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2001
ENGINEERING SENIOR DESIGN PROJECTS TO AID PERSONS WITH DISABILITIES

Edited By
John D. Enderle
Brooke Hallowell

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FOREWORD

Welcome to the thirteenth 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 NSF[1], 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.

This book, funded by the NSF, describes and documents the NSF-supported senior design projects during the thirteenth year of this effort, 2000-2001. Each chapter, except for the first three, describes activity at a single university, and was 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 and outcomes assessment 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

[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.

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 that were 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 was 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 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 Mr. William Pruehsner for technical illustrations, and Ms. Melissa Elliott and Ms. Natalie Douglas 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 & 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 a faculty member in 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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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, are prohibitively expensive, or are nonexistent. Many persons with disabilities do not have access to custom modification of available devices and other benefits of current technology. Moreover, 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 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 years past include a laser-pointing device for people who cannot use their hands, a speech aid, a behavior modification device, a hands-free automatic answering and hang-up telephone system, and an infrared beacon to help a blind person move around a room. The students participating in this program have been richly rewarded through their activity with persons with disabilities, and justly have experienced 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 2000-2001. 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 three 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.

After the three introductory chapters, 16 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 the device modification is usually included. Next, a technical description of the device or device modification is given, with parts specified only if they are of such a special nature that the project could not otherwise be fabricated. An approximate cost of the project is provided, excluding personnel costs.

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 individuals with disabilities.

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] 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 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-

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[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.

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 relationship.

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. Manufacturer's 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 as much detail as possible in the specifications. Specific components of the device, such as microprocessors, LEDs, and electronic parts, are be 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

Interfaces

Voltages

Impedances

Gains

Power output

Power input

Ranges

Current capabilities

Harmonic distortion

Stability

Accuracy

Precision

Power consumption

Mechanical Parameters

Size

Weight

Durability

Accuracy

Precision

Vibration

Environmental Parameters

Location

Temperature range

Moisture

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 the 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 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 should be analyzed and constructed with safety as one of the highest priorities. Clearly, the design project that fails should fail in a safe manner, a fail-safe mode, 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; thus, 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 also 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 design 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 will handle the problem. If the repair or modification is more extensive, another design student is 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 required 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 WWW 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 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 orientated 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 submit to 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, and generate a market analysis.
- Determine the process for company name registration, 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.
- Students must meet with patent attorneys, real estate agents, and members of the business community, bankers and a venture capitalist.
- Students must fully understand the cost of insurance and meet with insurance agents to discuss health and life insurance for employees and liability insurance costs for the company. Students are required to explore OSHA requirements relative to setting up development laboratories. Students are expected to generate much of the above required information using direct person-to-person contact and the vast amount of information on the www.

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 accessing 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 a design. Once a project has been chosen, the student must begin the process of generating a written technical proposal. This document must indicate clearly answers to the following questions:

- What are the project and its technical specifications?
- Why is the project necessary?
- What technical approach is going 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 Engineering

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 six 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 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, as well as 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 required 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. Projects are carried out by individual students or a team of two.

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, the faculty 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. In addition to individual and team progress, the rehabilitation engineering group 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 be 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 project be revised and reworked until they meet faculty approval.

At the end of each academic year, the faculty 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 "oppinionaire" 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 six 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 to the project 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 a printed circuit board(s) using OrCAD, and then finish the construction of the project 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 in 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. This NSF project was a pronounced change from previous design experiences at UConn that 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 WWW based approach was implemented.[4] Under the new

[4] Enderle, J.D., Browne, A.F., and Hallowell, B. (1998). A WEB Based Approach in Biomedical

scenario, students work individually on a project and are divided into teams for weekly meetings. The purpose of the team is to provide student derived technical support at weekly meetings. Teams also form throughout the semester based on needs to solve technical problems. After the problem is solved the team dissolves and new teams are formed.

Each year, 25 projects are carried out by the students at UConn. Five of the 25 projects are completed through collaboration with personnel at Ohio University using varied means of communication currently seen in industry, including video conferencing, the WWW, 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 on teams, design process, planning and scheduling (time-lines), 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

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Engineering Design Education. Biomedical Sciences Instrumentation, 34, pp. 281-286.

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 with a disability. The A.J. Pappanikou Center provided a database with almost 60 contacts and a short description of the disabilities in MS Access. 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 WWW based approach is used for reporting the progress on projects. Students are responsible for creating their own WWW 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.

Team Work

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[5,6]. There is 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.[7,8,9]

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,

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

[6] Witkin, H.A., & Goodenough, D.R., *Cognitive Styles: Essence and Origins.* International Universities Press, Inc., NY, 1981.

[7] Deming, W. *Out of the crisis: quality, productivity, and competitive position*. Cambridge, Massachusetts: Cambridge University Press, 1986.

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

[9] Larson, C. & LaFasto, F. *Teamwork: what must go right, what can go wrong.* Newbury Park, California: SAGE Publications, 1989.

- 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,[10,11] the two most essential determiners for success in teamwork are positive interdependence and individual accountability. Positive interdependence, or effective synergy among team members, leads to a final project or design that is better than any of the individual team members may have created alone. Individual accountability, or an equal sharing of workload, ensures that no team member is overburdened and also that every team member has 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 usually vital to success, eliminates most management issues, and allows the instructor to monitor the activities by student team members. For this to be a success, activities for each week need to be documented for each team member, with best success when there are 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 time-lines 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.

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10 Cottell, P.G. & Millis, B.J., 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, 1994.

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

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 required integration of speakers, a receiver, an amplifier, CD player, etc. In general, when teams were formed, the instructor would facilitate the team's 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 a 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 that 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 that allows the course professor or instructor to gage project progress. This allows the instructor to determine over the "larger picture" if the student is falling behind at a rate that will delay completion of the project within the required due dates.

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, 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. An example of a timeline showing concurrent tasks is shown in Figure 2.1.

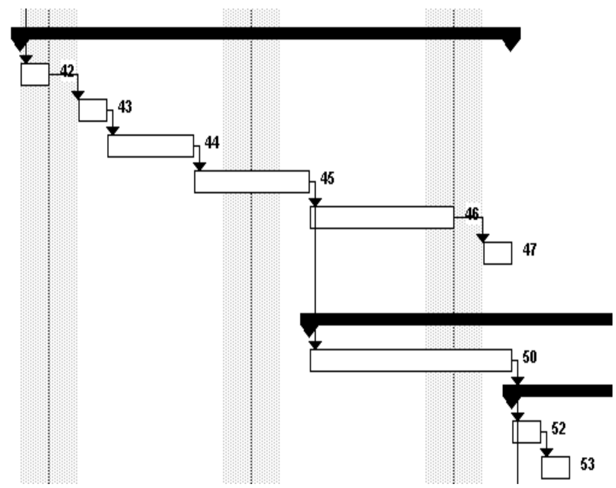

Figure 2.1. Shown above is a section of a typical timeline. The rectangular boxes represent certain tasks to be completed. These singular tasks are grouped into larger tasks, represented by thick black lines. The tasks are numbered to correspond to a task list that is not shown. The thin lines that descend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

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. With the timeline, by using time loading (resource management) a project manager schedules people and resources to operate at their most efficient manner. 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 or 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 manufacture 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 and on the WWW site. Weekly report structure for the WWW 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 WWW reports to keep up with 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
IMPROVING "MEANINGFUL" EDUCATIONAL OUTCOMES ASSESSMENT THROUGH DESIGN PROJECT EXPERIENCES

Brooke Hallowell

Of particular interest to persons interested in the engineering education are the increasingly outcomes focused standards of the Accrediting Board for Engineering and Technology (ABET).[12] 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, candidates for accreditation are required to demonstrate plans for assessing educational outcomes, and evidence that assessment results have led to improved of teaching and learning and, ultimately, better preparation for entering the professions. 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.[13]

"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".

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

[13] 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.

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

> An outcomes assessment program perceived by faculty and administrators as an imposition of bureaucratic control over what they do, remote from any practical implications... would not be 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.[14]

Outcomes Associated with Engineering Design Projects

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

Agreeing on Terms

There is great variability in the terminology used to discuss educational outcomes. How we develop and use assessments matters much more than our agreement on the definitions of each of the terms we might use to talk about assessment issues. 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.[15] 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 (or 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 of 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

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14 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.

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

are commonly characterized as belonging to one of three domains: cognitive, affective, and performative. Cognitive outcomes are those relating to intellectual mastery, or mastery of knowledge in specific topic areas. Most of our course-specific objectives relating to a specific knowledge base fall into this category. Performance outcomes are those relating to a student's or graduate's accomplishment of a behavioral task. Affective outcomes relate to personal qualities and values that students ideally gain from their experiences during a particular educational and 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, and by agreeing to develop outcomes assessment practices from the bottom up, rather than in response to top-down demands from administrators and accrediting agencies, current skeptics on our faculties 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
- demonstrate means by which certain assessments, such as student exit or employer surveys

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); and notice and reward curricular modifications and explorations of innovative teaching methods initiated by the faculty in response to program assessments.[14]

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

An Invitation To Collaborate In Using Assessment To Improve Design Projects

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

ABET's requirements for the engineering design experiences in particular[16] provides 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 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-post tests to assess "value added",
- Design portfolios,
- 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,

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

- Surveys of faculty regarding student design competence,
- Evaluation of writing samples,
- Evaluation of presentations,
- Evaluation of collaborative learning and team-based approaches,
- Evaluation of problem-based learning,
- Employer surveys, and
- Peer evaluation; e.g., of leadership or group participation.

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

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

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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Athens, OH 45701

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APPENDIX: Desired Educational Outcomes as Articulated in ABET's New "Engineering Criteria 2000" (Criterion 3, Program Outcomes and Assessment)[17]

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

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

CHAPTER 4
ARIZONA STATE UNIVERSITY

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UPPER EXTREMITY PROSTHESIS

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INTRODUCTION

The purpose of this project was to perform design and feasibility studies which may have applications for persons with upper extremity amputation living in a rural or Third World society. Many efficient, body powered and myoelectric upper extremity prosthetic designs are available in the US. However, these devices do not find broad application in rural or Third World environments because they are expensive, difficult to maintain, and require intricate methods of fabrication. The goal was to create a simple, cost-effective design for an arm prosthesis. Constructing all parts from inexpensive, readily available construction materials was essential. The design must also be fairly simple to fabricate with hand-held tools commonly available in an artisan's workshop.

Two upper extremity prostheses were designed for persons living in impoverished regions of Central America (Figure 4.1). The first design was made for an above elbow amputee and the second design was made for a below elbow amputee. The first design (Figure 4.2) consists of three major components, the socket attachment, the locking elbow, and the end effecter. The socket attachment consists of a foam-lined, hinged plastic pipe that attaches to the user's residual limb and is supported by a nylon body harness. The locking elbow mechanism joins the upper and lower arm members, allowing rotation around the joint. The angular position at the joint is fixed with an adjustable length nylon strap. As the length of the strap increases, the angle at the elbow also increases. The final component of the prosthetic design is the hand-like end effecter. This portion of the device is hook-shaped and consists of three pieces of plywood jointed with a small cabinet hinge. The opposable members can be opened about the hinged joint with a small wooden lever. The members are held closed with rubber bands. Thus, the end effecter is used to grasp objects between the two opposable members, or to carry objects with the hooked end.

Figure 4.1. Above Elbow Prosthesis (Right) and Below Elbow Prosthesis (Left).

The second prosthetic device consists of four major components: the terminal device, the socket, the harness, and the cable. The terminal device consists of two U-bolts, a toggle bolt, a PVC plug, an eyehook, nuts, washers, and rubber bands. The socket consists of ABS pipe and a flotation device. The harness consists of a packaging strap, metal buckles and a metal ring. The cable consists of a bicycle brake, U-clamps and a rope clip. The terminal device is body powered. It can be opened by either shrugging the opposite shoulder or by extending the amputated limb. The floatation device in the socket can be inflated to provide a snug fit. The harness can be adjusted to provide a proper fit. The harness is also padded to ensure a comfortable fit.

SUMMARY OF IMPACT

Only half of all new U.S. upper extremity amputees receive a prosthetic device each year. Only half of those who do receive one will continue to use it after one year. These numbers are even lower in Third World countries due to the lack of availability and the high cost of prostheses. The prosthetic designs developed for this project allow upper extremity amputees in third world countries to improve the functionality of their amputated limbs. Usually, amputees in Third World countries do not have the opportunity to own and use such a device and thus, are only able to use their one remaining hand to grasp and carry objects. Although the designs we developed are simple, they are helpful in performing easy tasks and making the remaining limb available to complete more difficult tasks. A good example would be using the prosthesis to hold a small pail of paint and using the other hand to apply the more sophisticated movements of the brush strokes.

TECHNICAL DESCRIPTION

The design specifications of the first device (for an above elbow amputee) were generalized for the average sized individual. However, the component sizes used in the design can be easily adjusted to compensate for the size and length of the residual limb, and the size of the individual using the device. The second device (for a below elbow amputee) was designed for a right arm amputee, but can be easily modified for a left arm amputee.

In order for these upper extremity prostheses to have an impact on the Third World, the major design requirements kept in mind were: (1) the device must be made of inexpensive, readily available materials; (2) the components must be easy to fabricate and assemble with common hand and handheld power tools; (3) in the event of component failure, fixing and replacing parts of the prosthesis should be easy to perform in the local environment; and (4) using the device should provide the operator with a substantial improvement to functionality without sacrificing comfort.

Above Elbow Prosthesis

The three major components for the upper extremity prosthesis (Figure 4.2) were the socket attachment, the locking elbow, and the end effecter. The socket attachment was made from 4” diameter ABS piping

Figure 4.2. Close-up of Prosthesis for an Above Elbow Amputee.

that is 8-7/8″ long. A 6″ segment of this pipe was cut in half through its axis and separated from the main portion of the pipe. Small cabinet hinges were used to attach these pieces to make a door that opens and closes. The inner lining of the ABS pipe was padded with convoluted packing foam. Velcro was glued to the outside of the ABS pipe. This will secure the door closed while the prosthesis is in use. To attach the prosthesis, the door on the ABS pipe would be opened, and then closed around the user's residual limb. This will provide a very tight but secure fit around the limb. A figure eight style nylon harness attached to the socket will allow the user's shoulders to provide additional support for the prosthesis. The socket was attached to the upper arm member with a 4″ ABS pipe cap that slips over the 4″ ABS pipe. A 1-7/8″ hole was drilled into the top of this cap to allow a male and female ABS pipe adapter to be assembled through the hole. The male ABS pipe adapter on the outside of the cap was then affixed to the 1-1/2″ diameter ABS pipe (3-1/2″ long), acting as the upper arm member.

The upper arm member was attached to the ¾″ PVC pipe (12″ long) acting as the lower arm member with a threaded pin going through the ends of each pipe. A hole was drilled at the end of each segment of pipe large enough for the threaded pins to be inserted. The smaller pipe was then inserted into the large pipe so the holes were lined up and the pin could be inserted. A cut 2-1/4″ long was made into the larger pipe, allowing the smaller pipe room to rotate upward. An adjustable length nylon strap was riveted midway along the length of the PVC piping and just below the opening door on the outer socket. Adjusting the length of this strap allows the locked angle at the elbow to be changed to any position in the range of 60° to 180°. Using a non-ridged locking mechanism causes one major disadvantage. The elbow will only lock in tensile loads and not compressive loads. This weakness was determined acceptable since the primary use of this prosthesis is to hold and carry objects; applying a compressive force at the elbow would rarely be desired.

The end effecter was the last major component of the upper extremity prosthesis. The end effecter was made from two ½″ pieces of plywood cut into a hook shape. The piece acting as the upper member of the hook shape was cut into two pieces 6-1/2″ from the hooked end. Of these two pieces, the straight end was glued to the lower member of the end effecter at its corresponding position. A small cabinet hinge was then used to attach the two pieces of the upper member together, once again completing the hook shape. A 3/8″ hole was drilled at an angle of 30° forward from normal into the hooked piece of the upper member. Glue was placed around the end of a 3″ x 3/8″ wooden dowel and inserted into this hole. Rubber from bicycle tires was cut to the shape of the hooked ends of the end effecter and glued to the inner surfaces of each member. The two pieces of the end effecter open and close about the hinged joint. Rubber bands were used to pull the opposing members closed and the wooden dowel lever was used to open the end effecter for grasping small objects. The bicycle tire rubber on the inside surface of the end effecter pieces give the grasping portion of the device a greater coefficient of friction to prevent objects from slipping out of the grasp. The straight end of the end effecter was sanded into a round shape of 5/8″ diameter so it can be slid into the ¾″ PVC lower arm and screwed into place.

Below Elbow Prosthesis

The second prosthetic device consisted of four major components: the terminal device, the socket, the harness, and the cable. The terminal device was made from two U-bolts, a toggle bolt, a PVC plug, an eyehook, nuts, washers, and rubber bands. To make the terminal device, one leg was cut off each of the two U-bolts, leaving enough room to form a strong hook. Next, a hole was drilled, centered in the top of the 2″ PVC plug. The PVC plug was used because of its light weight. A toggle bolt provided a hinge for the hook. Next, one of the U-bolts was screwed through the toggle bolt far enough into the plug so a washer and nut could be attached to the U-bolt. An eyehook provided a point of attachment between the cable and the terminal device. To ensure that the device is easily removed for maintenance and repairs, the terminal device was attached to the ABS cap with two 2″ nuts, one on the inside of the cap and one on the outside. The gripping strength for the hook was provided by rubber bands. Additional rubber bands can be added if greater gripping force is desired.

The socket consists of ABS pipe (6″ length of 3″ diameter) and a flotation device. The ABS pipe length may be altered depending on the length of the residual limb. After cutting the ABS pipe to size, the ends were sanded to ensure a level and smooth cut. Because ABS pipe is much lighter than PVC, ABS pipe was used to minimize the total weight of the device. A hole was drilled in the ABS pipe through which to pass the inflation valve. The flotation was cut to 14″ and resealed so it would line the ABS pipe inside in a single layer, with a little overlap at the ends. Vinyl glue was used to reseal the cut ends, and PVC glue was used to affix the top two inches of the flotation device to the inside of the ABS pipe. This allows the flotation device to be easily removed if it needs to be replaced.

The harness was made from a packaging strap, metal buckles and a metal ring. The harness was in the shape of a figure-8 with a metal ring to provide flexibility through a large range of movement. Quilted padding was used under the left arm to prevent the strap from cutting into the user's skin. A padded cuff was placed on the upper arm to provide a transition between the prosthetic device and harness. The cable was made from a bicycle brake, U-clamps, and a rope clip. The bicycle brake allows the cable to move freely while the housing is securely attached to the ABS pipe using U-clamps. The rope clip provides the attachment point to the harness. A fabric cover provides a finished and more aesthetically pleasing product.

Amputees were not available to test the prostheses. However, some tests were performed to evaluate the strength of each device. The first device was successfully loaded with a 25 Newton weight at the 90^{o} elbow position and was able to grasp objects weighing up to 4.9 Newtons. The end effecter was most reliable for grasping objects with a thickness of less than 1″ and weight less than 2.5 Newtons. Two tests were performed with the second device. The first test was to manually operate the cable to grasp and lift a 3-lb barbell. Two rubber bands easily provided the necessary gripping tension. The second test was to lift a 3-lb barbell using the closed hook position. The terminal device and connection performed well during these two tests.

An upper extremity amputee was able to comment on the usability of both devices. While neither device could compare with his custom made, body powered prosthesis, he was able to make positive suggestions. The primary need for future designs was to make a well fitting, rigid socket with minimal compliance between the residual limb and the prosthesis. The foam lined and pneumatic cushion designs made in this project were too compliant to allow the user much control. He also commented that the nylon strap used to lock the elbow of the above elbow prosthesis was not rigid enough, and any elbow lock needed to be able to resist flexion and extension simultaneously.

The total materials cost for the above elbow prosthesis was $28.84. The total materials cost for the below elbow prosthesis was $31.87.

SLIDING TRANSFER BOARD

Designer: Erica Andriano
Client: Delia Rubio
Client Coordinator: James Whitehouse and Mary Andriano, RN, American Transitional Hospital, Nashville, TN
Supervising Professor: Gary T. Yamaguchi, Ph.D. and James Egan, M.S.
Bioengineering Department
Arizona State University
Tempe, AZ 85287-9709

INTRODUCTION

Individuals who use wheelchairs sometimes lack the physical strength to lift themselves out of the chair and onto another surface. In such situations, a transfer board provides a smooth surface that bridges the gap between two horizontal surfaces, and allows the person to simply slide from one to the other. For example, a person can slide from a wheelchair to a chair, bed, or bench using a transfer board. Nurses also use transfer boards to easily move patients from one surface to another. Because the movement is horizontal when the surfaces are at the same elevation, there is no need to lift and carry the patient from one surface to the other.

Typical transfer boards are long, rectangular boards made of maple, birch, or plywood. Lengths are available from 24" to 30", and widths are typically 8". Available boards range from 1/8" to 1/2" thick. The more expensive models are polished on top and tapered to 1/8" thickness at both ends to allow for easy placement beneath the patient's hips. Some models have slots to aid in gripping the board and/or hooks to attach the board to a wheelchair more securely.

According to several patients, current transfer boards have many unfavorable qualities. An improved design was completed.

SUMMARY OF IMPACT

Current transfer boards have many unfavorable qualities. They are hard to hold, hard to slide across, hard to store for quick and easy access, and too long. When the ends are tapered, the ends were too sharp and cause pain. Also, the thinner boards tend to be too flimsy, and bend too much during use. Friction on the surface of the board makes it difficult for weaker individuals to pull themselves along the board. The new design will provide a light, but strong transfer board. The board will be safe and inexpensive.

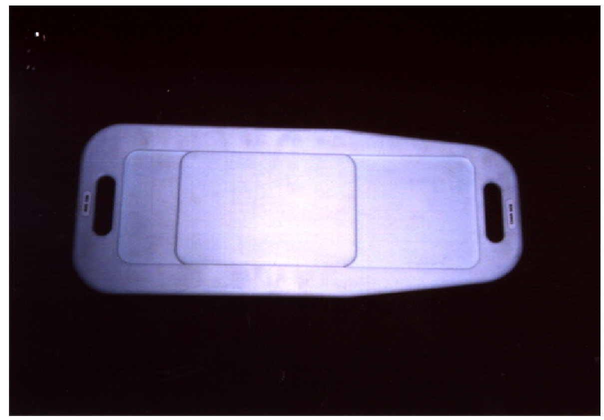

Figure 4.3. Improved Transfer Board Device.

TECHNICAL DESCRIPTION

The improved transfer board design (Figure 4.3 and Figure 4.4) provides an easier and more efficient way of sliding the patient along the board. The board itself is made of two pieces of ultra high molecular weight polyethylene (UHMW-PE), which is lightweight, strong, and self-lubricating. Two sheets of UHMW-PE were purchased, with dimensions 12”x36”x3/4” and 12”x12”x1/2”. One sheet of the UHMW is inset inside a channel cut into the other sheet (Figure 4.5). The material has a low level of sliding resistance. Therefore, while a person is sitting on it, the inlaid sheet easily slides back and forth. The final design was built and tested. Different loads in different situations were tested. This included moving different weights to and from different heights. Finally, the board was tested by using it as intended.

The cost for materials was $75.

Figure 4.4. New Transfer Board Device.

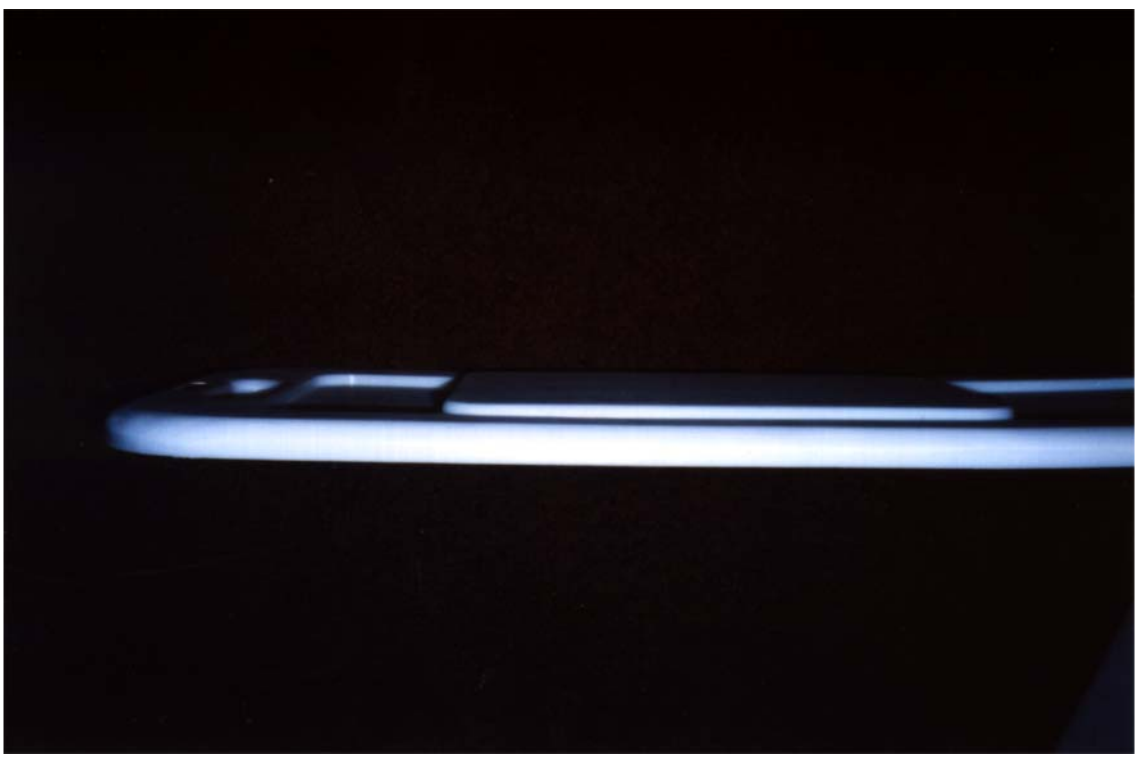

Figure 4.5. One UHMW-PE Sheet Set Inside a Channel Cut into the Other UHMW-PE Sheet.

MAGIC GOLF BRACE

Designer: Nan Huang
Client: Kevin Burke
Client Coordinator: Beckie Heffron, Prosthetic Orthotic Associates, Mesa, AZ
Supervising Professor: Gary T. Yamaguchi, Ph.D. and James Egan, M.S.
Bioengineering Department
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INTRODUCTION

As a result of a childhood traumatic brain injury, an active, adventurous man who likes to participate in outdoor activities has difficulty holding a golf club with his wrists in a neutral position, making it hard to hold and swing the club with authority. The right side of his body exhibits neuromuscular impairments, including a contracture that holds his right wrist abducted at approximately 80 degrees and keeps his thumb and forefinger tightly closed together.

The Magic Golf Brace (Figure 4.6) is an orthosis designed to temporarily straighten his wrist without adversely affecting his ability to hold onto a golf club with his right hand. The brace includes a ratcheting mechanism that allows him to gradually straighten his wrist with his other hand. Because it is a ratchet, he can straighten it a little, or a lot, according to his needs at the time. A release mechanism allows the device to instantly release following each golf swing, which allows his hand to relax and enables blood to flow back into the areas temporarily pressured by the orthotic device.

SUMMARY OF IMPACT

While using the device, the client is able to straighten his wrist and hold a golf club with better form. He is able to strike the golf ball with more control and power, and has increased his distance and reduced his score. It is not always best to position his wrist to emulate a normal golfer's wrist, but instead to enable him to perform at his best possible level. The client feels the brace will also allow him to participate more in other activities where a straight wrist is beneficial.

TECHNICAL DESCRIPTION

The first step in the design process was to define the need by observing his golf swing movements, and to interpret his needs in terms of design specifications.

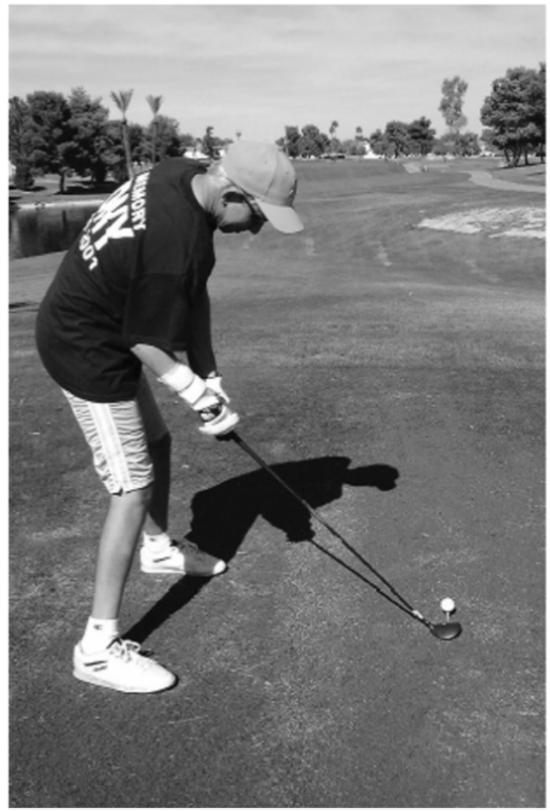

Figure 4.6. "Magic" Golf Brace

By observing him, it was determined that a moment of approximately 9.84 N-m was required to bring his wrist to a neutral position.

Researching patents and reviewing different types of commercially available gloves and braces indicated that it was unlikely for a "soft" type of glove to provide the necessary straightening moments about the wrist. Thus, a hybrid type of glove/brace was designed so that it minimally inhibits his swing and grip. The design is also reasonably lightweight, provides the necessary strength, is adjustable, rigid, and allows the wrist moment to be quickly applied and instantly relaxed.

Minimizing weight and intrusiveness resulted in minimizing the amount of contact area on the skin surface. Reducing the contact area increased normal and shear stresses applied to the skin. Because applying a large wrist moment was necessary, this meant leaving the brace in the active position for long periods of time would likely result in skin breakdown, blistering, and/or pressure sores. Fortunately, golf is a game that involves a lot walking and very little time swinging the club. For this reason, a different device with increased skin surface contact area would be needed for other activities such as kayaking, because the paddle would be gripped for long periods of time in a wet, skin-softening environment.

The materials for the brace included thermoplastic, foam padding, Velcro, and Aliplast. A Step Lock was used to provide the strong, ratcheting mechanism. Typically, Step Locks are used for ankle-foot orthoses, and include a steel bar (which resists both tensile and compressive loads) that passes through the ratchet and locks in one direction. The device was fabricated with the assistance of Prosthetic Orthotic Associates.

An 18-hole golf game served to field test the device. The prototype device accomplished many of the design goals. Improvements to the design were undertaken by the client and the orthotist. One improvement included rolling the edges of the plastic backward under the thumb to reduce irritation of the skin. Pressure points were identified immediately following a round of golf, and evaluated for the possibility of skin breakdown. While the pressure points were reddish in color, the skin appeared to be intact and healthy without blistering.

Cost for the device was approximately $55.

Figure 4.7. Close-Up of Magic Golf Brace.

TRANSFER DEVICE FOR AN ELDERLY PATIENT

Designer: Alison Dreyer
Client: Frederick Schermer
Client Coordinator: Diane Foss and Bradley Heal, PT, Desert Cove Nursing Center
Supervising Professor: Gary T. Yamaguchi, Ph.D. and James Egan, M.S.
Bioengineering Department
Arizona State University
Tempe, AZ 85287-9709

INTRODUCTION

Although many elderly patients use wheelchairs, most patients can use their legs to some extent. However, many of these patients do not have sufficient strength to pull or push themselves up and out of their wheelchair to transfer to a different location. The new transfer device will allow the patient to pull himself up into an erect standing position. The patient will then be rotated 90 degrees by an attendant so the patient can sit on an adjacent bed or chair.

SUMMARY OF IMPACT

The need for such a device was expressed by a professional working in the geriatric field. The device was designed for an elderly gentleman who was transferred from an assisted living home to a private home. The device was needed to assist the caregiver in transferring him to his bed. By the time the project was completed, his living situation had changed again, and he no longer needed the device. We believe the standing and turning frame will be useful for other individuals. The designers are currently seeking to improve the device and customize it for a new client

TECHNICAL DESCRIPTION

The design (Figure 4.6) consists of two major elements, the turntable and the frame. The turntable consists of a 24" square, 1/2" mild steel base plate and a circular turntable made of 1/2" aluminum. Two circular disks are made of ultra-high molecular weight polyethylene (UHMW-PE) inset into the top of the base plate and bottom of the turntable. This provides a self-lubricating joint between the mating surfaces.

The frame is made of 2" welded aluminum tubing. Horizontal frame members, which extend from the vertical tube, were positioned for easy prehension by the client. From this position, it was expected

Figure 4.8. Transfer Device Including Turntable and Sturdy Frame.

that the client would be able to easily pull himself up, and hold himself in an erect stance. The arms of the device wrapped around to the sides to provide armrests, a railing against which the patient could lean, and two vertical handles for the care provider to grab. With the caregiver's hands positioned on the vertical handles, the client would be completely enclosed within the frame by the arms of the caregiver. This positioning provided the greatest margin of safety against the client collapsing and falling out of the frame. Centering his body within the frame, the large basal area of support dimensions, and low center of gravity of the device also provided an adequate measure of security against the device tipping over and causing injury to the patient.

During prototype testing, the UHMW-PE bearings were adequate for a person weighing less than 150 pounds. However, for persons weighing more than 150 pounds, it became difficult to turn the device. The device must be positioned next to the client's bed so the rotation (counterclockwise for this client) moves the client toward the bed. Therefore, if the patient prematurely lets go, the patient will fall onto the bed.

The total cost for materials was approximately $815.

PASSIVE STANDING FRAME

Designer: Mathew Dixon
Client Coordinator: John Figy, ASU Physically Challenged Program
Supervising Professor: Gary T. Yamaguchi, Ph.D. and James Egan, M.S.
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INTRODUCTION

A passive standing device (Figure 4.9) was designed with the intent of offering standing assistance for a person seated in a wheelchair. The hand-cranked hydraulically powered standing device was designed for a university student recreational complex. The device is to be used to assist the many people who have wheelchairs and cannot stand on their own. The device is adjustable so it can accommodate people of various sizes. Adjustable vertical and horizontal knee and chest pads are coupled with an adjustable basket harness. The device can lift up to 400 pounds, yet is moved easily. Accessing and using the device is simple. The patient wheels up to the device, puts on the harness, and the device operator then pumps the hydraulic pump until the patient is in a standing position. While the patient is standing, he or she has access to a flat surface that can serve as a tray or a work area.

SUMMARY OF IMPACT

This device will help those in wheelchairs to stand. The passive standing frame will lift the patient to a standing position, and hold them there for the desired amount of time.

TECHNICAL DESCRIPTION

The device (Figure 4.9) was required to lift at least 400 pounds. Calculations were used to determine that the lever arm must be 1.5 feet long and the jack must be placed six inches from the initial connection. The height of the device is restricted by the height of the work tray. For the comfort of all users, the tray is adjustable, with a minimum height of 36 inches. The lever arm tucks under the tray and was placed 18 inches from the bottom of the device. The jack used for lifting the patient is 9 inches tall, 5-5/8 inches in diameter, has an overall extension of 12-1/4 inches, and a platform base of 6x6 inches.

The jack moves the lever arm in a circular motion. Therefore, the jack rotates on a stand with a pin connection at the level arm. The device also has adjustable knee and chest support. On this standing frame, the knee support is 15 inches from the floor, and the chest support is 36 inches from the floor. The harness is a basket type structure designed to wrap around the patient's waist and extend down the bottom of the gluteus maximus. The harness connects to the end of the lever arm with carabineers and eyebolts. The harness length can be adjusted and there are several eyebolt positions to allow for additional adjustments. The work tray is made from ¾" Lexan. There is a cutout in the tray for the chest pad. This allows the user to rest his or her arms on the tray. The tray is connected to the top of the frame using four inset bolts.

The materials for the device cost $186.40 and the labor to construct the device cost $80. The retail price would be $450. This is less than current passive standing frames on the market ($500-$1000).

Figure 4.9. Passive Standing Device.

WEIGHT ACTIVATED BRAKING ORTHOTIC KNEE BRACE

Designer: Aaron Gilletti
Client Coordinator: Sander Nassan, C.P.O., Prosthetic Orthotic Associates, Scottsdale, AZ
Supervising Professor: Gary T. Yamaguchi, Ph.D. and James Egan, M.S.
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INTRODUCTION

Many patients who experience a loss of extensor muscle control use long-leg braces to assist them in weight bearing activities such as standing and walking. Additional benefits may be derived if the design of the typical orthotic knee joint is altered to provide dynamic resistance to flexion without limiting or inhibiting extension.

A new orthotic knee joint design (Figure 4.10), incorporating polymeric inserts, was developed. It provides a soft but increasing resistance to flexion. The new design is compatible with standard orthotic components and is readily incorporated with customized orthoses.

SUMMARY OF IMPACT

A number of persons might benefit from such a device. The patient profile of possible candidates includes post polio patients, those with neuropathies (including diabetic neuropathies), persons with sciatic, spinal cord, and femoral nerve injuries, and stroke patients. In general, any patient who has limited control of extension and/or flexion in the knee could benefit from this device. The device could reduce the potential hazards associated with knee failure and current knee braces.

TECHNICAL DESCRIPTION

The knee joint for the brace was made from 410 hardened stainless steel. The brace was made such that the members articulate throughout the range of motion in a manner consistent with the action of the knee joint. A pin and slot arrangement allowed flexion extension to occur without creating a fixed hinge location.

The uprights for the brace were made from ¾”x 3/16” aluminum. The uprights are affixed to the distal and proximal ends of the joints by steel rivets to reduce the risk of fatigue failure associated with aluminum fasteners. The stop brake is made of elastomers supplied by Harkness Materials, Inc. The elastomers range in durometer values of 40A to 95A to suit the needs of the patient, and may be interchanged as needed in an existing joint. The elastomer material comes in sheets ½” thick and can be cut on a band saw or a table saw to the desired dimensions.

Materials and labor to assemble the device were under $1300.

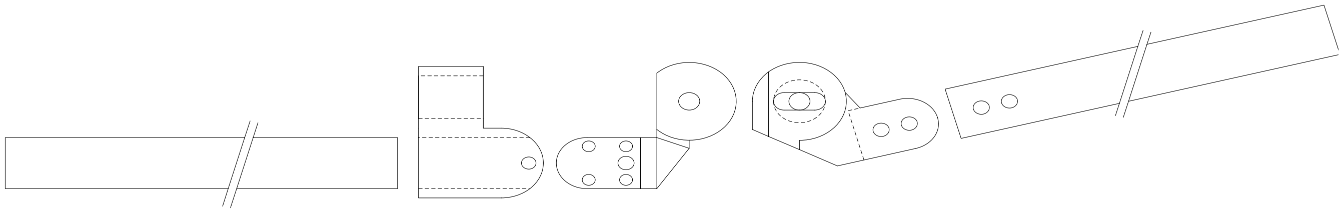

Figure 4.10. Exploded View of the Brace.

DYNAMIC ANKLE SUPPORT DEVICE

Designer: Andrew Kwarciak
Client Coordinator:
Supervising Professor: Gary T. Yamaguchi, Ph.D., James Koeneman, Ph.D., and James Egan, M.S.
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INTRODUCTION

Because of the orientation and mobility of ankle components, the ankle is susceptible to instability during physical activity. Couple this with increasing forces from acceleration and collisions during activities and this instability can lead to injury. The most common mode of injury occurs when the leg rolls over the foot. To prevent these injuries, athletes wear tape or ankle braces to provide stability. While these methods prevent excessive inversion and eversion motions, they also restrict mobility and agility of the athlete. The objective of this project was to design an ankle support device that prevents injury and preserves agility.

SUMMARY OF IMPACT

The ankle is a commonly injured part of the body, comprising nearly 15% of all sports injuries each year and frequent everyday use injuries. Each year, physicians see 1.2 million people with ankle sprains and 675, 000 with ankle fractures.

Obviously, both on and off sport fields, ankle injuries are a problem that demands more attention. Current devices (sports tape and ankle braces) can limit inversion and eversion, thereby reducing injury. However, the devices inadvertently also limit agility. In many sports, agility is crucial. Therefore, there is a need for a device that can prevent injuries, but preserve agility.

TECHNICAL DESCRIPTION

The new ankle support design (Figure 4.11) features a rigid plastic support, cut to resemble a stir-up. On the tapered portion of the plastic support, a Gillette joint, the most suitable for triplanar motion, connects the two sections. The plastic support is made from a sheet of ¼" Copoly. The Copoly is heated until it reaches a liquid-like phase, and then pulled over a plaster leg mold. The Gillette joint is fixed to the plaster leg prior to pulling the plastic. The plastic forms over the joint, creating a pocket in which the joint sits, thereby increasing the strength of the joint/plastic connection. The joint is removed, the plastic is cut into two pieces, two holes are drilled in the joint pocket, and the joint is re-attached to the support with special screws. The edges of the plastic are smoothed and the bottom of the heel cup is skived for a better fit inside of shoes. Elastic and nylon straps run parallel down the sides of the plastic brace. The straps are placed so they provide the maximum amount of support, but minimally inhibit agility. The elastic strap is pulled tight, while the nylon strap has some slack. The elastic provides a damping force on the foot/leg once rotation has exceeded the end of the predetermined range. This prevents any abrupt stops that would occur when the nylon is pulled taut. Holes were also drilled through the plastic and the straps were fixed to the rigid support with copper rivets at the top and bottom of the brace. On the heel cup, the straps were riveted directly into the plastic. On the upper cuff, the straps were attached via chafes, which were riveted just under the top edge of the brace. The same holes used to attach the straps were also used to attach the upper support strap. The upper support strap secures the brace to the ankle. Hooks and loops were sewn to the back of all of the straps to provide adjustable attachment points.

The inside of the brace was padded with a 1/8" foam pad. The pad was heated and allowed to cool inside of the brace. The brace molded foam was then cut, the edges were smoothed, and it was glued into place. From a 1/8" sheet of neoprene, a cuff was cut which was designed to fit snuggly around the device. The neoprene was fitted with a zipper to ease attachment. The neoprene cuff serves to make the device aesthetically pleasing.

The estimated cost for the device is $68.

Figure 4.11. New Ankle Support.

Figure 4.12. Ankle Support in Use.

CHAPTER 5
BINGHAMTON UNIVERSITY

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Principal Investigator:

Dr. Richard S. Culver, 607-777-2880

JANITORIAL CLEANING CART FOR AN ADULT WITH AUTISTM

Designers: Avraham Assaban, Rui Meng Hu,
Client Coordinator: Darlene Dickinson, Southern Tier Independence Center
Supervising Professor: Dr. Richard Culver
Design, Technology and Communications
State University of New York at Binghamton
Binghamton, NY 13902

INTRODUCTION

A janitorial cart was designed for an adult with autism who works as a janitor. The janitorial pushcart supports a vacuum cleaner on the main platform and has room for a garbage can. On the shelf, the client has room to store cleanings fluids, garbage bags, rags, a water bottle, and cups. Since one of the primary ways the client communicates is by pointing to a letter on a sheet of paper, a paper on which the alphabet and numbers was printed and laminated so that it would not get stained.

SUMMARY OF IMPACT

Previously, the client had no such device for carrying his supplies and, therefore, had to go back and forth between the storage closet and the offices he was cleaning. With this cart, all the necessary supplies, such as a garbage can and vacuum and cleaning supplies, are readily accessible to him. Also, since the cart is rugged and durable, the client can expand his employment to different offices in the area.

TECHNICAL DESCRIPTION

The cart is 28 inches wide, 38 inches long and 46 inches high. The dimensions are suitable for the client's height. The frame of the cart is made of 1 ¼-in furniture-grade PVC tubing. Steel tubes are used to reinforce the PVC tubes on the bottom center of the cart, to support the trashcan.

A white plastic sheet, reinforced by ¾-in particleboard, covers the top of the cart, providing a surface that is easy to clean. The handle bar on the back of the cart provides support and is used to push the cart. There are four 4-in diameter casters on the corners of the cart. The wheels are easy to move in all directions and the back two wheels are equipped with brakes. There is a wooden sheet in the front that holds the vacuum upright.

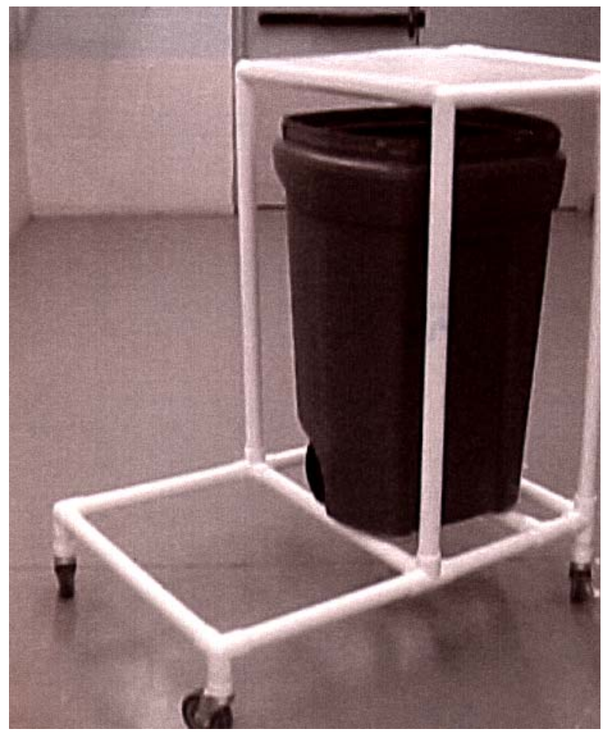

Figure 5.1. Cleaning Cart in Production.

There are two layers of the cart, the upper and lower. The trashcan is located on the bottom layer. The back of the cart is open for easy trash disposal. The trashcan is connected to the cart by a chain and is supported by a hook, which sits on the plastic frame. It can be tilted for dumping garbage. Since the client works in different buildings, the cart is lightweight and easily movable.

The cost of the material was about $ 130.

WHEELCHAIR ATTACHMENT TO SUPPORT SPEECH DEVICE

Designer: Alicia Heer, Kieron Ludde, Si Mai, Thomas Morrissey
Client: Melanie Coombs, Binghamton BOCES Developmental Center, Binghamton NY
Supervising Professor: Professor Richard Mecklenborg
Division of Engineering Design
Watson School of Engineering and Applied Science
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INTRODUCTION

A wheelchair attachment has been designed to support a speech device for an eight-year-old boy with cerebral palsy. As a result of his condition, Jared is unable to speak and balance anything on his lap. He uses a speech device to communicate with other people. The frame, which is made of ¾-in copper water pipe, supports a plywood table with a cutout to hold the speech device. The copper pipe is attached to the wheelchair with machined brackets.

SUMMARY OF IMPACT

As a result of the project, the client will be able to communicate with other people without the supervision of therapists. Moreover, the therapists will not have to carry the speech device around for the client because it can be directly attached to his wheelchair. It can also be detached when it is not in use. Furthermore, the frame can serve many other purposes when it is not supporting the speech device. For example, it may be used as a tabletop or a workstation.

TECHNICAL DESCRIPTION

The design constraints for the frame were that it be lightweight and detachable from the wheelchair. It must support the speech device, which weighs about 15 pounds.

The main materials for this project are two copper pipes (3/4 in. radius), a 11x14 piece of furniture-quality plywood (1/2-inch thick), and different types of clamps and elbows. These materials were chosen because they are very strong and light and can support the weight of the speech device and the forces exerted by our client.

Figure 5.2. Wheelchair Attachment To Support Speech Device.

The copper pipes are bent slightly into an L shape. The two pipes are connected to the two inner sides of the wheelchair with machined brackets, so the device is easily removable. A rectangular hole was cut in the wooden tabletop to fit and stabilize the speech device.

The cost of materials for this project is $10.

WATSON ALARM TO MONITOR A CHILD WITH AUTISM

Designers: Eugene Gasmen, Jason Gibbs, Vladimyr Gouin
Client Coordinator: Darlene Dickinson, Southern Tier Independence Center
Supervising Professor: Prof Richard Mecklenborg
Division of Engineering Design
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INTRODUCTION

An alarm device was designed to alert the family of a child with autism when the child leaves the house. The family's home is located at the intersection of two major highways, and the child has very good mechanical manipulation abilities. In the past, the family used different types of barriers to keep him from leaving the home. They did not want to use a two-sided keyed deadbolt because of the associated fire safety hazard. Also, it is difficult to have the house always on lockdown; the mother uses some of the doors to the house regularly to let dogs out and to hang out laundry. The alarm, which consists of transmitters that sound a central unit whenever any of the four armed doors is opened, is designed to be a safe and convenient remedy. It provides a non-intrusive form of safety for the child.

SUMMARY OF IMPACT

The design criteria for the alarm were dictated by the layout of the home and the desires of the family. The mother did not want an alarm that would be fixed to a wall somewhere in the house that would be so loud that it would wake her neighbors at night or scare the rest of her children. She asked us for some sort of portable, unit with adjustable volume to notify her when the doors are opened. She also desired four different doors in the home to be alarmed. There are three exits to the home and a closet that contains dangerous chemicals. However, the most important exit is the front door, because it leads out onto the road. As a result, she wants this door's alarm to be louder than the other three. If possible, she wanted four different tones for each of the four doors. Our alarm system produces four different tones, the front door's being the loudest and its alarm noise emanating from a portable, battery-operated, hand-held, volume-adjustable unit. The alarm provides safety and convenience for the whole family. Rather than having to unbolt large locks or worry about the safety of her child, the mother can know of his whereabouts. She can also do work outside of the home and monitor him.

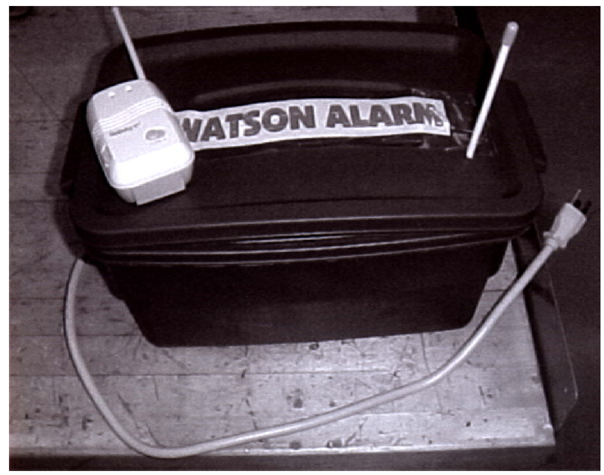

Figure 5.3. Base Unit and Handheld Receiver.

TECHNICAL DESCRIPTION

The alarm consists of two separate radio-frequency systems. The first system consists of wireless doorbells. The pushbutton transmitters are modified so that instead of the circuit being completed when the integrated button is depressed, it is completed by opening the door. This is accomplished by using magnetic switches that are normally used in security systems. These switches are soldered to the circuit board of the doorbell transmitter units such that opening the door mimics the depressing of the switch.

When a door is opened, the unit sends a signal to the transmitter, causing the doorbell receiver to sound. Doorbell units with two transmitters per receiver are used. In order to wire each of the doors in the home, two such sets were required. The factory defaults on these units send all signals at the same frequency. This would cause both receivers to sound if any one transmitter was tripped in the home. By changing the jumper settings on the circuit board of the transmitters and receiver of one set, it can be operated at different frequencies. Now all four transmitters work on different frequencies, but there are only two distinct sounds, those that come with the doorbell receivers. One is an eight-tone chime and one is a two-tone chime. By opening the receiver case and modifying the speaker, it was possible to cut the volume output and, to some extent, the sound frequency of one of the receivers. By doing so, one door chime sounds louder than the others.

The front door uses the loud eight-chime doorbell. The two receivers are placed in a locking plastic box. Along with them, a baby monitor transmitter is included. The microphone on the baby monitor picks up the noises of the doorbells and transmits it to a handheld unit with adjustable volume that the mother can attach to her belt. The plastic box is insulated with sound-deadening material that keeps the tones of the doorbells within it and can be placed anywhere in the home where it can be plugged in, out of sight. The only visible aspects of the design are very small transmitters of the doorbells, approximately ¾″ x ¾″ x 2″, the magnetic switches, ¼″ x ¼″ x 1 ¼″, and the baby monitor receiver, 1″ x 2 ½″ x 6″. The parts are readily available at local discount retailers and electronic supply stores.

Total cost for all parts and materials was less than $140.

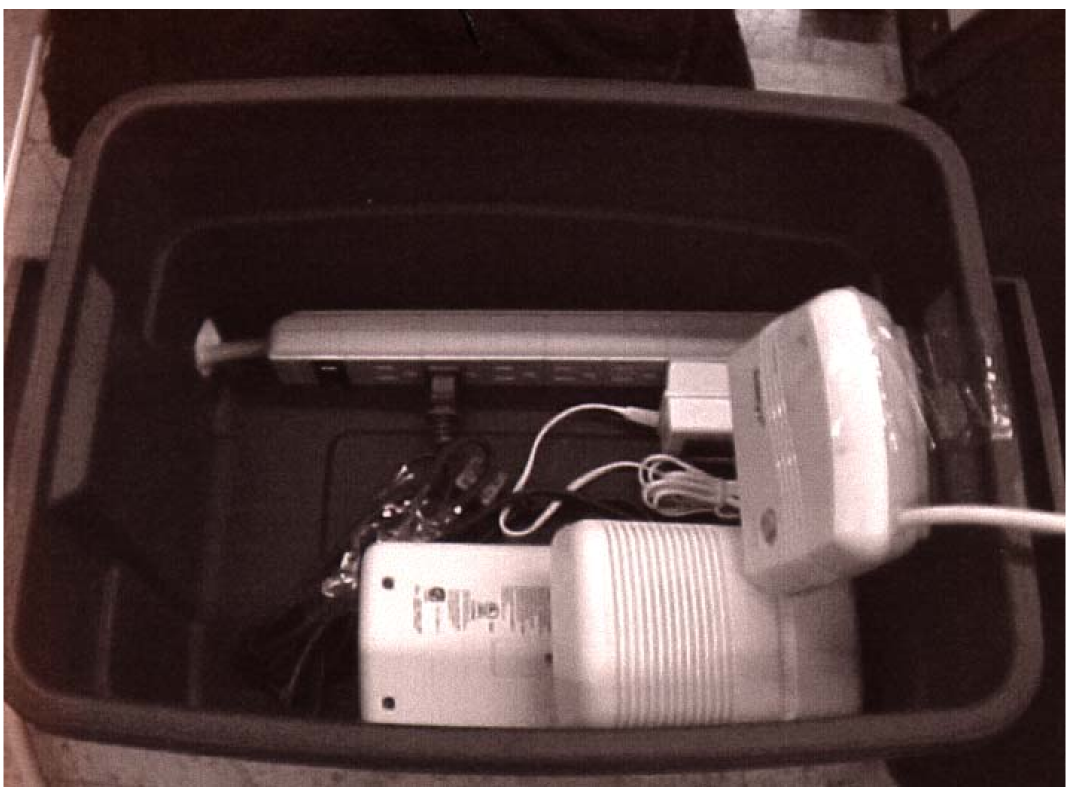

Figure 5.4: Interior View of Housing

MOVEABLE SHELVING UNIT

Designers: Matt Parker, Jamie Micha, Samit Pabuwal
Client Coordinator: David Scudder
Supervising Professor: Richard Mecklenborg
Division of Engineering Design
Watson School of Engineering and Applied Science
Binghamton University
Binghamton, New York 13902-6000

INTRODUCTION

A woman with muscular dystrophy was arranging her kitchen so that she would be able to work inside her home. She needed a moveable shelving unit to hold paper and other supplies for her work. A free-moving freestanding cart, set on four pivoting castors was built. She can roll it to the position she needs for her work and then store it under her desk when she is finished.

SUMMARY OF IMPACT

The moveable storage cart will help the client improve her independence by enabling her to move more freely around her kitchen/office when she works from her home.

TECHNICAL DESCRIPTION

The moveable shelving unit is made of ½-in. furniture-grade oak plywood with a dark oak varnished finish. It is lightweight and easy to roll. Each side has a large, easy-to-grip handle. The front and top of the cart are open, making it easier to reach in and out without the hindrance of pullout drawers or closed cabinet doors. The shelves are adjustable, allowing the client to arrange the unit in a manner fit to her specific needs. Four locking castors make it easy for her to move the cart and then lock it in place anywhere she needs.

The project cost approximately $75. Similar commercial products cost as much as $500.

Figure 5.5. Moveable Shelving Unit.

STANDING FRAME FOR A CHILD WITH REDUCED MOTOR ABILITY

Designers: Greg McDermott, Rijie Zheng, Hae Jin Lee, Dave Naeder
Client Coordinator: Anne Marie Murphy, Rehabilitation Services, Inc.
Supervising Professor: Prof. Richard Mecklenborg
Division of Engineering Design
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INTRODUCTION

William is a two and a half-year old boy that has reduced motor ability. During his physical therapy sessions, the client performs exercises to strengthen his balance and coordination. In one of the exercises, he pulls himself from sitting to a standing position with the aid of a bar. He had been suing an old walker for this purpose. A new frame was created to offer stability. It has a series of bars on the front and sides to grab onto.

SUMMARY OF IMPACT

The device helps the client develop his strength and coordination. It is lightweight and portable. The device can be used in the client's home so his parents can work with him outside of therapy. It has a surface that is stable for him to sit on and bars that surround him on three sides so that he can pull himself to a standing position. The bars allow him to maintain a standing position and work on his balance. The device allows him to work on his coordination and balance with the aid of a physical therapist or a parent.

TECHNICAL DESCRIPTION

The base of the standing frame is 36 x 36 in., ½-in. plywood. The frame is made of furniture-grade PVC piping, which is strong yet lightweight, so the device is easily transported. In addition, PVC is aesthetically pleasing and easy to clean. The device is open on one side so the client can be placed on the base. The horizontal bars on the front of the frame are 1 in. in diameter as opposed to the 1 ½-in. diameter of the rest of the pipes. The smaller pipes in front allow him to grip firmly the bars to pull himself up. The pipes were converted to different diameters using bushings on each joint of the front beams.

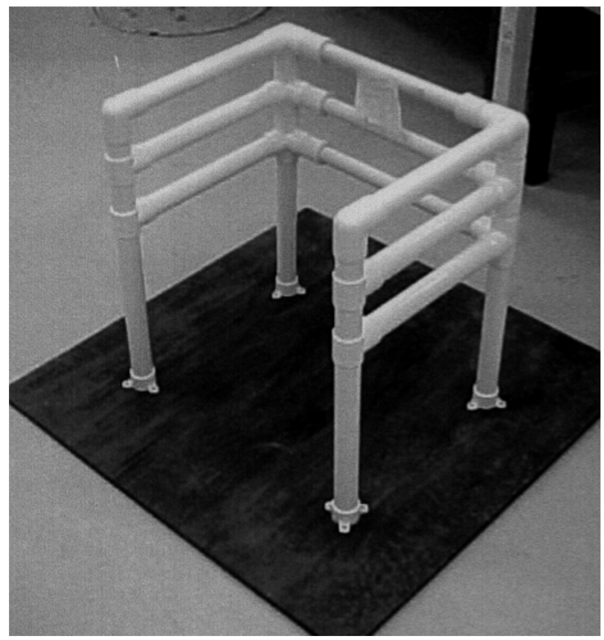

Figure 5.6. Standing Frame

WHEELED CART WITH LIFT-AND-LOWER PLATFORM

Designers: Kellen Wadach, Heather Sheiman, Weng Kai Sit, and Tania Philip
Client Coordinator: Darlene Dickinson, Southern Tier Independence Center, Binghamton, NY
Supervising Professor: Richard Mecklenborg
Division of Engineering Design
Watson School of Engineering and Design
Binghamton University
Binghamton, NY 13902

INTRODUCTION

The wheeled cart with lift-and-lower platform is designed to meet the needs of a legally blind client who breeds and sells rabbits. The client is 57 years old and recently had surgery on his back to remove a disk. Although he is able to see large objects, he is unable to see minute details. His rabbit business requires him to lift many 30-pound bags of rabbit feed from the back of his truck down to ground level. He was doing all of the lifting manually. Due to his recent back surgery, he is only able to lift one bag at a time. This process is inefficient and is putting a tremendous amount of strain on his back. A lifting device is needed that will lift at least 150-pounds at a time and be activated without putting strain on the client's back. The device was required to lift from ground level to over four feet and to be safe. .

SUMMARY OF IMPACT

Using the lifting device, the client will be able to run his rabbit business more efficiently. It will also help him recover from his back surgery more rapidly.

TECHNICAL DESCRIPTION

Many existing lifting devices are either too expensive or accomplish more than what the client needs. Only one hydraulic lifting table fit all of his needs. This lifting table weighs 215 pounds. It can lift about 770 pounds and it can rise from 13.8 to 52 inches. The dimension of its platform is 36" long, 20 " wide and 2.2 " deep. It operates with a foot pedal, contains a hand release. The client is concerned about the size of the wheels because of the cracks in his pavement but it appears to functions well. The platform was enlarged so the client can put more supplies on it at one time. The plywood surface is made of ¾ in. exterior grade plywood and is painted with exterior paint. It is 30 in. by 42 in.

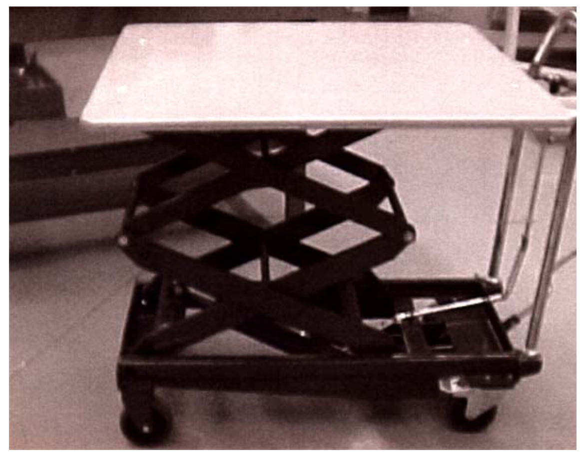

Figure 5.7. Cart with Lifting Frame

The total cost of parts and materials is about $380.

ADJUSTABLE TABLE FOR A PERSON WITH QUADRIPLEGIA

Designers: Austin Wong, Matthew Sills, Artem Treyger
Client Coordinator: Darlene Dickenson, STIC
Supervisor Professor: Richard Mecklenborg
Division of Engineering Design
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Binghamton University
Binghamton, New York, 13902-6000

INTRODUCTION

The adjustable table is has been built to fit around a wheelchair. Due to a cancerous tumor on his neck, the client is paralyzed from the neck down. With therapy, he has regained some limited movement in his left hand. The table enables the client to freely place remote controls, telephones, beverages, and other objects at a comfortable distance. The table is made of wood and conduit metal pipes. The table surface is height adjustable from 32 to 44 inches off the ground. The three castors are situated so that the support frame can straddle the wheels on the wheelchair. The table can be used when the client is sitting in his wheelchair and also when he is in bed.

SUMMARY OF IMPACT

The new table freestanding, sturdy, adjustable and easy to use. The table allows the client to place essential items, such as telephone, remote controls, and beverages, at a convenient height so that his mouthpiece can reach these items. The table can also be wheeled to his bed where it is adjusted to bed height.

TECHNICAL DESCRIPTION

The base of the table was made of steel EMT tubing. Two different sizes of the tubing were used: ¾-in. for the base frame, and ½-in. tubing that telescopes inside the ¾-in. tubing, to support the tabletop. The three castors were fastened onto the base by bolts. The base is composed of two pieces of conduit pipes, brazed together. The tabletop is 16 x 28 in., made of ½ in. furniture-grade plywood. ½-inch pipe clamps hold the tabletop in place. The 3/8-in holes, which enable vertical movement of the table, were drilled into the ½-inch pipe every three inches. Two ¼-inch pins are used to set the height of the tabletop.

Figure 5.8. Adjustable Table

The cost of materials is about $20.

CHILDPROOF KITCHEN DRAWER

Designers: Ryan Varnum, Aaron Wright, Akio Yanagisawa
Client Coordinator: Darlene
Supervising Professor: Richard Mecklenborg
Department of Mechanical Engineering
State University of New York at Binghamton
Binghamton, NY 13902-6000

INTRODUCTION

The Child-Proof Kitchen Drawer has been built to contribute to the safety of a child with autism. The device uses a complex series of actions to open the locking system. First, the handle must be rotated 90 degrees to release a latch, which locks behind the inside of the cabinet frame. This allows the drawer to be pulled out about 3 inches. Second, a tab on a plastic locking mechanism on the bottom of the drawer must be depressed to allow it to be pulled out far enough to remove the internal contents of the drawer.

SUMMARY OF IMPACT

A child with autism has a fascination with the knife set in the family kitchen. Standard childproof techniques have failed to work. Hopefully, the complexity of the Child-Proof Drawer will deter the curious toddler from accidentally injuring himself. Both parents are very busy with work and family care. Hence, they cannot constantly keep him under scrutiny to prevent him from injuring himself. Therefore, the parents requested a locking system that would avert the toddler from regularly gaining access to the knife set. They also needed something that was convenient for them to open without having to worry about a key. In addition, the environmental impact had to be minimized. The childproof drawer device relieves the parents from constant worry about the child's accessing the knives.

TECHNICAL DESCRIPTION

The Childproof Drawer is a modification of a standard kitchen under-the-counter drawer. The modifications of the drawer are composed of two components. The handle on the front of the drawer has been modified so that it is held on just one side. Attached to the back of the anchored side of the handle is a sheet metal bracket which, when rotated so that the handle is in its normal position, locks on the back of the cabinet frame that surrounds the

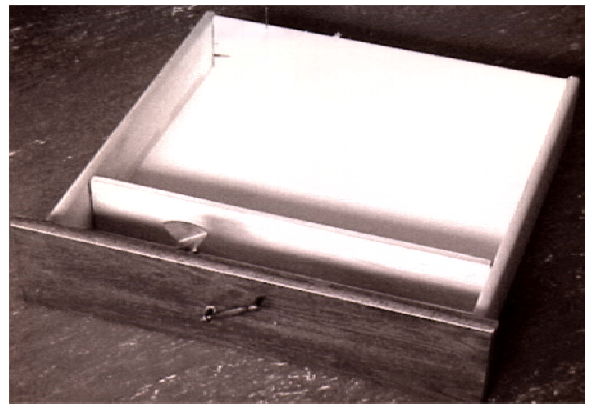

Figure 5.9 Childproof Drawer.

drawer. With the handle in its normal position, it appears that the drawer can be opened but, in fact, it can only be opened when rotated upward about 90 degrees so that the bracket no longer prevents the drawer from being opened.

The bottom of the drawer is equipped with a plastic glider manufactured by Delta Industries. Originally the Delta glider was mounted at the back of the drawer to prevent the user from unintentionally pulling the drawer all the way out and spilling the contents on the floor. The modification involved moving the Delta Glider forward about 10 inches, where it is glued to the bottom of the Child-Proof Drawer in such a way that the glider slides along the metal track that has already been installed.

Hence, to open the drawer the handle has to be rotated about 90 degrees. Then, the drawer can be pulled out a few inches. Then, by reaching underneath the drawer and depressing a small lever on the Delta glider will allow the glider to detach from the metal track. Thus the device can be fully opened and the contents of the drawer accessed. The complexity of the device should prevent the child from opening the drawer, but allow the parents to easily reach the kitchen knives.

The cost of parts and materials is about $5.

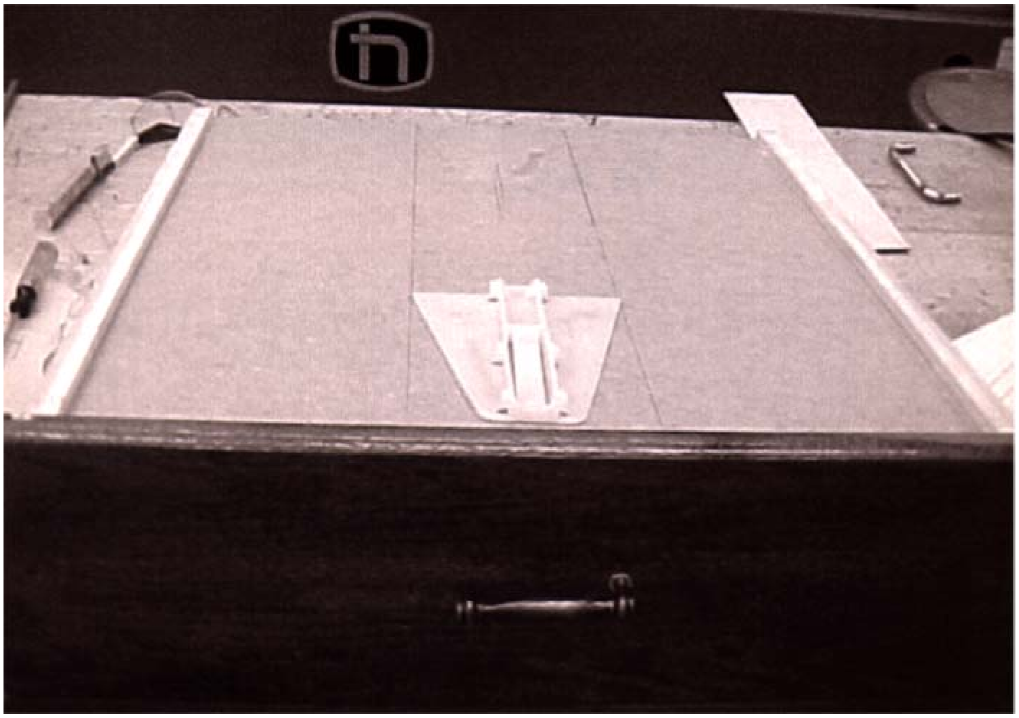

Figure 5.10. Plastic Locking Device.

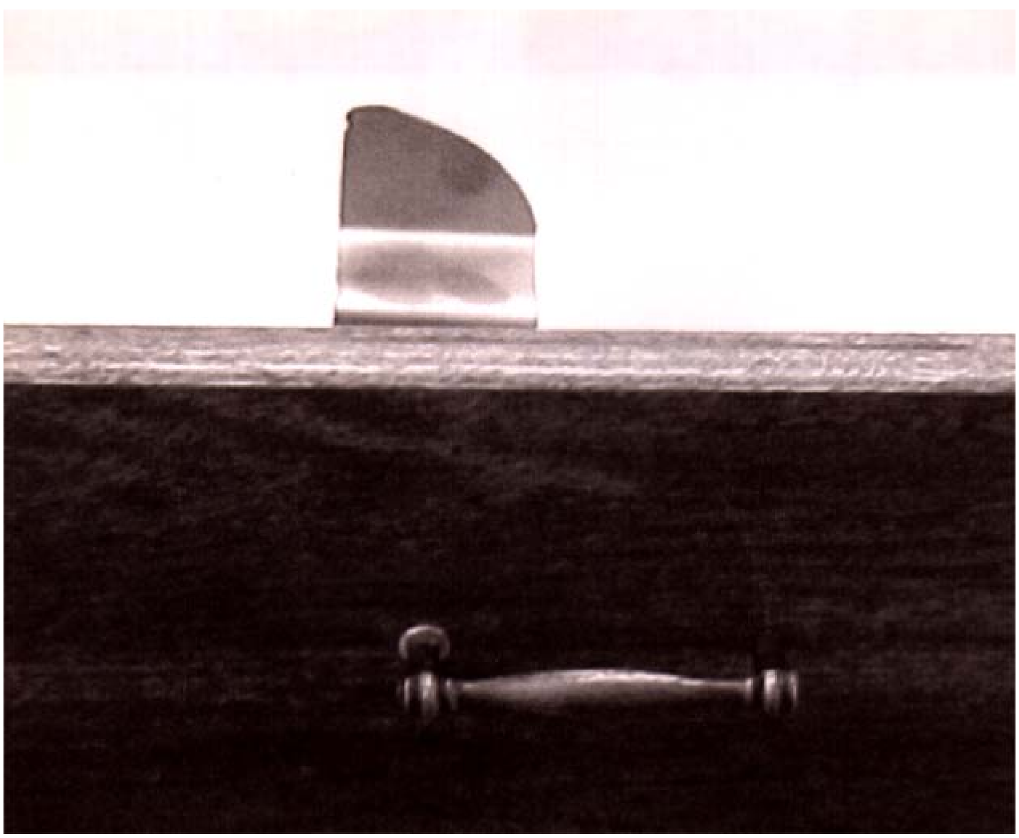

Figure 5.11. Locking Handle.

ONE HANDED CAN OPENER

Designers: Leo Yoon and Alan Weinberg
Client coordinator: Darlene Dickinson, STIC
Supervising Professor: Richard Mecklenborg
Division of Engineering Design
Watson School of Engineering and Applied Science
Binghamton University,
Binghamton, NY 13902-6000

INTRODUCTION

The One-Handed Can Opener (OHCOP) is designed to provide self-sufficiency in the kitchen for a person with hemiplegia. The OHCOP is an adapted electric can opener and has an exterior-mounted, adjustable support for the can. As the can is being opened, the person does not have to hold the can. This device requires only one action by the user for each can-opening operation. The OHCOP will accommodate up to one-quart cans.

SUMMARY OF IMPACT

The client has hemiplegia due to a brain injury caused by a motorcycle accident. The can opener allows her to open food cans with her functional hand and therefore allows her some self-sufficiency in the kitchen. The OHCO is small, reliable, easy to use, easy to clean, and inexpensive. With the possibility of making her own food with an adapted can opener, she will be more self-sufficient in the kitchen.

TECHNICAL DESCRIPTION

The original can opener is made by a Magic Chef. The main structure of the OHCO is the plastic outer shell of the initial can opener. The can support is made of 6061 -T6 aluminum. The vertical sliding base is supported by two vertical rods that, in turn, are anchored to an aluminum plate connected to the can opener. The sliding base is threaded and can be raised and lowered with one hand by twisting a knob on the top of a vertical screw. In operation, the can is placed on the base and the knob is twisted to raise the can until it engages the cutting edge. A lever on the can opener is depressed, puncturing the can and anchoring it to the can opener. The knob is then turned back slightly to remove pressure on the bottom of the can from the base. Once the lid is cut loose, the can settles onto the sliding base and is lowered with the vertical screw until it can be removed.

Figure 5.12. One-Handed Can Opener

The cost of parts and material was about $35.

CHILD'S SWING

Designers: Paul Checkovich, Scott Clough, Michael Cook, Christopher Cuevas
Client Coordinator: Anne Winschel, North Central NYS PTP
Supervising Professor: Dr. Richard S. Culver
Division of Engineering Design
Binghamton University
Binghamton, New York 13902-6000

INTRODUCTION

A swing was requested for a thirteen-year-old girl with limited use of her arms and legs. She enjoys swinging, but her mother could not find a swing that provided enough support and that could be used indoors. A wooden seat, which can be suspended from eyebolts in the ceiling of the family's house was designed in the form of an easy chair, specially designed to fit the client. It can be used as a regular chair when not suspended by ropes from the ceiling. A pommel on the seat keeps the client from sliding out of the chair. Four parallel ropes suspend the chair so that it will swing freely when suspended only 2 inches above the floor. The ropes are attached to the seat with carabineers, so they can easily be removed when not needed.

SUMMARY OF IMPACT

The swing will be helpful in entertaining the child. Because it is designed to look like a normal chair, it can be used as piece of furniture when not being used as a swing. The swing will also be used by the client's two young siblings.

TECHNICAL DESCRIPTION

The chair is built out of ½-inch furniture-grade plywood and finished with cherry stain and urethane varnish. The seat and pommel have foam rubber padding with Naugahide covering. The seat design was based on the client's dimensions, but with room for her to grow. It is lightweight and yet sufficiently sturdy that it can be used by the other children in the family without danger of destruction.

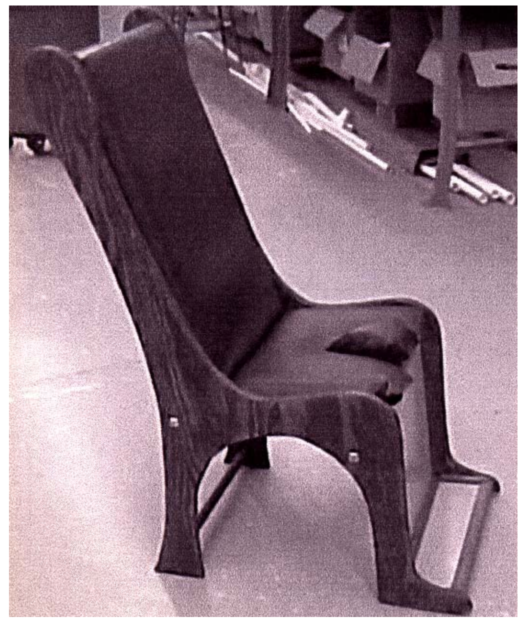

Figure 5.13. In-door Swing.

The supporting ropes are attached to eyebolts hidden under the seat. Four adjustable-length, ¼ inch nylon ropes are used to support the chair when it is used as a swing. The ropes are attached by carabineers to eyebolts, fastened to joints in the ceiling of the living room. Because the four ropes are parallel, the seat remains horizontal when it swings, so it can move freely with a minimum clearance from the floor. This reduces the potential impact if the client or one of the other children falls from the swing. The parents did not want a strap on the chair to secure the client when using the swing.

MAT TO DECREASE TACTILE DEFENSIVENESS

Designers: Dave Klepeis, Susan Kolakowski, Jena LaBagh and TJ Lamb
Client Coordinator: Maria Miller, BOCES, Binghamton, NY
Supervising Professor: Dr. Richard Culver
Design and Technology Engineering Department
State University of New York at Binghamton,
Binghamton, NY 13902-6009

INTRODUCTION

A mat was designed to help a young girl develop the ability to process and use sensory perceptions and to decrease her tactile defensiveness. During the design process She is 11 years old, weighs about 70 pounds, and is approximately 53 inches tall. She has cognitive impairment and is legally blind due to cerebellar cysts and demyelination. She verbalizes through noises and responds to a variety of sounds.

The mat consists of different textures and produces a variety of sounds. As the client lightly touches different areas of the mat, sensory switches inside activate different sounds associated with each texture. She will learn to associate these sounds with the textures she touches, and hopefully overcome her fear of unfamiliar surfaces.

SUMMARY OF IMPACT

Since birth, the client has had tactile defensiveness, difficulty touching various textures because she is afraid of the feel of certain objects. This condition affects her in many ways, from the clothes she wears to the food she eats. The aids at her school were very busy and were seeking a toy to occupy the child's time. They requested that the device be portable and washable.

TECHNICAL DESCRIPTION

The final design choice is a square mat with 30-inch sides and six 5- x 6-inch sections on one edge. The main difference between this mat and many of the design alternatives is in the way that it will be used. As opposed to walking across the different textures, the client will sit on one side of the mat and simply touch the different textures in front of her. This better accommodates the limited space available for the mat in her classroom.

The circuit board was removed from a children's toy that plays sounds when different buttons are pressed. Five of the six sections at the top of the mat are covered in differently textured materials. These are the sections the client will be encouraged to touch. The sixth section contains the mat's electronics. A Styrofoam panel separates the material of the section from the capacitor switch underneath. The capacitor switch (type QT-111) detects when the material of the section is lightly touched through the Styrofoam layer. Wires connect these switches to a fabricated circuit board. The fabricated circuit board connects each section's wire to two corresponding nodes on the circuit board taken from the toy. These nodes will activate 1 of 5 desired sounds. The remaining part of the mat is for the child to sit on. The entire mat is divided into two 30- x 15-inch pieces of plywood, which are covered in foam. One of these pieces of wood is only partially covered in foam, leaving a 30- x 6-inch area for the textured sections. The other half is completely covered by foam. Vinyl fabric then covers the foam and wood base. The two halves were connected with Velcro so they could be separated after use for easy storage.

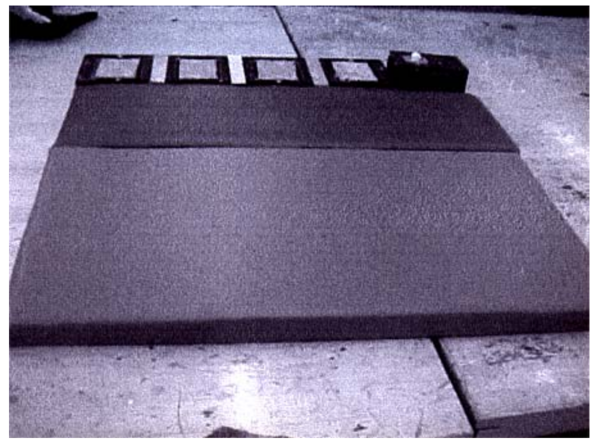

Figure 5.14. Tactile Stimulation Pad, Showing Capacitor Surfaces.

The mat design takes into account numerous safety considerations. First, the inner part of the mat is foam because it must be soft so that if the client falls over while she is using it, she will not hurt herself. Also, the mat is washable in order to prevent the spread of bacteria and germs. The mat's electronic device is low voltage, as it uses two AA batteries. It also has a low current, thus preventing electric shock in the event of a malfunction or a short circuit.

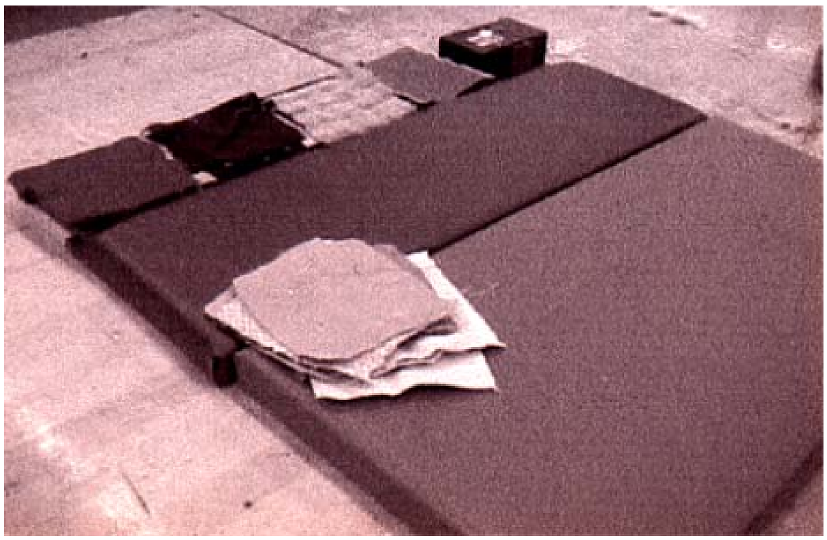

Figure 5.15. Various Cloth Materials for Tactile Stimulation.

CRAWLER DEVICE TO HELP DEVELOPMENT OF MUSCLE COORDINATION

Designers: Luigi Fosco, Daniel Durkin, and Sean Gove
Client Coordinator: Nicole Ruffo, Binghamton BOCES Developmental Center
Supervising Professor: Dr. Richard Culver
Mechanical Engineering Department
State University of New York at Binghamton,
Binghamton, NY 13902

INTRODUCTION

The crawler was designed to promote the development of muscle strength and coordination in children with reduced motor skills. The device is designed to allow the people working with these children to help them to learn to crawl so they can move under their own power. The device is a PVC tubing frame that supports the child from underneath in a sling-like harness so that he or she can learn the crawling motion with the help of fewer aids.

SUMMARY OF IMPACT

The crawler was designed to be used by aids at a center for children with disabilities while helping children learn to crawl. The children previously had to be pushed around in wheelchairs or have to drag themselves across the floor. The motor control and muscle strength gained from the crawler may help the children to learn to walk.

TECHNICAL DESCRIPTION

The frame of the crawler is 1½ inch PVC piping mounted on swiveling castors. The castors are mounted to the frame with bolts, and the frame is glued together with PVC cement. The child is supported by a cradle made of plastic sheeting, padding and cloth and is supported by a nylon strap. The cradle adjusts by varying the length of the nylon straps that connect it to the frame. The device is light, portable, adjustable, and easy to clean.

The approximate cost of the project was $45.00.

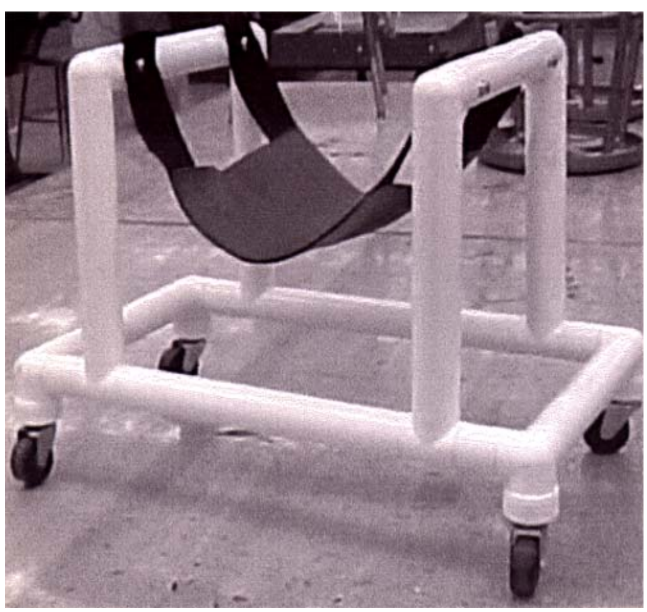

Figure 5.16. Crawler Device to Aid in the Development of Muscle Coordination.

WHEEL CHAIR UTILITY WAGON

Designers: Anish Patel, Don Miles, Josh O'Connor, Pat O'Hern
Client Coordinator:
Supervising Professor: Dr. Richard Culver
Binghamton University
Binghamton, N.Y. 13902

INTRODUCTION

The wheelchair utility wagon was designed for a man with cerebral palsy. It affixes to his wheelchair so that he can transport several large binders. Previously, the client uses a specially designed backpack that is very expensive and had worn out several times. The wagon attaches to the front of his wheelchair. The reason for attaching it to the front is that the client uses his right leg to propel himself backward while he looks over his shoulder. Despite other, more practical, design suggestions, the client specifically requested a wagon.

SUMMARY OF IMPACT

This design will last a long time and has proven very inexpensive to construct. The wagon will take up more room and be a bit difficult to control. The client likes challenges, so the added difficulty in maneuvering will give him something fun to do. Also, the open-topped container will make it much easier for the people he works with to pick up the binders.

TECHNICAL DESCRIPTION

The wagon frame is constructed of furniture grade PVC plastic built around a large plastic container. The wagon originally designed had four attachment points to the front of the wheelchair, but they were not necessary. The final design has only two attachment points at the base of the armrests. Since the armrests lift out of their socket with the simple flip of a switch, a method was developed to attach the device with a ring that fits around the base of the armrest post. The solution was to use an eyehook screwed into the PVC end cap. Two four-inch casters in the front support the device.

The total cost of the project is $50 dollars.

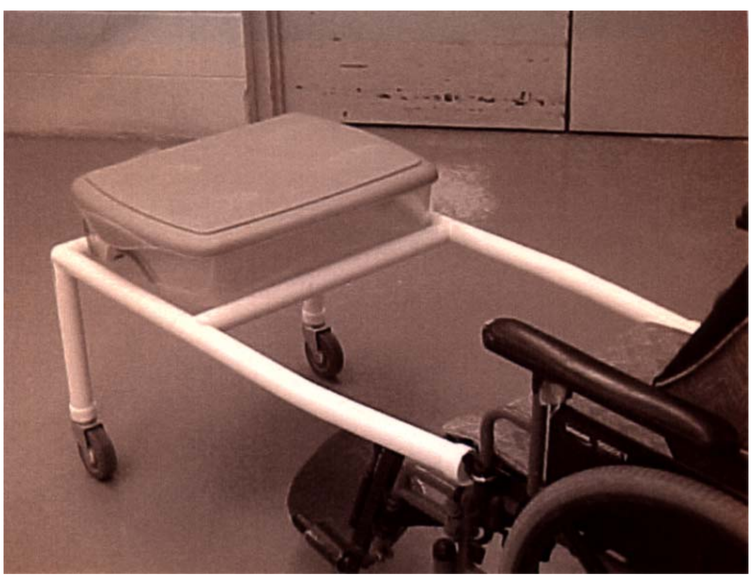

Figure 5.17. Wheelchair Utility Wagon.

STANDING TABLE TO IMPROVE CIRCULATION

Designers: Peggy Berkowitz, Rich Munn, Jeff Slocum, and Liz Talmage
Supervising Professor: Richard Culver
State University of New York at Binghamton
Binghamton, NY 13902

INTRODUCTION

The Standing Table was designed to provide a client circulatory stimulation to his legs. He is unable to walk and has problems with both his legs and feet because of the lack of blood flow to these areas.

