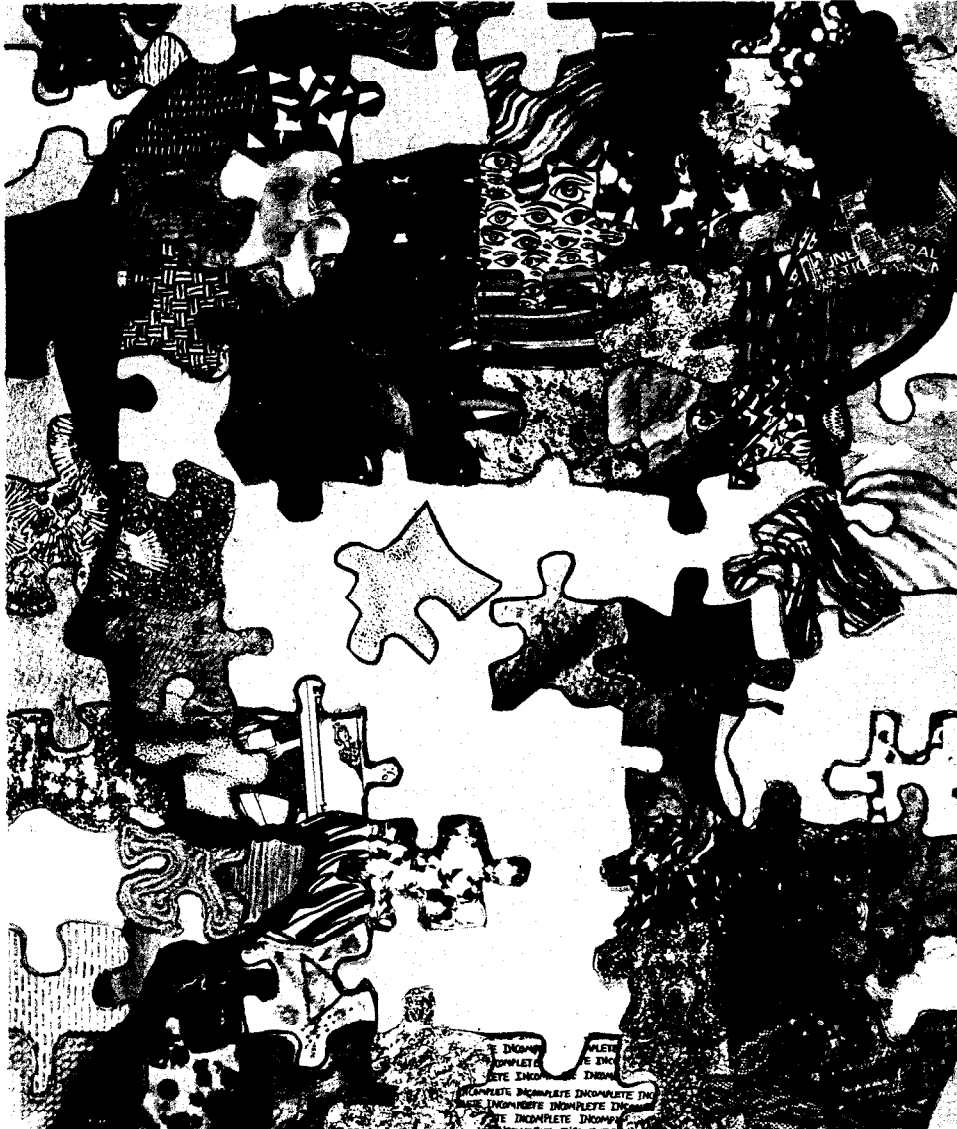


**NATIONAL SCIENCE FOUNDATION
1992
ENGINEERING SENIOR DESIGN
PROJECTS TO AID THE DISABLED**



**Edited By
John D. Enderle**

**NATIONAL SCIENCE
FOUNDATION
1992
ENGINEERING SENIOR DESIGN
PROJECTS TO AID THE
DISABLED**

**Edited By
John D. Enderle**

NDSU Press, Fargo, North Dakota 58105

PUBLICATION POLICY

Copyright and Reprint Permissions:

No copyright is claimed for the papers in this publication. These papers may be freely reproduced and distributed as long as the source is credited.

