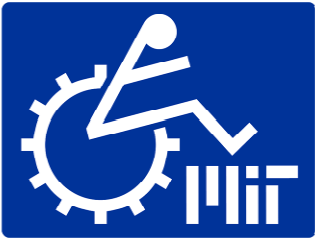




**WHEELCHAIR DESIGN IN
DEVELOPING COUNTRIES**

<http://web.mit.edu/sp.784/www>

Amos Winter (awinter@mit.edu)
PhD Candidate, MIT Dept. Mechanical Engineering



COURSE INFO

Lecturers: Amos Winter, PhD Candidate, Mechanical Engineering
Amy Smith, Senior Lecturer, Mechanical Engineering

Units: 2-2-5 (Lecture-Lab-Homework)

Lecture: Required, can miss two, but not more without instructor permission. Attendance taken starting second week of class.

Project and Labs: Project teams and class presentation times chosen next Thursday. Lab groups will choose own meeting time.

Homework: Project and team website primary components of homework. Additionally there will be readings and short assignments.

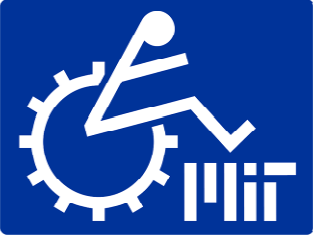
Grading: Final course grades will be assigned A-F.

- Class participation/homework: 10
- Strategy presentation: 15
- Concept presentation: 15
- Most Critical Module (MCM) Presentation: 15
- Final presentation and prototype: 25
- Team website: 20

Course website: <http://web.mit.edu/sp.784/www/index.html>

For a full description of the class, see “detailed course info” on the website

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PROJECT

Team: 3 to 5 members with lab instructor

Collaboration: Partnership between MIT students, US and European experts, and wheelchair manufacturers



Deliverables:

- PowerPoint presentation for the Strategy, Concept, MCM, and Final prototype.
- Poster for The MIT Museum in May
- Prototypes: Physical solution to each teams' MCM for MCM presentation. Proof-of-concept prototype for final presentation
- Website chronicling project development. Pages dedicated to major milestones. Website completed by summer fellows
- Weekly update emails to community partners and mentors

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RESOURCES

Monetary: \$4000 for prototyping (entire class budget)

Manufacturing:



Parts: African wheelchairs and bicycle components

Lab Space: Project work and storage in 1-005

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FELLOWSHIPS



- ~7 available
- Bring WDDC technology back to partner workshops
- Work in any or all 14 partner shops
- ~10 weeks duration
- Apply through PSC Fellowship process or other funding sources
- Develop your project proposal through SP.719

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SP.719

Objective: Guide students through the process of forming a project and writing a proposal

Date	Speaker	Topic
Feb 3	Amos Winter	Introduction to travel abroad options as part of regular class (no night session)
Feb 11	Sally Susnowitz (PSC Director)	Discussion about elements of a good proposal. What should be included, how information should be presented, etc. This is meant to be a broad overview of how one writes a good proposal.
Feb 18	Alison Hynd (PSC Fellowship Director)	Discussion about the PSC fellowship process and what makes a good PSC project. Tish Scolnik will also talk about her projects. She and Alison will go over why her projects were successful.
Weeks of Feb 17, Feb 25	Project consultations	Students meet with the PSC staff to discuss project ideas, get feedback, and begin writing the proposal.
Feb 25	Melissa Martin-Greene (UROP Program)	Discussion about UROPs and IROPs on international development, and elements of a good UROP project.
Mar 4	Kim Benard (Distinguished Fellowships Office)	Discussion about prestigious fellowships (like Fulbright) to fund international work. Details about the application process, deadlines, etc. for such fellowships.
Week of March 9	Proposal review	Students meet with PSC staff (or applicable other funding source staff) to review their proposals and get feedback. The meetings need to occur sometime this week.
Week of March 16	Proposal completion	Students revise their proposals this week and submit them before spring break and the PSC deadline – March 20.