The Standing Table gradually tilts from a horizontal position to a vertical one. Between the horizontal and vertical positions, the table can lock into other positions, so that the client can experience standing at different angles. By tilting him towards a standing position, circulation returns to his legs via gravity. Given that some of his leg muscles will also have to be used and this is another way for him to increase circulation to his legs and feet.

There are quite a few existing solutions for this problem. Currently on the market there are numerous types of standing devices. They include wheelchairs that can move into a standing position, standers that are made to hold a person in a standing position next to a table, and supine standers that tilt from the horizontal to the vertical position. The new design is most representative of the supine standers. But supine standers cost from $1,000-5000, which is why the client's supervisor requested this device.

SUMMARY OF IMPACT

Not only will the standing table benefit the client's circulation, but also it will give him the chance to get out of the wheelchair. The standing table could possibly even help him walk again some day. The table is mobile and washable.

TECHNICAL DESCRIPTION

The standing table is fabricated of wood (2x4s and plywood). It is made of two pieces. The top part like the top of any regular table and is approximately 2′ wide and 6′ long. The bottom part of the table is the frame that supports the top table and is approximately 33″ wide, 6′ long, and 3′ high.

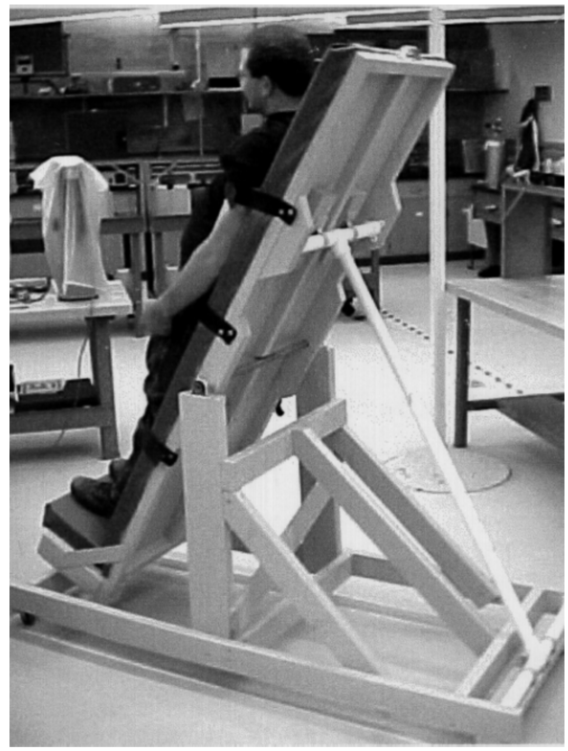

Figure 5.18. Standing Table to Improve Circulation.

The top table was made with 2x4s, plywood, and foam padding. The 2x4s created a base for the piece of plywood table surface. On top of the plywood is foam padding. The foam padding is covered with washable upholstery, stapled to the frame. Straps are attached to the side of the table to ensure that the client will not slide off. On the bottom of the table is a footrest upon which he stands when the table is near vertical. The footrest is made in the same fashion as the table. A hole is drilled on two sides in the middle of the 2x4 base for the plywood to hold a piece of pipe. This pipe allows the table to pivot.

The bottom frame is made of 2x4s. Castors with brakes are attached to the bottom four corners of the frame. Flange bearings are mounted to the two sides of the frame. These bearings hold the pipe that allows the table to pivot.

A telescoping arm constructed with PVC holds the table in different positions between the horizontal and vertical. A spring-loaded button locks the table into different positions.

The approximate cost of parts and materials was $200.

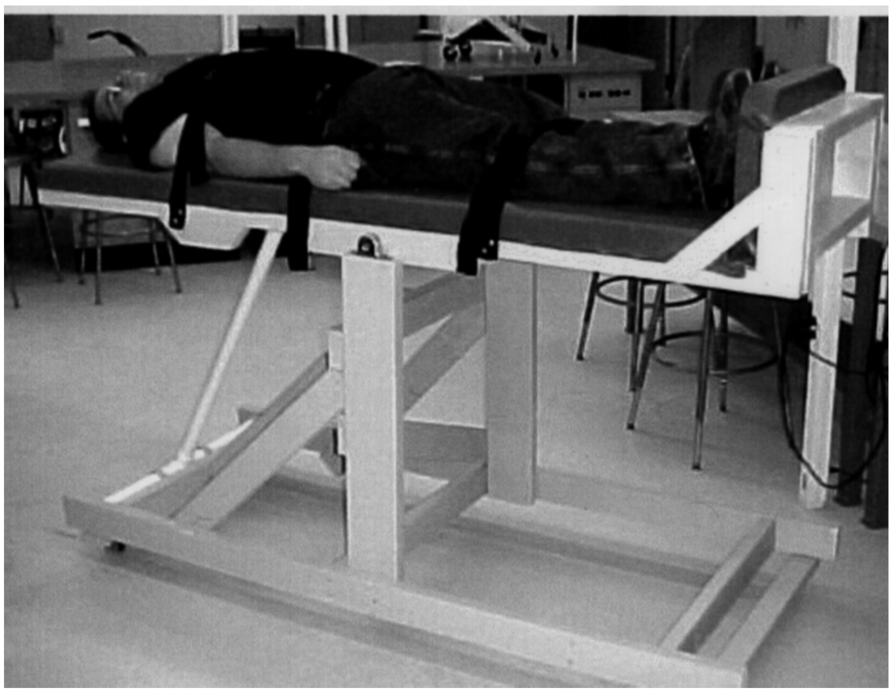

Figure 5.19. Standing Table.

CHAPTER 6
DUKE UNIVERSITY

Pratt School of Engineering
Department of Biomedical Engineering
136 Hudson Hall, Box 90281
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Principal Investigator:

Larry N. Bohs (919) 660-5155

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WHEELCHAIR DESK

Designer: Jennifer Glasgow
Supervising Professor: Dr. Larry N. Bohs
Department of Biomedical Engineering
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Durham, NC 27708-0281

INTRODUCTION

A high school student with Duchenne Muscular Dystrophy needed a wheelchair-mounted desktop surface for schoolwork, computer work, and eating. He previously used a commercial work surface that rested on his lap. This surface was cumbersome and would move undesirably when he moved. A removable desk was constructed to mount to the client's powered wheelchair. The desk slides on to two custom fixtures attached to the sides of the wheelchair frame, and can be removed for storage behind the chair. The desktop is edged with soft rubber tubing to prevent items on the desk from slipping off, and the desk shape allows for normal wheelchair function.

SUMMARY OF IMPACT

The client's mother had this to say about the desk: "He really likes it. It makes his schoolwork more accessible. He doesn't have to adjust to the existing tables, which are often not the right height. We put it on in the mornings, and he leaves it on all day. He can keep all of his work on top, so everything is handy. It has brought his work up to him, and has helped him a lot. It's been neat to see how he really wants it, and asks for it."

TECHNICAL DESCRIPTION

The desktop is made of ¼" thick clear polycarbonate and is lined around all edges with ½" diameter black rubber tubing for protection, slippage prevention, and comfort. The desktop attaches by four screws to a frame welded from ½" square steel tubing. Foam rubber padding lines both the top and bottom of the rear portion of the desk top, which rests on the wheelchair armrests. The padding on the bottom protects the armrests from damage caused by contact with the desk, while the padding on the top increases comfort during use. A cutout in the desktop allows the client to reach the power switch and joystick for his chair.

Two ¾" I.D. square steel tubes, both 10" long, are attached to the desktop frame by hinges, which are welded to these support tubes and the frame. The hinges allow the support rods to fold parallel to the desktop, so that the desk can be stored in the rear of the wheelchair. In the storage position, the desk rests between the back of the wheelchair seat and the client's backpack, on top of the wheelchair's battery housing. A single Velcro strap secures the desk in the storage position.

The support tubes slide over support rods, which extend from custom brackets mounted to horizontal members on each side of the wheelchair frame, below the seat. The brackets are made of ¼" plate steel, and mount to the frame members with two ¼-20 bolts. The support rods consist of ¾" square solid steel rod, 2" long, welded vertically onto the end of each bracket. The support rods are tapered to accommodate the support tubes for easy mounting and removal of the desk. To mount the desk, the support tubes are slid onto the support rods, which is a simple operation for one person. The brackets do not inhibit normal wheelchair use and remain on the wheelchair at all times. Because the horizontal members of the frame do not provide a vertical surface for mounting the brackets, custom aluminum wedges between the members, brackets, and mounting bolts ensure that the support pins are vertical.

All steel portions of the desk, except for the support rods, are painted black to blend in with the rest of the wheelchair. The support rods are unfinished to maintain the fit with the support bars.

Materials for the desk cost approximately $150; machining costs were approximately $400.

Figure 6.1. Wheelchair Desk.

FREESTANDING MOTORIZED CHILD SWING

Designers: Amy Congdon and Jessica Foley
Client Coordinator: Linn Wakeford, Frank Porter Graham Childhood Development Center
Supervising Professor: Dr. Larry N. Bohs
Department of Biomedical Engineering
Duke University
Durham, NC 27708-0281

INTRODUCTION

A four-year-old boy with cerebral palsy has limited vision and mobility and is dependent on adults. He enjoys motion, especially swinging. The goal of this project was to provide a powered swing he can control himself. A motorized swing controlled with a switch was designed and constructed. This freestanding swing safely swings a child up to 50 pounds in weight, and provides appropriate support for the client as he swings.

SUMMARY OF IMPACT

Most of our client's day-to-day activities require that he depend on adults. His limitations in play behavior make it difficult for his parents and therapists to create play opportunities for him that are both enjoyable and allow him to develop independence. His occupational therapist believes that "the swing will offer him the opportunity not only to do something he really likes, but also to control that activity to some extent. He can rely more on his own desire to engage, rather than on an adult's desire that he play with something." She added that the swing "really will enhance his quality of life." After five months of use, the client's parents commented: "As you know (he) is immobile and nonverbal. While he can't express himself directly, his pleasure (or displeasure) is quite apparent. The swing has brought great joy. He uses his swing every day and enjoys it most in the evenings after dinner. He laughs and kicks while in the swing and always comes out of the swing with a smile on his face."

TECHNICAL DESCRIPTION

The overall swing is pictured in Figure 6.2. It includes the swing frame, seat, drive mechanism, motor speed control and power supply. A drive plate is attached to the motor. A drive pin, surrounded by a cylindrical bearing and mounted on the drive plate, rides in a channel of the swing drive arm. As the motor spins the drive plate, the drive pin causes the drive arm to move in an oscillatory manner about a crossbar. The drive arm is rigidly attached to the swing arms, which freely rotate about the crossbar. The swing seat attaches to the swing arms with four ropes, which decouple the drive mechanism from the swing pendulum sufficiently to allow the swing to start from rest without a push. Horizontal cross-supports are added to the base of the swing frame, which was purchased commercially (Sammons Preston), for added stability. The frame is further stabilized by filling the lower legs and these cross-supports with sand. The motor mechanism is mounted with a custom plate and six ¼" bolts to the crossbar at the top of the frame. The motor is a 12V DC, 37 RPM, 1/5 HP gearmotor. A pulse-width modulated speed controller is mounted in a control box, and adjusted to match the motor speed to the natural frequency of the swing pendulum. 12V DC is provided with a computer power supply, mounted next to the control box on the swing frame. A relay in the control box allows an external switch with a 1/8" plug to actuate the swing. A bypass plug allows the swing to be used without the external switch.

Materials for the swing cost approximately $950; machining costs were approximately $600.

Figure 6.2. Freestanding Motorized Swing.

TILTING DESK FOR POWER WHEELCHAIR

Designers: Amy L. Caribardi and Lauren E. Schaffer
Supervising Professor: Dr. Larry N. Bohs
Department of Biomedical Engineering
Duke University
Durham, NC 27708-0281

INTRODUCTION

The client is a man with quadriplegia who uses a power wheelchair. Most commercially available wheelchair desks attach to the armrests, often interfering with the control joystick on power wheelchairs. The goals of this project were to construct a desk that easily attaches to the client's wheelchair, and that provides access to the wheelchair's joystick and a tilt feature that he can control himself. The project consists of a wooden desktop, supported by a steel frame. The frame inserts into clamps mounted to the footrests of the power wheelchair, avoiding the joystick. A ratchet mechanism allows the client to tilt the desk without assistance.

SUMMARY OF IMPACT

The client could not find a commercial desk that was suitable for his needs, and therefore had difficulty finding surfaces on which he could read, write, and eat. The wheelchair desk fastens to his power wheelchair without interfering with the joystick control. Its non-slip surface allows him to read, write, and eat without finding a non-slip table or transporting certain dishes and bowls. The client can tilt the desk without the help, thereby extending his independence.

TECHNICAL DESCRIPTION

The desktop is constructed of ¾″ maple for durability and to accommodate the client's aesthetic preference. It is comprised of three boards jointed together, 26″ wide, the width of the wheelchair's armrests. The corners are rounded, and the surface sanded and finished with polyurethane to make it waterproof. The center area is routed to accommodate a 12″x12″ sheet of hard rubber, which provides a non-slip surface for writing and eating. A wooden ledge, attached below the rubber insert, holds reading material in place when the desk is tilted.

Facilitating independent desk tilting for the client was an important structural consideration. Three pieces of ¾″ square metal tubing are welded together with a solid steel rod to form a rectangle. Two vertical supports of ¾″ square tubing are welded to this frame. The solid rod rotates within holes in wooden tie braces, attached to the bottom of the desktop. One end of the solid rod attaches to the drive point of a ½″ socket wrench. The arm of the wrench is bolted to the bottom of the desktop. An extension bar is attached to the ratchet mechanism of the wrench, extending 6″ above the desktop surface.

When the extension bar is pushed forward, the desk can be lifted to a desired tilt angle; it will stay at the highest angle achieved until the extension bar is pulled backward, which allows the desk to return to horizontal. The extension bar attaches to the ratchet mechanism using a screw and a milled groove, which allow the bar and ratchet mechanism to remain in contact under considerable force.

The desk is attached to the power wheelchair using two custom support brackets, which clamp to the foot rests of the chair. Screw-and-hinge clamps attach each bracket to two sites along the curved rods of each of the footrests. These clamps attach to a metal plate with an adjustable mounting, so that the exact fit of the brackets can be adjusted on the chair. The clamps are lined with foam rubber to prevent slipping. Also attached to each metal plate is a piece of square steel tubing, slightly larger than the vertical support poles of the desktop frame. The support poles are tapered slightly to make attachment and removal of the desk easier.

Two safety features of the desk help prevent damage to fingers that might be under the surface when it is lowered into the resting horizontal position. First, a strip of foam weather-stripping is attached to the underside of the desktop to cushion the area between the desktop and the metal frame. Second, an anti-slam lid support, as used for toy boxes, is attached between the desktop and frame. The device consists of a sliding track with a rubber disk that glides with adjustable friction. This lid support is adjusted using a single screw to create the desired damping effect.

Materials for the desk cost approximately $210; machining costs were approximately $300.

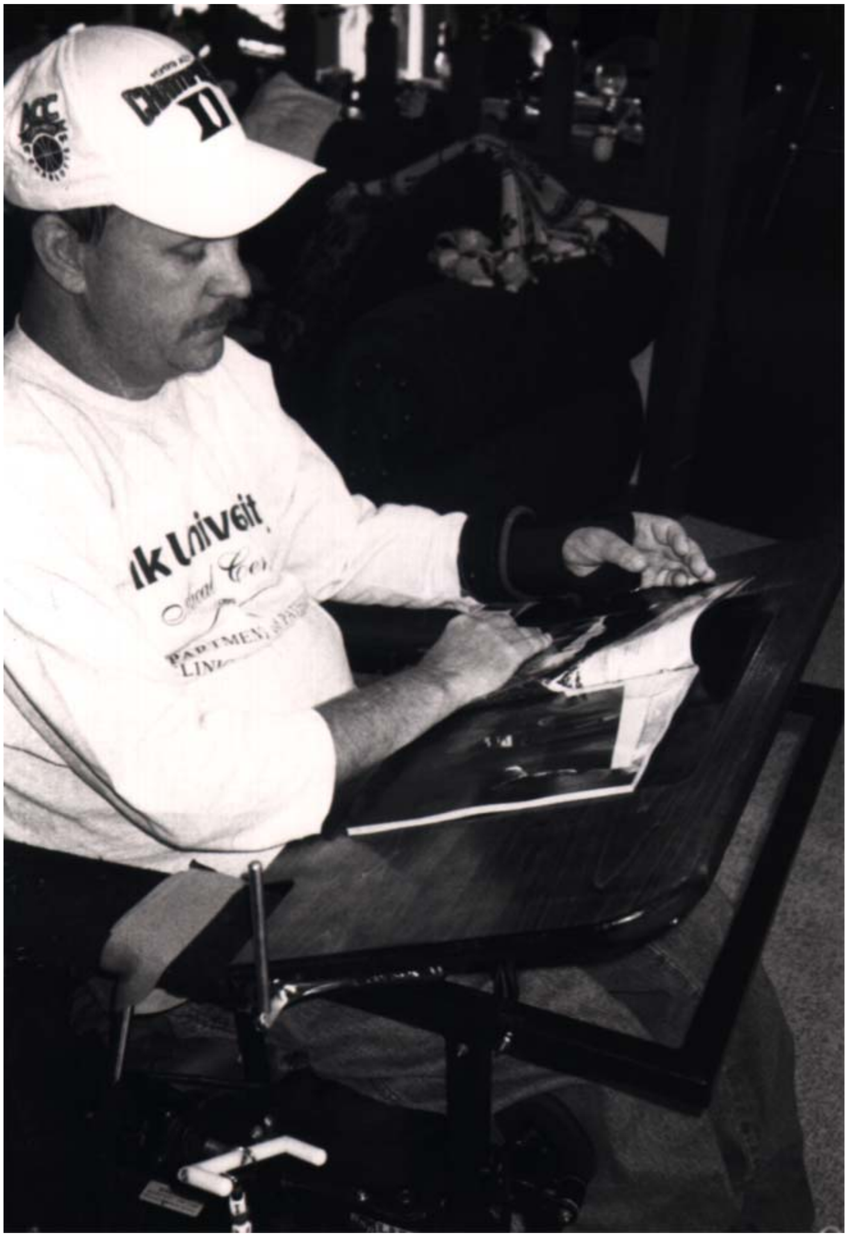

Figure 6.3. Tilting Desk for Power Wheelchair.

RECREATIONAL CHILD JUMPER

Designers: Jennifer Glasgow and Thomas Meese
Client Coordinator: Nancy Curtis, Easter Seals Foundation of NC
Supervising Professor: Dr. Larry N. Bohs
Department of Biomedical Engineering
Duke University
Durham, NC 27708-0281

INTRODUCTION

The goal of this project was to design and construct a recreational jumper for a five-year-old girl with cerebral palsy. The primary objectives were to make the jumper safe, comfortable, quiet, and durable. A commercial swing-quality bungee cord provides for the vertical jumping motion, while a padded seat comfortably supports the child. The device hangs from an eyebolt in the ceiling, and adjustable nylon straps allow the height to be changed. The client will be able to use the jumper for several years, providing her with a safe and enjoyable form of exercise.

SUMMARY OF IMPACT

The client works with her hands and torso at school, but without a jumper, she had no means for safe aerobic activity. She has a walker, but due to her limited vision, the walker does not provide a safe way to exercise without constant supervision. The jumper provides enough support to keep the client upright and balanced, yet provides weight-bearing exercise. Another important benefit is her enjoyment: she loves to jump and spin in the jumper, especially when her parents play her favorite music. Her physical therapist feels that "the jumper will provide her only means of safe and independent combination of play and movement."

TECHNICAL DESCRIPTION

The jumper is described from the top (ceiling connection) down to the seat. A locking caribiner clips into an eyebolt in the ceiling. Two bungee cords are suspended from the caribiner, with a second caribiner attached to the bottom of the bungees. The jumper uses commercial swing-quality bungee cords (Southpaw Enterprises, model 1938), rather than springs, to offer a greater rate of deflection and quieter operation. Currently, a double bungee loop supports a 60 lb working load. As the client grows, an additional single bungee can be attached in parallel to increase the maximum load to 90lbs.

An adjustable nylon strap is suspended from the lower caribiner. The strap has one metal adjuster clip and ranges in length from a minimum of 4 inches to a maximum of 4 feet. A swivel bearing is suspended from this strap, and a caribiner connects it to the center of a 1.75" diameter metal support bar. The support bar is padded for safety and includes a sewn-on warning label describing the weight limits of the device.

An eyebolt is attached to each end of the support bar, and an adjustable nylon strap is suspended from each of the eyebolts. Both ends of the nylon straps are sewn into the seat, which is padded and constructed from parachute fabric. The seat reaches a height that will allow it to support the child's chest and back. The front two nylon straps are surrounded at the bottom by plastic tubing for cushioning. Three horizontal pieces of 1" nylon webbing are sewn approximately 2.25" apart on the front and back of the seat. The ends of these straps are connected to clips on the left side and adjusters on the right side, allowing for over ten inches of adjustability in the horizontal direction.

The upper and lower adjuster straps can accommodate substantial variations in the ceiling's height, and provide an easy means for inserting and removing the client from the swing. The jumper was thoroughly tested by analyzing its components separately. According to load testing and manufacturer specification sheets, the jumper was to provide a minimum safety factor of 1.9.

Materials for the jumper cost approximately $300.

Figure 6.4. Recreational Child Jumper.

BATTERY TESTER FOR PEOPLE WITH PHYSICAL AND COGNITIVE DISABILITIES

Designers: Brandon Stroy and Ravi Baji
Client Coordinator: Lisa Williams, Generations Tadpole Assistive Technology Lending Library
Supervising Professor: Dr. Larry N. Bohs
Department of Biomedical Engineering
Duke University
Durham, NC 27708-0281

INTRODUCTION

A lending library that provides low-tech assistive technology devices and toys to people with disabilities has many products that use batteries, which must be tested regularly. Because the library employs people with various disabilities, an easily manipulated battery tester with obvious, multi-sensory indicators is needed. A device was built to make testing batteries simpler and more interactive. It features simple operation, as well as visual, auditory, and vibratory indications of a good or a bad battery. The device allows more employees to test batteries, improving their rate of pay and independence.

SUMMARY OF IMPACT

Employees earn income based upon the type and number of jobs they can accomplish. If employees learn to do a new task, they increase their pay. The director of the library had this to say about the Battery Tester: "The employees… have been using it daily. The employees are responding well to the variety of feedback that the battery tester offers. We have been able to allow five more employees to expand their job responsibilities to include testing batteries! This has increased their participation in the program as well as their salary. We have a young lady with a visual impairment and a hearing impairment who is now able to test batteries independently."

TECHNICAL DESCRIPTION

The battery tester (Figure 6.5) consists of a mechanical testing unit, a circuitry unit, and three peripheral response units. The testing unit allows all standard types of cylindrical batteries to be tested between two copper plates in the front of the device. The top plate is angled downwards, and held in position with a spring and hinges. Batteries are held vertically and inserted by sliding them to the back of the tapered testing unit. When the battery is pushed in completely, a rear pushbutton switch is contacted, signaling the circuitry to test. Two parallel copper strips on the top of the box test 9V batteries. One of the strips is spring loaded, with a contact pushbutton to signal battery insertion.

The circuitry unit includes four input optoisolators, which allow batteries to be inserted in either polarity orientation. When the battery voltage is above a threshold and the battery insertion switch is activated, a "good battery" signal is generated. If the voltage is below the threshold, a "bad battery" signal is created.

Three sensory outputs are available: LEDs (visual), vibration (tactile), and digital voice (auditory). Any combination of outputs may be selected to tailor the device for specific users. Two of the peripheral response units contain LEDs and digital voice circuitry. A good battery creates constant-on LEDs and a message such as "good battery" on one of the response units. A bad battery creates flashing LEDs and a "bad battery" message. The third response unit contains a motor with an offset weight to create vibration. A good battery creates constant vibration, while a bad battery creates pulsating vibration. The visual/auditory response units can be positioned in proximity to battery bins to facilitate sorting of good and bad batteries.

Materials for the battery tester cost approximately $500.

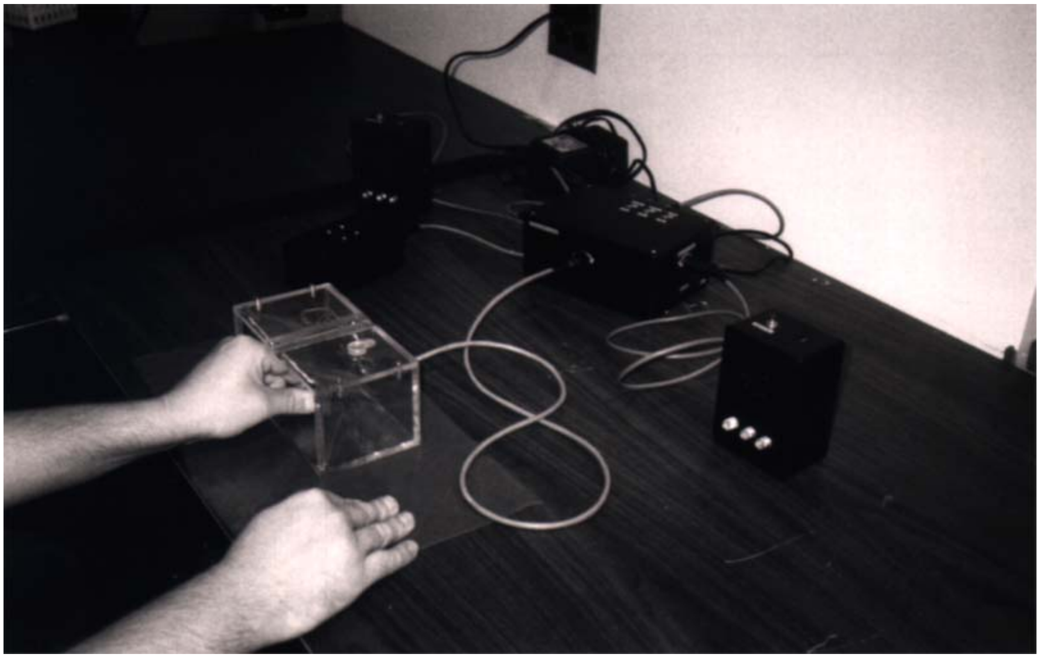

Figure 6.5. Battery Tester.

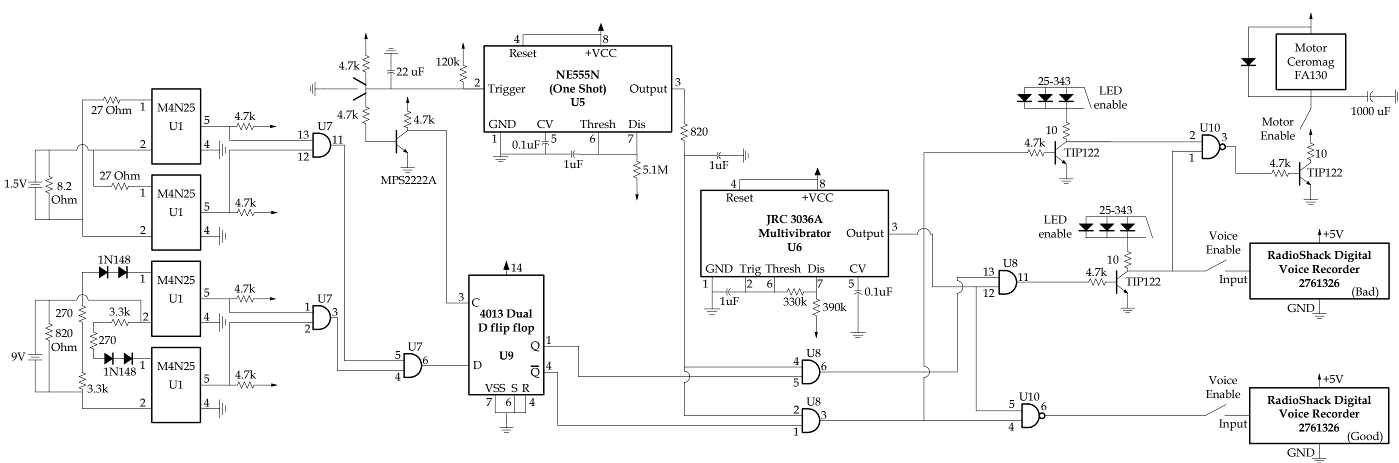

Figure 6.6. Battery Tester Schematic.

MOTORIZED SWING SUSPENDED FROM RINGS

Designers: Austin Derfus and Greg Garbos
Supervising Professor: Dr. Larry N. Bohs
Department of Biomedical Engineering
Duke University
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INTRODUCTION

The client is an eight-year old girl with cerebral palsy, spastic quadriplegia, blindness and hearing loss. Due to her limitations, swinging is one of the few stimuli she can enjoy. Her family desired a motorized swing because she often desires to swing for hours at a time. She is now 56 pounds, 42 inches tall, and has long outgrown her commercial motorized infant swing. The goal of this project was to design and construct a device to swing the client from rest for extended periods of time. It is to support her through adulthood. The swing is suspended from two rings, which support the swing's driving mechanism as well as the child. An offset crank converts rotational motion to oscillatory action. Two speeds are available to change the degree of swinging.

SUMMARY OF IMPACT

Few toys provide positive stimulus for the client due to her cognitive and physical limitations. Since swinging is known to be an enjoyable stimulus, a motorized swing allows her parents to more easily accommodate this need. Additionally, the swing gives her a new seating option. After five months of use, the client's mother said, "She has so few options for enjoyment, the swing gives her another choice for stimulation that she didn't have before. She uses it all the time. Other children with disabilities, including those with Down's syndrome, have visited and enjoyed the swing as well."

TECHNICAL DESCRIPTION

The swing suspends from two rings for compatibility with both the client's porch and her school. This design eliminates the need for a frame and increases the swing's portability. The swing's driving mechanism consists of a variable speed motor with an offset crank, and a drive channel attached to a drive shaft. The offset crank moves in the channel and oscillates the drive shaft, which is mounted with pillow block bearings to the swing suspension system. The motor and offset crank are mounted rigidly to the swing suspension system, which uses eyebolts (rings) screwed into overhead attachment points such as ceiling beams. A solid square steel rod slides through both eyebolts, and custom brackets clamp onto these to prevent the rod from rotating. The swing driving and suspension systems are mounted rigidly to this stationary square rod.

The suspension system includes two swing arms, which act as lever arms to push the swing. These arms are connected together with a round steel drive shaft, which is attached to the solid square rod by three pillow block bearings. These bearings suspend from the square rod and permit smooth rotation of swing's drive shaft. Adjustable-length chains connect the swing seat to the swing arms, allowing the swing to gradually obtain the speed of the driving motor. This design is compatible with any seat that can be attached to two chains, providing customization for a given user. Switching seats involves detaching two caribiners.

The swing is powered using standard 110V AC power, with a GFCI (ground fault circuit interrupter) attached for electrical safety. A variable speed control (Dayton 4Z827) converts the AC input to 90V DC for the 1/8 HP, 24 RPM DC gearmotor (Dayton 4Z130), and allows adjustment of the motor speed to match the natural frequency of the swing. Two variable settings in the offset crank allow for two different swing angles.

Safety of the client played a large role in the design. The attachment to two suspended rings prevents the possibility of tip-over. The final swing design was tested using no weight, 25 lbs., 50 lbs., and 170 lbs. For each trial, the swing started properly from rest, and swung to the predicted arc. Human trials were conducted to confirm the weight limit, and to observe the smoothness of the swinging motion. Additionally, a finite element analysis using Pro/MECHANICA was performed on the offset crank, which was considered the most crucial component of the design, to predict its maximum von mises stress and insure it was within the limits of the materials used.

While this device was made for a specific individual, it can be used in any location with two suspended eyebolts, used with any seat, and can swing individuals up to 150 pounds. Materials for the swing cost approximately $435; machining costs were approximately $500.

Figure 6.7. Motorized Swing.

AUTOMATED DESK MOUNTED ON WHEELCHAIR

Designers: Ethan Fricklas and Brian Alonso
Supervising Professor: Dr. Laurence N. Bohs
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INTRODUCTION

The client is a 17-year-old male with Duchenne Muscular Dystrophy who uses a power wheelchair. A senior in high school, the client currently uses a small lap tray that must be placed in front of him for reading and writing. To be more independent, the client desires a desk that he can move into place automatically without assistance. This project involved modifications to a 2000 senior design project. Chiefly, the previous design did not provide sufficient torque to lift the desk reliably. In addition, numerous safety features were incorporated. The Automated Desk mounts to the power wheelchair and is actuated with two switches. One switch rotates the desk from its storage position behind the chair, over the client's head, and into working position in front of him. The other switch controls a linear actuator that extends and retracts the desk to provide head clearance and suitable storage and working positions. Several sensors provide for safe operation and help automate desk motion. An electronic brake prevents the desk from moving when the rotational motors are not active.

SUMMARY OF IMPACT

Evaluation of the completed design on the client's wheelchair indicated that all functions of the deskwork as intended. Using two switches, the client can independently move the desk into a workable position, and retract it to a storage position. Nevertheless, further work is necessary to improve the overall appearance, to provide further clearance in two positions, and to build a printed circuit board for the electronics. The nature of this project is such that the client will rely on it heavily. For this reason, future development is required to address remaining issues such as product reliability and comprehensive safety testing.

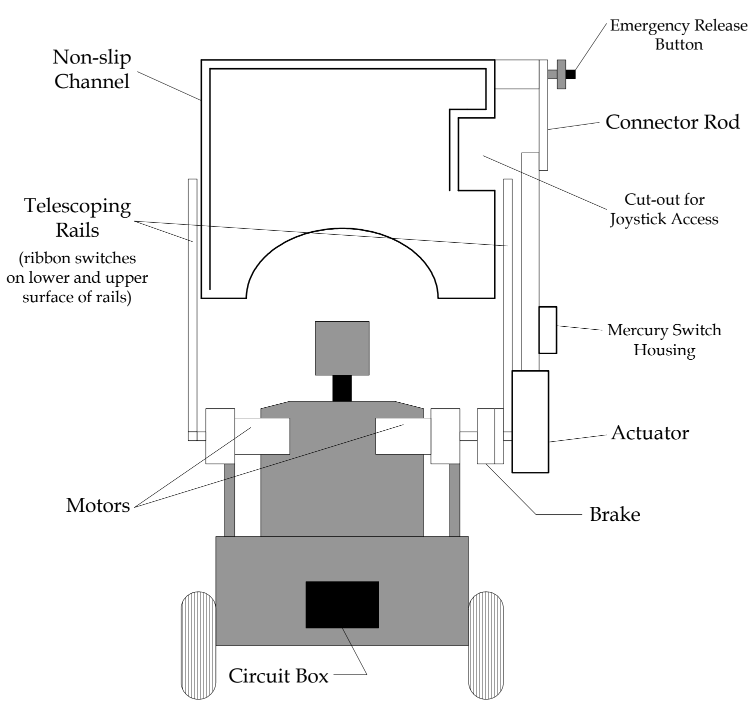

Figure 6.8. Rear View of Automated Desk.

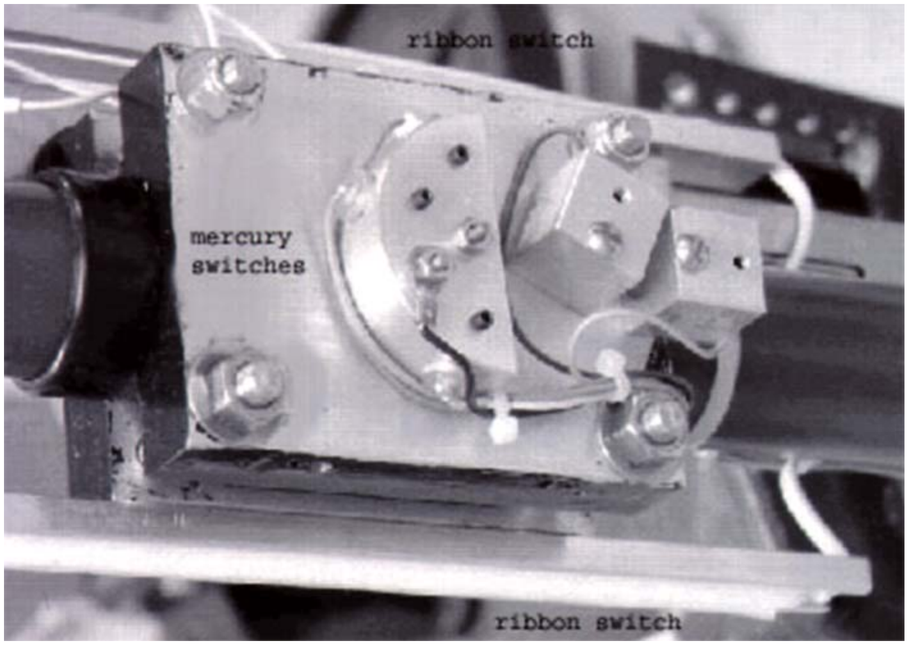

Figure 6.9. Mercury Tilt Switches with Housing.

TECHNICAL DESCRIPTION

The desktop is constructed from clear ¼” polycarbonate, with a steel reinforced under-frame. This assembly attaches to telescoping rails for extension and retraction using a 24VDC linear actuator (Dayton® 2506). In the initial design, the desk and actuator were to be rotated from the storage position to the armrests by a single 12VDC, 6 RPM gearmotor (Dayton® 1L474). This motor, located on the left-hand side of the wheelchair, can produce 500 lb-in of torque, which is insufficient to reliably rotate the desk. In addition, the motor speed was deemed too fast. To solve these problems, a second motor was added to the right side of the wheelchair, and a pulse-width-modulated speed controller integrated into the electronics to adjust the motors to the desired speed.

A custom mounting plate was machined out of ¼” steel and welded together so that the brake, extra motor, and actuator (Figure 6.7) all mount together to the right side of the wheelchair frame. On the left side, a ¼’ steel mounting bracket was fabricated for the single motor. All fasteners are Grade 5 bolts and nylon insert locknuts, to prevent loosening due to vibration.

A number of sensors and electronic logic circuits ensure safe operation of the desk. Along the linear actuator, upper and lower limit magnetic reed switches sense full extension and retraction of the desk. These switches are closed when contacted by a magnet mounted to the actuator shaft. Five mercury tilt switches are orientated at various positions on the actuator side of the desk (Figure 6.8). The combinations of signals from these switches at any given time are processed by the electronic logic circuit and dictate the position of the desk. The logic is designed to prevent the desk from ever touching the client or his wheelchair. For example, if the desk is rotated back from the working position, the actuator must be fully extended or the desk will not move beyond a certain limit. Additionally, ribbon switches placed along the upper and lower edges of the desk (Figure 6.7) will stop all motion if the desk comes into contact with an object.

The device is controlled with two remote single-pole double-throw switches, one for motor forward and back, and one for actuator extend and retract. The electronics are housed in a resilient plastic enclosure. The circuitry also contains a power conservation relay to minimize current draw when not in use, which significantly increases the time required between charging of the wheelchair's batteries. The cost of materials added to the project this year was approximately $375.

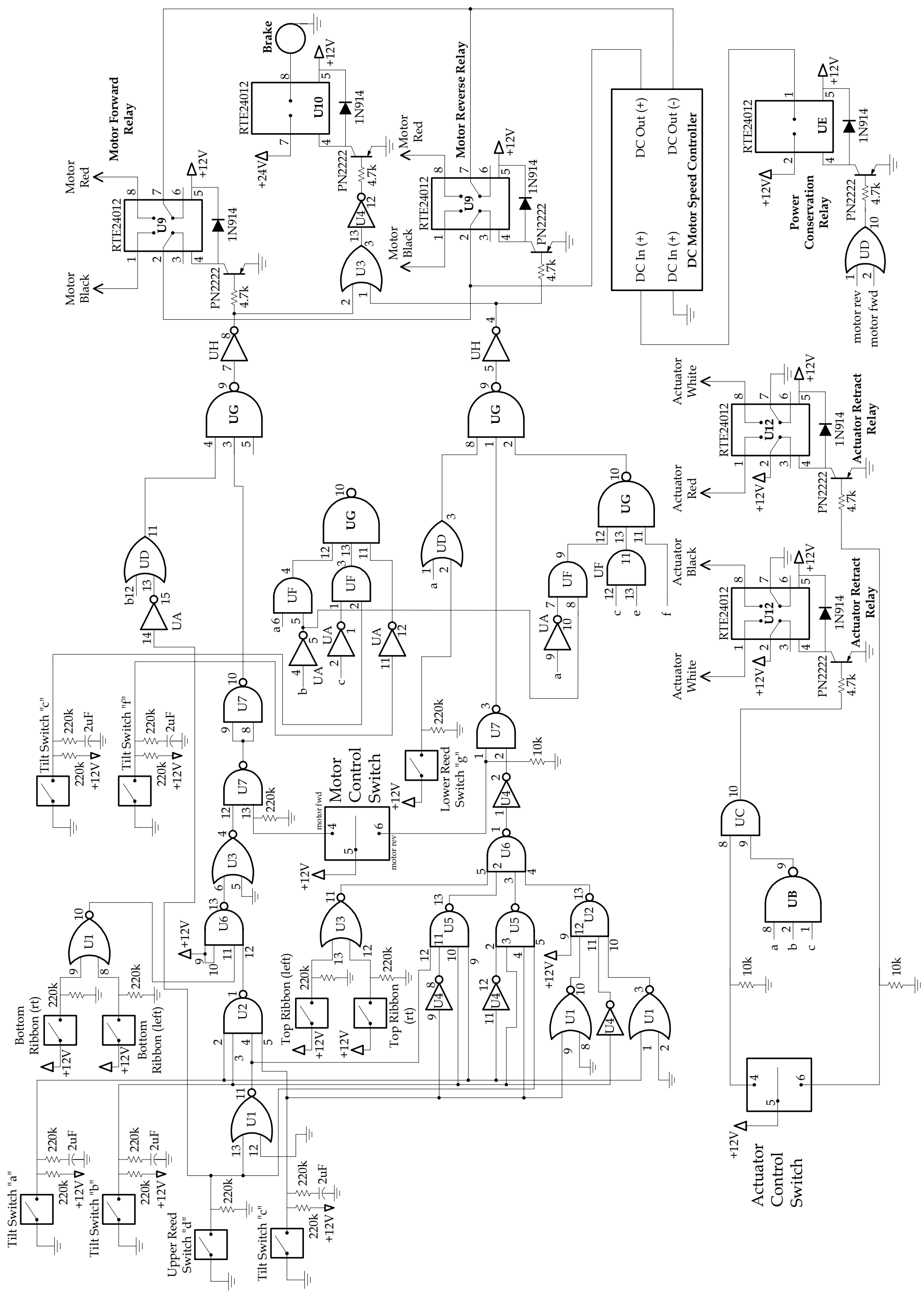

Figure 6.10. Schematic of Control Circuitry.

CHAPTER 7
MICHIGAN TECHNOLOGICAL UNIVERSITY

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EVEN LATERAL PRESSURE THERAPY DEVICE FOR A CHILD WITH AUTISM

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Client Coordinator: Lois Weber, O.T.R. M.Ed.; Joan Pavlowich, Occupational Therapy Assistant; Copper Country Intermediate School District, Hancock, MI
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INTRODUCTION

A client with autism has successfully used pressure therapy in the past to act as a calming influence when he is overwhelmed with sensory stimuli. His school desired to have a device built that would allow the student to activate the pressure at his desired level and time. The Even Lateral Pressure Device (ELPD) is controlled by the student, safe to use, and was delivered to the school for the student's use at the completion of the project.

SUMMARY OF IMPACT

With the ELPD, the student now has control over his environment, and can make choices about when he needs pressure therapy. Previously, a teacher or aide would provide pressure by hugging him or placing weighted beanbags on him. As he grows older, however, it becomes difficult and physically challenging for the teacher to provide adequate pressure. The student immediately accepted the ELPD, and currently uses it several times per day. Additional students may also be able to benefit from the device in the future.

TECHNICAL DESCRIPTION

The chair was fabricated from wood (2×4s, 4×6s and plywood), covered in foam for comfort and painted, as shown in Figure 7.1. The front of the chair has steel rods (diameter of 0.25 in) that connect to the back. These steel rods provide the track for the platform that provides the pressure. The platform is hinged so that the student can enter and is equipped with a removable cushion. A latch in the platform, similar to a car trunk latch, is used to securely close the door and can be opened by pressing a switch (for the user) or from an outside lever (for a supervisor). Bushings were inserted into the

Figure 7.1. Front of Even Lateral Pressure Device.

platform to provide a smooth motion on the steel rods. A set of pulleys connects the platform to the drive motor, and a locked compartment in the rear of the chair contains the drive motor and associated circuitry. Figure 7.2 shows the inside of the rear compartment of the ELPD.

To operate the device, the student opens the door, sits in the chair, and presses two buttons at his side. The platform must be completely closed and both buttons must be depressed for the motor to operate. This prevents the possibility of one arm getting caught in the mechanism or accidental operation. The motor may be stopped or started again at any point to either maintain pressure or provide additional pressure. When the student is done with his pressure therapy, he pulls a lever, which first slightly releases the pressure and then opens the latch so that the door in the platform may open. The initial release of pressure prevents the platform from opening in a forceful manner and accidentally injuring a nearby student.

One of the challenges of this design was selecting a motor that would provide an adequate amount of torque, pull the platform at an appropriate speed, maintain the pressure once the desired level was obtained, and operate on standard AC. The motor selected was a worm reduction motor (A0280 Texatron 1/3 HP AC Motor with 70:1 worm reduction). The worm gear maintains the position of the platform when it is not operating. A gear ratio was employed to produce the desired speed of the platform of approximately 8 seconds from start to maximal applied pressure. At this gear ratio, the motor could develop a torque of 440 ft · lbs., which was significantly higher than the torque deemed necessary (110 ft · lbs.). Several safety mechanisms were developed to address this concern.

The first safety mechanism is a rotational limiting switch, located on the drive pulley, which prevents the platform from traveling more than eight inches. As the pulley rotates, if the travel of the platform exceeds eight inches, a copper plate on the pulley activates the limiting switch. Once the limiting switch is activated, the power to the motor is immediately turned off. This limiting switch may be easily adjusted to change the linear travel allowed for the platform. A second safety mechanism, an adjustable current limiting switch, prevents the motor from developing too much pressure, or more pressure than is deemed necessary by the student's teacher or therapist. This switch is located in the rear of the chair, and is only accessible through unlocking the rear panel. The current drawn by the motor increases as the pressure exerted on the student increases. This switch senses the current drawn by the motor, and when the current exceeds the level set by the teacher, the motor will stop. An adjustable knob sets the current level.

Figure 7.2. Inside of Rear of Chair, with Pulley (Upper Left) and Motor (Lower Right).

The cost of parts/material was about $925.

INDEPENDENT RUNNING FOR A CHILD WITH VISUAL IMPAIRMENT

Designers: Jeffrey Klein, Amy Latimer, Darinda Miller
Client Coordinator: Colleen LaRose, Eaton Intermediate School District, Charlotte, MI
Supervising Professors: Dr. David A. Nelson and Dr. Debra D. Wright
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INTRODUCTION

Students with sight impairment often have difficulties participating in outdoor track events with their classmates. Although they are capable of running, they are generally unable to maintain a correct bearing while running. Most methods of guidance require an additional person to provide auditory direction or accompany the runner in the race. A school requested a device that would allow for students with sight impairments to independently participate in track events. A device was fabricated that constructs an electronic "lane" and signals the runner when he or she needs to adjust direction. The device was delivered to the school at the completion of the project.

SUMMARY OF IMPACT

The independent running device provides an excellent way for the students with sight impairment to participate in the same events as their sighted peers. There are no known devices that perform this function. It can be operated with minimal set up time and training. The students currently use vibration devices for mobility training, so this device reinforces their current activities and allows them to participate in others as well.

TECHNICAL DESCRIPTION

The device consists of three major components (see Figure 7.3): a beam transmitter (1), a beam receiver with walkie-talkie transmitter (2), and a vest with walkie-talkie receivers and vibration devices (3). Two beams are created with a security detection system (AX-650 MKII donated by Optex); they have a range of 200 m. Straight-line races of up to approximately 150 m can be accommodated with this system. These transmitted beams create the lane for the runner by way of a receiver at the other end of the track. The runner wears the vest, stands in between the two beams, and begins the race. If the beam is broken, it activates the walkie-talkie transmitter (Bellsouth 1010). The walkie-talkie transmitter sends a signal to the walkie-talkie receiver in the vest and activates the proper vibration device in the vest (see Figure 7.4). The runner adjusts his course, based on which vibration device was activated. The vibration continues until

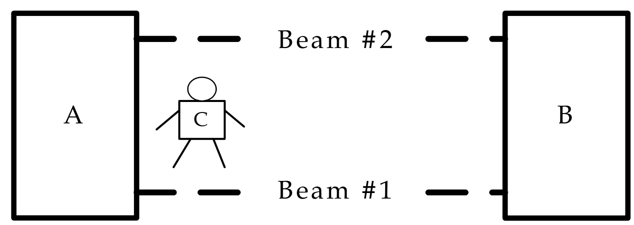

Figure 7.3. Schematic Illustrating Independent Running Device.

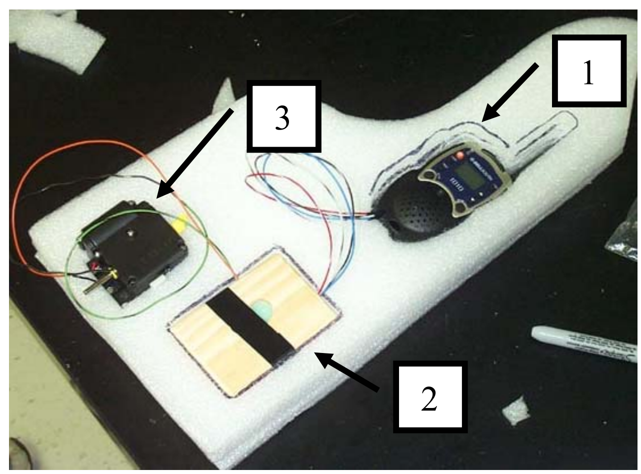

Figure 7.4. Inside of Life Vest: (1) Walkie-Talkie, (2) Circuit Board, (3) Vibration Device.

the beam is unbroken. At the completion of the race, a caller signals that the race is over with an air horn. No other runners can share the lane.

The Optex beams are powered by a 12-V tractor battery. The beam receiver is directly connected to the walkie-talkie transmitter. When the beam is broken, a voltage output in the Optex system changes, a switch is closed and the walkie-talkie transmitter is turned on. The walkie-talkie receiver is connected to the vibration device via a circuit. The circuit amplifies the voltage signal from the walkie-talkie and then converts it from AC to DC to provide power to the vibration device. The vibration device, obtained from a child's toy, has a motor with a rotating eccentric weight.

The Optex devices and associated circuitry are mounted on a tripod (see Figure 7.5). The tripod is equipped with a ruler and level so that easy beam alignment can occur. Both tripods and the vest fit into a plastic garbage can with wheels, so the system can be easily transported to the site of the race. It can be used indoors or outdoors. Because the runner is signaled via vibration, he or she can still hear team peers and the cheers from the crowd and fully participate in the race. The air horn used at the end of the race to signal the runner is significantly louder and more distinct than any of the other normal crowd noises.

The approximate cost of materials and supplies was $500. Optex Incorporated generously donated the Optex beams, valued at $850.

Figure 7.5. Beam Transmitters/Receivers on the Left and Right of Tripod.

WHEEL CHAIR ICE SKATES

Designers: Josh Cagle, Renee Mallory, Gabe Stark, Matt Tier and Eugene Wee
Supervising Professor: Dr. John Gershenson
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INTRODUCTION

A boy who uses a wheelchair desires to ice skate with his peers. A current device requires the user to exit the wheelchair and sit on a sledge, which resembles a standard sled. The user propels himself by using his arms and a spike that grips the ice. The user could also be propelled by an assistant pushing him. This device does not allow for normal interaction with his peers as he is seated very low on the ice, and the spikes are potentially unsafe for both the user and other skater on the ice. A prototype of an attachment to a wheelchair to provide natural ice-skating movement is discussed.

SUMMARY OF IMPACT

Although a prototype was developed, it was not suitable for active use. The design and potential modifications are discussed.

TECHNICAL DETAILS

The device is shown in Figure 7.6 attached to a wheelchair. One unit/skate would be attached to each wheel of a standard wheelchair. It would be connected to the wheel by a set of two nylon ratcheting tie downs. Each skate consists of two blades that are connected together by welding rods. The blades have the same circular arc as the wheelchair wheels, and are separated by the width of the wheels. Two sets of teeth are evenly spaced from the ends of the blades. Both sets of teeth resemble the "toe pick" on a standard figure skate; however, they span the width of the two blades. The forward motion teeth are slightly angled so that they grip the ice when the wheels are propelled forward, and the rear teeth are straighter, so that the chair will stop when those teeth contact the ice. Two portions of the blade allow for gliding motion – in front of the forward motion teeth and in between the two sets of teeth. Forward motion is provided by rocking the wheel to the front gliding portion, and then back to the middle gliding portion. During this process, the teeth responsible for motion grip the ice and provide acceleration. A change in direction can be accomplished by pulling back on one wheel. A cap at the end of the blade prevents the blade from slipping off.

The blades and assembly are custom machined. Each blade is laser cut out of ¼" sheet stock. The teeth are milled from stock steel, and the components are welded together using tig welding.

A natural gliding motion is not obtained using the wheelchair skates as described. To improve the skates, aluminum may be used to provide a lighter skate and less resistance for the user. The blades as described are flat; however, typical skates have a concave surface on the bottom of the blade. A concave surface increases the contact stress between the blade and the ice and allows for local melting of the ice, and ultimately, smooth gliding. These skates should be modified to provide a concave surface on the bottom of the blade. Finally, the gliding portion between the two sets of teeth must be optimized to allow for easier gliding.

The costs for parts and machining are approximately $250.

Figure 7.6. Wheelchair Ice Skates Attached to Standard Wheelchair.

MODIFICATIONS TO THE MULHOLLAND WALKABOUT STANDING FRAME

Designers: Jay Calewarts, Jesse Tegen
Client Coordinators: Lois Weber, O.T.R. M.Ed.; Jodi Tervo, PT Assistant; CCISD Hancock, MI
Supervising Professor: Dr. John Beard
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INTRODUCTION

The Walkabout 2A (Figure 7.7), produced by Mulholland Positioning Systems of Santa Paula, CA, was analyzed and modified to specifically address rehabilitation needs of the client. The client is a 7-year-old boy with cerebral palsy and limited cognitive abilities. He is ambulatory and uses the Walkabout 2A during school hours. Modifications were requested to decrease scissoring, increase muscle tone, add directional damping to the Walkabout, and provide a reward system. Additional constraints require that the Walkabout be easily adjusted to fit other clients with different needs and make placement of the client in the device easier.

SUMMARY OF IMPACT

With the modifications, the client is able to walk normally with no damping in the system; however, damping is added to the system if he overextends during standing. This causes the Walkabout to be more stable. The addition of the braking system allows natural gait patterns to be established, while also providing resistance to help strengthen leg muscles. The new spring system removes the need to lift the client when placing him in the Walkabout. An added convenience is that the spring can be preloaded to allow adjustment for different clients. A reward system allows positive feedback to be given to the client. The inclusion of a digital level allows easy adjustment of the seat angle.

TECHNICAL DESCRIPTION

As stated in the product literature, the Walkabout is an "an assisted weight bearing device, which allows degree of lift to be adjusted to provide minimal to moderate assistance to stand. As the user steps forward, the stander provides lateral and anterior/posterior stability, in addition to spring assisted lift." The Walkabout was modified (see Figure 7.8) to provide a rewards system, digital level, dampening, modified suspension, and a braking system.

Figure 7.7. Walkabout 2A.

The rewards system provides positive feedback to the client. To operate, the therapist inputs a value into the pre-settable counter. This value corresponds to the distance the therapist wants the client to walk. Once the client has walked the specified distance, he is rewarded with audiovisual effects. The effects are provided by automotive running lights and a small bicycle siren that have been mounted on the Walkabout. A proximity sensor counts wheel revolutions to measure the distance traveled. The sensor sends inputs to the pre-set counter that opens a relay when the pre-set value is achieved. When the relay opens, power is provided to the lights and siren. Power is provided by a rechargeable battery taken from a cordless drill.

The digital level is a SmartTool digital level that has been shortened to fit onto the rear column of the Walkabout. The level is temporarily attached to the rear column using magnetic strips that are adhered to the level and rear column. When adjustment is complete the level is removed. The level has an operating range of 360 degrees and .1-degree accuracy.

Damping is provided by a Fox Float-R shock absorber. The shock absorber has an externally adjustable rebound damping mechanism with 15 increments of adjustment. The shock was mounted between the rear column and the upper crossbar and provides damping only when the user travels upwards with great velocity, such as when jumping (which causes instability). The damping slows the user and makes the Walkabout more stable.

The spring preload system replaces the original suspension system. The new system consists of two springs in parallel. The springs may be preloaded, which allows the therapist to change the suspension to compensate for changes in the client's weight. The preload is achieved by turning a crank, which causes the springs to compress. The spring preload system also eliminates the need to lift the user into the seat.

A braking system was added to prevent the client from rolling freely when in the Walkabout. The ability to roll freely allows the client to build up momentum and coast, rather than providing motion by taking strides. The braking system can be used to apply resistance to either forward or backward movement, or zero resistance if desired. This was accomplished by attaching a ratchet to the axle. The ratchet is adjusted to determine the direction of resistance. The resistance is provided by a spring-actuated friction plate. A handle is turned to compress the spring and increase pressure on the friction plate. The approximate cost of materials is $725.

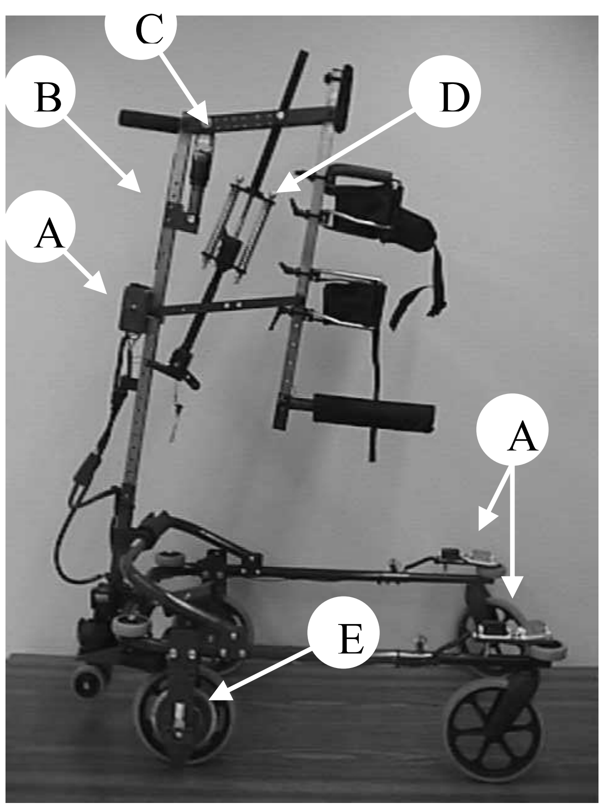


Figure 7.8. Walkabout 2A with modifications: A) Reward System, B) Digital Level (not shown), C) Damper, D) Spring Preload System, E) Braking System.

CHAPTER 8
MISSISSIPPI STATE UNIVERSITY

Agricultural and Biological Engineering Department
Mississippi State, MS 39762

Principal Investigator:

Gary M. McFadyen, (662) 325-0887

WEARABLE ECG MONITOR

Designers: John Kosko and Brian Flowers
Supervising Professor: Dr. Filip To
Agricultural and Biological Engineering Department
Mississippi State University
Mississippi State, MS 39762

INTRODUCTION

The purpose of this project was to create a device that would reduce the time it takes to respond to a heart attack by detecting conditions that could lead to the onset of cardiac arrest. This project was the hardware development portion of a broader project to develop a complete a low powered wearable device capable of outputting an ECG signal to a handheld computer

SUMMARY OF IMPACT

People who survive heart attacks sometimes have reduced physical and mental functions as a primary or secondary result of the heart attack. The leading cause of cardiac arrest is ventricular fibrillation. The key to preventing death or disability from cardiac arrest is recognizing the problem early and quickly providing proper treatment. This device will monitor the heartbeat of individuals who are at risk. Through the utilization of GPS and cellular communications, it will also notify emergency personnel in the event of a heart attack.

TECHNICAL DESCRIPTION

The hardware developed in this project was designed to detect the electrical impulses from the heart, amplify and filter these signals, convert the signals to digital format, and deliver the signals to a handheld computer for analysis. Pre-gelled silver/silver chloride disposable electrodes were used to measure the electrical impulses from the body. An amplification circuit consisting of three operational amplifiers was designed and fabricated. A prototype circuit was also fabricated using TI082 amplifiers. The electrodes were connected to the circuit using ribbon cable. LabView software was used to generate a simulated ECG signal to test the circuit. The device is shown in Figure 8.1.

This circuit will be integrated into a handheld computer for analysis of the ECG data.

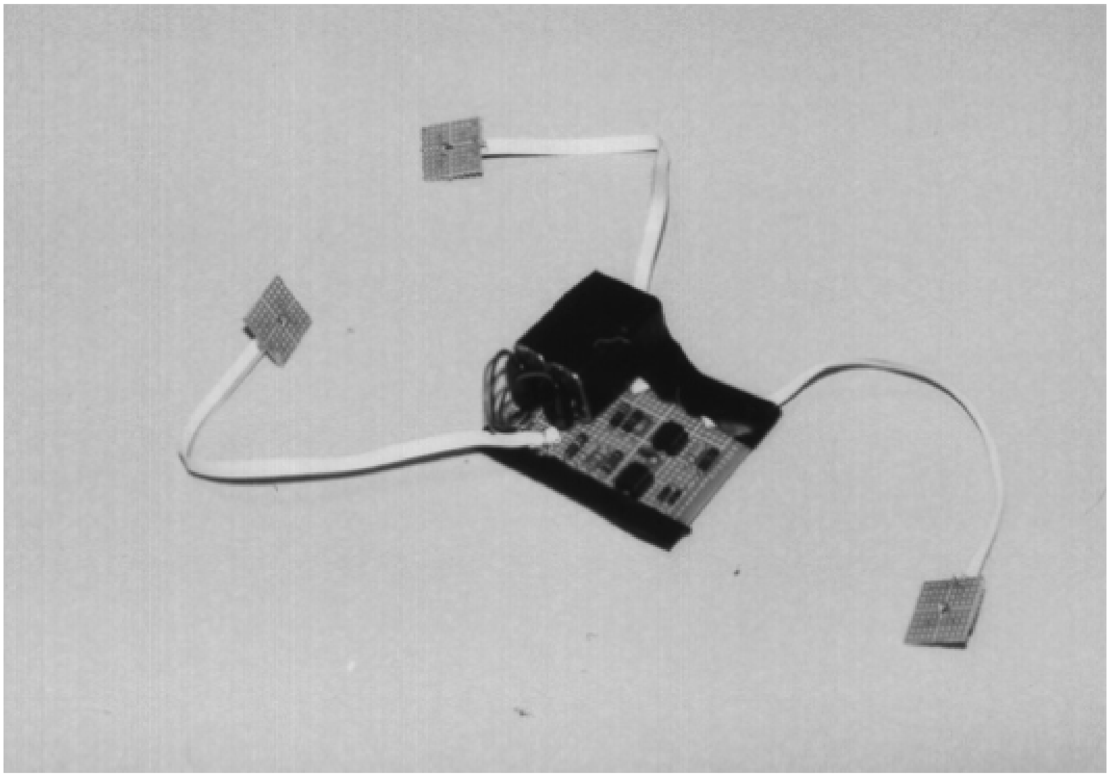


Figure 8.1. Wearable ECG Monitor.

ECG ANALYSIS SOFTWARE

Designers: Patrick Bergin and Brandon Etheridge
Supervising Professor: Dr. Filip To
Agricultural and Biological Engineering Department
Mississippi State University
Mississippi State, MS 39762

INTRODUCTION

Cardiac arrest is the leading cause of death in the United States. Therefore, advancements in current emergency cardiac care are needed. A critical factor affecting the recovery of a person who has a heart attack is the time between the onset of the attack and the beginning of treatment. This project is part of a larger project to design and fabricate a wearable EKG monitor that monitors the heart at all times. In its complete form, the unit will utilize a heart attack prediction algorithm to provide a notice of imminent problems. The device will then contact emergency medical personnel and alert them to the problem. This part of the design will detail the creation of a processing unit that accepts, translates, displays, and transmits an EKG signal.

TECHNICAL DESCRIPTION

The overall goal for this project was to design a portable system that can accept, store, display, and transmit EKG data. However, the project also has other requirements. The system needs to use minimal power, be comfortable to the user, and withstand outside forces in order to practically function.

This design utilizes a Palm Pilot handheld computer or the Visor from Handspring. The system must be able to interface through serial connections with EKG leads to process the heart signal and with a GPS device. Utilizing a microprocessor, the Palm Pilot must also host the algorithm to predict heart attacks. Newer versions of the Palm Pilot include built-in cellular phone and wireless Internet capabilities making it a viable communication option. The Palm Pilot and Visor both have battery lives of approximately two months. Therefore, using the Palm Pilot device would solve almost every design problem. This option would provide the best functionality with sufficient power efficiency and a reasonable development timetable. The Palm Pilot is small, and it is carried by millions of people every day. The Palm Pilot processor has sufficient ability to obtain the EKG signal, analyze this signal, and determine if a heart attack will occur. The Visor also has a module with upgrade capabilities. The module makes it possible to include additional hardware and programs such as EKG leads, the GPS system, and an algorithm for processing the EKG signal.

The first step in the design was to gather digital sample data in a compressed format from MIT's Cardiology Center (Physiobank, 2001). A C program was then written to decompress the data into a list of numbers. These numbers could then be displayed and graphed using Excel, thus providing a visible EKG sequence. This proved the validity of using a string of ASCII characters as a digital representation of the EKG system. The compression algorithm provided a good opportunity to save memory space on the handheld computer if needed.

The program operates on an event loop structure. An event can be any change noticed by the handheld computer. This could include the opening or closing of a program, movements with the stylus, or data entry into a field. The program continually loops while searching for and dispatching any event. The first event captured is the opening of the program. This event triggers AppStart, which opens the serial connection. When the close program event is triggered, the serial connection is closed by AppStop to avoid any errors. If no event is detected, the ScanSerial function is called for each loop. This program accepts data character by character until a full integer representation is recorded. The string is then converted to an integer and stored as EKG data within an array.

After the integer data are stored, the information is plotted on the Visor screen. The DrawLine function takes the previous data point and draws a line to the new data point, incrementing the horizontal location by one pixel. Once the graph has reached the end of the screen, the horizontal locator resets to zero and the function EraseRectangle is called. This clears the screen so the new data will not overlap. To check the accuracy of the data transmission, the function EchoData is called after a full screen of data (160 data points) has been processed by the handheld. This function sends the data string from the handheld to the computer display, and this can also be used later to send EKG data out of the serial port to other devices.

A program that can accept EKG data, store it, and display it on the screen was developed. Further development effort is required before a real time system can be realized. Critical components identified include the following: heart attack prediction program, power management, communication protocol, and a pilot study. This project has formed a basis upon which the complete wearable EKG system can be developed.

The cost of this project is $957.

VOICE ACTIVATED TELEPHONE

Designers: Sunil K. Singh, Andrew DeLongchamp
Supervising Professor: Dr. Gary McFadyen
Agricultural and Biological Engineering Department
Mississippi State University
Mississippi State, MS 39762

INTRODUCTION

A voice activated cordless telephone was designed for people with limited motor ability. This device allows one to dial, answer, and hang up the telephone by verbally stating the command he or she wants the telephone to perform. The required hardware for the project includes a Voice Extreme IC, a cordless telephone, a speaker, microphones, analog switches, and various other electrical components (see Figure 8.2).

SUMMARY OF IMPACT

Many people with disabilities have limited motor ability, making it difficult to operate a traditional telephone. There is a need for a voice-activated telephone.

TECHNICAL DESCRIPTION

This project was divided into software and hardware components. The code for the software portion of the project was written in a program similar to C and downloaded to the IC memory.

Software:

The software can be divided into three parts: 1) activation of IC, 2) choice, and 3) dialing. The first part requires the use of the Voice Extreme IC's capability of word spotting. This capability allows the IC to listen at all times to the user until a trigger word is spoken, making the phone truly hands-free.

The next part of the software is the choices menu. After the IC has spotted the trigger word, it prompts the user to please say a word. It then waits for the user to select one of six choices: 1) long distance, 2) local, 3) campus, 4) off campus, 5) answer, and 6) end. The program then accesses the proper function. The answer and end commands are used to answer and end a telephone call.

The third part of the program deals with the dialing of a telephone number. After one of the choices has been entered, the corresponding function is called. The function tells the program the number of digits it needs to store in memory to make the corresponding call. For example, to make a local call, seven numbers must be entered into a telephone. To do this, a speech recognition function was placed in a loop so the function would run seven times. Each time the speech recognition function is accessed, it prompts the user to say a digit of the telephone number. The function also stores the digit in an array so it can be used at a later point in time.

After all the digits have been stored into an array, the program prompts the IC to go through the answer protocol. Three hundred milliseconds after the phone is turned on, the program accesses the array in which the phone number was stored. The corresponding DTMF tones for the number are sent through the speaker.

Hardware:

There were two parts to the hardware section of this project. The first part deals with turning the telephone on and off. To perform any function on a standard telephone, the user presses a button. This action completes the circuit between two points on the keypad. Because the goal of this project was to make the phone completely hands-free, a way to simulate this pressing of a button was required. A Fairchild Semiconductor quad analog switch (p/n MM74HC4316) was used to provide this feature. The analog switch has a control input and two output pins. When the control input becomes high, the output pins are connected, thus closing the circuit. The circuit remains closed throughout the entire time the control input pin is high. Once the input becomes low again, the circuit opens.

The second part of the hardware deals with the integration of the telephone, IC's speakers, and microphones. The speaker outputs were connected in parallel to an 8-ohm speaker. An 18-ohm resistor was placed in front of the IC's speaker source. The resistor is used to protect the IC so it will not be driven by the telephone. The speaker has an impedance of 8 ohms. Therefore, placing an 18-ohm resistor (and adding that to the internal impedance of the IC itself) will direct most of the current coming from the telephone to the speaker.

The end results of this project allow one to answer a call, hang up after the conversation, and to dial a call. The cost of this project was approximately $750.

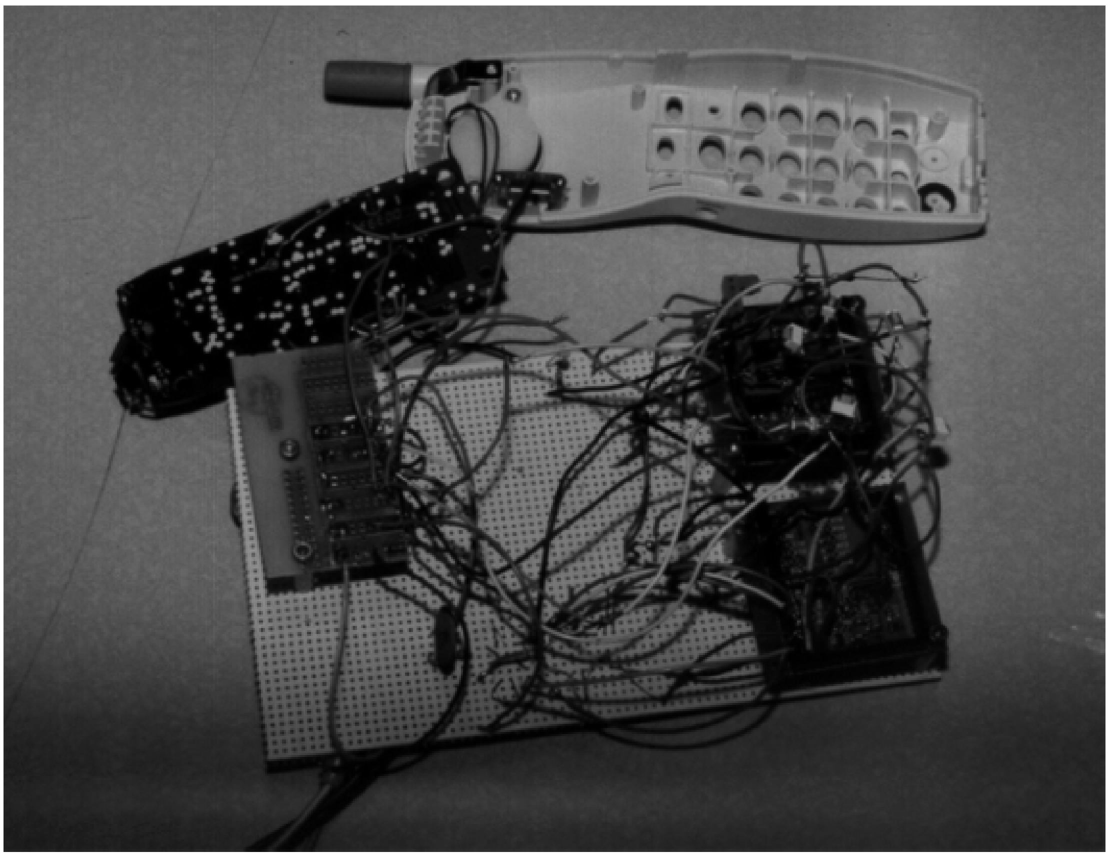


Figure 8.2. Voice Activated Telephone.

CHAPTER 9
NORTH CAROLINA STATE UNIVERSITY

College of Engineering
College of Agriculture and Life Sciences
Department of Biological and Agricultural Engineering
D. S. Weaver Laboratories
Raleigh, North Carolina 27695-7625

Principal Investigators:

Susan M. Blanchard (919) 515-6726

Roger P. Rohrbach (919) 525-6763

CRAWLER TO ASSIST A CHILD WITH DISABILITIES

Designer: Patrick S. Allen
Client: The Tammy Lynn Center, Raleigh, NC
Supervising Professors: Drs. R. P. Rohrbach and P. L. Mente
Department of Biological and Agricultural Engineering
North Carolina State University
Raleigh, NC 27695

INTRODUCTION

For this project, a crawler was designed to assist children who are unable to crawl independently. The frame is rectangular and has an attached sling to support the child. Swiveling castors are attached to the frame, enabling the device to move in multiple directions. Each of the castors has a brake that allows the device to be immobilized. The sling is constructed of nylon and climbing webbing, and it is attached to the frame via climbing webbing and climbing buckles. The buckles are used to adjust the sling. The crawler was designed for use in a therapeutic setting under close supervision.

SUMMARY OF IMPACT

Some children are unable to support their own weight and cannot correctly position themselves to make walking and crawling possible. The device designed for this project will enable them to begin to learn to crawl by eliminating the need to support their own weight. This crawler (see Figure 9.1) makes it possible for a therapist to assist a child in learning to crawl. The crawler allows the child to be correctly positioned so that he or she can move about without having to support his or her own weight. As the child becomes more proficient at crawling, the therapist can increase the amount of weight the child must support by adjusting the sling. This allows the child to progress toward independent crawling.

TECHNICAL DESCRIPTION

The crawler was designed for use in a therapeutic setting where an adult closely supervises the child. The main design requirements were that the project: 1) enable a child with disabilities to crawl; 2) allow the child to move in all directions; 3) not cause any discomfort for the child or therapist; 4) be able to vary the supported weight; 5) be sturdy and durable; and 6) have a brake that will prevent the crawler from moving when this brake is set.

Each component of this project is constructed from 6061 T6 aluminum. This was done to reduce the weight of the crawler while maintaining structural integrity. The frame is composed of aluminum tubing with an outer diameter of ¾-inch. The inner diameter of this tubing is 0.568 inches. The two pieces of tubing connecting the opposite frame pieces together are composed of the same material. The cross members welded onto the top of the frame are built of 2-inch wide and ¼-inch thick aluminum flat. Several ¼-inch diameter holes are drilled into the aluminum flat to provide attachment positions for the support sling.

The sling is constructed of double-layered nylon and another layer of polartec fleece. The fleece is to ensure that the sling is soft and comfortable for the child. The sling is stitched together using heavy-duty cotton thread. Five 2-foot pieces of climbing webbing are stitched into the sling. The opposite ends of the webbing have buckles attached to them so the sling's length can be adjusted. The sling may be removed for washing. A swiveling castor was attached to the frame at the base of each of the four legs. These castors make movement in all directions possible and inhibit motion when the brake is applied.

Several issues warrant more consideration. The strength of the frame is greater than necessary. Increasing the inner diameter of the aluminum tubing may be a feasible option to reduce the weight of the design. Lastly, the implemented castors are made of a hard plastic material. A softer plastic or rubber would be preferable for the castors to further reduce the slipping of the design when the child is using it. The approximate cost of the crawler is $300.

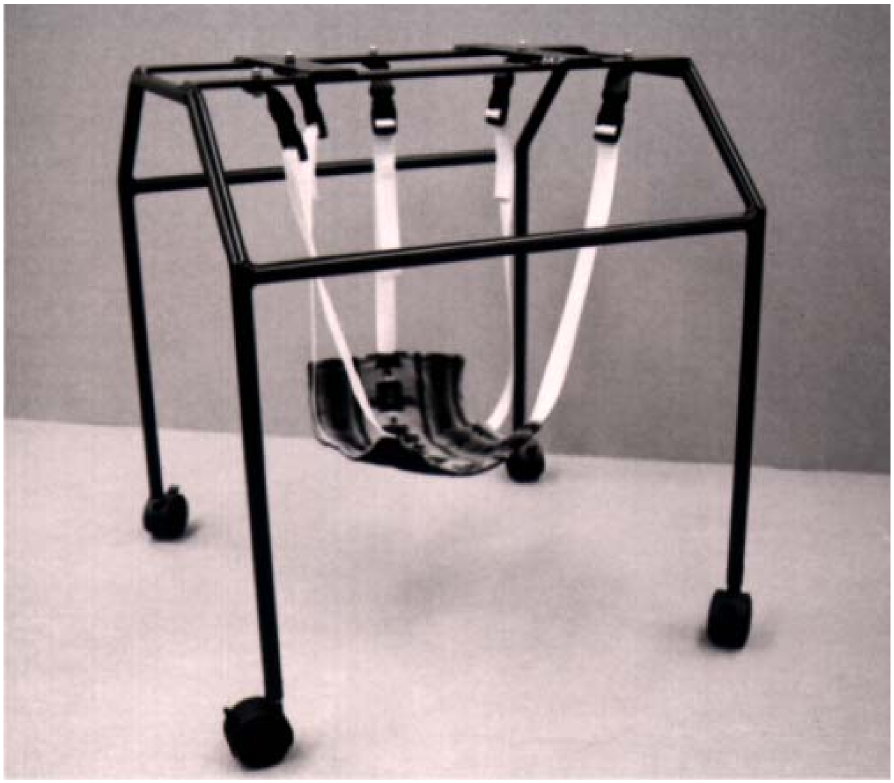


Figure 9.1. Device for Helping Children Learn to Crawl.

FOOT POWERED MECHANISM FOR PADDLING A CANOE

Designer: Kevin R. Johnson
Client: NC 4-H Youth Development
Supervising Professors: Drs. P. L. Mente and R. P. Rohrbach
Department of Biological and Agricultural Engineering
North Carolina State University
Raleigh, NC 27695

INTRODUCTION

A foot-powered mechanism for paddling a canoe was developed for children with disabilities. The mechanism (see Fig. 9.2) consists of the following three main components: an axle with an attached pedal, a U-shaped paddle arm, and a right angle gear box that connects the axle and paddle arm. The unit mounts on the inside of the canoe with braces attached by bolts. These bolts run through the sides of the canoe. Force from the child's foot on the pedal causes the paddle arm to sweep in an arc toward the back of the canoe. A spring pulls the pedal and paddle back to their original positions. During this process, a hinge folds the paddle back to decrease water resistance. This device was designed for use in a specific make and model of canoe used by the 4-H camps but could be used on other models depending on their dimensions.

SUMMARY OF IMPACT

Children with disabilities are sometimes not included in activities requiring physical involvement. For example, children with a disability of the upper body may find it difficult to paddle a canoe. This disability could be as temporary as a broken arm or as permanent as a degenerative muscular condition. If a child can participate in paddling the canoe rather watching others paddle, self-esteem will improve because the child will feel included in the activity. This mechanism allows participation in the paddling of a canoe by someone who cannot use his or her arms to paddle by the conventional method.

TECHNICAL DESCRIPTION

There design was required to: 1) provide a feeling of participation, but not necessarily contribute substantially to propulsion; 2) be removable so it could be taken off the canoe and stored when not in use; 3) be light, so that it does not hinder the movement of the canoe; 4) be durable in a wet environment; and 5) be safe for children to use.

The major components of this machine (See Fig. 9.2) are made entirely of aluminum to avoid any corrosion problems due to water contact. The axle and paddle arm are constructed of aluminum tubing with an inner diameter of 1″ and an outer diameter of 1-1/8″. The two braces, pedals and pedal links are all made from a ¼″ thick aluminum plate. Nyliner bearings, 1-1/8″ inner diameter, are used to decrease friction during the rotation of the axle and paddle arm. A canoe paddle, cut off 10″ above the blade on the aluminum shaft, is attached to the paddle arm using a universal joint. This joint is made of steel with a black oxide finish. It is pinned to the shaft of the paddle on one end and the paddle arm on the other. A piece of 1-1/8″ inner diameter tubing is welded to the back of the paddle arm to restrict joint movement in the forward and lateral directions.

The paddle arm is 18″ long and extends down at a right angle for a distance of 8″ and connects to a right angle gearbox. The other side has a 4″ piece at a right angle to pin to the universal joint. The right brace is 12″ long, 2 ½″ wide, and has a bracket that is 2 ¼″ deep. This brace supports the axle and attaches the mechanism to the right side of the canoe. The left brace has similar dimensions, but also adds a 4″ by 3 ¾″ mount for the right angle gearbox and two supports for the paddle arm as it rises from the gearbox. The use of an enclosed gearbox eliminates the safety risk of having open gears exposing pinch points. The pedal is 4″ wide and 6″ long and is held 8″ from the axle. This was done to increase the mechanical efficiency of the pedal.

Force applied to the pedal causes the axle to rotate forward. This rotates the paddle arm in a counterclockwise direction from the front of the canoe to the rear. A spring is attached between the pedal and an eyebolt on the right brace. When the pedal is depressed, the spring is extended. The spring contracts as force is removed from the pedal, and the paddle is pulled back to its original position. During the return stroke of the paddle, the paddle hinges at the universal joint and can be pulled forward at an angle of up to 80° to reduce water resistance.

The final cost of this paddling mechanism is approximately $250.

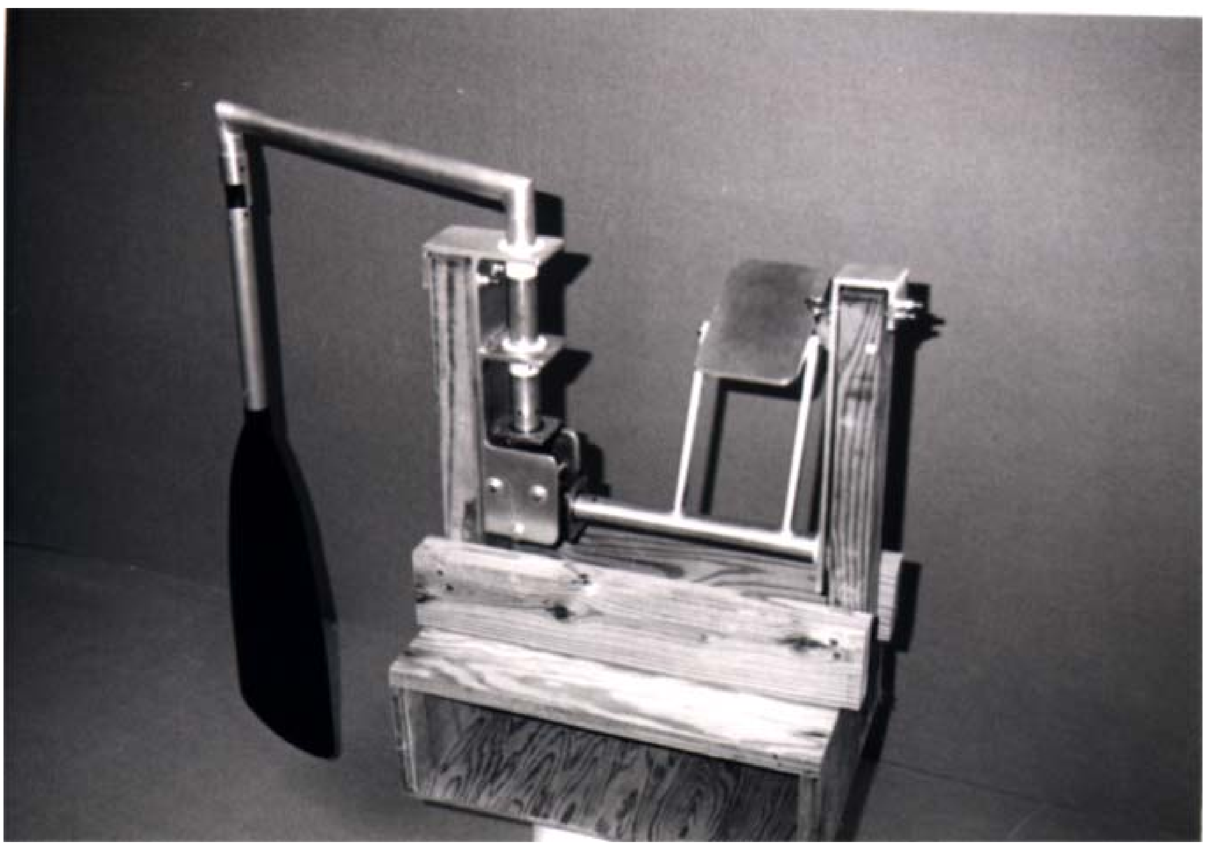


Figure 9.2. Canoe Paddling Mechanism in Wooden Frame.

LOWER EXTREMITY SENSORY PROSTHETIC

Designer: Keith R. Martin
Client Coordinator: David Patridge, CP
Raleigh Prosthetic and Orthotic Clinic
Supervising Professor: Dr. P. L. Mente
Department of Biological and Agricultural Engineering
North Carolina State University
Raleigh, NC 27695

INTRODUCTION

A lower extremity prosthetic for a person with an amputation below the knee has been designed to provide sensory information to the wearer. Force sensors embedded in the foot of the prosthesis provide a signal to electro-mechanical actuators (vibrating motors) that are molded into the socket of the prosthetic. These actuators vibrate in response to the sensors, providing stimulation to the residual limb. This stimulation is in proportion to the force encountered by the sensors, allowing the wearer to sense the amount of force encountered by the foot. The signal is further monitored and adjusted through feedback to ensure proper function. The added sensory information improves mobility, balance, and proprioception.

SUMMARY OF IMPACT

Currently, lower extremity prostheses offer no provisions to aid users in overcoming adaptation issues with regard to mobility. Many people who wear lower extremity prostheses have difficulty maintaining balance on uneven ground, walking up and down stairs, and detecting obstacles with their feet. These problems present additional and unnecessary challenges to overcome and can have a large effect on quality of life.

The overall objective of this project was to directly address these issues, develop a solution through engineering design, and evaluate the appropriateness of this solution. This was achieved by close interaction with a person who has had an amputation, assistance from a certified prosthetician (CP), and guidance from engineering consultants.

TECHNICAL DESCRIPTION

Anthropometric data from one specific person was used to design the prosthetic. This could be done for other people as well. The main design requirements were that the device: 1) provide lower extremity sensory feedback to the wearer; 2) be lightweight and practical; 3) be durable and comfortable for extended use; 4) be watertight to prevent electrical shock to the wearer; 5) have sensors to detect weight increments of 1/4 lb in order to distinguish between the different magnitudes of forces encountered; and 6) have sensors positioned at pressure locations of the gait cycle to aid in mobility. In addition, the sum of electrical components must weigh no more than 1-1/4 lb to prevent a pendulum effect, the added swing of a prosthetic leg caused by excess weight.

The sensor array is located in the foot of the prosthesis, which is embedded in the shoe. In-line connectors allow removal of the shoe, if necessary, and tuck out into the shoe itself for discretion. Three sensors each detect forces ranging from 0-100 lbs. These sensors are positioned at pressure locations for the heel-strike, mid-stance, and toe-off stages of the gait cycle. Their corresponding actuators are aligned vertically against the residual limb. They are in close enough proximity to one another to allow the wearer to feel the weight transfer from sensor to sensor while walking. Each sensor-actuator pair is able to operate independently.