CONTENTS

CONTRIBUTING AUTHORS	ix
FOREWORD	xi
CHAPTER 1 INTRODUCTION	1
CHAPTER 2 ARIZONA STATE UNIVERSITY	3
A Recreational Rafting Chair for Active Paraplegics.....	.4
A Bathchair for a Young Adult With Cerebral Palsy.....	.6
A Tray to Hold a Speak and Spell Device.....	.8
Electromechanical “Busy Box” .....	.10
Project Alpha.....	12
Kayak System for Active Paraplegics.....	.14
A Mobilizer for a Child with Cerebral Palsy.....	.16
Development Of A Therapeutic Busy-Box For Use By Children With Limited Fine-Motor Control	18
Variable-Mode Home Exercise System for a Partial Quadriplegic.....	.20
Ring Binder Opener/Closer for persons with Little or No Finger Manipulation.....	.22
Headache: An Electromechanical “Busy Box” for Cerebral Palsied Children .....	.24
A Car/Bus Seat for Children and Youths with No Torso Control.....	.26
CHAPTER 3 LOMA LINDA UNIVERSITY	29
Speech Aid	30
Timer Switch.....	32
Visual Scanner.....	.34
CHAPTER 4 MERCER UNIVERSITY	37
Navigational System for the Blind.....	.38
Adjustable Foot Stand for an Electric Wheelchair.....	.40

Cerebral Palsy Muscle Trainer .....	.42
The Drop Ball Game	44
Ping-Pong Paddle Game	46
Turbo Scooter..	48
Rotary Infant Bed	50
CHAPTER 5 MISSISSIPPI STATE UNIVERSITY.....	53
Sensory Stimulation Unit for the Severely/Profoundly Disabled .....	.54
Activator for a Pedal on an Electronic Organ .....	.56
Automatic Page Turner..	58
A Sandwich Holding Device for Quadriplegics .....	.60
CHAPTER 6 MONTANA STATE UNIVERSITY.....	63
A Dry-land Mono-ski Trainer.. .....	.64
Cycling Device for a Quadriplegic .....	.66
Adaptive Stroller for the User of a Wheelchair.....	.68
Transportable Bathing Support Device.. .....	.70
Dynamic Linkage for a Cross-country Sit-ski .....	.72
User Adjustable Chair for a Person With Cerebral Palsy.. .....	.74
Adjustable Computer Work Station .....	.76
CHAPTER 7 NEW JERSEY INSTITUTE OF TECHNOLOGY.....	79
Infrared Shade and Door Lock Control.....	.80
Infrared Temperature Controller.. .....	.85
Automatic Window Opener For The Home	89
Infrared Intercom Controller	91
CHAPTER 8 NORTHERN ARIZONA UNIVERSITY.....	95
Multi-Functional Rehabilitative Exercise System.....	.96
Laptop Computer Support System For A Wheelchair.....	.98
A Pressure Relief Trainer for a Client in a Wheel Chair.....	.100

CHAPTER 9 NORTH DAKOTA STATE UNIVERSITY 103

The Implementation of a Voice Recognition Computer Interface System 104

Human Voice Frequency Analyzer 106

Infrared Child Monitoring System 108

A Microprocessor Controlled Page Turner 110

The Turn Taker, A Behavior Modification Device. 112

A Voice Activated Thermostat for a Quadriplegic.. 114

Single Switch Telephone Dialer 116

Ultrasonic Obstruction Detector 118

for the Visually Impaired. 118

Printed Text Reader 120

CHAPTER 10 STATE UNIVERSITY OF NEW YORK AT BUFFALO 123

A Silent Whistle: A Device To Help The Deaf Play Refereed Sports 124

A Remote Rotary Control: A Device To Turn An Oven Temperature Control Knob For The Disabled. 126

