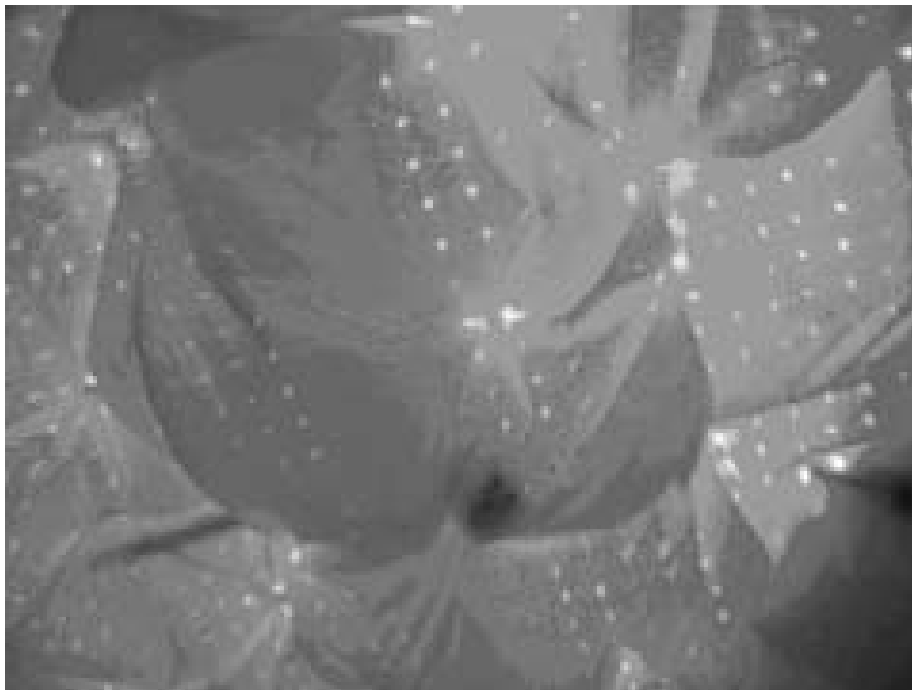


Figure 21.1. Lighted Cloud Ceiling

SUMMARY OF IMPACT

The lights will improve the therapy room's design, contributing to both the calming and stimulating purposes of the room.

TECHNICAL DESCRIPTION

The device consists of 18 strands of LEDup brand LED Christmas lights embedded into the ceiling panels. Nine pairs of strands are connected to one another and one from each pair is plugged into one of nine sockets in the project box.

The project box contains two breadboards, one with the LM555, the 4017B and 2- 7416 inverters, and the other board containing 9 TRIACS and TRIAC drivers. These chips are soldered with several other components (resistors, capacitors, etc.). The project box and circuit are clamped to the ceiling, where the AC power supply is available and is controlled by a switch in the room. The procedure for using this

device simply involves flipping a switch. There are no operation range limitations involved.

The arrangement of the lights allows a six-inch clearance around the sprinkler, and the pipes in the back of the room do not interfere with the design. Holes were drilled in the ceiling pads such that the lights are 3 inches apart and cover maximum area of the ceiling as desired. There are 18 rows of lights varying between 62 and 17 lights per row. However, because of the limitations of the circuitry, two rows were clumped together to illuminate at the same time. There are nine possible separate illuminations. To get the exact number of lights for each of the rows, these light strands were cut into smaller strands. Since these LED lights drew little current, a 2W, 560 Ohm resistor was used in the beginning and the end of each strand to drop the current. Given that these strands were smaller, the designers attached resistors, male and female plugs at the beginning and the end of each strand.



Figure 21.2. Ceiling with Fabric

Store-bought sheer fabric was sprayed with a fire-resistant spray. Three long panels of approximately seven yards each were cut and randomly pinned on the ceiling to give a cloudy billow effect.

A timing circuit was needed for controlling the lighting sequences. A versatile 555 timing chip (LM555) was used for this purpose. A 4017 Decade Counter was implemented to provide sequential logic output for pulse control of the timer.

An AC solid state relay was used to provide logic control of the 115V AC power for the lights. An AC solid-state relay was constructed using a 400V-4A TO-220 type TRIAC and an opto-coupled MOC 3031 Optoisolator TRIAC driver. The MOC 3031 contains an infrared-emitting diode optically coupled with a detector. The driver and TRIAC created a zero-voltage crossing circuit controlled by the logic output from the decade counter. A zero-voltage crossing circuit is a circuit that switches the load on or off only when the power-line sine wave passes through zero. When AC voltage is zero, no current

flows, thus making it easier and safer for the relay to turn off or on. Given that the MOC3031 required a low level logic input, an inverter was used to invert the logic output obtained from the decade counter. A snubber arrangement to protect the TRIAC from reverse voltages was also used.

All parts of the circuit were individually soldered and tested, and then put together into a project box. Holes were drilled in the box and circuit board clips were inserted through them to hold the circuit boards. Several holes were drilled in the box to insert female plugs that were then connected to the male ends of the LED lights. Two more holes were drilled for an AC input to the circuit and a DC input from the transformer that drops 115V AC to 9V DC.

The total cost was approximately \$860.