Five sensors, operating in the 0-25 lb range, are located along the outer edges of the shoe to allow detection of obstacles against the foot. Their corresponding actuators are placed against the residual limb in a way that provides position correlation with little learning. Therefore, the wearer can relate a position on the calf with an equivalent position on the foot, respecting lateral, medial, anterior, and posterior relations.

The control circuit (Figure 9.3) consists of eight operational amplifiers. Each of these amplifiers has a negative feedback loop and offset compensation, a voltage regulator, eight actuator drivers, and collective hysteresis comparators. These are all built onto a single circuit board mounted inside the structural frame and hermetically sealed. A replaceable 9-volt power supply and main control switch are accessible to the wearer. Offset compensation allows each sensor to be adjusted to provide a zero-stimulation base point to remove any forces created by mounting. The operational amplifiers provide initial signal conditioning, and the actuator drivers and hysteresis comparators initiate function. The latter are integrated into a series of two IC chips. If the current provided to the second chip rises too quickly or to high, separate hysteresis loops provide feedback information to the first chip. This in turn cycles the chips on and off at 20 Hz until normal operation is restored. This prevents actuator stall and overload, reduces the risk of heating and failure, and ensures a proportional response from the actuators to the sensor input.

Operational tests were performed in which known incremental forces were applied to the sensors and the current at the actuators was measured in response. It was concluded that the device functions as intended and is adequate for use. Final sensor and actuator placement were done according to wearer preference and required no further adjustment.

The total cost for the project, excluding donated items, is approximately $260. An estimated cost including donations is $1800.

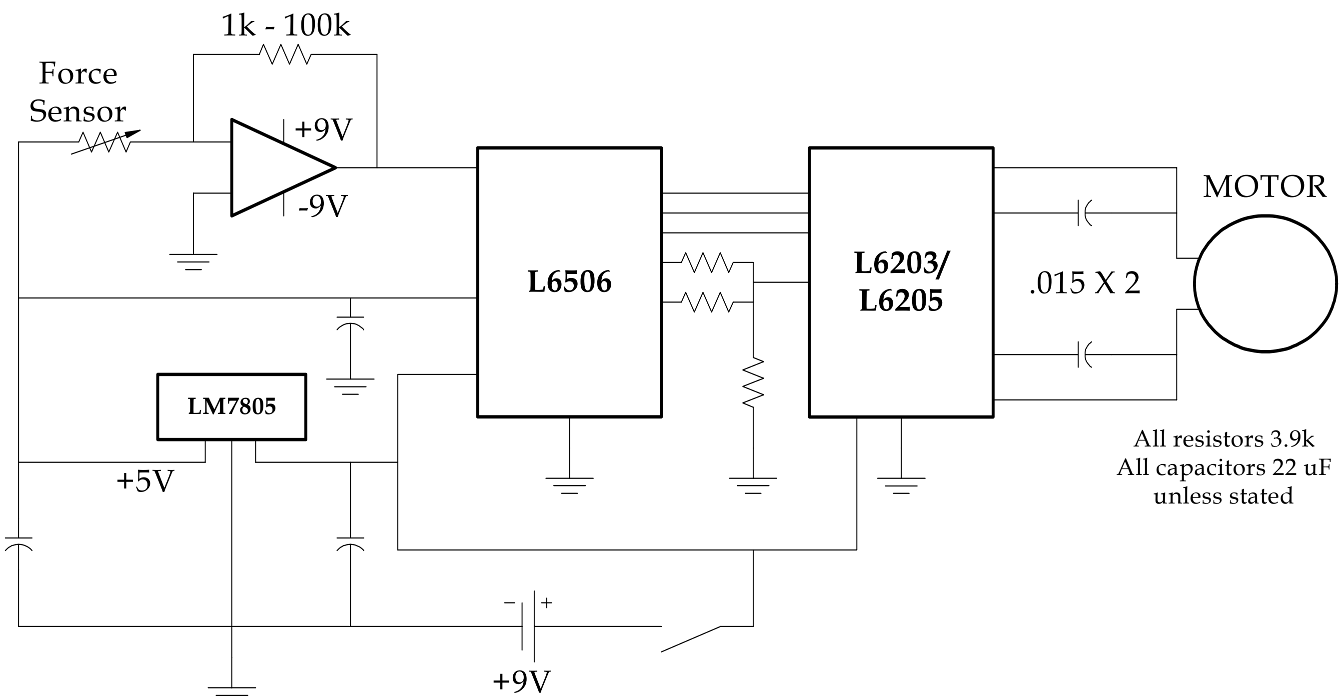


Figure 9.3. Circuit Schematic.

GO-CART FOR A CHILD WITH SPINA BIFIDA

Designer: John R. (Obie) Sullivan
Supervising Professor: Dr. G. R. Baughman
Department of Biological and Agricultural Engineering
North Carolina State University
Raleigh, NC 27695

INTRODUCTION

This go-cart (Figure 9.4) was designed and manufactured for a three-year old child. The child has a wheelchair, but he cannot keep up with his brothers when they go outside to play. The go-cart is built from an existing go-cart frame, but the frame was reduced to fit the child. Two 12-volt batteries power the go-cart by an electric motor obtained from a modified scooter. The motor has an electric mechanical brake. A switch that activates the brake is mounted on the handlebars. The motor is connected to the wheels by a chain and sprockets. The go-cart travels at a top speed of 11 mph and weighs 158 pounds. The device is equipped with both forward and reverse. Handlebars for steering and a thumb-throttle for speed control the go-cart. A small lever that is pushed by the child's thumb adjusts the speed. The lever propels the go-cart forward when it is pushed forward and backward when it is pushed backward.

SUMMARY OF IMPACT

This go-cart allows the child to become more independent and play with his brothers. The go-cart can be easily loaded into a pickup truck or van. This child can now participate in outdoor activities with his family. The go-cart is electric and can be used indoors if enough space is available.

TECHNICAL DESCRIPTION

The go-cart was built from an existing go-cart frame. The frame was shortened in width and length, 3 feet by 4 feet, to better fit the child. It was also designed with a smaller width, so it can fit through a standard doorway. Two 12-volt batteries were connected in a series to produce a total of 24 volts to power the electric motor. The motor was connected to the wheels by number 40 chain and sprockets. The sprockets were sized in order to produce a top speed of 11 mph. The drive sprocket is 8 inches, and the follower sprocket is 4.5 inches.

Figure 9.4. Modified Go-Cart.

The motor has an electrically operated mechanical brake. There is a spring that pulls the brake pad against the internal motor surface. When electricity is provided to the brake circuit, the brake releases. The brake circuit is energized through the main power supply to the motor. When the go-cart is turned on, the brake automatically releases. A push button switch is used to operate the brake. When the switch is pushed, the electric circuit is broken, and the brake is initialized.

The go-cart is equipped with both forward and reverse capabilities. Handlebars for steering and a thumb throttle for speed control the go-cart (see Figure 9.5). A small lever connected to a potentiometer controls the voltage to the motor. The throttle assembly has a mechanical barrier to maintain the go-cart at slow speeds while the child is young. As he gets older, this barrier can be adjusted in order to allow faster speeds.

A 155-pound student tested the go-cart. The performance of the device satisfied all design objectives and specifications. The go-cart was then given to the child who will be using it for more testing. It was initially too fast, so the speed was adjusted. At first the child did not know how to drive the go-cart. After some initial instruction, he learned the basics within the first hour. He did not understand how to avoid obstacles. He ran into curbs and other rigid objects. As he grows older, he will learn to avoid these obstacles. Driving the go-cart is an enjoyable activity for him.

The cost of the go-cart, excluding donations, was $559. The final cost of the go-cart, including donations was approximately $2,000.

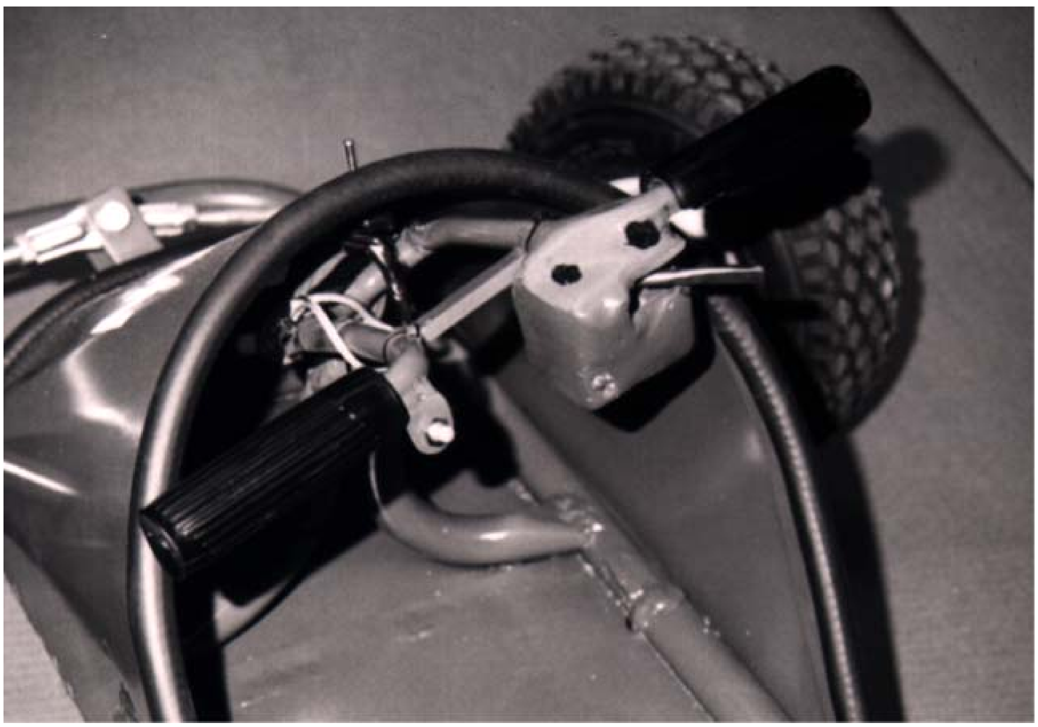


Figure 9.5. Thumb Throttle and Handlebars for Modified Go-Cart.

FLOOR CHAIR FOR CHILDREN WITH REDUCED MUSCLE CONTROL

Designers: Niki Wynne and Amanda Kirby
Client Coordinators: Stacy Crowder, PT
The Tammy Lynn Center for Developmental Disabilities
Supervising Professors: Drs. C. M. Sommerich and R. P. Rohrbach
Department of Biological and Agricultural Engineering
North Carolina State University
Raleigh, NC 27695

INTRODUCTION

A floor chair (Figure 9.6) was designed for children with poor muscle control due to physical disabilities. The chair consists of a basic frame, tray, headrest, harness, and seatbelt. The chair frame includes an upholstered seat bottom, a backrest, a piece to prevent tipping, armrests, and poles to support the backrest and armrests. The device is portable, as the entire chair weighs less that 50 lb.

SUMMARY OF IMPACT

Many children with physical disabilities are not able to sit upright on the floor for therapy sessions. This is true of the children for which this device was designed. Their therapists must hold the children in their laps and use a mirror to view the children's reactions to various objects placed in front of them. This is difficult for the therapists because they have no free hands to work with the children. Therefore, a floor chair was designed to fully support the children and enable them to sit on the floor by themselves.

TECHNICAL DESCRIPTION

The floor chair was designed with a particular child in mind, but it could also be beneficial for other students. The main design objectives were that the chair: 1) allow a child with disabilities to sit upright on the floor alone; 2) not tip over when a small child leans back; 3) give the child access to the floor; 4) the be constructed from materials that are easily cleaned and disinfected; 5) be lightweight and portable; 6) be sturdy and safe; 7) have armrests that accommodate all children who will be using the chair; 8) have a headrest that is adjustable and easy to use; 9) have restraints and supports that are comfortable for small children; and 10) have a removable tray that is lightweight and capable of clipping to the armrests without slipping. In addition, the chair must support the weight of a 50-lb child.

The design of the chair is similar to a stadium or booster seat, and the restraints must also accommodate a 50-lb child. The armrests and headrest must accommodate a child of a minimum of 3 feet and a maximum of 4 feet in height.

Dimensions and data from the children who would be using the device were taken and evaluated. It was decided that adjustable armrests were unnecessary because all the children were close to the same size. The width and height of the chair was also determined from the dimensions of the children. It was determined with assistance from the children's therapists that the optimum angle of inclination for the chair was 110°. A tip-over analysis was also conducted on the chair by determining the maximum possible force placed on the back of the chair and changing the moment arm. The maximum force was determined by anthropomorphic data. Without the back piece, the chair would tip at 10.55 lb, and it would tip at 31.65 lb with the back piece in place. The maximum possible force is 28.9 lb. The braces used to attach the back piece to the chair also help prevent tipping. A stress analysis was conducted to ensure the straps would not fail when the maximum load of the upper body weight was applied. The stress applied is 231.2 psi, and the ultimate stress for nylon is 6000 psi.

Several different students were placed in the chair under the supervision of the therapists and instructed to perform various tasks while in the chair. The chair exceeded expectations.

The estimated cost for labor and materials is approximately $200. Professional upholstery added an additional cost of $65. The headrest and harness were donated.

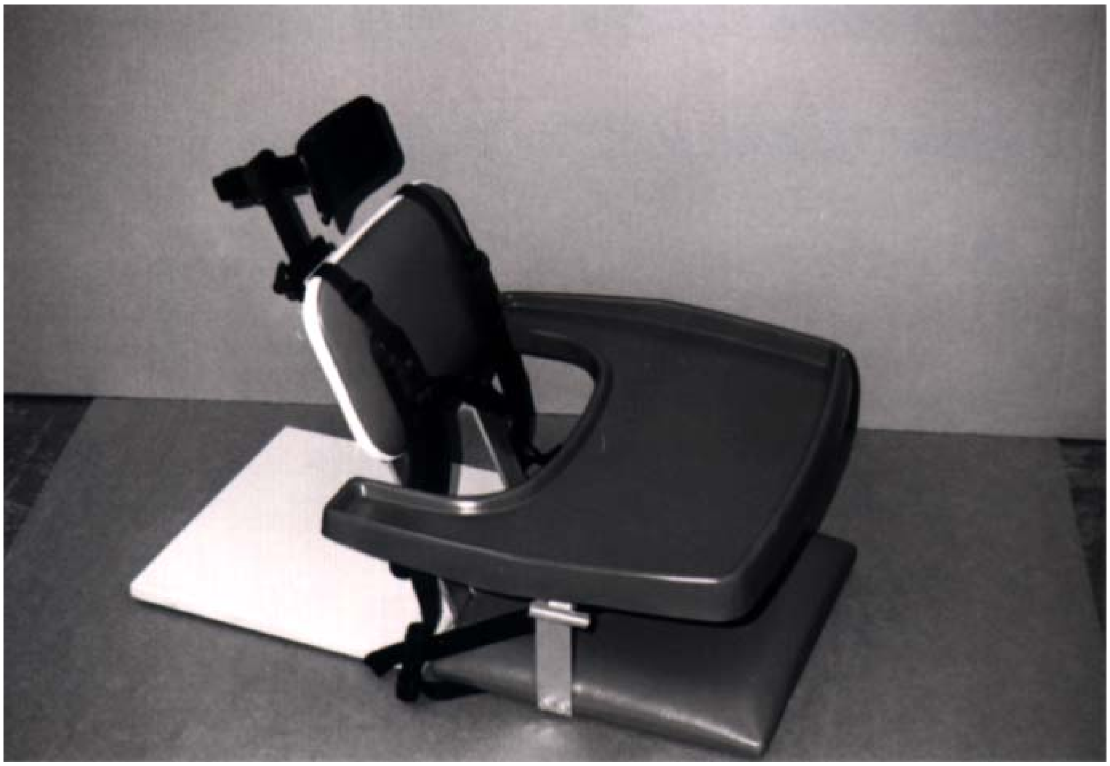


Figure 9.6. Floor Chair with Tray Attached.

MODIFICATION OF A POWER WHEEL TO MAKE FOR JOYSTICK CONTROL

Designer: Justin Carinci
Client Coordinator: Monica Cook, PT
Charlie Gaddy Center
Supervising Professor: Dr. S. A. Hale
Department of Biological and Agricultural Engineering
North Carolina State University
Raleigh, NC 27695

INTRODUCTION

A device was designed to teach fundamental joystick skills to children who will someday use an electric wheelchair. The device consists of a modified Power Wheel (See Figure 9.7). A Power Wheel is a miniature vehicle that mimics a real car. It is powered by two rear motors and is controlled by a mechanical steering system. The mechanical steering column was removed and replaced by a linear actuator. The actuator was mounted underneath the Power Wheel and connected to the front axle. The system is wired with a joystick as the primary control.

SUMMARY OF IMPACT

This device was designed to provide an enjoyable way to teach joystick skills to children. In the eyes of a child, a Power Wheel is more appealing than a chair with wheels. Children are provided with a learning tool that is fun. This experience will then provide them with the skills necessary for operating an electric wheelchair.

TECHNICAL DESCRIPTION

A linear actuator and a joystick are the two main components that provide the Power Wheel with electrical steering. The linear actuator was mounted underneath the Power Wheel approximately 4.6'' in front of the front axle. Since the Power Wheel is made of plastic, sheet metal was used to increase the mounting strength. Wood was also used to provide further stability. The actuator connects to the front axle by a bolt. The joystick selected to operate the Power Wheel was the NES Advantage. It operates by a series of switches.

Figure 9.7. Modified Power Wheel.

There are four switches located in the joystick, each representing a direction (up, down, left, and right). Current is released when the joystick is moved in any of these directions, and motion occurs in the corresponding direction.

Figure 9.8 shows the wiring schematic that integrates all the components. The pair of switches and a square box containing magnet coils is a simplified representation of a relay. The joystick emits a small current that enters the relay. This amplifies the signal and activates a magnetic field that attracts the spring-loaded armature. Once the armature is closed, the current from the power source reaches the motors and either turns them on or off.

An analysis was performed on the bolt connecting the actuator to the front axle to determine the proper bolt diameter.

The ultimate stress of steel is 50 kip. The length of the moment arm connecting the linear actuator to the front axle is 4.6''. The maximum amount of force exerted by the linear actuator is 250 lbs. The maximum moment applied was 1150 lb-in. Using these values, the diameter was determined to be approximately 5/8'' diameter.

The final cost of the modified Power Wheel was approximately $530.

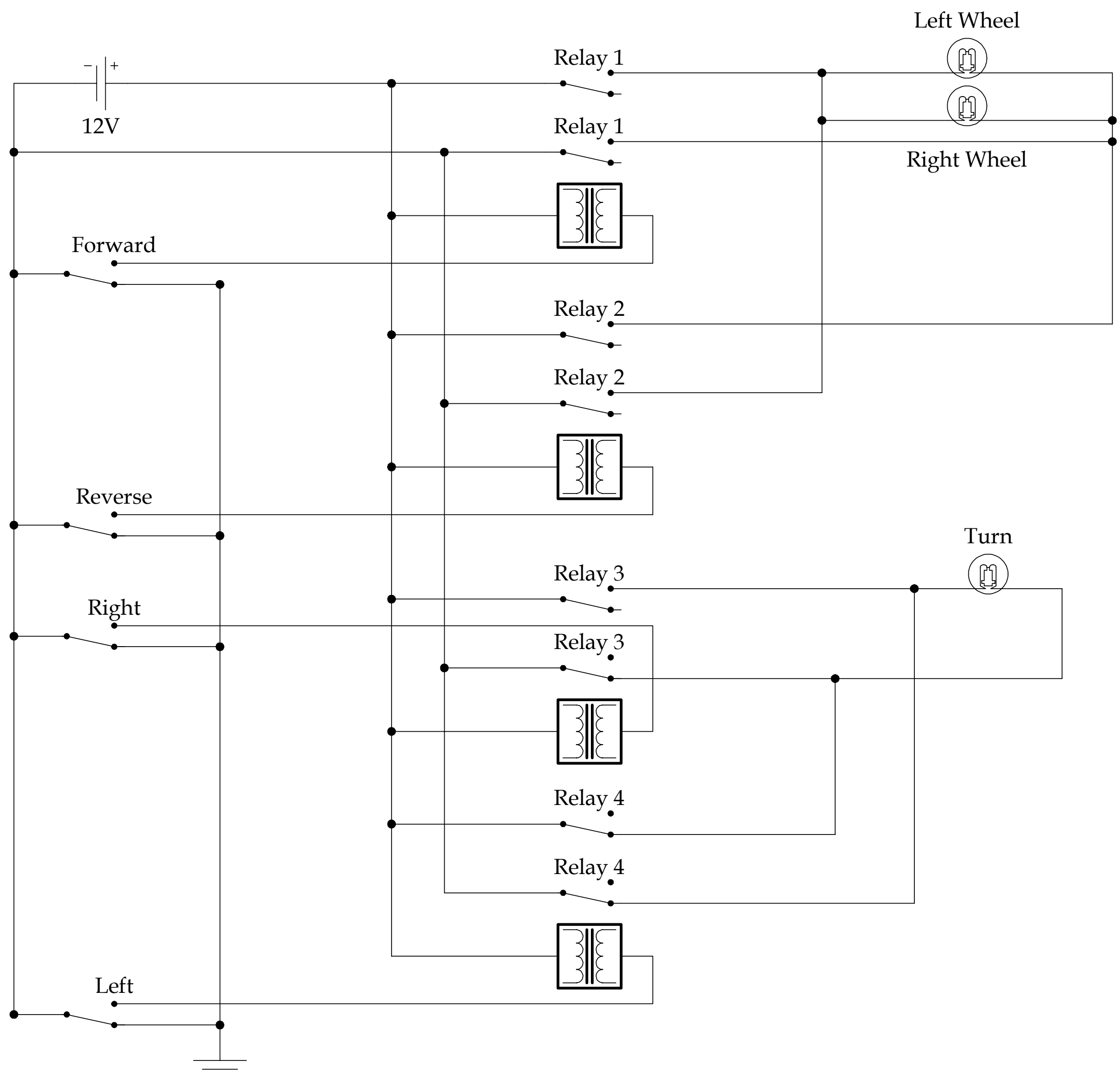


Figure 9.8. Circuit Schematic.

SWITCH CONTROLLED MOTORIZED FISHING POLE

Designer: Jeffrey Jones
Client Coordinator: Client's mother
Supervising Professor: Dr. R. P. Rohrbach
Department of Biological and Agricultural Engineering
North Carolina State University
Raleigh, NC 27695

INTRODUCTION

Many children who have cerebral palsy cannot go fishing because they are unable to coordinate the fine muscle movements this activity requires. The fishing industry has a narrow selection of rods and reels for people with disabilities. These rods and reels usually incorporate a switch-activated motorized mechanism to reel in the fishing line. However, most of these devices are tailored for people who have at least one fully functional hand. There is a need for a mechanism to drop and reel in the line of a fishing pole for a people who have cerebral palsy.

The device developed in this project (see Figure 9.9) is intended for a person who lacks skilled control of either hand. Some of the components of this prototype are an electric screwdriver, right angle gears and push buttons. The overall design is meant to create a safe and appealing product that allows people with disabilities to enjoy fishing.

SUMMARY OF IMPACT

This fishing pole design will allow a seven-year-old child who has cerebral palsy to participate in a new activity and gain independence.

Unplugging the pushbuttons allows the fishing pole to be easily carried separately along with the frame and pushbuttons. The child can handle the pushbuttons without having to worry about the rod or reel. The rod can sit inside a rod holder or be held by another person, and the reel and motor assembly sit on the ground. This setup creates the best scenario for the child to catch fish because he only needs to operate the pushbuttons.

TECHNICAL DESCRIPTION

A permanent adaptation was used to adapt the screwdriver for use by large switches. The original toggle switch on the screwdriver was rewired. Leads from the toggle switch were soldered to one-eighth- inch input jacks. The screwdriver is controlled using two double pole single throw switches. Any double pole single throw switch that is compatible with the input jack may be used to operate the screwdriver. The pushbutton switches were inserted into the jacks to activate the motor. In addition, the switches reel when they are held down.

The overall design was laid out on Pro-ENGINEER. Two right angle miter gears were used to connect the motor action of the screwdriver with the reel. The right angle gears meet at a brass bearing that stabilizes the gears in space. The reel system was directly attached to a miter gear by a component similar to a power nut driver used with drills. The other miter gear was attached to the torque action of the screwdriver through a hex chuck component. The screwdriver and reel were both mounted to a piece of steel, which serves as the base.

A site test was performed to evaluate the performance of the prototype. Two fish were successfully caught.

The total cost was approximately $250.

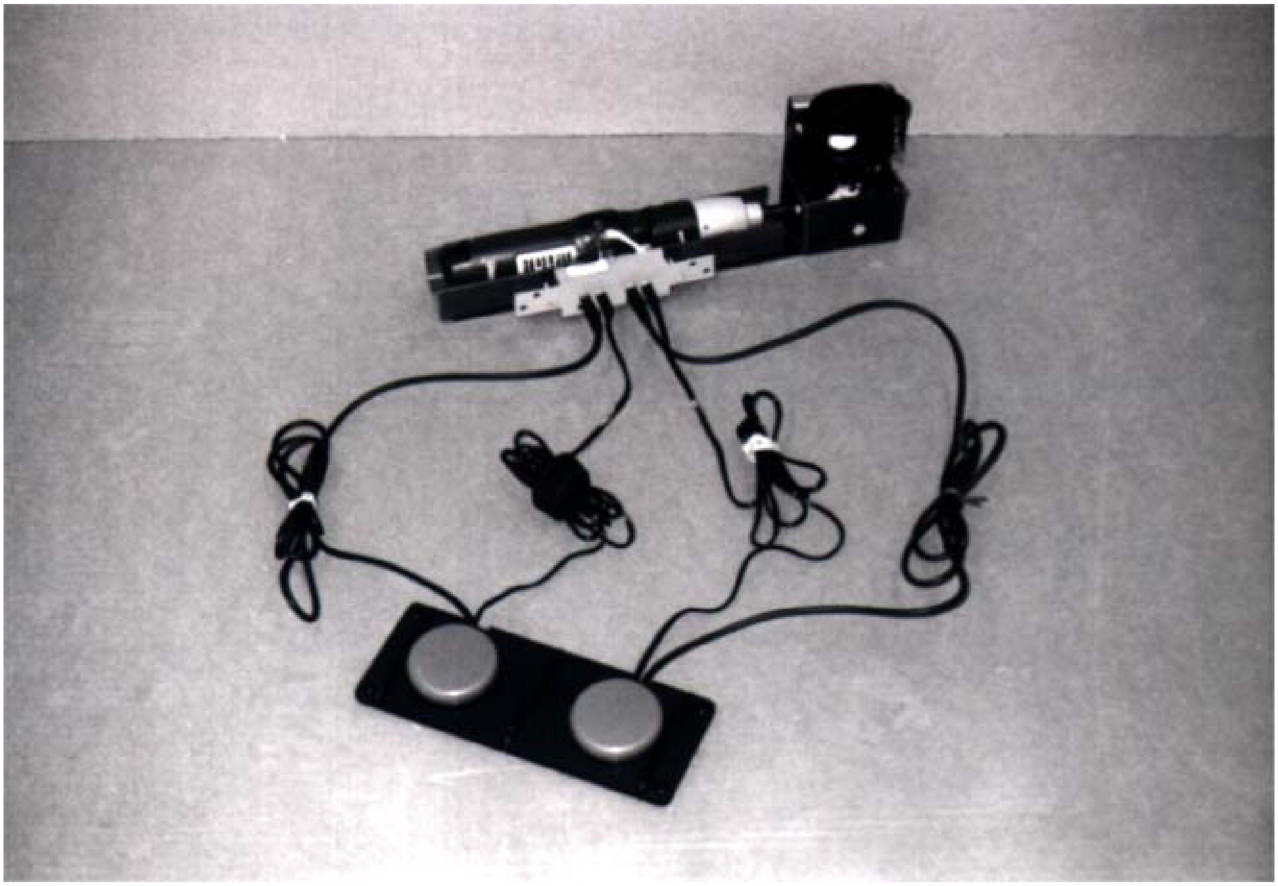


Figure 9.9. Switch Controlled Motorized Reel.

BICYCLE FOR A CHILD WITH SMITH-MAGENIS SYNDROME

Designer: Tong-Ying Wu
Client Coordinators: Kat King
Community Partnerships
Supervising Professors: Drs. R.P. Rohrbach, C.G. Bowers, S.M. Blanchard
Department of Biological and Agricultural Engineering
North Carolina State University
Raleigh, NC 27695

INTRODUCTION

Smith-Magenis Syndrome (SMS) is a chromosomal disorder characterized by a specific pattern of physical, behavioral and developmental features. Possible characteristics associated with SMS include developmental delay, learning disability, mental retardation, and low muscle tone. This special bicycle (Figure 9.10) was designed for a girl with SMS. The goal of this bicycle was to increase this child's muscle strength. The bicycle consists of the following main parts: two standard adult bicycles, a seat, and a pedaling mechanism. The two adult bicycles are linked together with the additional seat placed in the middle. All three sets of pedals are linked by bicycle chains to a common shaft.

SUMMARY OF IMPACT

This project can be used as a device to help people with minor disabilities gain leg strength. In the case of this 10-year-old girl, the project was aimed to enable her to ride a bicycle. This will provide her opportunities for more outdoor activities with her family.

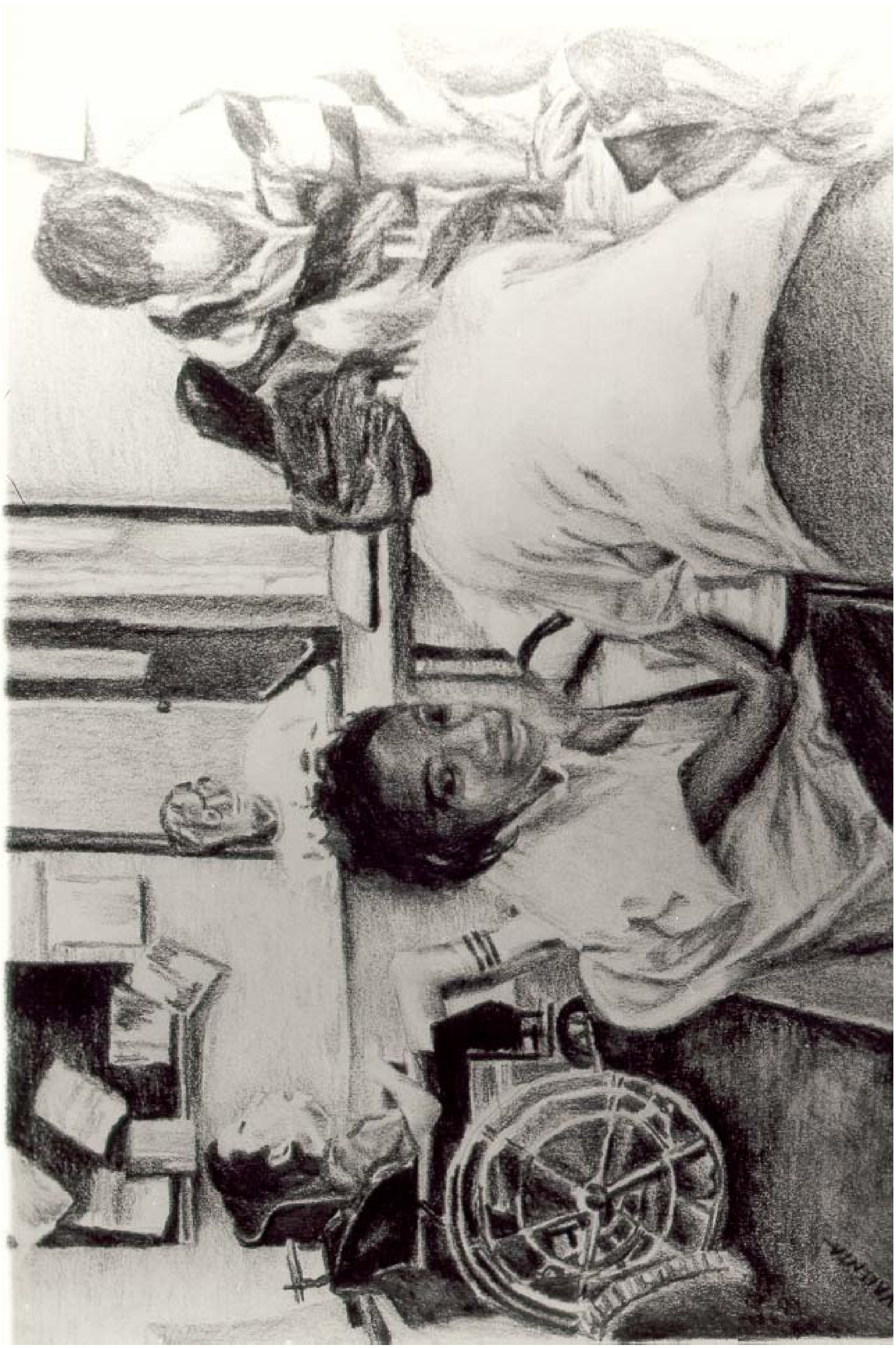
TECHNICAL DESCRIPTION

One of the major concerns this project was the safety of the child during operation. After considering the girl's ability to ride a bicycle, it was decided that her parents should control the steering mechanism and that the bicycle can only be operated in low speeds.

The linkages between the two bicycles are constructed from standard black pipe, ASTM A-120 and Schedule 40. There are three locations for connecting the two bicycles: 1) front and upper sections of the bicycle frame, 2) rear and lower sections of the bicycle frame, and 3) the tube under the bicycle seats. The front linkage is achieved by using U-bolts and 1" pipe. Both of the linkages located at the rear and underneath the seat use 3/4" pipe. The frame for the additional seat has two parts. These parts are the frame itself and the seat. The frame is incorporated within the rear linkage and connected to the front linkage via U-bolts and 3/4" pipes. It is made of a 3/4" pipe and two 1/2" pipes welded in an "II" shape. The pedaling device is located in the front of the frame. The seat is made of 1/2" pipes and 3/4" wood boards and is tilted backward 25 degrees for comfort. The seat belts are incorporated within the seat.

The total cost for this special bicycle was $750.

Figure 9.10. Bicycle for Child with Smith-Magenis Syndrome.



CHAPTER 10
NORTH DAKOTA STATE UNIVERSITY

Department Of Electrical Engineering
Fargo, North Dakota 58105

Principal Investigators:

Jake Glower (701) 231-8068

Dan Ewert (701)-231-8049

Val Tareski (701)-231-7615

PLAYSTATION INTERFACE

Designers: Charles Monson, Stephen Rambeck, Kevin Malinowski, Jeremy Lunke, Adam Swor
Designed for Anne Carlson School, Jamestown, ND
Supervising Professor: Dr. Jake Glower
North Dakota State University
Department of Electrical Engineering
Fargo, North Dakota 58105

INTRODUCTION

A child with poor motor skills needs to do exercises to increase motor abilities. The project attempts to integrate exercise with playing video games, typically a favorite activity of children. An electronic device was built to monitor the physical activity of the user. If the child is doing the required exercises, time is banked. Banked time can then be used to play a video game that is also controlled by this electronic device.

SUMMARY OF IMPACT

Children may be more motivated to complete their motor exercises if they are rewarded with time to play a video game. Future iterations of this design must address: 1) the type of physical activity to be monitored, 2) how the reward should be computed (what the ratio of play time to exercise time should be), and 3) how time spent playing the game should be regulated. Feedback from the staff working with the children using this device will be used to answer the above questions and determine the design of future devices.

TECHNICAL DESCRIPTION

The Playstation Interface consists of two main units. These units are the Activity Sensor and the Playstation Controller. The Activity Sensor (shown in the left side of Figure 10.1) monitors the exercising activity of the child. This circuit is a small, battery-operated unit that fits into a hat worn by the child. If the child is jumping, hopping, or doing sit-ups, the accelerometer sends a signal to the microcontroller. The microcontroller then filters the data to detect if the child is exercising. If so, a 1 kHz square wave is sent to an AM transmitter.

The second unit is the Playstation Controller. It monitors physical activity when in the Exercise mode and controls a Playstation when in the Play mode.

In the exercise mode, the Playstation monitors the signal from the AM receiver. If a 1 kHz signal is detected, a counter is incremented every 100ms. This counter then serves as the time the child has banked for later use.

In the play mode, the Playstation closes a relay, thus providing power to the Sony Playstation. While in this mode, the counter is decremented every 100ms until it reaches zero. When the counter reaches zero, the relay is opened, ending the child's playtime.

The activity sensor uses an accelerometer and microcontroller capable of measuring +/-4G's with 10-bit accuracy and sampling rates in excess of 1000 samples per second. With more sophisticated software, this should allow the activity sensor to detect specific motion, such as doing sit-ups (0 to 1 G at about 1Hz), jumping jacks (0 to 2 G at about 1Hz), or any other exercise.

Although the software is too sensitive (allowing one to register activity by simply shaking the device), the device does appear to work well. It records time as the child exercises and enables the Playstation as the child plays.

The total cost of this project was $280. This price includes the cost of the Sony Playstation.

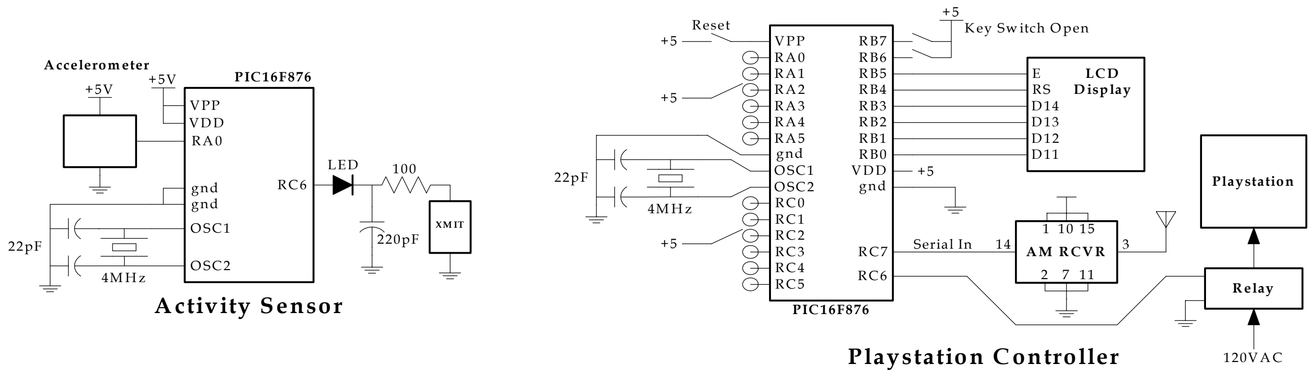


Figure 10.1. Playstation Interface Circuitry.

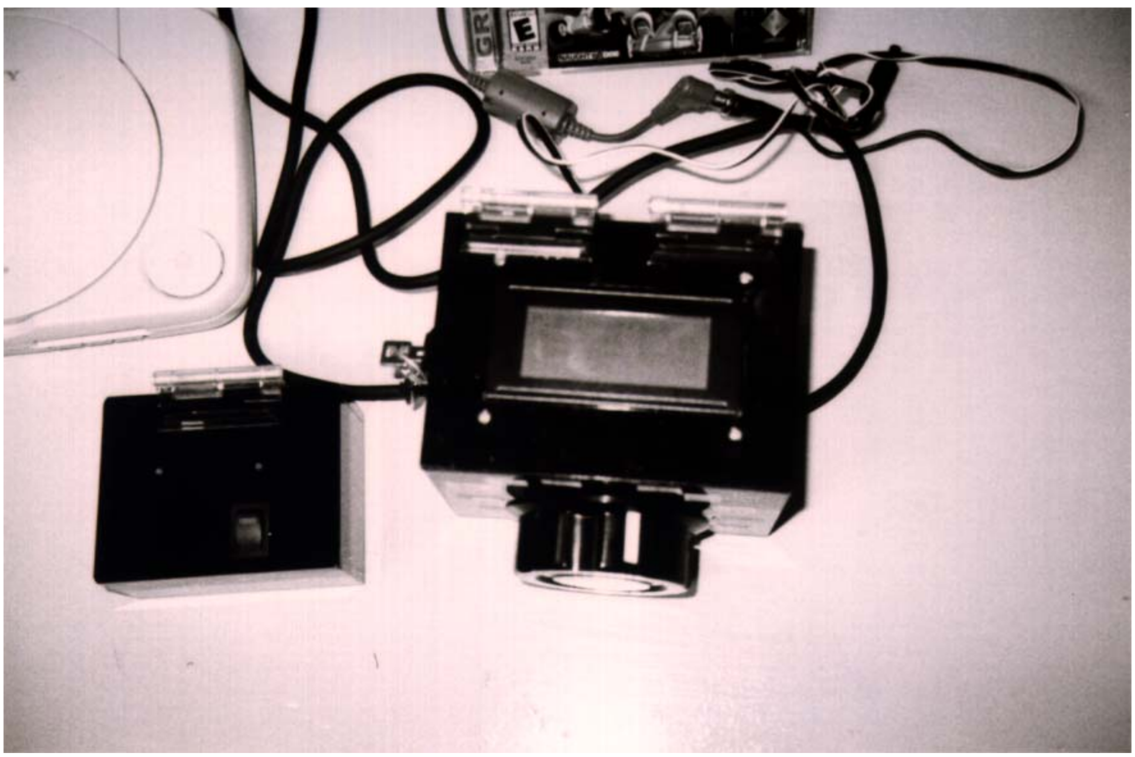


Figure 10.2. Activity Sensor and Playstation Controller.

CAMERA FOR PEOPLE WITH VISUAL IMPAIRMENTS

Designers: Joe St. Sauver, Dan Desrude, Brandon Slettland
Client: Designed for REM Rehabilitation Associates, Fargo, ND
Supervising Professor: Jake Glower
North Dakota State University
Department of Electrical Engineering
Fargo, North Dakota 58105

INTRODUCTION

A camera for people with visual impairments was designed to help them identify objects out of reach and use their sense of touch without being able to actually feel the object being identified. The concept is that the camera captures an image of an object and then this information is analyzed, and a tactile approximation of the object is produced. Unfortunately the solution is not as simple as the concept, and therefore only preliminary work was completed to test different design concepts.

SUMMARY OF IMPACT

A camera that transforms a visual image into a textural image would give people with visual impairments the ability to see out a window, observe a painting, or locate people in a room. Such a device would require a large number of pixels and a considerable investment to design. Before making such an investment, it is important to develop a good design. While conceptually simple, two previous design groups found that the implementation of this design was not as simple as it first appeared. In this project, the feasibility of using stepper motors and H-bridge amplifiers was tested.

TECHNICAL DESCRIPTION

The design for the Camera for People with Visual Impairments follows closely with that of previous design groups and is presented in Figure 10.3. Because concentration of this design is on the actuator, the sensor design from a previous group was used. Here, a lens focuses an image of four photovoltaic cells. These convert light intensity to a voltage, which is amplified by four instrumentation amplifiers and read at the A/D input of a microcontroller.

The microcontroller then drives four stepper motors according to the light level on each sensor. Although the microcontroller was more than capable of driving these four motors without any interface circuitry, shift registers were still used to expand three data lines into 16. This was done for two reasons. By reducing the number of I/O pins used, a smaller, cheaper microcontroller could be used in future designs. In addition, cascading more shift registers and latches together allows any number of pixels to be driven by this circuit.

The software for the microcontroller is also simple. For each sample, the light level is read on the analog inputs. This light level is then compared to counters in memory. If the light is brighter than before, the count needs to be increased. If the light is dimmer than before, the count needs to be decreased. Once the target count for each pixel is obtained, the drive signals are sent to the shift registers and latches. These signals cause the stepper motors to turn clockwise one step if the corresponding count is to be increased, and counter-clockwise if the count is to be decreased. This action is repeated until each stepper motor has gone the number of steps equal to the count obtained from the A/D readings.

The shaft of the stepper motors consists of a 10cm long screw. This screw causes the rotation of the stepper motor to be a translational motion, resulting in a peg sticking above a board proportional to the light level received from the corresponding light sensor.

Although this circuit did work, it was very slow. Stepping the motors 1024 times (the maximum vs. minimum brightness) took an average of 70 seconds. In addition, the power consumption was high, using approximately 1800mA to drive these four motors. As a result, this design is not ready for miniaturization. Future design groups will need to improve the speed, power consumption, and size of this device.

The overall cost of this unit was $280.

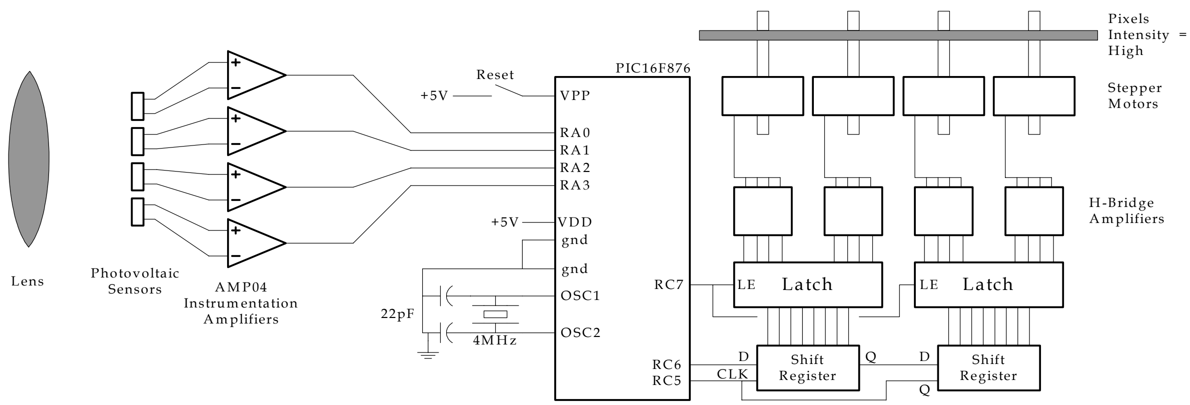


Figure 10.3. Schematic of Camera for People with Visual Impairments.

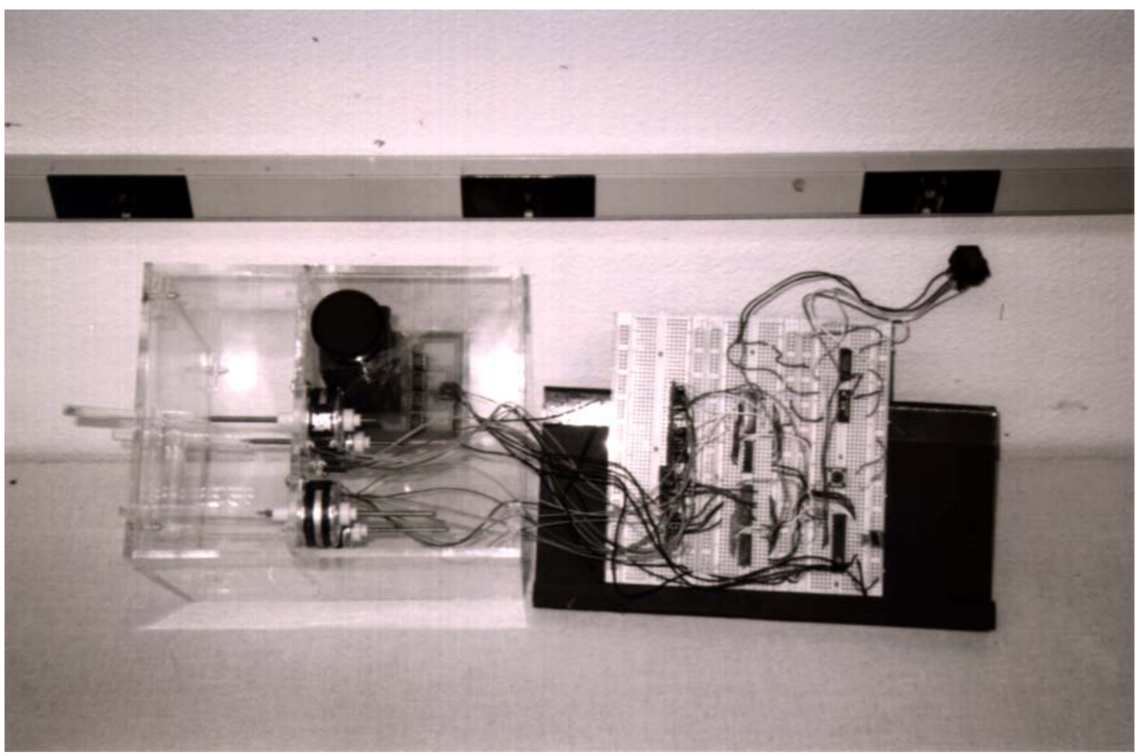


Figure 10.4. Camera for People with Visual Impairments.

GPS VOICE OUTPUT

Designers: Kurt Peterson, Neil Peterson
Client: Human Communications Associates, Fargo, ND
Supervising Professor: Floyd Patterson
North Dakota State University
Department of Electrical Engineering
Fargo, North Dakota 58105

INTRODUCTION

Most canes used by people with visual impairments do not tell them the direction they are heading, their exact location, or how far they are from their destination. The standard cane can only tell people what is in front of them. A seeing-eye dog cannot provide this information either. The GPS voice output device will provide this information to the user.

SUMMARY OF IMPACT

Ideally, the operator of this device will be able to hear a variety of types of information by pushing a button. This information includes the following: the coordinates of their current position in degrees latitude and longitude, the direction in which they are traveling, the distance to their destination, and directions to this destination.

The user will also be able to save the coordinates of a position into the device's memory, name the saved positions, and use these saved positions to reach the destination again later. The device will output warnings telling the user if the battery power is low, or if satellite transmission is weak or lost.

TECHNICAL DESCRIPTION

The overall block diagram of the GPS Voice Output is presented in Figure 10.5. To collect GPS information, a Magellian GPS receiver was used. This unit is relatively inexpensive (approximately $100), fairly reliable, and has a serial output port. The serial port of this unit is connected to the SCI port of a PIC16F876 microcontroller. Through the serial port, the microcontroller can program the GPS unit to send position, speed, and heading every 1 to 5 seconds. It can then log these data as they are received.

The keypad consists of large buttons for the operator. These buttons are monitored by the microcontroller. They are programmed to output the GPS position, heading (degrees from North), speed, distance to a desired location, and directions to this location.

In addition, operators can record their present position as a waypoint so they can find their way back.

The microcontroller consists of a pair of PIC16F876 evaluation boards (see Figure 10.6). These evaluation boards simplify the wiring and programming of the controllers by allowing one to display information (such as GPS data) on an LCD display. Future iterations of this design will presumably use a single microcontroller, because the LCD display will not be properly functional to the intended operator.

A V8600A Speech Synthesizer is connected to the microcontroller using 8-bit parallel communications to generate voice outputs. This device allows one to spell out words in ASCII text, and this text is then converted into intelligible words when fed to a speaker.

The overall design of the GPS Voice Output appears to work very well. If the user is walking around outside, the GPS receiver typically has no problem picking up the GPS satellites. In addition, the voice output from the speech synthesizer is clear.

The overall cost of this device was $420.

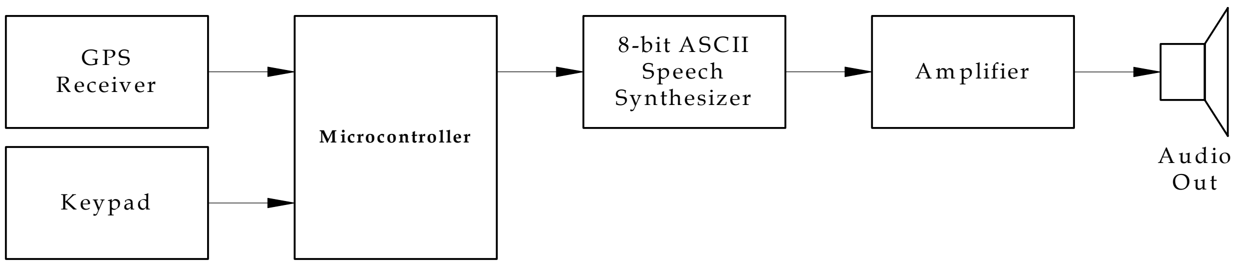


Figure 10.5. Block Diagram for the GPS Voice Output

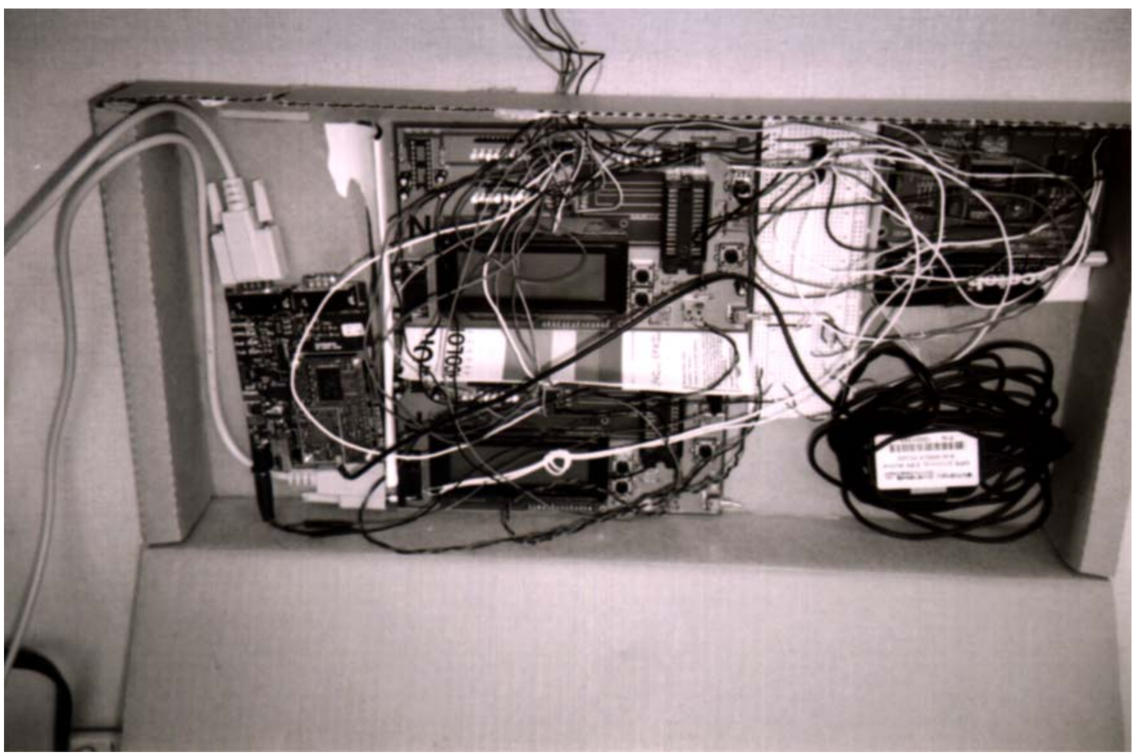


Figure 10.6. Final Design. A Second Design Group Will be making PCB's and packaging this device.

CHAPTER 11
NORTHERN ILLINOIS UNIVERSITY

Department of Electrical Engineering
DeKalb, IL 60115

Principal Investigators:

Mansour Tahernezhadi (815)-753-8568

Xuan Kong (815)-753-9942

SWITCH-ACTIVATED VOICE CONTROLLER

Designers: Lisa Day, Rebecca Delgado, Joseph Dowsett, Jason Dyer, Jaime Escobedo, David Galica, Jose Godinez, Steve Grujich
Supervising Professors: Dr. M. Tahernezhadi
Department of Electrical Engineering
Northern Illinois University (NIU)
DeKalb, IL 60115

INTRODUCTION

This design project was built for individuals who cannot speak. When the user pushes the appropriate button on the device, it produces a preprogrammed audio request. The design prototype allows selection from a set of four preprogrammed audio requests.

SUMMARY OF IMPACT

This portable switch-activated voice controller allows a person who has trouble speaking to choose from a set of preprogrammed requests. Each button on the device corresponds to one of these requests. The portable switch-activated voice provides a greater sense of independence and confidence for individuals who have a loss of vocal ability.

TECHNICAL DESCRIPTION

The first step in designing a switch-activated voice controller was to find a device capable of recording the voice. The Chipcorder ISD1100 series met the needs of this project. The ISD1110 chip was selected, because it is capable of recording and playing 10 seconds of a voice. It comes in a 28-pin dual inline package. The power supply required by the ISD1110 is 5 volts, which was achieved with a 9-volt battery and a 5-volt regulator.

The switches are simple tact switches capable of activating the ISD1110 by pulling certain pins LOW (to ground). The speaker is an eight-Ohm speaker. In order to create the switch-activated voice controller, several ISD1110 chips were placed in parallel. Since the recording is only done once, a separate recording circuit can be used to record the signal. This minimizes the need for resistors and capacitors. Once the signal is recorded, the chip can be placed in a play mode.

One feature of the ISD1110 is the capability to play up to 10 seconds of a recording. The 10-second slot can be addressed into 80 segments. Each of these segments is a minimum of 0.125 seconds in length.

Figure 11.1. Switch Activated Voice Controller.

Most of the messages this device is intended to record are short messages. Some examples of these messages are “I need to go to the bathroom”, or “I'm thirsty.” By utilizing the addressing capabilities, four messages can be recorded using only one ISD1110 chip.

Because only one chip is used, it provide recording and play with just five resistors, seven capacitors, and a microphone. An inverter chip was used to interface the tact switches with the ISD1110 record, play, and addressing functions. The 7404 TTL chip was chosen for this design.

The switches labeled Location four, Location three, and Location two are all connected on one end to a pull up resistor, which is connected to + 5 volts. When the switch closes, current flows through the pull-up resistor, and the input to the 7404-inverter chip drops to 0-voltage. The inverter chip converts the 0-volt signal to a 5-volt signal, and this signal is then fed to the address bit. When the address bits are high, the recording will begin at that address. Locations two, three, and four set address bits A4, A5, and A6 high. There are 80 different addressable locations, beginning at 00000000 (010) and going to location 0100 1111 (7910). A 0.125 s block separates each location in time. The eight addressing bits from lowest to highest are A0, A1, A2, A3, A4, A5, A6, and A7. A4 alone references location 0001 0000 (1610), A5 alone reference location 0010 0000 (3210), and A6 alone references location 0100 0000 (6410). Activating the PLAYE' button produces a message between locations 0 and 15 that can be played for a duration of 16*.125 = 2 s. Location two is from address 16 to 31, also producing a time of 2 s. Location three can play from address 32 to 63, producing a time of 4 s. Location four is from address 64 to 79, producing a time of 2 s.

It is possible to break the time durations into equal durations of 2.5 s beginning at locations zero, 20, 40, and 60. In binary, this is locations 0000 0000, 0001 0100, 0010 1000, and 0011 1100. This is implemented by adding a 2x4 decoder, tying A5 and A3 together, and tying A4 and A2 together. Then manipulating A4 and A5 would allow for playing/recording from locations one, two, three, and four.

Using time durations of equal length would require a decoder and an inverter. The decoder is necessary to decode bits A5 and A4. One consideration for any design is current consumption. The ISD1110 chip draws 15 mA for operation. The 7404 chip draws less than 10 mA during normal operation. A 9-volt battery can supply the necessary current.

The recording can be accomplished by tying the REC' pin LOW and speaking into the microphone. Playing can be either edge-triggered by PLAYE' or level-triggered by PLAYL'. Playing is initiated in an edge-triggered manner, because the design includes tact switches. In addition, there is no need for the PLAYL' pin.

The ISD1110 also has a pin to connect to an LED, which can be lit while the device records the voice. This pin is RECLED'.

The overall cost was approximately $80.

DIGITALLY SECURED RF CONTROLLED OUTLET

Designers: A. Ashraf, S. Basavatia, M. Benitez, F. Bogosh, M. Brennan, T. Butler, V. Chhay, and C. Custon
Supervising Professors: Dr. M. Tahernezhadi
Department of Electrical Engineering
Northern Illinois University (NIU)
DeKalb, IL 60115

INTRODUCTION

This project features a design to allow people with physical disabilities to wirelessly control household devices. The design consists of a digital transmitter and receiver that use 12-bit encoding. This is done to avoid false triggering due to electromagnetic interference caused by other nearby transmitters. The design accommodates up to four household appliances.

SUMMARY OF IMPACT

The designed prototype allows individuals limited mobility to have wireless control over household appliances. This provides a greater sense of independence around the home. The design consists of a handheld transmitter box with four switches that can switch a series of four electrical outlets on and off.

TECHNICAL DESCRIPTION

The transmitter and receiver used in this project are the 300 MHz amplitude modulations used for garage door openers. To avoid false triggering, both the transmitter and the receiver are communicated via a 12-bit sequence security code. This is accomplished by using a Holtek 12-bit series of encoders and decoder chips. The signal at the transmitter is encoded using a 12-bit encoder.

To accommodate an outlet box with four outlets, four bits are reserved for data. The remaining eight bits are used as the security combination bits. The design sets the same combination for all eight bits in both the encoder and decoder. This allows the device to know the data are being sent from the person controlling the outlet, and not by an interfering signal in the air.

After setting the combination at the transmitter and receiver boards, one is able to set up the external hardware needed to use the garage door opener as a radio frequency transmitter. Both transmitter and receiver require 12 volts for operation. Radio-Shack power converters are used to obtain the required 12 volts from a regular wall outlet. The encoder and decoder require 5 volts for their operation. Therefore, a 5-volt DC regulator capable of generating 5 volts from any DC supply greater than 5 volts is used.

After a switch corresponding to the desired remote appliance is pressed, the output signal is 12-bit encoded and transmitted to the receiver. At the receiving end, the received encoded data is decoded. The voltage levels on the four data pins on the decoder are either 5 volts or 0 volts, depending on whether the device is switched on or off. 5 volts are used to turn on a relay and drive the selected household appliance.

The overall cost was approximately $140.

Figure 11.2. Digitally Secured RF Controlled Outlet.

SWITCH-ACTIVATED SPEED DIAL

Designers: Christopher Gunderson, Joy Hastings, William Herzke, Sean Hopkins, Mike Ilic, David Jarovsky, Nick Kettman, and Veera Ladsaria
Supervising Professors: Dr. M. Tahernezhadi
Department of Electrical Engineering
Northern Illinois University (NIU)
DeKalb, IL 60115

INTRODUCTION

This design features a switch-activated speed dial system capable of storing and dialing up to 10 telephone numbers. This device would benefit older individuals and individuals with disabilities by allowing them to press two buttons on a keypad instead of entering an entire string of digits. A keypad is used to program the device by entering the desired number sequence via a processor. Upon decoding, the processor sends a series of digits to a dual tone multi-frequency (DTMF) generator for acoustic coupling to a telephone handset.

SUMMARY OF IMPACT

The prototype allows individuals with physical disabilities, limited finger movement, or poor memory to have speed dial access to a set of 10 preprogrammed phone numbers. A particular phone number is dialed by pressing two buttons on a keypad as opposed to entering an entire string of numbers. The switch-activated speed dial system enables the individual to have faster and more convenient means of contacting emergency personnel, friends, and family.

TECHNICAL DESCRIPTION

A keypad is used to program the device by entering the desired number sequences. The output of the keypad is given to the input of an encoder (MM74C922). The encoder selects one element in the array of numbers and letters on the keypad and sends the information signal to the basic stamp. The basic stamp sends a series of preprogrammed numbers to the tone generator. A crystal is connected to the tone generator, which then produces the required DTMF frequencies. These frequencies are then amplified through the speaker for acoustic coupling to a telephone handset.

The processor for the circuit is the BASIC Stamp II (BS2) by Parallax. The BS2 has two K of EEPROM, which is used to store the executable program and all data. 32 bytes of RAM serve as variable space and I/O pin interface for the BASIC program.

The BS2 chip is a 24-pin DIP consisting of numerous surface-mount IC's (voltage regulators, a crystal oscillator, a microcontroller, a BASIC translator, etc). The carrier board for the BS2 contains a prototyping area, a 9-volt battery clip, and an RS-232 serial port for program downloading and debugging. This serial port is connected to the serial port on a personal computer (PC). BASIC code is written in the BS2 editor program and downloaded to the module via the serial interface. Program debugging is accomplished by running the program on the BS2 while it is connected to the PC. When inserted into the program code, the DEBUG command returns a simple text message or the value of a variable.

The basic stamp code consists of a short main program and several subroutines. There are three subroutines. The dial subroutine is used to recall one of 10 stored telephone numbers by a simple two-button sequence. First press the A button, followed by any digit, zero through nine. Each digit represents a memory location that can hold up to 11 digits (one + area code + seven digit number). If a digit does not follow an A button press, the program will reset to the top. The DTMF tones for each digit are generated for 125 ms, with 25 ms of silence in between.

The store function is used to save a telephone number in one of 10 locations in EEPROM. This function works by first pressing B, then dialing the phone number, then pressing B again, followed by the desired memory location represented by digits zero through nine. During this process, a short blip signifies that a valid key has been pressed. As the phone number is entered, the program counts and saves the total number of digits. The program will only save the first 11 digits that are pressed, because this is the maximum size that was designed for the storage. Pressing B at any time during the phone number entry signifies that there are no more digits. The phone number and the number of digits are saved to EEPROM. The number corresponding to the digits is used in the dial function.

The manual function is signaled when a digit is pressed without immediately pressing A or B beforehand. This allows manual dialing of any digit sequence. DTMF tones are generated as long as a key is being pressed.

The C and D keys serve no function and are ignored in all subroutines. The design enclosure was constructed using a high quality durable plastic. The rectangular case contains the circuitry, a speaker, and a 9-volt battery. A hole was drilled on the bottom of the case to screw the speaker in place. The speaker was mounted upside down to amplify the DTMF frequencies as much as possible. Four small holes were drilled on the bottom of the case to screw the circuit board in place. The circuit board was mounted on top of the speaker. The mounting screws were covered with plastic cylinders to avoid interference between the metal screws and the circuitry. The casing for the 9-volt battery was mounted next to the circuit board.

The keypad, LED, and switch were mounted on the cover. Four small holes were drilled in the center of the cover for the insertion of the keypad legs. A fifth hole was drilled in the center of the cover to connect the wires from the keypad to the encoder on the circuit board underneath. Two additional holes were also drilled. One was for the LED and another was for the switch. Once all the circuitry was in place, the cover was mounted with a screw in each corner. Rubber legs were mounted on the bottom of the case so that the device would be lifted off the surface.

The overall cost was approximately $160.

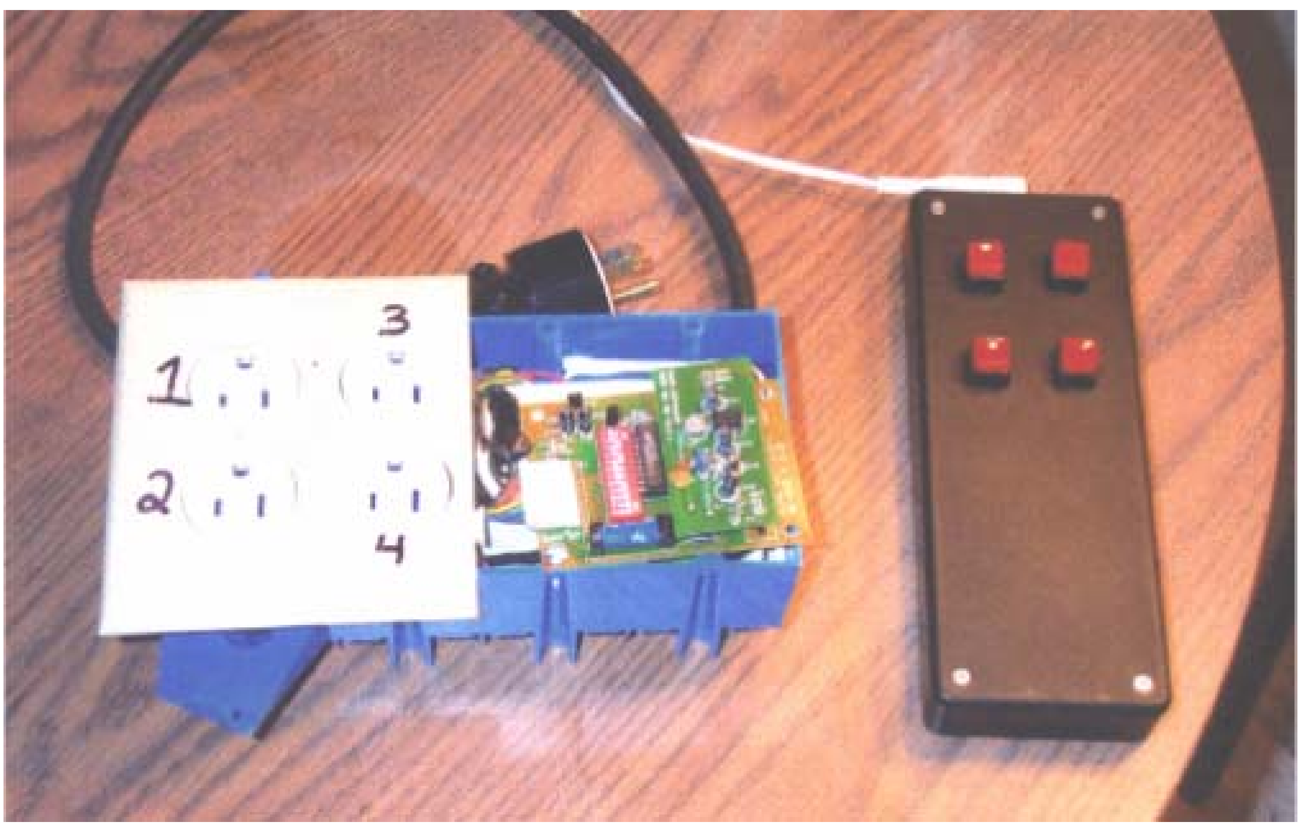


Figure 11.3. Digitally Secured RF Controlled Outlet.

WIRELESS KEYLESS ENTRY

Designers: Andrew Carnegi, Mike Ilic, Brian Kelenc
Supervising Professors: Dr. M. Tahernezhadi
Department of Electrical Engineering
Northern Illinois University (NIU)
DeKalb, IL 60115

INTRODUCTION

In this project, a wireless keyless entry was designed to enable an individual with disabilities to unlock a main entrance door to a house via a key-chain transmitter.

SUMMARY OF IMPACT

The prototype provides individuals with limited mobility wireless access to a residence. The receiver unit can be integrated into commercially available intercom systems.

TECHNICAL DESCRIPTION

The main components of the design project are an encoder, transmitter, receiver, decoder, door-latch drive circuit, and power supply units. The transmitter unit is a 300 MHz AM RF key-chain transmitter from Skylink. This transmitter receives a coded signal from the encoder and uses this signal to modulate its 300 MHz carrier. The encoder delivers a 12-bit code in serial format to the transmitter. The first eight bits of the encoder are address bits, and they must be matched to the decoder address bits to allow the transmitted signal to be received. The final four bits of the encoder are data bits, which are processed by the decoder only if the address bits are matched. The operating voltage of the transmitter/encoder key chain is 12-volt DC, and the operating current is 6.6 mA. This voltage is obtained from a 12-volt battery.

The decoder used in this project is a 12-bit decoder from Ming Microsystems. The first eight bits of the transmitted code must match the address bits of the decoder. After matching occurs, the last four bits are passed on to the data output of the decoder. The valid ID relay closes and remains closed until the incoming signal is no longer present. The four data bits latch and remain in the state in which they were programmed by the last transmission until they are changed by the next transmission. In this project, only one data bit was set high because there was only one device for the transmitter. However, the other data bit could be utilized for future expansion of the project to control additional devices.

The drive circuit uses the transmitted signal to permit power to travel to the door latch, which opens the door. Once the transmitted signal is received, the transmitted data is outputted through the data pins. The data pins are active low. Because the design requires a high output for the drive circuit, the desired data pin is passed through an inverter. The drive circuit is based on the totem pole configuration of a Darlington transistor that allows AC or DC current flow to power the door latch. The inverted output data bit is connected between the base and the emitter. When the transmitted signal flows through the base, the transistor allows the current to pass from the collector to the emitter and activate the door latch. The collector and the emitter are connected to intercom pin one and pin two respectively.

For the project, a 300 MHz AM RF receiver board from Min Microsystems (Part # RE-99) was used. The RE-99 receiver requires a wire antenna for the most favorable operating distance. The wire antenna can be insulated or non-insulated and is soldered to the antenna connection point on the receiver. A 22-gauge wire cut to 9.36 inches was used for optimal performance. The operating frequency of the receiver is adjusted by turning a variable capacitor on the top of the receiver board. Once it was determined that the decoder was operating properly, the receiver and transmitter pairs were tested. First, the address bits on the decoder were matched to the address bits on the encoder. If the addresses match, the transmitted signal closes the valid ID relay on the decoder motherboard. If the relay does not close, the variable capacitor on the receiver board is tuned to a point where the transmitted signal can be received and processed. This closes the relay. This procedure can be repeated at various distances up to 200 ft away from the transmitter.

The intercom system used for this project is a NuTone Model IK-15 Door Answering Intercom. This intercom system is powered by a standard 120 AC signal. The signal is routed through a 120/20 transformer that was also supplied by NuTone. The system is equipped with two-way speakers. One speaker is for visitors, and the other is for the resident. The resident has a talk/listen button and a door release button, which allows the visitor to open the door by pressing the button. Pressing the door release button allows the 20-volt AC output of the transformer to flow to the door release. This flow activates the door latch.

The overall cost, including the intercom system, was approximately $200.

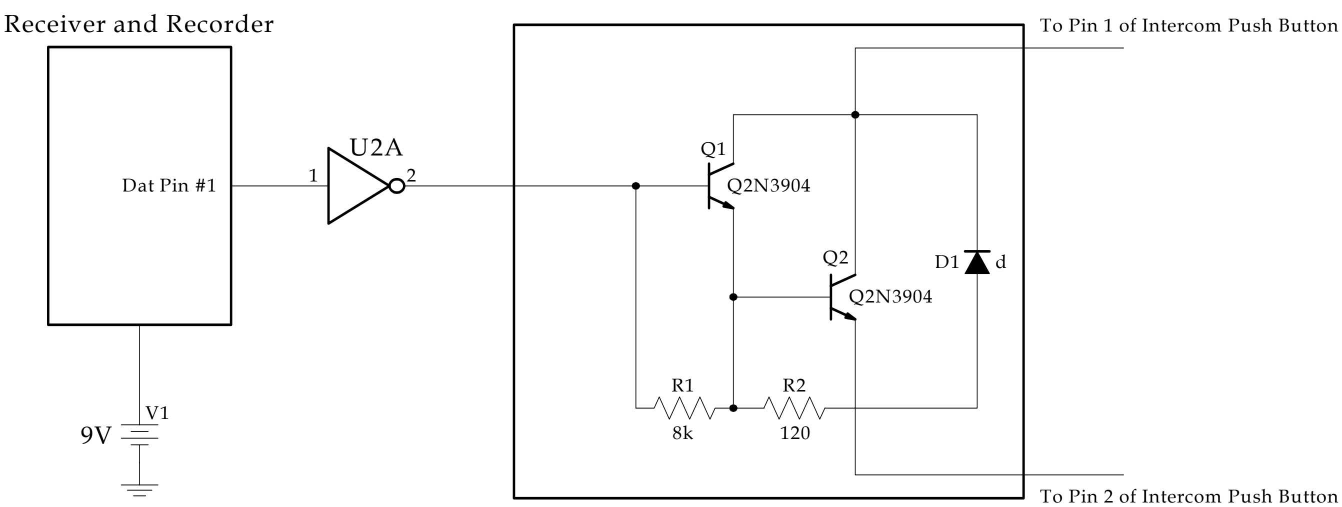


Figure 11.4. Schematic of Wireless Keyless Entry for Connection to an Intercom System.

CHAPTER 12
RENSSELAER POLYTECHNIC INSTITUTE

Department of Mechanical, Aerospace and Nuclear Engineering
110 8th St.
Troy, NY 12180-3590

Principle Investigator:

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SUBMERGED WATER STABILITY AND EXERCISE AID

Designers: Svava Maria Atladottir, Jose Canarte, Megan Fannon, Matthew Menard, Bryan Phipps, Jessica Reichard, Jennifer Sullivan, Christopher Wright, Brain Reece
Client Coordinator: Barbara Zawoysky, Capital District YMCA, Clifton Park, NY
Supervising Professor: Dr. Mark W. Steiner
Department of Mechanical, Aerospace and Nuclear Engineering
Rensselaer Polytechnic Institute
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INTRODUCTION

The water exercise aid was designed for an aquatic therapy class. It was designed to allow patients with various types of disabilities to exercise in the pool with stability, comfort and confidence. Water exercises provide a good workout, especially when the exercises are used for rehabilitation. The tendency of the body to float in the water alleviates stress on the joints. When in use, the apparatus sinks in the water and rests on the floor of the pool. The main component is a seat surrounded on three sides by a system of rails. This seat has a back support. It may be rotated to allow the back of the seat to be used as an additional support while the user is in a standing position. The height of the seat may also be adjusted to accommodate users of different sizes. The system of rails surrounding the chair contains various heights and is designed to aid in a number of stretching exercises. Furthermore, these rails provide support to the user, serve as anchoring locations for resistive bands, and allow up to four simultaneous users.

SUMMARY OF IMPACT

This device can be beneficial to anyone when used as a water exercise aid. It can be used for support, for stretching exercises, or as a circuit trainer in conjunction with resistance bands to provide a workout for virtually any muscle group. The device adds an element to water exercise that previously was unavailable. The device allows unstable or frightened patients to move away from the wall of the pool and into the water, therefore allowing a full range of motion and complete interaction with the class. The device allows performance of water exercises that were previously unavailable or difficult to complete. The design allows for the completion of many different activities while using the same apparatus. These activities include stretching, muscle toning, and muscle strengthening.

Figure 12.1. The Water Exercise Aid.

TECHNICAL DESCRIPTION

The basic material used for the device was 2-inch diameter PVC, because it is commonly available and satisfies the basic requirements. It is light and inexpensive compared to other materials. Holes were drilled into the pipes to allow water to enter. This makes the sinking of the device very simple, and the addition of extra weights is unnecessary. The platform at the base allows for additional weight and stability. Standing on the platform eliminates tipping and sliding. Finally, the system of rails provides a support for people while stretching. These rails can also be used as anchors for resistance bands.

The seat was constructed with 1.5-inch PVC and is designed to rotate. This enables the seat to face forward but also be rotated to face backward when not in use. Therefore the backrest of the seat may serve as an additional support when standing. The seat itself was mounted on a support that extends vertically from the base, which is composed of two pipes. One pipe is inside the other. The height of the seat is adjustable between 18 and 26 inches from the base of the platform. The inner pipe is able to move freely within the outer pipe to allow for height adjustment. The system is fixed in place by a 3/8-inch steel pin inserted through holes in both the inner and outer pipes. Even though the fixture for the seat is very strong, it was calculated that the chair would still deflect .164 inches given a weight of 300 pounds. This is a small deflection and deemed acceptable for this version of the device; however, future versions will include additional support for the seat.

Ballet-style bars were placed on three sides of the device. The two sides opposite each other include bars at six, 18 and 36 inches. The third side, opposite the chair, has bars at 12 and 30 inches. The bars were placed at these different heights to provide more options for the type of stretching exercises that may be performed. Different exercises work well with different heights, and placing bars at various levels allows more variety. The bars also act as a place to position resistance bands. The bands can be looped around the bars and used by patients for muscle strengthening exercises.

Both the bars and the seat were attached to the base of the device. The base was covered with flat platforms that were constructed from PVC sheets. The flat PVC platforms were placed along the outer edge of the ballet bars and on the seat. The sections next to the bars are 19 inches wide and provide a place for people to stand. The portion in front of the seat is approximately 35 inches deep, which allows enough room for a person to lean against the backrest of the chair and still remain on the platform. The platforms combined together act as a safety feature preventing the user from getting a foot caught between the tubing that composes base itself. Furthermore, the platforms stabilize the entire device in two ways. First, the added weight of the platforms helps add stability. Second, when the user is standing on a platform, the added weight is transferred as a downward force to the ground. Generally, one person on the platform is enough to prevent the device from sliding at all. Increasing the number of people using the platform increases the stability of the device as well. The cost of parts was approximately $500.

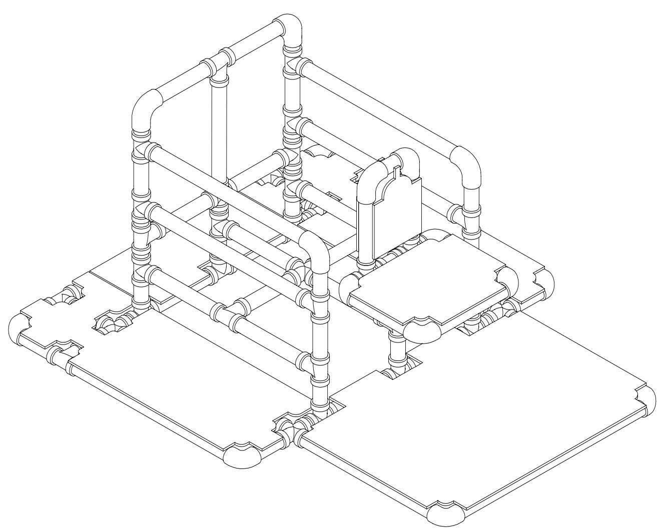

Figure 12.2. Mechanical Drawing of Device.

CHAPTER 13
STATE UNIVERSITY OF NEW YORK AT BUFFALO

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GOLF GENIE TO ENABLE A PERSON WITH DISABILITIES TO PLAY GOLF

Student Designer: James G. Hanna
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering,
SUNY-Buffalo Buffalo, NY 14221

INTRODUCTION

The Golf Genie was designed to allow individuals with lower-body motor disabilities and normal upper body strength to participate in golf. The design incorporates two belt tensioner springs for power storage and delivery. It uses a formed PVC club to deliver the force to the golf ball, which currently travels an average maximum of 77 yards. A more powerful design is currently under construction.

SUMMARY OF IMPACT

The Golf Genie will enable people who are unable to walk to play golf. The mechanism weighs about 20 pounds and is easily removed or attached to the platform, which is attached to the wheelchair via wing nuts. The platform weighs approximately five pounds and is attached to the wheelchair with clamps. The Golf Genie requires no modification to the wheelchair itself.

To operate the device, the loft of the club head is adjusted for the desired height to distance ratio. Next, the club slides into the mount and the bolts are loosely tightened. Then club is angled at the target and the bolts are completely tightened. The chair is positioned so the club is behind the ball. Finally, the unit is cranked to the desired power (between five and 10 clicks). The crank is removed and slid over the release lever, then pulled and held. For putting situations the crank remains on the release lever, and the operator can swing the club manually.

Although the Golf Genie is pictured on a manual wheelchair, the platform design is easily adaptable to most types of powered wheelchairs. With a motorized wheelchair and the proper inflatable off-road tires, the Golf Genie will not cause any damage to the golf courses on which it is operated. In addition, the holes dug as a result of a normal chip shot are not created when using the Golf Genie. The current 77 yard average maximum distance would require the golfer to play on smaller courses.

Figure 13.1. Golf Genie.

TECHNICAL DESCRIPTION

The mechanical components of the Golf Genie are simple in design. The power-input device is a ratchet with a 9/16” square socket connection. The club mount is a set of two clamps to hold the club in place and is welded to a frame. The frame is connected to a tube that bolts to the power shaft. The internal mechanism is set up like a winch. However, instead of winding a cable, it winds two springs. The springs and their housings were originally diesel engine belt tensioners made by Deutz. These tensioners hold one end of the spring in the housing and the other end through the diameter of a centralized shaft. To adapt the springs to the mechanism, the two shafts were replaced with one long shaft that powers the mechanism. A gear fixed to the power shaft is held by a catch that stores the spring tension until the crank handle is used to release the mechanism. A 90-degree head is used to minimize club flex. The club was constructed from a straight length of PVC tube with a 90-degree elbow fixed at one end. The club head was made from a short piece of PVC tubing that was heated and flattened at one end. All steel plates used in assembly are 1/8″ thick, and the power shaft was machined from a ¾″ bar of cold rolled steel. The gear and catch were made from hardened steel and created by a heavy-duty winch. The platform legs were made from ¾″ galvanized steel tubing, and the club was made from ¾″ PVC or aluminum tubing with a 90-degree elbow connected to a flattened tube club head. The total cost of The Golf Genie was approximately $250.00.

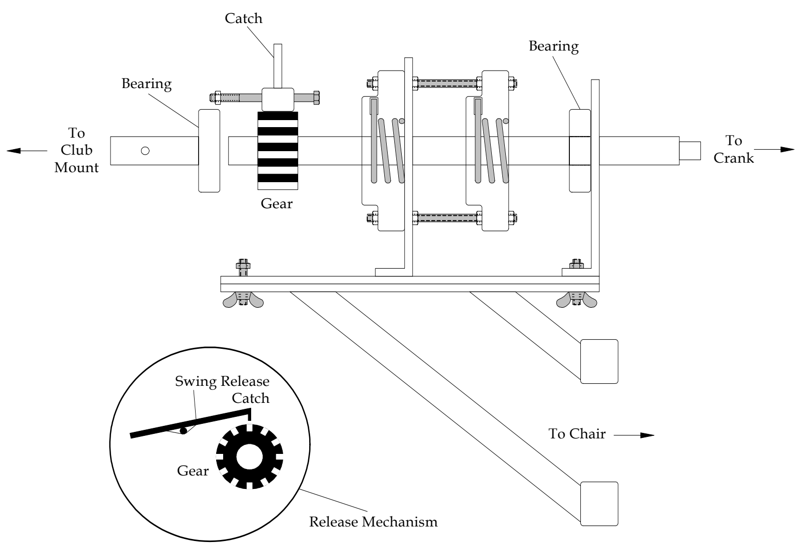

Figure 13.2. Schematic of the Power Input Device.

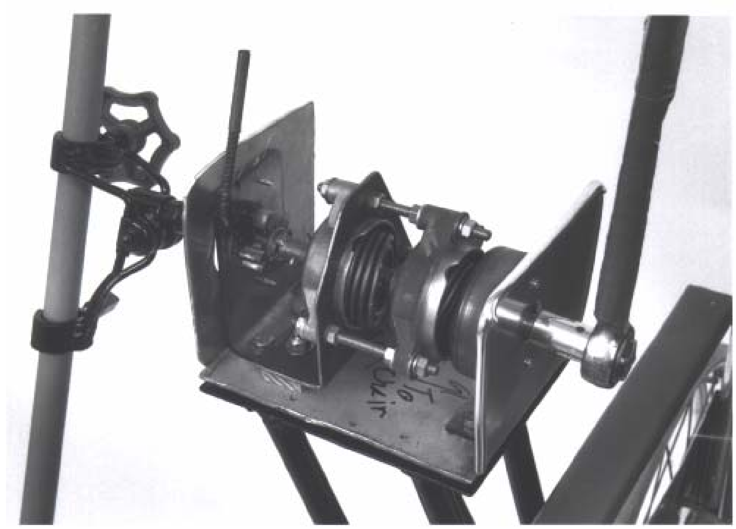

Figure 13.3. Power Input Device.

WHEELCHAIR CURB NEGOTIATOR

Student Designers: Russell Donath and Steve Jacques
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo, Buffalo, NY 14260

INTRODUCTION

This project addresses the problem faced by some people who use wheelchairs when they encounter a curb. Wheelchairs are not equipped to travel over curbs, and many sidewalks do not have the appropriate modifications.

The curb negotiator would allow a person to travel up or down from the curb of a sidewalk without relying on pre-constructed ramps. The focus of this project is to allow a person who uses a wheelchair to be more self-sufficient. Several similar devices exist on the market. However, these devices are large, heavy, and expensive. In addition, these portable ramps require an additional person to help deploy them. People who use wheelchairs can operate the curb negotiator with no assistance.

SUMMARY OF IMPACT

The device consists of two aluminum ramps and a simple storage rack that attaches under the wheelchair. The ramps are positioned separately and are raised and lowered by an attached cord. The ramps are lightweight but require users to have suitable upper body strength to position and propel themselves. The ramps are compatible with motorized wheelchairs, provided that the user is assisted in the deployment of the device. After use, the ramps are easily retrieved by means of the attached chords and stored out of the way under the seat. The device is kept simple and unobtrusive so it does not interfere with the original functions of the wheelchair.