A Motorized Toy Train to be Used in Therapy..... 128

A Motorized Toy Aeroplane to be Used in Therapy..... 130

A Motorized Toy Poppity-Pop Car 132

Motorized Toy Gears.. 134

A Trunk Supporting Walker.. 136

An Infrared Remote-Controlled Electrical Light Switch 138

A Joy Stick Unit to Facilitate Hospital Remote Controllers for TV and VCR.. 140

A Free Standing Motorized Arm Support 142

Prone Support Walker 144

CHAPTER 11 TEXAS A&M UNIVERSITY 147

Automatic Telephone 148

A Custom Corner Chair for Pre-school Children..... 151

A Laser Pointer Receiver for Environmental Control..... 152

User Operated Timers for Control of Decorative Mobiles.....	154
Systems for Providing Visual Stimuli to Speech Input.....	156
Power Saver Modification for a Digital Voice Recorder.....	158
An Overhead Track for Supported Ambulation.....	160
A Visual Display for Computer Audible Messages	162
CHAPTER 12 TULANE UNIVERSITY.....	165
Wheelchair Control Systems.....	166
Hand Assisting Devices	168
Walking Aids	170
Devices for Leg Exercise.....	173
Aids to Daily Living.....	176
CHAPTER 13 THE UNIVERSITY OF AKRON	181
Plastic Coated Exercise Hand-Weight Cutting Machine.....	182
Whistle Shaver - An Adaptive Device for the Cerebral Palsy Clients	186
CHAPTER 14 UNIVERSITY OF DELAWARE	189
Mobile Camera	190
Automatic Window: A Powering Device for Standard Double-Hung Windows	192
Exercise Equipment for the Elderly.....	194
Wheelchair Umbrella.....	196
Flexible Sink	198
Improved Tactile Sensing System (T.S.S.): Investigating the Tekscan Software/Sensing System	200
Computer Desk for the Handicapped	202
Rolling Walker.....	204
CHAPTER 15 UNIVERSITY OF FLORIDA	205
An Independently Operated Standing-Assist Chair	206
Computer Cursor Control for Disabled Computer Users.....	209
Microprocessor-Driven, Puff-Controlled Mirror System for a Quadriplegic.....	212

CHAPTER 16 UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN.....	215
Feeding Mechanism .....	..216
Discussion Distribution System.....	..22 2
Sensory Output Converter (SOC) .....	..22 4
Motorized Mount for a Light Talker .....	..22 6
A Tactile Pacer.....	..22 8
CHAPTER 17 UNIVERSITY OF SOUTH ALABAMA.....	231
Design of a Wheelchair Lift.....	..23 2
Floor to Wheelchair Lift .....	..23 4
Design of a Wheelchair Joystick Relocation Device .....	..23 6
Swing Design for Physically Challenged Child.....	..238
A Merry-Go-Round for a Physically Challenged Child .....	..240
Specialized Weaving Device Concept and Thread Alternating Transmission.....	..242
Modifications for a Standard Sewing Machine to Accommodate Handicapped Users.....	..244
CHAPTER 18 UNIVERSITY OF TENNESSEE AT CHATTANOOGA	247
Infrared Head Switch.....	..24 8
Chair for Vestibular Stimulation.....	..252
Wheelchair Passive Exercise Device .....	..25 4
Visual Communication Device.....	..256
Suspended Walking Device.....	..258
Pivoting Swing .....	..26 0
See-Saw for Wheelchair Bound Children .....	..26 2
Merry-Go-Round for Wheelchairs.....	..264
Therapeutic Walking Device .....	..266
CHAPTER 19 UNIVERSITY OF WASHINGTON.....	269
Programmable Timer Implemented in Surface Mount Technology.....	..270
A Device for Training the Spinal Cord Injured Patient and Monitoring their Activities .....	..27 2