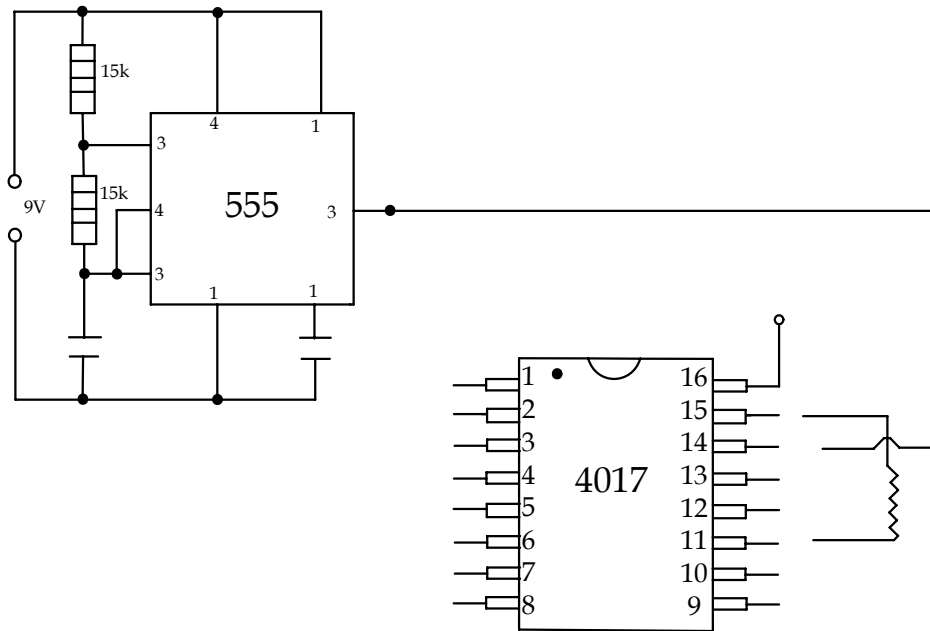


Figure 21.3. Timer and Decade Counter Circuit

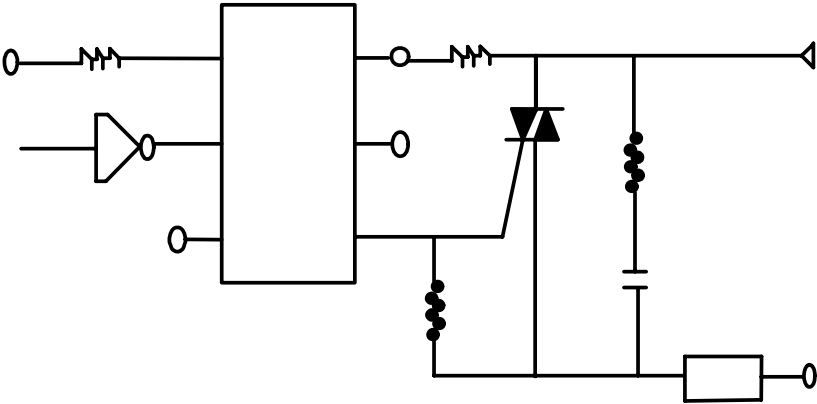


Figure 21.4. AC Solid State Relay Circuit

NURSING ALERT SYSTEM

Designers: Austin Balogh, and Jack Conyers III
Client Coordinator: Guy Parworth, United Rehabilitation Services
Supervising Professor: Dr. Thomas N. Hangartner
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

The staff of a rehabilitation center requested an efficient and standardized method of contacting the nurses in case of an accident or emergency. The nurses' station is located in a centralized location between several problem areas in the building. Although the nursing staff conducts rounds at various times throughout the day, nurses remain in the station for the majority of the day. If an emergency occurs, staff members must leave the scene to alert a nurse, or send another patient for help. The system is composed of five pieces: a nursing station unit and four units for locations where emergencies are most likely.

SUMMARY OF IMPACT

The problem area units allow a signal to be sent to the nursing station unit, which triggers an alarm and allows the nurses to send an acknowledgement that the alarm was received.

TECHNICAL DESCRIPTION

The system uses DC Voltage transformed from a wall outlet using a plug-in transformer. The chosen voltage was 9V since the BASIC Stamps microprocessors used to run the system are required to use a variable voltage from 6VDC to 24VDC. A current of 500 mA is sufficient to power all components. The nursing station unit issues power and commands to the four problem area units. It constantly queries the problem units. The problem units signal information in binary form if a button is pressed locally.

The nursing unit has one button for acknowledging if an alert comes in. It also contains eight LEDs, two per problem area. They show when an alert is present, and acknowledge that it has been pressed for a specific area. Another nursing unit feature is a buzzer alarm, which sounds when an alert comes in.



Figure 21.5. Nursing Station Unit Installed.

Each problem area unit consists of two buttons: an alert and reset. There are also two LEDs present on each problem unit: one informs the user that the button was pressed and the information has been sent to the nursing station, and the other shows that help is on the way once the "acknowledge" button has been pressed at the nursing station. The system is connected on a network.

When an "alert" button is pressed in any problem area unit, the nurses hear the alarm and press the "acknowledge" button in the nursing station unit. As soon as the "acknowledge" is pressed, the alarm sound ceases. The "acknowledge" light illuminates on the problem area unit panel showing that help is on the way. In addition, the "acknowledge" light illuminates in the nursing station, showing the nurses that the information was sent. After the problem is resolved, the nurse or staff member presses the "reset" button on the problem area unit panel. This turns off all unit area lights and resets the unit. In the case of an "acknowledge" being pressed before an alert is pressed, nothing happens and the system continues to run normally. In the unlikely case of all four or any combination of rooms having simultaneous problems, all lights remain on,

and the alarm sounds each time a new "alert" is received.

The total cost of parts and labor was approximately \$740.