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WDDC SYLLABUS

Week #	Tuesday	Thursday	Assignments	Milestones
1 (2/2)	Introduction to wheelchairs in developing countries and review of potential projects	Wheelchair/Trike relay race around campus	Readings about wheelchair usage and distribution, Review projects	
2 (2/9)	2007 summer fellow presentations on last year's projects Alison Hynd speaking from the PSC about summer fellowships	Designing wheelchairs for the developing world and deterministic design process Choose project teams	Read 2.007 lecture notes on design process, define functional requirements of project, Reading from Nothing about us without us, watch videos of wheelchair workshops and PAWBA conference	
3 (2/16)	Monday schedule	Guest Speaker: Joost Bensen Developmental Entrepreneurship	Reading from HBS case study "Note on Marketing Strategy"	
4 (2/23)	Abdullah and Daniel speaking to class	Abdullah and Daniel speaking to class	Reading from Independence through Mobility, 3/5-Encouraged to visit 2.007 lecture, 3/8-Encouraged to visit 2.007 lecture	Strategy presentations, time TBD
5 (3/2)	Guest speaker: Amy Smith and Amy Banzaert Appropriate technology, idea to product, successfully implementing technologies	Wheelchair role-play Results from Tanzanian Wheelchair Foundation Study	Readings about different appropriate and inappropriate technologies	
6 (3/9)	Wheelchair Biomechanics/Ergonomics and design for human use	Power output test up ramp in basement	Power calculations from class activity, reading from Positioning a Wheelchair, 3/1 - Encouraged to visit 2.007 lecture	
7 (3/16)	Manufacturing processes and strategies Watch video from local workshops in Africa and Vietnam. Watch economies of scale presentation from PAWBA conference.	Product design and critique of existing wheelchair designs	Reading from Mastering the Machine	Concept presentations, time TBD
8 (3/23)	Spring break	Spring break		
9 (3/30)	Material science/ mechanics of materials/welding with Mike Tarkanian	Material science/ mechanics of materials/welding with Mike Tarkanian	Reading from Mechanical principles of wheelchair design	
10 (4/6)	Watch "Murderball" in class Amos at conference	Finish "Murderball" and watch parts of "Emanuel's Gift" Amos at conference	Write short comment on the two movies, discuss portrayal of disability, mobility, public perception Project work	
11 (4/13)	Guest speaker: Ralf Hotchkiss Talking about his career and designing wheelchairs	Guest speaker: Ralf Hotchkiss Talking about his career and designing wheelchairs	Project work	Most critical module (MCM) presentations, time TBD
12 (4/20)	Guest Speaker: Prof. David Gordon Wilson Human-powered machines	Guest Speaker: Rory McCarthy Handcycle design and racing	Reading on wheelchair user image Project work	
13 (4/27)	Project work	Project work	Project work	
14 (5/4)	Project work	Project work	Project work	Poster and presentation for MIT Museum on Sat, 5/9
15 (5/11)	Project work	Project work	Project work	Final presentation of project with a working prototype, time TBD

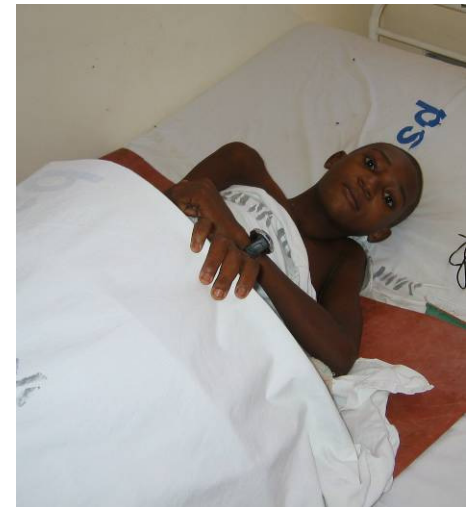
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MOTIVATION World's disabled

- The World Bank and other authorities estimate that there are as many as **600 million persons with disabilities around the world**, making them one of the largest minority groups of unserved, marginalised people. (UNESCO Bangkok)
- About 600 million people in the world experience disabilities of various types. **80% of the world's disabled people live in low-income countries**; the majority of them are poor and do not have access to basic services including rehabilitation facilities. (World Health Organization)
- Between **20 and 50 million people globally are estimated to be injured or disabled in road traffic accidents each year**. (World Health Organization, 2004)
- Close to **ten million severely or moderately disabled people are added each year** to the total global figure – or about 25,000 every day. (Helander, 1999)
- **70% of disabled people in developing countries are estimated to live in rural areas** (Groce, 1999)

(Statistics provided by Motivation UK)





MOTIVATION Need for wheelchairs

- The WHO and Pan American Health Organisation (PAHO), estimate that only **1-3% of people with disabilities in the South who require rehab services have access to them.** (Helander, 1999)
- Most people who sustain a **spinal cord injury in the South die within two years**, compared to a normal life expectancy in the North. (Werner, 1998)
- Conservative estimates put the number of people with disabilities in developing countries at close to half a billion. Of these, an **estimated 20 million require wheelchairs to be mobile.** (United States Agency for International Development, 2003)
- An estimated **95% of people who need a wheelchair don't have one.** (Werner, 1998)
- **Below 1% of the need for wheelchairs in Africa is being met through local production.** (United Nations Development Project, 2002)



(Statistics provided by Motivation UK)

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MOTIVATION

Consequences due to lack of mobility

- **Disability is both a cause and a consequence of poverty.** Eliminating world poverty is unlikely to be achieved unless the rights and needs of people with disabilities is taken into account. (UK Department of International Development)
- In Tanzania, **households with disabled members are 20% more likely to be living in poverty.** (UK Department of International Development, 2005)
- **“98% of children with disabilities in developing countries do not attend school.”** Earlier studies by UNESCAP and UNICEF show that this deplorable condition also applies to the Asia-Pacific region, where only around 2% of children with disabilities – one in every fifty children – have access to education of any sort. (UNESCO Bangkok)
- Worldwide, **only 2% of disabled children get any schooling.** (Action on Disability and Development, 2006)
- **Men, women and children who are discriminated against often end up excluded from society, the economy and political participation.** They are more likely to be poor. (UK Department of International Development, 2005)
- **Women and girls with disabilities face double discrimination based on disability and gender.** As a group, they fare far worse than nondisabled women or disabled men on most indicators of financial, educational and vocational success.” (Mobility International USA, 2002)





