

January 6, 2009

# ENGR110/210

## Perspectives in Assistive Technology



David L. Jaffe, MS



Professor Drew Nelson



Alex Tung, PhD Candidate

# Today's Agenda

- Welcome to the Course
  - Professor Drew Nelson
- Course Outline
- Introduction to Assistive Technology
  - David L. Jaffe, MS
- Student Projects
  - Prior Years' Student Projects
  - Project Suggestions for this Quarter





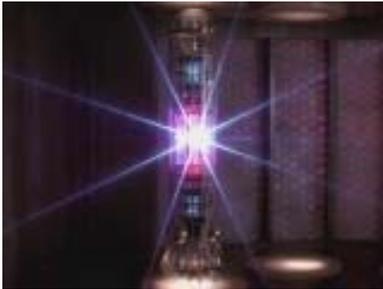
# to the Class

- Welcome to students and community
- Introduce Professor Drew Nelson
- Introduce Alex Tung – Public Service Coordinator
- Administrative items
  - Time conflicts
  - Sign-up form
  - Attendance sheet



Who are these people and why are they smiling?





# Class Genesis

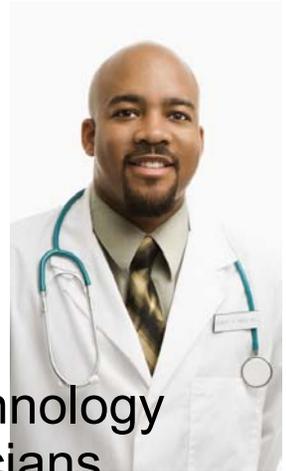


- How this course came about
- Why it is being offered





# Course Goals



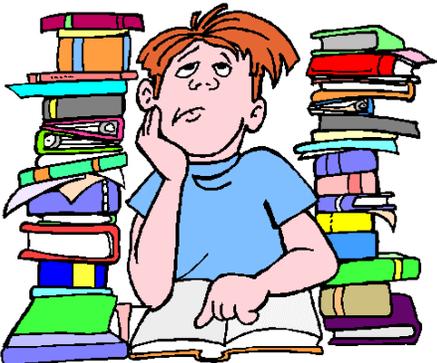
- Disseminate background knowledge about Assistive Technology through lectures and interactions with professionals, clinicians, and users
  - learn about the different perspectives in the design and use of assistive technology
  - be prepared to develop a prototype, conduct user testing with that prototype, and iterate / refine the design in the Spring Quarter in ME113, CS194, or as independent study
- Introduce engineering students to concepts of effective design that that goes beyond technical engineering aspects
- Provide information to the greater Stanford community
- Caveats





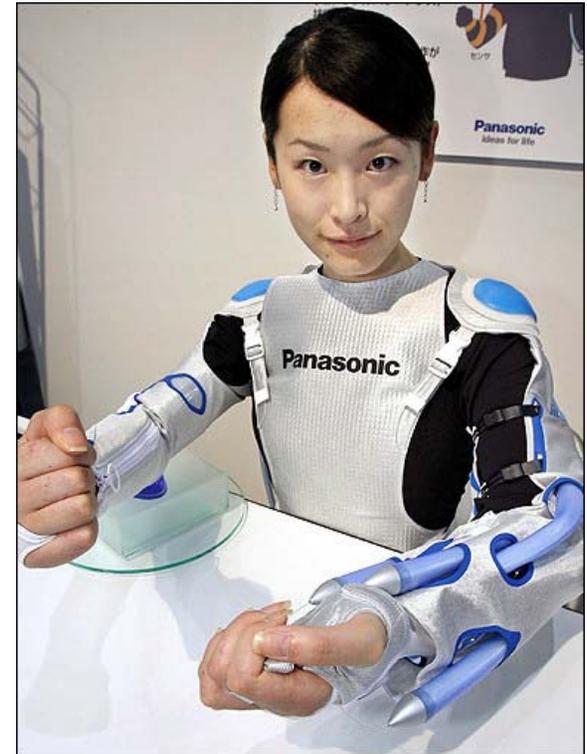
# What this Course isn't

- Not about starting a company
- Not about commercializing a device or product
- Not about business or manufacturing
- Projects not with corporations or in other countries
- No exams or quizzes
- No books to buy or required reading
- No problem sets



# What this Course is

- Engineering design-development process:
  - Need-finding
  - Brainstorming
  - Prototyping
  - Testing
- Team-work
- Partnering with local community



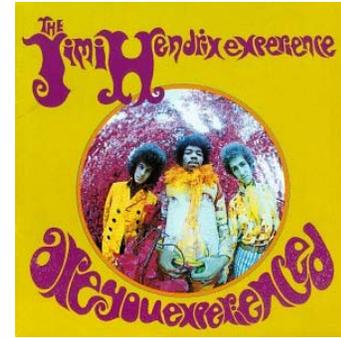
# Course Structure

- A twice-weekly lectures exploring perspectives in the design and use of assistive technology by engineers, designers, entrepreneurs, clinicians, and persons with disabilities
- An opportunity to work in project teams and engage in a design experience that includes need-finding, project identification, and design





# Student Experience



- Gain an appreciation for the psychosocial, medical, and technical challenges in developing assistive technologies
- Learn about engineering concepts, design strategies, ethical issues, and intellectual property rights

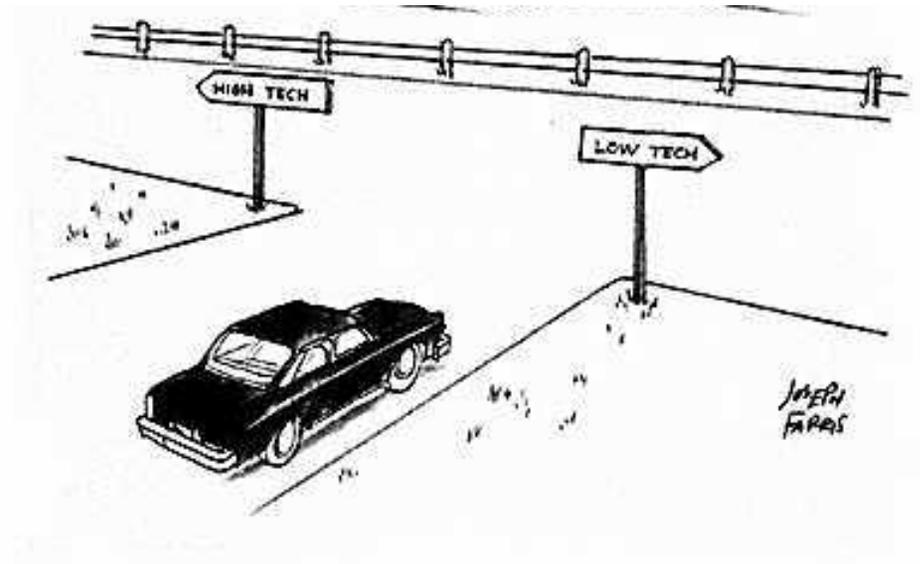
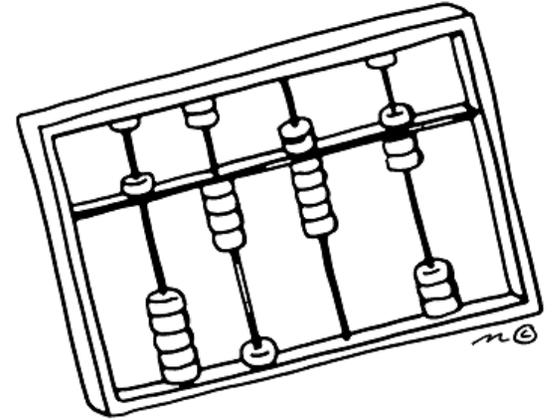
For those working on a project this quarter:



- Engage in a comprehensive design experience that includes working with real users of assistive technology to identify needs, prototype solutions, perform device testing, and practice iterative design
- Employ engineering and design skills to help people with disabilities increase their independence and improve their quality of life

# Projects

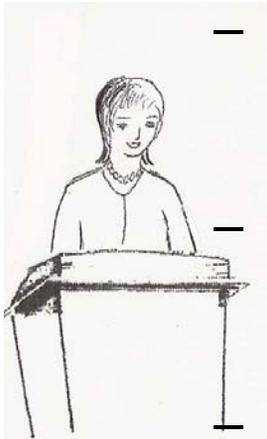
- Need not be impressive
- Low tech is ok
- Getting it to work is a priority



# Credit Options



- **1-unit option:**
  - attend **at least 10** ENGR110/210 lectures, no participation in a project, no continuation in the Spring Quarter
- **3-unit options:**
  - attend the ENGR110/210 lectures, participate in a project, continue with ME113 or CS194 in the Spring Quarter
  - attend the ENGR110/210 lectures, participate in a project, continue with independent study credit in the Spring Quarter
  - attend the ENGR110/210 lectures, participate in a project, no continuation in the Spring Quarter



# ENGR110/210 Project Activities



For those working on a project:

- Review project suggestion offerings
- Select a project
- Form a team
- Investigate project needs with an individual with a disability
- Evaluate the needs and further define the project
- Gather relevant background information for the project, including any prior design approaches
- Brainstorm, evaluate, and choose a design concept
- Prototype, fabricate, test, and assess the design
- Prepare and present a design proposal giving background, criteria, initial concepts from brainstorming, selected design candidate, and any prototyping, fabrication, and testing

# ENGR110/210 Course Assignments



For those working on a project:

- Submit a **Problem Identification Report**
- Attend a mid-term design meeting
- Submit and present a **Design Proposal**
- Reflect on your class experience





# Grading

For those working on a project:

- Problem Identification Report 30%
- Design Proposal Report 30%
- Design Concept Presentation 30%
- Individual Reflections 10%
- Participation 10%

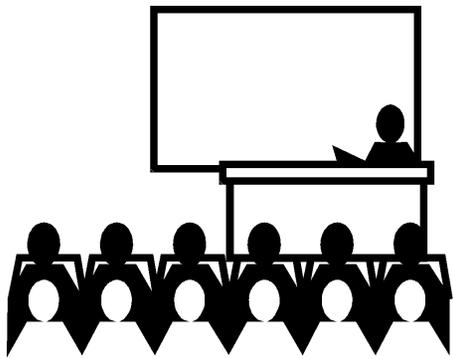
Participation includes actively listening, posing questions to speakers, and submitting thoughts & analyses.





# Spring Quarter Activities in ME113 or CS194

- Continue brainstorming several design approaches
- Evaluate the approaches and select the most promising one to pursue
- Prepare an updated design proposal
- Perform detailed design and analysis
- Prepare a midway report
- Build a first cut prototype to demonstrate design feasibility
- Test the prototype and get feedback from users
- Redesign as necessary
- Construct a second, improved prototype
- Pursue re-testing and get feedback
- Prepare a final report documenting the results of a project and suggesting steps to further develop the design



# Lecture Titles 1 of 2



- Introduction to Assistive Technology
- Team Formation & Project Review
- The Transdisciplinary Team: Bridging the Gap between Consumers and Products in Rehabilitation Medicine
- Community Service and Engineering
- Computer Access Case Studies
- Inventorship, Intellectual Property, and Stanford's Office of Technology Licensing
- Spinal Cord Injury
- Design in Action
- Sit Your Ass Down! Perspectives from a Lifetime of Disability

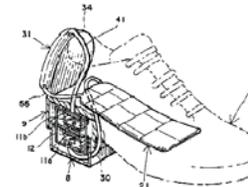
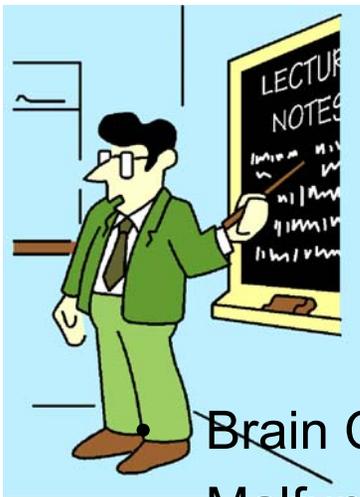
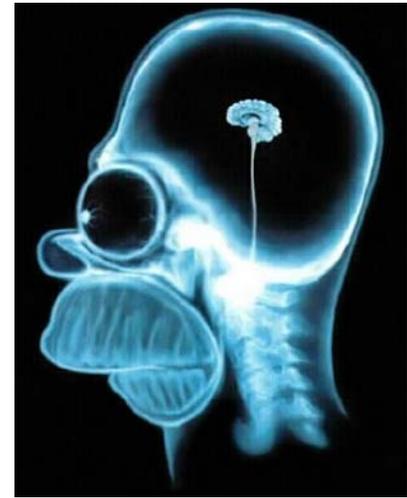


FIG.2





# Lecture Titles 2 of 2



Brain Control: Surgical Technology for Fixing the Malfunctioning Brain

- Eyes-Free Interaction: Moving the User Interface to the Background
- Design Challenges in Assistive Technology
- Human Subjects in Research
- An Introduction to Gait Analysis
- Crutches: Walking with Four Legs
- Designing Beyond the Norm to Meet the Needs of All People
- Sean Keegan – Associate Director, Assistive Technology