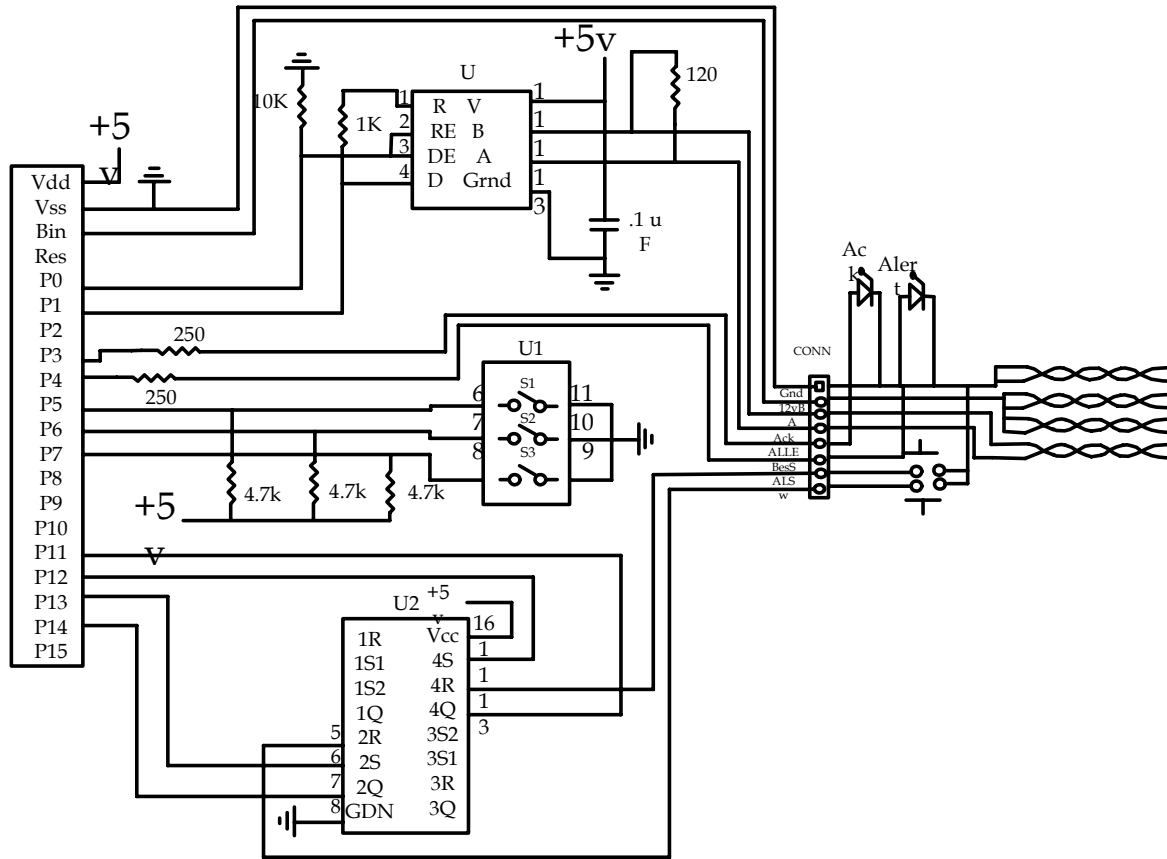


Figure 21.6. Problem Area Circuit Diagram

HAND WASHER

*Designers: Johanna Bell, and Grant Roush
Client Coordinator: Guy Parworth, United Rehabilitation Services
Supervising Professor: Dr. David Reynolds
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001*

INTRODUCTION

An automatic hand-washing device was designed to assist individuals with hand washing. The machine was required to have an independent power source to run electrical components, and to have water run into and out from it. The device has inner and outer housings. The inner housing is a water chamber, which contains the washing sponges; the user places a single hand inside this chamber. The outer housing contains a battery-powered motor used to spin sponges to scrub the hand. Plumbing provides water, and soap is available.

SUMMARY OF IMPACT

The mechanism utilizes soap and water, runs off of DC current, is stationary in a restroom setting, and fits easily into the space allotted.

TECHNICAL DESCRIPTION

The design incorporates electrical parts and moving parts with water. There are two housings: an outer housing that encases the motor, solenoid and electrical components, and an inner housing that encloses the sponges and flowing water (showerhead). The housings are made of acrylic. The acrylic is 1/4" thick on all sides, except the base, which is 3/8" thick. This allows for a sufficient surface area for bonding the pieces together. Minimal water exits the housing during washing with the aid of clear silicon sealant and Teflon tape.

For water input, a 12V, 14-watt solenoid valve is used to turn on and shut off water flow. The solenoid valve is rated for 80PSI, which is the standard water pressure in the building where it is to be used. The bottom of the inner housing has a hole cut into it to support a drain where water will be directed into one pipe that removes the waste water. Under ideal conditions, the device will be hooked directly into the building plumbing.

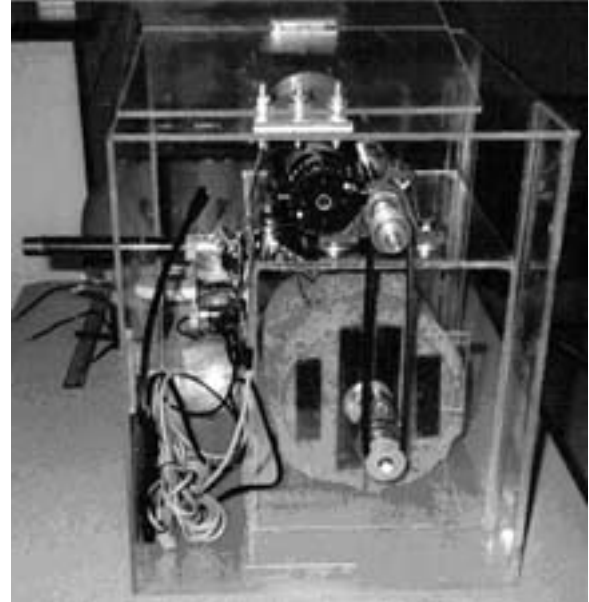


Figure 21.7. Hand Washer

A small, low-powered motor is used to spin the driveshafts of the sponges. The system uses two gears, one on the motor and the other on the driveshaft that is attached to the top of the inner housing. The gears use a 2:1 ratio; the larger gear is on the motor to increase the speed. The drive shaft on top of the inner housing is secured by two pillow blocks mounted to the top of the housing. This driveshaft drives two belts used to spin driveshafts on which two sponges are mounted on discs. The belts are connected to the driveshafts using 4 V-belt pulleys, and the sponge driveshafts are attached to the inner housing using two bolt flanges. A 12V DC, 136RPM motor is used to power the sponges. The low-voltage allows for the safest possible environment for the user.

Two batteries are used: one 12V, 7.5 Ah for the solenoid, and one 12V, 18 Ah for the motor. These batteries are rechargeable, and use connections that

allow minimal contact with the terminals. The batteries are hooked up to the components using relay switches and infrared LED optical sensors. The relays function to minimize the current flow through the switches, since they can handle only 100 mA. The optical sensors are used to trigger the “on” and

“off” setting of the device, and are mounted around the inner housing. When a hand is inserted, the device turns on; when a hand is removed, the device turns off.