TECHNICAL DESCRIPTION

The two ramps are made of ¼-inch thick diamond plated aluminum. Each ramp has dimensions of 40 inches x 4 inches x 1 inch. The 1-inch height was produced by bending the ramp on each side to an angle of 90-degrees. The 1-inch bend running the length of the ramp helps prevent the ramps from flexing, and it also keeps the wheels of the wheelchair from rolling off the ramp during use. A 10-degree bend was built into the ramp. The bend is 4 inches in length. This bend was produced by cutting the 1-inch sides, bending them by hand, and welding the gap produced by the bend.

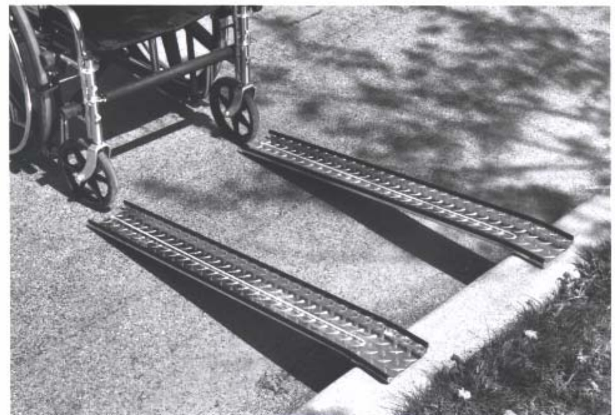

Figure 13.4. Deployed Ramps.

Each one of the ramps is equipped with a rope that runs the length of the ramp and attaches to the bottom of the ramp with a small hook. These ropes enable users to lower the ramps and then attach the hooks to the wheelchair, thus allowing free hand movement as they go up the ramp. After they are up the ramp, they are then able to retrieve the ramp. After the ramp is retrieved, the rope is connected to the bottom of the ramp.

The storage system consists of one-inch diameter PVC piping. One piece of the piping is fixed across the front of the wheelchair. A small piece of bungee cord is placed over the ramp to pin it down on the piping. In the back, the PVC piping is set up in an upside down U shape. The piping on the back of the wheelchair is used to support the ramp. Both pieces of PVC piping are attached with wing nuts. This allows the wheelchair to collapse after use.

The total cost of the project without the cost of the wheelchair was about $70, and $220 when the cost of the wheelchair was included.

Figure 13.5. Stored Ramps (Front View).

Figure 13.6. Stored Ramps (Rear View).

HAND CADDY FOR THOSE WITH CARPAL TUNNEL, ARTHRITIS, AND OTHER DISABILITIES OF THE HAND

Student Designers: Denis Leff, Chris Diebner
Supervising Professor: Dr. Joeseph C. Mollendorf
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo, Buffalo, NY 14260

INTRODUCTION

Many people do not have complete functionality of their hands and fingers. Whether they lose this ability over time or have a sudden accident, disabilities of the hand can drastically change the way people live their lives. The Hand Caddy can be used to improve everyday living by allowing users to hold items of light to moderate weight. Some examples of these items would be handbags, purses, and grocery bags. An important aspect in creating The Hand Caddy was to keep it concealed so that users would not feel awkward while wearing it.

SUMMARY OF IMPACT

This device enhances independence. People who are recovering from an accident resulting in a temporary disability can also use this device.

TECHNICAL DESCRIPTION

An important design criterion was being able to shift the weight of an object from a person's weaker fingers to their stronger forearm. To accomplish this, a holding device was first constructed. This is a solid Plexiglas hook that can hold a range of handle sizes. A flexible joint that improves the maneuverability of the hook while allowing free movement of the wrist and hand was also included. Inside the joint are thin woven steel cables that are used to transfer the weight from the hook into the forearm cuff. The forearm cuff contains a lightweight aluminum bar, which distributes the weight evenly throughout the cuff. This results in the weight being distributed throughout the forearm.

To keep the device concealed, a clear finger-contoured form-fitting holding hook was used where the fitted flexible joint presses tightly across the palm region of the hand. Finally, a cuff similar to an orthopedic wrist brace was used as the forearm mass-distributing device.

Figure 13.7. Hand Caddy.

The maximum carrying weight is approximately 10 lbs. This limit is sufficient for school bags, pocket books, and groceries. Hand Caddies capable of

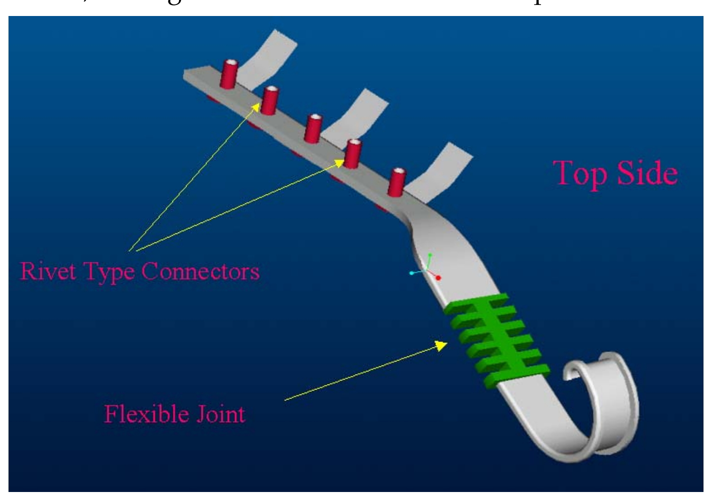

Figure 13.8. Computer Generated Regeneration of Linkage of Aluminum Bar to Cuff.

withstanding higher weight could be built using stronger materials.

The total cost of the Hand Caddy was $40.

Figure 13.9. Wearing the Hand Caddy.

FOOT MOUSE: FOOT-OPERATED COMPUTER INPUT DEVICE

Student Designer: Min-sang Kwon, Wonsub Choi
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo
Buffalo, New York 14260

INTRODUCTION

The mouse and the keyboard are the most frequently used of all computer components. However, grasping a mouse and moving it can be difficult for people with certain disabilities. A foot mouse was created to help people who have problems moving their hands. People without disabilities might choose to utilize this device as well.

SUMMARY OF IMPACT

This device consists of three parts: the mouse unit, the buttons, and the mouse pad. The buttons and the mouse pad are combined together so people with disabilities can use them more effectively. A thin wire connects the mouse and the button unit.

TECHNICAL DESCRIPTION

This project was divided into two parts: the mouse and the box (buttons and mouse pad) unit. The box unit was designed first. The angles for the two buttons were 20 degrees. The final dimensions of the box unit were 0.75m x 0.40m x 0.205m. The hinges were attached to the buttons on the box unit for maintenance purposes. Handles were also attached to the box unit to allow easy opening. Attaching hinges was the most effective way of mounting the button pads. Hinges were attached between the box unit and the button pads from the inside of the device. After mounting the two button pads (right and left), the mouse was constructed. The mouse had to be disassembled in order to analyze its contents. The mouse mechanism was simple, and it was determined that the wires could be attached beneath the circuit panel without removing the existing buttons inside the mouse. First the wires were attached to the circuit panel with a soldering iron, and then they were connected to the buttons. The final part of the construction of the box unit was installing the buttons inside the box. The positions of the buttons were set, and the buttons were then mounted inside of the box unit. The last part of the project was embedding a mouse inside a sandal. Silicon was placed on top of the mouse to fill gaps between the sandal and the mouse. Finally, the device was coated with polyurethane spray for protection.

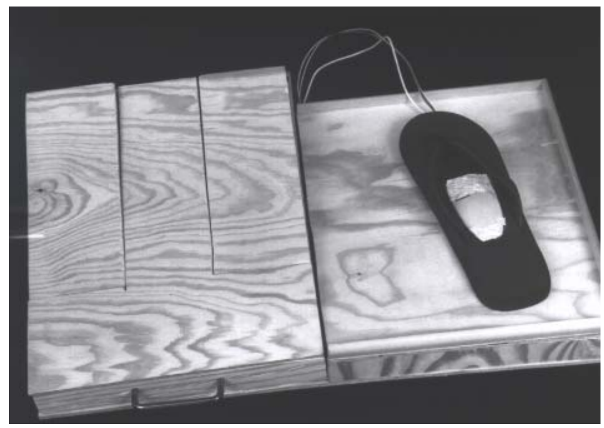

Figure 13.10. Finished Unit.

The total cost of the project was $ 145.

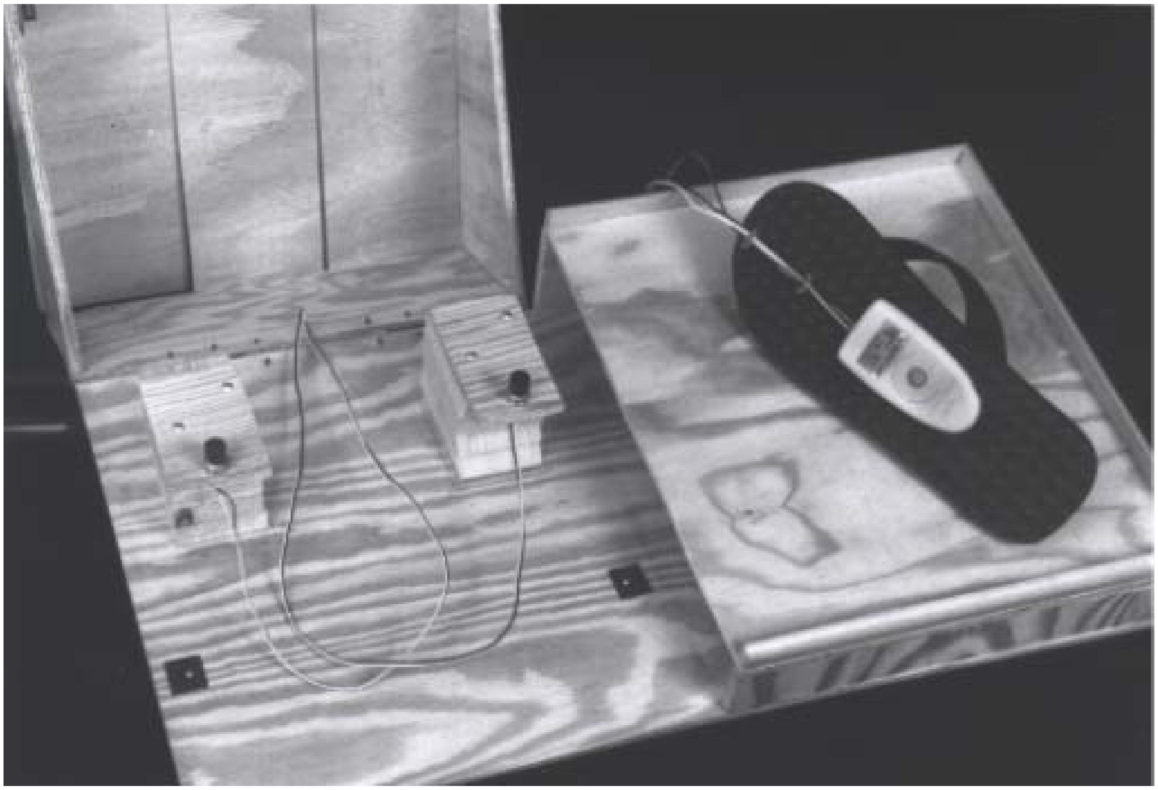

Figure 13.11. Inside View of the Box Unit.

JAR OPENER

Student Designer: Michael J. DeGrave
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering
University at Buffalo, State University of New York
Buffalo, NY 14260

INTRODUCTION

This device facilitates the removal of jar lids by keeping the lid stationary while the user turns the jar. It mounts under a cupboard and slides forward for use and backward for storage. The device relies upon mechanical advantage rather than electrical power, and may accommodate jars with lids up to 5.25″ in diameter. It was developed to assist people with limited grip strength or limited range of motion due to arthritis, tendonitis, or any other physical disabilities.

SUMMARY OF IMPACT

Many daily tasks become difficult for people with arthritis and other disabilities that restrict range of motion and strength in the wrists and hands. This device eliminates the need to grasp onto a lid when opening a jar. Both hands may be used instead of one to turn the jar, and this provides a much larger area for the user to grasp.

TECHNICAL DESCRIPTION

A drawer slide allows the user to mount the device underneath a cupboard or cabinet. The device, which consists of a slender brass base and two aluminum grips, is mounted to the drawer slide. Each aluminum grip is assembled from two separate pieces of aluminum plate. The pieces are stacked at a 90-degree angle and fastened with machine screws. The brass base features a stepped-slot, which is milled longitudinally. One of the grips is mounted at one end of the base. The other grip slides along the milled slot and may be locked into place anywhere by a standard bicycle quick-release seat post binder. The grips are designed to pass over one another, thus accommodating for very small lids. Rubber strips bonded to the gripping surfaces provide friction to help open the jar. When the moveable grip is closed around a lid and locked into place, the user may turn the jar while the lid remains stationary, thus opening the jar.

Figure 13.12. Close-up of Jar Opener.

The total cost of this project was $42.

Figure 13.13. Jar Opener with Fully Extended Lever Arm.

MODIFICATION OF AUTOMOTIVE ROOFTOP CARRIER: TO FACILITATE RIGID WHEELCHAIR USE

Student Designers: Benjamin Geiss and Jason McLachlan
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo, Buffalo, NY 14260

INTRODUCTION

Assistive devices allow people who use wheelchairs to drive automobiles. While driving they need a place to store their wheelchairs. The Chair Topper™. (by the Braun Corporation) lifts a folding wheelchair and stores it on the roof of a car. However, many people who use wheelchairs prefer to use a rigid wheelchair due to the extra comfort and support this type of chair provides. Unfortunately, the Chair Topper™ doesn't accommodate rigid wheelchairs. Therefore, it requires users to travel with a foldable wheelchair. The new device is a replica of the Chair Topper™ with modifications to accommodate a rigid wheelchair.

SUMMARY OF IMPACT

This device will give people who use wheelchairs a choice to use a rigid or foldable wheelchair when they drive. With this device they can choose the wheelchair they want without the hassle of storage while driving. Accessories are provided for both foldable and rigid wheelchair storage.

TECHNICAL DESCRIPTION

Some major changes were implemented to allow a non-foldable wheelchair to fit into the compartment overhead. The fiberglass cover was raised 1 foot off the base to allow the extra room needed. Aluminum was used in the prototype because it was highly available. It would be more efficient and sturdy if a new fiberglass mold were made, and one solid piece were assembled.

Next, the portion of the frame used to tilt the foldable wheelchair parallel to the car had to be transformed into a rigid upright fixture. The bolts holding the frame were removed, and the electrical wires used to control the motor were extended. The bottom of the folding frame was welded to the bottom of the rigid frame using steel "L" brackets. 12-inch steel bars were welded at a 45-degree angle on either side to give more support to the top-heavy structure. The motor and chain assembly that lifts the chair are located at the top of the frame. The chain is stored in triangular steel boxes. These chain boxes interfere with the wheel of the rigid chair when lifted, because the chair is wider when unfolded. To eliminate this problem, the entire chain-motor assembly was disconnected and moved back until the chain box was flush with the front of the frame. The assembly was re-welded with additional supports. The area where the chains descended had to be modified next. Previously, the chains dropped straight down from the chain box over a set of sprockets that were attached to the motor. Since the motor was moved back and the center of a folded chair extends further than an unfolded one, the chain drop point was extended 13 inches horizontally. Aluminum plates bolted on to the outside of the old assembly were used. In addition, holes were drilled at the drop point where the bearings were installed. A steel rod was passed

Figure 13.14. Closed Mechanism Next to Rigid Wheelchair.

through these bearings, and a new set of sprockets was attached to the bar. The switch that transfers power between the chain motor and the closing motor had to be relocated. A piece of plastic tubing was placed on the end of the switch to extend the length of it by 2 inches.

The hook that lifted the folded chair was no longer able to lift the rigid chair. Small pieces of steel were welded to the hook, and eyeholes were drilled into the steel pieces. Wires were slipped through the holes, and a plastic coated steel hook was attached to each end. This created four hooks in the four corners of the chair. This was ideal for a balanced lift.

The total cost of this project was $650.

Figure 13.15. Mechanism closing with wheelchair inside.

Figure 13.16. Interior view of device showing modifications

MECHANISM TO LOWER A CUPBOARD TO AN ACCESSIBLE HEIGHT

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INTRODUCTION

The objective of this project was to design and create a cupboard that is easily accessible to people with disabilities. This ease in accessibility is possible because the cabinet is lowered and extended outward over the existing countertop. This device was designed for people using wheelchairs or walkers and people with limited arm movement.

This cupboard was designed to appear as a regular household cupboard. The device is driven by a hydraulic system that enables the cupboard to operate smoothly. This mechanism is powered by a 12-volt battery but may be converted to operate from household electricity as well.

SUMMARY OF IMPACT

This mechanism allows people with disabilities more independence, because it eliminates the need for assistance from another person to obtain materials directly out of reach. This mechanism also allows people with disabilities to utilize more kitchen space. Another benefit is that the cupboard is brought down to eye level, thus allowing a closer inspection of the items contained in the cabinet.

TECHNICAL DESCRIPTION

The hydraulic system used to actuate the cupboard-frame assembly is composed of three main components. These three components are a pump, a solenoid, and a dump assembly. The other smaller components include a 12-volt battery, a cylinder, a three-way switch, wiring, and hoses.

The pump used in the system was originally intended for snowplowing. This type of pump was used to because its principal use was similar in application. The hydraulic pump drives a head of fluid from the reserve tank to the cylinder. A check valve was used at the pump output to prevent the fluid from flowing back into the pump head. The head gearing determines the velocity of the fluid flow. The pump used in this system was geared to move the fluid at a slow speed, which worked well for this application.

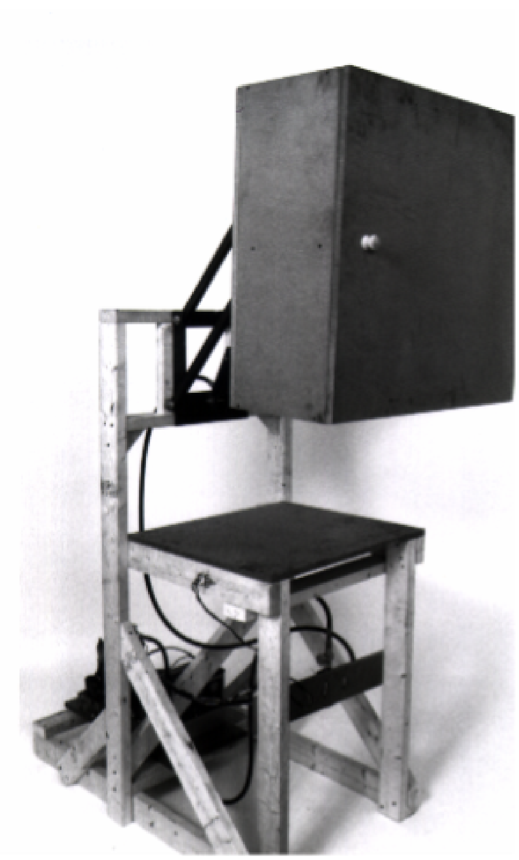

Figure 13.17. Movable Cupboard.

The 12-volt solenoid used in the system is a switch to activate the pump motor. The solenoid has three positions. The first is the neutral position, which occurs when no current is passed through the solenoid. The other two positions occur when a current is passed through the solenoid. The direction of the current determines which position is activated, either the pump or dump assembly. The solenoid uses a magnetic field to close the circuit, which in turn activates one of the assemblies. A second switch is used to send a current through a coil to create the field.

The fluid only flows from the pump to the cylinder because a check valve was used. Another method must be used to allow the fluid to flow back into the reserve tank. A dump assembly was used for this purpose. The dump assembly has three ports and a solenoid actuator. The normal position of the dump assembly, without current, leaves ports one and three open and port two closed. This allows the output from the pump to be connected to port one, and the hydraulic cylinder to be connected to port three. The second position of the dump assembly connects to a port in the reserve tank to allow the fluid in the cylinder to flow back into the tank.

The normal position (the switch in center position) occurs when the system is inactive. When the switch is moved to the upward position, it activates the solenoid and allows current to flow to the pump. This elevates the cupboard. Then the switch returns to the normal position upon release. When the switch is moved to the downward position, the dump assembly is activated. This allows the fluid to flow from the cylinder back to the reservoir tank, thus lowering the cupboard. The switch returns to the original position upon release.

Figure 13.18. Mechanical Linkage.

The total cost for this project was $530.

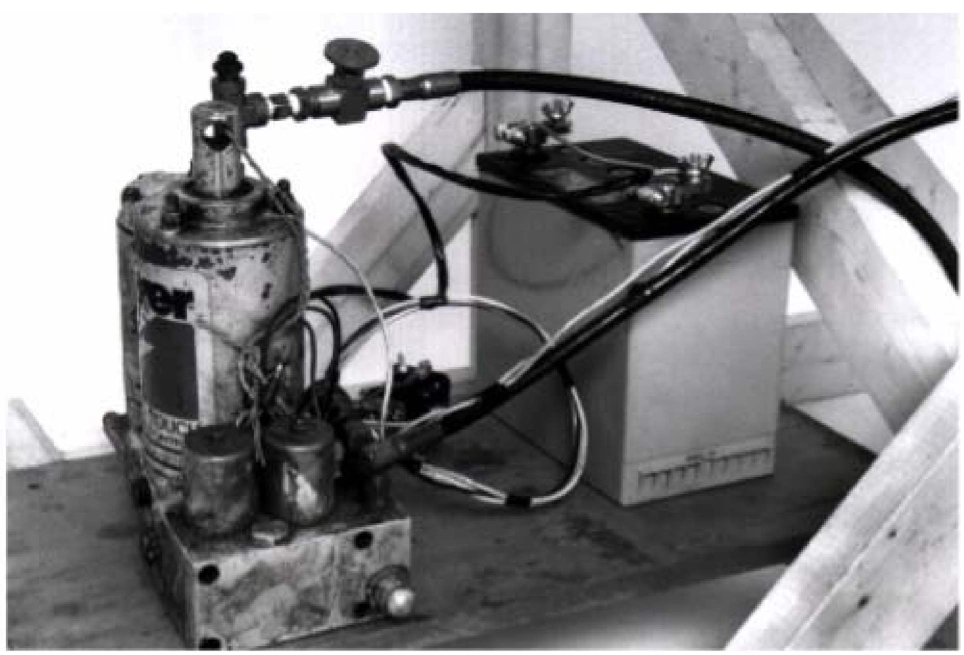

Figure 13.19. Hydraulic Assembly.

HEIGHT ADJUSTABLE CHARCOAL GRILL

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INTRODUCTION

Individuals who use wheelchairs sometimes have difficulty with outdoor grills due to grill height. An extension was developed to raise and lower an outside cooking grill.

SUMMARY OF IMPACT

This grill is not limited for use only by individuals with disabilities. It may be used anytime safety is a concern.

TECHNICAL DESCRIPTION

This device utilizes an AC motor in conjunction with a rotating machine screw. A collet is threaded onto the machine screw and attached to the grill. The motor delivers torque to the machine screw and causes rotational motion. The non-rotating collet is forced to move along the axial direction. The non-rotating collet is attached to the machine screw at one side, and it is also fixed to a static assembly, which includes the grill. The static assembly moves on adjacent posts, creating a dynamic support system. The support system has two purposes. The first purpose is to prevent the grill from spinning, and the second is to create a very rigid structure. As the machine screw is rotated, the collet moves up and down the screw and thereby raises and lowers the grill. The grill is equipped with a larger than normal handle and a locking mechanism for the lid for when the grill is in the open position. Finally, an enlarged temperature gauge is placed in the middle of the lid, making it easier to read the numbers.

Figure 13.20 Completed Grill.

The overall cost of materials and supplies for the project was approximately $150.

Figure 13.21. Non-Rotating Collet.

Figure 13.22. Dynamic Support System.

WHEELCHAIR SEAT HEIGHT AND RECLINE ANGLE ADJUSTMENT

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INTRODUCTION

It can be difficult for people who use wheelchairs to exit their chairs without help. This project was designed for an individual who uses a wheelchair and is capable of pumping a hand pump. The pump extends a hydraulic cylinder, which raises and tilts the seat of the chair forward. The user is then in a comfortable and safe position to exit the chair.

SUMMARY OF IMPACT

This wheelchair modification project concentrated on aiding individuals in exiting a wheelchair from a seated position. This was done by raising and tilting the seat forward so the user can safely and effectively exit the chair without putting excessive strain on his or her legs and back.

TECHNICAL DESCRIPTION

When the hand pump is engaged, hydraulic fluid is supplied to the cylinder. This enables the piston to provide an upward force to the bottom of the wheelchair seat. The upward motion of the seat is restricted by a set of 6-bar linkages mounted on each side of the seat.

The utilization of linkages makes this project unique compared to similar designs in the past. Previous designs have a hinge on the front of the chair that acts to tilt the chair only forward. A hinged connection was chosen was because of collapsibility constraints; previous designs could not develop a linkage that would fully collapse. Collapsibility is necessary because the seat rests upon the surface of the linkages. If the linkages did not collapse, the seat would rest in an undesirable tilted position.

Figure 13.23. Chair in Collapsed Position with Near Armrest Removed.

The top and bottom links to the linkage were constructed of 1½-inch aluminum C-channel. After the C-channel was machined, the interior two bars were able to fit in between the top and bottom links, thus enabling a completely collapsible linkage. Figure 13.24 illustrates the extreme positions of the linkage.

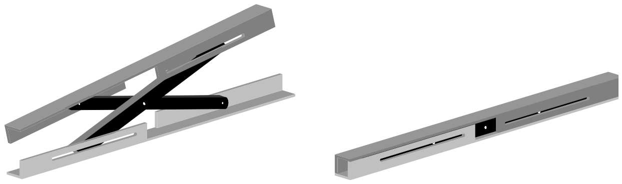

Figure 13.24. Extended Position of Linkage and Collapsed Position of Linkage.

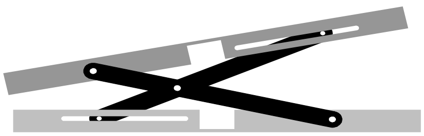

Figure 13.25. Side View of Extended Link.

Another benefit of using these linkages is the control they allow over the range of motion of the seat. These linkages tilt the seat to an angle of approximately 45 degrees and also displace the front of the seat 4 inches upward. The back of the seat is raised 9 inches. This produces a more comfortable and safer position to exit the chair (See Figure 13.25).

Each set of linkages consists of two slotted pieces of C-channel, two solid links, five pins, and two sliders. The linkages were constructed of aluminum for a lightweight design. The interior links were constructed of ½-inch aluminum to prevent bending. They were mounted on each side of the chair, and the seat was mounted on top of the linkages.

The hand pump was mounted on the left-hand side of the chair and requires a downward force of 20 pounds at maximum position. It requires nine pumps to lift the seat to its maximum tilted position,

Figure 13.26. Chair in Extended Position with Near Armrest Removed.

although the chair may be exited before the linkage is fully extended. It was important while filling the cylinder and hoses with hydraulic oil to prevent air from entering the system. If this occurred, the air would be compressed before the fluid could displace the piston. This would cause the user to waste extra pumping strokes.

The hydraulic cylinder has a maximum stroke of 9 inches. A 1½-inch cylinder was designed to lift a load of 300 pounds. The inner diameter of the cylinder is 1 inch; therefore the maximum pressure developed by the cylinder is approximately 240 psi. The cylinder was pinned to the bottom of the seat by a clevis and to the bottom of the chair by a U-bolt. This allows the cylinder to have flexible movement while the seat is raised.

The total cost of parts was approximately $498.

WHEELCHAIR TURNTABLE DEVICE TO FACILITATE POSITIONING OF A WHEELCHAIR IN A VAN

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INTRODUCTION

Many wheelchair accessible vans are small, and positioning a wheelchair in these vehicles can be difficult. In addition, rotating the wheelchair within the confines of a vehicle is troublesome. Reducing the difficulty of this task would increase mobility for people who use wheelchairs. The device is designed as a retrofit to an existing mini-van. With some modifications, the design may be incorporated into the new construction of a van as it is being converted for wheelchair use.

SUMMARY OF IMPACT

This unit encourages the use of transportation for individuals with disabilities by creating more accessibility for them and making it easier for an assistant to position a wheelchair in a vehicle.

TECHNICAL DESCRIPTION

An electric chain-drive mechanism is used to power the unit. The smooth operation of the unit can be attributed to the single row ball bearing support and ¼″ thick aluminum plate construction. The low profile design of the unit makes egress effortless. Countersunk fasteners, rotation limit switches, hand-free operation, and a non-skid surface are safety considerations incorporated into the design. The unit has dimensions of 33″ x 33″ x 1.75″. A voltage requirement of 12 volts and a current draw of 5 amps are required for the motor. The rotating platter of the unit is supported by eight single row ball bearings, with one additional bearing in the center of the platter to provide alignment. The electric motor utilizes a worm gear-drive that rotates the platter. This combination assures positive stops at any position. The worm gear-drive motor operates a chain that has attachment points on the underside of the platter. These attachment points serve as a trigger for the limit switches. Therefore a 90-degree rotation of the platter position is accomplished. The unit is attached to the floor of the vehicle with bolts. This method of attachment provides a secure mount without sacrificing structural integrity. The foot-operated switch can be positioned for easy access near the ramp position. A 12-gauge stranded wire from the battery to the vehicle ground is required. Both the cost of the components and the ease of installation were considered in the design process. The end result is a functional and relatively inexpensive device.

Figure 13.27. Wheelchair Turntable.

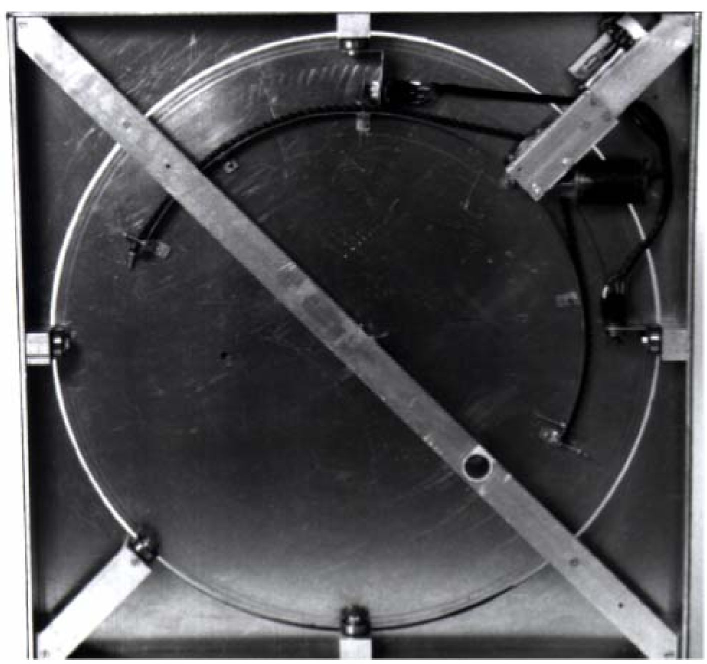

Figure 13.28. Close-Up of the Drive Mechanism.

A TIME TELLING DEVICE FOR INDIVIDUALS WITH VISUAL IMPAIRMENT

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Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

The objective of this project was to design and build a device that people with visual impairments could use to tell time. This type of device already exists, but these devices announce the time out loud. The purpose of this project was to design something that people with visual impairments could use discreetly.

The design integrates a computer board, a timepiece, and sixteen solenoids to form a Braille pattern from which the user can read the time. The timepiece is battery powered. The user can activate it whenever he or she wishes to know the time by flipping the on/off switch.

SUMMARY OF IMPACT

The timepiece will have an impact on the quality of life for people with visual impairments in that the user may privately, discreetly and independently know the time.

TECHNICAL DESCRIPTION

The project is divided into two parts. The first is the electronic design of the computer board, and the second is the final assembly of the parts. The microprocessor (an EVBU board) controls the timepiece. A Dallas Semi-Conductor time-keeping unit was attached to the microprocessor. This unit maintains real time within the timepiece. Computer code (written in machine language) was used to transfer the time from the time unit to the microprocessor. 16 electric circuits (consisting of resistors, transistors and electric latches) were made on a daughter board and plugged into the EVBU board. This extra circuitry was necessary to accommodate the plug-ins for 16 solenoids (7/16" in diameter), because the EVBU board was only equipped with three plug-ins. The 16 solenoids were attached to the EVBU board through the use of the plug-ins. Eight 1.5-volt batteries power the computer board, because the solenoids are 12-volt intermittent duty solenoids.

Figure 13.29. Outside View of Timepiece.

The solenoids were connected to pins that protrude through a plastic face located on the top of the timepiece. These pins form a Braille grid for four numbers. When the user activates the switch, the computer board reads the time and relays the message to the appropriate solenoids. The solenoids then form the pattern of time in Braille for the user to feel by pulling their respective pins down. The time is given for 5 seconds, after which the solenoids return to their default position (all raised). The solenoids used are pull-type solenoids. Rubber bands were attached to the solenoids to allow the pins to return to their normal position at the end of the 5 seconds. Time is read off in military style. The outside dimensions of the timepiece are 9.5" x 8.5" x 8.5". It was constructed from poplar wood.

The total cost of the project was approximately $605.

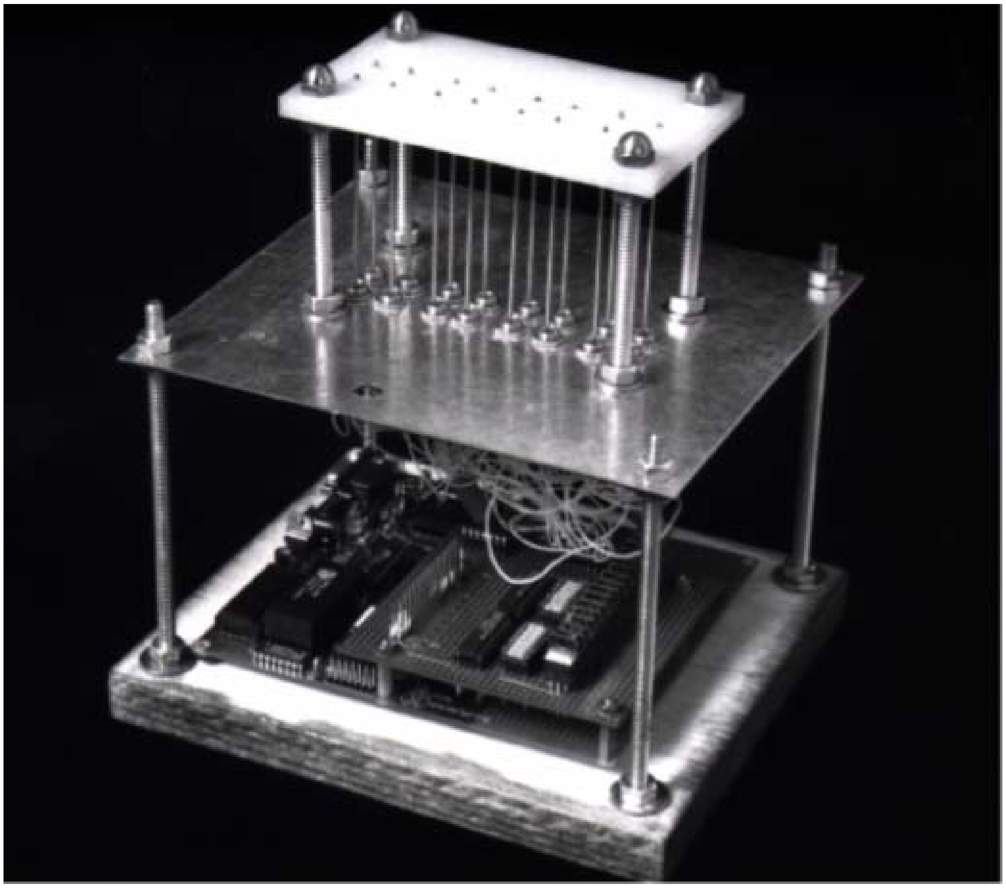

Figure 13.30. Inside Circuitry of Timepiece.

STAIR CLIMBING WALKER

Student Designers: Melanie DeWitt, Michael Lewandowski
Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

The common walker is lightweight, foldable, and offers stable support to the user. However, in order to climb stairs, the user must lift the walker up each stair before climbing. The stairs must also be modified to allow the entire base of the walker to be supported. This device eliminates the need for lifting of the walker and modification of the stairs.

The design utilizes a motorized, chain-driven mechanism and a rechargeable battery that allows the user to proceed up a flight of stairs at his or her own pace. When activated, the motor rotates a linkage that conforms to the stair and lifts the walker. The only required effort of the user is to push the walker forward on the stair in order to maintain an upright position.

Safety and reliability were the primary aspects considered in the design of the stair-climbing walker. Other considerations were weight, cost, and the operation time period.

SUMMARY OF IMPACT

With the assistance of the stair climbing walker, the mobility and independence of the user is increased. The design eliminates the need for specialized staircases and the help of a caretaker for household mobility.

TECHNICAL DESCRIPTION

The linkage chosen to lift the walker is a three-piece 1-inch square aluminum bar formed to mold to the stair. In order for the linkage to move in the desired square path, a chain drive mounted on Plexiglas was used. The drive system uses 40-roller chain with ½-inch pitch-type S-2 connecting pins and 1.61-inch diameter sprockets.

The motor utilized to drive the mechanism is a 50 in-lb, 90-degree, 12-volt DC gear motor. To minimize the loss of interior walker space, the motor is mounted in between the upper-front sprockets, and it is connected to the sprockets via a ½-inch aluminum shaft. The power supply used is a rechargeable 12-volt gel cell battery. The final weight of the stair-climbing walker is 30 lbs. The user activates the lifting mechanism by depressing and holding a micro-switch located on the handgrip. If extra support is required during operation, the user may stop the mechanism when it has reached ¾ of its revolution to offer maximum support. The total cost of the project was $520.

Figure 13.31. Finished Unit.

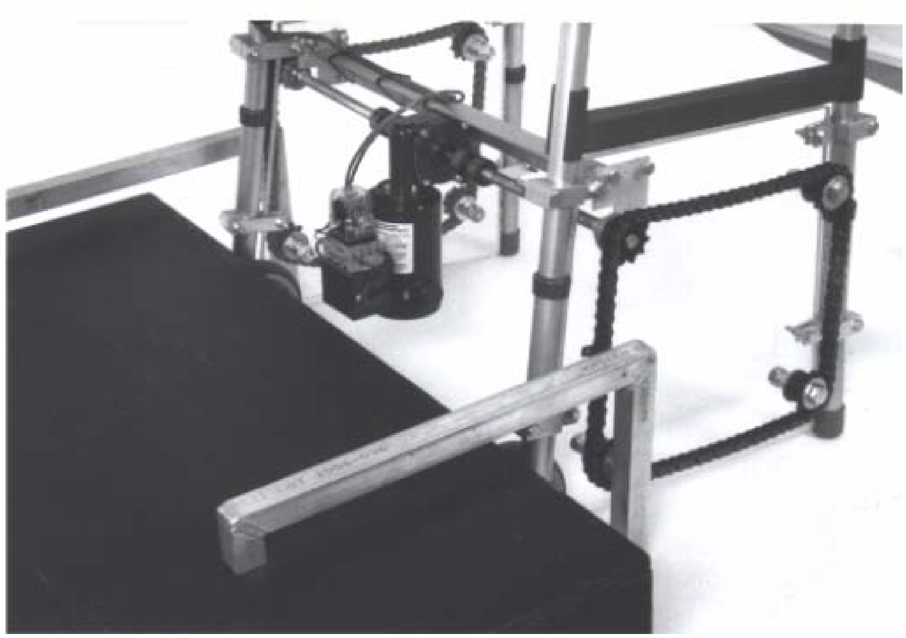

Figure 13.32. Drive Mechanism.

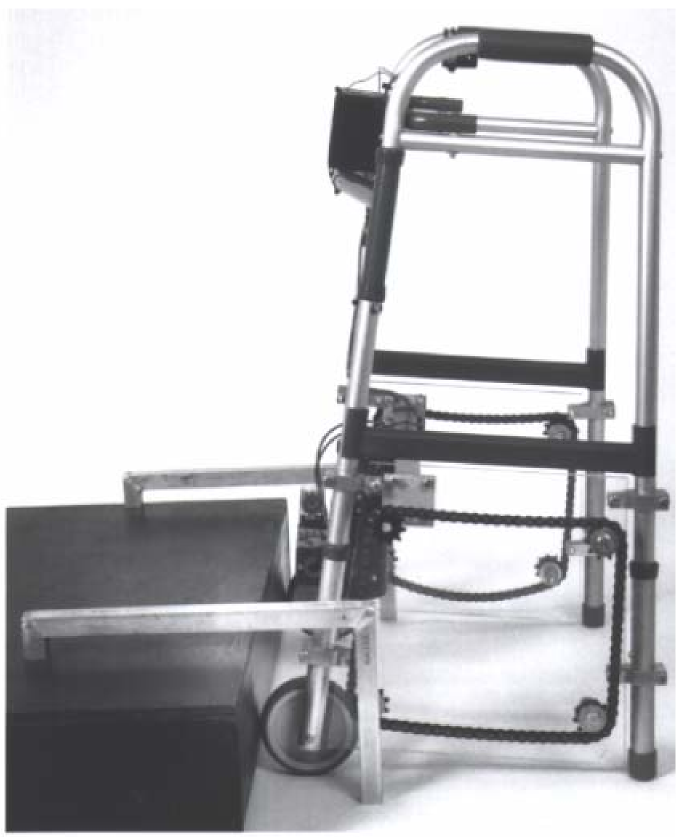

Figure 13.33. Walker On Stair.

WHEELCHAIR PROPULSION DEVICE

Student Designer: Michael C. Terry
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Mechanical and Aerospace Engineering Department
State University of New York at Buffalo, Buffalo, NY 14260

INTRODUCTION

The objective of this project was to design an accessory for wheelchairs that allows the user with a minor back injury to remain sitting upright while propelling himself forward.

SUMMARY OF IMPACT

This device offers an inexpensive alternative to motorized wheelchairs in the marketplace. It is simple to use and easy to maintain.

TECHNICAL DESCRIPTION

A project goal was to create a design that could easily be adapted to fit any wheelchair. Therefore, the new propulsion system was mounted directly to the wheel utilizing the holes previously used for the handrails. An aluminum plate was made with a bolthole pattern identical to that of the wheelchair. This plate is the only part of the accessory that attaches to the wheelchair. All other parts mount directly to this plate.

The next step in the design was to find a way to transmit the torque applied by the handles to the shaft mounted on the aluminum plate. To accomplish this, an overrunning clutch-bearing assembly was utilized. This allows the torque to be transmitted in one direction while moving freely in the other. In the selection of this clutch-bearing assembly, cost and torque were considered. For this design, a Torrington clutch-bearing assembly was chosen because of its high torque capabilities (840 lbs/in) and its relatively low cost.

The next step was to design the shaft. The clutch-bearing assembly requires that its mating surface have a hardness of 53 Rockwell C. To meet this requirement, a cold-rolled 4140-alloy steel was selected. The clutch-bearing assembly was pressed into a coupling made of 1040 annealed carbon steel. The handles were then welded to this coupling.

Figure 13.34. Finished Unit Mounted On A Wheelchair.

In order to allow the user to stop, a brake system was created. A disc made of aluminum was used as a rotor. The calipers used were bicycle brakes. The brake controls were mounted at the top of the handles.

The authors express appreciation to Kenneth Peebles and Roger Krupski for assistance in manufacturing of the shaft and coupling.

The total cost of the project was \$365.

Figure 13.35. Close-Up of Handle Assembly.

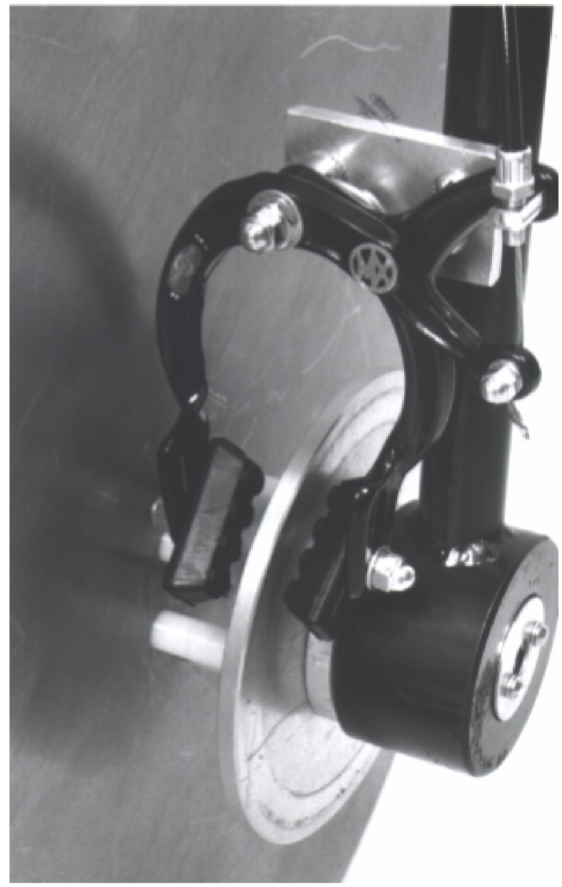

Figure 13.36. Close-Up of Brake System.

MOVABLE SEAT CHAIR TO FACILITATE SITTING AND STANDING

Student Designer: Ashwin P. Gurnani, Ho Joon Chang
Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

A movable seat system was designed to facilitate sitting down and standing from a chair. The device was to be simple to operate. A seat was designed that attaches to hinges, and these hinges pivot by means of a piston placed on the end of the seat. An electrical switch that triggers the lifting mechanism operates the seat.

SUMMARY OF IMPACT

This device will make standing up and sitting down a more pain-free experience. It will also give the user greater independence, because he or she will no longer need assistance to sit down or stand up from the chair.

TECHNICAL DESCRIPTION

The basic design uses a linear actuator with a trailer ball in its shaft hole. The ball moves along a wooden, smooth, curved slider that is fitted to the dimensions of the trailer ball. The close-up view of the trailer ball sliding in the slider is shown in Figure 13.39.

The linear actuator is a shaft that moves up electrically and is operated by a control switch. The actuator operates on a screw mechanism with a motor attached to it, as opposed to a hydraulic piston cylinder assembly. The control switch is a joystick positioned on one side of the chair accessible to the user. When the joystick is shifted upward, the actuator screw pushes the shaft upward. This causes the trailer ball to slide up along the slider and move the seat upward. The seat is supported on one end by hinges attached to the vertical columns, and the other end is free. The process is reversed when the joystick is shifted down.

Figure 13.37. Front View of the Device in the Relaxed Position.

The device works on a tractor battery that would eventually run out of power after continuous usage. Possible options for a power source may be a 12-volt DC source, similar to the power source used in a computer. Another option is to include a battery charger in the unit, which could be plugged in to recharge the tractor battery.

The authors thank Mr. Peebles, the machine shop technician, and American Wheelchairs, who provided the actuator at a subsidized cost.

The total cost of this project was $650.

Figure 13.38. Back View of Device with Seat at Maximum Height.

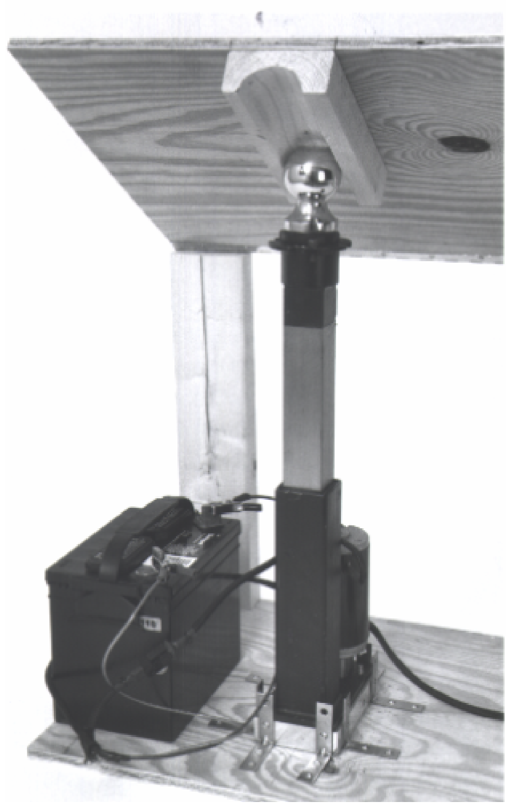

Figure 13.39. Close-Up View of Slider.

WEATHER-SHIELD DEVICE FOR WHEELCHAIRS

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Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo, Buffalo, New York, 14260

INTRODUCTION

The objective of this project was to design a device to be used as an accessory on wheelchairs. The device is a canopy that shields people who use wheelchairs from adverse weather conditions. Existing wheelchair canopies were designed to protect only from the sun. This device will also protect the user from rain and snow.

Safety, reliability, cost, size, and weight were the main concerns considered in the design process. Once mounted, the Weather-Shield does not affect the comfort of the person using the wheelchair. It also does not interfere with the maneuverability of the wheelchair. It is retractable, which allows the canopy to be assembled and disassembled with ease.

SUMMARY OF IMPACT

The Weather-Shield combines comfort and efficiency into one. Its design offers more autonomy to people who use wheelchairs. It is safe, easy to assemble, and fits any wheelchair.

TECHNICAL DESCRIPTION

The Weather-Shield is a waterproof canopy with a supporting structure made of PVC pipe. It has a truss-like arrangement that can be easily assembled and mounted onto the wheelchair. The PVC makes the structure very light. The upper portion of the canopy extends outwardly in a curved position. The size of the canopy is 46” x 30”. It covers a surface area of 840 sq. in.

The total cost of the weather-shield was $90.10.

Figure 13.40. Assembled Weather-Shield.

Figure 13.41. Disassembled Weather-Shield.

CHAPTER 14
STATE UNIVERSITY OF NEW YORK AT STONY BROOK

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POWER ASSISTED WALKING TRAINER

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Client Coordinator: Thomas Rosati, Forest Brook Learning Center, St. James, NY
Supervising Professors: Dr. Imin Kao and Dr. Messiha Saad
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INTRODUCTION

The Variable Assisted Walker (VAW) is a device to be used by a 14-year-old child. She had surgery to release tension in her Achilles tendons and allow for better leg movement when walking. She has difficulty walking without fatigue. Additionally, her tonic leg position with little knee movement creates a problem with moving in a straight line. The VAW (see Figure 14.1) is a device that will enable the child full motion of her legs in a predetermined manner, thereby teaching coordination, increasing muscle strength and allowing for mobility within her school. The VAW is a fixed walker frame, mounted on a mobile platform. The platform utilizes the features of a Nordic-Track© exercise system design. The foot pedals trigger the operation of a DC motor, and thereby facilitate walking while allowing mobility around the learning center.

SUMMARY OF IMPACT

. The device enables the student to gradually increase leg strength while allowing mobility around her school. VAW will help guide corrective walking motion. The design incorporates many safety features that are important for children with disabilities.

TECHNICAL DESCRIPTION

The overall structure of the VAW is aluminum. The skating mechanism, tensioner, variable pulse width circuit, steering mechanism, and main control panel have all been successfully tested and meet necessary requirements.

The device provides a method of power assistance for the student. The design incorporates a skating mechanism to produce a walking motion (see Figure 14.1). The skates are lightweight and have low friction resistance. They are attached to pulleys, which allows the student to step forward with one foot while the other foot is pulled back.

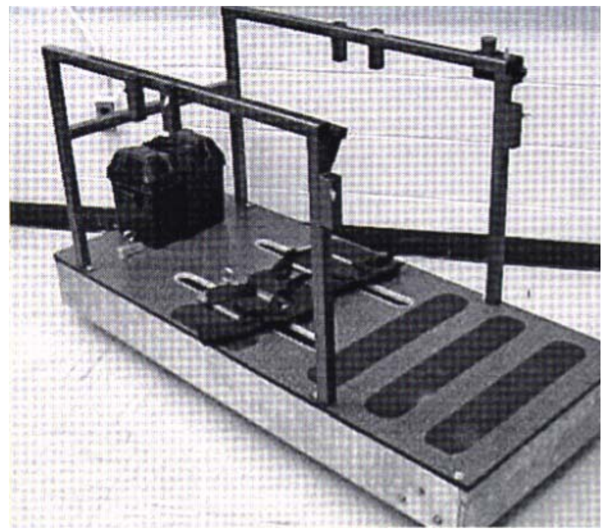

Figure 14.1. Variable Assisted Walker.

A 1/4 Hp 12-volt DC motor is used. The current is supplied to the motor by a 12-volt deep cycle marine battery with an 80amp/hr capacity. A variable pulse width generation circuit that latches to a digital logic relay controls the motor. The pulse width is initially triggered by two sets of Photo-Diodes, which change state by the operation of sliding pedals. The low to high change output signals created by a comparator are forwarded to an OR-gate. The pulse is then directed to a monostable multi-vibrator, which holds the signal for predetermined pulse duration. The circuit incorporates an internal reset function that allows for a constant high pulse. Implementing a variable resistor will provide variable pulse widths. In addition, the motor controller includes a continuous mode feature, which enables the motor to run continuously. The student simply changes the control switch to continuous mode.

The tensioning unit was obtained from a Nordic-Track© exercise unit. The tensioner consists of a flywheel, belt, spring, and adjustment control. The student can vary the degree of tension placed upon the flywheel and resistance on the foot pedals by using the adjustable control knob.

A steering mechanism was also implemented into the design of the walker. This mechanism allows the student to remain in a straight line or be turned left or right in a fixed turning radius.

The cost of this project was approximately $1500.

GAIT RACER FOR GAIT AND WHEELCHAIR TRAINING

Designers: Markus Benkert, Panagiotis Gogas, Dowlat Sugrim
Client Coordinator: Thomas Rosati, Forest Brook Learning Center, St. James, NY
Supervising Professors: Dr. Robert Kukta and Dr. Messiha Saad
Department of Mechanical Engineering
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INTRODUCTION

This Gait Racer was designed to improve the quality of life of a 15-year-old boy who has used a wheelchair for most of his life. Choices of similar devices are limited to either an assistive walking device or a wheelchair. This product combines these two options, allowing the boy to alternate between practicing to walk safely and sitting to rest. He can also use the device to wheel himself manually as he desires and ultimately provide more independence in his mobility.

SUMMARY OF IMPACT

The Gait Racer was designed to help children with physical handicaps learn to walk. A gait training method was implemented to fulfill the design criteria. A harness is placed on the child that suspends his weight from the boom allowing smooth foot movement. As the child's abilities increase, a larger bearing load is applied to his feet. After training, the child may be able to walk unaided.

TECHNICAL DESCRIPTION

All major components of the Gait Racer are adjustable. This includes the heights of the boom, seat, footrest, harness, and handrails. In addition, the forward-to-rear location of the harness has four positions. This is to accommodate children of different heights and weights. The mainframe components are made of steel. Each component was sized by performing stress and deflection calculations. The base-frame subassembly is designed with the rear wheel support plates welded into place. An appropriate size spacer was placed in between to prevent distortion of the plates when welded. Two 1 x 3 cross bars are welded at the rear to strengthen the structure and provide a mounting platform for the 2 x 4 upright with base plate. Two 2 x 6 steel plates are welded to the underside of the cross bars where the base plate of the upright mounts on top. These plates add rigidity to resist torsional forces. Four handrail adjustment pins are welded onto the top of the base-frame as guides for the handrails. Mounting holes are provided on the base-frame bottom for the caster wheels.

Figure 14.2. Gait Racer.

The boom is made of 2-inch round pipe with a 1/8-inch thickness. The bend in the boom has a curvature of 4 inches. Four 3/8-inch clearance holes are drilled for the eyebolts. These eyebolts provide different locations for the harness strap, thus making the device usable for people of various weights. Two u-bolts are welded to the shorter end of the boom for mounting to the 2 x 4 upright with a backing plate. These u-bolts provide a precise level of adjustability.

Five ½-inch clearance holes are provided on the bottom half of the upright for adjustable mounting of the seat. The seat release mechanism is made up of ½- inch aluminum brackets and spring-loaded release pins with pull knobs. The seat bottom pivots down as the brackets rotate on a 2-inch round pipe section. A bracket is also provided for mounting the seat back.

1-inch diameter aluminum hand rails with 2 ½-inch radius bends are mounted on guide pins. These pins have six tapped holes each, 1 inch apart, for a total adjustability in height of 6 inches. The handrails are held tightly in place and can be quickly adjusted by ¼-20 bolts with knobs. In addition, the armrest pads are mounted on the handrails.

The caster wheels are attached on bottom of the 1 x 3 frame with one nut each. The wheels include safety brake hardware to provide stability when a child is secured to the device.

The harness assembly is comprised of a full body harness, carabiners, and adjustable straps. It is normally used for rescue operations; therefore it is durable and adjustable. The carabiner is specified for a maximum weight in excess of this design requirement. The adjustable straps can support the up to 1200 pounds. A caregiver or therapist can adjust the harness based on the child's height and weight. The extra length of the strap allows the child to be placed in the seat before disconnecting the straps.

The cost of this project was approximately $800.

COMPACT STANDING WHEELCHAIR

Designers: David Chan, David-John Lugo, and Vivian Shao
Client Coordinator: Thomas Rosati, Forest Brook Learning Center, St. James, NY
Supervising Professors: Dr. Peisen S. Huang and Dr. Messiha Saad
Department of Mechanical Engineering
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Stony Brook, NY 11794-2300

INTRODUCTION

The Compact Standing Wheelchair (CSW) was designed for a student who needs to be transferred from a wheelchair to a standing supine board as part of his mobility program. The device is similar to a regular wheelchair (see Figure 14.3). It is unique because it utilizes three positions. The device can shift from a sitting position to a flat position, and then to a standing position. The CSW will take the place of two separate devices the student previously used. This device will help ease transitions and requires less storage space when not in use.

SUMMARY OF IMPACT

The design criteria for the CSW were defined mainly by the needs the particular student who has little muscle tone and poor control of most of his body. He cannot sit up straight independently. His wheelchair is usually tilted back to support his head. In addition, the student needs support to maintain a sitting position. He uses a tray to keep his arms in front of him. He cannot reach for anything close to his body or on either side of his body. Every day he is placed into a stander to give his legs circulation, strengthen leg muscles, and place him in a position best suited for class work. The paraprofessionals had been lifting him out of his wheelchair and placing him on the stander to move him into the standing position. The student's low muscle tone and the cumbersome nature of altering positions in a stander made this process time consuming and difficult. The CSW was designed to address these problems.

TECHNICAL DESCRIPTION

The overall structure of the CSW is composed of mild steel 1-inch in diameter and 0.083 inch thick. The measurements of the CSW as a whole were determined by the standards for average wheelchairs and doorframes.

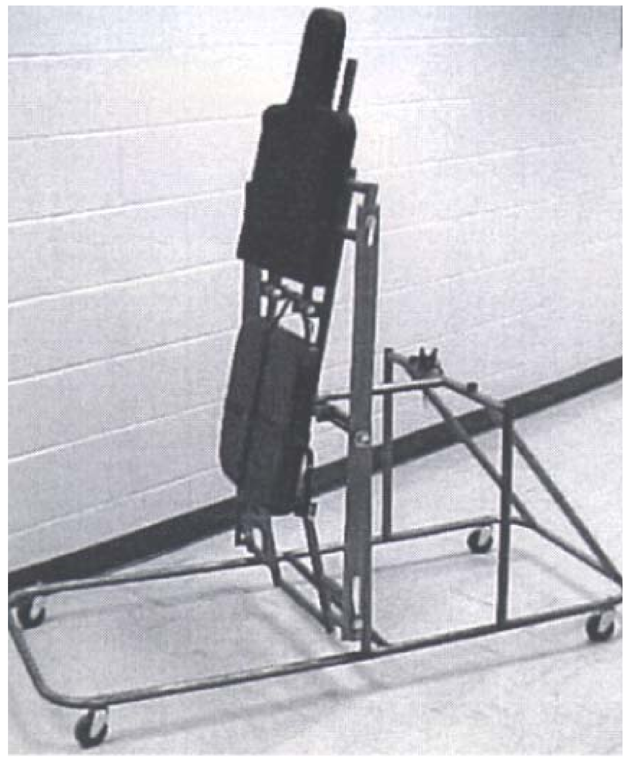

Figure 14.3. Compact Standing Wheelchair.

The base of the CSW is similar to the stander that was previously used by the student. Using an established device's measurements assures the safety of this device. As few welded joints as possible were used to decrease the amount of potential failure in the device. Four bends were used in the bottom of the base. The rest of the device was put together like the base of the stander the student previously used.

The design of the CSW was based on a slider joint mechanism. The chair would slide from a sitting to a laying position and then pivot about a fixed point into a standing position. The slider mechanism was composed of a pivot using a cam. The slot in which it slides was cut from a thin sheet of metal. The slot was determined at its maximum and minimum points (laying position and sitting position). The four-slider joints were placed two on each side, one on the leg rest and one on the backrest.

The pivot point is in the middle of the seat. There are locking mechanisms to keep the chair in both the sitting and standing positions. The device is moveable due to the use of caster wheels. The back wheels may be locked into position for safety.

The cost of materials was approximately $350.

AUTO BLINDS

Designers: Marta Soto, Pablo Porras, David Kane
Client Coordinator: Thomas Rosati, Forest Brook Learning Center, St. James, NY
Supervising Professors: Dr. Alonso Peralta and Dr. Messiha Saad
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INTRODUCTION

Auto Blinds were created to benefit children with disabilities. The device consists of two motors that control the tilting and sliding of the slits (see Figure 14.4). This design was chosen because the children for whom it was designed do not have full motor functions. For this reason, it is difficult for them to turn a rod to adjust the tilt of the slits or pull a cord that will open or close blinds.

SUMMARY OF IMPACT

The automation of blinds gives a child in a wheelchair the ability to operate the blinds independently despite motor disabilities. The children feel that they are accomplishing something without any assistance while utilizing this device.

TECHNICAL DESCRIPTION

The material used for the rail is aluminum, and the slits are made of vinyl. This design has two 12-V DC motors. A coupler connects a 12-V DC motor to the shaft, which turns the blinds. The 12-V DC motor is connected to a switch that reverses the current of the motor. This motor controls the motion of the slits and has a range of motion from 00 to 1800.

The other 12-V DC motor is connected to another shaft. This shaft is connected to the worm gear, and the worm gear is also connected to the coupler. There is a chain and sprocket on the shaft. The motor drives the worm gear, which in effect turns the chain. This mechanism is the same as those seen in bicycles. To make the blinds move from one side to the other as the chain moves, a c-clamp is designed to connect the chain and the blinds. Everything is interconnected into one unit in order to make the mechanism slide the blinds back and forth. The chain carries the motion of the first slider from the left to the right, and this first slider controls all the others. The approximated linear velocity of the auto blinds is 2 inches per second.

A circuit that allows the current to flow in two directions across a 12-V DC motor was included. When the current flows in one direction through the motor, the blinds open. When the current flows in the opposing direction, the blinds close. To operate this circuit, a logic symbol is connected to a power supply. The power supply is connected to two MOSFETs, a p-channel and an n-channel MOSFET. The p-channel MOSFET is used to switch the positive supply to the motor for forward direction. It is turned on when the logic symbol is approximately 12 V. When this occurs, the n-channel MOSFET is automatically closed. The n-channel MOSFET is turned on when the voltage is approximately 0 V. When this happens, the p-channel closes, thus allowing no current to flow through. An n-channel MOSFET is used to switch the negative supply to the motor for reverse direction. Using the two MOSFETs allows the motor to be controlled in the stop, forward and reverse modes.

The cost of the materials was approximately $200.

Figure 14.4. Vertical Blinds.

ADJUSTABLE WHEELCHAIR FOR EASY REACHING

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Client Coordinator: Thomas Rosati, Forest Brook Learning Center, Saint James, NY
Supervising professor: Dr. Messiha Saad
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INTRODUCTION

The adjustable wheelchair was designed to help a person in a wheelchair reach to high places. The device also provides easy transfer when the patient goes to bed (see Figure 14.5). This adjustable device is a simple electromechanical jack that is mounted and secured at the bottom center of a wheelchair. Once the motor is secure to the frame, it can be set into a vertical motion by remote control.

SUMMARY OF IMPACT

The device allows children with disabilities greater independence because the vertical motion of the wheelchair seat allows them to reach items they would not normally be able to grasp.

TECHNICAL DESCRIPTION

The overall structure of the wheelchair is constructed from standard stainless steel tubing, 7/8′′ in diameter. The high strength-to-weight ratio and durability of this material provided the necessary structural integrity needed to support a maximum weight of 300 pounds. The frame supports and seat are designed in such a way that all members come together at 90-degree angles with the existing frame for easy welding. The seat support and jack platform are fastened together by bolts and nuts. Any additional components are also attached in the same manner.

The vertical movement is completed by the jack mechanism that is divided into three telescoping sections inside the housing. Each section is raised or lowed by the torque that the DC electric motor provides. The driving gear is connected to the motor, which is then geared down by two other gears in order to have the desired speed needed to safely operate the motor. In addition, this motor assures a large lifting capability due to the high torque produced by the output. The DC motor is already incorporated with a jack mechanism that includes a circuit and a sensing remote receiver. The actual motion results from pressing the up/down button on the remote pad, therefore providing a signal that triggers the motor by applying voltage. Furthermore, the circuits contain an external 15-amp fuse and kill switch in case of an over load. In addition to the lifting device, an adjustable backrest support is also implemented.

The approximate cost of the Adjustable Wheelchair is $450.00.

Figure 14.5. Adjustable Wheelchair.

PORTABLE WHEELCHAIR LIFTER

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Client Coordinator: Thomas Rosati, Forest Brook Learning Center, Saint James, NY
Supervising Professors: Dr. Raman Singh and Dr. Messiha Saad
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INTRODUCTION

The portable wheelchair lifter (PWL) was designed to provide extra mobility for people who use wheelchairs. A larger model was originally designed but was scaled down due to budget concerns (see Figure 14.6). Although it would not actually be possible to use this smaller model, it does demonstrate that the design principle of such a device can be achieved. The PWL is able to lift a desired object in an upward and downward motion. The design principles of the PWL include ergonomics and easy operation. The device was also designed to be safe for usage in a school setting.

SUMMARY OF IMPACT

The design process was focused on the comfort and safety of the user. The PWL was designed to be stable and easy to use to enhance the level of safety when the device is operated. To make the PWL a convenient device for users, it was designed to be portable, as opposed to a stationary like others that are available. Users operate the device themselves.

TECHNICAL DESCRIPTION

The model that was built is approximately ¼ the size of the original model. The overall structure of the PWL is composed of 6061 aluminum. A miniature 24- volt DC gear motor is used to operate the device. It has a maximum rotational speed of 215 rpm and a torque of 45 in-oz. Its gearbox has a 19.7 to 1 ratio. The motor is powered by a 24-volt DC power supply. The motor's maximum current output is 0.6 amps.

Two ½-inch, 10-treads-per-inch acme screws were used because of their self-locking capability. This is an important safety feature to prevent the elevated platform from moving downward. Each screw is 18 inches long and is machined at both ends to accommodate gears and bearings. Both screws are supported at the bottom by thrust bearings and at the top by flanged ball bearings. The total threaded length is 16 inches. These are matched with a bronze nut attached to a steel flange that is screwed to the platform support. Upon operation of the DC motor, the platform is able to lift in an upward and downward motion for a total of 16 inches. Four 3/8-inch aluminum rods with linear bearings guide the platform.

A ¼-inch steel shaft linked to both acme screws ensures both acme screws have the same rotational speed and torque output.

The cost of materials was approximately $1000.

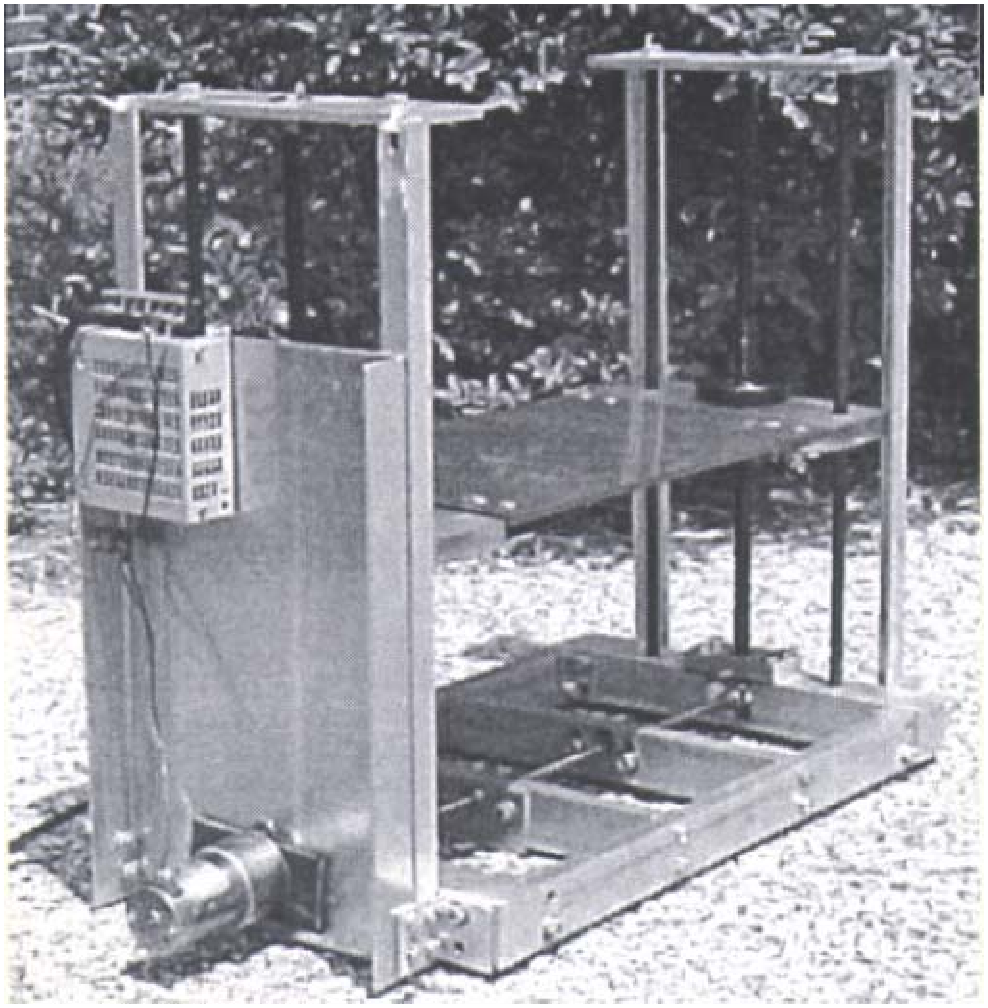

Figure 14.6. Portable Wheelchair Lifter.

DIRECTIONAL DIVERTER FOR A CHILD'S WALKER

Designers: Antonio Limjuco and Vincenzo Verrelli
Client Coordinator: Thomas Rosati, Forest Brook Learning Center, St. James, NY
Supervising Professors: Dr. Robert Kukta and Dr. Messiha Saad
Department of Mechanical Engineering
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INTRODUCTION

The directional diverter (DD) was designed to provide enhanced mobility for children with multiple handicaps. The device is a motorized platform that is controlled by the assistant via a joystick (see Figure 14.7). The bottom frame of any standard walker device can be bolted to the platform, thus providing a security and safety. The individuals for whom this device is intended have reduced motor and cognitive skills. The main goal of the DD is to allow greater mobility for the children through an alteration of their existing walker. The walker was designed to be controlled by the child's assistant. This may enhance physical therapy sessions.

SUMMARY OF IMPACT

The design criteria for the DD were defined mostly by the needs of a 17-year-old student who has visual impairments. The designs of standard walker devices already available were also taken into consideration. In general, traditional walker devices are heavy and difficult to maneuver through narrow hallways and around obstacles. The walkers are also expensive. It was therefore decided that any major altering of the walker would be unnecessary. The implementation of a dolly to which the walker could be bolted was a simpler and more effective alternative. With the use of a Basic Stamp Microcontroller, the assistant can easily control the motors that drive the dolly and provide steering through the use of a joystick. The overall mobility of the user is greatly increased by implementing this feature.

TECHNICAL DESCRIPTION

The overall structure of the DD was constructed from angle slotted zinc members that were bolted together. All additional parts were fastened to the frame using nuts and bolts.

The electrical components responsible for providing motion to the DD are two 24V, 1/20 hp DC motors. Power is supplied by two 12V, 9.5 amp hour rechargeable lead acid batteries. A Basic Stamp Micro Controller converts the analog signals coming from the joystick to digital signals that are interpreted by the interface board. The interface board outputs analog signals to the motor controllers. Depending on the signal, a relay is activated and opens or closes a circuit. The activated circuit in turn determines the motor output (counter clockwise or clockwise), thus providing the appropriate motion. Steering is accomplished when the pivoting wheel turns more slowly than the opposite wheel. This difference causes the DD to turn in the direction of the pivoting wheel. The main advantage of this steering technique is that it allows the DD to turn while it is stationary.

In designing the DD certain safety issues had to be considered. Among the most important were stability of the entire unit (walker plus dolly), the possibility of electrical shock, and the power output of the motors. The device incorporates two driving motors that also serve as steering motors. This was done was to reduce the possibility of any tipping or jerking motion of the entire unit. The cost and complexity of the unit were reduced through the utilization of only one pair of motors rather multiple motors for steering and driving. In choosing the motors, the output had to be great enough to provide power adequate for steering and forward/reverse motion, while at the same time not overpowering the unit. It is for this reason that 1/20 hp motors were chosen. The maximum speed of the DD matches that of its user, which is about 1 ft/s. Using insulated wire and the installation of a protective covering over the main circuitry reduces the risk of electric shock and short circuits. The cost of materials was approximately $600.

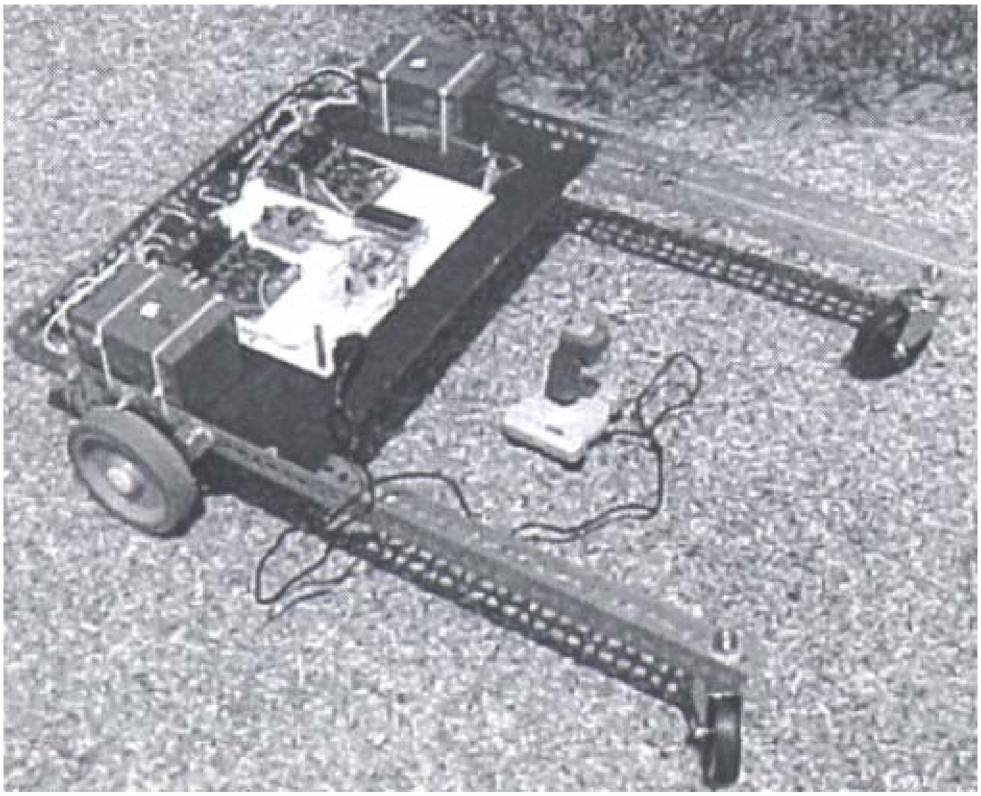

Figure 14.7. Directional Diverter.

E- STICK: ELECTRONIC WALKING STICK FOR PEOPLE WITH VISUAL IMPAIRMENTS

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Client Coordinator: Thomas Rosati, Forest Brook Learning Center, St. James, NY
Supervising Professor: Alex Doboli
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Stony Brook, New York 11794-2350

INTRODUCTION

The E-Stick is an electronic walking aid for people with visual impairments (see Figure 14.8). The device's primary function is to provide the user with object notification and vertical plane drops. It produces vibrations in the handle of the stick to notify the user of any objects and drop-offs detected by the sensors. The secondary function of the E-Stick is to provide the user with his or her relative position and direction in reference to landmarks. This is determined by the use of GPS and a compass. This information is referenced against land-marked positions. The stick then informs the user of this information though a voice output

SUMMARY OF IMPACT

This project simplifies indoor and outdoor navigation.

TECHNICAL DESCRIPTION

The E-Stick is microcontroller-based. The primary function outlined in the section above consists of a battery-operated, small microcontroller programmed in Basic. This program reads the infrared sensors and outputs the processed information to small pager-motors to produce the vibrational output. The battery, microcontroller, sensors, and motors are embedded within the stick.

The secondary function of the E-Stick is also microcontroller-based. This separate microcontroller is also battery-powered and is more complex and programmed in C. This microcontroller interfaces with the GPS receiver, the compass, and the output voice module. The secondary functional components lie in a box attached to the stick and can be removed without interfering with the E-Stick's primary operation.

The cost of materials was approximately $1200.

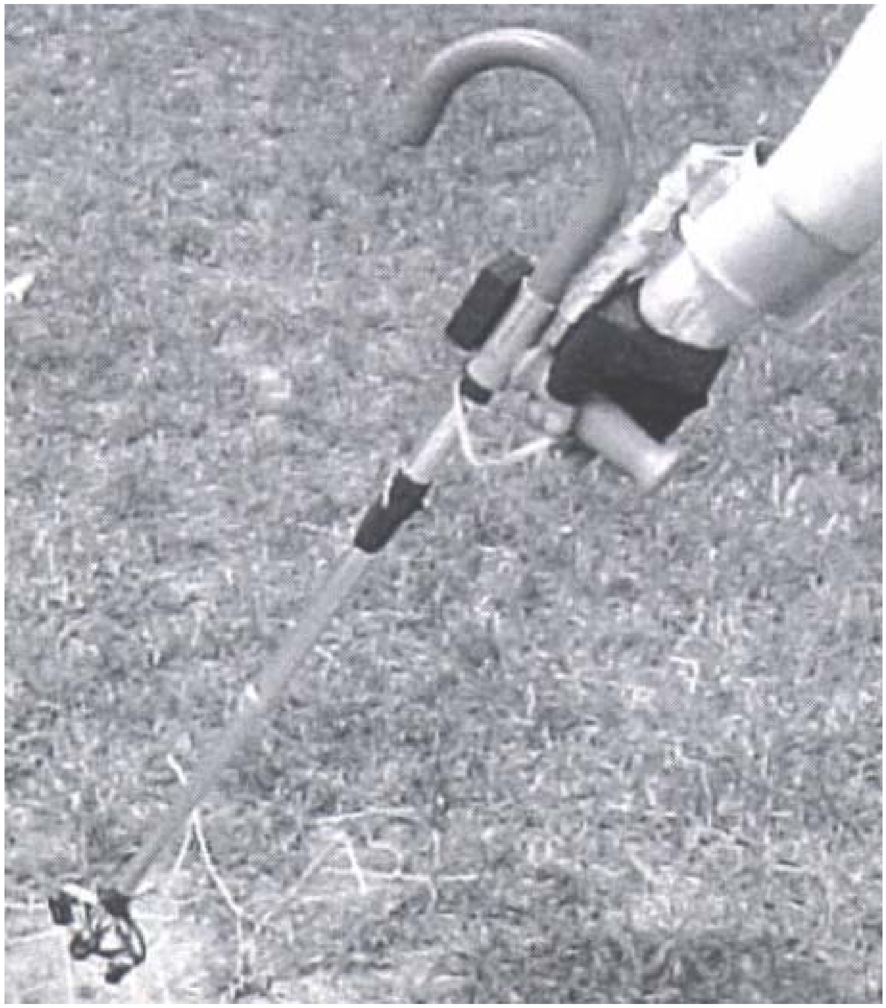

Figure 14.8. E- Stick.

CHAPTER 15
TEXAS A&M UNIVERSITY

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3120 TAMU
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Principal Investigator:

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REHABILITATION FORCE TRANSDUCER WALKWAY

Designers: John M. Green II, Micah J. Johnson, David G. Teltschik
Client Coordinator: Clarice Butler
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Supervising Professor: Dr. William A. Hyman
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INTRODUCTION

The goal for this project was to develop a gait-training device that would provide various textures to assist patients needing proprioception therapy. The device needed to fit within the existing parallel bars. It also needed to have different surface textures so patients could improve their balance and coordination in response to stepping on the surface of the device. In addition, the physical therapists wanted a form of biofeedback to determine exactly how much weight was being placed on each leg. Traditional force plates can cost thousands of dollars due to their three dimensional measurement capabilities. The goal became incorporating the accuracy of one-dimensional (vertical) force plates into the design to give the necessary feedback to the physical therapists. The finished system is shown in Figure 15.1.

SUMMARY OF IMPACT

During gait-training therapy, patients are instructed to place as little pressure on their legs as possible. They are to place most of their weight on the parallel bars instead. Gradually, they move to placing increasing amounts of weight on their legs. However, the percent of the patient's body weight is never really known without the use of a real time force plate analysis device. This causes problems because it is uncertain what percentage of body weight is being placed on the legs at any given time. It is difficult to increase from a percentage that is unknown. Commercial force plates were not feasible for this project because of their expense. Therefore, this system was built around strain gages used in deformation plates to provide the uni-axial, vertical force. The resulting real time feedback will provide the therapist with percent body weight totals related

Figure 15.1. Rehabilitation Force Transducer Walkway.

to the manually entered input weight of the patient.

TECHNICAL DESCRIPTION

The walkway can be considered both mechanical and electrical. There are five major components: 1) 233 megahertz Pentium II® computer with monitor; 2) mobile computer station; 3) National Instruments® Data Acquisition board, signal conditioner and cable; 4) custom 25-pin and 37-pin connectors; 5) left and right treads with four different textured surfaces each. The surfaces are comprised of finished oak, foam, tile, and padded carpet.

The functional components of the device are the deformation plates (see Figure 15.2). Strain gages, placed in both tension (top) and compression (bottom) configurations, are incorporated into these plates. The device utilizes current deformation plates used in electronic consumer scales. However, these scales use a microprocessor to determine the load applied. This device uses only the deformation plates and configures them in a Full-Wheatstone bridge. Once configured in a bridge circuit, the change in resistance resulting from deformation produces a change in voltage across the bridge.

Based on the dimensions of the parallel plates, left and right treads were constructed. Both were designed to contain four force transducer measurement pads each, spaced approximately 6 inches apart. The frame was first constructed out of 1-inch x 4-inch oak and 3/8-inch plywood. Due to the height of the device, entrance and exit ramps were incorporated. (Figure 15.3) The exit ramps serve another purpose as well, allowing wiring access between treads and to the computer. The force plates were wired with extension wire according to the full bridge circuit and connected to a common terminal. This allows a common loss due to increased resistance throughout each bridge. Pads of different materials were then positioned so they would distribute weight to the deformation plates when stepped upon. Once the pads were placed in the 12-¼-inch x 14-¾-in plywood based opening, the surfaces were shimmed to the top level of the device. Handles were added to the device, allowing it to become portable via two-person lift. A removable centerboard was also provided. This is helpful for patients whose legs cross over during attempted ambulation.

The computer was assembled with both donated and purchased components. Two of these components are a DAQ board and a signal conditioner built specifically for measuring the voltage differences of strain gage bridges. The signal conditioner utilized was the SC-2043-SG eight-channel strain-gauge signal conditioner. The SC acts like a filter, amplifier, and transformer for the strain gauge signals. The DAQ board used in this design was the PCI-6043E 68pin DAQ board from National Instruments. The DAQ board received the conditioned analog signals from the signal conditioner and converted those signals to a digital signal that the computer could use. A trial version of LabVIEW™ was also installed in order to use the computer as an instrument. After custom connectors were made to complete the connection between the force plates and signal conditioner, an executable program to detect voltage changes was developed. The final step was to formulate an equation that would relate the change in voltage to the load applied. Gym weights were used in a calibration run to obtain that equation. This equation was then used in the program to show the physical therapists how much weight was applied to each pad.

Total project expenses were about $2785.

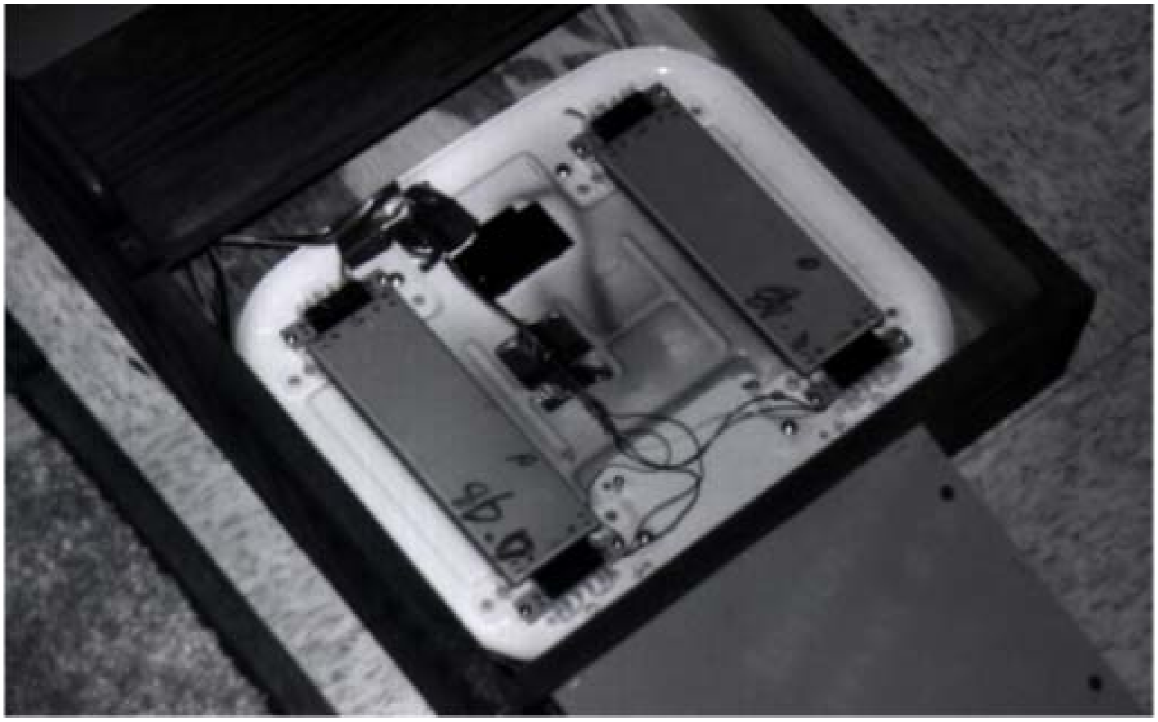

Figure 15.2. Deformation Plates Orientation with Full Bridge Design.