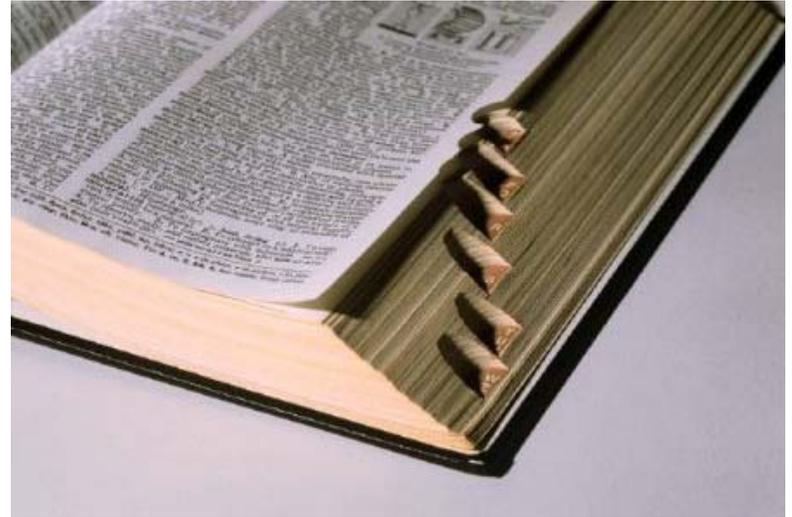
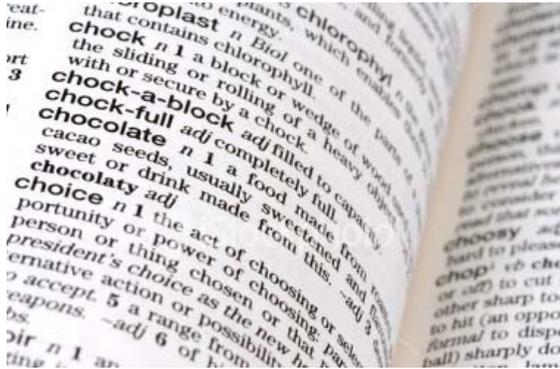
Questions so far?

# Introduction to Assistive Technology

- Definitions
- Broad overview
- What is a disability?
- Range of disabilities
- People involved - demographics and numbers
- Goal of rehabilitation
- Needs of people with disabilities
- Perception of people with disabilities
- Examples of assistive technology products and devices
- Phraseology, semantics, and social correctness



# Definitions



- Disability
- Assistive Technology
- Rehabilitation
- Rehabilitation Engineering



# Disability

## Work-Based Definition

Persons with a disability are those who have a “health problem or condition which prevents them from working or which limits the kind or amount of work they can do”.

Current Population Survey

Cornell University Disability Statistics

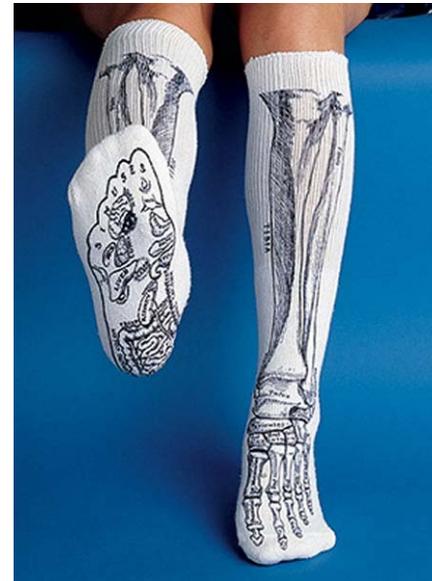


# Disability

## Anatomically-Based Definition



The Department of Veterans Affairs uses a percent disabled definition partially based upon loss of use of limbs, etc that “interferes with normal life functions”.





# Disability

## Activity-Based Definition

- Disability is defined in terms of limitations in a person's activities due to a health condition or impairment.
- Activities is a broad enough term to include working, doing housework, taking care of personal and household needs, and other age-appropriate activities. - National Health Interview Survey
- UCSF Disability Statistics Center



# Disability

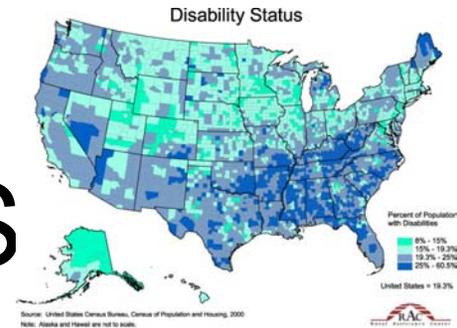
## Opportunity-Based Definition

Disability is defined as a health condition or impairment that prevents an individual from taking full advantage of life's opportunities such as education, vocation, recreation, and activities of daily living





# Disability in the US



- 43 million citizens are disabled, about 17% of 250 million
  - Some reports cite 49 to 78 million
- 24.1 million individuals have a severe disability
- 11 million children have a disability
- Disability is the largest minority group
- 15 million are 65 or older
- 10 million people with vision impairments
  - 1.3 million are legally blind
- 24 million people with hearing impairments
  - 2 million are deaf
- 1 million wheelchair users
- 6 million people who are mentally retarded
- Less than 5% are born with their disability





# Disability in the US



- Disability rates vary by age, sex, race, and ethnicity
- Disabilities result in a reduced chance for employment
- Disability is associated with differences in income
- As the nation ages, the number of people experiencing limitations will certainly increase.



# Disability Types

- Congenital
- Physical
  - Sensory
  - Functional
- Psychological / neurological

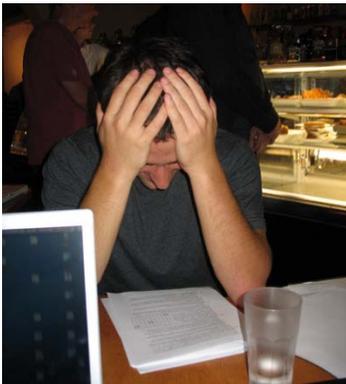




There is a group of individuals who are so impaired that they spend 12 to 25 years in institutions before they can contribute significantly to society



There is a group of individuals who are so impaired that they spend 12 to 25 years in institutions before they can contribute significantly to society



**Students!**



# Needs / Desires of People with Disabilities

- Regain function
- Perform tasks independently
- Improve quality of life
- Take full advantage of all opportunities
  - Educational
  - Vocational
  - Recreational
  - Activities of daily living
- Pursue happiness
- Integrate into society



# Perceptions of Disabilities

- In the US:
  - A diminishing stigma
  - Mainstreaming
  - ADA
- In other countries:
  - Taken care of, but often hidden away
  - Pursuit of a technology solution is a priority





# Social and Political Correctness



- Put the person rather than the condition first:
  - Individuals or people with a disability
- Focus on capabilities rather than disabilities
  - Wheelchair user
- Refer to the person rather than the disability group – be inclusive
  - The Blind, the Disabled, the Deaf