The total cost was approximately \$1155.

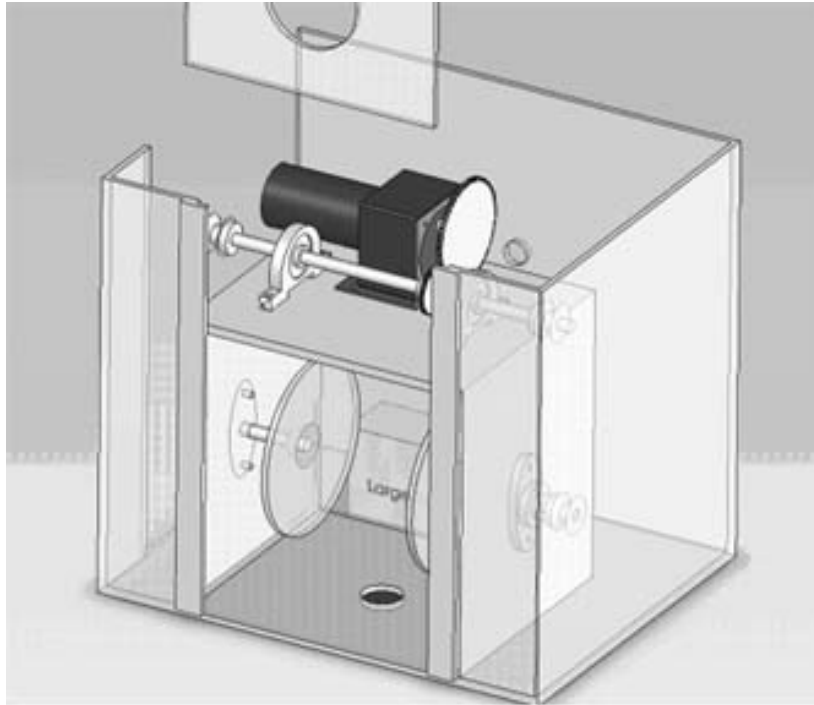


Figure 21.8 Solidworks CAD Drawing of Final Design

AUDIO-VISUAL ALERT SYSTEM

Designers: Andrea Bolds, and Victoria March

Client Coordinator: Guy Parworth, United Rehabilitation Services

Supervising Professor: Dr. Ping He

Biomedical, Industrial and Human Factors Engineering Department

Wright State University

Dayton, OH 45435-0001

INTRODUCTION

Staff members at a rehabilitation agency requested an audio-visual alert system in their adult activity center (AAC) room to notify the staff when a “help” button is pushed in the women’s or men’s restroom. The activity center is adjacent to both the women’s and men’s restrooms. At any given time, there are a total of five employees in the AAC room, all of whom are trained to respond to the call button from the restroom. The noise level in the AAC room often prevents these employees from hearing the alert siren from the restroom. The new design was to work in conjunction with an existing alert system.

SUMMARY OF IMPACT

The new system works in conjunction with the existing system, and expands the alert area by placing a second light tower in the AAC room. The women’s and men’s restrooms each have six stalls. A red pushbutton is located in each stall. When the button is pushed, it triggers a siren, and a blue light begins to flash outside the corresponding restroom. At the same time, a light tower turns on and the system flashes blue for men and green for women. The siren and the flashing lights do not stop until one of the reset buttons is pushed. This system requires little to no maintenance.

TECHNICAL DESCRIPTION

The system is composed of five major components: two transmitters, two receivers and a light tower that informs the staff in which restroom (men’s or ladies’) an alert button has been pressed.

Transmitter I is the reset button, and the only part of the system with which users will have contact on a daily basis. This wireless mobile pushbutton is located on the wall, under the light tower. The device runs off a 9-volt battery. Because the comparable receiver has a one-meter-long wire, the range of the transmitter is 500 meters. Receiver 1 is used for the reset. The receiver is powered by a 15V



Figure 21.9. Light Tower Installed in the Adult Activity Center

DC transformer. It is located in a project box in the AAC room next to the reset button.

Transmitter 2 is a two-channel transmitter that is normally controlled manually, modified so that it now functions as a voltage-controlled switch. A 12-volt DPDT relay was used to short-circuit the pushbutton switch. To reduce maintenance requirements, the transmitter was changed from a 9-volt battery to a 9-volt DC transformer. This transmitter is located in the ceiling of the men’s restroom; the location of the central hub. The range on this transmitter is 500 meters, the same as the one-channel transmitter. A voltage of 13.75 volts goes through the relay to activate the pushbutton. This voltage comes from the red pushbutton in the

restroom. Receiver II is located in the AAC room and is connected to the light tower. This is where the signal is received to turn the light on. The power supply is a 24-volt transformer.

The light tower (Patlite Corporation) is located in the AAC room. It has two different alarm sounds. The blue light is paired with alarm 1 and the green light

is paired with alarm 2. The sound is adjusted via a knob at the bottom of the tower. The range is from 0 to 90 dB. The client requested a minimum sound level of 70 dB. The maximum volume of 90 dB was used. A project box, close to where the transformer plugs in, holds the 1A fuse for the tower.

The total cost was approximately \$950.