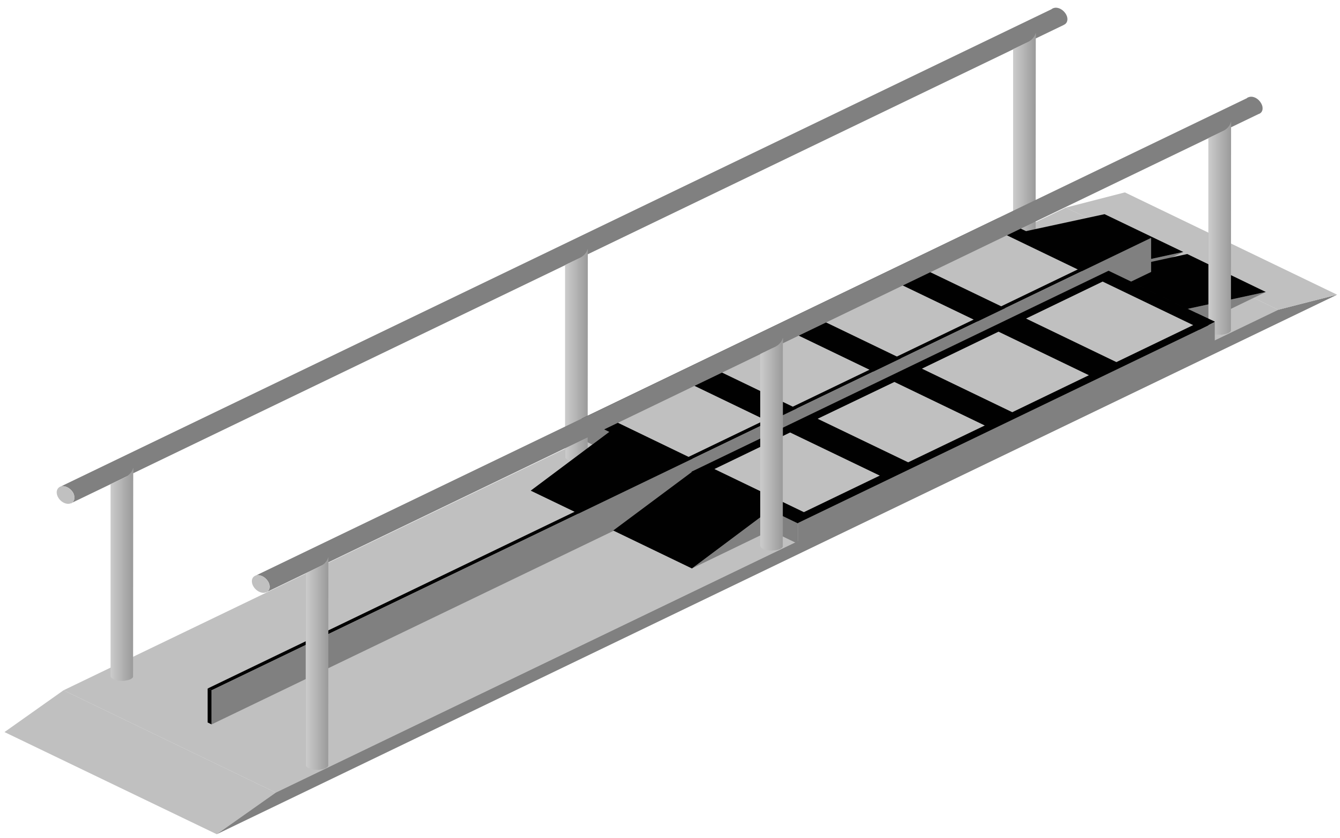

Figure 15.3. Rendering of Assembled Walkway System.

ROTATING FOOT BLOCKER

Designers: Kate Davenport, Sarah Steinhorst
Client Coordinator: Clarice Butler
Sherwood Healthcenter, Bryan, Texas
Supervising Professor: Dr. William Hyman
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INTRODUCTION

A rotating foot blocker was designed for use in physical and occupational therapy. The idea for this project stemmed from a meeting with a local occupational therapist (OT). He reported that it is very difficult to help patients shift from a seated position to a standing position. To do this, he must place his feet in front of their feet to keep them from slipping. He must then use his body strength to lift them from a seated position. He also mentioned difficulty with rotating them to a different angle for ambulation, especially if they have knee or hip problems. A full day of lifting the patients in this way causes unnecessary fatigue on the OT's back and legs. In addition, there is the risk that a patient may fall.

The foot blocker consists of pinewood and a lazy susan bearing. The bearing sits between two circular wood pieces. The top circle serves as a foot support and the rotating portion of the device. The bottom has a non-slip surface to keep the device from slipping when used. On the top rotating circle, a block was added to support the patient’s toes. A pin-locking mechanism was also added. The unit is small and portable, allowing it to be transferred to different patients’ rooms.

SUMMARY OF IMPACT

The foot blocker to met three key design requirements in that it: 1) prevents the patient from slipping while shifting from a seated to standing position, 2) is safe for the patient, and 3) operates on a swivel for easy rotation of the patient.

TECHNICAL DESCRIPTION

The overall design of the device is fairly simple. It is similar to a lazy susan television stand. The challenge of this project was to securely attach the bearing to both the upper rotating circle (circle A) and to the bottom base circle (circle B). However, once A is attached directly to the bearing, B cannot be connected directly because the bearing does not come apart. The screws connecting B to the bearing would penetrate into A, halting rotation.

Arcs were routed into A so the screws from B could penetrate and still allow free rotation. The top piece of wood was pre-cut into an 18-inch diameter circle with a thickness of 1 inch. Pine was selected due to availability, but any finished wood product could be used. For the bottom piece, an 18-inch diameter circle was cut from ½-inch pine. Four arcs were routed into the underside of A to create the stopping mechanism. When the entire system was placed together (the bearing, A and B), the screws attaching B to the bearing penetrated into the routed arcs. However, the non-routed segments between arcs stop the screws. This allows for free rotation up to 90-degrees, preventing the patient from excessive rotation and loss of control.

Two holes were drilled at either extreme of the 90-degree rotation. A pin was placed through the holes to create a locking mechanism. A 12-inch circle was cut from a rubber mat and attached to B with epoxy glue. This created a non-slip surface to interface with the ground. A 12-inch x 1.5-inch x l-inch block was added to the top of A, ½-inch below the pinhole. This serves as the toe-stopper, or the area where the patient's toes rest when lifted from a seated to standing position. Wood glue and four brackets on each side of the block were used to secure the block to A.

In order to use the final device, the OT places the patients’ feet on top of the device, with their toes resting against the toe-stopper. The therapist may then easily lift the patient without fear of either the device or the patient slipping. Once the patient is standing on the device, removal of the pin enables 90-degree rotation. This allows easy access to wheelchairs or beds.

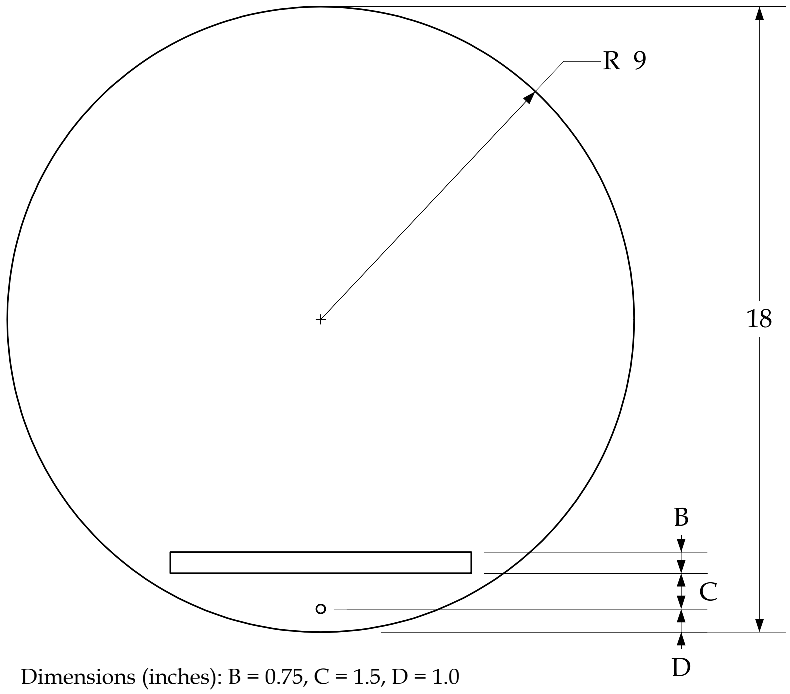

Figure 15.4. Top View Showing Position of Toe Stop.

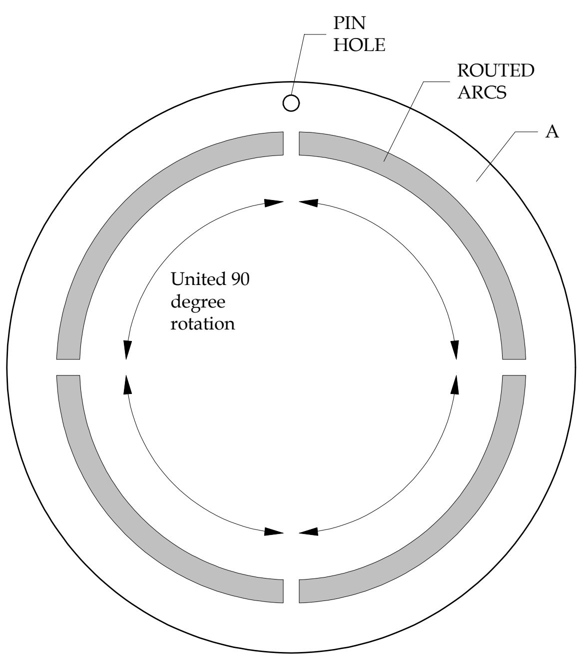

Figure 15.5. Underside of Top Showing Routed Areas and Pinhole.

CHAPTER 16
UNIVERSITY OF ALABAMA AT BIRMINGHAM

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Principal Investigator

Alan W. Eberhardt, PhD

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WHEELCHAIR ROCKER

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Client Coordinators: Gary Edwards, PhD, Marlese Delgado, PT, United Cerebral Palsy of Birmingham
Supervising Professors: Alan Eberhardt, PhD, Raymond Thompson, PhD1
Department of Biomedical Engineering
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INTRODUCTION

The primary goal of this project was to produce a device to provide sensory stimulation through motion using a client's existing wheelchair. Specifically, the device was designed to enable a rocking motion with comfortable rocking angles and speed. It was designed to be compatible with wheelchair ramps by following the ADA guidelines for appropriate dimensions. It accommodates a maximum weight of 300 lb., including both the child and the wheelchair. It is corrosion-resistant and operates on a standard 110-V outlet. The rocker utilizes wheelchair restraints to maintain a fixed relative position.

SUMMARY OF IMPACT

This rocker was requested for use by children with a wide range of physical disabilities. The soothing motion of a rocking chair is known to have a calming effect on irritable children. The Wheelchair Rocker was developed so children can be wheeled onto a platform and rocked without having to be transferred from their wheelchair. It utilizes industrial tie-downs to ensure safety and stability for the children.

TECHNICAL DESCRIPTION

The Rocker has four main components: 1) an aluminum square-tubular framework, 2) a motor with a linkage attached to the shaft and to the top plank of the rocker, 3) safety straps made for automotive use, and 4) an electrical control panel (See Figure 16.1). The aluminum structural framework is made from square 6061 tubing with an outer square area of 1 square inch and an inner square area of 0.5625 square inch. Welds were made using a MIG weld torch.

The volume contains six column pieces at 2.5 inches tall, four 50.5-inch pieces running the length of the rocker, and four 37.5-inch pieces running the width of the rocker. One 37.5-inch round tubular shaft with a diameter of ¾ inch is located 21 inches from the end of the rocker. This piece runs the length of the rocker and acts as the pivot axis. Another 37.5-inch square piece runs under the pivot axis and contains two 1.5-inch pieces located 13.5 inches from either side of the device. These pieces provide support for the pivot axis.

Pillow block bearings were placed 9 inches from each end of the pivot axis. These bearings attach the shaft (pivot point) to the rocking plank of the Wheelchair Rocker. The rocking plank has dimensions of 36 inches x 48 inches x .25 inches. These dimensions meet ADA requirements. The wheelchair was attached to the rocker using Sure-lok safety straps. The straps are retractable and bolted to the platform of the rocker in accordance with Federal Motor Vehicle Safety laws.

The rocking motion is created by a single-phase ¾ hp, 68-rpm alternating current gear motor that operates on 115 volts. The shaft of the motor turns in a clockwise direction, guiding a linkage that is offset from the center of the motor by 1.463 inches. The linkage is bolted to a shaft collar with a 3/8-inch grade A bolt attached to a female studded spherical rod end. The linkage has a female plain spherical rod end bearing with an ID of 0.375 inches on the opposing end. The linkage is connected to the rocking platform by a rod with threaded ends and a male plain spherical rod end that is bolted to the platform.

The linkage is made of a 7.45-inch rod that is threaded on both ends. The rocker motor is two-speed and has an external speed controller. Toggle switches determine high and low speed. There is also a stop switch. The control box is placed on the outside of the wooden paneling on the side of the rocker. The wiring, switches, and the bulk of the motor are housed within a control panel to ensure that other children do not tamper with the switches.

A key switch ensures that a staff member is present during operation of the device.

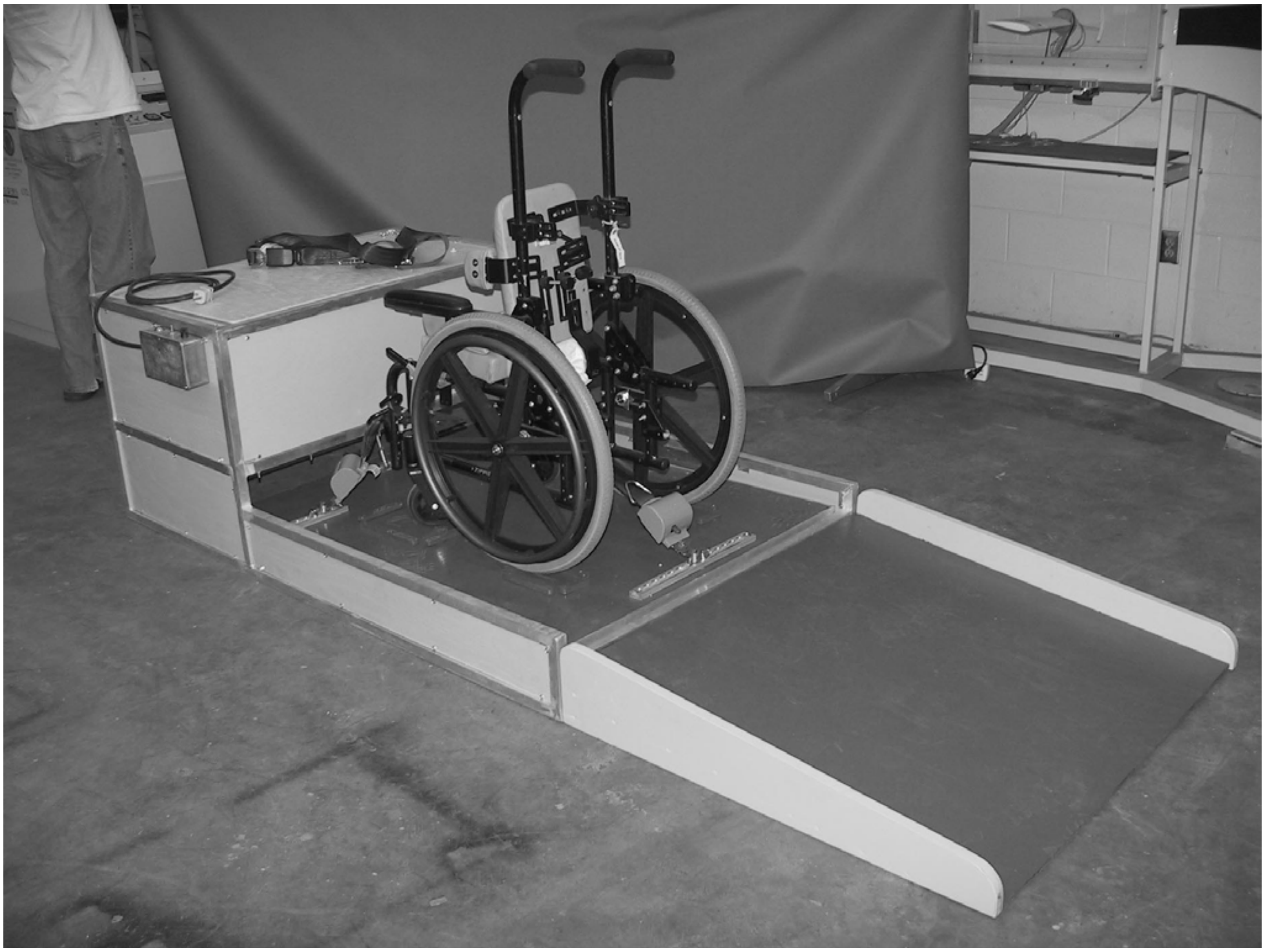

Figure 16.1. The Wheelchair Rocker.

THE DRIVER'S SEAT

Students: Rob Hayes, Mantoua Green, Brad Baird
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Supervising Professors: Alan Eberhardt, PhD, Raymond Thompson, PhD1
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INTRODUCTION

This project is a modified floor sitter. It helps children with cerebral palsy sit in a position that enables them to play with other children at floor level. The project was designed for a child with the following measurements: 10"-15" arm length, 7"-10" shoulder width, and 8"-12" seat to shoulder height. The device will accommodate up to 50 lbs. The child is secured in the sitter by a seat belt system. This system may be adjusted to increase or decrease the force needed to keep the child's back and neck in the correct position. It does not inhibit lateral, horizontal, or vertical motion of the child's arms. The device is lightweight, portable, and corrosion-resistant. It is lined with padded material for comfort.

SUMMARY OF IMPACT

A device was needed that assisted children who are unable to sit up on their own to do so. This would provide them the opportunity to play with toys on the floor and interact with their peers. The biomedical focus of the floor sitter is to control the child's pelvis by promoting neutral rotation in relation to the abdomen. This position allows no lateral flexion of the trunk.

TECHNICAL DESCRIPTION

The final design is constructed from ash (Figure 16.2). Ash is a fine-grain wood ideal for construction of small, lightweight components that require high strength. The fine grains of the wood are also ideal for preventing splintering and fracture. The sitter is sealed with a low gloss, polyurethane, non-toxic coating. This coating prevents warping and bowing associated with environmental conditions such as humidity and temperature.

A hinge and lock mechanism maintains a backboard structure capable of positions ranging from 20° (folded forward) to 125° (completely extended). The back support rotates on a set of wide-leaf utility hinges. They are swaged for mounting into panels and zinc plated to provide maximum protection against rust and corrosion. Locking pins are used to secure the back support structure at the appropriate angle. These pins are positive locking, with ball bearings that lock the pin into its receptacle. The ball, ring, spring, shank, receptacles, and spindle are all made of stainless steel.

The floor sitter is lined with a urethane padding with density of 32 kg/m3. This density retains shape and stiffness under a concentrated force of 50 lbs. The urethane is upholstered in washable vinyl. A four-point chest support strap (body point harness) along the back support structure is used to keep the spine and head erect and aligned. The straps are made from a polymeric material called Rubatex. Velcro attaches the chest support to the back support and keeps the child's pelvis correctly oriented in the chair. Metal end-fittings and slides are provided for a strong, adjustable means of attachment. Medial placement of the secondary straps secures the position of the pad and keeps the hip belt from sliding up to the abdomen. The seat belt is adjustable and locks into place. An adjustable footrest is held in place with a set of plastic dowels.

Racecar stickers were added to the final product to enhance the racing theme of The Driver's Seat. The total cost was approximately $500.

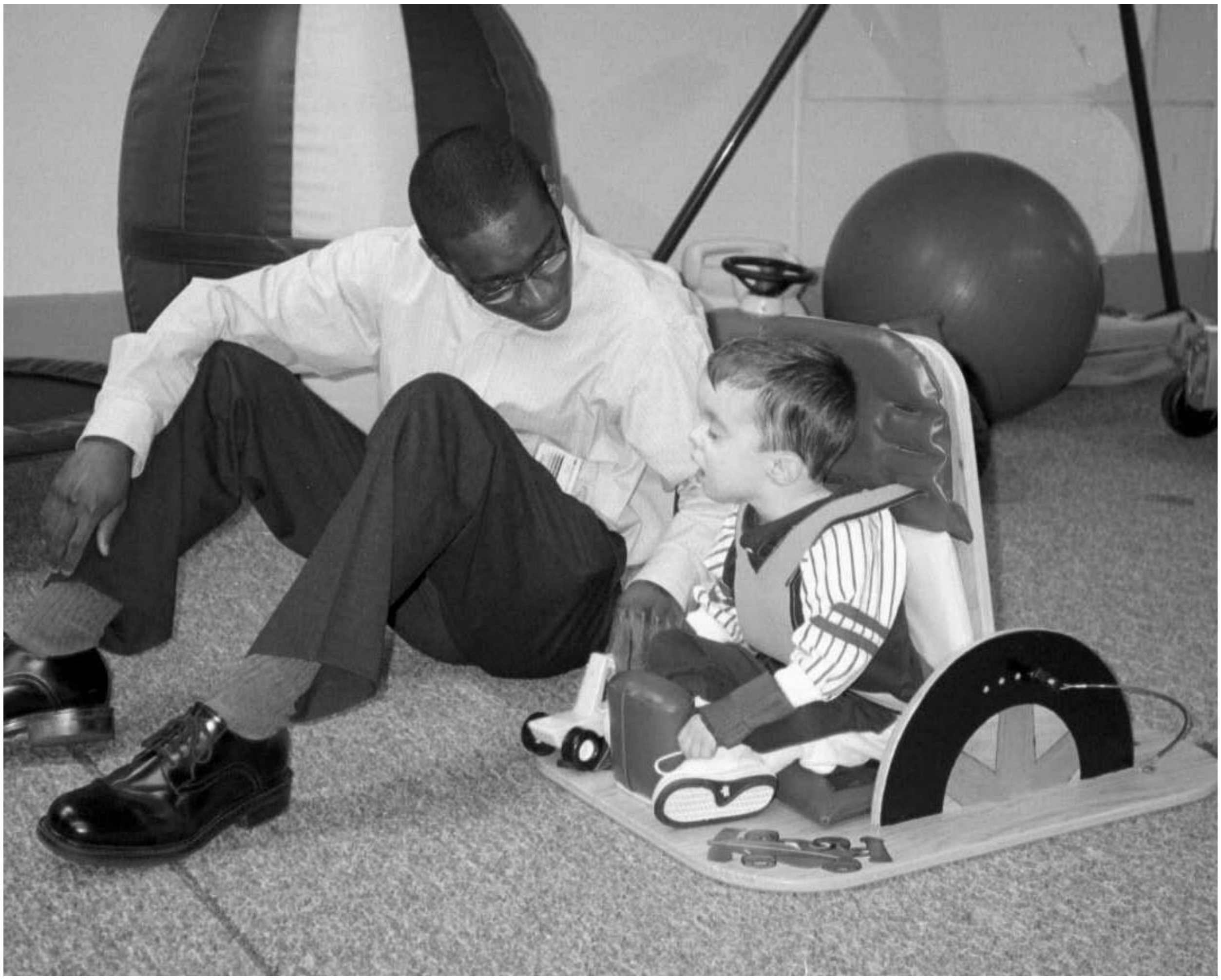

Figure 16.2. The Driver's Seat.

MULTI-SERVICE MODIFICATION TO THE WINSFORD FEEDER

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INTRODUCTION

The Model 5 Winsford Feeder is an automated feeding aid used by local physical and occupational therapists. Slight movements of the head, hands, shoulders, hips, or knees control the feeder. The original design accommodates only small amounts (1 teaspoon) of food. The therapists wanted to add components to enable the feeder to hold a larger item, such as a sandwich, napkin, or drink. The present design includes a sandwich holder accommodating sandwiches up to 2 inches thick. The napkin holder holds the napkin securely and is curved outward so it can be used comfortably. The device is corrosion resistant and electrically safe, with all the wires insulated and hidden. The arm accelerates and decelerates at less than 27.57 ft/^{s2} to prevent spillage. The additions to the feeder have a combined weight of less than 15 lbs.

SUMMARY OF IMPACT

Children with cerebral palsy, spinal cord injury, muscular dystrophy, upper extremity amputation, or brain injury may not have adequate motor control to feed themselves. The existing Winsford Feeder is the result of a mechanical engineer's dream to develop a device that such children could operate. Although it is fully functional, the original feeder requires staff members to cut the food into very small pieces. The present improvements allow a drink, napkin, or single bulky food item (e.g., sandwich, cookie, piece of pizza) to be safely raised to the mouth of the child. Giving the children the abilities to eat more diverse substances and wipe their faces with the napkin increases their independence. The device also makes feeding time quicker and more efficient.

TECHNICAL DESCRIPTION

The final design consists of an instrument box and a mechanical arm. There is a rotating circular plate with partitions for the napkin, cup, and sandwich on the instrument box. The mechanical arm engages one item and brings it forward to the child's mouth after the switch is activated (See Figure 16.3). The instrument box has two sections at different heights. The section on which the plate is mounted is 3.375 inches high. The top surface of the instrument box, which is triangular in shape, is 5.5 inches high. This extra height provides a vertical-mounting wall for the mechanical arm. The height also provides additional space in the instrument box for the mechanical and electrical system.

The plate is supported on three rollers and is rotated along a ¼-inch stainless steel drive shaft mounted at the bottom of the plate. The drive shaft enters the enclosure through a bearing assembly mounted on the instrument box. The opposite end of the drive shaft is fixed to a steel bracket and bearing assembly inside the instrument box. A cam block and pulley are mounted onto the steel drive shaft with a socket head screw. The cam block serves as the drive motor switching system, and the pulley serves as the plate rotation. The plate is made of acrylic, which is approved by the U.S. Food and Drug Administration to be used as a food contact surface. It can be cleaned using soap and water. The plate motor is mounted onto a steel bracket and drives a beveled gear system mounted on a 0.250-inch diameter shaft between two sealed bearing units. The sealed bearing units enable the rotation of the drive shaft. A timing belt connects the two drive pulleys and the idler pulley.

The arm mechanism is 9-1/2 inches long by 2 inches tall by 0.5 inch wide. It is mounted to the 45-degree vertical wall on the instrument box. It has a diameter of 0.3125-inch and is made of stainless steel. The arm rotates 130 degrees at an average angular velocity of 0.58 radians per second. The arm interior contains a drive belt that holds the arm at a level position while it lifts to the feeding position. The arm mechanism consists of a 7.7-rpm motor that drives a crank and connecting rod. One-half of the revolution of the drive motor raises the arm and the next half lowers it. The switch stops the motor after each half revolution. The torque needed to lift the arm is 400-in-oz. A motor was chosen accordingly. A .5-inch x .5-inch Type 304 SS square bar that is 4 inches long extends from the lifting arm. It is held parallel to the ground by the arm assembly mentioned earlier and will lift the holders off of the plate. A 0.365-inch x 0.365-inch square peg extends 2 inches vertically from the bar. A square tube with a nominal wall thickness of 0.0625 inch is welded onto the end of the sandwich, cup, and napkin holders. The peg on the end of the bar inserts into the tube upon lifting of the arm.

The switching control system addition consists of three single throw switches, an additional wiring harness, a six-lead system, and a four-position switch. Pushing and releasing the control switch activates the arm motor. When the arm starts to lift, the arm position switch closes to keep the arm moving. The arm stops at the top of its movement. Pushing and releasing the other control switch activates the plate motor. The gears are made of nylon. The motor for the original feeder was also utilized for this device.

Total cost of the modification was approximately $1,200.

Figure 16.3. Schematic of Winsford Feeder Modification.

WHEELCHAIR SHOPPER

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INTRODUCTION

This project provides a strong and stable carrying unit that attaches to a child's wheelchair. The device is for use with manual (non-motorized) wheelchairs. Design requirements were that the device fit a specific wheelchair (dimensions given below), have a storage capacity of at least 1.95 cubic feet (3354 cubic inches), and support at least 85 lbs. of groceries. When placed in the folded position, the shopper measures 36 inches x 36 inches x 18 inches. The weight of the device is less than 25 lbs and it can be assembled and connected to the wheelchair within 1.5 minutes. It is capable of traveling up a grade of 6% (ANSI Standard A117.1-1986).

SUMMARY OF IMPACT

Parents of children who use wheelchairs are in need of a device they can attach the children's wheelchair to make shopping an easier experience. Currently, many of these parents have to push their child in front of them and pull the shopping cart behind them. This is difficult for the parents, and the wheelchair shopper will eliminate this problem. There are also financial benefits because the parents do not have to hire a sitter to stay with the child while they go shopping. The wheelchair shopper also allows parents to spend more time with their child.

TECHNICAL DESCRIPTION

The device is for use with manual (non-motorized) wheelchairs with the following dimensions: maximum weight = 50 lbs, height from floor to handlebars = 34 - 38.5 in., inside distance (width) between frame rails = 9 - 11 in., outer diameter of rear wheels = 12.5 in., frame tubing outer diameter = 1 in., wheelbase (center to center) = 18.5 in. The final design incorporates a rigid frame and a basket (Figure 16.4). Two symmetric sides of the frame are constructed from round 1026 steel tubing. The tubes are welded at the joints. The two sides are connected with a folding brace comprised of ball joints and connecting rods. They are separated by approximately 10 inches in the front and 20 inches in the back.

Two 4-inch caster wheels are mounted at the rear, one wheel per frame side. The top bars have two purposes. They serve as a "steering wheel" used to push the wheelchair, similar to the handlebars on the wheelchair. They also serve as a place to hang grocery bags. The vertical tubes, one on each side, provide a place to mount the rear caster wheels. These wheels act as anti-tipping mechanisms. The entire frame is mounted so that no more than 0.5 inches exists between the bottom of the caster wheels and the ground.

The shopper extends into a clamping mechanism installed and adjusted by National Seating employees. The mechanism does not interfere with the normal operation of the wheelchair while the basket attachment is not in use. The clamp has a 3-inch tube extension that is butt-welded to the mounting blocks. The inner diameter of the each tube has a 50 thousands tolerance between the outer diameter of each of the 3-inch tube extensions. This tolerance provides room to slide the tubes together.

The basket is made of a rubber-coated polyester with rip-stop protection. This provides weight savings and the ability to use quick clamps to attach the basket. These quick clamps use 1-inch cotton straps to attach to the nylon quick clamps. There are three connection straps on both sides of the basket. The corners are double stitched to retain the strength of the polyester.

Total cost of materials was approximately $448.46. The total cost of assembly and construction was approximately $420.00.

Figure 16.4. The Wheelchair Shopper.

CHAPTER 17
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AUTOMATIC DOOR OPENER

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INTRODUCTION

The Automatic Door Opener is a modification of a conventional household door into an automatic door that opens and closes upon user's requests through a remote control, a pushbutton, a keypad entrance, and or a key bypass. This project was designed for clients with poor hand control. With this design, clients will be able to open and close the door with a touch of a button, and the door will unlock and open or close and lock itself. There are many commercial doors that can be operated automatically, but those devices are expensive ($3,000 to $5,000) and are not suitable for household usage. This design, however, is inexpensive and is easy to install and use. (Figure 17.1)

Figure 17.1. Automatic Door Opener.

SUMMARY OF IMPACT

Previously, the client could only get in and out of her house by asking one of her family members to turn the doorknob. With the door unlocked, she had to pull the door open using a long piece of string. However, it was hard for her to reach the string because of the highly sensitive control of the wheelchair she is using. Fine adjustments back and forth to the door on the wheelchair had added another degree of difficulty to the door opening and closing processes. With the new device installed in her house, the client will be able to open and close the door on her own. The client will press the OPEN button on the remote control to unlock and open the door, or she will press the LOCK button to lock the door once it is automatically closed. Other family members can also benefit from this design by using the keypad or the pushbutton to open and close the door.

TECHNICAL DESCRIPTION

The Automatic Door Opener can be accessed via the remote control, the pushbutton (mounted inside the house), and the keypad (mounted outside the house). Upon receiving the signals, a sequence of door opening processes will start: retracting the deadbolt, unlatching the door strike, and powering up the door motor. After closing the door, the door will be locked after a time delay. (Figure 17.2)

The door closing process includes locking the electric deadbolt after the door has automatically closed. The series of actions is controlled by the PIC16F877 40-pin EEPROM microcontroller. The microcontroller was programmed to take in inputs from the LINX receiver (with the matching transmitter as the client's remote control), the pushbutton and the keypad. The microcontroller then sends out signals to the electric deadbolt, the door strike, and the door motor. (Figure 17.3)

The microcontroller check which input component (pushbutton, remote control, or keypad) is used to open or close the door. The remote control sends a signal to the matching LINX receiver on the main control circuit, which then triggers the microcontroller to start the door opening or closing process. The pushbutton also works in a similar way. If the keypad is used, the user has to enter a password for security reasons. The password routine utilizes the EEPROM ability of PIC16F887. If the correct password has been pressed, the door opening sequence will be activated. For locking the door from outside, the users can simply press the "#" sign on the keypad. The PIC program also allows the users to change the password periodically. This password is saved in the FLASH memory of the microcontroller, and it will be stored even if there is a power failure.

The total cost of this design (parts and materials) was $1,500.

	1s	2s	3s	4s	5s	6s	7s
Deadbolt							
Strike							
Motor							

Figure 17.2. Door Opening Sequence.

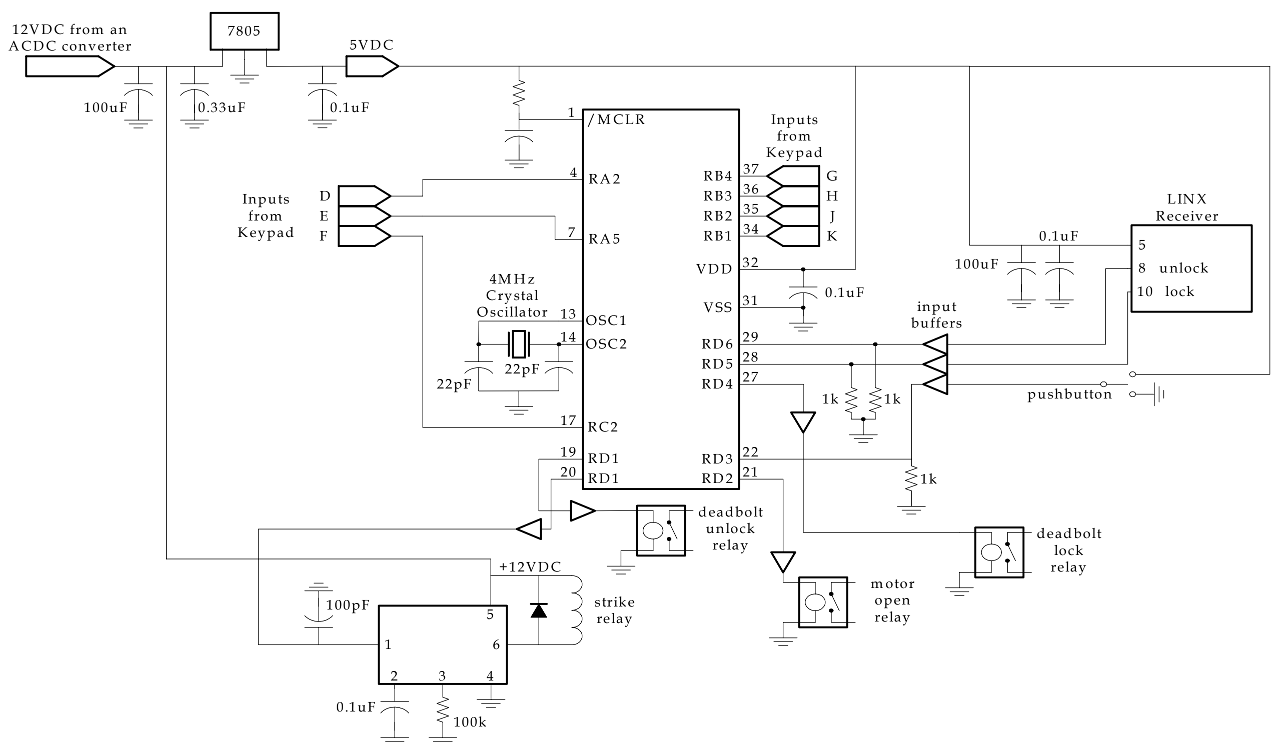

Figure 17.3. Input and Output Diagram of PIC16F887.

AUTOMATIC DOOR OPENER B

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INTRODUCTION

The Automatic Door Opener is a device intended to give a person with disabilities the freedom of using their front door. The client is in a wheelchair and has use of only one hand. The device allows the client to operate the door via remote control and her family to operate the door using a keypad from the outside or a push plate from the inside. The device gives the client the freedom to enter and exit the house at will, offering more independence to the client and easing the schedule of the family. (Figure 17.4)

SUMMARY OF IMPACT

The specifications for the Automatic Door Opener are a result of interviews with the client and the client's parents, as well as measurements taken at the client's home. Additionally, budget restrictions were considered. The unit is useful to anyone who uses a wheelchair or who does not have the strength to operate a door. The design is flexible in that an unlimited number of remotes may be programmed to operate the unit, so it can be placed in a facility that is home to multiple persons with disabilities.

TECHNICAL DESCRIPTION

The system is comprised of a Stanley Magic Access door opener, HES electronic strike, Weiser Lock electronic deadbolt, a 12 digit keypad, a push plate, Linx transmitter and receiver pair, and a prototype PCB circuit to control the system. Many of the components are readily available commercially and are easily converted to work with the system. The Stanley Magic Access header assembly was used to house the DC power supply so that all the 120VAC connections are made within a grounded metal enclosure. A twisted pair was used for transmission of the 12VDC to the PCB so as to minimize added noise.

The prototype PCB circuit utilizes a 7805 voltage regulator and filtering capacitors to deliver clean

Figure 17.4. Prototype Automatic Door Opener.

power to the circuit devices. The PCB is enclosed in a plastic box so that it can receive and transmit RF signals. An OEM Linx transmitter was used because it is contained in a small waterproof key-chain enclosure as per the user specifications. The PIC features buffered inputs and outputs so that it is not required to drive large loads nor receive as much feedback from noisy external components such as the pushbutton switch (Figure 17.5).

The Stanley Magic Access door opener and electronic deadbolt are controlled using reed relays. Reed relays were used because they are reliable for low current applications, quiet, inexpensive, and easy to replace. The electronic strike is controlled by a solid state current driver with over current protection. The current driver was chosen over a relay because it introduces little noise, is TTL compatible, uses little power, uses over current protection, uses thermal shutoff and is inexpensive.

The Weiser Lock electronic deadbolt is controlled by the circuit using the remote that comes with the deadbolt unit. The remote is modified so that two reed relays in the PCB circuit simulate pressing the lock and unlock buttons. The remote was utilized because it makes it possible to communicate with the deadbolt assembly without making a physical connection to the swinging portion of the door.

The specifications were met so that the door can be installed in its intended location.

The total cost of parts and materials was about $1500.

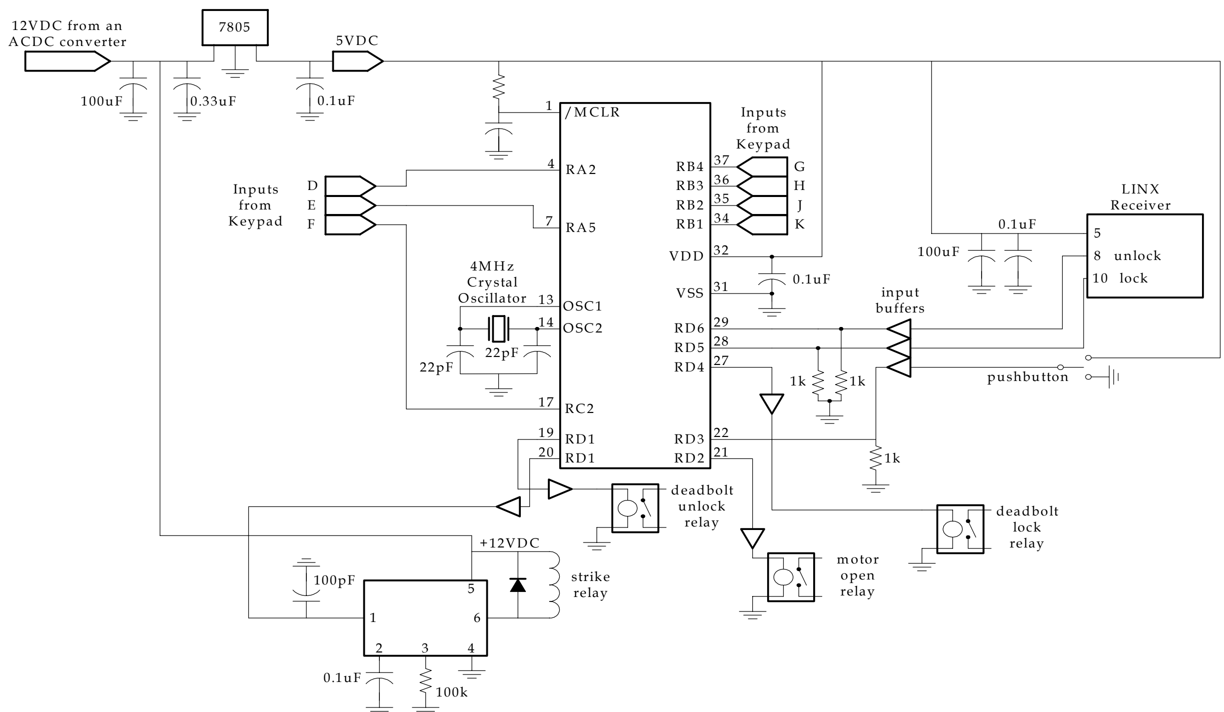

Figure 17.5. PCB Circuit Layout.

BUMP AROUND

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INTRODUCTION

Specialized bumper cars were designed for use by children with various disabilities at a school. As a result of physical and cognitive disabilities, the children can not use bumper cars or go-carts available on the market. Teachers and therapists want the children to be exposed to sensory input involving motion, sound and sight in hope that they will have a pleasurable experience. Navigation of the newly designed vehicle is completely automated.

SUMMARY OF IMPACT

The bumper car provides the children with a form of entertainment and fun. In addition, the sound and light effects in the vehicle provide the children with a more exciting ride.

TECHNICAL DESCRIPTION

The most important design considerations concern the safety of the clients, durability of the vehicle, and versatility of operation. The bumper car is to be operated indoors in the gymnasium and it must be able to be navigated in the gymnasium. The seating is critical to the client's comfort and safety. The seat must be able to recline back because the client's spine can not support his or her weight. The seat must also offer excellent head, neck, and shoulder support. The maximum speed of the bumper car is set so that impact will not result in injury to the clients. Since the vehicles are to be operated at a school, it should not be so loud as to disturb the other classrooms.

Ultrasonic sensors were chosen for this project due to their range of detection. An ultrasonic sensor can accurately detect objects within a 10-meter distance, and it serves the purpose of distance measurement more than other forms of measurement. A Polaroid transducer and Texas Instruments sonar ranging module were used. The operation of this unit needs to incorporate additional circuitry in order to achieve the input that is necessary for the PIC16C74B microcontroller.

Figure 17.6. Bump Around.

The central processing unit of the autonomous vehicle is the "brains" of the vehicle. The processor receives inputs from the various sensors located around the vehicle, toggle switch, remote on or off switch, and a push-button switch. The sensors allow the processor the ability to determine the direction of the vehicle’s travel. The toggle switch is used to turn the car on or off. The remote off switch gives the instructor of the child the autonomy of shutting down the ride. The push-button switch is used to drive the car.

The motor control circuitry is responsible for taking commands from the Microcontroller and driving two permanent magnet 12 VDC motors. The entire motor control circuitry contains three circuit block diagrams. The stage-1 circuit block is made up of three components that consist of a frequency to voltage converter, a square wave comparator, and a monostable multivibrator as a frequency-divider network.

The Motor Controller Design also implements a LM 7406N IC for improved current stability, and control over the IRF 3205 N-channel MOSFETs. The upper and lower MOSFETs are in an H-Bridge circuit configuration. The upper and lower MOSFETs are designed to work together in pairs. Therefore, it is advantageous that both IRF 3205 N-channel MOSFETs be equally matched when turned on. The control over the enhancement of the N-channel of the MOSFET improves the performance of the H-Bridge circuit. The LM7406N outputs drive the N-channel MOSFETs in a high side or low-side switching applications. The main function of stage-1 circuit block is to control the DC motor speed by Pulse-Width-Modulation. The pulse width modulated signal is generated by the difference between the current sensing feedback signal from the motor, and the control voltage signal. The motor driver characteristics consist of a digital to analog interface network, current sensing, and 6 Amp max current output capability

The sound and light effects help grasp the client's curiosity and thus the child may pay more attention to the audible and visual stimuli. The voice chip module uses an ISD single-chip voice record/playback device that is often found in telephone answering machines. The actual chip is the ISD2560 (the "60" standing representing the 60-second duration of the voice signal that can be stored). There are two visual light display (LED) features and they are placed at different locations in the vehicle. The first display turns the lights on in sequence from the left and then to the right. The second display turns the lights on in sequence moving in one direction.

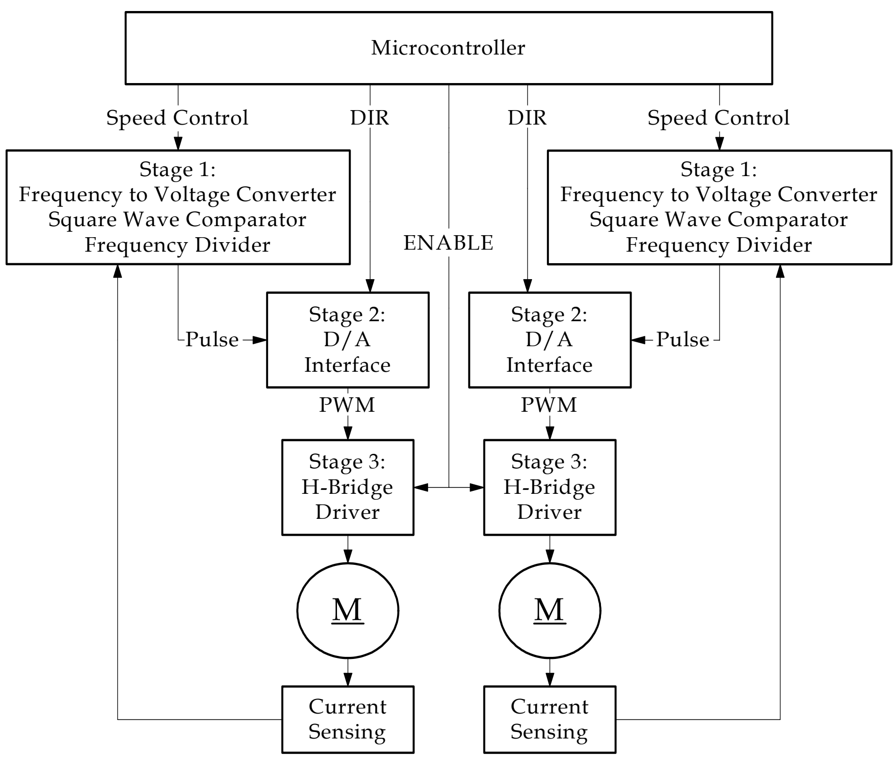

Figure 17.7. Block Diagram for Bump Around.

CHILD MOBILITY CAR

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INTRODUCTION

The purpose of this project is to aid the mobility of a six-year-old girl with cerebral palsy. She previously used a large power wheelchair. However, this wheelchair is large and bulky and severely restricts her movement within small areas. In turn, this greatly limits her ability to play with and interact with other children. The Child Mobility Car is a small, motorized vehicle that allows the girl to move about in small places such as a play area, with far greater freedom, facilitating her ability to interact with other children (Figure 17.8). Because the girl can easily manipulate a joystick, a joystick was used for direction control. The car also acts as a form of entertainment for the child.

SUMMARY OF IMPACT

The Child Mobility Car greatly increases the child's mobility within play areas. The girl possesses far greater freedom of movement in play areas, providing her the capability to play with other children to a much greater extent.

TECHNICAL DESCRIPTION

The car has three different systems: a main controller, a drive train system, and a joystick for control of direction. The car also has a total of five boards which include the control board, two H-bridges, and two small boards that assist the interfacing of the control board with the two H-bridges. The drive train consists of two DC motors, two H-bridges, and the two small interfacing boards.

The microcontroller controls all of the different systems in the car. It is inserted into a 40-pin IC socket on the control board and it is programmed in assembly language. It is a PIC16F877 microcontroller that is manufactured by Microchip Technology Inc. It possesses 33 I/O pins and this makes it simple for the microcontroller to control a number of tasks involving input or output. This microprocessor is FLASH programmable, which means it is erased by sending a voltage signal to it. The 5V for the controller is provided by a 7805 voltage regulator whose output is rated at 5V and 1A. This 7805 provides 5V to all of the components that require it. The input to this voltage regulator is 12V provided by a 12V lead-acid rechargeable battery rated at 7.0 Ah. A 4 MHz resonator is connected to the microcontroller in order to allow it to function. Two pins on the PIC output independent pulse-width-modulated (PWM) signals to each of the two H-bridges. Each H-bridge controls one of the two motors, which function independently of each other. The two motors run at 12V and are rated at 50A. The two H-bridges are designed specially for 12V motors that are to be controlled using PWM. It is almost impossible to burn these H-bridges out and the only way to do so is to short-circuit the leads to the motors. This substantially protects the drive train system.

Figure 17.8. Child Mobility Car.

The two front wheels are fixed in orientation and raised slightly above the floor, and they serve no function other than appearance. Underneath the car are two small caster wheels that replace the two front wheels. All of the steering is done through the two rear wheels. To move forward, both rear wheels turn forward. To move in reverse, both rear wheels turn in reverse. To turn right or left, one rear wheel turns in one direction and the other rear wheel in the opposite direction. To go forward and turn at the same time, both wheels rotate in the same direction but at different speeds. The same situation occurs when the car goes in reverse and turns at the same time. This steering system makes the car easily maneuverable. It is capable of turning either left or right while rotating on an axis rather than transcribing an arc.

The PWM signals are square waves of 5V amplitude with duty cycles controlling the rate of rotation of their respective rear wheels. The voltage sent to the motors is proportional to the duty cycles; the greater the voltages, the greater the speed of the motors.

The PIC microcontroller receives input from the joystick. The joystick is a switching joystick rather than one with potentiometers. It has one input and four outputs, where the input is 5V and the outputs are forward, reverse, left, and right. If an output is 5V, then the car moves in the direction to which its voltage corresponds. The car is capable of going in eight different directions: forward, reverse, left, right, forward-left, forward-right, reverse-left, and reverse-right, where the latter four directions are combinations of the first four directions. From the inputs from the joystick, the PIC determines appropriate PWM signals to send to the two H-bridges that in turn control the motors.

The PIC outputs four other signals in addition to the two PWMs. These four signals are each 5V or 0V. Each H-bridge has two pins, one to enable forward and one to enable reverse. For a given H-bridge, if the forward pin is 5V and the reverse pin is 0V, then the corresponding motor turns forward at a speed determined by the PWM. Likewise, if the forward

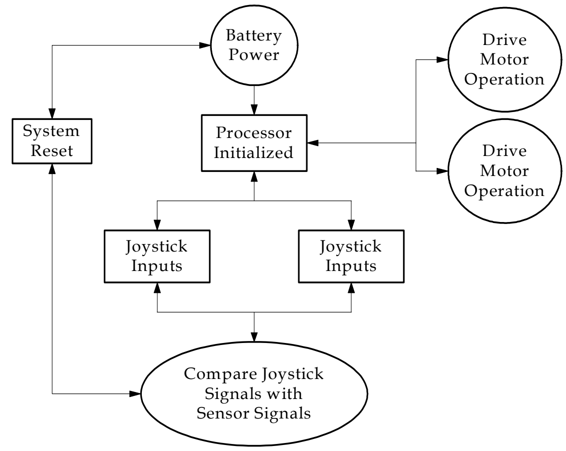

Figure 17.9. Block Diagram.

pin is 0V and the reverse pin is 5V, then the motor turns in reverse. These four signals must be sent to two small driver boards before going to the H-bridges. Each board receives one forward signal and one reverse signal for a particular motor.

The two driver boards are designed as follows. Each driver board has two 3904 bipolar junction transistors, two 330 ohm resistors, and two REED relays. These form two common-emitter amplifiers that amplify current but not voltage. The driver boards are used because the PIC cannot output signals of a high enough current to be used by the H-bridges. The common- emitter amplifiers amplify the current enough in order to activate the two relays. The relay outputs in turn are fed to the H-bridge directional control. Many of the parts of the car, including the battery, the two motors, the H-bridges, and the control board have one common ground. Many parts that require power are connected directly to the battery (Figure 17.9).

E-RACER: AN ELECTRIC GO-KART

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INTRODUCTION

The E-Racer was designed to give a young man with cerebral palsy some independence and fun. He has limited muscular control except for in his left hand. The project entailed modifying an existing electric go-kart to be controlled through a single joystick. The project was delivered to the client upon completion.

SUMMARY OF IMPACT

The design criteria for the E-Racer were established according to the capabilities of the young man as well as his parents' input. The client enjoys racing his wheelchair, but his wheelchair has limited racing options. The main restriction is the wheelchair's lack of speed. Due to the roll-cage, special racing seat with harness, and the remote kill-switch, the E-Racer go-kart provides him the ability to drive faster and satisfy the need for safety.

TECHNICAL DESCRIPTION

The existing brake that came on the original go-kart was used. It consisted of a frictional band wrapped around a wheel disk. This band was connected to a cable, which was connected to a foot pedal. As the pedal was pressed by the driver, the cable tightened, clamping the band on the disk. The only modification to the original go-kart was the removal of the foot pedal.

A linear actuator was added to apply the new braking power. The actuator motor was attached to the roll-cage behind the driver. The cable was attached to the end of the actuator. As the actuator extended and retracted, the frictional band was loosened and tightened around the wheel disk. The actuator was controlled through limit switches, which stop the movement of the actuator arm, and through switching the polarity applied, which reversed the direction of motion of the actuator arm. This was achieved through the use of relays. These

Figure 17.10. E-Racer Go-Kart.

relays were controlled through a comparator chip that compared the location of the joystick to a preset level. When the joystick was pulled back, a signal was sent to the chip, which in turn activated the relays reversing the polarity to -12V. This retracted the actuator until it reached a limit switch, effectively applying the brake. With the joystick in the center or forward position, the joystick sent a different signal to the chip. The chip then de-activated the relays, reapplying 12V. This extended the actuator until it reached the other limit switch. This fully released the brake. The tension applied to the cable while the brake was applied, was designed to stop the go-kart the fastest while avoiding skidding. This was obtained through trial and error. The relays used had to be high power since the actuator motor could draw up to 8A at full load. An actuator with a 250lb load limit was used to assure long life and accurate braking under extreme conditions.

For safety reasons, a remote kill-switch was implemented as well. When the button on the remote was pressed, it retracted the braking actuator as well as stopping the drive motor, effectively stopping the go-kart. This was done through another relay. The relay was placed between the joystick and the comparator chip. When the button was not pressed, the joystick signal was sent through the relay to the chip. When the button was pressed, the relay switched. This cutoff the signal from the joystick and applied a signal to the chip. This signal would activate the power relays that powered the actuator. The actuator would then apply the brake.

The cost of parts/material for braking was about $300. The cost of parts/material for entire go-kart was about $2500.

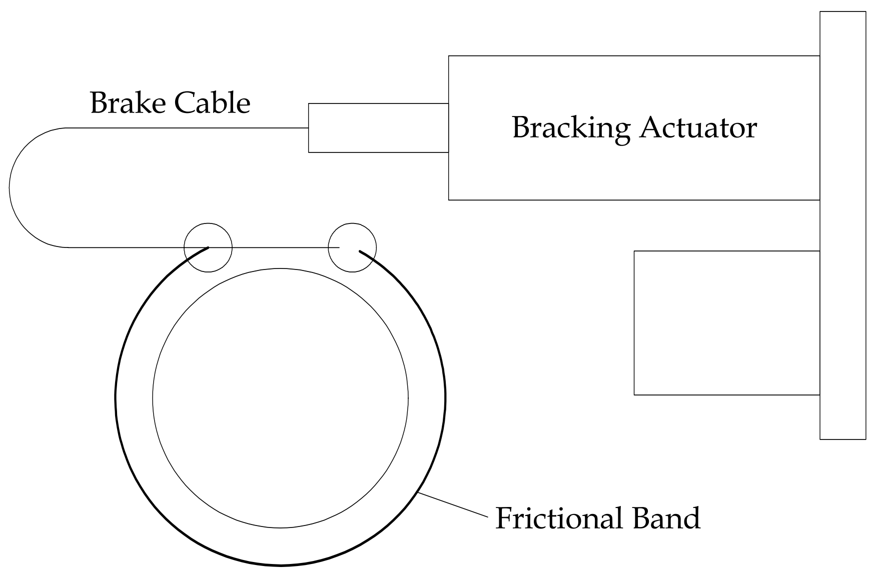

Figure 17.11. Braking Actuator.

E-RACER

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INTRODUCTION

The E-Racer is a modified, joystick-controlled electric go-kart. (Figure 17.12) The device was built for a teenage male with cerebral palsy. This go-kart has the ability to accelerate up to 25 mph. and to safely carry the client for miles. A drag-style racing seat and 5-point restraint system keep him secure at all times and a steel roll-cage ensures his safety in the unlikely event of a roll over.

SUMMARY OF IMPACT

The go-kart was designed to be controlled by the client. It allows him to play with his friends. Until now the only equipment the client had was an electric wheel chair with a top speed of 7 mph. The device will help with the client's physical therapy, improving his motor skills especially with his left hand.

TECHNICAL DESCRIPTION

The go-kart acceleration system is based on the original electric go-kart, which was purchased from Kango Electric Go-Karts. The go-kart accelerates through a potentiometer. When 30 ohms is applied, the go-kart does not move. As the resistance is increased to 5 kilo ohms, the go-kart increases speed.

The joystick supplies 2.5V, when it is centered. As the joystick is pushed forward, the voltage increases to a maximum of 4V. The voltage is compared to a preset level. As the voltage goes above the preset level, a relay is switched on, placing a new resistor into the circuit. This increases the resistance across the driver circuit. There are four relays leading to four distinct levels of acceleration (Figure 17.13).

By closing a circuit across the original main driver solenoids, the go-kart reverses. This is accomplished by a pushbutton on the top of the joystick. The pushbuttons send a signal to a relay, closing the relevant circuit and engaging reverse drive.

Total cost of parts and material was $2,500.

Figure 17.12. Modified E-Racer.

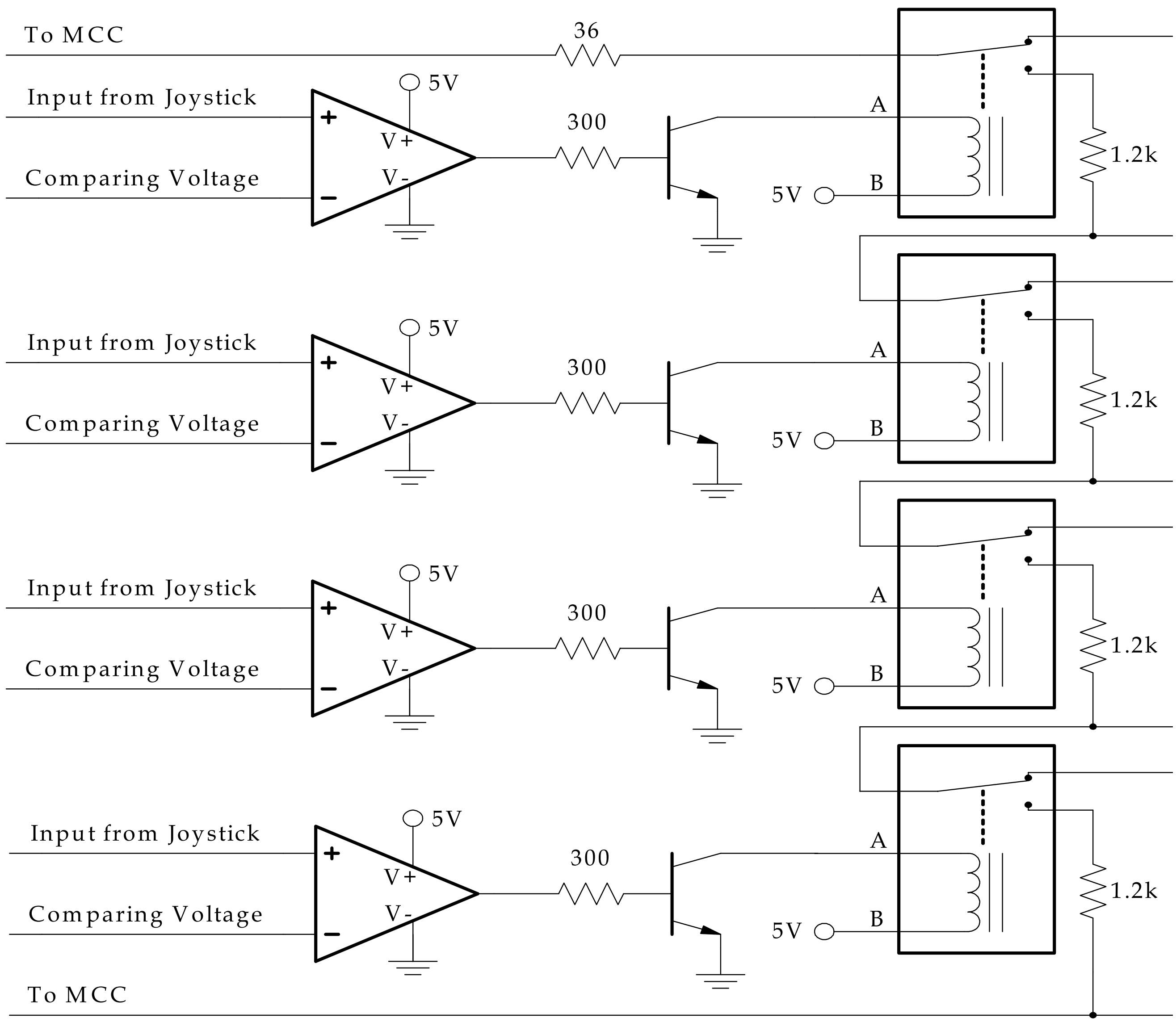

Figure 17.13. Acceleration Circuit.

GET UP AND GO

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INTRODUCTION

A powered wheelchair may enrich the life of a client with limited upper body mobility, who would like to live more independently, performing daily tasks such as clothes washing or household cleaning. The Get-Up and Go device fits the client's existing wheelchair with wheel drive motors. Fitting of a wheel drive system to her wheelchair enables her to move around a greater area without tiring. Additionally, a seat lifting mechanism elevates the client from her normal seated position and places her in a position that is near or slightly greater than what would be her standing height. This higher position allows her to perform various tasks that she would not otherwise be able to perform from a lower seated position.

SUMMARY OF IMPACT

The Get Up and Go project allows the client to perform the daily tasks that she desires without depending on others for assistance. The ability to reach for objects that were previously out of reach has greatly increased the tasks that the client can perform.

TECHNICAL DESCRIPTION

The Get Up and Go design is a modification of an existing wheelchair. It involves an added seat lift and wheel drive units. These two systems are both controlled by a single joystick. The major components in this system are the joystick, wheel drive unit, the seat lift unit, and the batteries. An overall block diagram of the system is shown in Figure 17.15.

The joystick controls both the directional movement and the seat lift functions. The directional control is accomplished by moving the joystick in the desired direction of travel. This sends a signal to the motor control, which turns the motors on. The seat lift control is accomplished by using the rocker switch on the top of the joystick. The joystick is mounted to the right armrest of the wheelchair.

Figure 17.14. Get-Up and Go.

Motor Control Unit

The motor control controls the speed and direction of the two drive motors. This is accomplished by using a microcontroller-based system. The microcontroller processes the signal from the joystick and sends a pulse width modulated signal to the driver board. The driver board then controls the power board which pulse width modulates the drive motors.

Seat Lift Unit

The seat lift control is microcontroller based. It processes the signal from the joystick rocker switch and turns the seat lift motor in the appropriate direction. Pressing the rocker switch forward lowers the seat. Pressing the rocker switch backward raises the seat (Figure 17.16).

The approximate cost for the Get-Up and Go project is $2,500.

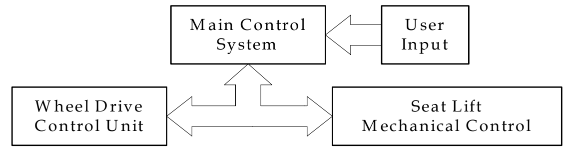

Figure 17.15. Block Diagram.

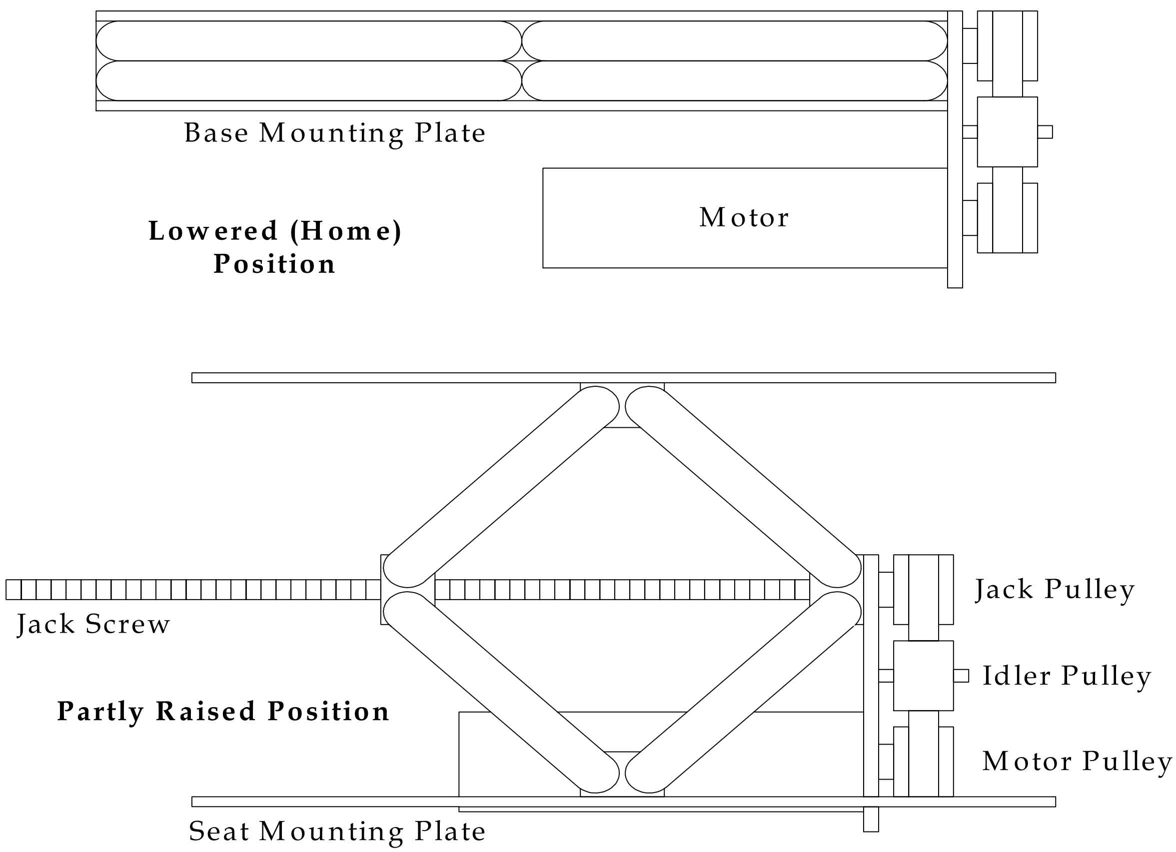

Figure 17.16. Mechanical Drawing of the Device.

LIGHTS ON/LIGHTS OFF

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INTRODUCTION

The Lights On/Lights Off device was designed to provide easy access to the lights in a client's room. The device is a module into which a lamp can be plugged. Once plugged in, the lamp can be controlled by voice commands. It also has a module that can be used for remote control purposes. This device will help a person who has an inner ear disorder. As a result of this disability, the client is unable to maneuver in the dark. She needs a device that will be able to turn on the lights before she enters the room (Figure 17.17).

SUMMARY OF IMPACT

Previously, the client had to turn on other lights in her room before she could turn on a desired desk lamp. After doing so, she had to turn off the lights she just turned on. This project will help an individual be more independent by enabling her to turn on different lights.

TECHNICAL DESCRIPTION

The most important part of this project was the voice recognition chip. This device had to be trained to recognize commands. As the chip was trained for voice recognition, it was filtered and sent to an A/D, D/A converter. This captured a voice signal and converted it from an analog signal to a digital signal. The message is sent to both a serial EEPROM and a decoder. From the decoder the message is transmitted and the lamp module is turned on or off.

The most problematic part of this project was to gain a high range of chip sensitivity to the voice commands. X10 devices are also apart of this project. They were used as backup along with a remote control, which provided a manual control for the lamps in the room. The remote control is a transmitter that sends out the X10 commands, which is then captured by the receiver. This receiver is the plug-in X10 module.

The cost for this project is about $50.

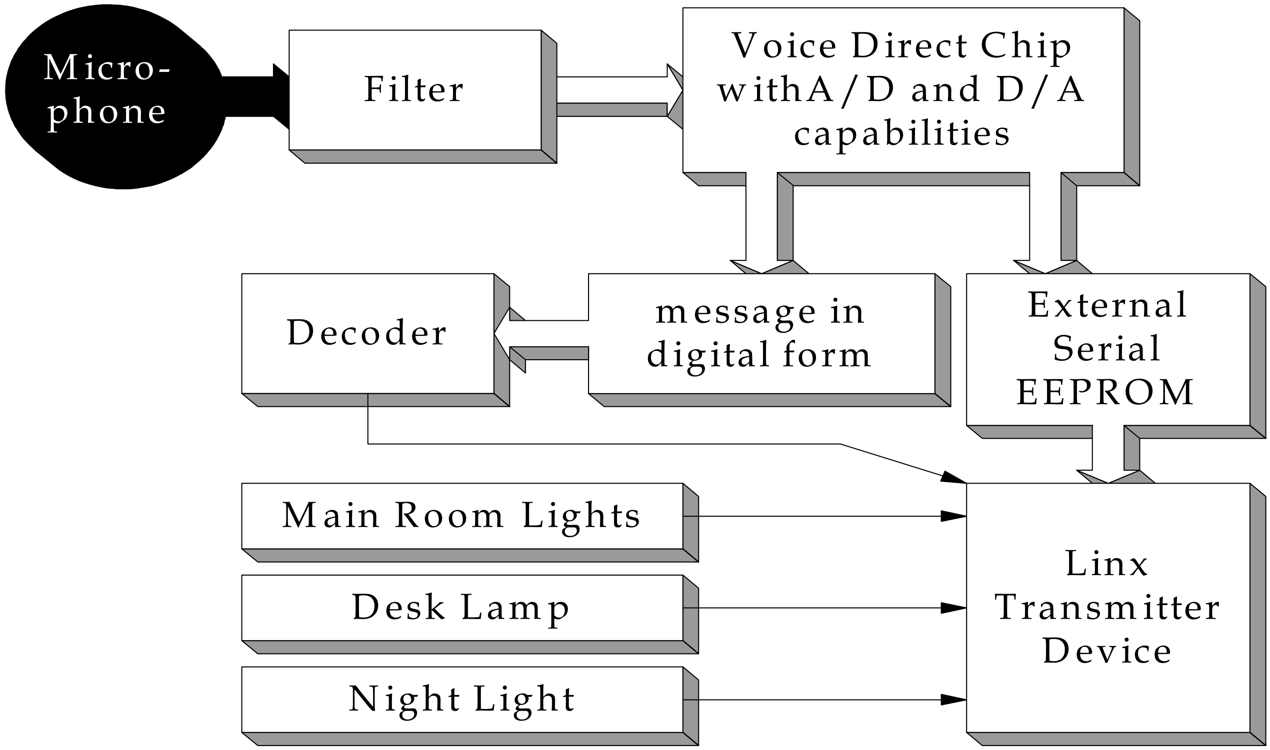

Figure 17.17. Lights On/Lights Off.

DIRECTED MOTORIZED CHAIR

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INTRODUCTION

The LED Directed Motorized Chair is a standard wheelchair that has been converted into a motorized wheelchair for a person with cerebral palsy. An LED display and head switch is incorporated to allow hands free control of the chair. The client has limited control of her lower body, arms and hands and requires assistance to move. The client uses voice synthesizing equipment and software to communicate, operated mainly by a switch that is activated with her head. This design has motors and a gear and pulley system mounted connected to the wheels of a standard non-motorized chair. Each wheel has microcontroller-based circuitry to allow independent movement. The microcontroller input consists of a head switch. An LED display is the visual direction indicator (Figure 17.18).

SUMMARY OF IMPACT

With the LED Directed Motorized Chair, the client has increased independence. No longer does the client need the help of another to move from place to place.

TECHNICAL DESCRIPTION

The main components of the LED Directed Motorized Wheelchair's motorized wheel system consist of batteries, motor circuits, the LED display/pre-motor circuit, motors, and the pulley/gear system.

Batteries

Two lead acid batteries that supply 12 volts are placed in the series. This is done because the two motors require 24 volts at 13.5 amps to run. The batteries will be mounted inside the wheel hub with the motor and other accessories. Two batteries can be recharged using a battery charger provided.

Motor Circuits

Two motor circuits are used. These circuits control the speed and direction of the motors that in turn control the direction of the wheelchair's wheels. Each individual motor circuit controls its own independent wheel. The circuits were manufactured by Diverse Electronics and are able to handle up to 30 volts and a continuous 20 amps. For the high voltage and amperage the motors require, these circuits suit the design.

Figure 17.18. LED Directed Motorized Chair.

Head Switch

The head switch is the only part of the system that the client will use to control the wheelchair. The head switch (in tandem with the LED display) replaces the joystick on most motorized chairs on the market. These two parts allow the client to choose the direction of the wheelchair.

LED Display/Pre-Motor Circuit

The integral part of the LED Directed Motorized Chair is the LED Display/Pre-Motor Circuit. This circuit consists of two PIC microcontrollers, an 8-channel multiplexer, a quad two input AND IC, a quad two input OR IC, 5 LED's and resistors. The LED Display circuit controls the order and time in which the LED's light up. The program lights up the LED's as follows: Forward, Right, Left, Backward. When the head switch is compressed, the chair goes in the desired direction and Stop lights up on the display. When the head switch is pressed again, the rotation continues as the wheelchair stops. The Pre-motor part of the circuit controls the direction that the motors will run. The motors spin in either a forward or reverse direction (Figure 17.19).

Motors

The two motors are rated for 12 volts at 13.5 amps and 1200 RPM. The motors control the direction the chair travels. The two motors work in tandem to go forward or backwards. When the chair turns right or left, the chair acts as an army tank in that one wheel pivots as the other rotates.

Pulley/Gear and Hub System

Due to the high speed (RPMs) of the motors, a dynamic system was created. This was done by incorporating a system using both pulleys and gears. This requires a ratio of 25 to 1 from the motor to the wheel to produce 5 mph. The primary part of the system implements two gears. The first gear of 1.0 in. diametric pitch is connected to the shaft of the motor. The second part is a gear of 6.0 in. diametric pitch which connects to the first gear and is held by a gear stand. The secondary part of the system implements two pulleys. The first pulley of diameter 1.0 in. is welded to the 6.0 in. gear. The pulley connects to the hub of wheel via a 4.2 in. diameter pulley welded onto the inner hub of wheelchair's wheels. When the pulley/gear System connects the motor to the hub of the wheel, a speed of less than 5 mph is attained.

The total cost of the LED Directed Motorized Chair is $1000.

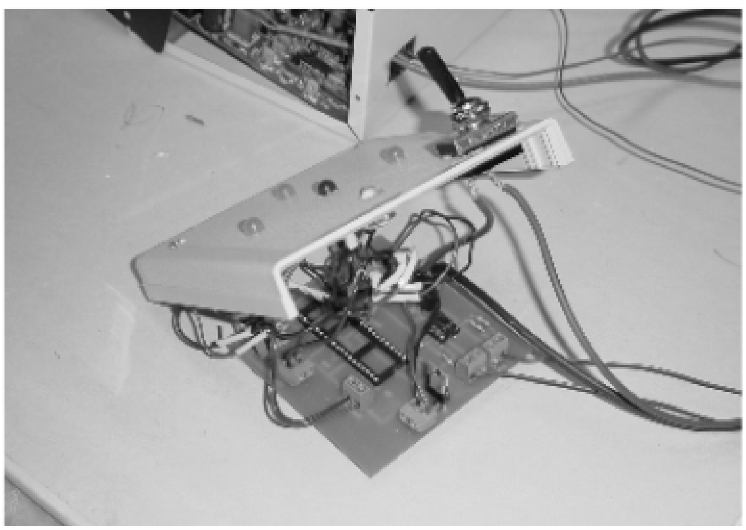

Figure 17.19. LED Display and Circuit.

RISE AND SHINE

Designers: Harold Haugland, Michael Lindstrom, Michael Melinosky
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INTRODUCTION

As a result of cerebral palsy condition, an 11-year-old child has decreased strength in his legs and depends on a wheelchair. He needs help with bathing and toileting at all times. Due to his age, the client wants more privacy. The new device allows him to move from his wheelchair to the toilet, bathtub, bed, and back again by himself.

The device is based off of a Hoyer lift design with a few modifications. This device aims to replace the usually needed health care assistant. Instead of using a person to move the device, a remote control is operated by the user. If the user wants to use the device, he simply steer it over to himself via remote control and puts on the harness.

The remote controlled Hoyer lift is quite different than the ones currently on the market today. Two of the distinguishing features are the ability to rotate the mast and the ability to increase the width of the base. Standard lifts have a fixed mast and the whole unit is pushed to the desired patient location. With the current design, the user does not need to be close to the desired location. He can widen the base (from the 28 inches needed to get through a doorway to about 60 inches). He can then rotate the mast and move where he wants.

SUMMARY OF IMPACT

This project will allow the client to move from his wheelchair to his bed or bathroom without assistance from another person. He will not have to rely on a health care worker to be there every time he needs to get up in the morning and perform tasks of daily living.

TECHNICAL DESCRIPTION

Given the client's needs, it was determined that a Hoyer lift would be the best place to start the design. Since Hoyer lifts are quite expensive, a similar, but les expensive product was modified. Car engine lifts serve a very similar purpose to the Hoyer lifts with the added bonus that they are built of tubular steel and are rigid. To provide forward motion to the device, two 1/10 horsepower motors were used. If the device were inputted to move forward, then both motors would rotate in the same direction. Similarly, turning is accomplished by rotating the motors in opposite directions from each other. Rotation is accomplished by mounting the mast of the device on a large chain driven sprocket. The sprocket was mounted on a cylindrical steel shaft supported by two bearings. The two stabilizer legs were mounted parallel to the lift's legs, and they are spread out and taken in by linear actuators. A winch replaced the original hydraulic pump used to lift the boom.

The user operates the device via remote control. The remote control has four pushbuttons and a selector switch. The selector switch allows the device to be focused on one particular task while the pushbuttons allow for operation within a task. The three tasks are motion (forward, back and turn), stabilizer leg control (legs out and in), and winch and boom control (move the winch up and down and rotate the mast). For example, if the user wishes to make the device move forward, he must put the remote control into the motion position and then he can make each motor move forward and backwards. The user will not, however, be permitted to rotate the mast or move the legs due to safety precautions.

The remote control contains a Basic Stamp 1 (BS1) continuously monitoring the buttons. If there is no button pressed, the BS1 will serially output an ASCII character. Each button has a character associated with it so that if it is pressed, a different character is transmitted. This serial data is sent to a Linx RM series transmitter operating on the 433 megahertz band. This data is received on the device via Linx receiver and is analyzed by a Basic Stamp 2SX (BS2).

The BS2 looks at the incoming data and waits until two of the same character are received. It then turns an output pin high which activates a transistor wired to a DPST relay. The relay takes care of the higher current needed to operate the motors of the devices (Figure 17.20).

The device costs approximately $3500.

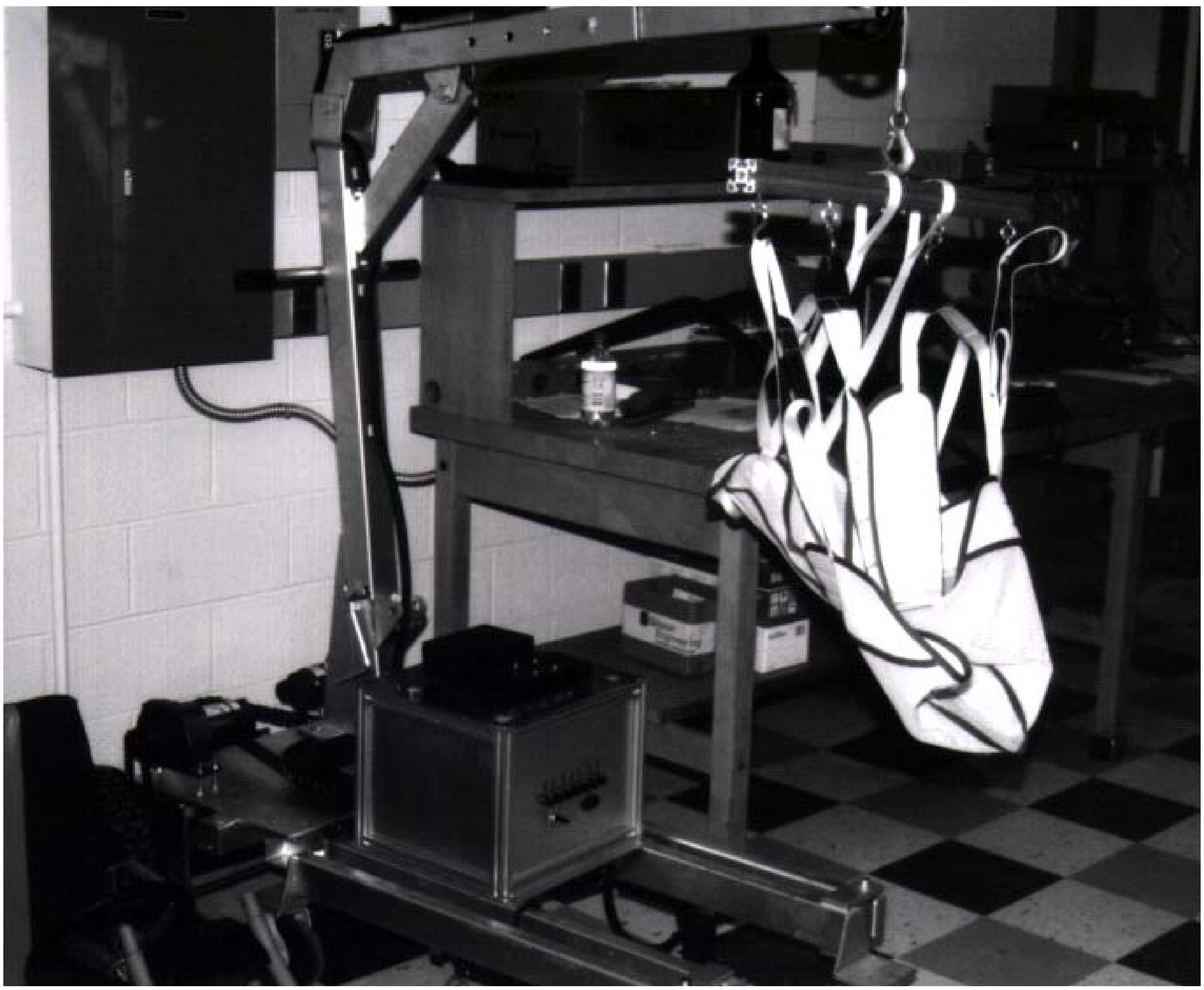

Figure 17.20. Completed Device.

TELESCOPIC OBJECT RETRIEVER

Designer: David Pham
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INTRODUCTION

Wheelchair Assist Devices was designed to meet the specific needs of a child with cerebral palsy by equipping his wheelchair with a variety of useful devices. One such device is the Telescopic Object Retriever (TOR). The TOR is a power extension arm that allows an individual in a wheelchair to pick up objects that lie outside his immediate reach. The TOR has a maximum reach of 4.5 feet and it can be reduced to a compact length of 1.8 feet. A motorized grip at the end of the arm is used to grasp the object.

SUMMARY OF IMPACT

From his wheelchair, the client is at a distinct disadvantage when reaching for anything outside of arm's length. Consequently, the client is dependent on the help of others when encountering obstacles of this nature. The Telescopic Object Retriever will provide the client with the means to be more independent in this area of his life.

TECHNICAL DESCRIPTION

In order to make the TOR extendable and retractable, the arm consists of four interlocking, spring-loaded cylinders. There is a steel cable that runs inside the cylinders.

The cable originates from a reel at the base of the largest diameter cylinder and is connected to the base of the smallest diameter cylinder. A 26-oz. 24VDC motor is used to rotate the reel. Once the motor stops moving, the position of the reel is held in place by gears.

A motorized grip is affixed to the end of the arm. A 9-oz. 24VDC motor is used to open and close the grip. The shaft of the motor is screwed to a worm gear. The worm gear is aligned with a second gear,

Figure 17.21. Telescopic Object Retriever.

which is in turn connected to a long screw. Rotation of this long screw is what opens and closes the grip.

The TOR is able to angle downward at an angle of about 56 degrees and upward at an angle of 18 degrees by hinging one end of the largest diameter cylinder and connecting the other end of the cylinder to a small linear actuator. There are three control circuits that are used to drive the three motors of the TOR (Figure 17.22 and Figure 17.23).

In addition to allowing the user to change the direction of the motor, the design prevents the motor from exceeding its full load condition. When the motor reaches its full load condition, the circuit initiates dynamic braking, which brings the motor to an abrupt halt and reduces the current to zero. This feature eliminates the using of fuses to prevent the motors from overloading.

There is one limit switch in the TOR. Once the arm is fully extended, the reel must stop unwinding. Failure to do so will cause the arm to retract since the unwound cable will be drawn back in, this time in the opposite direction. The limit switch assures that once the arm is fully extended, the forward signal is interrupted thus causing the reel to stop turning.

The cost of parts and material is $3800.

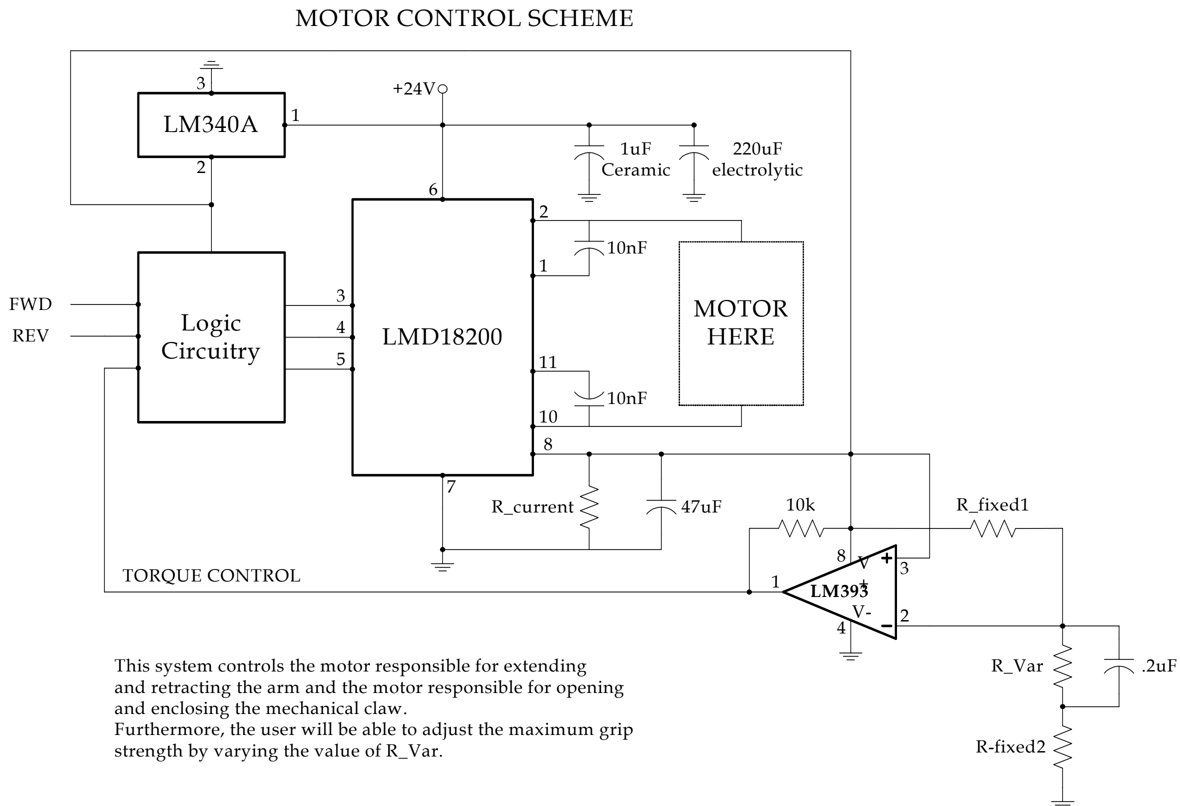

Figure 17.22. Control and Driver Circuit

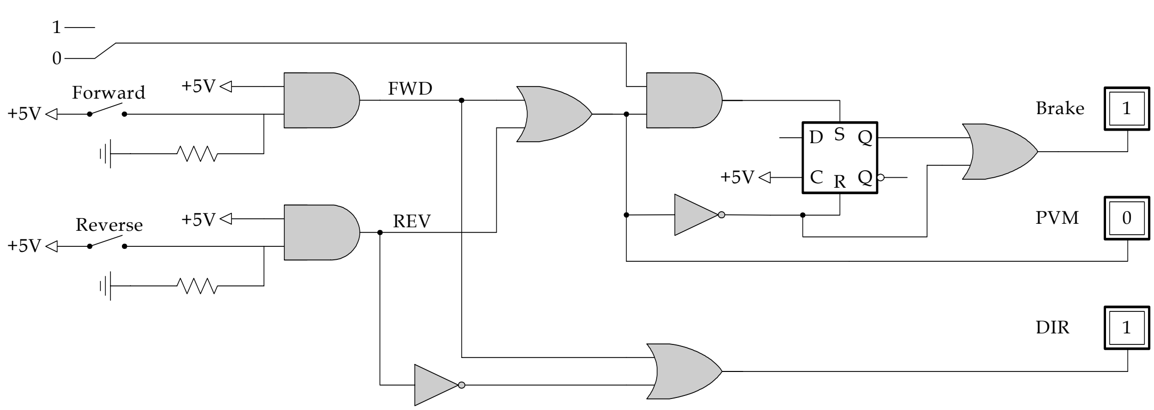

Figure 17.23. Logic Circuitry to Control LMD18200 H-Bridge

AUTOMATIC DOOR OPENER

Designer: Amol Jain
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INTRODUCTION

The Automatic Door Opener automates the process opening and closing of a front door. A child with cerebral palsy is unable to open and close the front door of his home. This problem was solved in two parts: first, the door opens (and closes) and unlocks (and locks) using motors. Second, the only feasible method by which this child could control these motors is via remote control. A keypad and a pushbutton are also integrated to allow the rest of the family to use this system. A microcontroller is at the heart of this system; it receives the requests to open the door, and activates the circuits that drive the motors. There are no other automatic door openers similar to this project (Figure 17.24).