A Device to Assist the Physically Handicapped in Everyday Activities	274
A Self-Contained, Portable Keyboard for the Physically Impaired	276
A Device to Ease the Usability of Remote Control Devices for the Physically and Mentally Disabled	278
A Device for Assisting Memory-Lost Clients in Handling Daily Routines.....	280
A System for Monitoring Work Rate and Providing Reinforcement Scheduling.....	282
CHAPTER 20 WORCESTER POLYTECHNIC INSTITUTE	285
The Art Class Assistor: A Drawing Armrest for Students Who Suffer from Muscle Weaknesses.....	286
Slide-Away Laptray Design.....	288
The Design and Development of a Reacher/Gripper.....	290
CHAPTER 21 WRIGHT STATE UNIVERSITY.....	293
Object Communication Display	294
Lighted Communication Board.....	296
Page Turner	298
A Continually Adjustable Tray With 0 to 60 Degrees Tilt Angles	300
Table Walker.....	302
Portable Four Light Communication Device	304
Adapted Shower Chair.....	306
CHAPTER 22 UNIVERSITY OF WYOMING	309
Heat Sensor and Alarm.....	310
INDEX.....	313

CONTRIBUTING AUTHORS

Robert Allen, Department of Mechanical Engineering, University of Delaware, Newark, DE 19716

Holly K. Ault, Mechanical Engineering, Worcester Polytechnic Institute, 100 Institute Road, Worcester, MA 01609

Ronald C. Anderson, Biomedical Engineering, Tulane University, New Orleans, LA 70118

Gaetano Borriello, Electrical Engineering, University of Washington, Seattle, WA 98195

R.J. Conant, Mechanical Engineering, Montana State University, Bozeman, MT 59717

John Enderle, Electrical Engineering, North Dakota State University, Fargo, ND 58105

Clifford D. Ferris, Electrical Engineering, University of Wyoming, Laramie, Wyoming 82071-3295

Jerome A. Gilbert, Agricultural and Biological Engineering, Mississippi State University, Mississippi State, Mississippi 39762-5465

Robert I. Gray, Biomedical Engineering, Mercer University, Macon Georgia 31207

David E. Hartman, Mechanical Engineering, Northern Arizona University, Flagstaff, AZ 86011-1560

Robert J. Hirko, Engineering Sciences, University of Florida, 231 Aerospace Building, Gainesville, FL 32611

Allen H. Hoffman, Mechanical Engineering, Worcester Polytechnic Institute, 100 Institute Road, Worcester, MA 01609

William A. Hyman, Bioengineering Program, Texas A&M University, College Station, TX 77843

Yongmin Kim, Electrical Engineering, University of Washington, Seattle, WA 98195

Daniel J. Krause, Electrical Engineering, North Dakota State University, Fargo, ND 58105

Paul C. Lam, Mechanical Engineering, University of Akron, Akron, OH 44325

Edward H. McMahon, School of Engineering, University of Tennessee at Chattanooga, Chattanooga, TN 37403

Gerald E. Miller, Bioengineering Program, Texas A&M University, TX 77843

Joseph C. Mollendorf, Mechanical and Aerospace Engineering, State University of New York at Buffalo, Buffalo, NY 14260

Chandler Phillips, Biomedical and Human Factors Engineering, Wright State University, Dayton, OH 45435

Jonathan W. Pote, Agricultural and Biological Engineering, Mississippi State University, Mississippi State, Mississippi 39762-5465

Edward M. O'Brien, Biomedical Engineering, Mercer University, Macon Georgia 31207

Cecil H. Ramage, Mechanical Engineering, University of South Alabama, Mobile, AL 36688

David A. Rice, Biomedical Engineering, Tulane University, New Orleans, LA 70118

Charles Norman Rhodine, Electrical Engineering, University of Wyoming, Laramie, Wyoming 82071-3295

Blair A. Rowley, Biomedical and Human Factors Engineering, Wright State University, Dayton, OH 45435

Subrata Saha, Orthopaedic Surgery, Loma Linda University, Loma Linda, California 92354

Mark G. Strauss, Rehabilitation Education Services, University of Illinois, 1207 South Oak Street, Urbana, IL 61801

Gary Yamaguchi, Chemical, Bio, & Materials
Engineering, Arizona State University, Tempe, AZ
85287-6006

John A. Zelano, Electrical Engineering, 323 Martin
Luther King Boulevard, New Jersey Institute of
Technology, Newark, NJ 07102