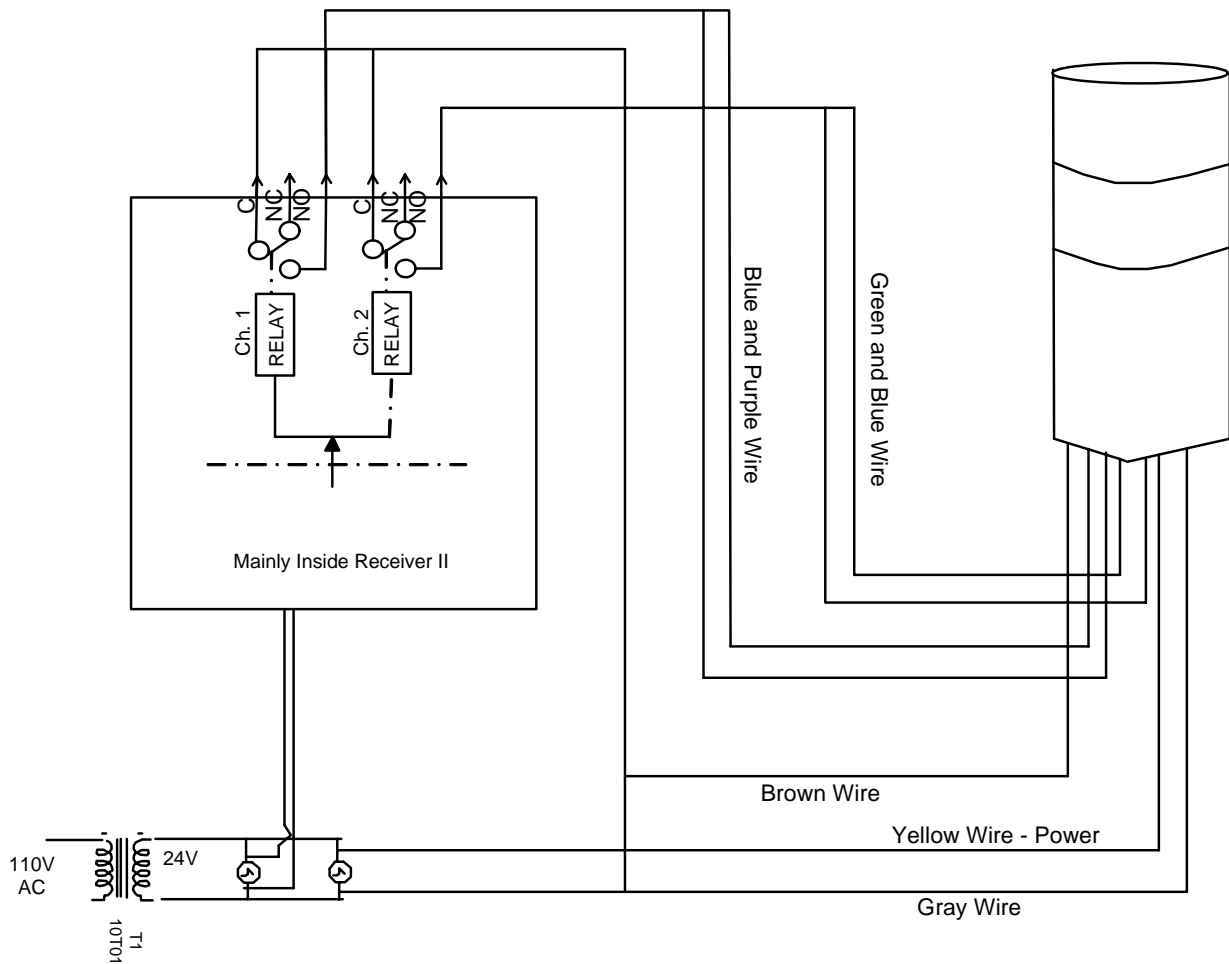


Figure 21.10. Connections between Receiver II and Light Tower

PAPER COLLATING MACHINE

Designers: Chet Closson, and Emily Ervin
Client Coordinator: Guy Parworth, United Rehabilitation Services
Supervising Professor: Dr. David Reynolds
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

A device was designed to aid a client in sorting a stack of papers into different piles, one sheet at a time. The client has the cognitive capability to decide where each paper is to be placed, but has physical limitations that make it difficult to sort the papers independently. The device specifications included being lightweight and portable. Additionally, the device was to be durable and to function as quietly as possible so as not to disturb others.

SUMMARY OF IMPACT

The user must have good arm control because the arm needs to stay in place for several seconds in order for the suction to begin lifting the paper. The user also may need to practice in order to lift the sheet of paper successfully and move it to the desired location.

TECHNICAL DESCRIPTION

The device consists of four major parts: the vacuum housing box, the vacuum, tubing and wires, and the arm piece. The purpose of the vacuum housing is to contain the vacuum and decrease the amount of noise. The box was created of scrap plywood. The length, width and height of the housing are 12, 9, and 6 inches, respectively.

The top of the box sits on hinges to allow easy access to the inside. On top of the box is a gold handle used to carry the device. The front has a latch for keeping the lid closed when transporting the device. There are three slots in the back of the housing for ventilation. On the left side of the box, a one-inch square has been cut out for the vacuum cord. When the device is not being used, the cord can slide through the hole and back into the box for storage. The right side of the box has a circle cut out with a diameter of $\frac{3}{4}$ ". This is where the tubing and wires fit through the box. When the device is not being used, the tubing can be wrapped around the two

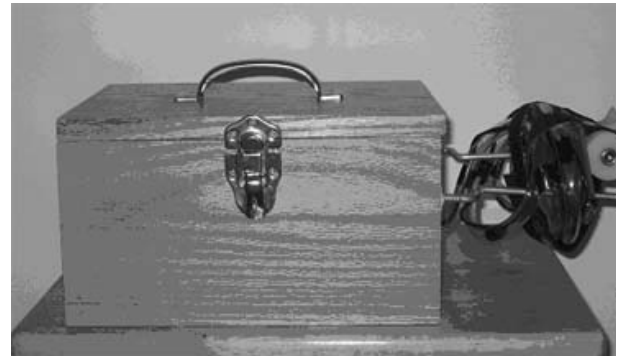


Figure 21.11. Front View of Paper Collating Machine

metal hooks attached to the right side. The hooks are screwed into the box, and are used only for storing the tube.

The vacuum is a computer keyboard vacuum. It is a standard vacuum that plugs into the wall and runs off 120 volts. A small vacuum was used in order to reduce the amount of suction and also to keep the device lightweight. The vacuum is secured to the bottom of the box with a bracket to prevent it from moving during transport.