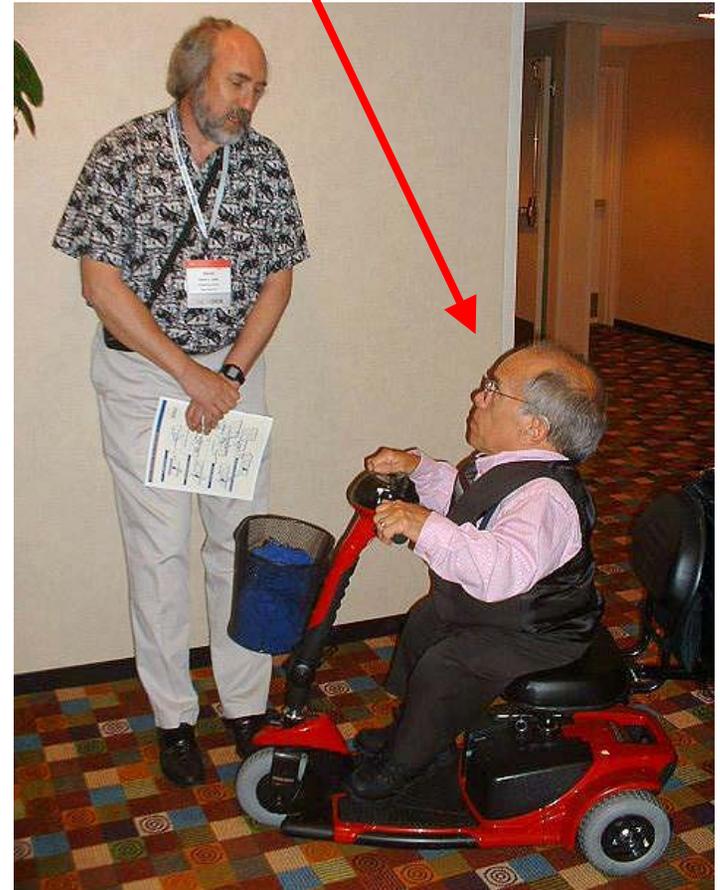
# Social and Political Correctness

- Shorthand terms:
  - Para, Quad
- Derogatory terms:
  - Gimp, Crip, Spaz, Retard
- Use of terms:
  - “Patient”, “User”, “Subject”, “Consumer”
  - “Suffering from”, “Afflicted with”, “Confined to”, “Victim of”
  - “Diagnosed with”, “Living with”, “Survivor of”



# Robert Van Etten

- Dwarf
- Midget
- Shorty
- Little person
- Munchkin
- Elf
- Vertically challenged
- Scooter-man



# Bob





# Assistive Technology



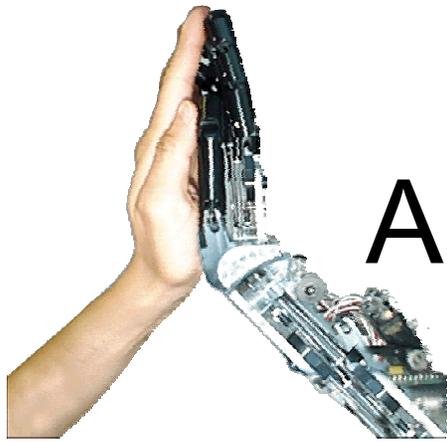
- Assistive Technology (AT) is a generic term that includes both:
  - devices that benefit people with disabilities and
  - the process that makes these devices available to people with disabilities.
- An AT device is one that has a diagnostic, functional, adaptive, or rehabilitative benefit.
- Engineers employ an AT process to specify, design, develop, test, and bring to market new devices.

# Assistive Technology

Health care professionals (not just engineers) are involved in evaluating the need for AT devices; working on research, design, and development teams; prescribing, fitting, and supplying them; and assessing their benefit.

- Physicians
- Clinicians
- Therapists
- Suppliers
- Policy makers
- Educators





# Assistive Technology



AT devices provide greater independence, increased opportunities for participation, and an improved quality of life for people with disabilities by enabling them to perform tasks that they were formerly unable to accomplish (or had great difficulty accomplishing, or required assistance) through enhanced or alternate methods of interacting with the world around them.



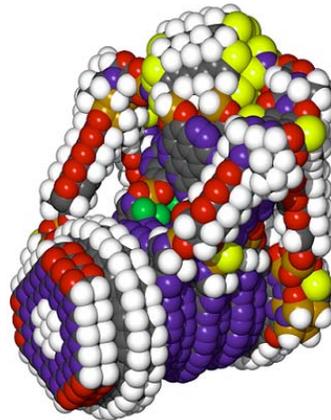


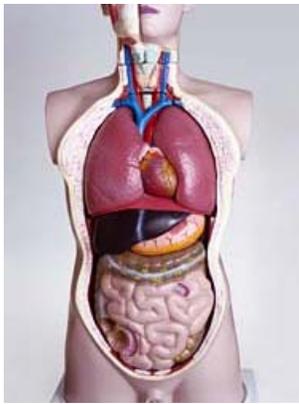
# Assistive Technology



New AT devices incorporating novel designs and emerging technologies have the potential to further improve the lives of people with disabilities.

- Computers
- Robotics & mechatronics
- Nanotechnology
- Medical technologies





# Rehabilitation

- **Medical model:** Restoration of function caused by disability – through surgery, medication, therapy, and/or retraining
- **More inclusive model:** Includes Assistive Technology



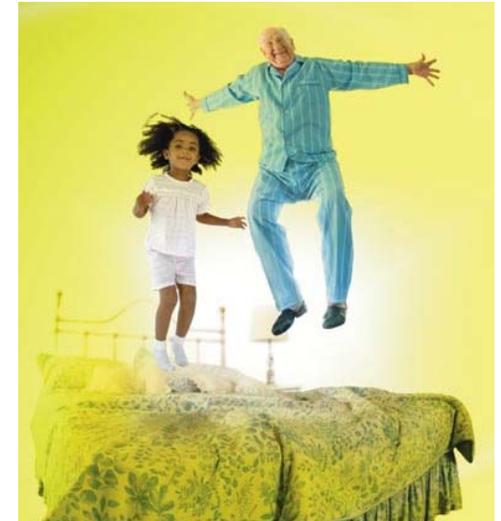
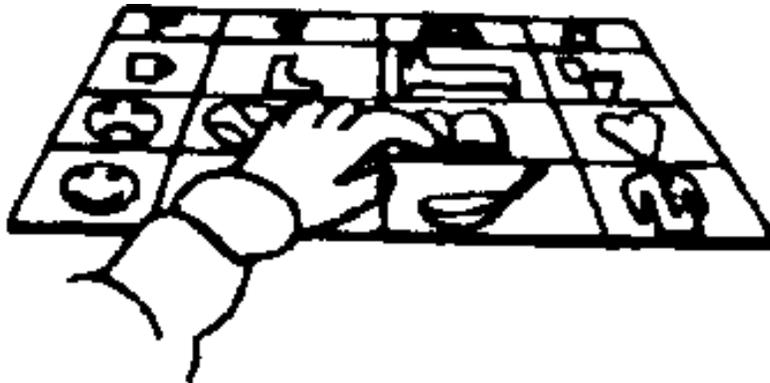


# Goals

- Goal of Rehabilitation
  - Restore function



- Goals of Assistive Technology
  - Increase independence
  - Improve quality of life



# Rehabilitation Engineering

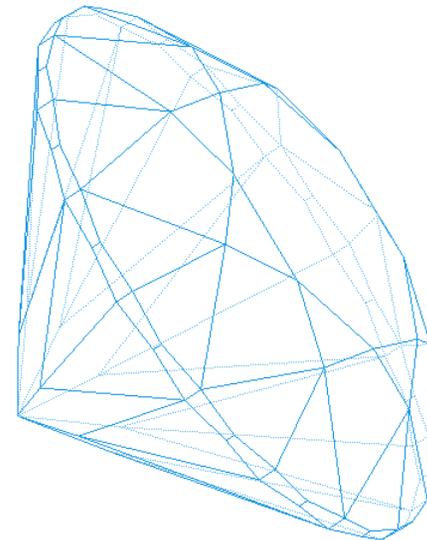
Rehab Engineers assist people who have a functional impairment by engaging in one or more:

- Device Design
- Research & Development
- Technology Transfer
- Marketing
- Provision
- Education & Training



# Facets of Rehabilitation Engineering

- Personal Transportation (vehicles and assistive driving)
- Augmentative & Alternative Communication
- Dysphagia: Eating, Swallowing, Saliva Control
- Quantitative Assessment
- Technology Transfer
- Sensory Loss & Technology
- Wheeled Mobility & Seating
- Electrical Stimulation
- Computer Applications
- Rural Rehabilitation
- Assistive Robotics & Mechatronics
- Job Accommodation
- Gerontology - Technology for Successful Aging
- International Appropriate Technology
- Universal Access



# Assistive Technology Market

- Many people with a disability – in US and world-wide
- Every consumer has unique needs and desires
- Largest homogeneous group in the US is wheelchair users
- Lack of a well-defined mass market means that companies serving individuals with disabilities are small and their products are expensive



# Example Assistive Technology Devices

- Projects I worked on at the VA RR&D Center
- Commercial devices and research projects
- Technologies that have made an impact



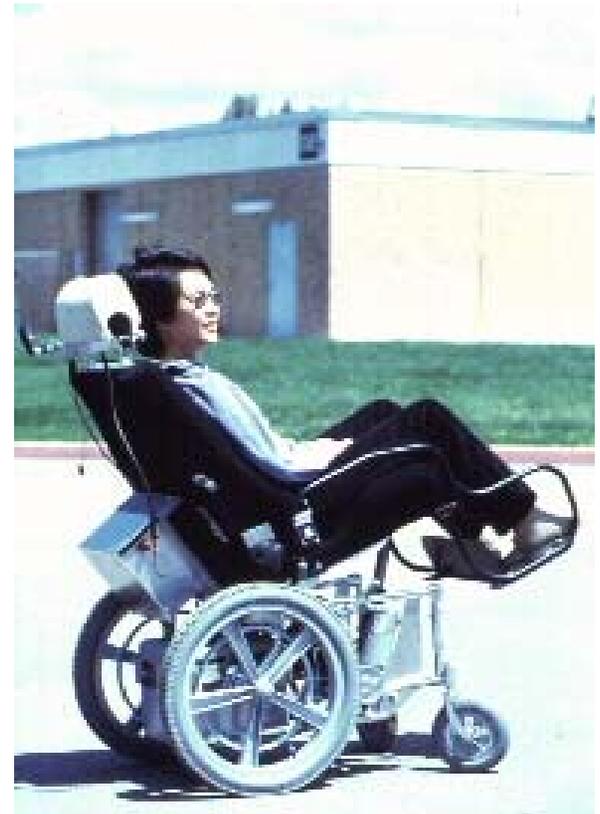
# Head Control Interface

- **Features**

- 2 degrees of freedom
- real-time operation
- non-contact interface
- front or rear sensing
- mouse or joystick substitute

- **Applications**

- control of mobility (electric wheelchair)  
contrast with voice control alternative
- control of cursor position with hands on keyboard
- demonstrated robot control



# Ralph Fingerspelling Hand

- **Ralph** offers individuals who are deaf-blind improved access to computers and communication devices in addition to person-to-person conversations.
- Enhancements of this design include better intelligibility, smaller size, and the ability to optimize hand positions.



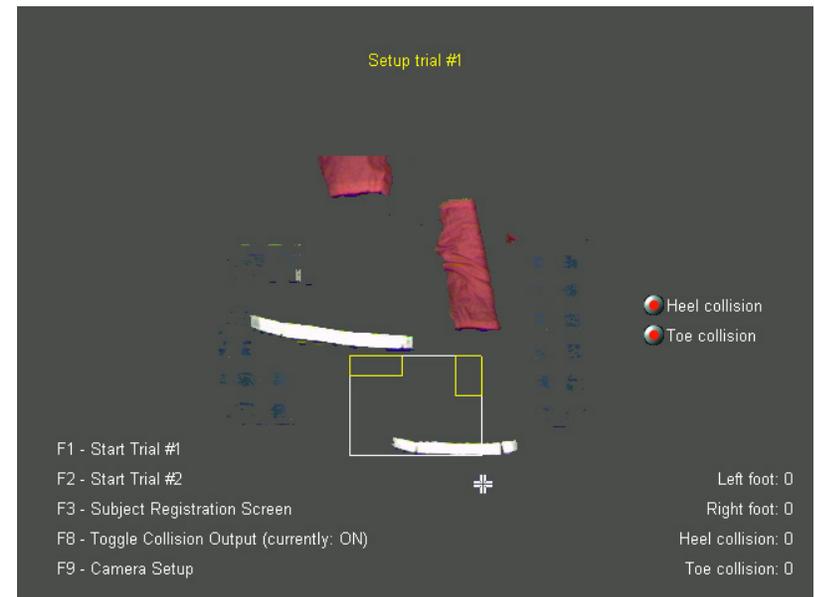
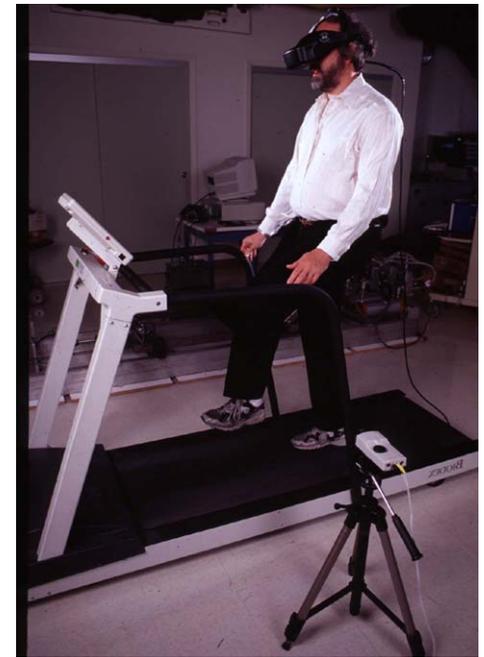
# Virtual Reality

- Features

- treadmill-based training aid
- step over virtual obstacles
- harness prevents falling
- computer senses “collisions”

- Applications

- safe training aid for clinic
- range of motion, coordination, balance



# Driving Simulator

- The goal of this project was to evaluate the potential of a high quality computer-based driving simulator to accurately assess and improve the driving ability of veterans with Stroke and Traumatic Brain Injury (TBI).
- Create realistic driving scenarios to address specific cognitive, visual, and motor deficits in a safe setting
- Compare driving performance with traditional “behind-the-wheel” assessment and training



DriveSafety Model 550C 3-Channel Simulator with Saturn car cab.

# Brain Control Interface

- Noninvasive – picks up surface EEGs
- EEG signal is modulated by the flash-rate of characters on the display
- Computer determines which character is being looked at
- Used by ALS subjects



Wadsworth Center - NY

# Ultimate Robotic Hand

- Responds to voice commands
- Employs laser scanners for obstacle detection
- Segway base for mobility
- Grasps and handles physical objects



STAIR - Stanford

# Advanced Prosthetics

The **Proprio Foot** is a \$30,000 device that uses artificial intelligence, sensors, and microprocessors to adjust automatically to the user's gait as well as to surface angles. It's capable of remembering exactly how its owner walked up a flight of stairs or down a hill, and can be trained to respond differently.