FOREWORD

Welcome to the fourth issue of the National Science Foundation Engineering Senior Design Projects to Aid the Disabled. Started 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 disabled individuals. Through the Bioengineering and Research to Aid the Disabled (BRAD) program of the Emerging Engineering Technologies Division of NSF¹, funds were awarded competitively to sixteen universities to cover supplies, equipment and fabrication costs for the design projects. A book entitled, "NSF 1989 Engineering Senior Design Projects to Aid the Disabled," was published that reported on the projects 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 twenty-two. Following completion of the design projects funded under this initiative during the academic year 1989-90, a second book was published describing these projects, entitled, "NSF 1990 Engineering Senior Design Projects to Aid the Disabled."

In 1991, a third issue of the National Science Foundation Engineering Senior Design Projects to Aid the Disabled was published by NDSU Press. This book described the almost 150 projects carried out by students at twenty universities across the United States.

This manuscript, funded by the NSF, describes and documents the NSF supported senior design projects during the fourth year of this effort during the academic year 1991-92.

As before, the purpose of this manuscript is to report on the engineering senior design projects developed and implemented through participating

schools in the BRAD program. Each chapter describes the activity at a single university and, except for the introduction, was written by the principal investigator(s) at that university. Individuals wishing more information on a particular design should contact the designated supervising principal investigator. Additionally, an index is provided so that projects may be easily identified by topic.

It is hoped that this manuscript will enhance the overall quality of future senior design projects directed toward the disabled by providing examples of previous projects, and by motivating other universities to participate because of the potential benefits to the student, school, and community. Moreover, the new technologies used in these projects will provide examples in a broad range of applications for new engineers. The ultimate goal of both this publication and all the projects that were built under this initiative is to assist disabled individuals in reaching toward their maximum potential for enjoyable and productive life.

It should be evident from reviewing this manuscript that the BRAD program has brought together individuals with widely varied backgrounds. Through the richness of these interests, a wide variety of projects were completed, and are in use. A number of different technologies were incorporated in the design projects, so as to maximize the impact of the device on the individual.

For the most part, a two-page project description format is used in this text. Each project is described with a nontechnical description, followed by a summary of impact that illustrates the effect of the project on the disabled person's life. A detailed technical description then follows. Photographs of the devices and other important components are incorporated throughout the manuscript. Some of the projects are described with a much more extensive description covering many pages; these projects are typically the first project in each chapter.

It should be noted that none of the students or faculty received financial remuneration for building devices or writing software for the disabled in this program. Each participating university has made a

¹ In March of 1989 the Directorate for Engineering (ENG) was restructured. This program is now in the Division of Biological and Critical Systems.

commitment to the program for a minimal five-year period. A yearly review publication is planned, and it is anticipated that additional universities will choose to participate in the future, so that an even greater impact on the lives of the disabled may be achieved.

Sincere thanks are extended to Dr. Allen Zelman, Program Director of the NSF BRAD program, for being the prime mover behind this initiative. Additionally, thanks are extended to Drs. Peter G. Katona and Karen M. Mudry, former and current NSF Program Directors of the Biomedical Engineering and Aiding the Disabled, who have continued to support and expand the program. I wish to 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. I also wish to acknowledge and thank Ms. Barbara Mykleseth and Ms. Kathy Sjostrom for their administrative assistance during the preparation of this publication. Additionally, I wish to acknowledge and thank Joyce Mayo for drawing the technical illustrations shown throughout the book.

The information in this publication is not restricted in any way. Individuals are encouraged to use the project descriptions in the design of future design projects for the disabled. The NSF and the editor make no representations or warranties of any kind

with respect to these senior design projects, and specifically disclaim any liability for any incidental or consequential damages arising from the use of this publication. The projects presented here have been implemented in the fourth year of this initiative; they have a wide range of depth and usefulness. Faculty members using the book as a guide thus should exercise good judgment when advising students.

For more information on this program contact Dr. Karen M. Mudry, Program Director, Biomedical Engineering and Aiding the Disabled, National Science Foundation, Washington DC 20550; telephone number: (202) 357-7955.