Figure 17.24. Automatic Door Opener.

SUMMARY OF IMPACT

The project will provide the child some independence in his daily routine; he can now open and close the front door by simply pressing a button on his remote control.

TECHNICAL DESCRIPTION

In the input control circuits for the keypad/pushbutton and the remote control, (Figure 17.24 and Figure 17.25) when the keypad's or the remote control's buttons are pressed, then the output to the microcontroller goes LOW (normally the output to the PIC is HIGH). The microcontroller senses this change from HIGH to LOW, and starts the program. First, it activates the solenoids motors that will unlock the door; the output control circuit 6ses LMD18200 current driver.

Next to open the door, a relay control circuit activates the door motor (Figures 17.26, 17.27, and 17.28). When the microcontroller supplies +5 V, the transistor saturates and turns on the relay.

The total cost of this project was $1350.

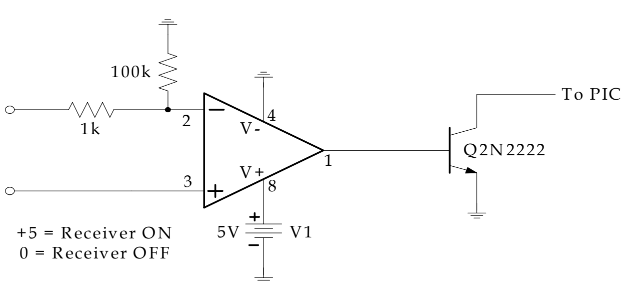

Figure 17.25. Input Control Circuit.

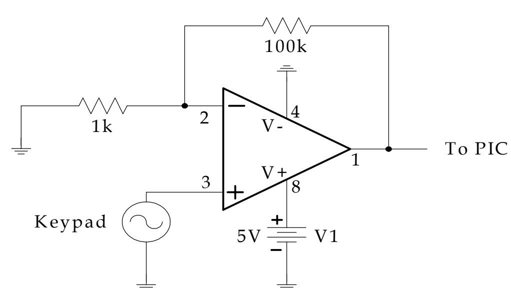

Figure 17.26. Keypad circuit.

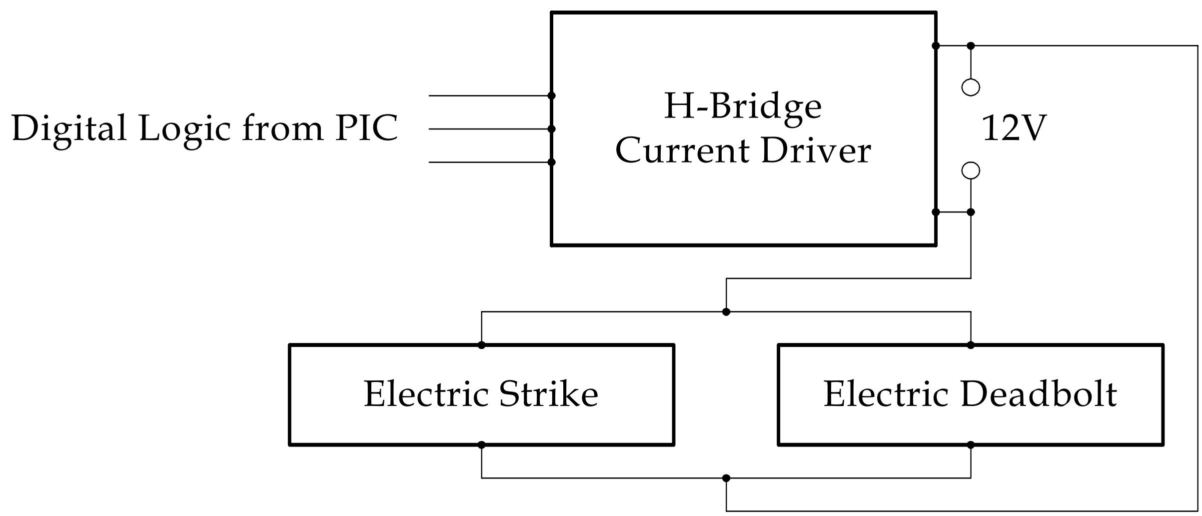

Figure 17.27. Block Diagram.

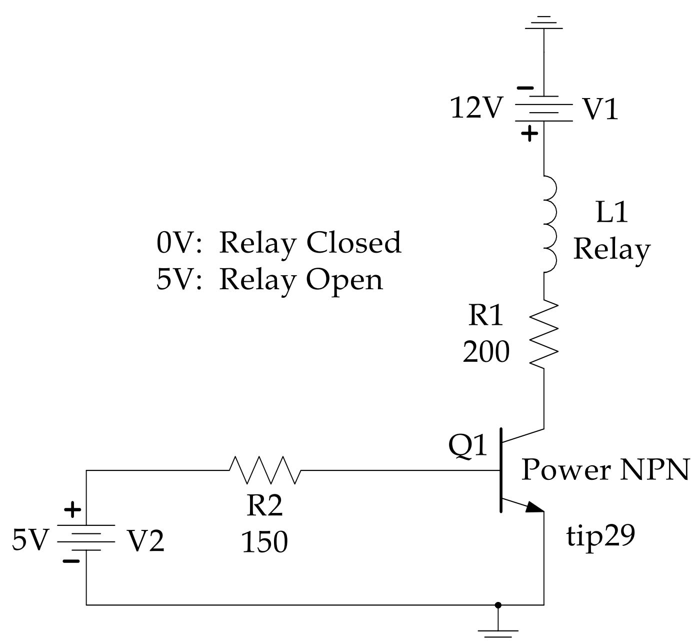

Figure 17.28. Door Relay Circuit.

VERTICAL MOTION FOR THE OBJECT RETRIEVER

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INTRODUCTION:

The Vertical Motion for the Object Retriever system was designed to work along with a mechanical object retriever to help a child with cerebral palsy reach objects from his wheelchair. The system uses a linear actuator to move up and down in a vertical motion. The object retriever is operated electronically (Figure 17.29). The linear actuator is attached to the object retriever which is supported by the wheelchair. This approach is different from existing inventions, such as pure mechanical methods for the vertical motion of a mechanical arm. These available methods require a great deal of strength by the user to operate. Instead, this design is electronically controlled by the user with the push of a switch.

SUMMARY OF IMPACT

The client simply pushes a switch to operate the object retriever in the up and down motion. The client can reach higher objects than the level of his wheelchair, such as a cereal box on a kitchen counter or a glass in the middle of a table. As a result, the client can reach higher objects without the need for someone to do it for him, enhancing his independence.

TECHNICAL DESCRIPTION

The design uses an H-Bridge from Diverse Electronic Services Company. This H-Bridge is the MC6 – 24/12 which is capable of delivering up to 30 amps; however, in this design only 7.5 amps are required by the (12VDC, 250 lbs, 8" stoke) linear actuator from Thomson Saginaw. Such current is more than enough to lift the object retriever and at the same time to support it with a 4lb load.

The actual up and down motion of the linear actuator is controlled by a double pole single throw switch. This is a pushing switch that when not activated goes back to the off position.

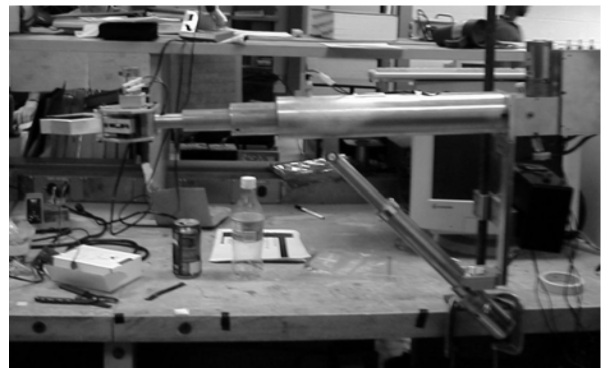

FIGURE 17.29. Object Retriever with Linear Actuator for Vertical Motion.

A linear actuator was picked for this design because there is no need to control the speed of the vertical motion. However, the speed of the actuator can be set by a potentiometer that controls the current in the H-bridge. At 4.7 kilo ohms, it allows the actuator to move at a constant speed of 8 in per 12 seconds. Also, this actuator has its own breaking system so that when it reaches its full extension it stops, ensuring safety of the motor.

Aside from the MC – 6 H-Bride, this circuitry uses a 24/12 VDC adjustable voltage regulator (Figure 17.30) rated at 7.5 amps. This regulator is required to bring down the voltage from 24 VDC to 12 VDC of the wheelchair's battery. In addition, a 7.5 amp fuse is used to prevent the voltage regulator from burning.

The cost of parts and material was about $320.

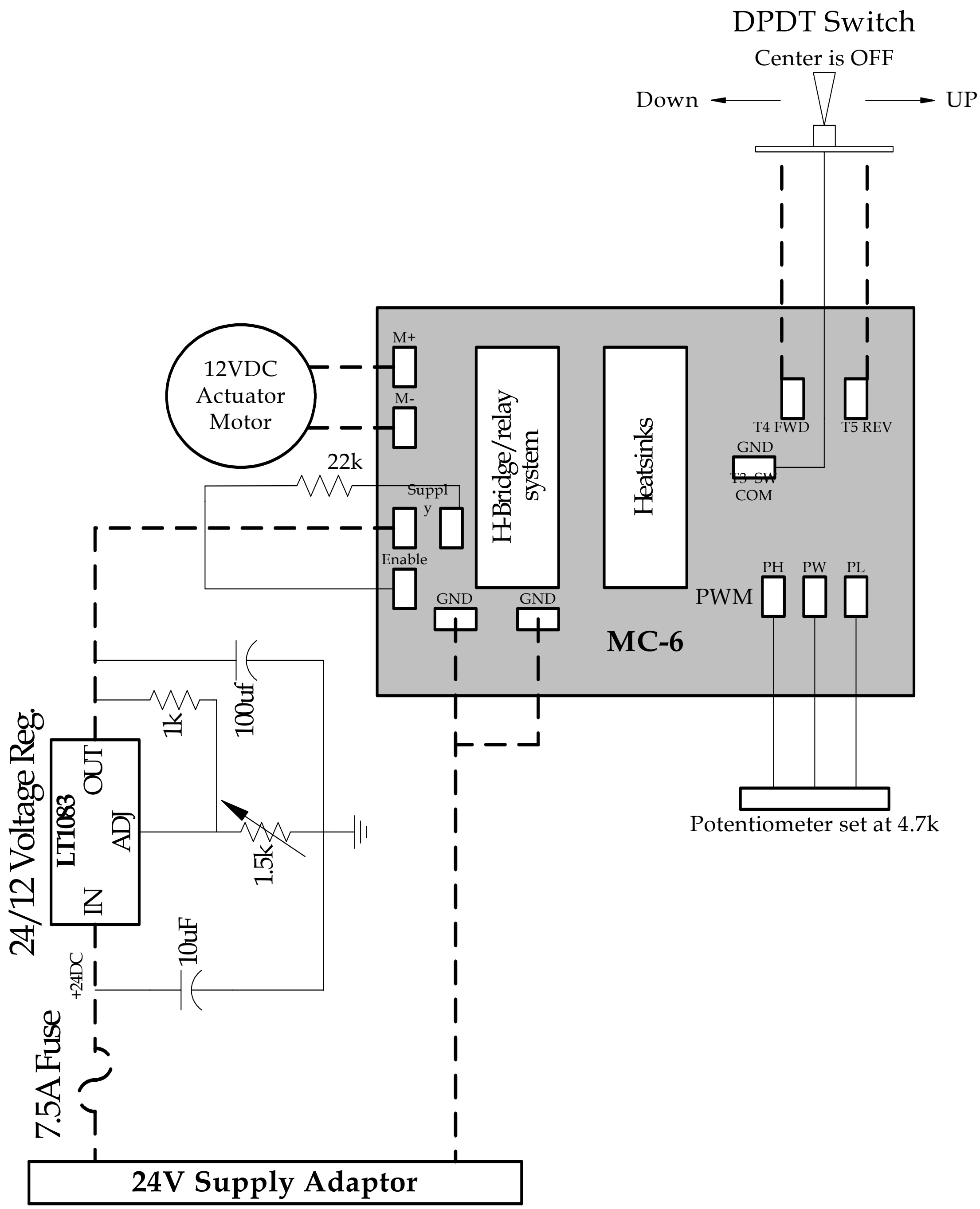

Figure 17.30. Vertical Motion Circuitry for Linear Actuator.

ELECTRONIC DOOR OPENER

Designer: Vincent J. Berkun
Client Coordinator: Dr. Brooke Hallowell, Ohio University
Supervising Professor: Dr. John Enderle
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INTRODUCTION

The Electronic Door Opener is part of a group of three modules designed to facilitate independence for a client with quadriplegia who spends much of his time in a wheelchair. Going in and out of his house can become a burden because the client has limited mobility. The electronic door opener solves this problem by automatically opening the front door of the client's house at the push of a button on a remote control or by a keypad. The door opener will also allow the client to leave the house by pushing a large button or by the remote control. An electric strike and an electric deadbolt work in conjunction with the door opener. These unlock when the trigger events happen to allow the door to open. The whole project is controlled with a microcontroller that runs assembly code. A brief flowchart is included to show the operation of the project (Figure 17.31).

STATEMENT OF IMPACT

The client has trouble with conventional door handles, which makes coming in and out difficult. The door opener solves this problem.

TECHNICAL DESCRIPTION

The main feature of the door opener is that it has a remote control that is bundled as part of another project. The remote control works up to approximately 20 feet. There is also a keypad that is attached outside the door of the house. The keypad takes a four digit password consisting of the numbers one through nine. The code is them followed by the '*' symbol. After a correct code is entered, the door will open. To enter a new code, a correct code must first be entered and then the '*' symbol. Then the new code is entered followed by the '#' symbol. The new code will then be stored. The client can also open the door from inside the house by pushing a large indoor button.

All of this is controlled by a Microchip PIC16F877 microcontroller. It is a 40-pin microchip that runs at 4 kilohertz. The code has several sections. One section scans the keypad, which is a 3X4 matrix. Each row and column of the keypad is connected to the PIC. It puts power on one row, and then it looks to see if a column goes high. If the code knows the row and the column, then the code can figure out which button was pushed. Another section poles the

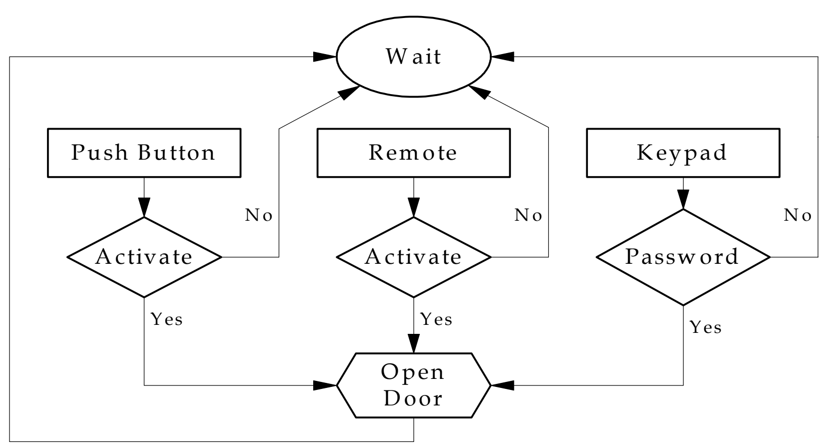

Figure 17.31. Flowchart from Door Opening System.

push button's input to see if it was pushed. If it does find that the input was high, it waits and sees if the input is still high. If it is not still high, it resets the waiting sequence. If it is still high, it carries out the opening sequence. Thus, the button is de-bounced with code. Another section of code stores and retrieves the password from EEPROM. This allows the password to be retained in case of a power failure.

The main circuit board, another supporting circuit board, and the receiver for the remote, were all fabricated and designed in house. The relay board is a group of three relays and driver circuits that is triggered by the PIC. When a trigger event happens, the PIC sends the correct pins high. These pins turn on three parallel NPN transistors (one for each relay). The emitter of the transistor goes to a ground state and is also tied to one side of the coil of a relay. The other side of the relay is tied to +12V. When this happens, the relay is tripped and 12V can go to the electric strike and deadbolt. The other relay shorts two wires that are tied to two pins of the Stanley Magic Access door opener.

The boards are mounted in a fiberglass 12X12' fiberglass enclosure. The project runs off of standard house 120VAC and comes with an external un-interruptible power supply. The leads for the electric deadbolt and electric strike can source 12V at 900 mA and are fused with 1A fuses (Figure 17.32).

Figure 17.32. Project and Demonstration Door.

BACKPACK RETRIEVER

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INTRODUCTION

Currently, a client relies on assistance from others to access his school materials, which are placed on the back handles of his motorized wheelchair. The backpack retriever is designed to enable the client access to his school materials without the assistance of others. The backpack retriever consists of a book bag attached to a motorized-arm, and a custom designed mounting bracket. The arm is mounted on the back of the wheelchair (Figure 17.33). The arm will swing from the back of the client's wheelchair to the side of the wheelchair making the materials carried in the book bag accessible for the client. The client, via a wired remote control, easily operates the backpack retriever bringing the book bag to the side of the wheelchair for access to his materials or to the back for the carrying position.

SUMMARY OF IMPACT

Due to a tragic accident at the age of 19, the client has quadriplegia and relies on the assistance of others to accomplish common and routine tasks. The design of the backpack retriever was intended to provide the client with enhanced independence. Therefore, self-operation of the module by the client is the most important factor considered in the design of the backpack retriever module.

TECHNICAL DESCRIPTION

The backpack retriever is designed to address the needs of a specific client. This module is designed to mount on the back of the Lancer 2000, Everest and Jennings motorized wheelchairs. The module is mounted to the frame, on the back left-pole of the wheelchair, using a custom designed bracket. The back left-pole on the frame of the wheelchair is compressed between two support plates using wing nuts and steel bolts that run through these two plates.

The backpack retriever module mainly consists of three parts: the custom designed mounting bracket, an L shaped arm, and a modified book bag that

Figure 17.33. Backpack Retriever.

slides easily in and out of the L shaped arm. The L shaped arm is attached to the shaft of a 24Volt DC motor. This motor rotates the arm making the book bag travel through a 270° motion accessible to the client. (Figure 17.34)

The client can operate the backpack retriever module through a wired remote control. The client can bring the book bag to an accessible position by pressing the button labeled "Backpack" in the remote control. Pressing this button once more will move the book bag to the carry position, in the back of the wheelchair. The motion and positioning of the backpack retriever is accomplished with the use of a microcontroller, a motor driver circuit, and position sensors. The position sensors provide the microcontroller with information on the position of the module, either in the back of the wheelchair or in the side of the chair. The microcontroller provides the direction and the Pulse Wave Modulation (PWM) required to drive the motor through the motor driver circuit.

To ensure that the module is capable of moving and carrying 25 pounds of book bag loads, one inch steel tubing is used to create the backpack retriever arm.

The cost of the project was $785.

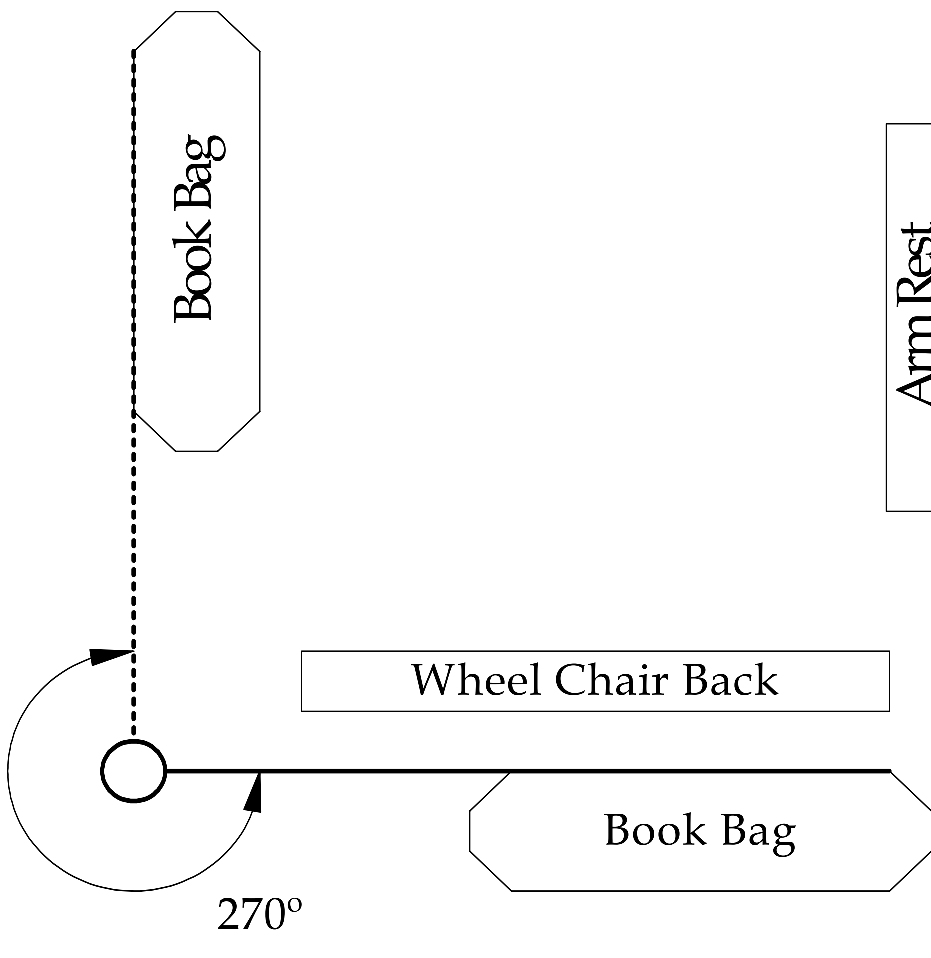

Figure 17.34. Backpack Retriever Arm Movement.

TRAY PLACER

Designer: Javier Santiago
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Supervising Professor: Dr. John Enderle
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INTRODUCTION

The Electronic Tray Placer places a surface in front of a client seated in an electric wheelchair. Once the tray is in place, the client elevates the angle of the tray to his liking, up to 20°. Currently, the client relies on assistance from others to place and remove a tray from his wheelchair. This tray is non-portable. The Tray Placer is designed to provide the client with a surface that is removable. Wheelchair size prevents the client's access to any table or desk. The tray is mounted on the right side of the wheelchair (Figure 17.35). The arm rotates 180°, swinging from the 'Store' position to the 'Upright' position. The client then manually lowers the tray placing it in the 'Ready For Use' (Figure 17.36). The angle of the tray surface is now ready for adjustment. Tray Placer control is accomplished via a wired remote control.

SUMMARY OF IMPACT

Due to the disabilities resulting from a tragic accident, the client relies constantly on the assistance of others to accomplish common and routine tasks. The design of the Tray Placer provides the client with a higher degree of independence. Therefore, operation of the module by the client is the most important factor in the design of the Tray Placer module.

TECHNICAL DESCRIPTION

The Tray Placer is designed to address the needs of a specific client. However, this module may be used with other motorized wheelchairs. The module is mounted to the frame, under the right armrest. It is fastened by a horseshoe clamp and bolts. The Tray Placer module consists of three parts: the custom designed tray, the 24Volt DC motor, and the circuitry.

The client operates the Tray Placer module through a wired remote control. The client can bring the tray to an accessible position by pressing the button labeled "Tray" on the remote control. Once the tray is accessible, the client lowers the tray into the 'Ready For Use' position (Figure 17.35). Adjusting the angle of the tray is accomplished through the use of a linear actuator. Pressing the "Up" button on the controller increases the tray angle while pressing "Down" decreases the tray angle. The linear actuator

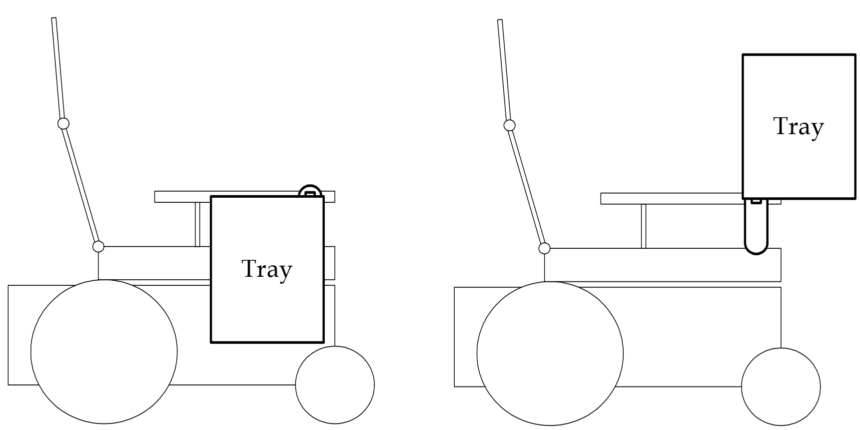

Figure 17.35. a) Tray Placer in Store Position, b) Tray Placer in Upright Position.

has built in limit switches to prevent the device from over- extension or retraction. Pressing the "Tray" button once more will move the tray to the store position, on the right side of the wheelchair. However, the tray will not try to return to the 'Store' position if the tray is currently in the 'Ready For Use' position. This is intentionally done to prevent damage to the module.

All positions and direction of motion of the module are determined through limit switches, which electrically feed signals directly to a microcontroller. The motion of the Tray Placer is accomplished with the use of the microcontroller, a motor driver circuit, and position sensors. The microcontroller provides the direction and the Pulse Wave Modulation (PWM) required to drive the motor through the motor driver circuit.

The cost of this project was $525.

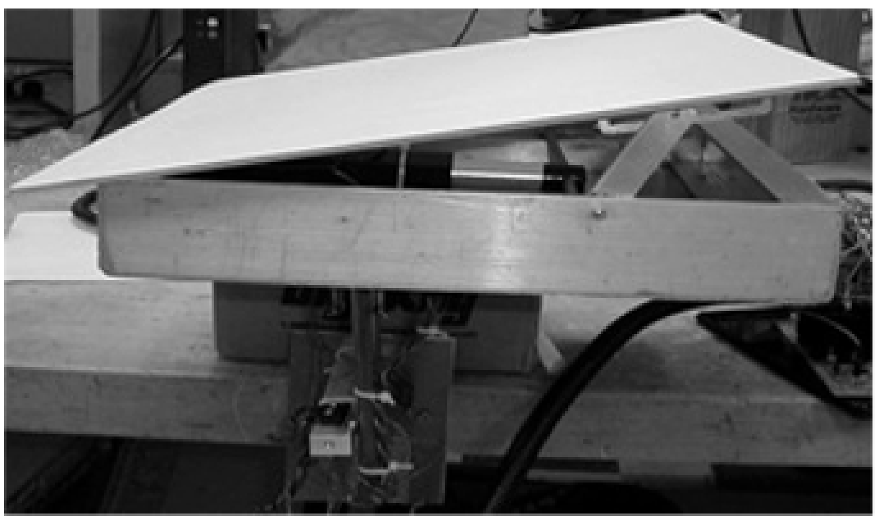

Figure 17.36. Tray Placer.

FRONT WHEELS MAGIC

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INTRODUCTION

The aim of the project was to design a device that allows a patient with reflex sympathetic dystrophy syndrome (RSDS) to adjust the front wheels of her wheelchair easily, with no need to move her body, while minimizing vibrations. The device (Figure 17.37) is affordable and comfortable. It is removable in order to not affect any other parts of the wheelchair.

SUMMARY OF IMPACT

This project is designed to help a specific individual control the front wheels of their wheelchair without the need of any extra strength or external aid.

TECHNICAL DESCRIPTION

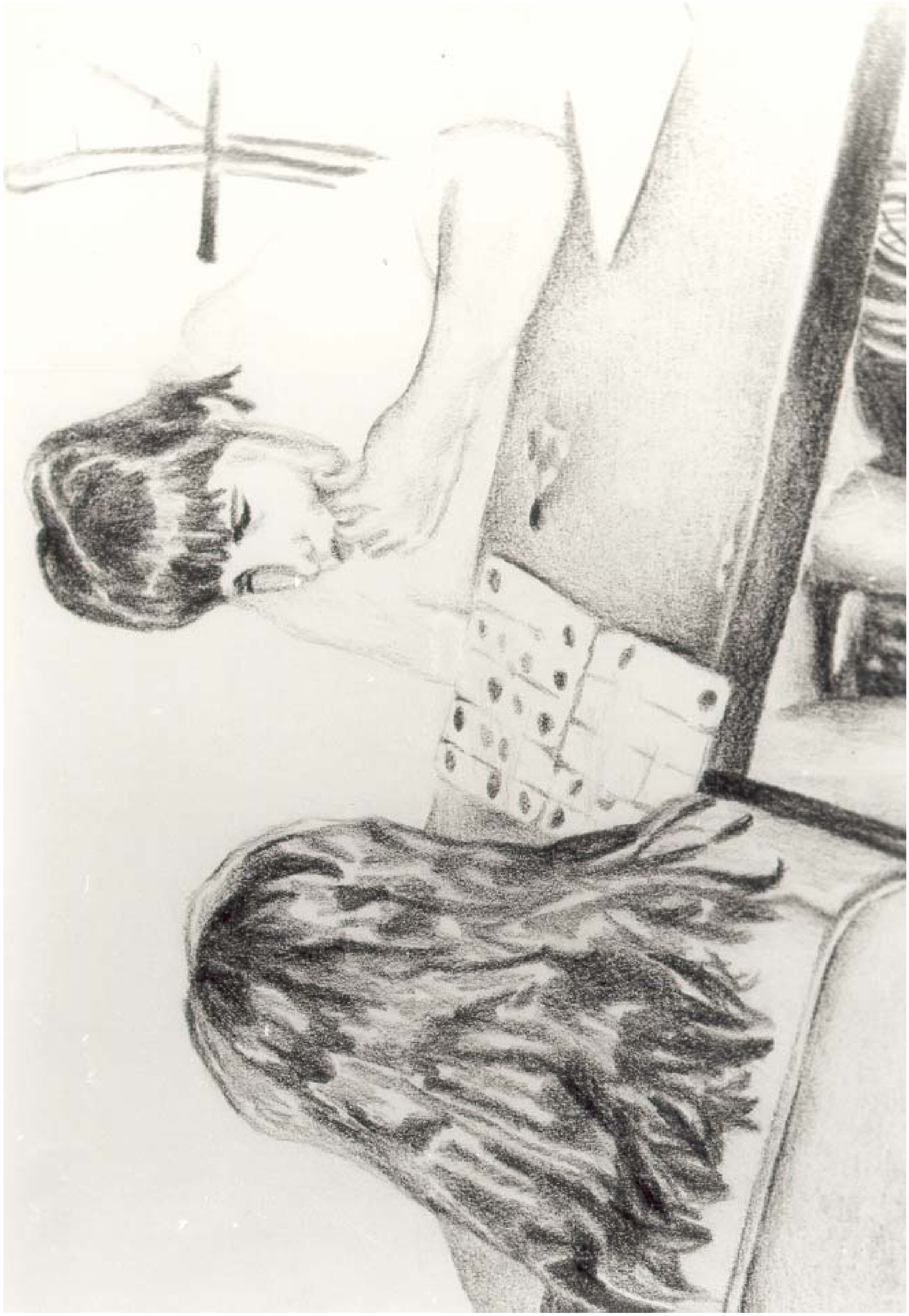
Many factors are considered in the design such as weight, material consideration, user friendliness, and cost.

The device is composed of two similar components, each of which includes three major parts: the linear actuator, the toggle switch, and the mechanical assembly (including a cylinder and handle).

There is one mechanical assembly for each individual front wheel. This device functions by using the toggle switch as the signal generator This device is designed to help the client adjust her front wheels when they get locked in a 0/180 degrees. A simple touch switch by the client allows +12 volts to go through the linear actuator pushing the wheels inside. By touching the switch again, an opposite voltage will go through, forcing the linear actuator to pull the wheels to the outside.

The total cost of this device is approximately $330.

Figure 17.37. Front Wheel Controller Attached to the Wheelchair.



CHAPTER 18
UNIVERSITY OF MASSACHUSETTS AT AMHERST

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LATERALLY EQUALIZED, SELF FEATHERING SCULLING OARS

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INTRODUCTION

The purpose of this project was to facilitate access to recreational rowing for users who have difficulty operating a conventional pair of oars. The basic design objectives include the oar to be self-feathering and laterally equalized. Additional considerations include existing adaptive solutions within the canoe and the rowing shell.

A crank-arm at the oar grip and a modified oarlock promote the self-feathering function. During the pull stroke, the crank-arm aligns with the direction of pull, moving the oar-blade perpendicular to the water surface. During the return stroke, the user pushes down and forward causing the oar-blade to rotate to a position parallel to the water surface. The oars are joined grip to grip by a flexible universal joint and are forced to move in unison. Consequently, the user's stronger arm assists the weaker arm. The power delivered to the water is the same on either side of the rowing shell.

SUMMARY OF IMPACT

The physical benefits from exercise and success in a physically taxing endeavor may improve the user's self image. The design is simple in concept and readily adaptable to any rowing shell as modifications to the boat end at the oarlock socket. A limitation of this design is that the flexible universal joint impairs the user's ability to turn the shell by rowing on only one side of the shell. Thus, the lateral equalization feature is only useful if applied when a second user steers the shell or when a separate rudder system steers the shell.

TECHNICAL DESCRIPTION

The primary components of the design include the following: an offset grip affixed to the inboard end of the oar shaft, a stepped shaft collar at the oar or oarlock interface, an oarlock with a stop cleat feature and a removable elastomer universal joint between the oar grips. The oars used are standard 2.9-meter delta models manufactured by Alden Rowing Shells.

Figure 18.1. Oars Prototype.

The offset grip feature (Figure 18.2) causes the oar shaft axis to rotate about the oar blade perpendicular to the water during the pull stroke and parallel to the water during the return stroke. The grip itself is free to rotate within the crank-arm. Thus, the user does not need to turn his or her wrist to feather the oar. Rotation of the oar during feathering is constrained to 90° by the interaction of the stepped shaft collar and the oarlock stop cleat (Figure 18.3). The universal joint is an elastomer tube that constrains the oars to move in unison equalizing the energy to each oar. The joint is connected to the grip by means of a detent button within an aluminum tube that slides into the end of the oar grip (Figure 18.2). The inboard end of the aluminum tube is fixed within the elastomer tubing by a friction interface. Materials for the grip or crank-arm assembly, oarlocks and universal joint connection are machined 6061 aluminum and 304 stainless steel. The stepped cleat is constructed of UHMW polyethylene. The universal joint is formed of thick wall natural rubber tubing.

The cost is approximately $425.

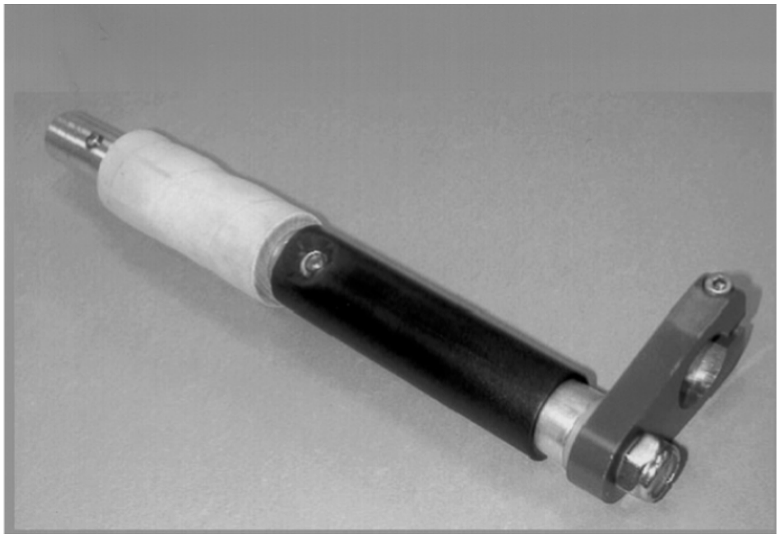

Figure 18.2. Offset Grip/Universal Joint Assembly.

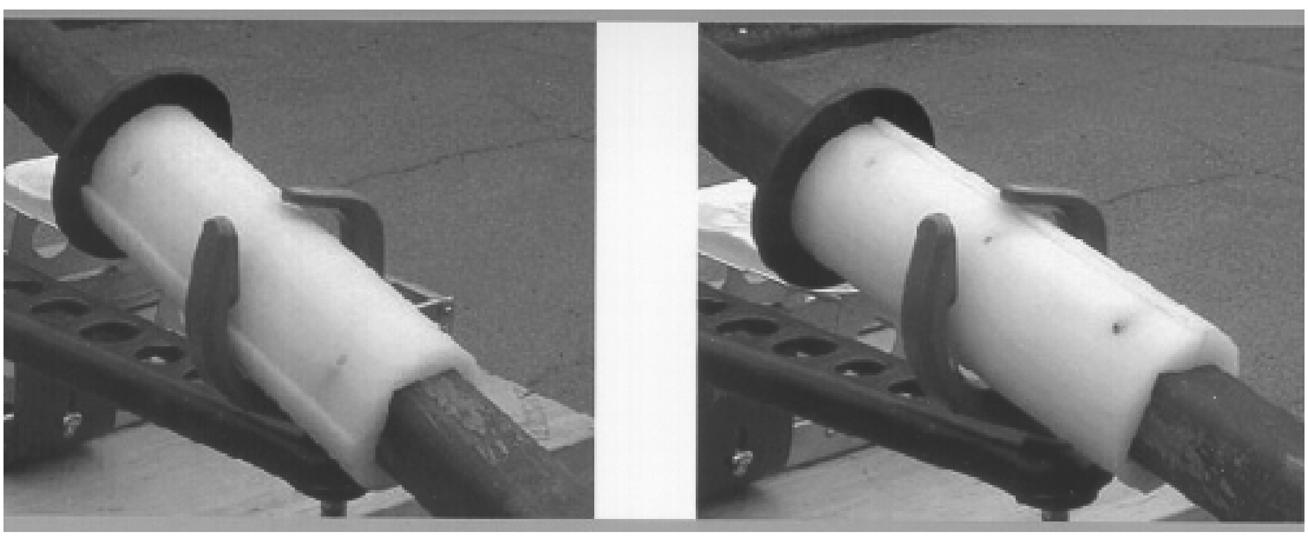

Figure 18.3. Shaft Collar/Oarlock Interface.

PERSONAL STANDING AID

Designers: S. Bousquet, E. Hoffmann, and D. Sirois
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INTRODUCTION

There are several lifting devices available on the market to facilitate standing among the elderly. A current device, often called a transfer lift, uses a large rolling crane structure with a cloth seat. This large device lifts a person by means of hydraulics or motors. These devices are expensive and inconvenient to use in a private residence. The objective of this project was to design a new lift for use in the home.

SUMMARY OF IMPACT

The average cost of a transfer lift is about $2500. In addition to being costly, these lifts are large and cumbersome to use. The new standing aid design is a compact, lightweight and inexpensive device. By virtue of the simplicity in design, it is easy to operate and portable.

TECHNICAL DESCRIPTION

The device is 3′ tall and 2′ wide (Figure 18.4). Two triangular supports are connected by a 2′ long hollow tube, as in a sawhorse design. The Cambridge Engineering Selector software facilitated the material choice of wrought aluminum alloy. A pair of cables runs from the cloth seat to the pulleys on the outside of each triangular support and ends at the cable drums. The motor is connected to the gearbox that powers the cable drums to lift the seat. The tube has a diameter of 1-1/4″. The motor mounting plate is made of a 6″x8″x1/4″ plate with holes pre-drilled to mount the motor. These materials were welded together to create the frame of the lift. The gearbox is made of two 6″x6-1/2″x3/8″ plates with several holes drilled through them for the gear shafts. Co-axle drums were used (Figure 18.5).

The mounting for the outside pulleys was altered to ensure convenient size and storage. Two bars hold the two pulleys on opposite sides of the lift. These bars are held in place by two ¼″ hardened bolts, allowing the pulleys to be removed when not in use (Figure 18.6).

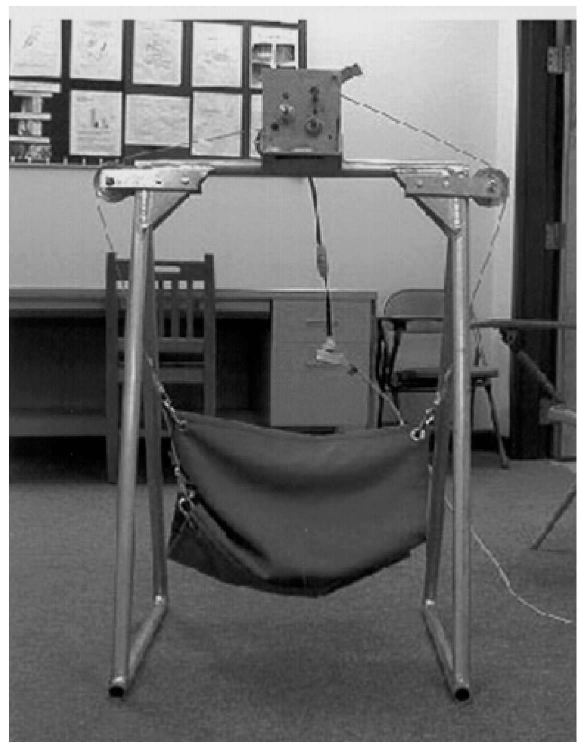

Figure 18.4. Personal Standing Aid.

The seat is made of a double layer of a canvas and polyester blend for strength and comfort. The cables that run from the gearbox are each split into three sections at the bottom, all with a small carabineer clip. These clips are attached to the grommets in the seat.

A limitation with the prototype is the amount of warping in the metal from welding. This causes a larger amount of friction on the gear shafts than planned, significantly reducing the lifting power of the motor. A possible solution is constructing the motor plate to be thicker. Additionally, the following other suggestions may facilitate client satisfaction and safety. First, the motor should be placed on the ground to prevent it from being in the way of operation. Secondly, the lift should be placed on a set of wheels to aid mobility and to enable an alternate use as a temporary walker. If used as a temporary walker, a set of hand bars parallel to the two triangles near the top for sidebars is recommended. Finally, a slightly larger motor may benefit the lift in the design.

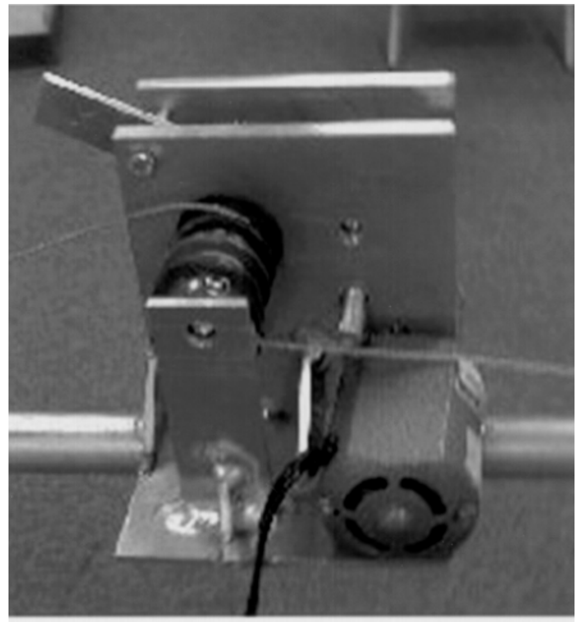

Figure 18.5. Gearbox and Motor Mount.

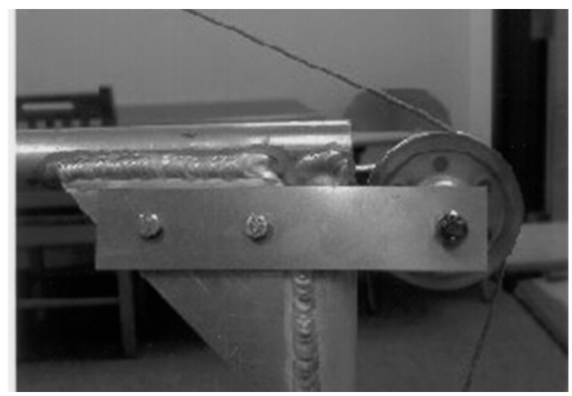

Figure 18.6. Outside Pulleys.

SMART PRESSURE SLEEPING BAG (SPSB)

Designer: Rajesh Luharuka
Client Coordinator: Community Resources for People with Autism, Easthampton, MA 01027
Supervising Professor(s): Robert Gao, Ph.D. & Sundar Krishnamurty, Ph.D.
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INTRODUCTION

Sleep disorders have often been reported in children with autism. Parents of children with autism often use weighted blankets, gym mattresses and similar products to apply deep pressure on their child while sleeping. Clinical research has shown that applying deep pressure to the body of a child with autism can have a calming effect.

SUMMARY OF IMPACT

Sensory integration is a much-practiced theory in treating children with autism. Temple Grandin's "Squeeze machine" (Figure 18.7) and weighted vests are popular products that provide deep pressure stimulation. However, there are no products currently available on the market that specifically address the sleeping disorder in children with autism. The proposed device will automatically control the pressure applied based on the physiological feedback (GSR) of the child.

TECHNICAL DESCRIPTION

The criteria for the design of the device include the following: safety, low noise level, uniform pressure distribution and high controllability. The device should apply pressure in the range of 0.01 to 0.50 psi. The physiological sensing system should be non-intrusive and robust. For functionality purposes, the device is divided into different modules. (Figure 18.8)

A mummy shaped sleeping bag was used, with a 1-inch thick foam padding replacing the "fill material" in the bag. An extra inflatable outer chamber is provided for pneumatic pressure application. A Galvanic Skin Response (GSR) sensor monitors the physiological state of the child in the sleeping bag. GSR is the result of changes in electric conductivity of the skin caused by an increase of sweat glands. The GSR of a person is low when one is asleep compared to when one is awake (Figure 18.9).

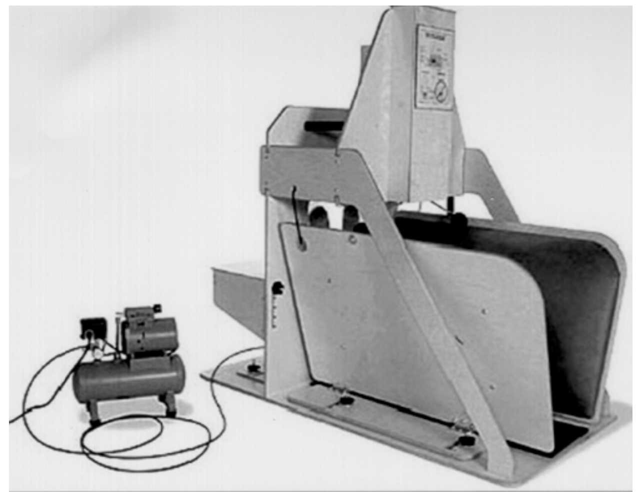

Figure 18.7. Temple Grandin's Squeeze Machine.

The control system receives inline pressure and physiological feedback and then processes the signals to control the pressure. The controller maps the physiological signal to the pressure required. The SPSB has a manual control option. A correcting algorithm to fine-tune the pressure to be applied will track the performance of the controller.

The estimated cost of this project is $5000.

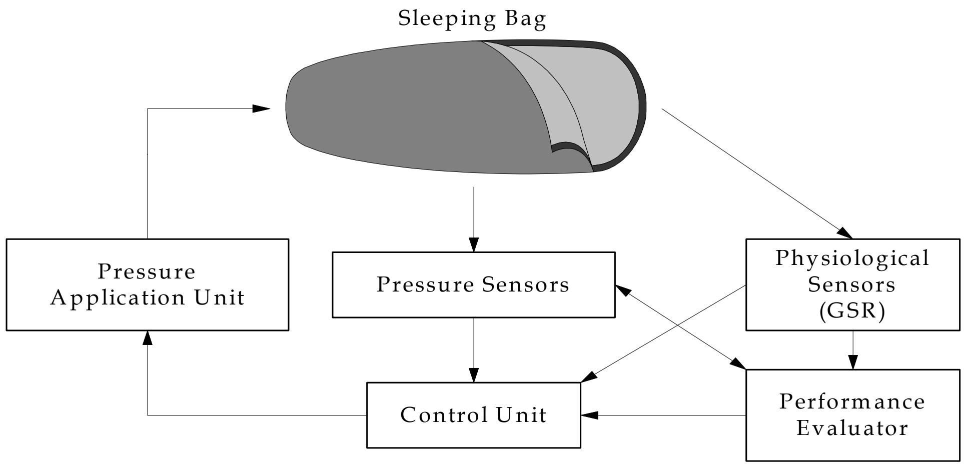

Figure 18.8. Schematic Diagram of the SPSB.

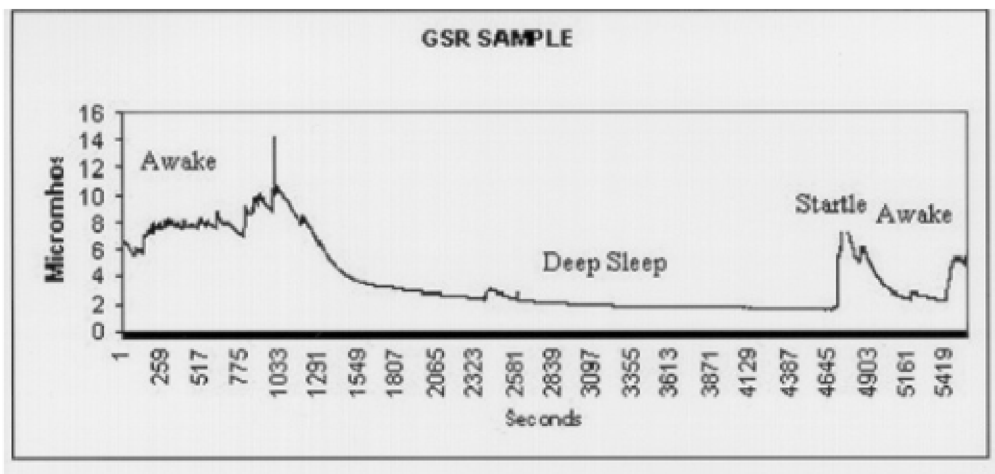

Figure 18.9. Sample GSR Plot of a Subject While Sleeping

WHEELCHAIR CUPHOLDER

Designers: J. Goyette, J. Barnes, and S. Poon
Supervising Professor: John E. Ritter, Ph.D.
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INTRODUCTION

A beverage cup holder for a wheelchair was designed to enable the user to move a chair freely even when the cup holder is in place. A cup holder that is both aesthetically pleasing and accommodating to several types of beverage containers is necessary.

SUMMARY OF IMPACT

Although trays are available for wheelchairs, there are no cup holders available on the market today. Unfortunately, the trays are not safe for use when the wheelchair is in motion. A beverage container may slide off of the tray, perhaps resulting in personal injury. The design can be easily adapted to other wheelchairs available on the market

TECHNICAL DESCRIPTION

One of the main objectives of the design was to have a cup holder that is visually appealing. Since it is difficult to determine exactly what type of disability the user might have, the cup holder was made to be lightweight and require a minimum level of dexterity (Figure 8.10). The Cambridge Engineering Selector software facilitated material selection and estimated cost. The cup holder was designed to withstand maximum bending and a torsion load of 20 lbs. (Figure 18.11) For most wheelchairs the armrests of the wheelchair are supported by a vertical or a horizontal metal tube of various diameters. Therefore, a universal tubing bracket that allows the user to attach the beverage holder to either the vertical or horizontal piping was used. The tubing bracket was attached to the beverage holder by means of the attachment knob on the mounting device. The material for the cup holder was a polymer that could be injection molded, Styrene Acrylonitrile.

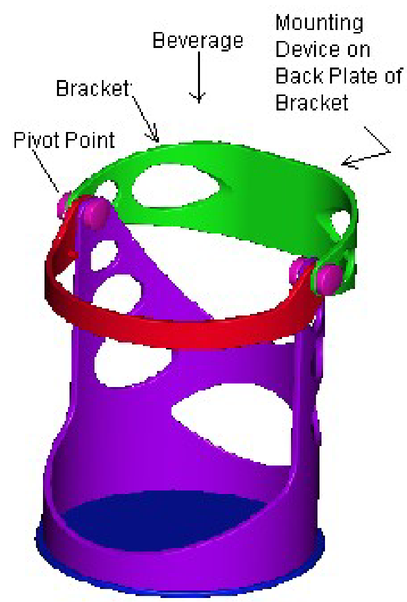

Figure 18.10. Solid Model of the Cup Holder Assembly.

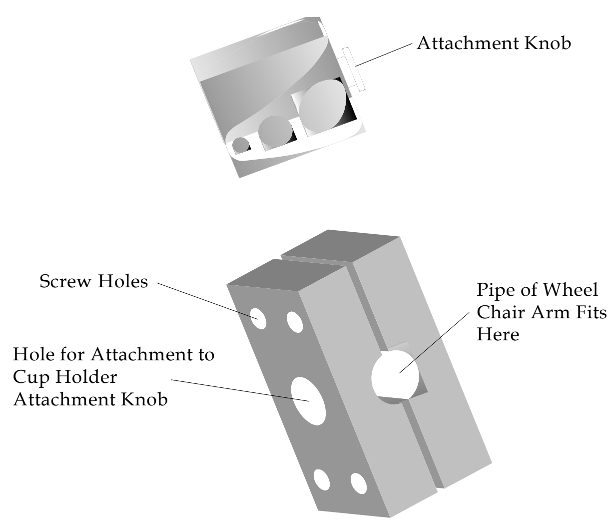

Figure 18.11. Mounting device and Bracket.

Figure 18.12. Prototype of the Cup Holder.

DOORKNOB EXTENSION

Designers: J. Chan, M. Ivy and J. Topor
Supervising Professor: John E. Ritter, Ph.D.
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INTRODUCTION

An existing doorknob extension design had deficiencies, including mounting difficulties, high cost, and lack of aesthetic appeal. The mounting problem was corrected and the cost was reduced dramatically in this project (Figure 18.13). The redesign was made out of polyvinyl chloride. The 6" long lever arm greatly reduces the effort required to open a door. A U-shaped semi-soft rubber foam grip allows the redesigned doorknob extension to mount on any standard doorknob.

SUMMARY OF IMPACT

A door handle extension helps persons who have limited use of their hands. Converting a doorknob into a lever greatly reduces the amount of effort needed to open a door. It would also benefit most persons in a wheelchair, or on crutches, in opening a door.

TECHNICAL DESCRIPTION

The current doorknob extension design is a rectangular shaped, machined finished metal (Figure 18.13). There are three screws around the periphery that secure the doorknob extension onto the knob. The screws are secured on to a plate behind the knob. The extension can be removed if need be, however, the three small screws and back plate make it difficult. Other limitations of the current design are as follows: First, the extension is not aesthetically pleasing; second, the hand can easily slip off because of the smooth surface; finally, the design has a set radius that accommodates only a small range of doorknob sizes.

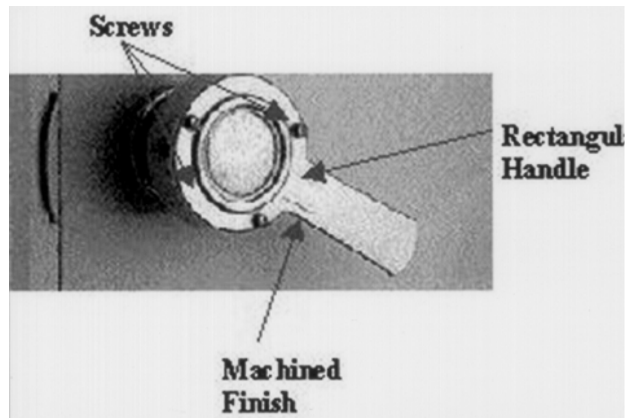

Figure 18.13. Doorknob Extension.

The objective of the redesign was to eliminate the limitations of the existing design. The proposed redesign for the doorknob extension can accommodate all standard size doorknobs. The inner part of the doorknob extension is a rubber, U-shaped foam that will grip to the existing doorknob. Also, only one screw is needed for mounting. This screw is on the bottom and can be easily accessed since no back plate is required. The rubber foam is attached to the inner part of the doorknob extension with an adhesive (Figure 18.15). A ring was added to the end of the handle to keep the user's hand from slipping The doorknob extension material chosen was polyvinyl chloride (PVC) and the process used is injection molding (thermoplastics).

The proposed design would cost about $5 if mass-produced. The existing doorknob extension costs $9.85

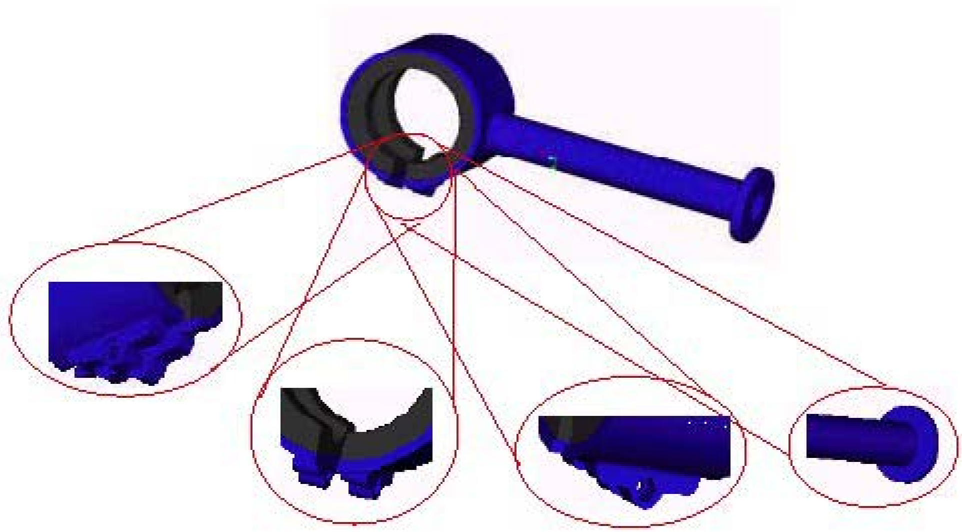

Figure 18.14. Solid Model of the Redesigned Doorknob Extension.

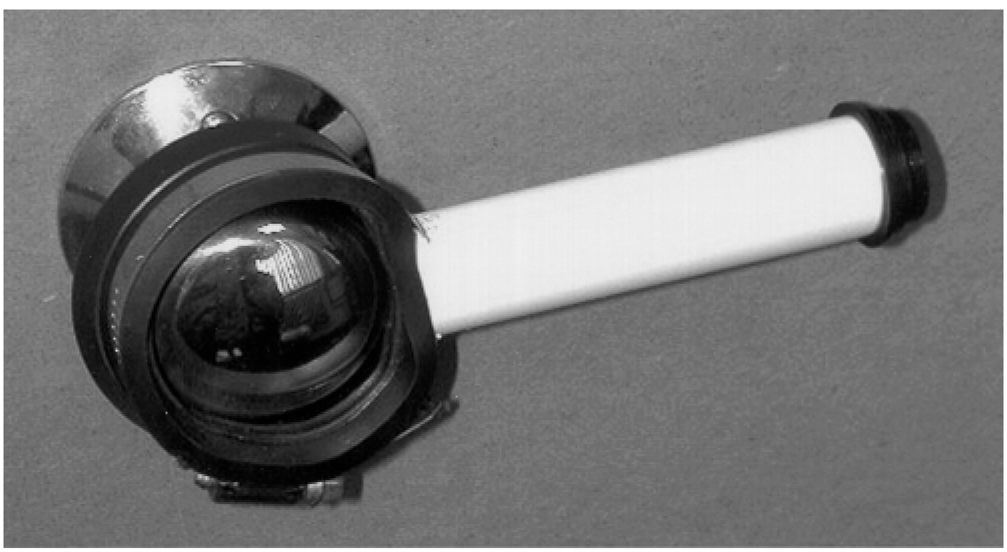

Figure 18.15. Redesigned Doorknob Extension.

PORTABLE INTELLIGENT DEEP PRESSURE VEST

Designer: Jeremy K. Paskind
Supervising Professor: Sundar Krishnamurty, Ph.D.
Department of Mechanical and Industrial Engineering
University of Massachusetts
Amherst, MA 01003

INTRODUCTION

Clinical studies have shown that the application of deep pressure (simulating a hug) around the upper body and shoulders of children with autism has a calming effect. A pressure vest is designed to provide children with autism with deep pressure stimulation around the upper body and shoulders.

SUMMARY OF IMPACT

One current product on the market that addresses deep pressure stimulation is a weighted vest. These vests apply static pressure onto the shoulders of the user at all times while being worn. Other large pressure devices also exist in limited quantity, convenience and economical cost. Each current design has major limitations in terms of effectiveness and/or availability.

The Intelligent Vest combines the portability of the weighted vests with the selective pressure application of the pressure machines. It applies deep pressure instead of static pressure, similar to the "Squeeze" machines.

TECHNICAL DESCRIPTION

Since the vest is to be worn on a regular basis, primarily by young children, one of the most important design considerations is its level of comfort. A bulky or otherwise annoying mechanical operation could render the design useless. Since children vary drastically in size, the design of the vest must be able to be replicated for each individual user, regardless of their physical dimensions. The vest should also be aesthetically pleasing.

The design uses air to fill up the space inside the vest, causing pressure to be applied to the abdomen and shoulders of the child. Common vests can be used, chosen in a variety of sizes to fit the majority of children in need. The system utilizes a diaphragm air pump with two three-way solenoid vales to inflate and evacuate the air from the vest (Figure 8.16).

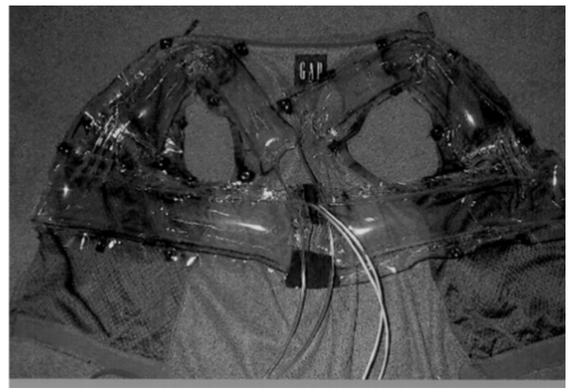

Figure 18.16. Model of Air Containment Tubes.

The "L" shaped air containment tubes are attached to the inside of a standard vest and covered with an additional layer of stretch material for added breathability and comfort. The top portion of each "L" inflates to apply pressure on the shoulders of the individual. At the peak of the shoulder, the tube is almost sealed so as to restrict bulging in this area while still allowing airflow between the two sides. The purpose of this "dead" space is to apply a squeezing sensation to the shoulder area. The bulge, due to inflation, only occurs on the sides of the shoulder, not on the top.

The bottom half of each "L" tube is connected to the other with elastic fabric. The tube then surrounds the torso when worn, just slightly under the armpit of the child. The elastic allows for vest sizing error as well as pressure relief with the child's normal breathing. The pressure in the torso area is a result of the consumption of extra space inside of the vest.

The inflating and deflating processes of the vest is accomplished using a standard medical DC diaphragm pump. Both processes are controlled using two, three-way solenoid pneumatic valves. Each component will be run at 6 volts, a standard voltage available for both the pumps and the valves. The current model used a 120-volt AC current (for simplicity) to run the pump and is manually controlled (Figure 8.17).

The GRS device will be used in the final design to monitor the child's level of excitement and activate the pressurizing vest automatically. A small computer chip will be used to interpret the GSR output and signal for the activation of the pump and valves as needed. Override buttons will be built in to increase or release pressure upon desire of the child.

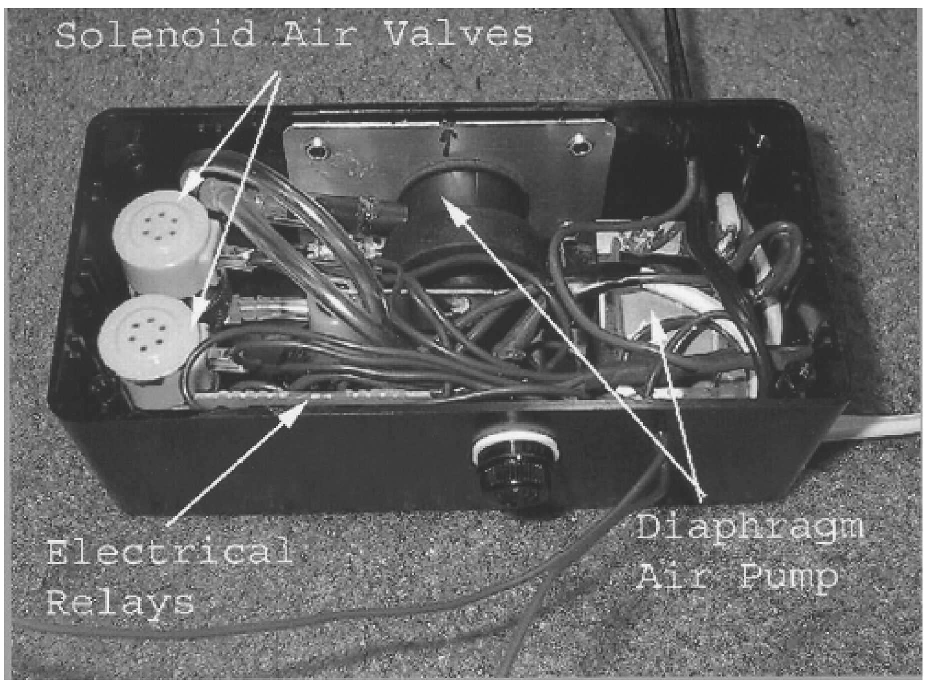

Figure 18.17. Vest Inflation Module.

BICYCLE TORSO SUPPORT

Designers: R. Melnik, S. Ferguson, and D. Fitzgerald
Supervising Professor: John E. Ritter, Ph.D.
Department of Mechanical and Industrial Engineering
University of Massachusetts
Amherst, MA 01003-3662

INTRODUCTION

A bicycle torso support was constructed to alleviate shoulder stress during bicycle operation. Decisions regarding the construction of this apparatus were based upon direct input from the client, a 6'1" male, who weighs 220 lbs. Throughout project development, various body and bicycle measurements were to ensure that the apparatus may be used by individuals of different heights and builds.

The design is a torso support that attaches to the top crossbar of an existing bike frame. This allows the user to rest his upper body weight on the two chest supports instead of using his arms. Wrought aluminum alloy was chosen as the material for the torso support and the optimal process selected for manufacturing of the torso support was extrusion with a series of secondary processes.

SUMMARY OF IMPACT

Shoulder stress after participating in competitive sports may cause severe cartilage and ligament damage. This damage may impede an individual's ability to ride a bike. An apparatus to support an individual's body weight is thus essential. This device can be attached to a client's current bicycle. The torso support directly addresses support to the client's upper body, alleviating shoulder stress.

TECHNICAL DESCRIPTION

The design criteria were that the torso support:

- Be aesthetically pleasing,
- Not deflect more than 0.75" during normal operation,
- Not exceed 10 lbs, and
- Service a maximum weight of 250 lbs.

A device (Figure 18.18) that mounts to the top crossbar of the frame of the bike was developed. Flexibility was incorporated into the design to permit use by various individuals. A shock absorber device is used to offer adjustment by telescoping from the main shaft. A standard quick release bicycle seat clamp is used to lock the torso support at the desired height. Two members extend from the

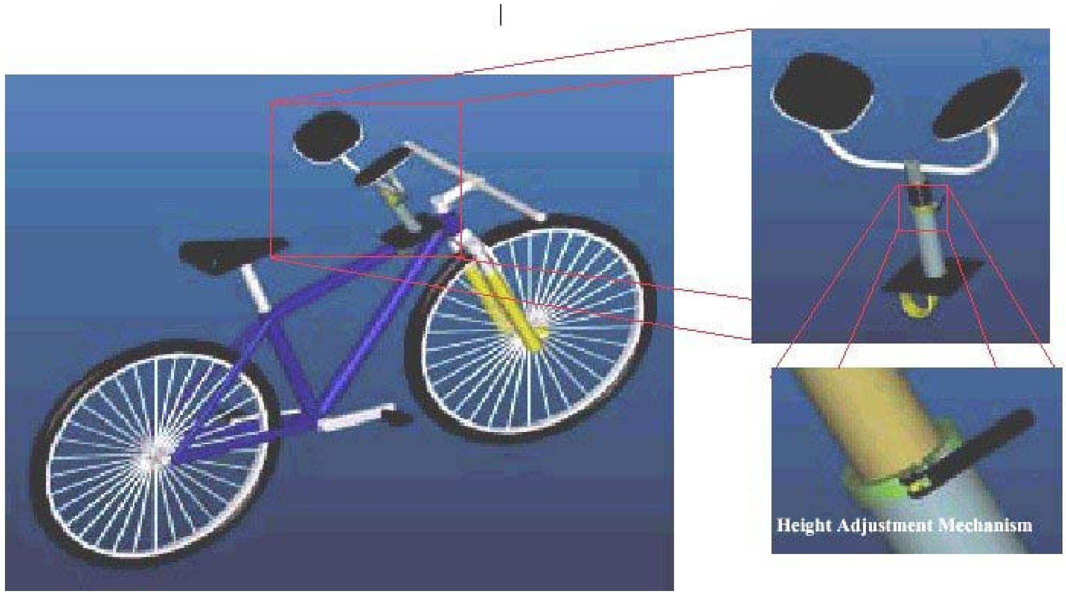

Figure 18.18. Solid Model of Torso Support for a Bicycle.

top end of the telescoping shock absorber. Each member carries one foam padded chest plate that can support the torso. The chest plates are attached using a ball and socket connection to allow for rotation (Figure 18.19).

Performance indices were derived to maximize strength while minimizing mass and deflection under full load. Using these performance indices, the Cambridge Engineering Selector (CES) software was implemented to select an optimal material that would also be consistent with those used in current bike manufacturing. The material selected was wrought aluminum alloy. The CES Process Selector was also used to determine the manufacturing process, extrusion.

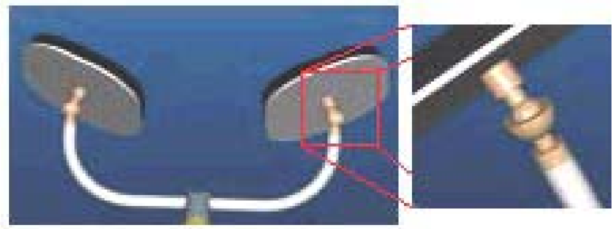

Figure 18.19. Ball and Socket Connection.

The cost was $85 per completed assembly.

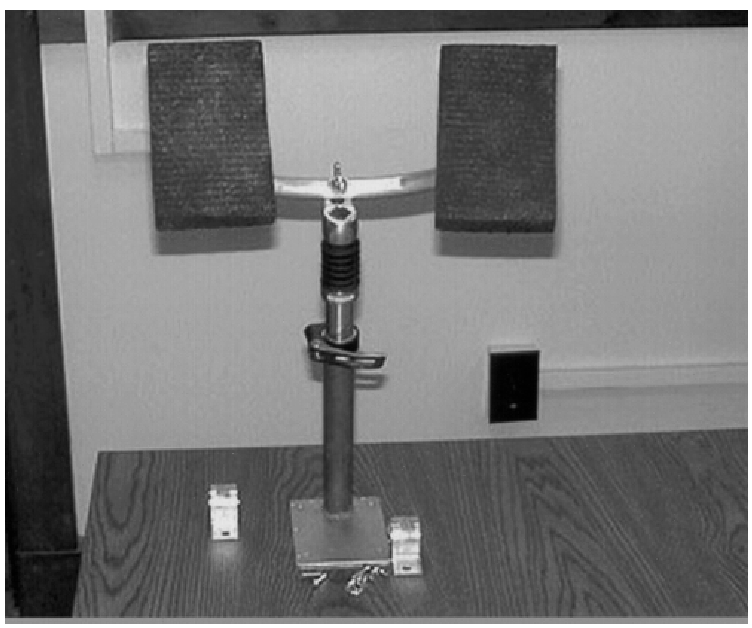

Figure 18.20. Prototype of Torso Support for a Bicycle.

ADJUSTABLE TOILET SEAT

Designers: J. Cashman, J. Sullavan, and A. Huseinovic
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INTRODUCTION

Existing raised toilet seats (RTS) for individuals with disabilities function well, but can be expensive, difficult to use, and unattractive. In addition, existing RTSs have several flaws in their design. By increasing the functionality of the existing RTSs, a new RTS was designed. Based on engineering analysis and use of the Cambridge Engineering Selector (CES) software, a new design was developed.

SUMMARY OF IMPACT

Most of the current RTS designs do not allow for height adjustment. The designs that do have adjustable height features use screw systems and adjustable legs, which are clumsy and inefficient

In this new design, an RTS is made of high density polyethylene (HDPE). For a production run of 100,000 units or more, injection molding would be the best manufacturing process. The new design uses simple seat raisers that can be snap fitted to the toilet seat to adjust height.

TECHNICAL DESCRIPTION

The following specifications were implemented into the design to maximize function and robustness:

- Total weight less than 5 lb,
- Minimum life span of 20 years,
- Maximum load on the seat of 450 lb, and
- Varying heights (1, 3, and 5 ").

The objective of this redesign is to develop a RTS that is lightweight, inexpensive, sturdy, and aesthetically pleasing (Figure 18.21).

The design has four seat raisers to adjust the height of the toilet seat and ensure stability (Figure 18.22). The raiser is snap fitted into a channel on the bottom side of the toilet seat. Three different raisers were designed for three different heights (1", 3", and 5"). Finite element analysis was carried out using COSMOS/Works® software on the critical components of the proposed seat design with a load of 2000 N (440 lb person) acting on the seat, with the top area of the raisers. The analysis clearly showed that the model is designed with an overall Factor of Safety 2.11, confirming the HDPE material choice.

The weight of the seat is about 3.5 lb. As previously mentioned, injection molding was the selected process of production. Additional details that should be considered in improving the RTS are as follows:

- Adhesive rubber pads on the bottom of the raisers to minimize shifting,
- Additional raisers to achieve greater variations in height adjustment,
- A splashguard to fit on the bottom of the RTS, and
- Colors to maximize the aesthetics of the RTS.

The cost of each unit is about $20.

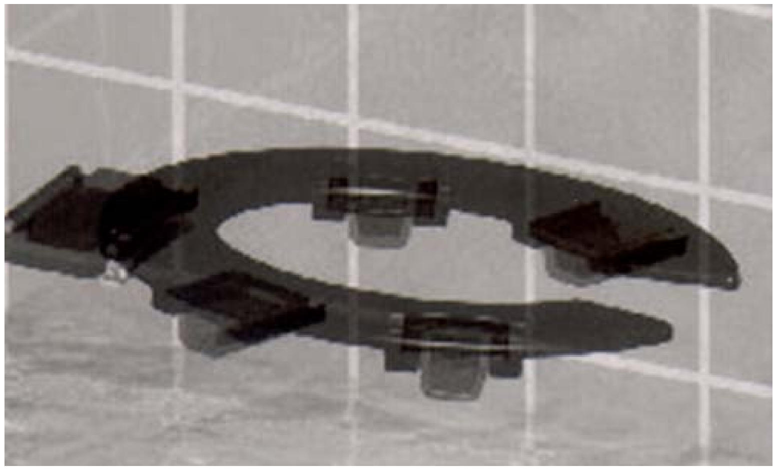

Figure 18.21. HDPE Adjustable Toilet Seat.

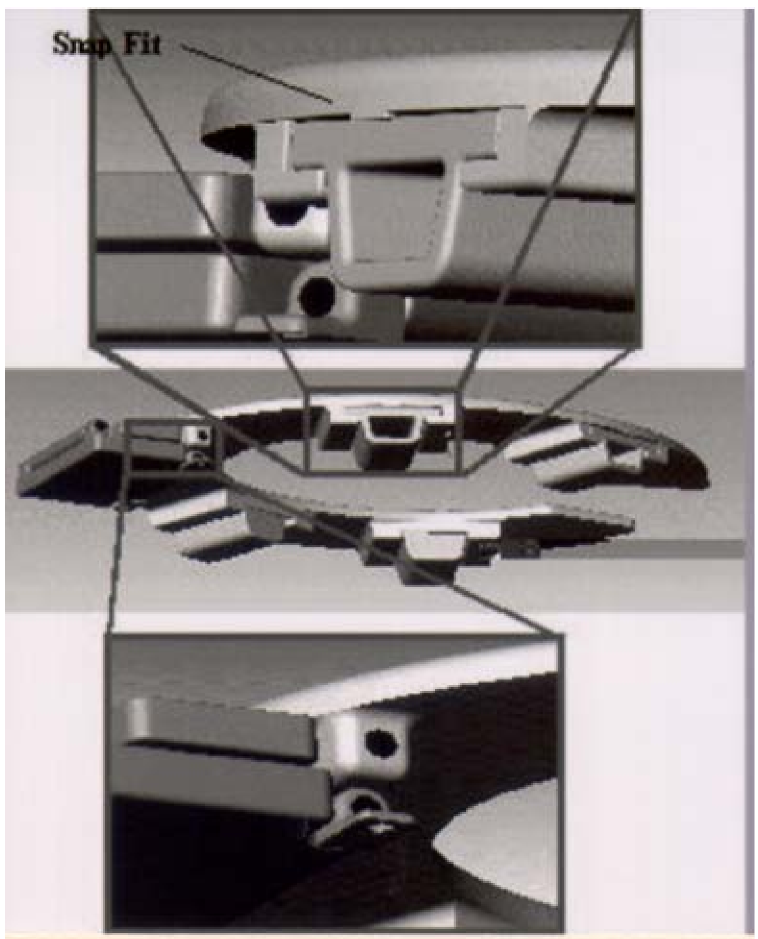

Figure 18.22. Raiser and Seat Attachment Assembly.

QUICK-RELEASE FOLDING CRUTCH

Designers: B. Jones, K. Connoy, and E. Warren
Supervising Professor: John E. Ritter, Ph.D.
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INTRODUCTION

The main disadvantage of the standard underarm, laminated wood or aluminum crutches is the fact that they are awkward to use and to store. The only full height, collapsible underarm crutch design available on the market today is telescopic in nature and retails for about $180. By comparison, standard crutches retail for about $20 to $30.

An aluminum crutch was designed that could be folded into thirds to allow the user to fit it into a gym bag. By constructing the folding crutch out of standard extruded aluminum tubing and using only off-the-shelf items, the increase in cost as compared to that of standard aluminum crutch is relatively small, while the value added is quite substantial.

SUMMARY OF IMPACT

A standard underarm, laminated wood or aluminum crutch cannot be easily stored. All current collapsible, underarm crutches are telescopic and expensive. An inexpensive, collapsible and storable crutch is in order.

TECHNICAL DESCRIPTION

The objective of this project was to design an aluminum crutch that could be folded into thirds. This value addition was to be implemented without any compromise to the stiffness of the standard underarm crutch (Figure 18.23).

The crutch pivots about two pins (P) that have threaded ends secured with a lock-tight nut. The release mechanism is a push button or detent pin mechanism (Figure 18.24). The button is pushed down against the spring, which pulls the detent pins out of their respective holes, thus unlocking the middle frame from the lower frame. The lower

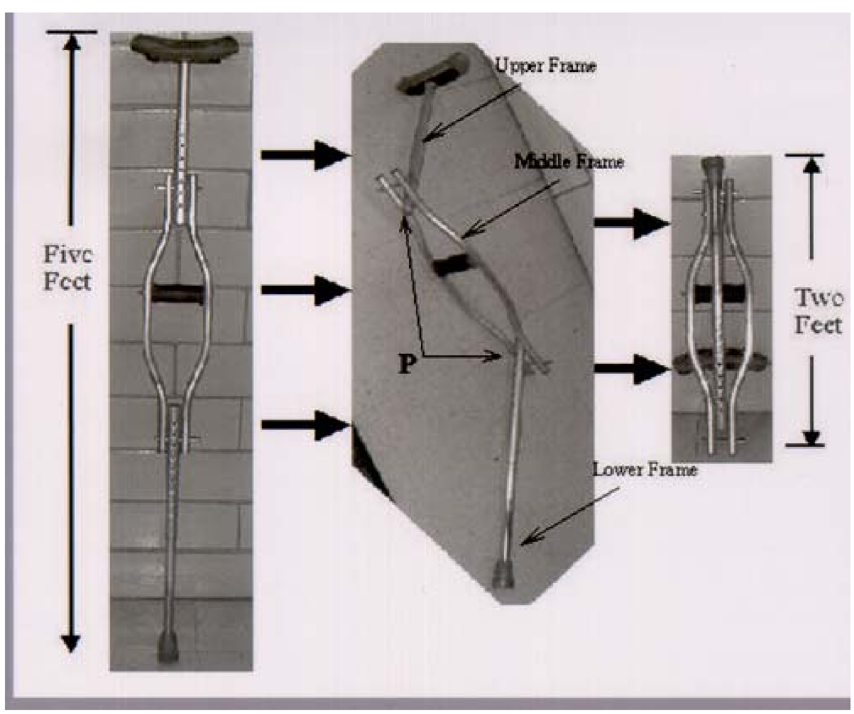

Figure 18.23. Folding Crutch.

frame is then free to pivot about the pin and, subsequently, be folded. The push button requires little effort to retract the detent pins fold the crutch. When the crutch is unfolded, the detent pins are simply pushed back into their holes, locking the crutch into an upright position. The same mechanism is used for the second fold between the middle and the upper frame.

The prototype design was as stiff and reliable as the standard aluminum crutch, while having the distinct advantage of convenient storability.

The fold-up aluminum crutch costs less than $10.

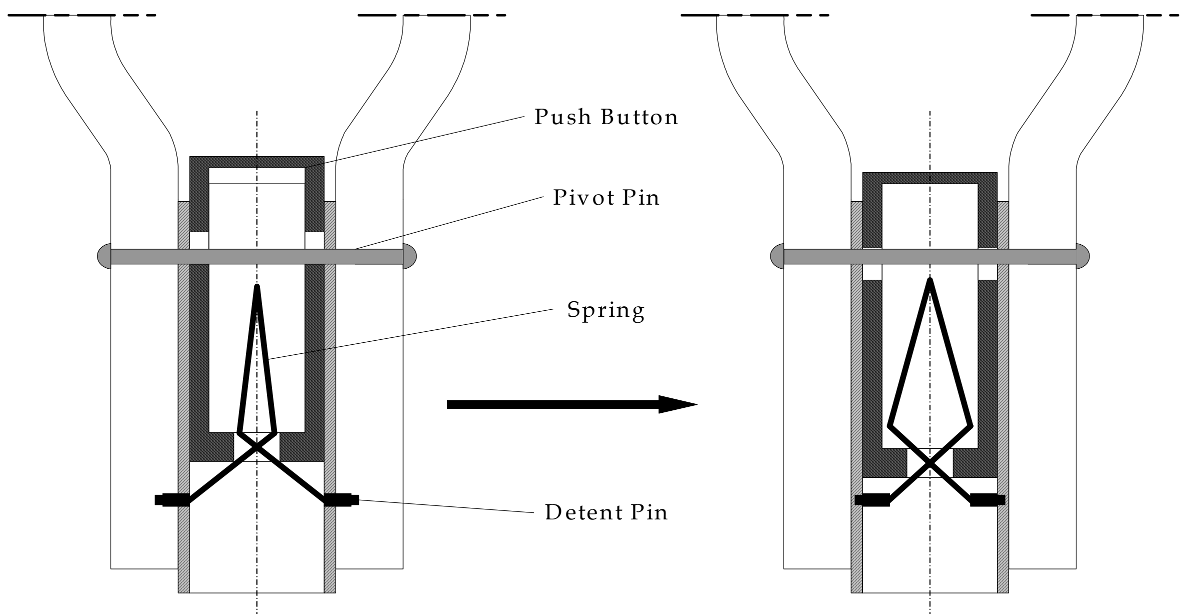

Figure 18.24. Locked and Unlocked Position of the Release Mechanism.

ONE-HAND DISHWASHING AID

Designer: Kirk P. Pitta
Supervising Professor: Janis Terpenny, Ph.D.
Mechanical and Industrial Engineering Department
University of Massachusetts
Amherst, MA 01003

INTRODUCTION

Currently, there are no products available that assist individuals with one hand in cleaning dishes. Due to the concepts available for washing glassware with one hand, the project focus was narrowed to accommodate plates. The selected design configuration is a holder for two commercially available brushes.

SUMMARY OF IMPACT

This design will enable people with one functioning hand to wash plates without experiencing shoulder pain. In addition, the device may be able to accommodate other dishes or utensils if they fit between the brushes. The device represents the beginning of a solution to washing dishes without a dishwasher. However, there are some improvements that could be made to the device. The next step would be to incorporate the design with solutions for other types of dishware to provide a more complete solution. For example, the design could be integrated with a version of a glassware design used by bartenders (Figure 18.25).

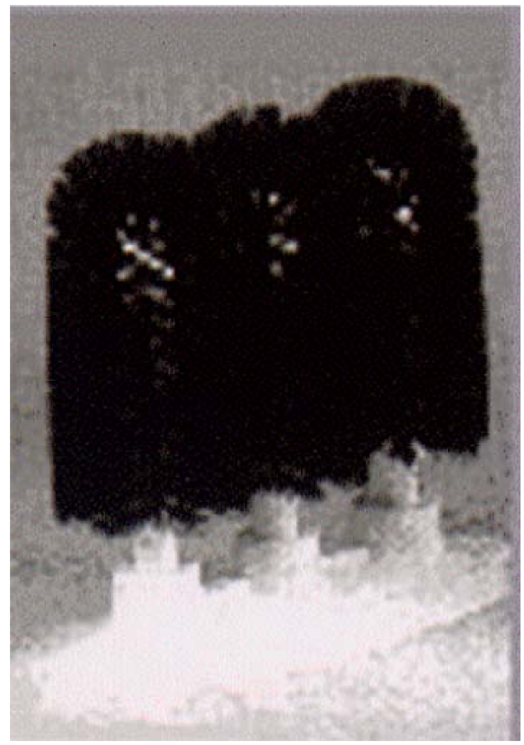

Figure 18.25. Bartender's Glass Cleaning Device.

TECHNICAL DESCRIPTION

After review of several design alternatives, the brush holder (Figure 18.26) was selected because it accommodates a large range of plates, is easy to use, is simple in design, and is low in cost. Force analysis demonstrated that the design could withstand the expected loads from cleaning plates. This loading situation was modeled as a cantilever beam in bending. Finite Element Analysis verified the hand calculations from a force body diagram. In addition, force analysis was conducted on the suction cups. This proved that the suction cups could withstand an expected loading without dislodging.