# Robotic-Assisted Stroke Rehabilitation

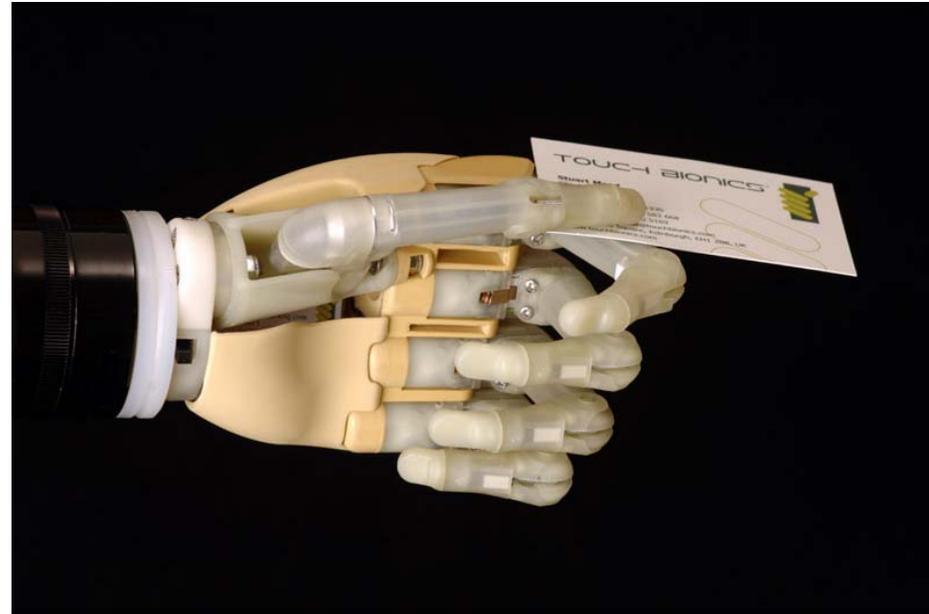
Researchers at Rice University have designed and fabricated a robot for upper extremity stroke rehabilitation that is capable of applying assistive or resistive forces during reaching movements. Motions of the shoulder and elbow are controlled by the MIME (Mirror Image Movement Enabler) system, which utilize a Puma robot. Motions of the forearm and wrist are controlled by the RiceWrist, a parallel structure cable driven robot mounted on the end of the PUMA.



Rice Wrist mounted on the MIME Rehabilitation System

# Bionic Hand

- Individually powered digits
- Myoelectric signal input to open and close fingers
- Cosmetic covering available



i-LIMB Hand – a fully articulating and commercially available prosthetic hand.

# Mobility for Small Children

- Provides mobility to children who are unable to fully explore the world on their own
- Employs obstacle sensors



UD1 - University of Delaware

# PowerKnee

- The **PowerKnee** is an active orthotic device. It provides active assistance, resistance, rehabilitation of knee function for those with impaired mobility and is constructed with patented actuator technology, an embedded computer system, sensors, and a software control system. The result is a transparently activated, sensor-driven device which greatly enhances mobility and rehabilitation.
- The photo at the right is the prototype FlexCVA attached to a knee brace. Future versions will reduce the size and allow the entire device to fit under loose-fitting clothing.



# iBot Wheelchair

- The **Balance Function** elevates the user to move around at eye level and to reach high places independently. In this function, the front wheels rotate up and over the back wheels, while the user remains seated at an elevated position.
- The **Stair Function** enables the user to safely climb up and down stairs, with or without assistance, giving them accessibility to previously inaccessible places.
- The **4-Wheel Function** enables the user to climb curbs as high as five inches and to travel over a variety of uneven terrain, such as sand, gravel, grass, thick carpet and other surfaces.
- Johnson & Johnson Independence Technology



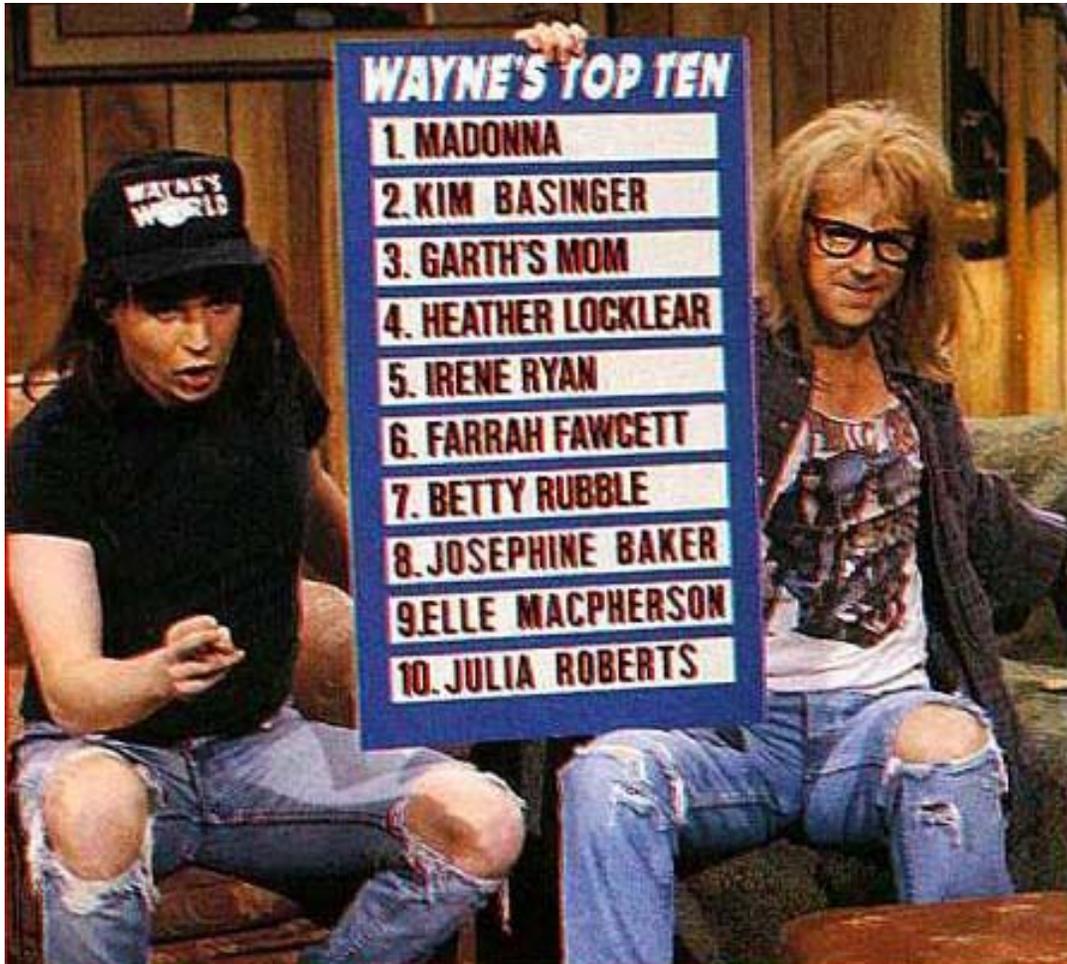
# Lokomat Walking Retrainer

- The Hocoma **Lokomat** Robotic Ambulation System for body weight supported treadmill training is an effective therapy for persons with spinal cord injuries.
- Research indicates that spinal and cortical nervous systems have the ability to recall the walking process from repeated walking therapy.