Polyethylene tubing, with an inner diameter of $\frac{3}{8}$ " and an approximate length of five feet, connects directly to the end of the keyboard vacuum. It attaches to a brass fitting at the other end. The fitting has a tight seal with the arm piece. Two five-foot 18-gage wires are taped to the tubing. These wires connect the vacuum switch to the switch in the arm piece. They are taped to the tube to prevent tangling.

The arm piece was machined from a nylon cylinder approximately $1\frac{1}{2}$ " in diameter. It is six inches in length and has a $\frac{3}{8}$ " threaded hole on each end. One end allows the fitting for the tube to twist into place. The other end was created only to simplify the drilling process. This end was closed off with a flat

fitting that was threaded into place. The bottom of the arm piece has two grooves, two threaded holes, and one rectangular hole. The two grooves were cut to keep the Velcro straps in place when the client is using the device. The threaded holes were created to screw suction cups into place. The rectangular hole was created for the switch. Two smaller grooves were cut from this hole, allowing the wires attached to the switch to sit slightly inside the piece and not

dangle in the way. The metal block fits over the switch to protect it, and is simply screwed into the nylon cylinder. On the top of the cylinder, a flat piece of acrylic is screwed into place so that the cylinder will not rotate on the user's arm when moving the arm piece.

The total cost of parts and labor was approximately \$570.

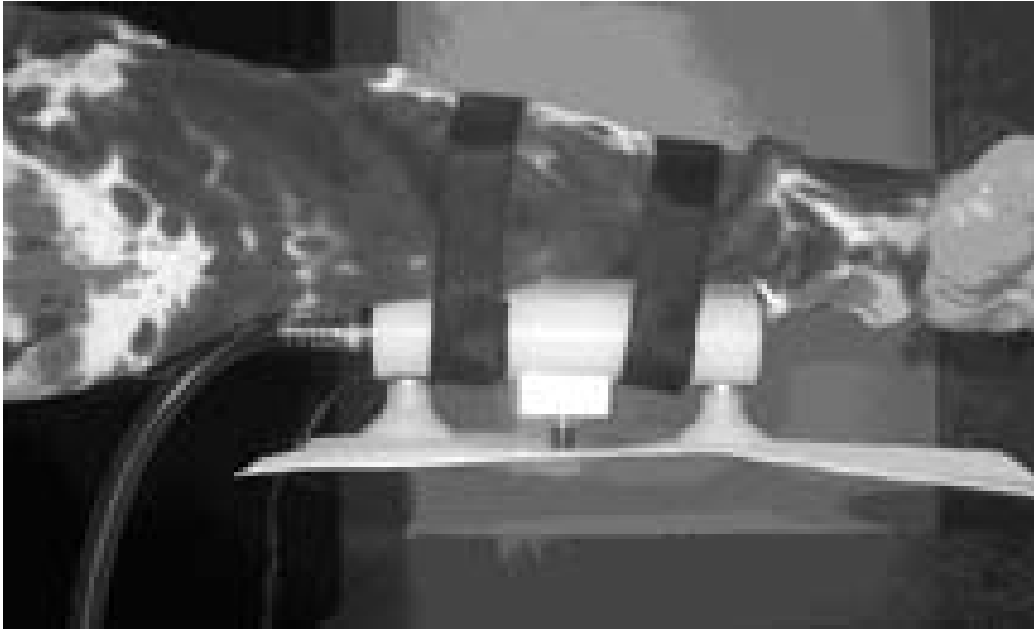


Figure 21.12. User Successfully Lifting a Single Sheet of Paper

ADAPTED RADIO

Designers: Veena Ganeshan, and Andrew Maley
Client Coordinator: Guy Parworth, United Rehabilitation Services
Supervising Professor: Dr. Blair Rowley
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

A standard radio was adapted for clients with limited fine-motor abilities so that they could independently control on/off, volume up, volume down, station up, station down, and AM/FM toggle switches. The radio was to be durable.

A conventional radio was rewired to accommodate adapted switches and a unique control interface upon which to mount the switches was built. A moderately priced model radio was rewired and fitted with headphone jacks so that adapted switches could be plugged into it. A wooden control interface was built and lined with Velcro so that switches could be attached to it and be easily rearranged.

SUMMARY OF IMPACT

This radio is now operable by both the factory set buttons and any adapted switch that uses a 1/8" headphone plug. All factory-set buttons still operate as standard button switches and all functions may also be operated by pressing the appropriate adapted switch. Operating the radio requires only the push of a factory button or adapted switch that corresponds to the function desired.

The clients who were previously unable to operate standard switches can now operate the radio using the adapted switches. Users are able to reach the switches because of the specially designed interface. The device does not use more power than a standard radio, takes up only slightly more space

than a standard radio, and does not require much training to use. It allows the users independence with a task that they could not previously perform.

TECHNICAL DESCRIPTION

The dimensions of the radio are 8.5" X 3.5" X 10.8". Each speaker is 4.7" X 5.9". The weight of the radio is approximately seven pounds. The radio is rewired and designed to operate using adaptive switches with 1/8" plugs. These switches are placed on a wood interface that consists of two parts. The wooden base has Velcro on top, used to attach the wood blocks to the base. The wood blocks have Velcro on the bottom to stick to the base. The blocks are designed with a vertical and an inclined portion for support and ease of use.

The mechanical design consists of two parts: the wooden base and six wooden blocks. The wooden base is a 3' x 2' oak-plywood board with Velcro on top and two handles for easy carrying. The second part consists of six wooden blocks. Each block is made out of 4" X 4" X 6" wood chemically treated to withstand all weather conditions. There is Velcro on the slope and the bottom of the block. There is a hole on the top of the block, allowing the wired portion of the switch to pass through the back of the block. This prevents interference with the front portion of the interface. The sharp edges on the wood board were smoothed using sandpaper and lining to reduce the risk of injury.

The total cost was approximately \$770.