Selection of materials included consideration of cost, weight, stiffness, and resistance to water. The CES software facilitated the material selection process. Six grades of lower-grade engineering polymers were selected along with ABS in the event that a consumer desires to clean the device in the dishwasher. Ranges for the variables of tolerance, roughness, and aspect ratio were specified. The process of thermoplastic injection molding was selected by CES in order to use multi-cavity molds in a high production environment (Figure 18.27).

The cost per unit is $8.87.

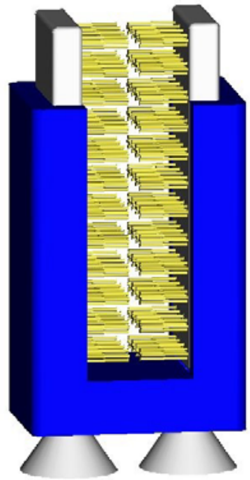

Figure 18.26. Brush Holder Device.

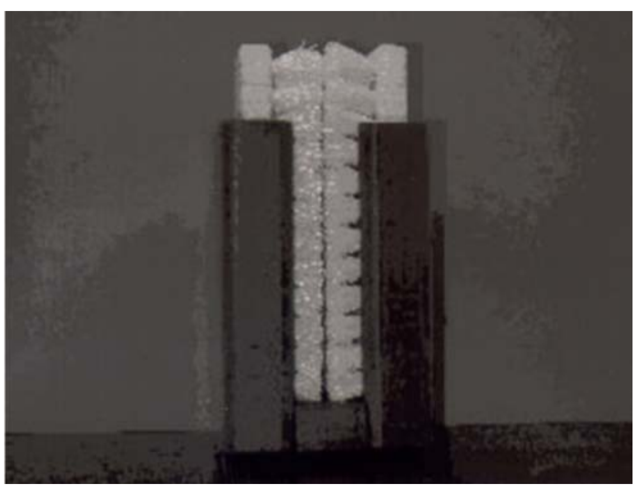

Figure 18.27. Prototype of the Brush Holder Device.

ONE-HANDED BOTTLE OPENER

Designers: G. W. Matsumoto, N. H. Veilleux, and R. D. Yazbeck
Supervising Professor: John E. Ritter, Ph.D.
Department of Mechanical and Industrial Engineering
University of Massachusetts
Amherst, MA 01003-3662

INTRODUCTION

A one-handed bottle opener was designed for an individual with a weak or amputated hand. From a material and processing analysis using the Cambridge Engineering Selector software, a design was developed that uses wrought austenitic stainless steel as the material and stamping as the manufacturing process of choice.

SUMMARY OF IMPACT

Currently, existing bottle openers require the use of both hands to effectively open a bottle. Although one-handed bottle openers are available on the market today, they require permanent attachment to a wall or kitchen counter. The goal of this project was to create an innovative design that would require only the use of one hand while still being inexpensive and portable. With a one-handed bottle opener the user slips the bottle opener on the bottle with one hand and then with the same hand supplies the force necessary for the cap release.

TECHNICAL DESCRIPTION

Design criteria for the one-handed bottle opener include that it be able to withstand the bending forces necessary to pry a cap open, be small and lightweight, and be inexpensive. Additionally, since it will be exposed to liquids the material must have good corrosive resistance.

The operation of the bottle cap opener is simple (Figure 18.28). The user simply positions the bottle opener in the same way as a standard two-handed opener by allowing the "lip" of the bottle cap to be above the notch (Figure 18.29) while the first bend stage rests on top of the bottle cap. Once positioned, the handle acts as a counterweight to allow the bottle to remain in its required position of operation. The user simply applies a force on the plastic-coated handle with his or her fingers while using their thumb to apply a minimal force on the other end to ensure that the notch of the bottle opener is always under the "lip" of the cap. Once the bottle is opened, the opener remains in the hands of the user instead of falling on the floor (Figure 18.30). The moment required to pry the cap off a bottle was determined from wheatonsci.com to be 1.01 N-m. Given the established moment and the length of the bottle opener, a force of 15.3 N was needed. Also, in order to achieve a stiff and robust bottle opener with a quality feel, a maximum deflection of 5 mm was specified during its operation.

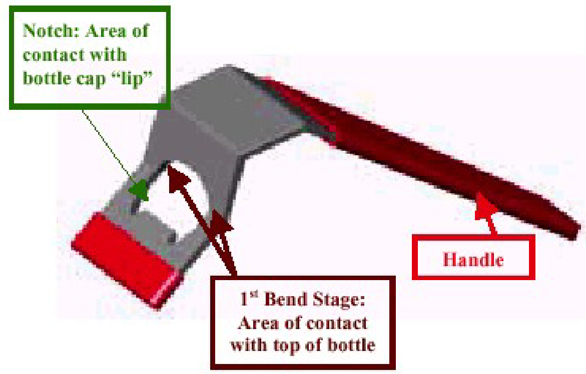

Figure 18.28. Solid Model of One-Handed Bottle Opener.

The plastic coating on the handle allows for an easier grip and enhances the aesthetic appeal of the opener. It is available in multiple colors.

On cost analysis, stamping was found to be the most cost effective process to produce the bottle opener at a volume of 100,000 units. The final material selection was decided to be wrought austenitic stainless steel. The weight of the one-handed bottle opener was calculated to be about 50 gm (Figure 18.30).

This design costs about $1.00.

Figure 18.29. Solid Model of Bottle Opener.

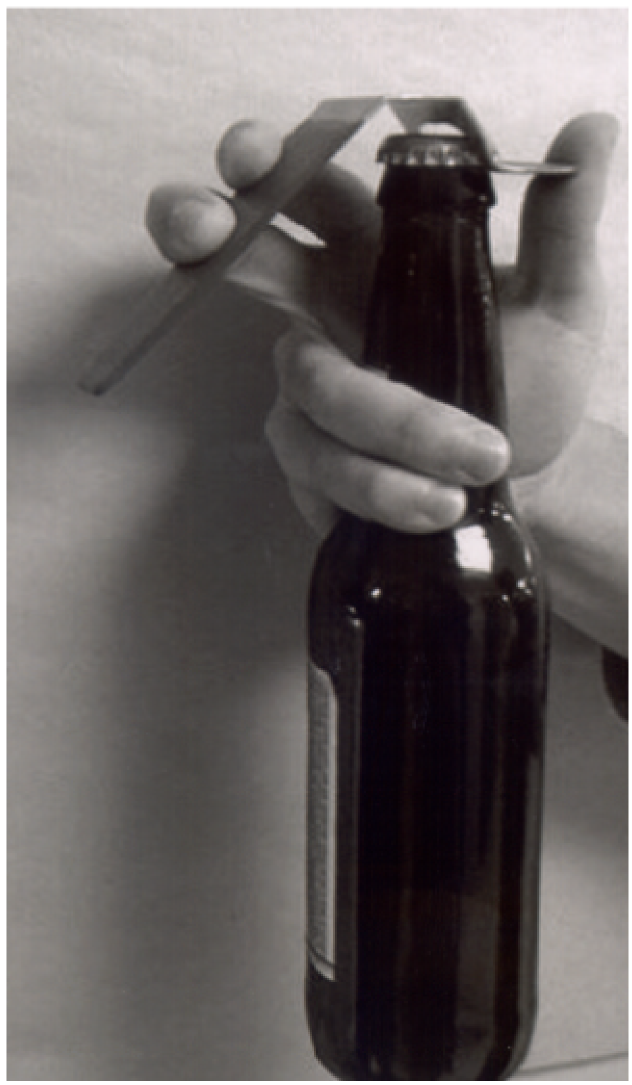

Figure 18.30. Prototype in Use

BAK-PAK

Designers: M. Baldwin, H. Gelinas, and T. P. Shoman
Client Coordinator: Ms. Tara P. Shoman
Supervising Professor: John E. Ritter, Ph.D.
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INTRODUCTION

During prolonged sitting without any type of back support, the spinal cord posture deteriorates due to muscle fatigue caused by incorrectly contracted muscles and ligaments. Pressure on the intervertebral discs of the lower lumbar spinal column increases by 30% in the sitting posture. A lumbar support was designed to decrease muscle fatigue and strain on the intervertebral discs (Figure 18.31). This support system was to be compact and portable.

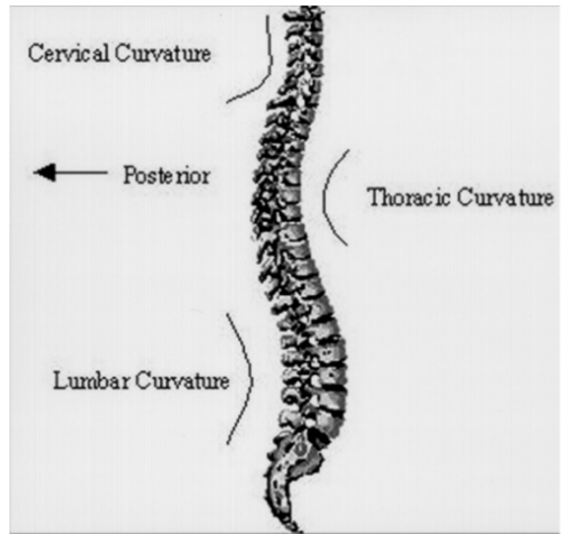

Figure 18.31. Vertebral Column.

SUMMARY OF IMPACT

Some factors that are detrimental to the spinal column include sitting in poorly designed chairs and reading and writing at a table that force an incorrect back and head posture. Irreparable postural damage can be caused by poorly designed school furniture. Most desks and chairs in a classroom are not designed to reduce lumbar pressures. Thus, a lumbar support is necessary not only for someone who has a lumbar back disorder, but also to prevent anyone from developing poor posture or back pain.

TECHNICAL DESCRIPTION

The support system must be able to keep its shape to ensure proper posture. This was accomplished by making the product out of a durable material with a high stiffness value. Another criterion was that the support system be carried inconspicuously when not in use. This was accomplished by making the support system lightweight and compact so that it fits in a purse, school bag, or briefcase.

This support system has been designed to be hidden in a backpack. An adjustable strap was provided so that the lumbar support system can be secured to a wide range of chairs. This adjustable strap goes around the chair, snaps together and then can be tightened. Polypropylene was chosen as the material for the lumbar support insert based on various performance indices using Cambridge Engineering

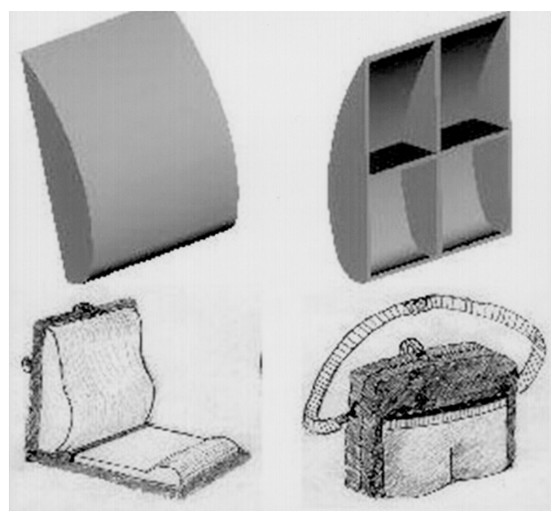

Figure 18.32. Solid Model of Lumbar Support Insert and Sketch of Backpack.

Selector software. Injection molding was found to be the most suitable process for manufacturing the lumbar support in batch sizes of 10,000 (Figure 18.32 and Figure 18.33). Future designs of the lumbar support could include a foam pad adhering to the lumbar support to give added cushioning.

The cost of the support system was estimated to be about $21.

Figure 18.33. Prototype of Lumbar Support Insert.

HEADSTAND

Designers: J. Wohlander, J. Daley, and R. Koller
Supervising Professor: John E. Ritter, Ph.D.
Department of Mechanical and Industrial Engineering
University of Massachusetts
Amherst, MA 01003-3662

INTRODUCTION

Various conditions may require patients to remain inactive, immobilized or even bed-ridden for several weeks. One operation that necessitates that the patient be immobilized for a period of time is used in some cases of retinal detachment. In the operation, a gas bubble is injected into the eye and is used to reattach the retina by pushing against the area of the retinal tear. The patient is instructed to lie face down for about four to six weeks for the gas bubble to float to the back of the eye in order to repair the damage. A Headstand was designed for the patient to lie face down and still enjoy certain activities such as eating, playing cards, watching television and so on.

SUMMARY OF IMPACT

The treatment for retinal damage was discussed with a renowned specialist in the field of retinal trauma and surgical repairs. According to him, there is no recovery period enhancement product available on the market. Based on his recommendations, a headstand was developed. It offers a realistic solution to the problem of providing some everyday freedoms to the patient without jeopardizing the patient's chances for a full recovery.

TECHNICAL DESCRIPTION

The specifications for the design of the Headstand were as follows: low weight, little deflection under full load, low cost, aesthetically pleasing, and adaptable. Hollow tubing with a circular cross-section was selected for the primary structural component. To make the Headstand adaptable to the wide variety of the bed styles and sizes available on the market, the Headstand was designed to accommodate height adjustability from 19" to 32". The use of round tubing also enabled variable height adjustment with the addition of a telescoping section that locks into position using spring-loaded ball pins.

Figure 18.34. Solid Model of the Headstand.

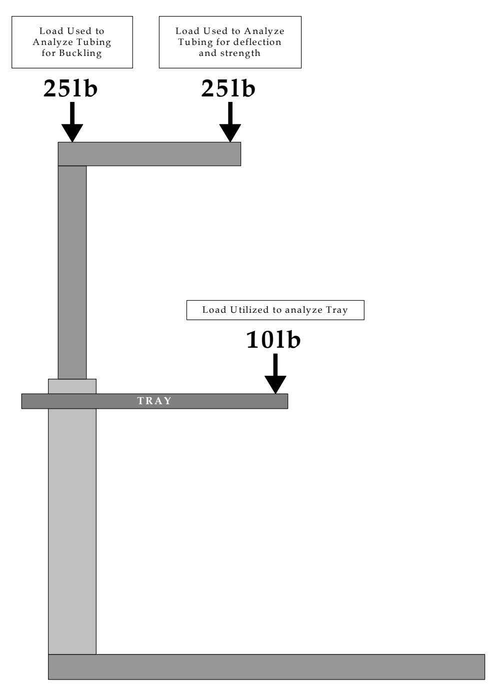

Figure 18.35. Diagram.

The components of the headrest portion of the product were sized according to data gathered for average head sizes of adult males. To reduce stress concentrations and to allow more free space for head placement, the two headrest support shafts were arranged in Y-neck fashion. A padded Velcro strap was chosen for the head-supporting band that mounts between the two head supporting bars (Figure 18.34).

An activities tray was included. It mounts between the patient's head and the floor. The tray provides a small work area where patients may lay out a book or magazine, write letters, or play cards. The height of the tray is adjustable and the tray could also be removed. For stability, the legs should be positioned at 45-degree angles to either side of the headrest and should extend twice (e.g. 16") as far in the same direction as the headrest (Figure 18.35) A polymer coupling device was used to join the various sections of the tubing.

Wrought aluminum alloy was selected as the tubing material to meet the requirements of high strength to weight ratio, low cost, and availability in tubular form. The material selected for tray and the connecting components was epoxy/glass fiber composite (Figure 18.36).

The cost of the headstand is around $18.

Figure 18.36. Headstand Prototype.

SIT-SKI BRAKE DESIGN FOR A CROSS-COUNTRY SKIER

Designers: T. Choiniere, J. Jablkowski, and C. Torrao
Supervising Professor: John E. Ritter, Ph.D.
Department of Mechanical and Industrial Engineering
University of Massachusetts
Amherst, MA 01003-3662

INTRODUCTION

A Sit-Ski is designed to enable people who are paralyzed below the waist to enjoy cross-country skiing. In current skis, the user must use ski poles as a braking device. This mode of breaking is inadequate even at an average slow speed. Thus, there is a need for an alternative breaking system. A new design, a center braking system is proposed, which can be attached to the existing frame of the Sit-Ski.

SUMMARY OF IMPACT

A braking device for the present Sit-Ski has been designed to provide a reliable cost efficient braking mechanism for a cross-country skier with disabilities. People with one functioning hand may also use the proposed braking device. The brakes stop the Sit-Ski without rotating the skis, regardless of which arm exerts more force.

TECHNICAL DESCRIPTION

The objective of this project was to design an efficient braking device that can be added to existing Sit-Skis and that could also be used by individuals with disabilities. The brake must stop the skier without causing the Sit-Ski to rotate. The braking system should be stiff so that there is minimum deflection (Figure 18.37).

The brake was designed to act between the skis to avoid any rotation of the Sit-Ski when applying the brake. Two separate lever arms are available on either side of the Sit-Ski and these lever arms join behind the skier to act in unity. Having a triangular shape where the wider edge digs into the snow provides an ample stopping force (Figure 18.38).

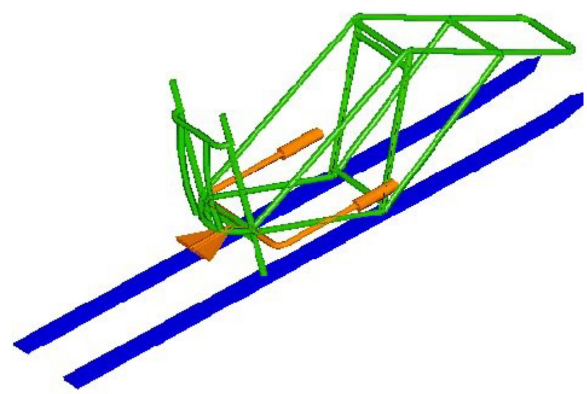

Figure 18.37. Solid Model of the Proposed Braking System in Sit-Ski.

The braking system was attached to the Sit-Ski with two sheet metal clasps. Since the lever arms of the braking mechanism have significant bends, it will be subjected to high bending and torsion stresses. Thus, the material must be tough, strong and lightweight. The Sit-Ski frame is made out of wrought aluminum alloy tubing. Thus the braking system should be constructed out of the same material for ease of construction, cost, and aesthetics.

A prototype was built and tested on a Sit-Ski (Figure 18.39). Aluminum tubing with an outer diameter of 5/8" was used to build the braking mechanism. The total length of one lever arm is 10". These arms have two 90-degrees bends with a bend radius of 2". The triangular aluminum brake is welded to the tubing arms.

The total cost would be about $14 based in mass production.

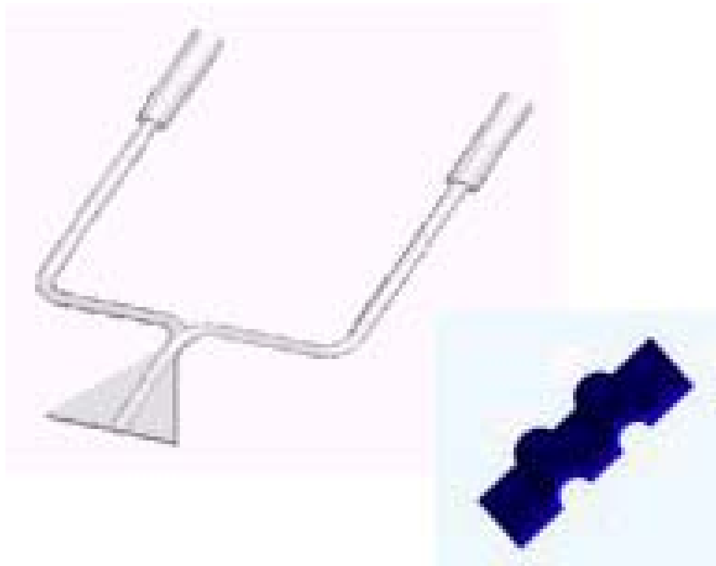

Figure 18.38. Sketch of the Braking Mechanism and Clasp for Attaching the Brake to the Sit-Ski Frame.

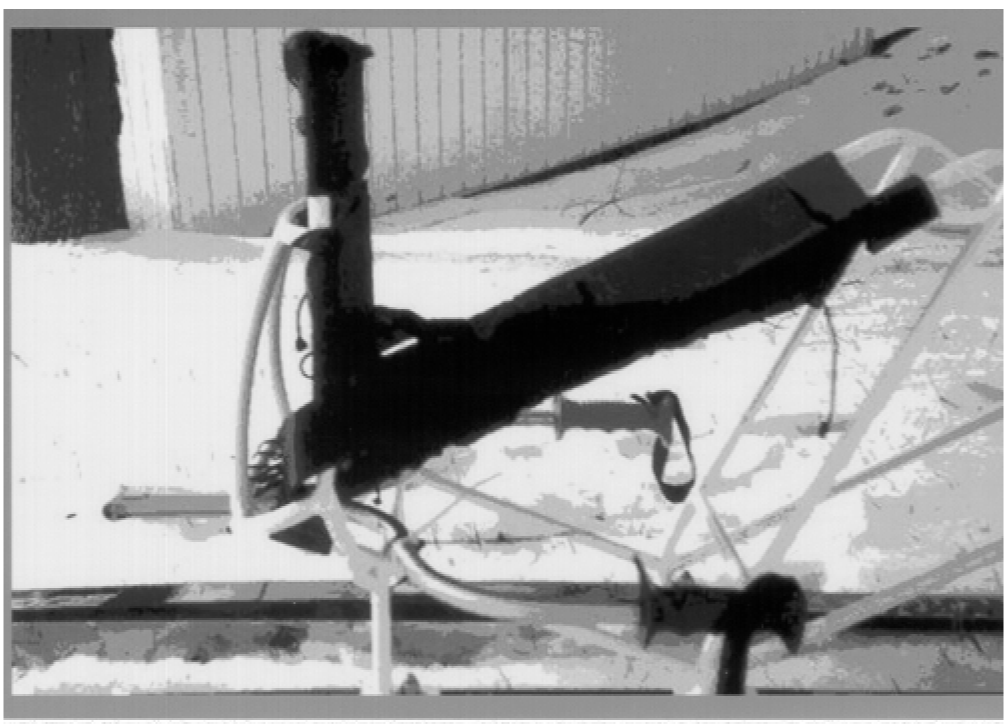

Figure 18.39. Prototype of the Braking System Tested on a Sit-Ski.

CHAPTER 19
UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL

Department of Biomedical Engineering
152 Macnider, CB #7455
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Principal Investigator:

Richard Goldberg (919) 966-5768

JOYSTICK MODIFICATION FOR BARBIE POWER WHEELS JEEP

Designers: Todd Atwood, Jeremy Bowman and Covey Lathan
Supervising Professor: Dr Richard Goldberg
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INTRODUCTION

Commercial Power Wheels vehicles cannot be easily controlled by children with poor muscle control. This project involved the modification of a Barbie Jeep for use by an 8-year-old girl with cerebral palsy. A joystick control and supportive seat were added to facilitate use and to promote independence.

SUMMARY OF IMPACT

The modified Barbie Jeep (Figure 19.1) will allow the client to gain experience for future operation of joystick-controlled wheelchairs and will allow the client to have increased independence. The modifications allow the client to practice fine motor control and visual-spatial skills, and enable her to participate in active play and outdoor activity. The joystick controls allow forward or reverse motion, with future additions to include left or right control. The modified seat (Figure 19.2) provides leg and torso support and a seat belt to ensure child safety.

Figure 19.1. Modified Barbie Jeep with Supportive Seat and Joystick Control.

TECHNICAL DESCRIPTION

Analog-based circuitry (Figure 19.3) was chosen to provide a comparable driving experience when operating the car. The original 12V battery that comes with the car is maintained to operate the original propulsion motors, which require high currents. Two 9V batteries are used to power the joysticks and circuit components in the modified design. The batteries are located under the hood and have a power switch to turn the system on and off in order to preserve the batteries.

The joystick outputs a speed signal corresponding to the position of the lever. The signal range of the joystick is +2.6V to –3.0V as it moves along the y-axis. A comparator checks whether the signal is positive (forward motion) or negative (reverse motion), then relays number one and two are triggered to set the selected direction of motion for the motors.

The maximum speed of the modified car is slightly less than before the alterations. The speed is distributed evenly over the range of the joystick and seems to be a safe velocity for both forward and reverse movement. The proportionality of the control will eliminate any jerky motions from the motors and provide for a smoother ride and acceleration.

The main limitation of the car is that the joystick does not control the left or right motion of the car. Due to possible client challenges in operating the manual steering wheel, a parent or therapist must control the steering.

The seat of the car is specifically designed to provide torso support and hip support. A six-inch semicircle is used to separate the client's knees and an armrest is positioned on the left side to better joystick control. The base and back are 1/8′ plywood and 1″ x 6″ quadrilateral pieces of wood were used for the hip supports.

Comfort and aesthetic value were important when incorporating the seat. (Figure 19.2) Two layers of foam were added to each surface that contacts the client and the foam was covered with pink vinyl to match the color of the jeep. This redesigned seat has the same dimensions as the original seat.

The approximate cost of the modifications to the car was $110. This excludes the price of the car itself.

Figure 19.2. Modified Seat.

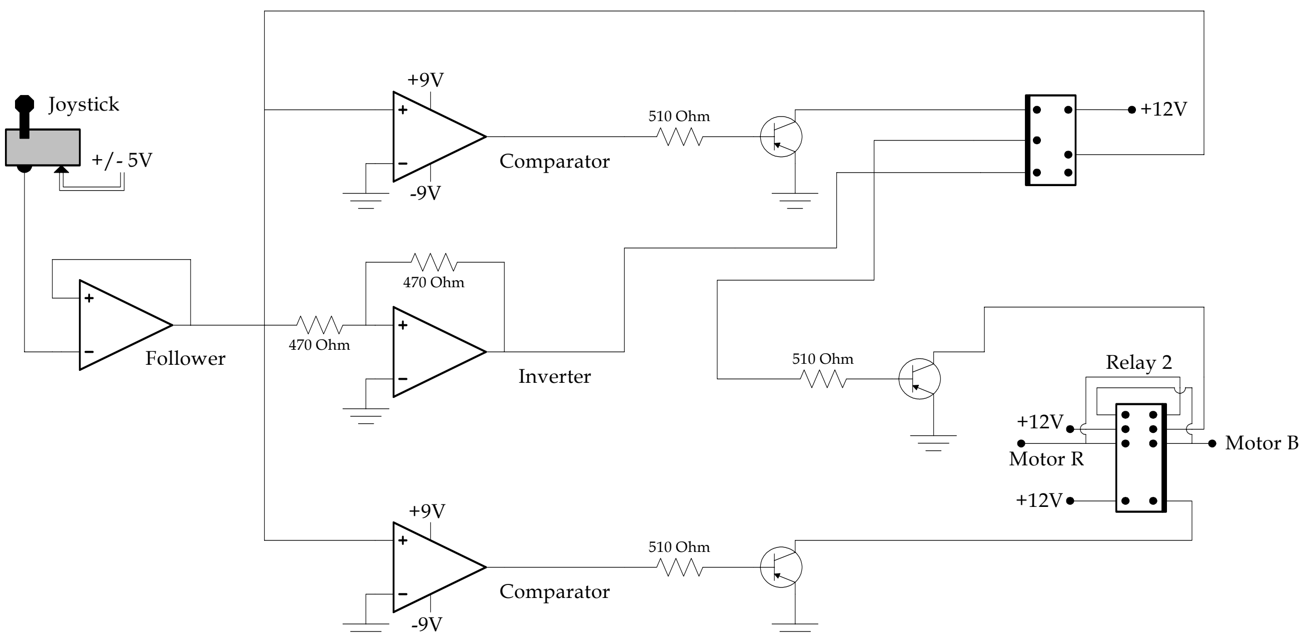

Figure 19.3. Wheel Propulsion Circuitry Located Under the Vehicle Seat.

INFANT PATTING DEVICE

Designers: Dan Cooney and Brian Rucker
Supervising Professor: Dr. Richard Goldberg
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University of North Carolina at Chapel Hill
Chapel Hill, NC 27599

INTRODUCTION:

An infant patting device (Figure 19.4) was developed to simulate a hand patting motion during bottle-feeding in abneonatal intensive care unit (NICU). A hand patting motion calms the baby to facilitate bottle-feeding. It may also decrease the probability of food aspiration into the lungs during feeding. This device provides an easy, safe way to comfort the patients in the NICU, while providing relief to their caregivers.

SUMMARY OF IMPACT:

Some NICU infants require two nurses to feed them: one to hold the infant and the bottle, and another to pat the infant's back. This device performs the patting task, allowing a single nurse to manage all feeding tasks in a safe and timely manner. The patting, performed independently of feeding, may allow the infant to remain calmer for the duration of the stay in the NICU. Clinical approval of the device is currently pending.

TECHNICAL DESCRIPTION:

The system (Figure 19.6) works by providing puffs of compressed air to an inflatable bladder (Figure 19.5) that is held up to the infant. Compressed air sources are available throughout the NICU. An air input hose connects this air source to the system. A timer circuit turns a solenoid valve on and off to provide puffs of air. These puffs flow along the air output hose (25′ long, ½″ inner diameter) to the inflatable bladder that provides the patting motion. The bladder can be suspended in foam padding or placed directly on the infant. An escape hose attaches to the bladder to direct the airflow out of the bladder and away from the baby.

The system is encased in an aluminum project box (12″ x 12″ x 8″) equipped with wheels to facilitate movement. There is a power switch and large knobs that allow the user to control the air pressure and patting rate. A commercial 24V wall transformer provides electrical power. Throughout the system, ½″ diameter tubing is used, large enough to not restrict air flow.

Figure 19.4. Infant Patting Device.

The puffs of air are provided by a pressure regulator, timer circuit and solenoid valve. Since the compressed air source has a pressure of 60 to 85 pounds per square inch (psi), a regulator is necessary to lower the pressure. The user can adjust the regulator output pressure to the range of 2 to 60 psi. A solenoid valve opens and closes to provide puffs of air to the inflatable bladder. The solenoid has a large 5/8″ aperture to maximize the flow of air and runs off of a standard 24V plug-in power supply. In order to switch the solenoid on and off, a 556 timer circuit is used. This timer uses a 5V power supply provided by a 24VDC to 5VDC voltage regulator. The frequency at which the timer operates is controlled by a potentiometer, which can be adjusted using the frequency knob on the box.

The patting motion is provided using a custom neoprene bladder. The bladder is circular with a 3

½″ diameter and it has connections for an air supply and air escape hose.

When the valve is open, the puff of air from the solenoid causes the bladder to expand. The air leaves the bladder passively through an open tube. The tubing is 25′ long to enable the nurses to freely move with the device and to ensure that the released air from the bladder flows away from the infant.

The system is safe for use and easy to clean and sterilize. The metal box provides an effective casing for the electrical equipment and it also safely separates the infant and the caregiver from the electrical circuits. Neoprene was chosen for the bladder to prevent any possible side effects from latex allergies.

Aesthetic concerns were addressed by decorating the plain aluminum box with child friendly, decorative Sesame Street® stickers.

The total cost of this project was $667.

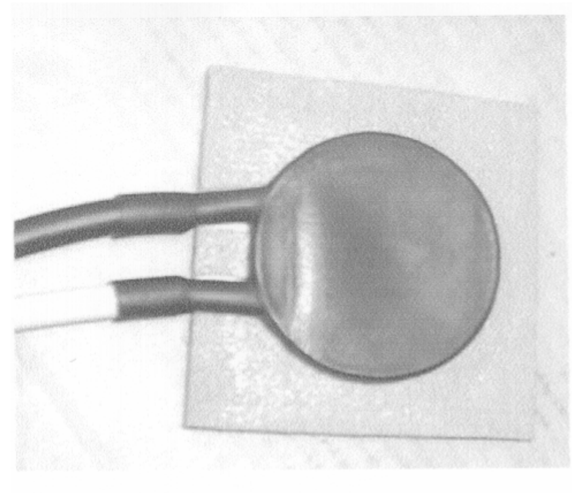

Figure 19.5. Neoprene Bladder.

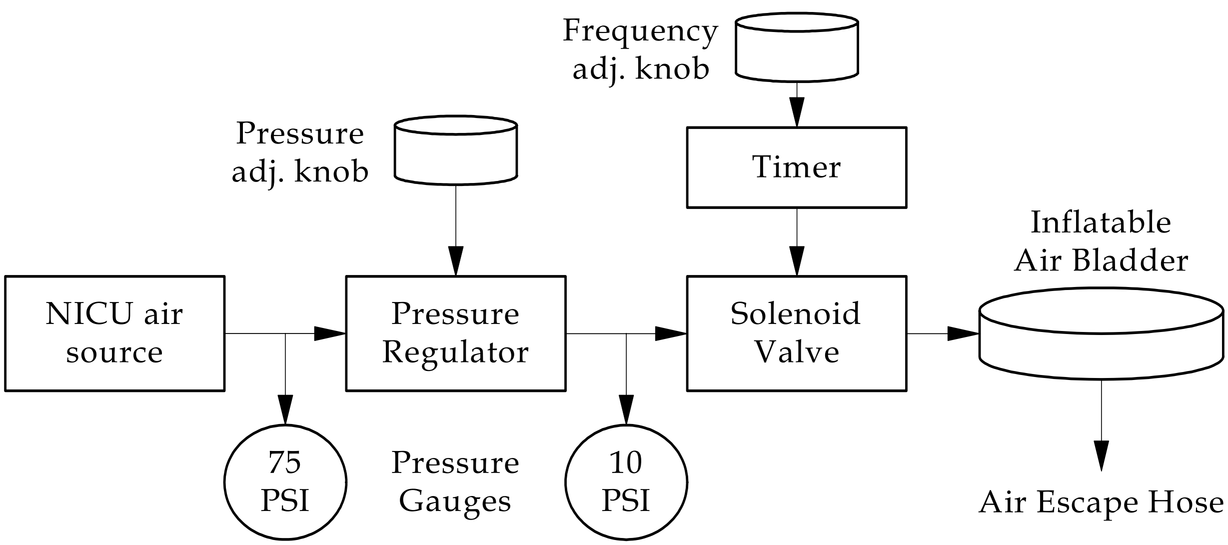

Figure 19.6. System Block Diagram.

HEARING LOSS SIMULATOR

Designers: Jason Edwards
Supervising Professor: Dr. Richard Goldberg
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INTRODUCTION:

The hearing loss simulator is a computer program that modifies a sound clip based on a child's audiogram. The audiologist enters audiogram data into the program, characterizing the child's hearing loss. The program then records, modifies and replays a voice or a music clip as the child would hear it.

SUMMARY OF IMPACT:

This program provides a means by which parents of a child with hearing loss can understand what their child is capable of hearing. This program will help the parents have realistic expectations of the child's performance. Additionally, the program will aid in the formation of Individualized Education Plans by providing a more accurate representation of hearing loss. Hearing loss is often classified as profound, severe, moderate and mild. Most individuals have difficulty applying these general terms to what a child can hear. Current audio examples of hearing loss are not specific to the child and may give only an approximate idea of the sounds that a child is able to hear. This program gives a more specific, personal replication of the child's functioning.

TECHNICAL DESCRIPTION:

The Hearing Loss Simulator consists of five primary components: a microphone, a PC, a sound card, a software program, and a speaker system.

The audiologist must first enter data from the child's audiogram into the simulator. A polynomial function is matched to the data points and then used to apply the appropriate attenuation at selected frequencies to a recorded audio signal. The PC receives input from the microphone via the sound card. Contained within the sound card is an analog to digital converter that transforms information from the microphone into a form usable by a software program on the PC. Based upon information taken from a patient's audiogram, the program processes the recorded audio. This altered digital signal is then transformed back into analog format by a digital to analog converter housed on the sound card and ultimately played by a speaker. (Figure 19.7)

The programming is done using Visual Basic 6 and requires a computer running Windows 9x or NT at 266MHz or higher. In order to hear the modified sound clip, a 16-bit A or D sound card, a microphone and speakers are necessary.

Preliminary testing of the simulator has demonstrated that it is qualitatively accurate. Several simple scenarios, such as filtering all high frequencies or all low frequencies, have generated the expected results. The initial impression of professional audiologists is optimistic. Although further testing is needed to prove that the simulator is quantitatively accurate and clinically useful, the outlook is promising. The current limitation of the device is that only up to seven data points may be entered from an audiogram and that an auditory signal must be recorded and modified before being played back. One possible solution may be to allow the audio to be modified and played as it is being sampled, thus permitting a real-time system. As it stands, the Hearing Loss Simulator may be beneficial in communicating a child's level of hearing loss to a parent.

The total cost of this project was $505.

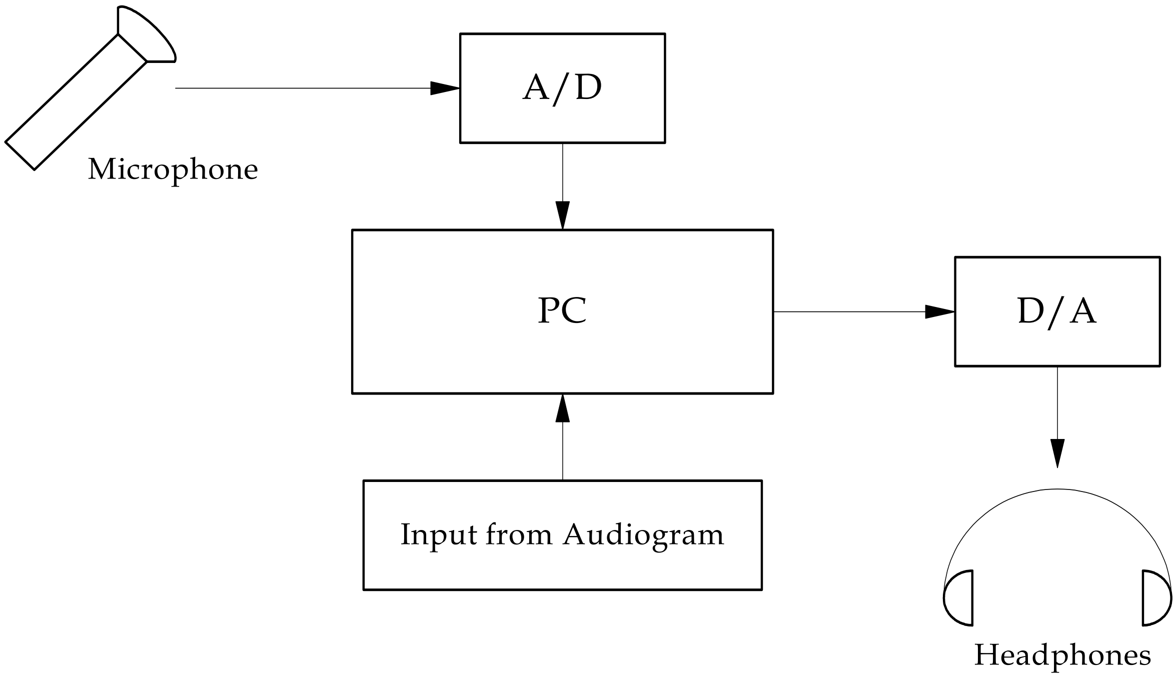
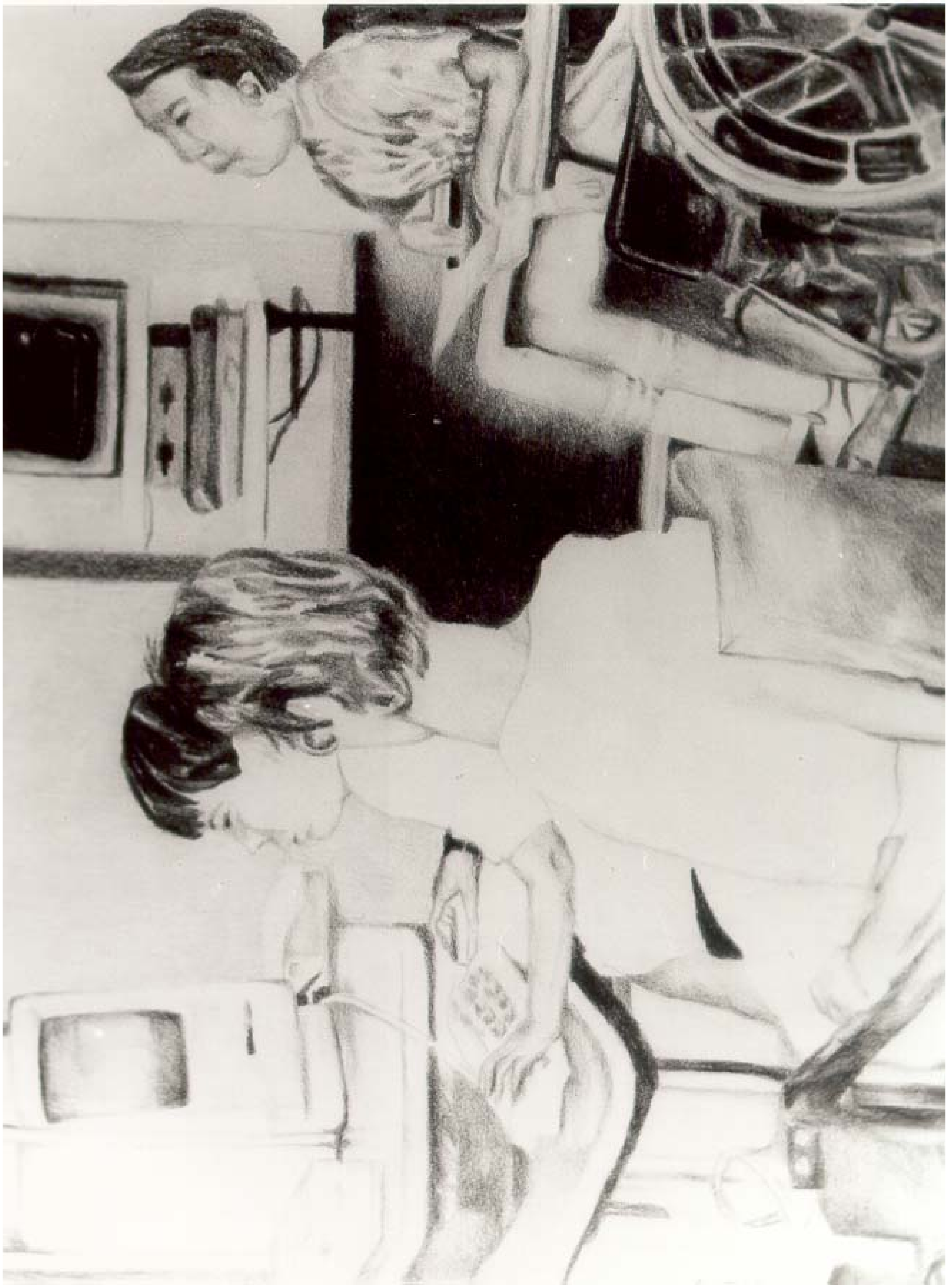


Figure 19.7. Hardware Used to Implement the Hearing Loss Simulator.



CHAPTER 20
UNIVERSITY OF TOLEDO

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MANUAL RACING WHEELCHAIR

Designers: Group 1 (seating team): Tim Langer, Matt Kent, Paul Boehnlein, Keith Stanney; Group 2 (steering team): Greg Homan, Matt Lewis, Marisa Baysa, Dennis Harrigan; Mechanical Engineering Students
Client Coordinator: Dr. Gregory Nemunaitis, Department of Rehabilitative Medicine, Medical College of Ohio
Supervising Professors: Dr. Mohamed Samir Hefzy
Biomechanics Laboratory, Department of Mechanical, Industrial & Manufacturing Engineering
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INTRODUCTION

The purpose of this project was to design and construct a manual racing wheelchair for one of the racers of a racing wheelchair team. This individual is a male with paraplegia due to a T4-T5 spinal cord impairment. This type of spinal cord injury results in a loss of muscle control and feeling from the abdominal trunk area down, including both lower extremities. Two groups of students were formed to work on this project. The first group focused on the seating. The second group concentrated on the steering and the frame. Both groups worked in synergy to produce a completely functional and ergonomically designed product. Figure 20.1 shows the client using the prototype during the test trials.

Figure 20.1. Client Using Manual Racing Wheelchair with Student Designers.

SUMMARY OF IMPACT

This racing wheelchair prototype provides an active physically challenged individual with an opportunity to participate in a challenging and exciting sport. The seat fixture design allows him to have maximum control of the racing chair while positioning his body for maximum force with each power stroke. The steering mechanism allows him to focus his efforts in propelling the wheelchair with limited concern for the chair's direction. The seat fixture in conjunction with the steering mechanism provides him with state-of-the-art maneuvering capabilities. This prototype will allow him to enjoy the challenges of both road and track competitions.

TECHNICAL DESCRIPTION

A T-frame style design was selected based on its current popularity in the racing wheelchair industry. Most wheelchair athletes prefer to maneuver the chair, while road racing, by simply shifting their weight. To produce this effect the operator's center of gravity must be oriented so its location is mainly a function of the operator's torso angle. Therefore, allowing him/her to control the chair simply by altering his/her torso angle. This ability is directly related to the sizing of the chair. The chair must be designed around the operator resulting in a snug fit. Therefore, the operator can easily direct the chair by applying body forces to the seat fixture members.

Seat Fixture:

An open V-seat fixture, shown in Figure 20.1, was employed to support the racer. Its dimensions were determined such that it snugly fit the operator. A vinyl seat harness was purchased from the Invacare Corporation such that this seat fixture and harness system fixes the operator's upper and lower leg angles at 5° and 35°, respectively, with the horizontal. Therefore the location of the center of gravity (cg) of the operator's body is a function only of the arm and torso angles. A sensitivity analysis was then conducted to determine the effects of these two angles on the location of the cg of the body. It was found that altering the arm angle had minimal effect. On the other hand, the location of the cg was highly affected by the torso angle.

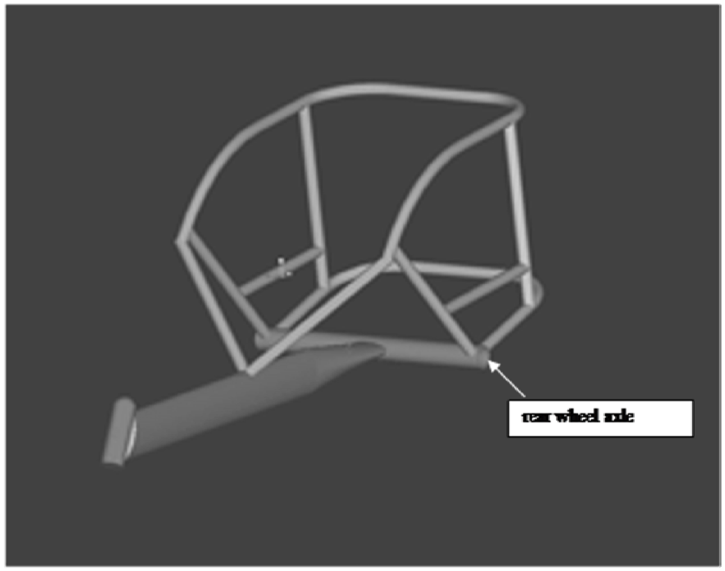

Figure 20.2. Open V Seat Fixture.

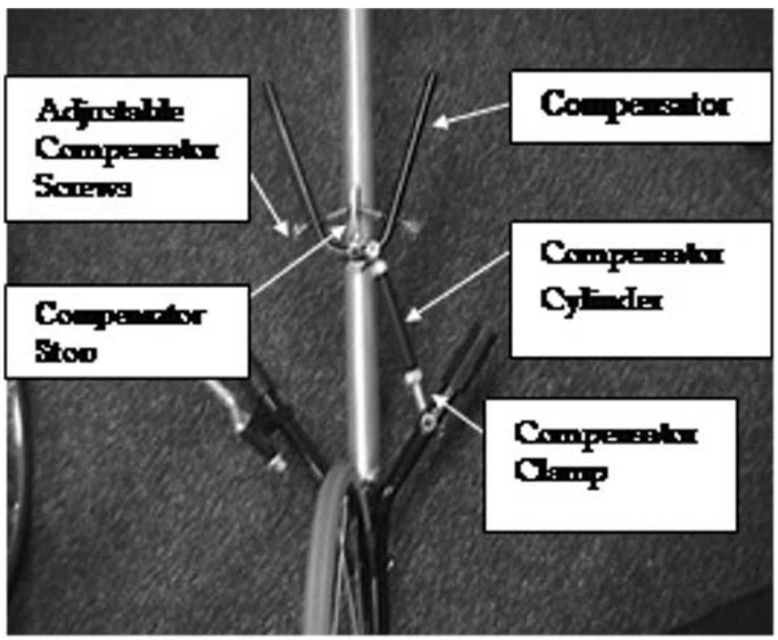

Figure 20.3. Steering Mechanism.

Under normal operating conditions the operator's torso angle will vary between 30° and 40° corresponding to the beginning and end of his/her power stroke. To establish possible static load cases for normal operating conditions moment balances were performed about the operator's hip to determine the forces applied to the seat fixture at the restraint locations for different operator postures. Finite element analysis was then conducted using SDRC I-DEAS to determine the maximum stresses in the seat fixture. Under these conditions the maximum von mises stress was approximately 1.29 x 104 psi. To perform a fatigue analysis additional load cases were established corresponding to the forces exerted by the operator while propelling the wheelchair. The conditions are the same as those for normal operating conditions with the exception of a 145 lb force applied to the fixture to account for the push force of the operator. These applied loads resulted in alternating and mean stress of 500 psi and 11.5 x 103 psi. Using the Distortion Energy Theory of Failure for the static case and the Modified Goodman Diagram for the fatigue case, material selection and member dimensions were determined corresponding to static and fatigue factors of safety of 3. T6-6061 aluminum was selected as the design material due to its weight, strength, and manufacturing characteristics. The seat fixture members for this design have a diameter of 3/4 in and a wall thickness of 1/8 in.

Under normal operating positions the operator's center of gravity was found to be approximately five inches in front of the rear axle. This distance controls the angle that the torso must reach in order to unload the front wheel of the chair. At a distance of five inches in front of the rear axle, the operator will have to rotate his torso angle to 70° to lift the front wheel of the chair. Under normal operating conditions the racer's torso angle will vary between 30° and 40° indicating that the torso angle must be increased 30° in order to lift the front wheel. This amount of angular rotation was deemed optimal through discussions with the client and racing wheelchair professionals.

Steering Compensator Mechanism

The steering compensator mechanism selected for this chair is constructed of four main components: a compensator bar, a compensator cylinder, two compensator screws, and a compensator stop as shown in Figure 20.3.

The compensator cylinder supplies a return force during road racing and also acts as the motion transfer member between the compensator bar and handlebars during track racing. The compensator cylinder consists of an outer casing which encloses a cylinder, bushing, and a standard heavy-duty die spring. The spring has a stiffness of 60 lbf /in. It is pre-compressed inside the casing in order to give the compensator cylinder some initial stiffness. The compensator cylinder can be extended 1.050 inches and compressed 0.625 inches, which creates a change in force of 63lbf and 37.5lbf respectively. Handlebars are two types: straddle-type fork and trailing-arm. Trailing arm design is not recommended to be used with the T-style frame because it produces an undesirable amount of flex in the front end of the chair during racing.

The main function of the compensator bar is to supply a convenient way for the racer to turn during track racing. The compensator bar is made of hollow aluminum tubing that pivots on a threaded stud that is attached to the frame as shown in Figure 20.3. The compensator cylinder is attached to the compensator bar by a threaded stud. Two compensator adjustment screws are threaded into the compensator bar. These screws along with the compensator stop are used to adjust the angle of turn during track racing.

The steering compensator mechanism is used for both road racing and track racing. During road racing the compensator bar is tightened snug to the main frame in order to keep the front wheel straight when the racer is not turning. The compensator adjustment screws can also both be positioned snug against the compensator stop to help keep the front wheel straight during road racing. However, this limits the angle of turn that can be made with the steering device to approximately 15° when turning right and 20° when turning left since the compensator cylinder can only compress 0.625 inches and extend 1.050 inches respectively.

During track racing the compensating mechanism provides a simple way for the racer to turn and to continue propelling the wheelchair during the curved portion of the track. It also helps to keep the wheelchair straight during the straight portions of the track. During track racing, turning is accomplished by the racer forcing the compensator bar into a new position. When the compensator bar is moved to a new position, the offset between the pivot point of the compensator bar and the point where the compensator cylinder is attached creates a linear motion that is transferred to the handlebars through the compensator cylinder. This linear motion causes the steering wheel to be turned. The adjustment screws are set so when one of the adjustment screws is in contact with the compensator stop the front wheel is straight, and when the other adjustment screw is in contact with the compensator stop the front wheel is at an angle of turn that will allow the racing wheelchair to follow the radius of the track. The compensator bar is tightened snug to the main frame in order to assure the front wheel will track straight in the straight portions of the track and will remain at the correct angle of turn during the curved portions of the track. At maximum adjustment the largest angle of turn that could be made using the compensating mechanism in this way is approximately 8°. Using Akerman geometry the turning angle needed for an average track radius of 75ft is approximately 3°. Therefore this compensating mechanism has plenty of turning capability for track racing.

Redesign of Main Frame, Rear Axle and Wheel Mounts

The rear axle width and overall wheelchair length were determined using client dimensions, body position, steering accessibility, and accepted racing standards. Through research and contact with various wheelchair manufacturers, a T-style main frame was chosen for this design. The T-style provided a more stable framework and enabled a broader range of seating positions. T6061 aluminum was chosen as the material for the frame to reduce the weight of the wheelchair while maintaining structural integrity. The frame consists of a 3-inch by 1 ½-inch seamless tube with a wall thickness of 0.065-inches. Using measurements taken of the client's sitting location, arm reach, and body position, an overall wheelchair length of 66-inches was determined to be acceptable. The overall wheelchair length was measured from the front-most part of the front tire to the rear-most part of the rear tire. The front tire had a radius of approximately 9 ¼-inches and the rear tire had a radius of approximately 13 ½-inches. Therefore the frame length was dependent on the ability to reach the steering system and brake while in the racing position.

The rear axle width was determined using the upper inside frame width, the lower inside seat width, and the axle position. These dimensions are dependent on individual measurements of the client and seating position preference. Based on these factors, an axle width of 16 ½-inches was chosen. The rear axle was also made of T6061 aluminum but had a constant 1 ½-inch outside diameter with a wall thickness of 0.065-inches.

The rear wheels were attached to the rear axle by means of ½-20 studs mounted to the center of the wheels. To decrease the possibility of rolling while turning at higher speeds, the rear wheels were angled toward the racer producing a slight camber. Through research and interviews with an experienced racer, 12-degrees from vertical was determined to be the optimal wheel camber angle. If the individual racing the wheelchair had a higher seating position, then this angle would have to be increased. Inserts were designed to act as rear wheel mounts while providing the correct rear wheel camber. T6061 was chosen for the material of these inserts because it is both lightweight and easily machined. Rear wheel stud spacers were also designed and manufactured. These spacers were designed to keep the rear wheel studs from bottoming out in the camber inserts, which will help to keep the studs from turning out of the camber inserts while the wheelchair is being used. These spacers were also made from T6061 aluminum.

Additional components were designed and manufactured for the attachment and use of the steering compensator mechanism. A compensator bar attachment insert was designed and integrated into the mainframe. The attachment insert consists of an inch long, 1.25-inch diameter cylinder with a ¼-28 tapped hole, which will be used to attach the compensator bar to the main frame. The attachment insert was integrated into the frame by positioning it into a pre-drilled hole in the main frame and then welding it solid. A compensator stop, which is one of the main components of the steering compensator mechanism, was also designed and welded to the main frame. The compensator stop was manufactured from 1/8-inch thick T6061 aluminum bar. Again T6061 aluminum was the material used for both the compensator bar attachment insert and the compensator stop because it is lightweight and easily machined.

Finite Element Analysis of Main Frame and Back Axle

The stress analysis of the wheelchair frame was completed using I-DEAS finite element analysis software package. The back axle was modeled exactly as a 16.5-inch long tube with an outer diameter of 1.5 inches and a thickness of 0.065 inches. Since the main frame diameter changed down of the length of the wheelchair, the average diameter was used to model the main frame. The thickness was still 0.065 inches, but the average of the diameter was 2.25 inches. The head tube was modeled as a 4-inch long tube with a thickness of 0.065 inches.

Roll Stability while Turning

As wheelchair racers improve techniques and are able to reach faster speeds, it is important to examine the dynamic stability of racing wheelchairs. As with the design of many vehicles, dynamic roll stability analysis is a standard procedure. Since the client will be starting out in track racing the purpose of this analysis was to determine whether the new wheelchair design can withstand speeds up to 20 mph during track racing without flipping over. This speed is a maximum for world-class athletes and is well above the average speeds of a beginner racer. The analysis was conducted to calculate the roll stability critical velocity. In this analysis the following assumptions were made:

- The chair does not slip radially,
- The track is level, and
- The rider/wheelchair system is rigid.

The roll stability critical velocity can be defined as the velocity at the instant when the torque rotating the racing wheelchair and rider is equal to that of those forces holding it down. The roll stability critical velocity for this system was determined by equating the torques acting upon the center of gravity about a line connecting the outermost rear and front wheels of the racing wheelchair. A radius of 75 ft (900in) was used since this value is an average radius for an oval track. The roll stability critical velocity for the racing wheelchair was calculated to be 24 mph. Since this velocity is greater than the maximum track speed of world-class wheelchair athletes of 20 mph, the design was considered to be stable. .

The new racing wheelchair was designed for a145 lb racer. To test the racing wheelchair a test subject who weighed approximately 170 lb was used. The testing included trial racing to insure that the chair frame would be able to withstand the dynamic loading and to make sure the location of center of gravity of the racer would allow the racer to turn by skidding. Both of these objectives were confirmed by the testing. Figure 20.4 shows the completed racing wheelchair.

The completed prototype was delivered to the client. The total cost of parts and labor was $1,200.00.

Figure 20.4. Final Prototype of Manual Racing Wheelchair.

VERTICAL WHEELCHAIR PLATFORM LIFT FOR HOME ACCESS

Designers: Susanne Bellante, Eric Stevens, Tully Esterline, Anthony Vonderembse and Kurt Knapke
Client Coordinator: Dr. Gregory Nemunaitis, Department of Rehabilitative Medicine, Medical College of Ohio
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Biomechanics Laboratory, Department of Mechanical, Industrial & Manufacturing Engineering
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INTRODUCTION

This project involves the design and construction of a vertical wheelchair platform lift to be used by a man with paraplegia and limited use of his arms. The individual used to enter and exit his home using a long ramp in front of the house. This is inconvenient and unsafe for him and his family because he cannot easily exit his home during the winter when the ramp is covered with snow and ice and would be at risk if the ramp would ever be inaccessible during a fire or other disaster.

SUMMARY OF IMPACT

The objective of the project was to safely lift this physically challenged individual 14 inches from the garage floor to the house level. The design meets the client's needs of independent operation and incorporates standard safety features. The lift is capable of raising 1000 lbs (4448 N), which includes the weight of the individual, his motorized scooter and the supporting platform. A dual linear actuator system was incorporated into the design that allowed for minimum platform height at the lowered position. The prototype provides a safe and reliable method of transporting the client between his garage floor and his ranch style home.

TECHNICAL DESCRIPTION

Five methods of driving the lift were investigated, which include using a hydraulics system, linear actuators, scissor lifts, wench and pulley system, and power screws. A dual linear actuator system was selected using a matrix approach based on several design criteria, which include a smooth and independent operation, platform height, design simplicity, safety, and costs. The design parameters included the platform size, the weight to be lifted, and the amount of travel of the lift.

Figure 20.5. Vertical Wheelchair Platform Lift in Use.

The platform size needed to be large enough to fit the wheelchair as well as to have room for the client's arms as he turns the wheels to enter and exit the lift. The rear wheels of the client's wheelchair are 32 inches apart. Allowing for ample room for the client's arms as well as the switch box, the platform was designed to be 42 inches across. The weight of the individual, his motorized scooter, the platform and its holding frame was estimated as 500 lbs (2224 N). A design load of 1000 lbs (4448 N) was used to ensure a minimum factor of safety of 2. The amount of travel of the lift was 14 inches, which is the height of the step between his garage and his home. Also, the platform height at the lowered position cannot exceed two inches from the ground to allow the client to easily roll himself onto the platform. Given that the individual will operate the lift independently, the design must allow him to roll onto the platform using a forward motion from either the garage or his home.

The system, shown in Figure 20.5, consists of two main parts: the fixed outer frame and a part that moves up and down the frame. The platform and its inner holding frame form the moving part. The linear actuators are attached to the holding frame and the fixed outer frame, as shown in Figure 20.6. Steel rectangular tubing was used for constructing both frames. All pinch points on the lift were enclosed to prevent injury and for aesthetics.

A critical component in the system is the pin that connects each frame to the linear actuator. Calculations were conducted to ensure that the pin would not fail due to shear failure, bearing failure, or tear-out. The lowest calculated factor of safety was found to be 4.7.

Finite element analysis (FEA) was conducted using SDRC I-DEAS on the inner holding frame to determine the maximum stresses. Beam elements were used in the FEA model. Three different loading conditions were investigated: a 1000–lb distributed load across the platform, a four-point loading condition of 250 lbs. each, and a two-point loading condition of 500 lbs. each. As expected, the worst case corresponded to the two-point loading situation where forces were applied at the very front edge of the inner frame. In this case, a maximum stress of 23,100 psi was calculated. The lowest yield stress of steel is 24,000 psi. This produces a design factor of safety of 2.08 since the design load is twice the actual load of 500 lbs. This is the worst case and would not occur in normal usage. The client in his chair would need to be more centered on the platform.

The linear actuators are wired to a capacitor and connected to a power source using a regular 110-volt wall outlet as shown in Figure 20.7. The wire routing and electrical boxes were mounted to move up and down with the inner frame so that the only wire that would tighten during travel would be the extension cord to the wall outlet.

Total cost of parts and supplies was $1,200.

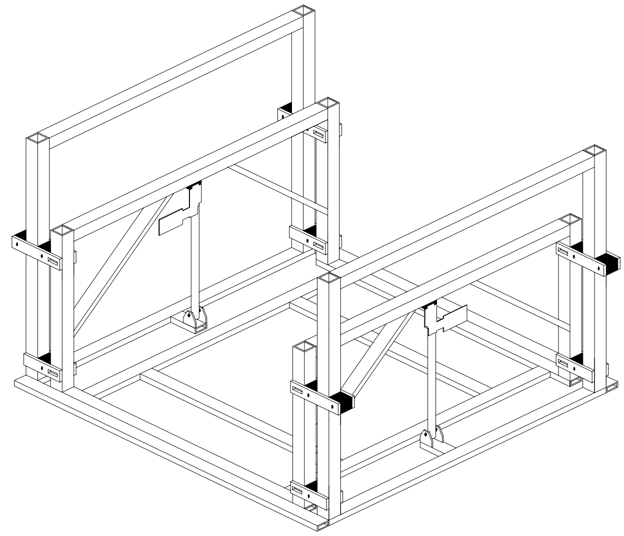

Figure 20.6. Isometric Schematic of the Vertical Wheelchair Platform Lift.

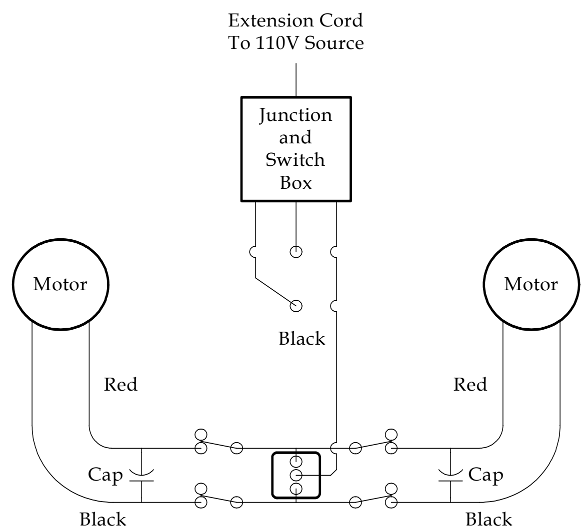

Figure 20.7. Electrical Wiring Diagram .

HOIST MECHANISM TO LIFT LOGS

Designers: Troy Medlar, Kevin Wickenheiser, Mike Karpinski, Shawn Nichols,
Mechanical Engineering Students
Client Coordinator: Dr. Gregory Nemunaitis
Rehabilitative Medicine, Medical College of Ohio and St. Vincent Mercy Medical Center
Supervising Professor: Dr. Mohamed Samir Hefzy
Department of Mechanical, Industrial & Manufacturing Engineering
The University of Toledo
Toledo, Ohio, 43606

INTRODUCTION

The purpose of this project was to design and construct a hoist mechanism to enable a mushroom farmer with quadriplegia to work independently and reduce his fatigue. The client grows shitake mushrooms on his property. In the spring, the he and his employees cut oak trees into logs that are approximately 4 feet in length. Forty to fifty 3/8" diameter holes are then drilled along each log, filled with spores, and corked. He then applies hot wax over the filled holes to seal the planted spores. The logs are stacked and kept moist on the client's property, and growth of the mushrooms begins around two months after the spores are planted. The logs are transported into the client's barn on a pallet. Logs 4 feet in length (3"-8" diameter) were to be lifted from a pallet on the floor to a table approximately 4 feet in height. Since the client has minimal use of his hands and fatigues quickly, the mechanism was to minimize the amount of input work required. After completion of the drilling operation (see next project), the client needed to be able to use the same hoist mechanism to stack the finished logs onto another pallet located at the end of the work area.

The mechanism selected includes a hoist that is connected to two skates via a mounting plate. The skates roll inside a Unistrut track attached to the ceiling of the client's barn. The hoist raises and lowers a bar and cuff assembly, which was designed to slide over each end of a log and support it as it is lifted to and from the work area as shown in Figure 20.8.

SUMMARY OF IMPACT

The client has poor manual dexterity and tires quickly. Before having this device, the repetitious movements in the mushroom farming process quickly fatigued him. The hoist mechanism allows him to work independently and reduce his fatigue. At no time during the operation of the hoist mechanism is he required to bend over or support the weight of the log. The only work performed by the farmer is to position the bar and cuff assembly around each log, depressing the appropriate button to raise or lower the hoist, sliding the hoist along the track, and taking the cuffs off each log.

TECHNICAL DESCRIPTION

Several ideas were investigated including using a pneumatic device to push the logs up onto the table, a mobile hoist mechanism and a scissor type platform lift. A hoist mechanism mounted to skates that roll along the ceiling in a track was found to be the most cost-effective, easiest to install, and easiest to operate. The hoist will be moved to the front of the table to load the logs, and to the end of the table to unload the logs.

Hoists and winches were considered. A hoist was selected because of its vertical lift design. The Lil' Mule hoist was employed. It offers a lift speed of 12 feet per minute, a maximum load of 500 lbs, and a weight of 16 lbs. Unistrut was used for the ceiling track. Its weight is 1.8 lbs per foot, and can withstand a 1500 lb distributed load when braced every 24 inches. Two skates roll inside the Unistrut track. The hoist was mounted to the skates using a plate. The cuff assembly was made using schedule 40 PVC pipe. Two 1.5" wide circular sections were cut from the pipe, and then machined to specifications.

The mechanism was able to raise logs from ground level to a maximum height of eight feet. The logs were secured by the bar and cuff assembly.

Total cost of this project was $750.00.

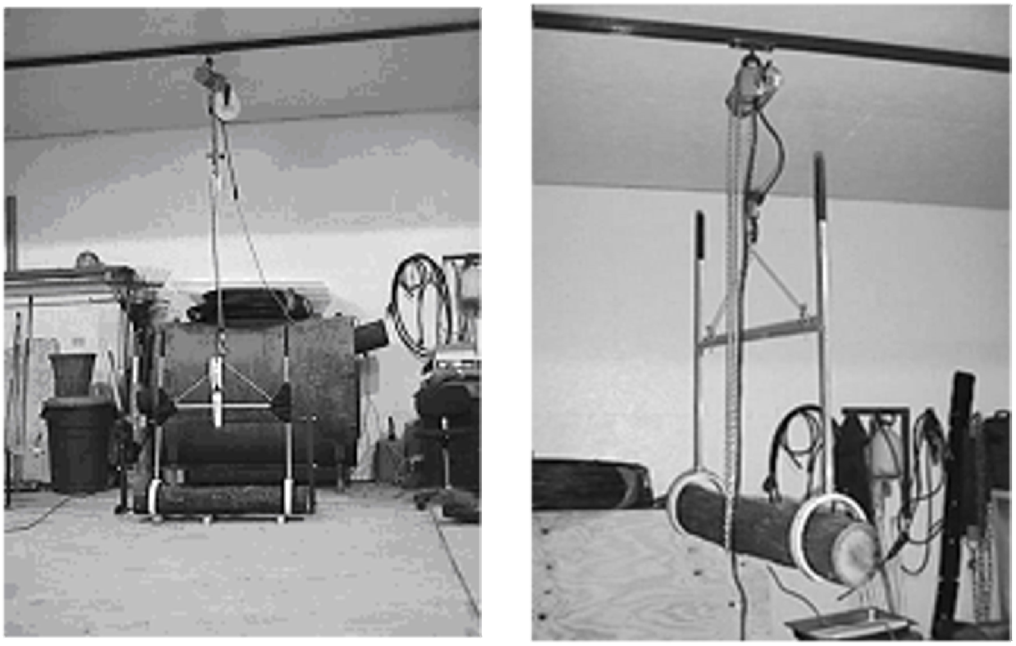

Figure 20.8. Hoist Mechanism Lifting (Left) and Lowering (Right) a Log.

ADAPTIVE DRILLING FIXTURE FOR MUSHROOM FARMING

Designers: Timothy Hartigan, Mark Fenstermaker, Mark Bills, Matthew Miller, Mechanical Engineering Students
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Supervising Professor: Dr. Mohamed Samir Hefzy
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INTRODUCTION

The purpose of this project was to design and construct a drilling fixture to assist a shiitake mushroom farmer with quadriplegia. His preparation of oak logs involves drilling 40 to 60 holes per log and plugging the holes with shiitake mushroom spores. The drill fixture allows the farmer independence during the drilling process, and eases the physical fatigue encountered by holding the drill. A two-axis, vertical drill, utilizing a pre-manufactured drill-press assembly was employed. Figure 20.9 shows the design concept. Figures 20.10 and 20.11 show a front view and a rear view of the prototype, respectively. A lever initiates the drilling action, and the drill moves along the horizontal axis by hand. The log is rotated by hand with the assistance of concave nylon strips located under the drilling fixture. The prototype is made to be compatible with a hoisting apparatus designed and manufactured by another group of students (see previous project).

SUMMARY OF IMPACT

The procedure for impregnating the mushroom spores includes drilling 5/16" diameter holes 3/4" deep, into a 4-foot long by 6" diameter oak log. After the holes are drilled, mushroom spores are inserted into the holes and the holes are covered with a cheese wax coating. The drilling fixture that was designed and constructed is a cost-effective and simple assistive technology device that will allow the farmer to increase his independence and productivity in mushroom farming. The fixture will reduce fatigue and allow the farmer to drill for longer times.

TECHNICAL DESCRIPTION

The design objectives of the drilling fixture were to:

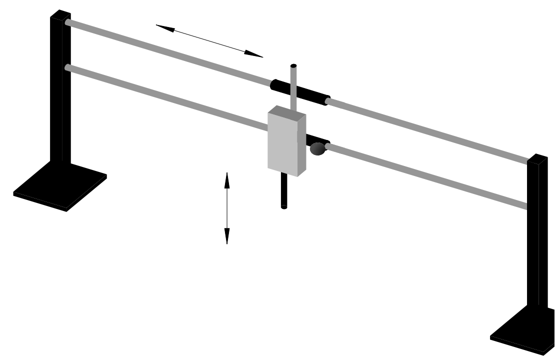

Figure 20.9. Design Concept for Two-Axis Drill Fixture.

Develop a safe fixture to minimize fatigue during drilling by eliminating holding of the drill,

Minimize human-generated forces required to drill into the logs,

Increase the farmer's independence by making the operation of the drill simple,

Ensure that the drilling fixture is compatible with a hoist mechanism used to lift and lower the logs, and

Implement the design in a cost effective manner

Several ideas were carefully studied, including horizontal and vertical drills, motorized and non-motorized drills, and a zero gravity recoil mechanism. A two-axis, vertical drill, utilizing a pre-manufactured drill-press assembly was employed. The drilling action is initiated using a lever, while the drill is moved in a horizontal direction by hand. The log is rotated by hand with the assistance of concave nylon strips located under the drilling fixture as shown in Figures 20.10 and 20.11.

The fixture includes two linear bearings that allow the drill assembly to slide the full 48″ width of the fixture to allow holes to be drilled at any point along the log. The drill assembly consists of a pre-manufactured holder that accepts any ½″ corded or cordless drill.

The drilling action is initiated by pulling down on the lever just as in a normal drill press. Two seamless steel alloy rods (1″ in diameter and 51″ in length) were used to allow the bearings to slide the length of the fixture. The rods are held in place by a length of ½″ threaded rod that is tightened in place by a washer and locking nut on each end. This was used to allow easy assembly and disassembly. The whole fixture is held in place to a table by two ½″ bolts located on each side of the fixture. These ½″ bolts run through the upright supports and into the table used during the drilling process.

After the fixture is secured to the table, three runners are secured to the table using 5/16″ wood screws. These runners are concave in the center to allow the log to be centered under the drilling assembly. The concave is lined with 1/8″ X 1 ½″ Teflon. The Teflon allows the logs to be easily rolled during the drilling process.

The completed prototype was tested at the client's facility. The prototype was tested by installing the drill used during the drilling operation. The fixture was then used to drill holes in several logs by both the team members and the client. The fixture was then tested with the hoist mechanism (see previous project) and no problems were encountered when the two finished prototypes resulting from the two projects were used simultaneously.

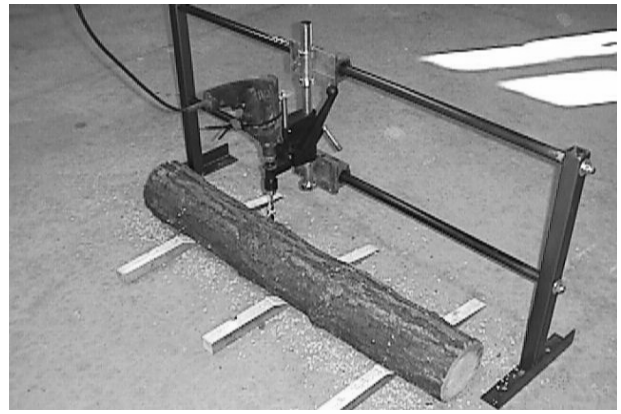

Figure 18.10. Front View of Drill Fixture.

Figure 18.11. Rear View of Drill Fixture.

The total cost of this project was $350.00.

CAMPER ACCESS LIFT

Designers: Colby Benbow, Long Gao, Steven DeWitt, Mechanical Engineering Students
Client Coordinator: Dr. Gregory Nemunaitis
Rehabilitative Medicine, Medical College of Ohio and St. Vincent Mercy Medical Center
Supervising Professor: Dr. Mohamed Samir Hefzy
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INTRODUCTION

A man who uses a wheelchair and has limited use of his hands and arms wishes to continue camping with his family. Currently, he utilizes a ramp and winch mechanism to gain entrance to the family owned travel trailer. This mechanism requires assistance for setup and operation. The purpose of this project was to design and construct a mechanism to be attached to the trailer, which will allow for its normal use and provide this individual an independent means of access. The system utilizes three actuators and a platform supported by two lift arms as shown in Figures 20.12 and 20.13. The lift arms are attached to a solid shaft, which is attached to two actuators by two cylindrical lever arms. As the lever arms rotate, the solid shaft rotates, causing the lift arms to rotate, in turn rotating the platform to raise it and/or lower it. The third actuator is used to extend and retract the platform from under the trailer.

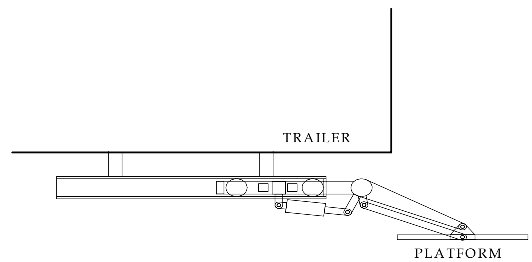

Figure 20.12. Schematic of Attached Lift Assembly.

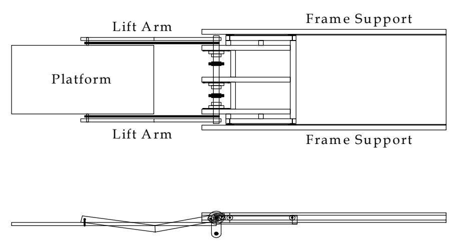

Figure 20.13. Details of Lift Assembly.

SUMMARY OF IMPACT

The successful attachment of this lift mechanism to the family camper allows the client to gain access to this trailer independently.

TECHNICAL DESCRIPTION

Several design criteria were identified. First, the lift needs to be independently operable by the disabled individual. This includes the lift controls, which must be easily manipulated by an individual with limited use of their hands. Second, the lift must be able to accommodate a minimum of 500 pounds. This is the combined weight of the client and his wheelchair. Third, the lift must be completely retractable. The trailer is already 95 inches wide and difficult to manage. Any increase in width will add to this difficulty at best, and at worst create an illegal situation. The maximum legal trailer width in Michigan (where the client resides) is 102 inches. Fourth, the lift must fit under the trailer without ground contact. Fifth, the lift must have a full range of motion. The platform must be accessible to the client if grade slopes to or away from the trailer. These grade conditions will affect the range of motion the lift operates within and must be accommodated. In addition the lift must be able to raise the client to the sill of the trailer door, without contacting the trailer. Sixth, the lift must be safe for the operator. The platform must have devices that keep the client from accidentally rolling off the platform and protected from pinch points. Seventh, the lift must be self-contained. This will allow the lift to be easily transferred to another trailer if required. Lastly, the lift must not interfere with the original factory steps. These factory steps must remain usable when the lift is in the stored position.

The system that was designed and constructed includes three actuators and a platform supported by two arms. The lift arms, shown in Figure 20.14, are attached to the solid main shaft shown in Figure 20.15, which is attached to two cylindrical actuators, shown in Figure 20.14, by two short lever arms, shown in Figure 20.15. Each lift arm is made of welded square tubing (3″ x 1.5″ x 40″). The solid main shaft is 36 ″ long and 2″ in diameter. The short lever arms are made of solid square steel machined to a teardrop shape. As the lever arms rotate due to the actuator forces, the main shaft rotates, causing the lift arms to rotate, in turn rotating the platform, causing it to be raised or lowered. A separate third actuator, also attached to the main shaft, is used to extend and retract the platform. All three actuators are mounted on a carriage that rides on track rollers mounted on the frame support, which is attached to the bottom of the trailer, as shown in Figures 20.12 and 20.13.

The lift was installed successfully on the trailer. The total cost of parts only was $3,500.00. Several corporations contributed to this project by providing $2,500.00 for parts, and the cost of the labor involved in the welding of the different components.

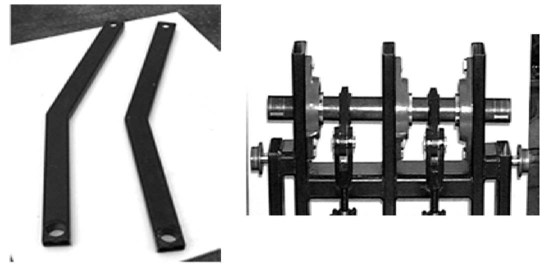

Figure 20.14. Lift Arms Made of Welded Square Tubing (Left) and Main Shaft (Right).

Figure 20.15. Hydraulic Cylinders (Left) and Lever Arms (Right).

FOLDABLE COMMODE SHOWER CHAIR

Designers: Dennis Jeansonne, David Zeller, Bryant Whitcomb, Mechanical Engineering Students
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INTRODUCTION

An active individual with paraplegia requested a foldable commode/shower chair. Units available on the market are not foldable. The purpose of this project was to design and fabricate a foldable commode/shower chair to be used by this individual. Design criteria were that the device:

- Fit over a toilet to provide support for the trunk and to allow for a level surface transfer from the wheelchair to the commode,
- Have an armrest that is removable to allow for transfer, yet allow for support once the user is on the commode, and
- Be foldable, compact and light enough to allow for transfer into a car.

The fabricated unit includes a removable nylon back for comfort, a standard padded toilet seat, foldable arms with pads, foldable notched legs, rubber feet and round and square aluminum tubing construction, as shown in Figure 20.16. To provide additional stability, the seat was fastened to tabs, which were welded to square tubing.

SUMMARY OF IMPACT

A middle-aged, adult male, weighing approximately 150 pounds hasT-3 paraplegia, possessing normal or near-normal upper limb function and no abdominal muscle function or active trunk movements. He has full use of his arms and hands, but no motor use of his legs or feet. He is an active outdoorsman who enjoys hunting and fishing. The foldable commode/shower chair provides him greater independence. The fabricated unit will not only be used in his home, but also at different public restrooms he may use during his hunting trips. Since the unit is foldable and lightweight, it can be loaded in and out of his van easily.

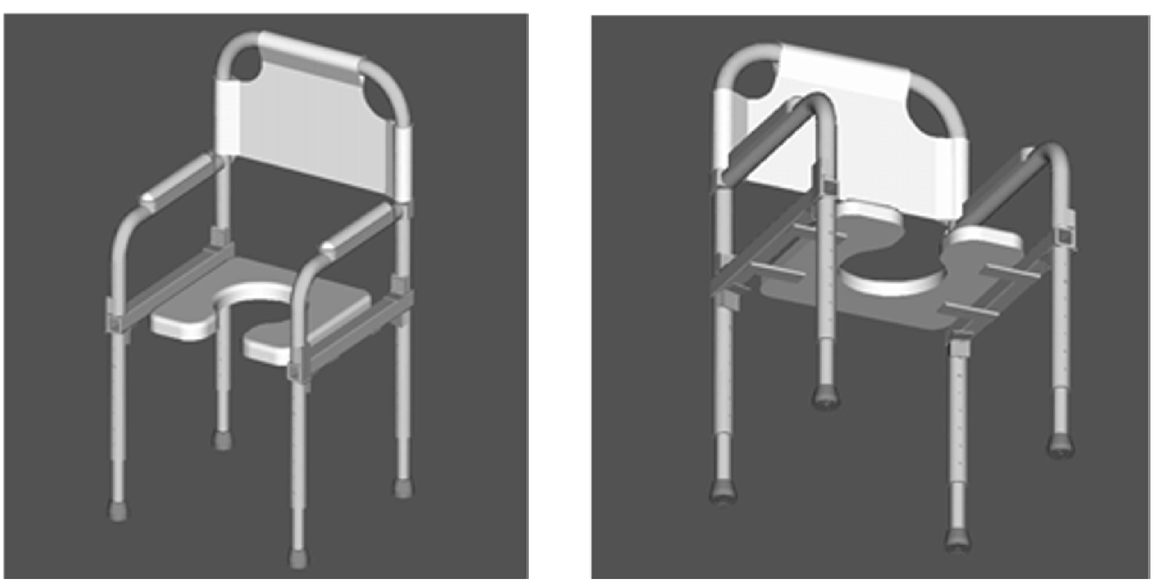

Figure 20.16. Isometric View of Prototype (Left) and Seat with Tabs (Right).

TECHNICAL DESCRIPTION

Existing products available in the market were first benchmarked during the brainstorming process. Figure 20.17 (left) shows an existing stainless steel chair and Figure 20.17 (right) shows a chair made of PVC. Neither design accommodated the client needs.

It was determined at the beginning of the design phase that safety and stability are the primary concerns for the client. Accordingly, the idea of using a soft seat was eliminated because of a concern about stability. In addition, and to improve stability, rubber feet were recommended over wheeled feet that could provide mobility while seated. The armrests were designed to fold completely out of the way to allow for side-to-side and level surface transfer. To enhance versatility, the mechanism of telescoping the legs to adjust leg height was evaluated against a notched mechanism. The notched mechanism was proven to be the stronger and more durable method.

3D modeling using Pro/Engineer was employed to establish fits, interferences and mechanism layouts. The chair has a removable nylon back, a standard padded commode seat, and foldable arms with pads, foldable notched legs, rubber feet and aluminum tubing construction. Twenty feet of aluminum tubing were used in the construction. To provide additional stability, the seat was fastened to tabs welded to square tubing. Figure 20.16 shows a complete virtual model of the chair.

A finite elements analysis FEA of the model was conducted using SDRC I-deas with a design weight of 250 lbs. Three loading conditions were evaluated. The first was a distributed load of 250 lb across the seat to simulate the chair in use. The second concentrated load of 250 lbs at the front of the seat to simulate a person sitting forward on the seat. The final loading condition was a downward load of 250 lbs applied on the arm assembly to simulate a person pushing himself or herself up out of the chair.

The total costs of parts and labor, including welding, was $300.00.

Figure 20.17. Stainless Steel Chair (Left) and Chair Made from PVC (Right).

UNIVERSAL RICKSHAW EXERCISE MACHINE

Designers: Lisa Reyome, Matt Schulze, Tim Carney; Mechanical Engineering Students
Client Coordinator: Dr. Gregory Nemunaitis
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Supervising Professor: Dr. Mohamed Samir Hefzy
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INTRODUCTION

The Rickshaw Machine is a piece of exercise equipment that helps develop the muscles in the arms and the sides. These muscles are imperative for wheelchair movement and transfers. This machine is designed to simulate the pushing down motion of the arms such as when one is pushing down on the wheels of a wheelchair. The current design shown in Figure 20.18 (left) is not safe to use when working with heavy weights, cannot be used independently, and is not adjustable. When working with heavy weights, the front wheels of the wheelchair tend to rise and the individual may tip back or fall over. Free weights are currently used and cannot be picked up and placed on the machine by an individual in a wheelchair. The machine's arms are in a fixed position and do not account for individuals of different sizes. The objective of this project was to design and construct a prototype for a new Rickshaw Machine that is adjustable to different sizes. For safety purposes, the prototype was designed to keep the wheelchair stationary. Straps were used to stabilize the wheelchair and the individual. A pulley system with machine weights was selected because of safety and the ease of changing the weights. The arms were made adjustable by sliding in and out allowing for different sizes of wheelchairs; a pin was used to hold them in place. The finished unit shown in Figure 20.18 (right) accounted for safety, independence, and adjustability.

SUMMARY OF IMPACT

Many individuals can use this redesign of the Rickshaw Machine. The new prototype can be used independently and is adjustable. It will improve the quality of life and mobility of individuals who use wheelchairs.

TECHNICAL DESCRIPTION

The following concerns and issues associated with the design of a new Rickshaw Machine were identified as follows:

Safety. This is a primary concern since the wheelchair lifts up from the existing unit when a person pushes down on the arm.

Kind of Weights Used. Exercise equipment is built to use either machine weights or free weights. Machine weight equipment has weights built into it, and the desired weight is selected by changing a pin

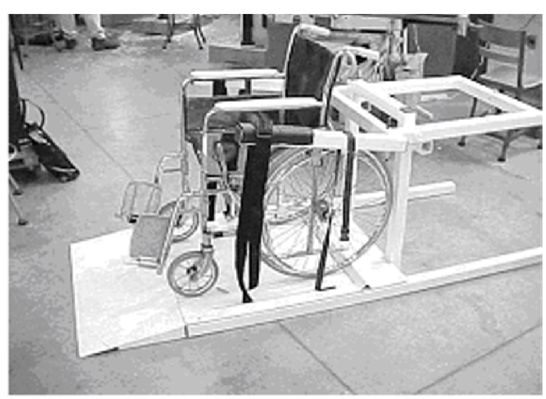

Figure 20.18. Existing Unit (Left) and New Prototype (Right).

in the stack of weights. The user does not have to get up to change the weight. However, the weight can only be added in specified increments of 10 lbs. The latter equipment uses cylindrical disc shapes having certain weight designations. More variations of weight can be used. However, these weights are less stable, and cannot be changed by the user without getting up out of the seat.

Adjustability. The distance between the two arms of the machine has to be directly related to the width of the wheelchair and to the height of the person exercising. A standard width cannot be used because there are wheelchairs of different sizes. The arms need to be as close to the wheels of the chair as possible to simulate the arm extension.

The frame of the new prototype was taken from a butterfly exercise machine. Pulleys were mounted at the bottom and the top of the frame as shown in Figure 20.19. Figure 20.19 (bottom) shows the machine weights used. In order to make the force used to push down the arm equal to the weight stack, the pivot point was located midway between the location where the arms are pushed down and the weight stack.