# Top Ten Rehabilitation Technologies

As judged by Denis Anson - not in any particular order



Alex Eben Meyer



# Adaptive Firmware Card



Developed by Paul Schweda in the late 1970s, this card allowed people with severe disabilities to access "mainstream" computer programs on the Apple II. The card included virtually all modern access technologies (expanded keyboard support, Morse code, single switch) except for voice input, and worked in a computer that didn't have a real operating system, to allow keyboard replacement in virtually any program. It promoted the idea that people with disabilities should be able to use the same programs as anyone else, not just the programs produced by hobbyist therapists.

# Quickie UltraLight Wheelchairs



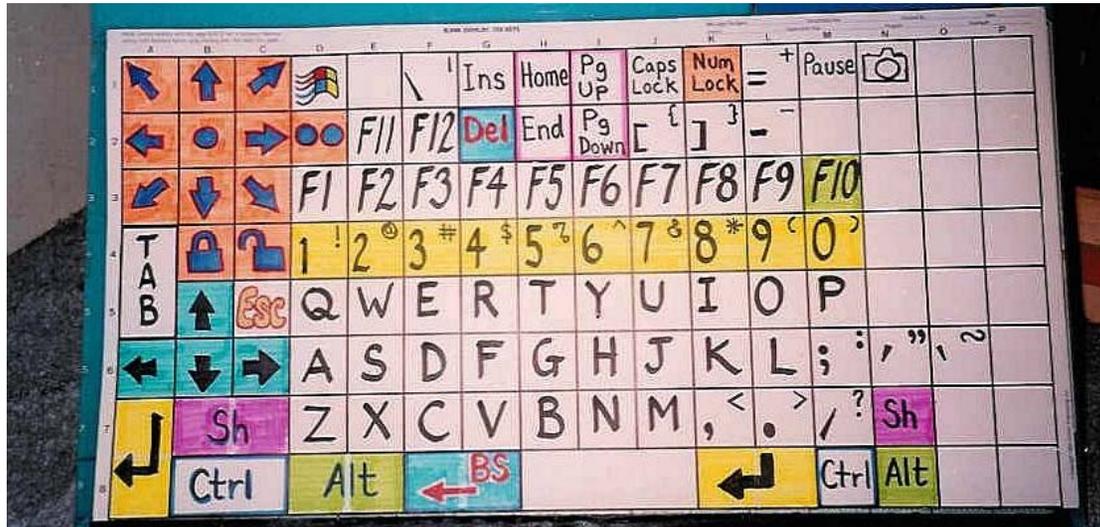
Back in the days when standard wheelchairs were big, heavy, flexible, and inefficient, Quickie showed up with rigid chairs that were light weight and adjustable. Originally designed for wheelchair athletes, they were actually most useful for folks with very limited endurance, who lacked the energy to propel themselves in conventional wheelchairs.

# High-precision Wheelchair Bearings



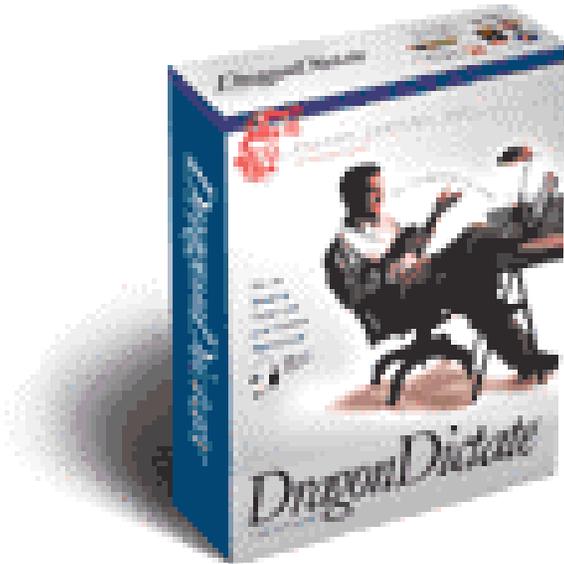
Those old wheelchairs, and even the early ultra-lights used standard wheel bearings, which meant that you could push them and they'd quickly roll to a stop. Then we started getting high-precision bearings, and the silly things started rolling, on their own, to the low points in the therapy area floor if you forgot to set the wheel locks. Suddenly, the effort required to propel all chairs, chairs, and especially ultra-lights, decreased markedly!

# Portable Augmentative Communication Systems



When the Adaptive Firmware Card came out, it included a demo program that allowed messages to be stored behind keys of the Unicorn Keyboard. When you pressed a key, the attached Echo synthesizer spoke the message. Therapists went wild! It's a communication system! It lets non-vocal folks talk! And here is where you plug it in! Of course, it wasn't a communication system, it was a quick and dirty demo program in AppleSoft BASIC. But later, Zygo, among others, developed systems that did the same thing, and that had enough batteries to operate in the real world. Those big, clunky, and \*SLOW\* systems started it all.

# Speech Recognition Software



It originally cost \$6000! It required the most powerful PC money could buy, and it required that you stop after each word to let it decide what word you had spoken, but it was a large vocabulary, general purpose speech to text system that allowed people who couldn't use the keyboard to generate written text.

# IBM ViaVoice



Introduced at \$149, it forced the price of speech recognition down to a level that mere mortals could afford. In the process, it also moved speech recognition into the mainstream, and away from disability, so the customer support changed to a much lower level of involvement.

# LC Technologies Eye Gaze Computer



I first saw this at a RESNA conference exhibit hall, and was blown away. I could sit at the computer, and just by looking at letters on the screen, type. I could look away and look back, and go right on typing. It was cool! While I was gazing, a person came in to the booth behind me, and, after a moment, asked what it cost. I don't recall exactly what the price was, but I think it was on the order of \$60,000. The person squawked, "Why would I spend \$60,000 on this, when right over there, I can buy a HeadMaster for \$1000?" The booth person said, "If you could use a HeadMaster, you'd be out of your mind to buy one of these. This is for people who can't use anything else." In 1994, they had sold 50, but they allowed 50 people to talk and to work who would not have been able to do anything else.

# Morse Code Input



Al Ross, at University of Washington, was a ham radio operator as well as a communications specialist. In the course of his work, he started to wonder if people with profound disabilities might be able to use Morse Code to communicate. He wrote a grant, and did some research with Kathy Yorkston, a speech pathologist, and some others, and found that, indeed, Morse could be used by people with significant cognitive disorders to allow communication at much faster rates than single switch scanning. As part of the project, they built some communication systems to be used for the 6 months of the study (1980). In the late 1990s, some of these communicators were still in daily use.