Figure 21.13. User Operating the Adapted Radio

HEAT- AND OCCUPANCY-DETECTING SYSTEM

*Designers: Jenna Garber and Mark King
Client Coordinator: Alena Hagendorn, Ohio Transportation Center
Supervising Professor: Dr. Ping He
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001*

INTRODUCTION

A device was built to detect when there is an occupant in a vehicle and to track the temperature in a closed car. The device also automatically cools the car down when an occupant is inside at dangerous temperatures. An alarm system coincides with the car's cooling system to seek outside help in case the victim has no means of exiting the car without outside intervention. Door and engine sensors were added to make the device user-friendly and reliable.

SUMMARY OF IMPACT

Situations in which false alarms could be signaled include getting into the car while it is hot or driving in bumper-to-bumper traffic on a hot day. Both the engine and door sensors provide safeguards and a way to reset the circuit. These ensure that the system only activates in hazardous conditions.

TECHNICAL DESCRIPTION

A passive infrared motion sensor was selected for its ability to specifically detect heat radiation that living beings produce. This allowed a natural filtration via the glass windows of the car to prevent pedestrians from setting off a false motion signal, as infrared does not pass through glass easily. It also ensured that a change in heat radiation in the system is a living being, rather than someone bumping the car, or an object falling in the car, both of which would activate a motion sensor.

A basic thermistor (143-502LAG-RC1, Newark Company) was selected as the temperature-sensing device based on cost and reliability. The thermistor changes its electrical resistance in response to temperature changes. Resistance can be calculated by extrapolating the change in voltage within the circuit. Application of this principle to a basic comparator circuit proved to be the most optimal and accurate way to read temperature.

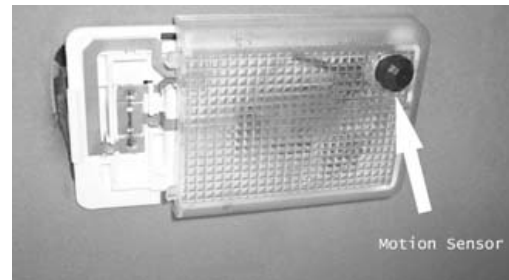


Figure 21.14. Motion Sensor Installed

The product sits in a 1.5" x 9" x 5". plastic box. Once the device is installed in the user's vehicle, use is simple. If the system triggers by mistake, one need only open any of the doors or start the engine, as either of these actions immediately deactivates the horn and ventilation system. If, for some reason, this does not shut off the system, the user can simply separate the plastic connector that connects the product box to the car wires.

The transistor must support the current needed to trigger the relays connected to both the horn and the ventilation system. The relays required 160 mA. The NPN 2N2904 Transistor used can handle up to 200 mA of current. The Napion AMN12111 motion sensor was selected because of its size and its ability to detect slight motion. The slight motion detector allows very little movement before a signal is sent. The detector covers the entirety of the interior of the 1994 Saturn SL2 car in which the system is installed. The motion sensor provides an additional advantage of being able to be wired in parallel, offering bigger cars the advantage of having several motion sensors to ensure full coverage in the vehicle.

The thermistor permits the temperature/resistance relationship to stay within a 5% stability range. Once the final product was installed in the test car, it met all of the specifications.

The total cost was approximately \$530.

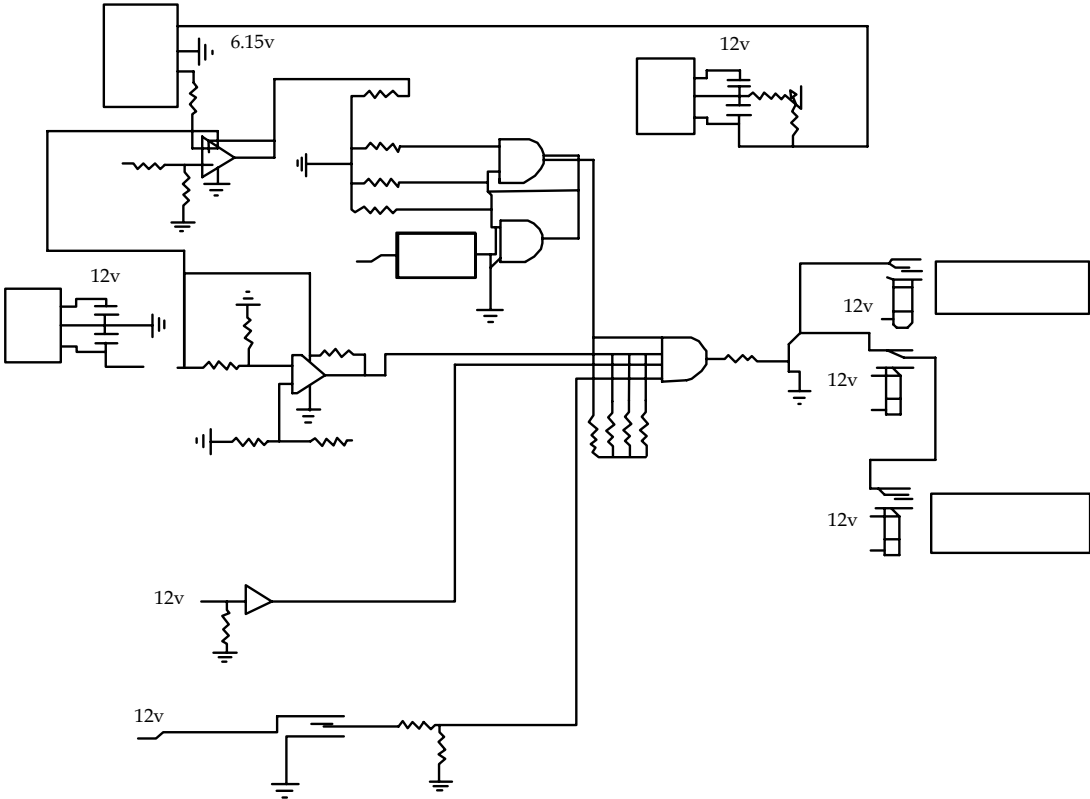


Figure 21.15. Circuit Diagram

ACOUSTIC VIBRATING PILLOW

Designers: Christina D. Schrider, and Jennifer Wappler
Client Coordinator: Diane Fredericks, Fairborn Primary School
Supervising Professor: Dr. Julie Skipper
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

A vibrating acoustic pillow was designed for children with autism in a special needs classroom. The product was requested to fulfill a need for an additional therapeutic device for the four- and five-year-old students who are receiving sensory integration therapy. The goal was to develop a design similar to the Somatron line of sensory pillows, mats, and chairs, yet include a stronger source of vibration and an integrated music source.