It is hoped that this book serves as a catalyst and a source of information for future design work. The editor welcomes any suggestions as to how this review may be made more useful for subsequent yearly issues.

John D. Enderle, Editor
Department of Electrical Engineering
North Dakota State University
Fargo, North Dakota 58105
Voice: (701) 237-7689
FAX: (701) 237-8677
e-mail: j.enderle@ieee.org

**NATIONAL SCIENCE
FOUNDATION**

1992

**ENGINEERING SENIOR DESIGN
PROJECTS TO AID THE
DISABLED**

CHAPTER 1

INTRODUCTION

Devices and software to aid persons with disabilities often need custom modification, are prohibitively expensive, or nonexistent. Much of the disabled community does not have access to custom modification of available devices and other benefits of current technology. Moreover, when available, engineering and support salaries make the cost of any custom modifications beyond the reach of the disabled.

In 1988, the National Science Foundation (NSF) provided a mechanism, through the Bioengineering and Research to Aid the Disabled (BRAD) program of the Emerging Engineering Technologies Division of NSF, whereby student engineers at universities throughout the United States designed and built devices for persons with disabilities. This NSF program enhanced the educational opportunities for students and improved the quality of life for disabled individuals. Students and university faculty provided, through their normal ABET accredited senior design class, engineering time to design and build the device or software, and the NSF provided funds, competitively awarded to twenty-two universities, for supplies, equipment and fabrication costs for the design projects.

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. Design is a course that brings together concepts and principles learned in other courses. In the past, students were typically involved in design projects that enabled the student to improve the quality of their life, for instance, by designing and constructing a stereo receiver. Under this new BRAD program, engineering students at the universities participating in this initiative are involved with designs that result in an original device or a custom modi-

fication of a device that improves the quality of life for a person with disabilities. The engineering design students are provided an opportunity for practical and creative problem solving to address a well-defined need, and the handicapped individual receives the product of that process. There is no financial cost incurred by disabled persons participating in the BRAD program and upon completion, the finished project becomes the property of the individual for whom it was designed.

Under faculty supervision, students developed specific projects through their senior design classes to address the identified needs of particular disabled individuals. Local school districts and hospitals participated in the effort by referring interested individuals to the program. Each project is specifically designed for a disabled individual or a group of disabled individuals with a similar need by a single student or a team of students.

The emphasis of the program is to:

- Provide disabled children and adults, student-engineered devices or software to improve their quality of life and provide greater self-sufficient capability.
- Enhance the education of student engineers by designing and building a device or software that meets a real need.
- Allow the university an opportunity for unique service to the local community.

Some of the projects described here are custom modifications of existing devices, modifications that would be prohibitively expensive to the disabled individual were it not for the student engineer and the BRAD program. Other projects are unique one-of-a kind devices wholly designed and constructed

by the student for the disabled individual. The students participating in this project have been singularly rewarded through their activity with the disabled, and justly have experienced a unique sense of purpose and pride in their accomplishment.

After the introduction, twenty-one chapters follow, with each chapter devoted to one participating school. The chapters begin by completely identifying the school and the principal investigator(s). Following the chapter introduction for the school, each senior design project description is written using the following format. On page one, the individuals involved with the project are completely identified, including the student(s), the professor(s) who supervised the project, and the many professionals involved in the daily lives and education of the disabled individual. A brief nontechnical description of the project follows with a summary of the impact on how the project has improved the quality of life of the disabled person. A photograph of the device or the device modification is usually included. Following this, 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 be fabricated without knowing the

exact identity of the part. An approximate cost of the project is provided, excluding personnel costs.

Most projects are described in two pages. However, the first 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.

The purpose of this publication is two-fold. One obvious purpose is to serve as a reference or handbook for future senior design projects. If this goal is achieved, the quality of senior design projects will improve and an even greater project impact will be felt by persons with disabilities. Additionally, students will be exposed to this unique body of applied information on current technology, thus providing an even broader education, especially in the area of rehabilitation design. Secondly, it is hoped that this publication serves to motivate both student and graduate engineers, and others, to work more actively in rehabilitation, leading to an increased technology and knowledge base to effectively address the needs of the disabled.