# Dynamic Display AAC Systems



Early communication systems were limited by the number of keys that could be used, and the amount of information that could be displayed at once. You could swap overlays to get more versatility, but that meant that someone else had to assist (in most cases). If you put lots of icons on the screen, the clutter make it difficult to interpret for many. If you ask the user to remember what the generic symbols mean, you put a lot of load on them. But with dynamic displays, you only have to show the current meaning of a key, not all of them, and the user doesn't have to remember as much.

# Graphical Computer Displays

```
Directory of C:\
08/30/2007  02:58 PM                0 AUTOEXEC.BAT
08/30/2007  02:58 PM                0 CONFIG.SYS
08/30/2007  03:02 PM        <DIR>          Documents and Settings
01/05/2002  03:38 AM        54,784 msvci70.dll
09/04/2007  10:49 AM        <DIR>          Omnipage 16
09/04/2007  10:38 AM        <DIR>          OP16Pro
09/11/2007  01:35 PM        <DIR>          Program Files
08/31/2007  09:35 AM        <DIR>          TEMP
09/12/2007  08:49 AM        <DIR>          WINDOWS
09/04/2007  02:23 PM        <DIR>          WYNN5
                3 File(s)          54,784 bytes
                7 Dir(s) 18,439,569,408 bytes free

C:\>chkdsk
The type of the file system is NTFS.

WARNING! F parameter not specified.
Running CHKDSK in read-only mode.

CHKDSK is verifying files (stage 1 of 3)...
File verification completed.
CHKDSK is verifying indexes (stage 2 of 3)...
10 percent completed.
```

A watershed event, but not one for the better. Text screens are easy. You need to be able to emulate a keyboard, and generate 128 unique characters. Piece of cake. Then we got the Mac, and Windows. Now, you need to be able to move to any spot on the screen, you need to be able to capture text off the screen without knowing where it is (it's not just the 40th character in the 12th row, it can be anywhere!). The difficulty in providing access to a graphical computer, as compared with a text based one is immense. It was a great leap backwards for disability access, and one that we are still recovering from. (How's your access to Windows Vista?)

# History of Assistive Technology Projects in ME113

- Projects from 2006
- Some student projects and experiences from last year



# Standing Aid

- Device to assist a young male wheelchair user to stand while urinating, without assistance



# Wheelchair Lift

- Portable wheelchair lift to facilitate the transfer of a patient and caregiver to/from bed / wheelchair



# Page Turner

- Microcontroller-based prototype page turner to allow a man with ALS, a neuromuscular disorder, to independently read a book – Caitlin Donhowe



# Aid for Donning an Artificial Leg

- A motorized device with wireless remote control that makes it easier for an individual with a below-knee amputation to don an artificial leg
  - Barrett Heyneman
  - Linus Park



# LiquidMetal

## Redesign of the White Cane

The **LiquidMetal** team explored the unique properties of LiquidMetal, an amorphous metal alloy, that would make a superior white cane for blind travelers.



# Let's Get Physical Pediatric Gait Project



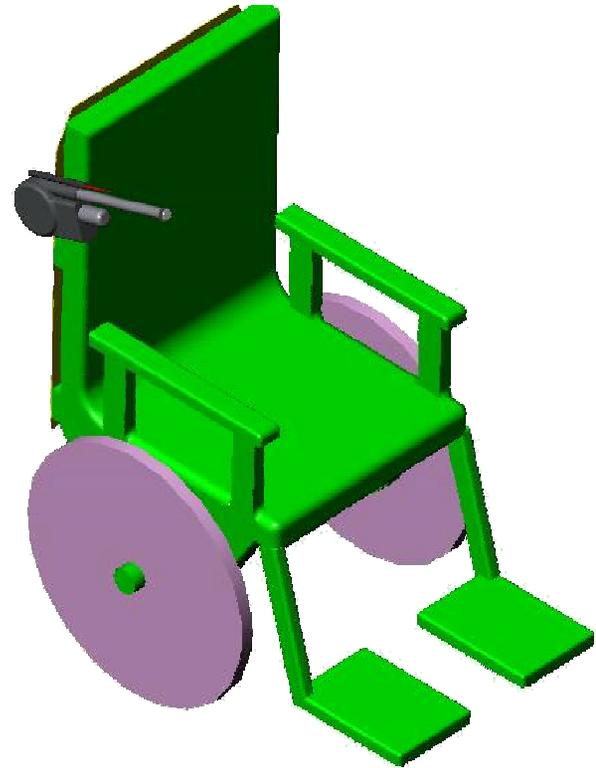
The design team, **Lets Get Physical**, developed a physical therapy motivational device for use by children with Cerebral Palsy who are learning to walk. Combining innovative audio effects with a fun, portable design, the device encourages users to keep walking outside physical therapy classes.



# ElevAid

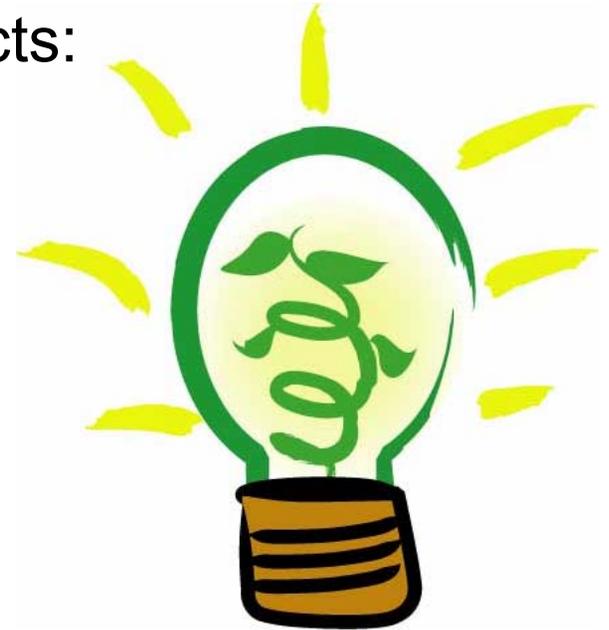
## Device to Press Elevator Buttons

The **ElevAid** team addressed the need of a Stanford student who uses a powered wheelchair to access the elevator call button and to press the button corresponding to the floor desired.



# Project Ideas

- Listed in handout
- Further work on prior year's projects:
  - Page Turner
  - Standing Aid
  - Wheelchair Lift
- Accessible interfaces for:
  - iPods and MP3 Players
  - Cellphones
  - Gameboxes
  - Remote Controls
- Projects listed in the NSF guidebook
- Student-defined projects



# Student Project Resource People

- Debbie Kenney – Occupational Therapist
- Doug Schwandt – Mechanical Engineer
- Kyle Smith – Physical Therapist



# Contact Information

- Websites:
  - <http://www.stanford.edu/class/engr110/>
  - <http://www.stanford.edu/class/me113/>
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# Questions?



# Thursday

## **Team Formation & Project Review “Who is Disabled?” & “Questions for Contemplation” Discussion**

Project presentations by suggestors:

Mark Goldstein

Debbie Kenney

Elaine Levin

Ron Sidell

# Adjourn