SUMMARY OF IMPACT

The new soft textured pillow that plays music and provides strong vibration is now in use in a classroom sensory integration therapy program.

TECHNICAL DESCRIPTION

The final design consists of a removable, stretch fabric cover with a pocket for the children to nestle under. The stretch fabric was also used to contain expanded polystyrene pellets in a three-section, two-layer bean-bag style pillow with two compartments used to house water mattresses, which assist in vibration wave propagation. The pillow was designed with hook and loop fasteners on the compartments housing the water mattresses, which allow access for repair or replacement in the event of a leak. All of the pellet compartments were sewn closed to prevent accidental ingestion of the pellets.

Hitachi massagers were used to provide vibration through contact with the water mattresses from beneath. They are embedded in the crib mattress foam and memory foam wedge. A Pillowsonic speaker system, located in the memory foam wedge under the child's head area, provides sound for the user but is not obtrusive to others in the classroom. The power, music components, and vibration control switches are in a foam wedge and base housed inside a steel project box under the pillow.

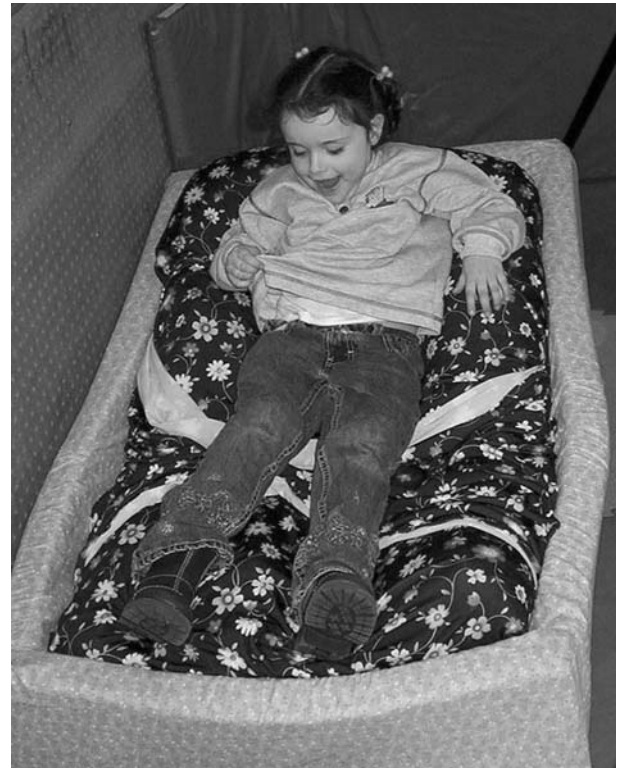


Figure 21.16. Child Using Acoustic Vibrating Pillow

The music and vibration are initiated simultaneously via dual-switch operation consisting of one on/off rocker switch and one timer switch. The power switch and timer switch work together to supply power to the pillow, but the power switch allows the user to interrupt a session before the timer has returned to the zero (off) position.

To meet classroom space constraints, the acoustic vibrating pillow was designed to be small. Additionally, the size, weight, and nylon belting handles ensure portability. The final dimensions of the product are 42" long, 28" wide, 14" high at the head, and 9" high at the foot of the pillow.

The total cost was approximately \$725.

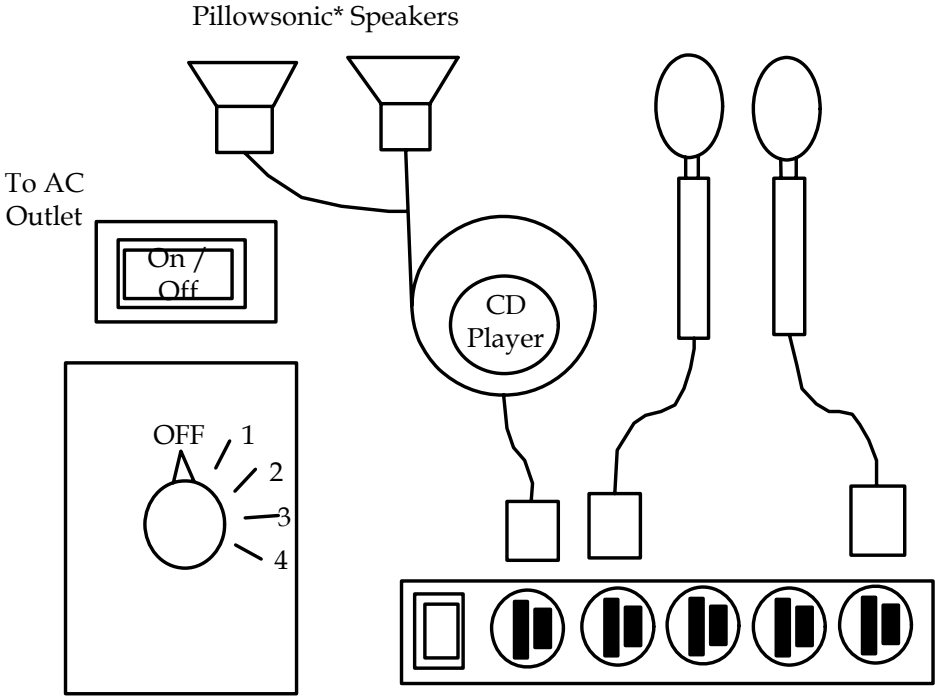


Figure 21.17. Circuit Diagram for the Acoustic Vibrating Pillow



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