Steel square tubing (2x2x0.125″) was used for all the sections of the frame. A 7/8″ pin and 7/8″ impregnated bronze bushings were used to construct the pivot point. A stainless steel plate, ¼″ thick, was used as a base plate. The arms were made to slide in and out of the frame allowing for a maximum wheelchair width of 38.5″ and a minimum wheelchair width of 26.5″. The sliding of the arms was made possible by welding a telescoping square bar (1.75″ x 1.75″) to each arm to act as an extension that fitted into the horizontal top tube of the rear arm supporting frame. Three holes were drilled in each of the arm extensions allowing for three possible wheelchair widths. A ramp was welded to the front of the base plate, which was welded to the base frame. The wheelchair was stabilized using straps that extend from the base plate and around the chair, as shown in Figure 20.18 (right), thus stabilizing the individual as well as the chair. The problem of the wheelchair tipping back was eliminated since the straps went around the individual's knees. The wheelchair user was able to tighten the straps independently. Long slots were cut in the base plate to allow the

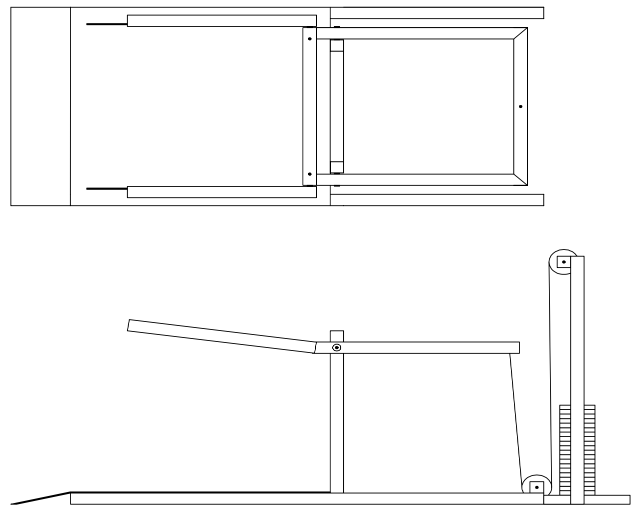

Figure 20.19. Top View (Top) and Side View (Bottom) of Rickshaw Machine.

The new design allows for adjusting the distance between the arms (width), but does not allow for adjusting their heights. This is an area of future modifications. Straps to move back and forth for adaptability.

The total costs of parts and labor, including welding, was $825.00.

ADAPTATION OF A ROWING MACHINE

Designers: Kevin Potter, Rachel Harvell, Anthony Hiss; Mechanical Engineering Students
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Supervising Professor: Dr. Mohamed Samir Hefzy
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INTRODUCTION

An active athlete with L4 paraplegia was unable to properly utilize her rowing machine. The objective of this project was to modify her rowing machine to provide adequate support for her lower extremities. The modification process focused specifically on four key issues: stabilization of the client's feet and lower leg, enhancing seat comfort, repositioning of the rowing handle bar to be within reach when the client is seated, and the addition of exercise performance feedback. Figure 20.20 shows two views of the modified rowing machine, including the ankle brace and the wooden foot guard.

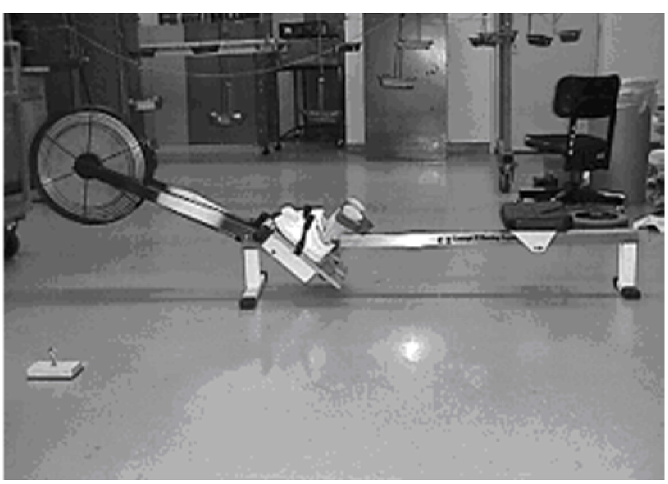
SUMMARY OF IMPACT

The successful completion of this project provided the client with the ability to exercise independently and safely.

TECHNICAL DESCRIPTION

The client was videotaped while exercising to determine the problems associated with her use of the rowing machine. Careful analysis of the videotape revealed that the primary cause of the client's inability to use the machine was because of her feet falling off the platform and the abduction of her right hip. Additional problems were noted with the seat, the handle bar, and a lack of exercise performance feedback.

A foot restraint system was designed to include a formed ankle brace, a Velcro lined shoe sole, a foam pad, and a wooden foot guard. A 5.5″ x 4″ piece of Velcro was put on the bottom of the client's shoes to cover the width of her shoe and was bent down about 5″ to adhere to the wooden platform. The heel stop thickness was increased from 1″ to 2″ to move the position of the client's ankle higher so that it would not contact the chrome monorail. A foam pad was also placed on the sides of the monorail to keep her foot a set distance from the monorail. An ankle brace was constructed out of a composite plastic to provide strength and support to the ankle joint. This was done in consultation with Cole Orthotics, a company that specializes in making



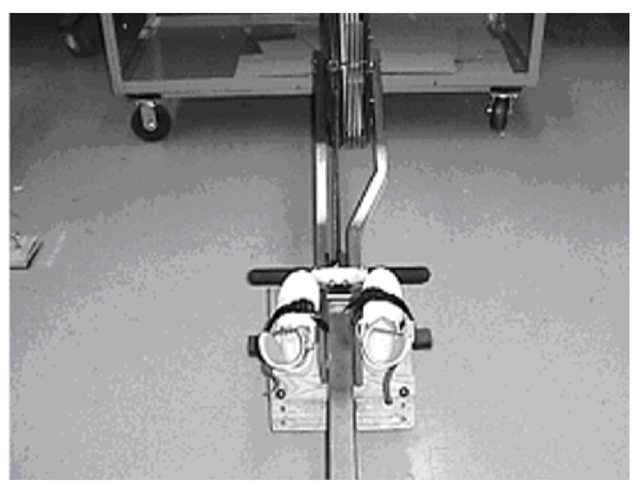


Figure 20.20. Side View (Left) of Rowing Machine and Top view (Right) Showing Ankle Brace and the Wooden Foot Guard.

prosthetics and orthopedic devices for children with disabilities.

The second of the two major issues preventing the client from using the rowing machine properly was the abduction of her right hip, causing her leg to twist outward. A gait belt, made of thick cloth, was used to restrain her thighs where the strength of her left leg was used to counteract the abduction of her right leg.

Secondary modifications included the seat and the handle bar. The seat was modified by adding a foam pad. This alleviated discomfort the client was experiencing during her rowing sessions. Furthermore, it could be seen by inspecting the machine that a bracket was needed to bring the handle bar within grasp while the client was seated in the rowing position. A bracket designed to retrofit the unit was secured from the manufacturer, and installed on the rowing machine. The last of the modifications was the installation of a digital display that relays exercise performance feedback. The client intends eventually to be able to row on water and compete in crew events. An accurate workout-measuring device is thus especially important. The feedback of this device includes calorie expenditure, heart rate, time, target output level, pace, and distance. With its built-in memory function, the client can review the workout when completed. Cosmetic modifications were also made to the unit including installing a new rust-free monorail, new foot straps, and a new paint job.

The client tested the modified unit and was very pleased. The total cost of modifying the rowing machine was $500.

MODIFICATION OFA POWER WHEELCHAIR FOR RACING

Designers: Randy Behrendsen, Natalie Castro, Amy Millimen; Mechanical Engineering Students
Client Coordinator: Dr. Gregory Nemunaitis
Rehabilitative Medicine, Medical College of Ohio and St. Vincent Mercy Medical Center
Supervising Professor: Dr. Mohamed Samir Hefzy
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INTRODUCTION

A member of a racing wheelchair team has C6 tetraplegia. This injury prohibits him from moving his legs, hands, abdomen, and trunk, and he has only partial use of his arms. This athlete owns a power wheelchair that he uses in competitive racing. The objective of this project was to modify this power wheelchair to increase its speed capability while maintaining stability for racing purposes. It was also desirable to make the wheelchair lighter. The maximum speed of the wheelchair was increased by modifying the gear box to change the gear ratio. The modified gear box is shown in Figure 20.21. The total weight of the wheelchair was decreased by replacing the original batteries with smaller and lighter batteries.

SUMMARY OF IMPACT

The successful completion of this project allowed an athlete to become more competitive during wheelchair racing. He purchased his power wheelchair with an intention to use it in a competition in which racers dash down a straightaway 60 meters in length. When he used the wheelchair during racing, he found that when he reached top speeds, the front wheels began to flutter, which forced him to reduce his speed to maintain control and stay in his lane. This did not allow him to race at a competitive speed. The modified chair raced at a maximum speed about 60% faster than that the original wheelchair maximum speed. The weight of the chair also decreased, allowing increased acceleration during racing.

TECHNICAL DESCRIPTION:

Time trials were conducted to determine the top speed of the power wheelchair with a 150-pound passenger. The top speed was found to be approximately 4.4 mph. A goal was established to increase the overall top speed to approximately 8 mph.

When the client accelerates and finally reaches top speeds, the front wheels of the original wheelchair start to flutter and vibrate. To keep the chair under control, he has to reduce the speed, causing underachievement of the full potential of the motor. Also, the client sometimes experiences a wheelie effect at the start of the race in this power wheelchair, where the front wheels lift off the ground.

This power wheelchair is propelled via two motors, one hooked to each rear wheel. A controller is used to allow the user to choose high or low speeds and to steer the wheelchair. The front wheels have no steering capability. According to Wheelchair Sports USA, the governing body of the race that the wheelchair will be used in, there are no specific rules about modifications to the power wheelchair. The only guidelines were not to make obvious modifications to the chair thus giving the contestant an unfair advantage. This eliminated the obvious choice of replacing the motors with larger more powerful ones.

The following two modifications were introduced to achieve the goals of this project and improve the racing capabilities of the power wheelchair:

- Changing the gear ratio of the gearbox of the wheelchair to increase its top speed and
- Replacing the old batteries with smaller and lighter batteries.

The gearbox was first disassembled. A schematic showing the interface of the motor, the gears of the gearbox and the output shaft is shown in Figure 20.21. The speed of the output shaft (mounted on gear 2) was measured as 118 rpm. The number of teeth on gears 2 and 3 in the gearbox before modification was 32 and 12, respectively. The speed of gear 3 before modification was thus calculated as 314.67 rpm. Since the speed of gear 3 is the speed of the motor, it was kept constant in the modification process. The number of the teeth on gears 2 and 3 was then varied to allow the speed of gear 2 to become 75% faster, running at a calculated speed of 206.5 rpm. Using a trial and error procedure, the modified number of teeth on gears 2 and 3 was calculated as 27 and 17 teeth, respectively, causing the output shaft to run at 198.1 rpm. Since the diameter of the wheel attached to the output shaft was 12.5 inches, the velocity of the wheel was expected to increase from 4.39 m/h to 7.37 m/h. The two new gears were manufactured professionally. The diametric pitch of gears 2 and 3 was 12.7. Accordingly, the pitch diameters of gears 2 and 3 were established as 2.12598 inches and 1.33858 inches, respectively.

To reduce the weight of the wheelchair, the original batteries were replaced. Two 12-volt batteries connected in series were used to give the power wheelchair 24 volts of power. These batteries were standard wheelchair batteries that were rated at 33 amp-hrs and are heavy, weighing approximately 25 pounds each. The motor draws 3.3 amps, so these batteries would last for approximately 10 hours before they would need to be recharged. Since the client plans to use this wheelchair specifically for racing it is not necessary that the batteries last that long. The original batteries were thus replaced with two 17 amp-hr batteries of the same type and voltage, but weigh about half as much. These new batteries would need to be charged about every 5 hours. This modification allowed plenty of time to complete the race and, at the same time, reduced the weight of the chair since the weight of the original batteries was about half of the overall weight of the wheelchair.

When the modified chair was tested fluttering did not occur. This may have been due to tightening the bolts on the front wheels, which reduced the amount of play in the wheels and reduced the vibration causing the fluttering.

The total cost of modifying the wheelchair, including the new batteries, gears and replacement bearings was $1,150.00. Machining the two new gears was the most expensive item. A part of the cost was absorbed through a donation from Dana Corporation.

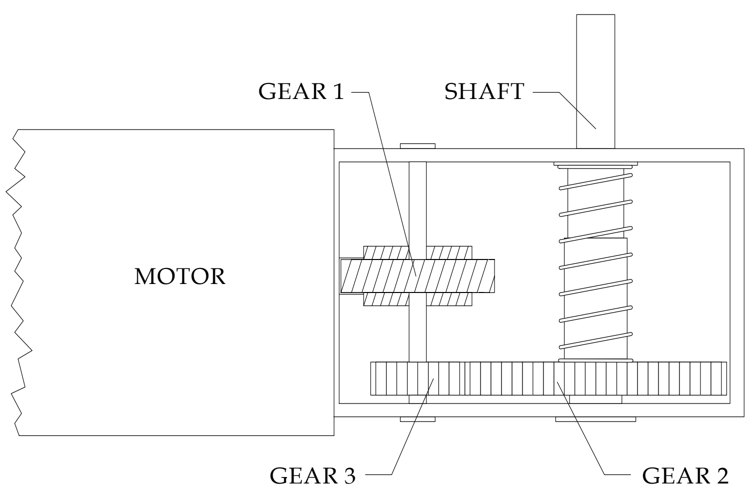

Figure 20.21. Gear Box Modified by Changing Gears 2 and 3.


1205

CHAPTER 21
WAYNE STATE UNIVERSITY

College of Engineering
Department of Electrical & Computer Engineering
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GUIDELINES FOR DESIGNING AN ACCESSIBLE WEBSITE FOR SMART

Designers: Suhail Hirani, Web Site Design for SMART
Goran Jancevski, Hassan Taleb, Raymond Ryan, and Steven Weber, Web Site Accessibility SMART Web Site Guidelines
Client Coordinators: Mr. Ronald Ristau, Director of Service Development, SMART
Supervisor: Dr. Robert Erlandson
Department of Electrical and Computer Engineering
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Detroit, MI 48202

INTRODUCTION

SMART (Suburban Mobility Authority for Regional Transportation) is a public service organization, established by the State of Michigan, responsible for planning, acquiring, constructing, operating, maintaining, and contracting public transportation services in Wayne, Oakland, and Macomb counties. As a public website, SMART must provide an accessible website in compliance with the Americans with Disabilities Act (ADA). Furthermore, Section 508 of the Rehabilitation Act requires that information technology used, developed, and procured by the Federal government and agencies that contract with it must be as accessible to people with disabilities as it is to people without disabilities.

The evolving guidelines for web site accessibility derive from the World Wide Web (W3) Web Accessibility Initiative (WAI) accessibility guidelines. For example, web sites must be compatible with assistive technologies, such as text-to-speech readers used by individuals with disabilities. The ability to access a website by people with disabilities as effectively as by people without disabilities is referred to as Web Content Accessibility. An accessible web site allows all users to access it, regardless of their browser, resolution, settings, eyesight, hearing, or motor skills.

The transformation of the Internet from a text-based medium to a robust multi-media environment has created a crisis – a growing digital divide in terms of access for people with disabilities. Previously, people with visual disabilities were able to access the Internet with their screen readers audibly reading aloud the text on a web page. Today, graphical web pages are a barrier if they do not incorporate accessible web design. It is a paradoxical twist that as web technologies advance and incorporate more multi-media in websites to titillate mainstream users, such technologies can deny access to users with disabilities.

Thus, public website designers should create accessible websites that are in compliance with WAI

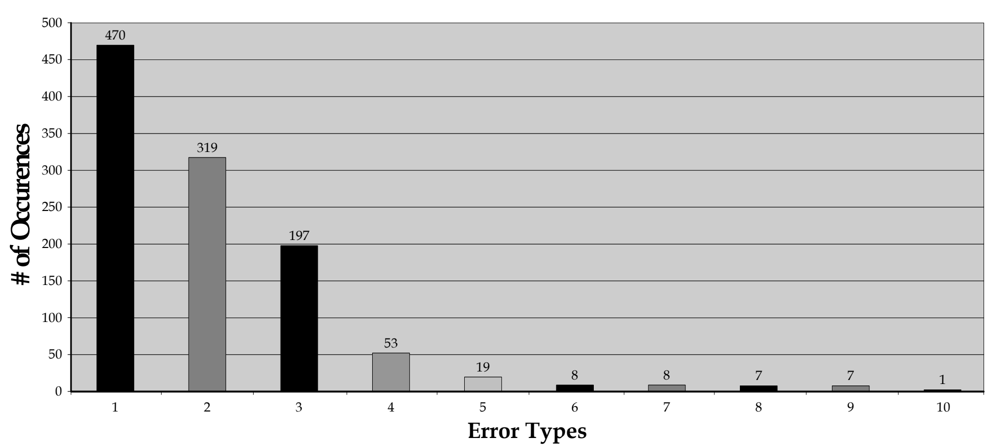

Figure 21.1. Chart of Priority 1 Accessibility Errors.

guidelines thereby reducing the risk of ADA-related legal action against them. Unfortunately, the majority of web designers and their clients are not aware of the specifications of Web Content Accessibility criteria. Among those who are aware of the guidelines, many have misconceptions about accessible web pages, such as: they must be written in HTML 2.0; they must cater to the lowest common denominator; they must be dull, text-only, designs.

SMART will be contracting with a consulting firm to design their web site. The consulting firms thus far contacted are either not aware of the guidelines, unfamiliar with handling the various elements of accessible website design, or believe that they need not comply with WAI guidelines. The goals f both student research projects were to research the need and criteria for accessible websites, provide examples of accessible and non-accessible web sites, and then provide references to guidelines for SMART's website, which will be forwarded to the selected web design consulting firm.

SUMMARY OF IMPACT

SMART's staff has reviewed the material provided in the student reports. Of particular benefit were the detailed comparisons of apparently similar web sites, one satisfying CAST's Bobby Priority 1 (Center for Applied Special Technology) accessibility criteria and the other not satisfying these criteria. The student reports provided URLs to demonstrate versions of IBM's Home Page Reader and the Lynx text browser. With these readily available packages SMART staff has been able to experience accessibility issues, problems, and solutions greatly enhancing their understanding and appreciation of the WAI guidelines. (Figure 21.1)

The reference material provided in the student projects has helped SMART staff educate the consulting companies they are contacting as to the needs and resources available to design accessible web sites (Table 20.1). CAST's Bobby web evaluation system provides a tool for simple web site evaluation and links to the WAI guidelines for more detailed evaluations if required. Also, with the IBM Home Page Reader and the Lynx browser they will be able to experience the web site and thereby assess its accessibility firsthand.

Table 21.1. Examples of Web Based Material on Accessible Design.

Example	URL	Content
The US Access Board	http://www.access-board.gov	Laws, regulations
Center for Applied Special Technology (CAST)	http://www.cast.org	Bobby web evaluation tool
TRACE Center	http://trace.wisc.edu	General Information
The Enabling Technologies Laboratory	http://www.ece.eng.wayne.edu/etl	General Information
IBM Accessibility Center	http://www-3.ibm.com/able	Home Page Reader
Microsoft Accessibility	http://www.microsoft.com/enable	General Information
W3C Web Accessibility Initiative (WAI)	http://www.w3.org/wai	Web Accessibility Guidelines

PAPER CUTTER/SWITCH OPERATED PRESS

Designers: Robert Chen, Ahmad Hammoud, Vlad Iliescu, Jose Mabesa Jr., and Mohamed Mansour
Client Coordinators: Kathy Vordburg, Kennedy Center in Pontiac, Michigan and Cathy McQuillan, Torrent Center, Jackson, Michigan.
Supervisors: Dr. Robert Erlandson, Enabling Technologies Lab, Department of Electrical and Computer Engineering and Dr. Eugene Rivin, Department of Mechanical Engineering
Wayne State University
Detroit, MI 48202

INTRODUCTION

The Ellison Embossing System consists of a press fitted with steel dies that make paper cutouts that teachers use for various classroom activities. While the Ellison press itself is not expensive, the complete die set is expensive, thus making it difficult for each school to own a complete system. It is common practice for a school district to have only one complete embossing system, usually kept at the school district headquarters. In order to use it, teachers must invest additional time after school hours to travel to the facility and to use the press. Teachers at one special education school had created a unique program that eliminates this problem while providing students requiring special education with meaningful work. Another school requested a similar program.

The hand-operated Ellison press is difficult to use for all but the most able-bodied students. Students place pre-cut paper in the press, then place a die on top and push down on a lever that applies force on the die and cuts through the paper. Many students find it difficult to align the paper and die within the press. Exerting the necessary amount of force onto the lever to cut the paper is also problematic for many students with physical impairments (Figure 20.2). The staff at both centers wished to create a process that can be expanded to include students with more severe physical and or cognitive disabilities.

SUMMARY OF IMPACT

Now teachers at both schools can order cutouts and have them delivered to their classrooms. The device was well received by both students and staff. Students use the device to produce cut-outs for teachers.

Figure 21.2. Student Using the Old Ellison Press System.

TECHNICAL DESCRIPTION

The Switch Operated Press is designed to incorporate redundant mechanical and electrical safety systems. Mechanical safety design considerations include the following:

- A mechanism to that isolate the workings of the press from unauthorized physical contact,
- A means of preventing the tray from being pulled out while the press is in operation, and
- A physical barrier to the press to prevent injury should students place their hands or some other body part within the path of the press.

Electrical safety design considerations include the following:

- Systems that prevent the press from operating while the tray is pulled out,
- Clearly visible visual signals that indicate the operational status of the press,

- Systems that prevent accidental static discharge from activating the motor, and
- An activation button that can be placed at a safe distance from the press.

The system consists of the following: reversible AC motor with thermal protection, a screw press, a plastic drawer plate, electrical and mechanical safety features, a control box, and Plexiglas casing.

The system uses a reversible AC motor with thermal protection. Thermal protection is required so that the motor will shut down without being burned out in case the system experiences a jam. Reversible action is required because the press first moves down to cut the paper and then moves up; this change in direction must occur without interruption.

Two major safety features, one electrical and one mechanical, ensure that if one fails the other works. First, a safety switch turns on when the drawer is completely closed and turns off when the drawer is pulled out. This switch ensures that the motor cannot run and the press cannot move when the drawer is open. Second, a steel pin extends down from the ram plate, which fits in a small hole drilled in the wooden part of the drawer. As the press goes down, the pin locks the drawer, preventing it from being opened. The drawer does not open until the press reaches its highest position.

Incorporating an activation switch eliminates the need for students to physically push or pull on a handle; instead, students simply press a button. The system accepts the full range of switches used in a special education environment. Enclosing the press in Plexiglas casing ensures that fingers and hands stay clear of the press at all times.

Loading the paper and die no longer involves squeezing them into the press. With the new design, students use the handle to pull out the tray, load the paper, place the die sideways on top of the paper, and push the tray back in. This process is reversed to remove the paper and die once the press makes the cut-out. (Figure 21.3)

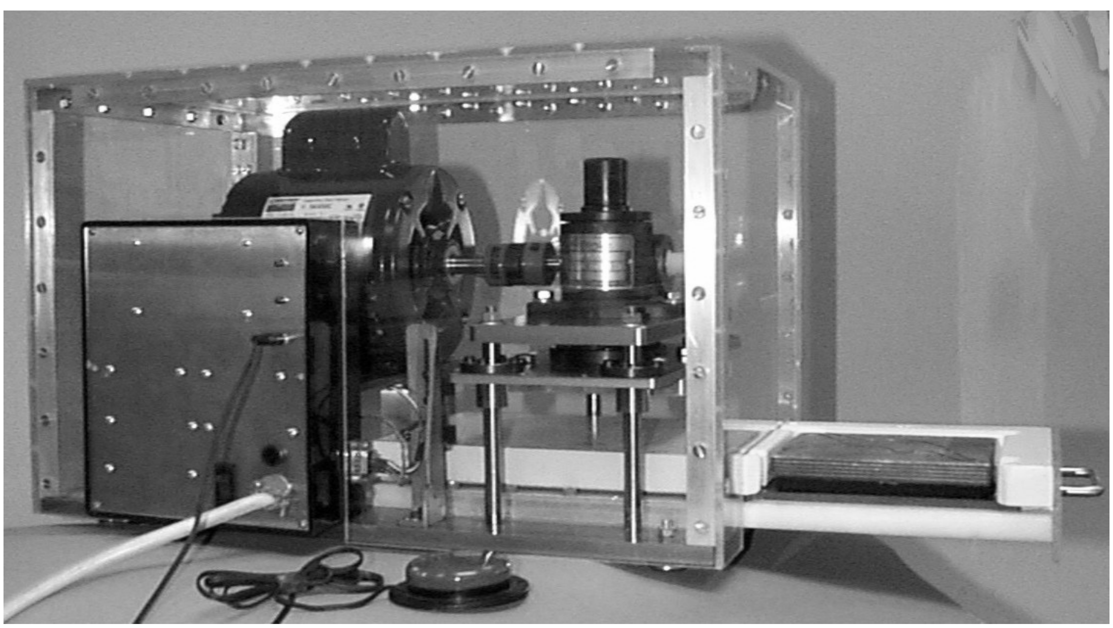

Figure 21.3. Paper Cutter/Switch Operated Press Compatible with the Ellison Die Embossing System.

FORCE FEEDBACK MOUSE USED FOR A PHYSICS EXPERIMENT

Designers: Brian Farrell
Client Coordinator: David D. Baldyga, Junior, Mechanical Engineering Student who is legally blind.
Supervisor: Dr. Robert Erlandson
Department of Electrical and Computer Engineering
Wayne State University
Detroit, MI 48202

INTRODUCTION

Teaching science involves hands-on experiments that are often difficult to modify for students with visual impairments. This project explores the use of the Logitech Wingman Force Feedback Mouse in a computer simulated physics experiment. This mouse is a commercially available device commonly used in video games to provide more realistic user interaction with computer generated characters and environments. The intent is to use the force feedback capabilities of the Wingman to provide additional feedback to the user.

A blind mechanical engineering student participated in the project as a consultant and collaborator. The experiment explores the relationship between a spring's length, applied force and spring constant. The experiment is designed as a gaming system that includes voice feedback, tactile feedback, and sound feedback (an auditory homing signal); this design provides a media-rich simulation environment. In addition to demonstrating a physics principal, the Force Feedback Mouse experiment demonstrates the feasibility of simulating experiments for individuals with visual impairments.

SUMMARY OF IMPACT

Field-testing of this program was conducted by a student who is legally blind. The following is an excerpt from his written analysis: "The computer simulation has advantages for students with visual impairments and fully sighted students. Equipped with voice-assisted instructions, it provides an added dimension to a classic physics experiment. Students with visual impairments can benefit by performing it with little or no assistance. The feel of the spring being compressed adds reality to the simulation that goes far beyond simply crunching numbers in standard computer simulations. Fully sighted students can also benefit by experiencing the feel of the spring being compressed."

Figure 21.4. Main User I/O Screen.

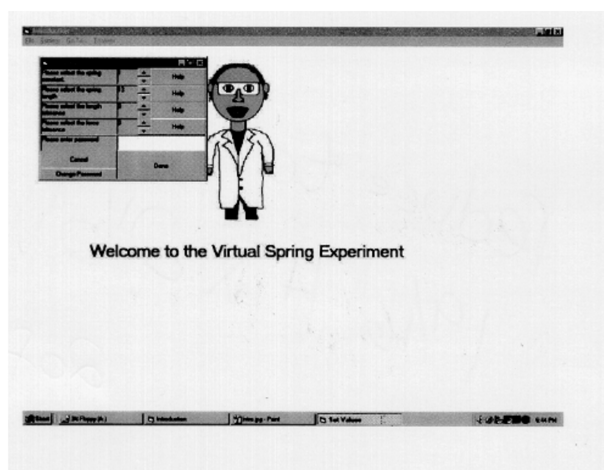

Figure 21.5. Set Value Screen.

TECHNICAL DESCRIPTION

The spring experiment was created using Visual Basic 6.0. An immersion web type library ActiveX controller was installed to control the force feedback mouse. The spring experiment uses Microsoft's Speech Software Development Kit (Speech SDK 4.0), which can be downloaded from Microsoft's web site. The Microsoft Voice Text ActiveX controller was added to the Visual Basic package for text to speech control. The spring dynamics were simulated using Visual Basic.

The spring experiment application window consists of a pull down menu bar, a "lab helper", bar graphs for spring length and force applied, and a simulated spring (Figure 21.6). When the application is launched, a voice is heard that walks the user through the menu selections. The software will read through all of the available choices to assist users.

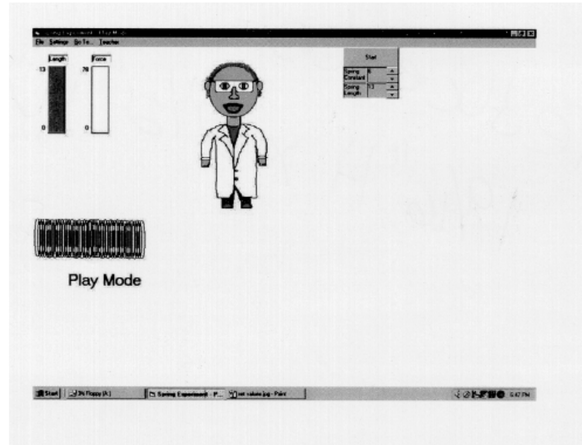

Figure 21.6. Play Mode Screen.

The first menu selection is located under the File heading. Available options include a Play command that begins the experiment or a Quit command that ends the application (Figure 21.8). The second menu selection is labeled "Settings". Available options under "Settings" include the ability to turn the lab helper on or off, to turn the voice on or off, and to assist the user with finding the spring on the screen. A third menu selection is labeled "Go To…." Available options include "Overview" where the user is instructed as to the significance of Hooke's law as well as how the experiment is conducted and which parameters of Hooke's law are measured. Advice is also given to the user as to how to increase the accuracy of the experiment. A "Results" option allows the user to view the results of the experiment.

A final menu item labeled "Teacher" allows a password protected screen to appear (Figure 21.7). This allows staff to adjust the spring constant, length of spring, a length tolerance, a force tolerance, and the password. Help is also available for all of the parameter adjustments.

HVAC DISASSEMBLY PROCESS AND WORKSTATION DESIGN

Designers: Tomica S. Champion and Claudia Ricaurte
Client Coordinators: Ms. Jane Resutek, teacher Warren Woods Towers High School, Mr. Jim Resutek, Engineer, Delphi.
Supervisor: Dr. Robert Erlandson
Department of Electrical and Computer Engineering
Wayne State University
Detroit, MI 48202

INTRODUCTION

The HVAC Disassembly Process and Workstation Design project provides new job opportunities for high school students with learning disabilities and promotes recycling of damaged heating, venting, and cooling (HVAC) units. It combines the simultaneous efforts of process design, workstation design, material flow, and facilities layout for the entire disassembly process from incoming product to output of the final harvested parts. The project's objectives were to:

- Develop and build an efficient and safe workstation layout,
- Develop and implement an efficient and orderly storage area, and
- Develop and build an efficient and safe material handling system.

SUMMARY OF IMPACT

With this project, students disassemble HVAC units and store the parts. This experience allows them to gain technical skills and prepare them for the automotive workforce. It also teaches them general work skills such as following instructions, working with a supervisor, and working as a team player. The school previously did not have a workstation suitable for the disassembly process. A safe and ergonomically correct work environment was needed to disassemble HVAC units while attending to the students with disabilities.

TECHNICAL DESCRIPTION

A quality function deployment (QFD) model was used to assess and prioritize the client's wants, which included: student independence, ergonomics, cost effectiveness, and inventory control. The technical requirements were: process disassembly design, workstation design, material flow design,

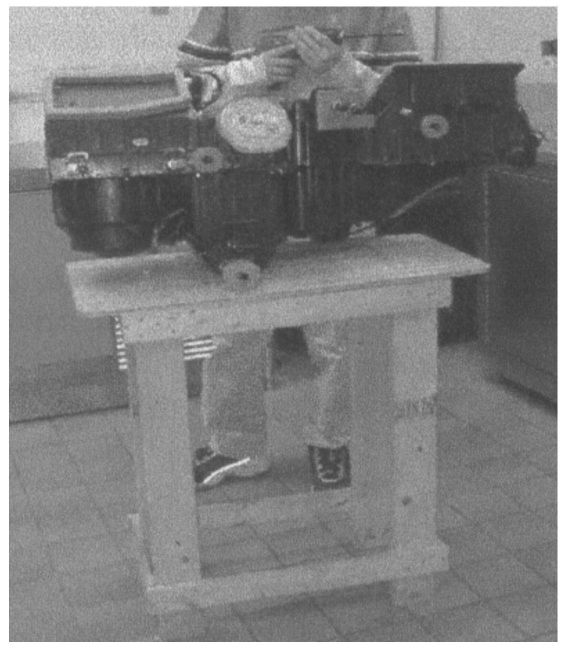

Figure 21.7. Original Workstation.

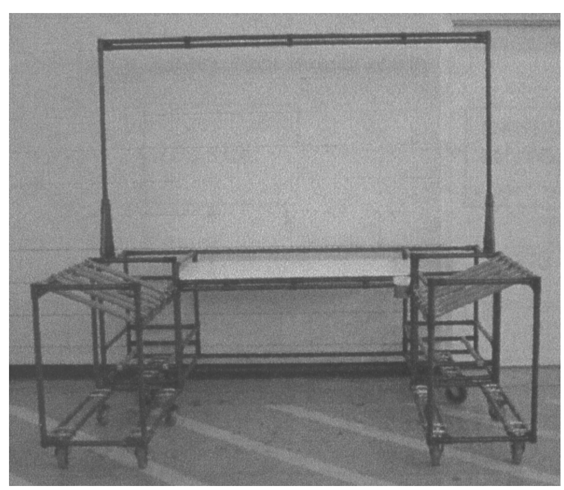

Figure 21.8. Completed Workstation.

and facility layout design. Workstation design was the first priority followed by the disassembly process design, material flow design, and facility layout design.

There were five different HVAC units, each a different size and weight and harvestable components. However, there was considerable similarity among HVACs, which allowed for a usable generic disassembly procedure. Based on this disassembly procedure and worker ergonomic needs, including wheelchair accessibility, the workstation was designed and assembled.

The workstation is built from Creform, a pipe and joint agile device technology. The pipe and joint technology allows for rapid proto-typing yet is strong enough to be used for the final product. The station is wheelchair accessible, yet it allows non-wheelchair users to work comfortably. There is an overhead rack for support of disassembly tools and fixtures. A counter balance will support a power drill so that the worker does not have to accommodate the weight of the drill while involved in disassembly. There are two mobile detachable side carts with slanted racks. One holds the HVACs and the other holds the harvested parts in plastic containers placed on the tilted cart rack.

A facilities layout was provided along with suggested material flow and storage suggestions. These were preliminary and will be subject to re-evaluation in a subsequent project.

PAPER COUNTER AND DISPENSER

Designers: Vincent Alexander, Michael D. Kresbaugh, Vincent Palazzolo, and Jamie Waldrup
Client Coordinators: Ms. Lynne Hagmann, Western Wayne Skills Center
Supervisor: Dr. Robert Erlandson
Department of Electrical and Computer Engineering
Wayne State University
Detroit, MI 48202

INTRODUCTION

The Paper Counter and Dispenser will assist individuals with physical and cognitive disabilities in clerical work that involves paper sorting and bulk mailing. The electro-mechanical Paper Counter and Dispenser feeds sheets of paper, varying in size, into an output tray where the user may easily collect the sheets of paper. More specifically, the device accepts a stack of paper that is loaded into the machine. A supervisor sets the total number of sheets to be fed and the user activates the paper dispenser by pressing a portable switch pad. The mechanized rollers grab the paper, pull it onto the device, count the paper, and dispense it into the output tray. The device continues this cycle until it reaches the set number; then it automatically deactivates. The output tray is fitted with raised channels, which allow the user to easily remove the paper.

The dispenser must be safe for all possible users. The dispenser's drive mechanisms must be enclosed. The dispenser must also be operated by the push of a button. Multiple students at different workstations will use the dispenser, so it must fit on a tabletop for easy relocation.

SUMMARY OF IMPACT

The device will allow students with physical and cognitive disabilities to take part in the paper sorting, counting, and mailing tasks.

TECHNICAL DESCRIPTION

Low speed, low volume paper handling, sorting, and counting operations are common components in special education office skills classes. While high-speed office automation systems are commercially available, they are too expensive for classroom use. More critically, they are not designed for the low volume, low speed, person-based operations found in the special education setting. The design challenge is to find a low cost, safe, and reliable system for low volume, low speed, operator-involved paper handling, sorting, counting, and dispensing system.

The client's major objective is to provide a technological intervention that will allow students with a range of physical and cognitive disabilities to participate in mailing, sorting, and counting tasks. Furthermore, the technological intervention should allow the students to work as independently as possible. Based on the client's specifications, the system was to handle single sheets of letter and legal sized paper in various sizes, folded single sheets, envelopes, and, if possible, small multi-page pamphlets and newsletters. In addition, the system was to be able to count the items and dispense them in a way that is easy for the students to retrieve. It must be easy for the students to place the sheets into the system. The system should be operable by a movable pad switch.

The essential components of the system include: an ergonomically simple input process or mechanism, a reliable sheet-separating mechanism integral with the paper grabbing and movement mechanism, an ability to count sheets electronically, and an ergonomically sound collection and operator retrieval process/mechanism. (Figure 21.9)

There is an input tray that slides out of its holder so that it is easy to place paper, envelopes, or newsletters into the tray. The tray has movable sides so that different sizes of paper can be accommodated. When the input tray is pushed into place, a pressure panel in the bottom front of the tray moves over a spring-loaded roller on the base of the unit. This spring loaded roller puts pressure on the bottom panel and forces the paper upward toward the drive roller. The persistent force between the top sheet of paper and the drive roller ensures that the roller will grab the paper and move it forward.

As the feed rollers grab a sheet of paper a friction based separation pad works to separate the top sheet from other sheets that may be attached. Next, a second feed roller that rotates faster than the lead feed roller catches the top sheet. This speed differential is created by the geared belt drive mechanism. The speed differential causes the top sheet to advance faster than any other sheets. A slip gear drives the initial feed roller so that when the second faster drive grabs the top sheet and pulls it forward, the increased reverse force on the initial feed roller causes it to slip. This slippage further enhances the sheet separation process in that sheets not caught by the second roller slow or stop forward movement.

A photoelectric sensor is mounted just beyond the second roller. As the sheets exit the roller and drop into the output tray, there is a separation that can be sensed and a signal transmitted to an electronic controller unit. When the controller senses the required number of sheets it stops the feed rollers. The student can then remove the specified number of pages from the output tray.

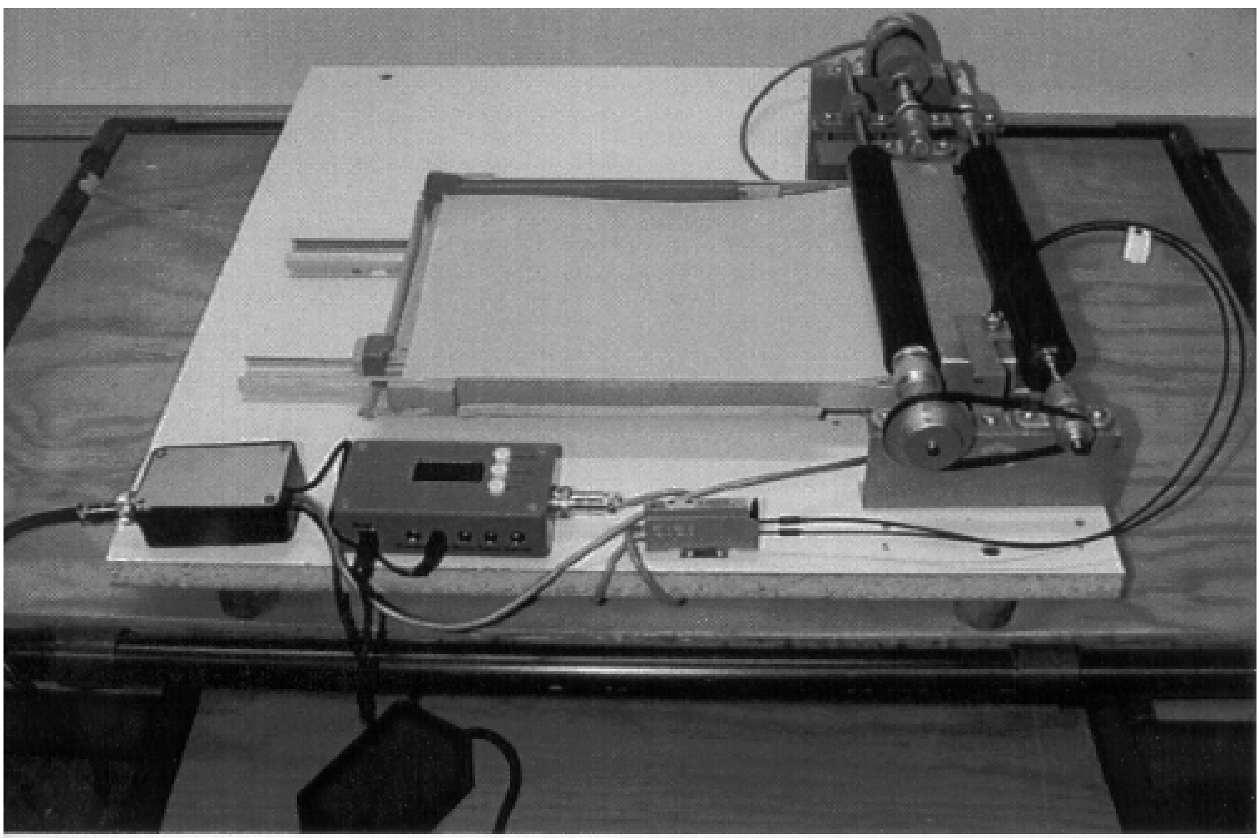

Figure 21.9. Paper Counter and Dispenser.

CHAPTER 22
WRIGHT STATE UNIVERSITY

College of Engineering and Computer Science
Department of Biomedical and Human Factors Engineering
Dayton, Ohio 45435-0001

Principal Investigators:

Chandler A. Phillips (937) 775-5044
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AUDIO VISUAL TACTILE TIMER

Designers: Joyce Bevington, Sarah Brugger, Douglas Fisher
Coordinator: Ms. Nancy Moles
Supervising Professor: Dr. Hangartner
Department of Biomedical and Industrial Engineering
Wright State University
Dayton, Ohio 45435-0001

INTRODUCTION

The Audio Visual Tactile Timer is a redesign of an existing timer called the Time Timer. This project addresses teaching of concepts for time and time management. The previous product, while appropriate for simple, unchanging environments, did not have the flexibility or options to function effectively in a diverse classroom setting. The clients include a broad spectrum of students with autism, ADHD, ADD, language delay, and hearing and visual impairments. Based on the shortcomings of the Time Timer and lack of a good replacement, it was appropriate to redesign the product.

SUMMARY OF IMPACT

The utilization of the timer instills a greater comprehension level of elapsed time, which leads to more independence and effective use of time by students. The timer is appropriate for activities such as timed activities, time out, quiet time and time remaining for an activity.

TECHNICAL DESCRPTION

The engineering principles used during the design of this project include electrical analysis, mechanical/structural design, and ergonomic analysis. The circuit design (Figure 22.3) is driven by the Basic Stamp II microprocessor and a 6V, 0.85A precision stepper motor. To determine how the position of the clocks would be monitored, an RC circuit is implemented in conjunction with the Basic Stamp II, which provides both high resolution and the linearity necessary to accurately determine the position of the disks.

The peripherals such as lights, sounds, ticking, and vibrations are controlled through the use of transistors. All units incorporate LEDs to indicate power and operation of the timers. Due to the size constraints on the Tactile Timer, a circuit card was manufactured to ensure proper fit. Because of the similarity between the Main and Tactile circuitry, a duplicate card was also used in the Main Timer.

The Main Timer also provides a once per second ticking sound to indicate that time is passing. Reference bumps and the vibrating face of the Tactile Timer give feedback with regard to time passage and end of task to students with visual impairments. The Main and Tactile Timer face layout maintains the original design of a standard clock face to aid in teaching recognition of time. The Secondary Timer has a linear layout because of its

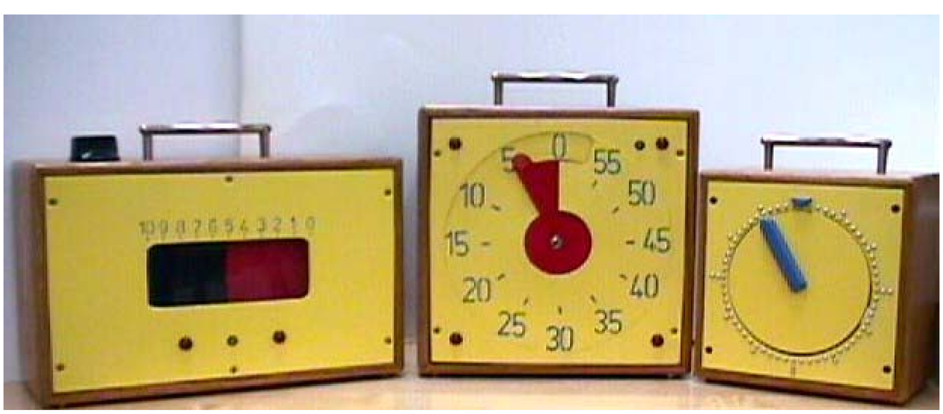

Figure 22.1. Secondary Unit, Main Unit and Tactile Unit – Front Views.

short time frame so as not to be confused with the layout of the other timers. (Figure 22.2)

The Main Timer (Figure 22.5) is used to time tasks for up to 55 minutes. It has multiple options to aid the teacher or other user in timing tasks.

This unit is constructed of ¾″ red oak with a 6mm thick inset Celtec 700 PVC plastic face and back. The wood frame has been treated with a cherry stain and multiple polyurethane coats for durability. The PVC face and back were also painted with multiple paint and clear coat layers. The guide plastic and red disk in the timer face consists of 1/32 plastic sheet treated in the same fashion as the PVC faces. The face of the Main Timer has four end-of-task lights and a power light.

The Tactile Timer (Figure 22.6 and 22.7) can only be used in combination with the Main Timer. At the end of the task, a small motor causes the face of the timer to vibrate.

The case and faces match the Main Timer in both material selection and preparation process with the exception of the 1/32 plastic. This unit incorporates stainless steel balls as reference indicators for time. Stainless steel was chosen because of its resistance to oil and sweat from the hand, preventing corrosive effects.

The Secondary Timer (Figure 22.8 and 22.9) is intended to time shorter tasks. It has an upper limit of 10 minutes. The Secondary Timer has a linear face so the students would not confuse the shorter time duration with the circular face of the Main Timer. The timer could be used for one or more students in a specific activity while the rest of the class uses the Main Timer for a different task.

Figure 22.2. Two Students Using the Secondary Timer.

The Secondary Timer case was manufactured in a similar fashion to the Main and Tactile Timers. There is an inset Plexiglas window on the front of the timer to prevent the students from touching the timer belt. The face of the timer has two end-of-task lights and one power light.

The total cost was $946.

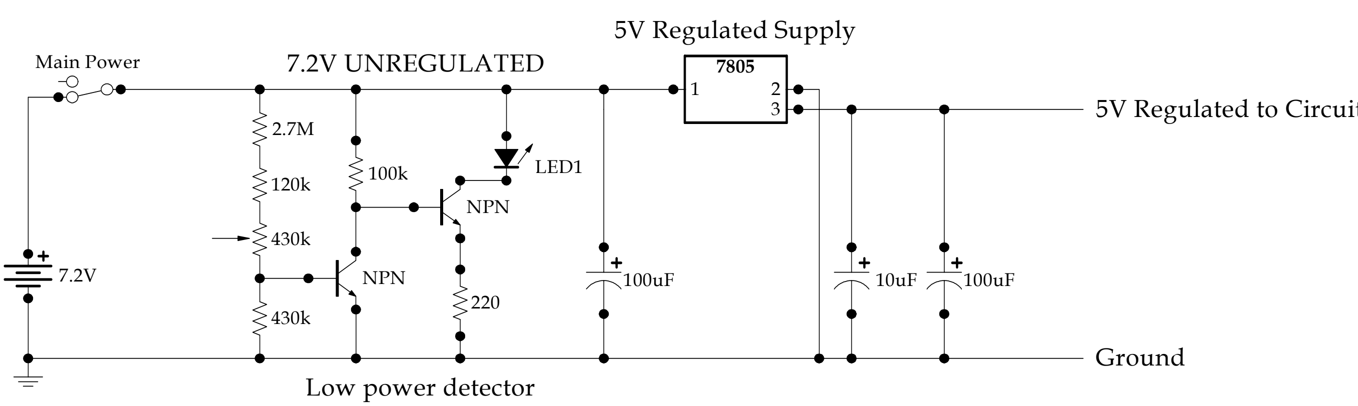

Figure 22.3. Power Supply Circuit.

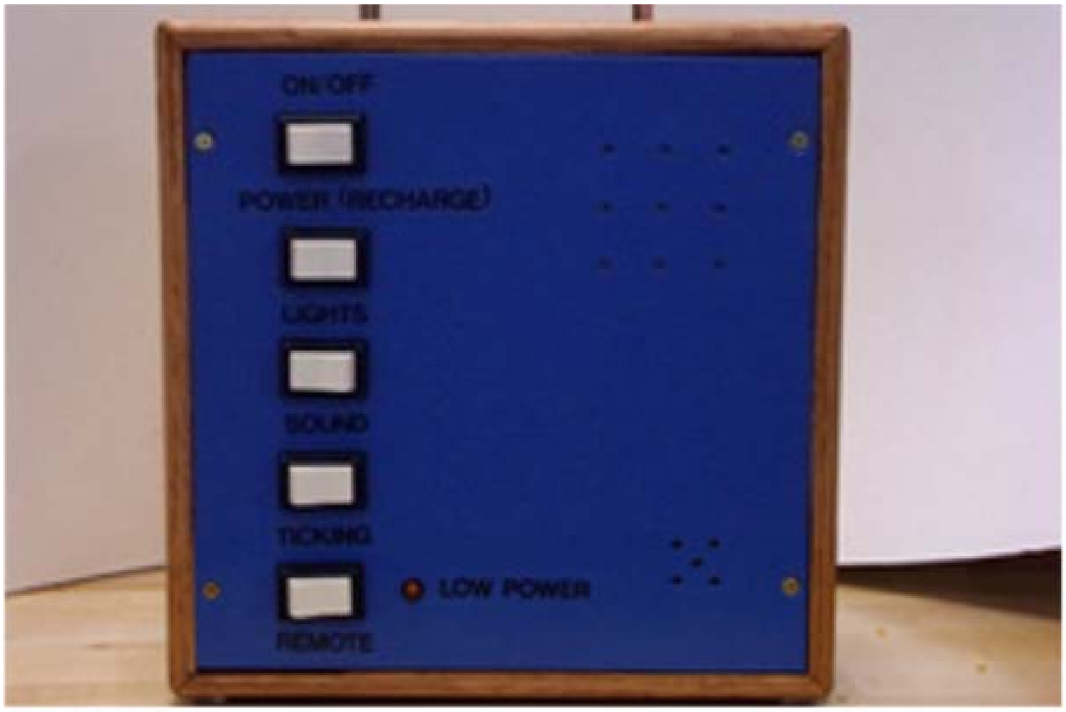

Figure 22.4. Face and Control Panel of the Main Timer.

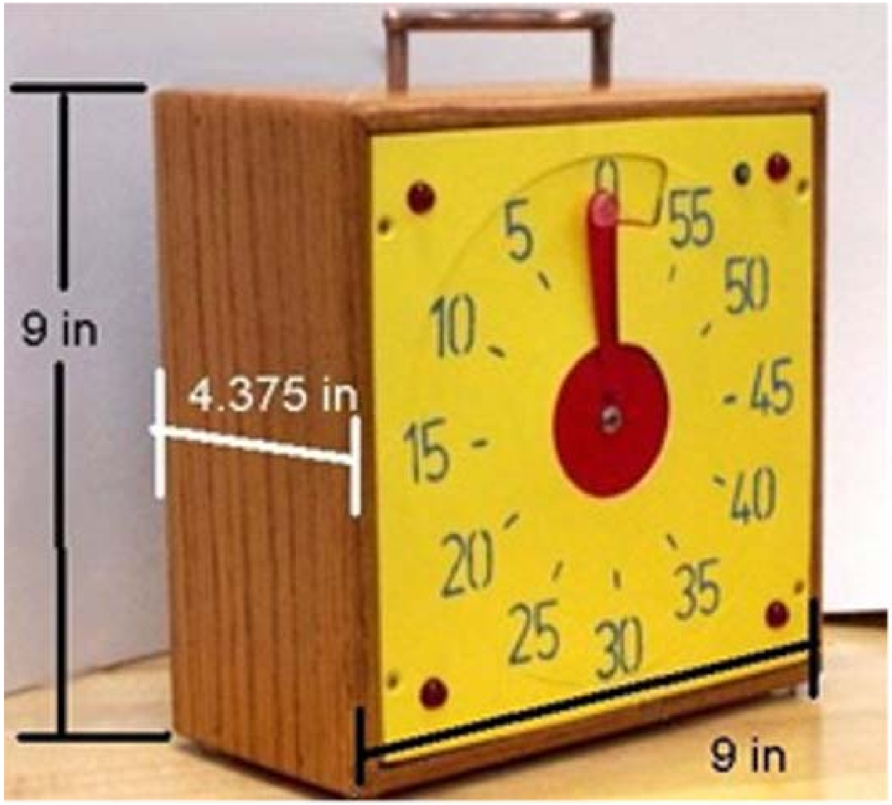

Figure 22.5. Dimensions of the Main Timer.

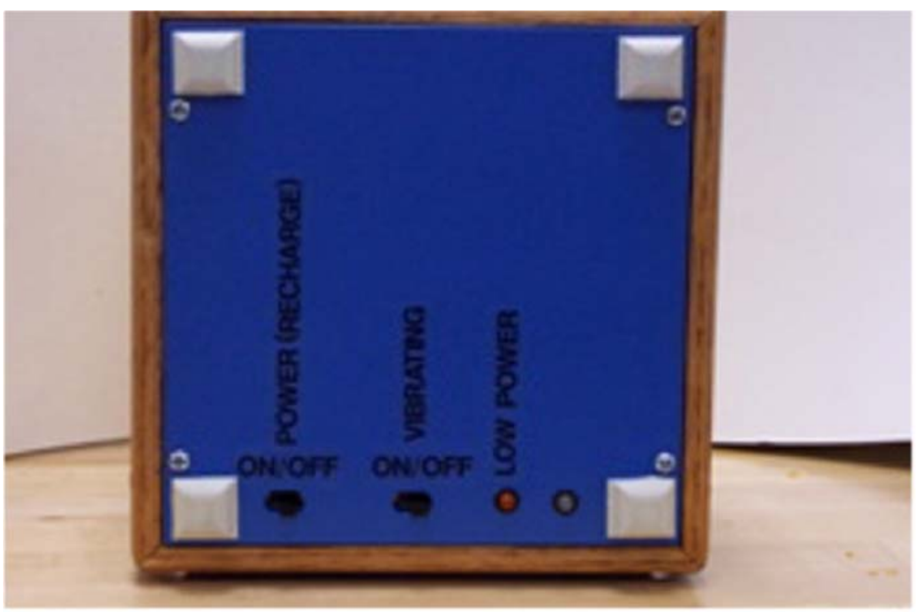

Figure 22.6. Face and Control Panel of the Tactile Timer.

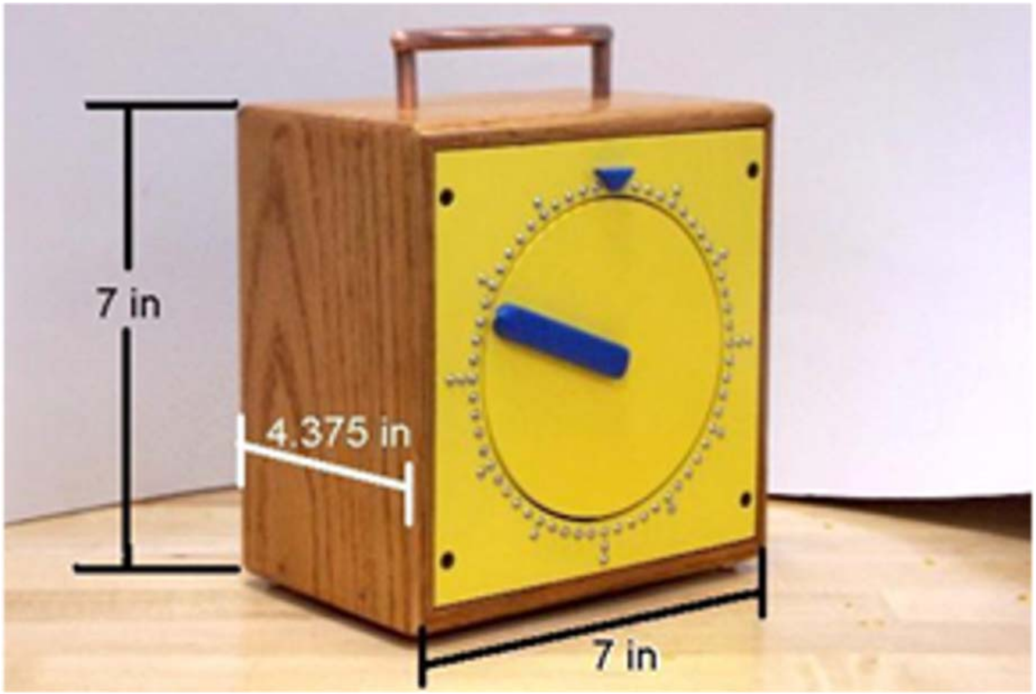

Figure 22.7. Dimensions of the Tactile Timer.

Figure 22.8. Face and Control Panel of the Secondary Timer.

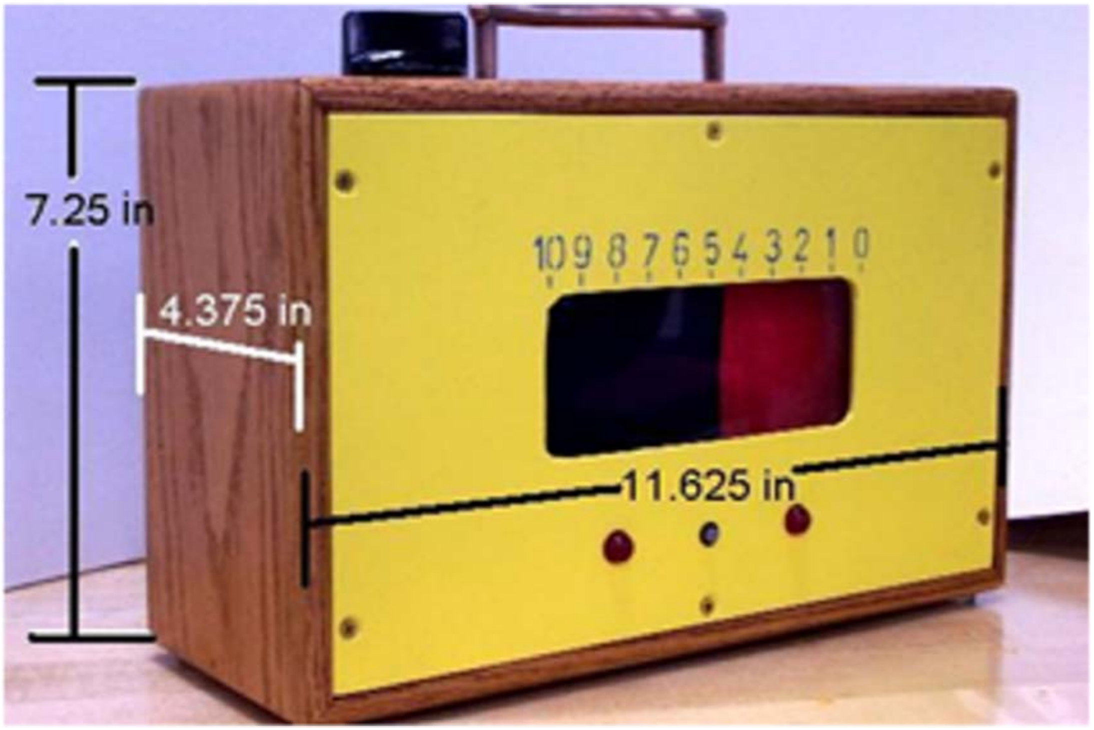

Figure 22.9. Dimensions of the Secondary Timer.

PEDESTRIAN CHILD HEADFORM

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WSU Advisor: Dr. David Reynolds
VRTC Advisors: Roger Saul, Jason Stammen
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INTRODUCTION

The goal of this project was to design a child headform that will meet the revised specifications set by the International Harmonization Research Committee (IHRC). Presently, there is only general adult and child headform in existence. As a result of testing, the existing child headform has been determined to be inappropriate for a six-year-old child. This problem stems from an inaccurate moment of inertia. The goal was to design the headform with a realistic moment of inertia and a natural frequency that does not interfere with that of the accelerometer.

SUMMARY OF IMPACT

The significance of a pedestrian headform is to reduce the number and impact of injuries.

TECHNICAL DESCRIPTION

The order of importance for the design is mass, center of gravity, accelerometer placement at the center of mass, vibration characteristics, and moment of inertia (Figure 22.12).

The headform is being built by First Technologies Safety Systems (FTSS). The structural analysis is considered in the design of the headform because the aluminum shell can not fail or deform during repeated use of the headform. The aluminum shell is the main load bearing structure of the design. The structural integrity of this component was also analyzed using DesignSpace®. On average, the headform experiences about 330g at impact. To provide for extra integrity, the force applied to the impact end of the shell was over-estimated at 350g. This is equivalent to 12,000 N of force. The maximum amount of stress undergone was at the impact end of the shell and was approximately 19 MPa. In the design, the shell underneath the headskin is entirely aluminum and the cap, or base-plate, is steel. The accelerometer is mounted at the center of gravity and will see natural frequencies no

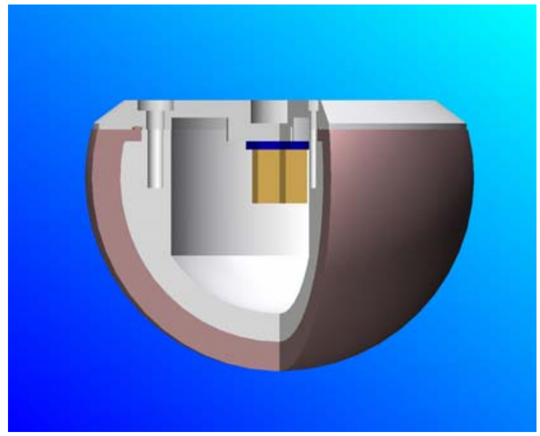

Figure 22.10. Headform Design Cutaway.

higher than about 5000 Hz. This accelerometer is a tri-axial damped automotive accelerometer made by Entran®. (Figure 22.10)

When evaluating pedestrian safety issues in car or pedestrian collisions (Figure 22.11), accident reconstructions can be done to evaluate damage done to the head. If the desired data is a result of only the head impact, accident reconstruction tests can be done, by setting up a headform and propelling it onto specific point locations of the

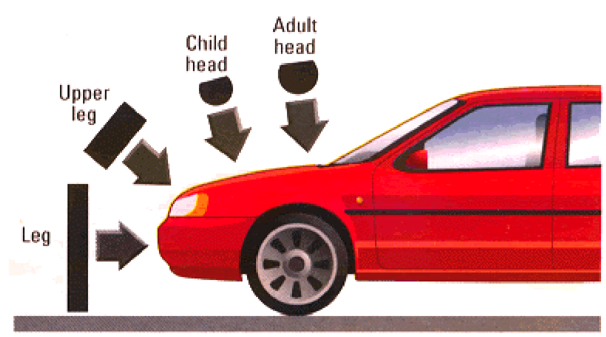

Figure 22.11. Pedestrian Collision Impact Areas.

vehicle.

These points, along with impact velocities and angles, are determined through computer simulations based on actual collision data. The headform is used to collect data that is then linked to actual pedestrian impact and injury data to create an index of impact severity to injury sustained, called Head Injury Criteria (HIC).

Specifically, the accelerations of the headform are recorded and the HIC are calculated using the following formula:

$$HIC = \int a(t)^{2.5}\,dt$$

The aim is then to use the HIC values to estimate relative injury that could be suffered from particular vehicle designs and provide guidelines for the surfaces of new cars to make them less injurious to pedestrians.

The total cost of the Pedestrian Child Headform is $700.73

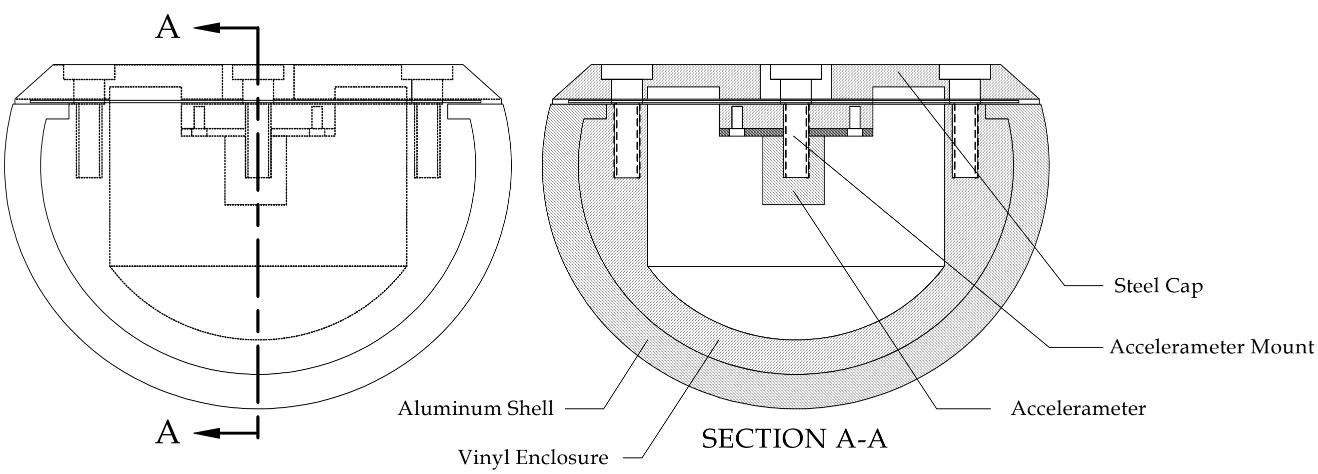

Figure 22.12. CAD drawing of Assembly.

EMERGENCY CALL BUTTON FOR A HYDROTHERAPY POOL ROOM

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INTRODUCTION

An Emergency Call Button was needed for a Hydrotherapy Pool Room. The previous call button was not easily accessible to therapists. Requirements and design constraints included the need for a lever with a pull cord attached to a loop, an audio and visual alarm, and poolside placement of the auxiliary actuator. The moist, highly chlorinated and warm environment presented design constraints related to corrosion and waterproofing.

SUMMARY OF IMPACT

In providing treatment to individuals with disabilities in the pool, therapists are in need of an effective alarm. This alarm will facilitate quality care to patients receiving therapy as therapists are now equipped to obtain water-trained personnel in an emergency. The audiovisual alarm is an alerting device that indicates to staff that an emergency is occurring in the hydrotherapy pool area. (Figure 22.13)

Figure 22.13. User Demonstrating the Activation of the Auxiliary Alarm.

TECHNICAL DESCRIPTION

The testing procedures performed throughout this design project were static load testing on the human actuator interface, static load testing on the limit switch with the human actuator interface, and the measurement of voltage and current of the alarm system.

The human actuator interface is a pull cord allowing the user to actuate the auxiliary alarm system. The human actuator interface consists of a ring, break-away system, and a rope, all of which are resistive to the hydrotherapy pool environment.

The ring is a grasping device for the human actuator interface. The chosen ring for the final design is a rubber molded dog toy. The rubber molded dog toy is durable and is able to withstand applied forces in excess of 50 pounds. The ring is connected to the break-away system by looping the Velcro (Figure 22.14) around the ring. The break-away system is a safety feature designed into the human actuator interface. The break-away system is made from a hook-n-loop form of Velcro, which loops around the ring. The Velcro surfaces break away from each other at a force of twenty pounds per square inch. The break-away system is attached to the rope using repetitive stitching with mason twine and tightening the Velcro strap by wrapping the twine around the rope and Velcro combination.

The electrical components of the system consist of a limit switch, a disconnect switch, an audiovisual alarm, and the existing system. The system is wired with twelve gauge stranded industrial wire in an appropriate configuration allowing the alarm to be seen and heard.

The limit switch (Figure 22.15) is a D Square electromechanical switch with a lever arm attached for activation purposes. The switch has one million cycles and introduces minimal impedance to a system when closed. This switch can be wired normally open or closed. For this project, the switch is wired normally open. The limit switch is wired in series with the disconnect switch.

The disconnect switch is a selector switch allowing the auxiliary alarm to be turned off or on. In the off position, the auxiliary alarm will not function if activation occurs, as an open connection exists in the loop and current cannot flow. In the on position, the loop is closed allowing current to flow and the auxiliary alarm to be activated. This switch is installed as a safety mechanism should the auxiliary alarm fail or the customer chooses not to have it functioning depending on the patient in the hydrotherapy pool. This switch is also normally wired open.

The visual portion of the alarm is a strobe light with a blue acuity lens covering. The audio portion of the alarm is a vibrating horn with a power level of 118 decibels. The audiovisual alarm is part of the existing system.

After static load testing was performed on a prototype of the human actuator interface, a pool diving ring was determined to be the weakest component of the interface. (Figure 22.16)

The final cost was $914.15.

Figure 22.14. Stitching and Looping of Velcro.

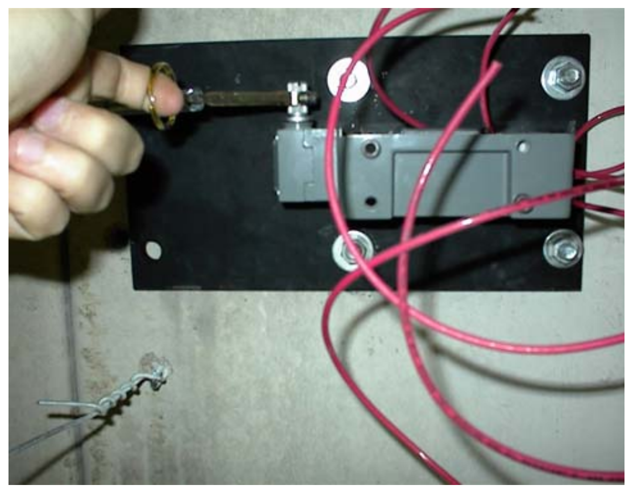

Figure 22.15. Limit Switch (Gray Box in the Center of the Black Plate).

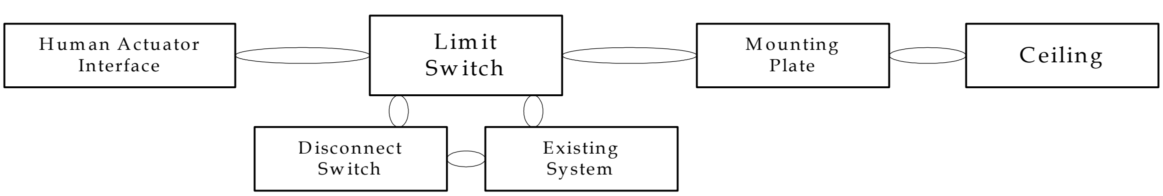

Figure 22.16. Block Diagram.

PEDIATRIC ADAPTABLE COMMODE CHAIR

Designers: Jeremy Chaney, Sharon Dillhoff, Julia Rose
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INTRODUCTION

Gorman Elementary School was in need of a re-design of a restroom chair for their students with disabilities. One commonality of these disabilities is poor muscle control, which inhibits the students from sitting independently, and therefore the students cannot use the restroom without assistance.

The Pediatric Adaptable Commode Chair is a product that can be wheeled over the existing toilet, and when not in use, can be stored under the changing table that is located in the restroom facility. The chair is mobile so that a person without a disability can easily move the product out of the way and use the toilet.

This product offers support in the form of a security strap, high back support, headrest, footrest, and front support (i.e. tray to lean on). The product is mobile because its base has four swivel casters with locking mechanisms. The chair's high back can be easily folded down for storage purposes. The chair is made of materials that can be easily cleaned for sanitation reasons. The final product has the ability to support the requirement of 60 pounds.

SUMMARY OF IMPACT

The adaptable commode chair design allows a child with physical disabilities to independently stay on the toilet.

TECHNICAL DESCRIPTION

The pediatric toilet is 10 inches in height and narrow enough to fit between the wall and the pipe, which is less than 19.25 inches wide. The product must also be small enough so that is can be stored under the changing table in the restroom, which is only 27.5 inches above the floor. (Figure 22.19) The design must also be made of easy-to-clean non-corrosive materials due to the fact that it will be used in a restroom environment. It must also offer security or support (straps, headrest, and footrest) to the user. The design must also be comfortable, functional and flexible in order to accommodate heights of children of 30 to 42 inches. (Figure 22.20)

Figure 22.17. Front and side view of the Pediatric Adaptable Commode Chair.

The engineering principles that were applied to the design of this product were the usage of static analysis. The engineering analysis was evaluated in Design Space. A 500 Newton load (approximately 120 pounds) was applied to the device, which was evenly distributed over the plates.

The Flamingo Seat ® by R82 (Figure 22.18) was found to be the best choice because it is made of easy-to-clean materials (ABS plastic), supports enough weight, is comfortable, and is able to be folded down for storage. After obtaining this chair, a mobile base was designed to fit the space limitations and weight requirement. Stainless steel was chosen for the mobile base because of its strength and resistance to corrosion. The design of the mobile base was entered into Solid Edge ® and analyzed using Design Space ® (stress, deformation, and safety factor). This base was made mobile by using four two-inch, swivel caster wheels. Straps, footrest plates, a tray, and a vertically adjustable headrest were added to aid in supporting the user. Finally, the product was powder coated and assembled.

The approximate cost of the product is $931.71.

Figure 22.18. Baby Crane ® Toilet in Classroom's Restroom.

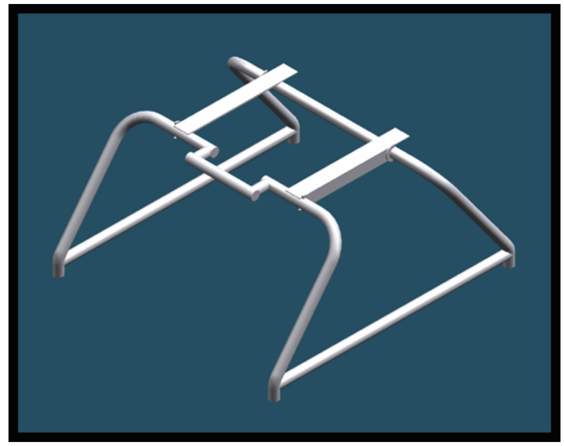

Figure 22.19. 3-D View of Mobile Base in Solid Edge ®.

Figure 22.20. Pediatric Adaptable Commode Chair Folded Down for Storage.

ADAPTIVE KEYBOARD AND INTERACTIVE SOFTWARE

Designers: Ruzbeh Shariff, Joseph Blake, Tejdeep Rattan
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INTRODUCTION

A teacher desired a stepping stone to the Intellikeys® system. The design team created a new system consisting of an adaptive keyboard device interfaced with the standard personal computer, related materials, and a software package.

SUMMARY OF IMPACT

The system is designed to offer feedback to the student on the accuracy of his or her answer. This is necessary so that each student recognizes the correctness of his or her response in comparison with the task that is prompted by the teacher. Such feedback will allow the system to be an interactive educational tool.

In the new system there is a strong emphasis to create a product that provides adequate visual and audio feedback. To create this adequate feedback, a system that is simple but at the same time clear and powerful is necessary.

TECHNICAL DESCRIPTION

The parallel port is the optimal means of interfacing the adaptive keyboard device to the standard PC. Many PC's have different design standards regarding their parallel port and as a result, all calculations in this design are based on data regarding IEEE 1284 standards. The standard parallel port is most commonly found at base address 378h and is usually labeled as LPT1 by the PC. It is composed of a data register (8 bits), status register (5 bits), control register (4 bits), and 8 ground bits. The data register is primarily used to send data from the PC to an external device. The status register is used to receive data from an external device. The control register is more versatile and allows bi-directional data transfer. The following is a pin-out of the standard 25 pin, female D-type parallel port connector and labeled bits. D denotes data register bits, S status register, and C control register bits. (Figure 22.21)

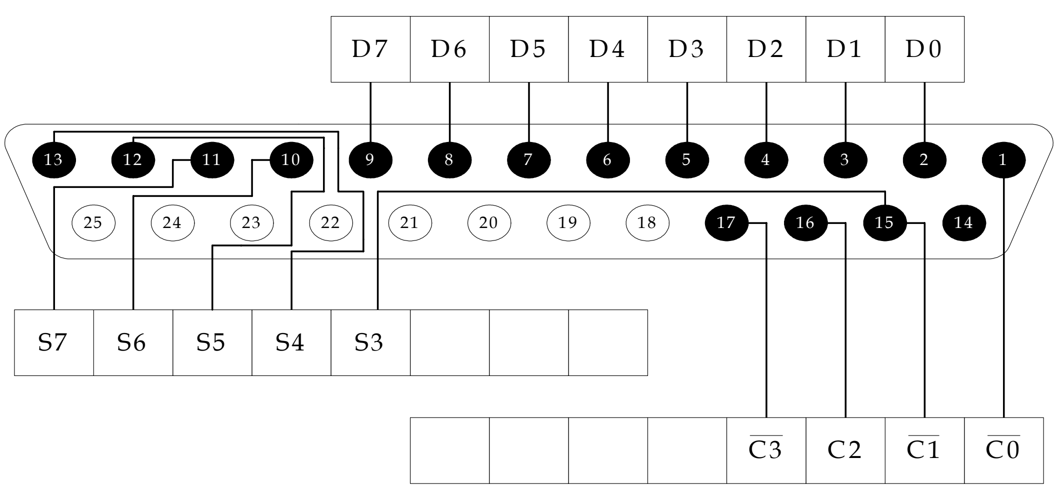

Figure 22.21. Parallel Port Pin-Out Information.

While the control register does allow both input and output, it has some advantages about it that make using the status register the most practical for the five switch inputs to the computer. Since the parallel port is composed of three registers, in order to read or write anything on these registers, it is necessary to know the address of each.

Visual Basic 6.0 was selected as the development environment to create the program that will interact with the adaptive keyboard. The device consisted of five buttons and five lights. The device was modified externally by removing a cover and attaching picture insert holders.

Internally, the device was dismantled and in place of the original circuitry the design team inserted the new circuit board, which operates the adaptive keyboard device (AKD). In consideration of the needs of the students, a stand was created for which the AKD attaches. The stand allows the AKD to be presented at various angles by a mechanism on the rear of the stand that is manually changed by the teacher.

Safety considerations were made regarding the voltages and currents used in the design of the device. Since the adaptive keyboard device does not operate with voltages greater than 5 volts and currents more than 36mA, the device housing that covers the internal components of the device is adequate to protect users from possible shock or injury. (Figure 22.23)

The system gathers external input from the sensing switches via the status register of the parallel port. The software program written in Visual Basic interprets this input information. The software program then compares the pressed switch to the switch that it prompted the student to press. Then it sends a signal to the data port to turn on the keyboard lights appropriately for negative or positive feedback (Figure 22.22).

Figure 22.22. Modified Device.

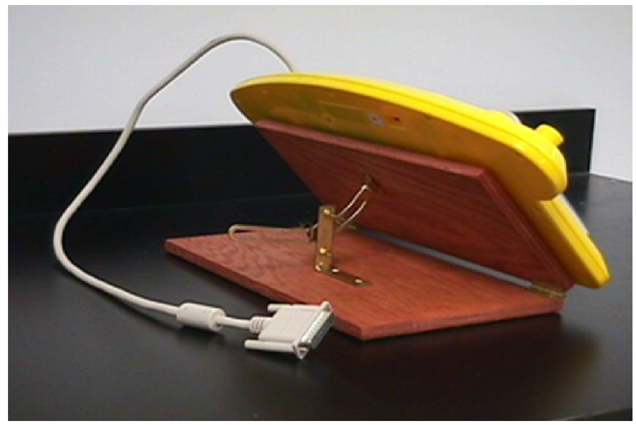

Figure 22.23. Adaptive Keyboard Device Stand.

The total cost of the Adaptive Keyboard and Interactive Software is $550.

TIME KEEPING TASK SCHEDULER

Designers: Patty Gehring, Rachel Kinsler, Ed Sims
Supervising Professors: Dr. Ping He
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INTRODUCTION

A microprocessor-controlled device allows the instructor to program time intervals for up to 12 tasks as a facilitating tool in teaching students with autism. Data entry is accomplished using a digital alarm clock type interface. The tasks are pictorially displayed on one-inch square cards around a clock-like face. As the time interval for each task expires, a window closes, concealing that task. Finally, several rows of LEDs turn on and off and audio tones of varying pitches remind students as time intervals progress. Power is provided using rechargeable batteries. The wood and plastic materials used in the case design result in a durable, attractive and easy to use task-scheduling device.

SUMMARY OF IMPACT

First, the device features a microcomputer controlled, sealed design that prevents the students from accessing the task images or sliding the task cover or timer devices. Access to the mechanical elements of the device is only possible by releasing the quarter-turn quick release door fasteners located at the front and back of the unit. These fasteners are operated using a common, flat-tipped screwdriver. While the use of a tool to open the device is more cumbersome than would be the use of hand operated closing devices, it also makes opening the device by the students virtually impossible.

The audio and visual attention getting stimuli feature a five-row LED display and sound system. As the time for each task advances, the five rows of LEDs incrementally flash and extinguish row by row, while a pulsing tone sounds at 1/5 time intervals. For example, if the device is timing a 15-minute task, after three minutes have elapsed, all LEDs flash and the first row of LEDs is extinguished, while a tone of a certain frequency beeps several times. After another three minutes, the remaining LEDs flash and the second row of LEDs is extinguished, while a tone of a lower frequency beeps. This continues until all LEDs are off, at which time the window over the task will be completely closed. The timer advances to the time entered for the next task, all the LEDs re-light, and the process begins again.

The problem of the teacher controlling the device, and thereby being viewed as the controller of time, is eliminated by the use of the microprocessor to control all timer elements. The teacher is free to monitor other classroom tasks, and any aggressive tendencies of the student towards the timekeeper are passed from the teacher to the device. (Figure 22.24 and 22.26)

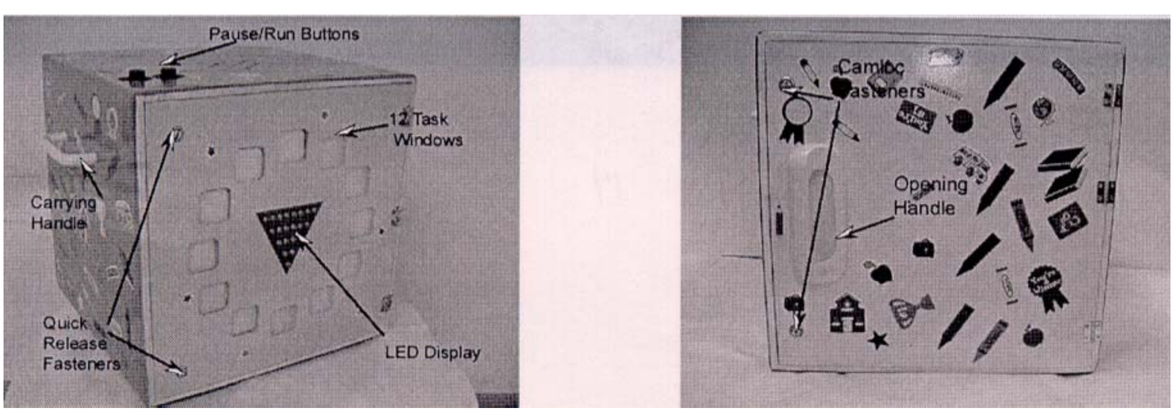

Figure 22.24. Front and Back Views of the Time Keeping Task Scheduler.

TECHNICAL DESCRIPTION

The cubical casing is constructed of half-inch thick hard maple. The front face is Optix ® clear acrylic. The casing is decorated with Krylon ® paint and clear coat, and stickers with a school theme. There are two white plastic handles on the side for ease of transportation. Four anti-skid vinyl pads are attached to the bottom to prevent slippage of the device and scarring of the paint. The front face and back panel both have two quarter-turn quick-release fasteners that open with a common flat-tip screwdriver. The back panel also has a wooden handle for opening it.

The task window plate is composed of a steel plate bonded to an aluminum plate. There are cutouts in the aluminum plate to allow placement of the task pictures. The steel plate provides a surface for the magnetic backing of the task pictures. An eight-inch diameter notched plastic disk is attached to the gearhead shaft with small aluminum mounting plates. This disk rotates from behind to in front of the task window plate, thus covering the task pictures.

Behind the disk and task window plate is the aluminum plate to which the gearhead and motor assembly is attached. The motor and gearhead assembly consists of two steel spur gearheads with ratios of 60 to 1, in series with a 12VDC stepping motor. The overall gearing ratio is 3600 to 1 from motor shaft to output shaft to which the plastic disk attaches. The purpose of using the gearheads is to improve the torque output and provide an extremely fine rotational resolution. (Figure 22.25)

The heart of the system is the BASIC Stamp IIe microprocessor located on the Stamp Module near the front of the interior of the device. The Stamp IIe is a 20 megahertz microprocessor manufactured by Parallax Inc. It features 32 bytes of RAM, 8 x 2 kilobytes of EEPROM, 16 I/O lines, and is programmed using PBASIC, a form of the BASIC computing language specially formulated by Parallax. This processor was chosen for its ease of programming, processing speed, and size of memory locations.

The total cost of the project is $944.10.

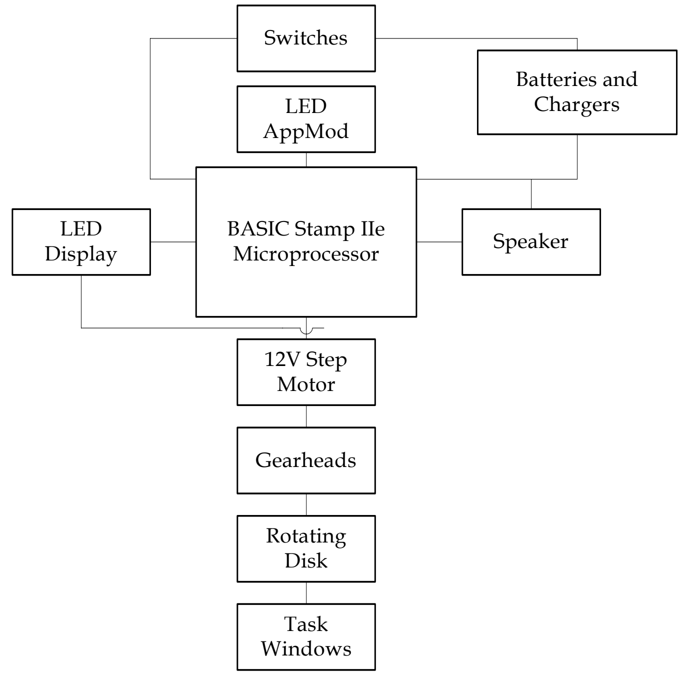

Figure 22.25. System Block Diagram.

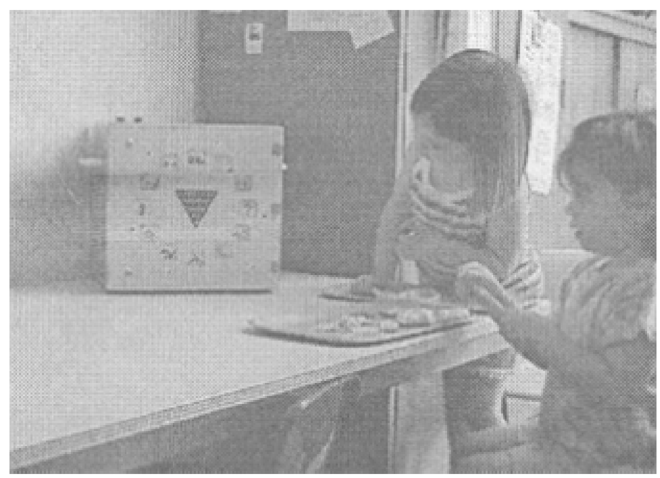

Figure 22.26. Students with Timer.

CHAPTER 23
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