ROLE OF MIT IN DEVELOPING WHEELCHAIR TECHNOLOGY

What MIT can offer

- Enthusiastic, creative students who are excellent engineers and work for FREE
- Resources, facilities, manpower to pursue high risk/high payoff projects that workshops or NGOs may not otherwise be able to develop
- A fresh perspective on wheelchair problems; new students every year
- Opportunities for cross-cultural, collaborative exchange of ideas
- World-wide recognition of MIT draws attention to wheelchair issues



February 3, 2009



BETTER TECHNOLOGY THROUGH COLLABORATION

Goal: By partnering with expert organizations, MIT can aid in making great improvements to mobility technology in developing countries

Innovation



MIT

- Next generation of great technical minds
- Excellent facilities/resources
- Strength of MIT reputation
- Specialize in sound engineering and innovation
- Students work for free

Local knowledge



Example: Mobility Care

- Best understanding of community
- Working directly with wheelchair users
- Knowledge of local factors: parts/materials, labor skill, cultural stigmas, terrain

Experience



Example: Whirlwind

- 30+ years designing wheelchairs
- Experts in wheelchair requirements for developing countries
- World-wide workshop network



PERSONAL MOTIVATION TO IMPROVE WC TECHNOLOGY

Summer 2005: Assessment of WC technology in Tanzania

Parties interviewed

Supervision organizations

- Tanzanian Training Center for Orthopedic Technologists, Moshi, TZ
- Whirlwind Wheelchair International, San Francisco, USA



Wheelchair users

Interview locations



Wheelchair workshops

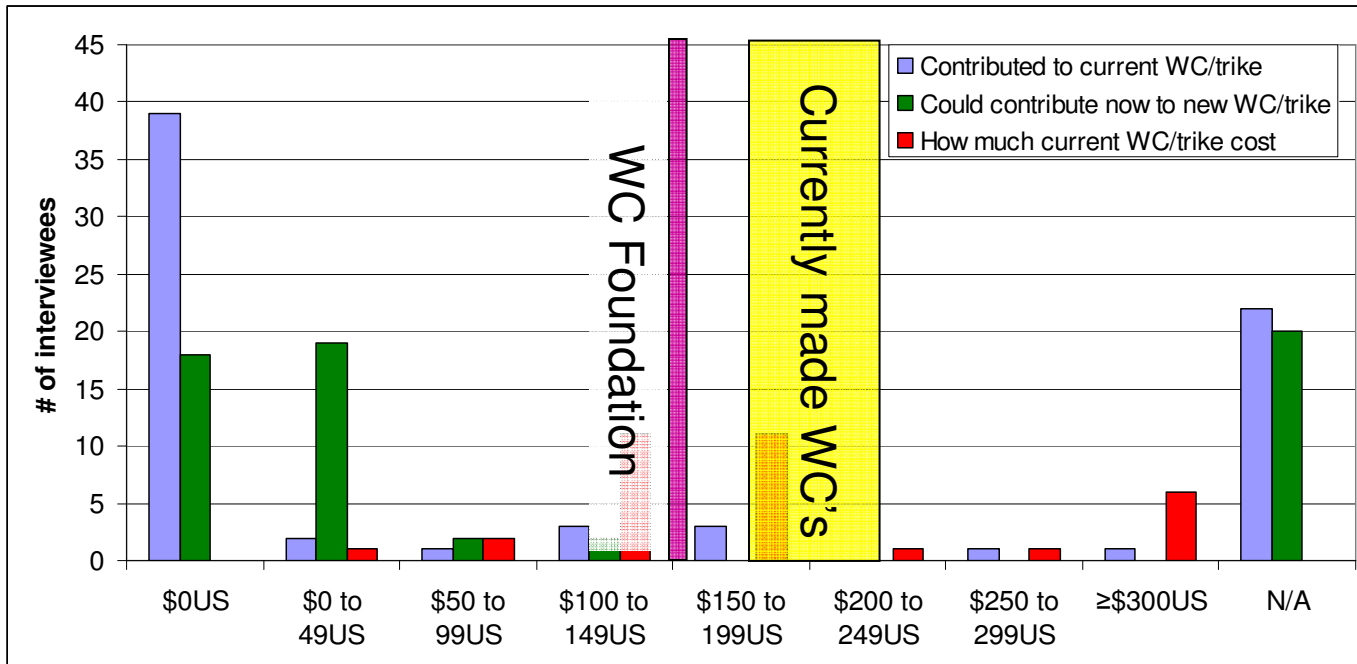


Wheelchair advocacy groups



TZ WHEELCHAIR ASSESSMENT

Opportunities for purchasing and competing with imports



- \$100 to 150 price gap between what chairs cost and what people can afford
- Most people rely on donations to acquire a wheelchair

Largest donor in TZ



- Since 2000, WC Foundation has donated nearly 7,000 WCs in Tanzania
- Each WC foundation chair costs \$150US, \$50 to \$100 less than Tanzanian WCs but same price as TZ tricycles

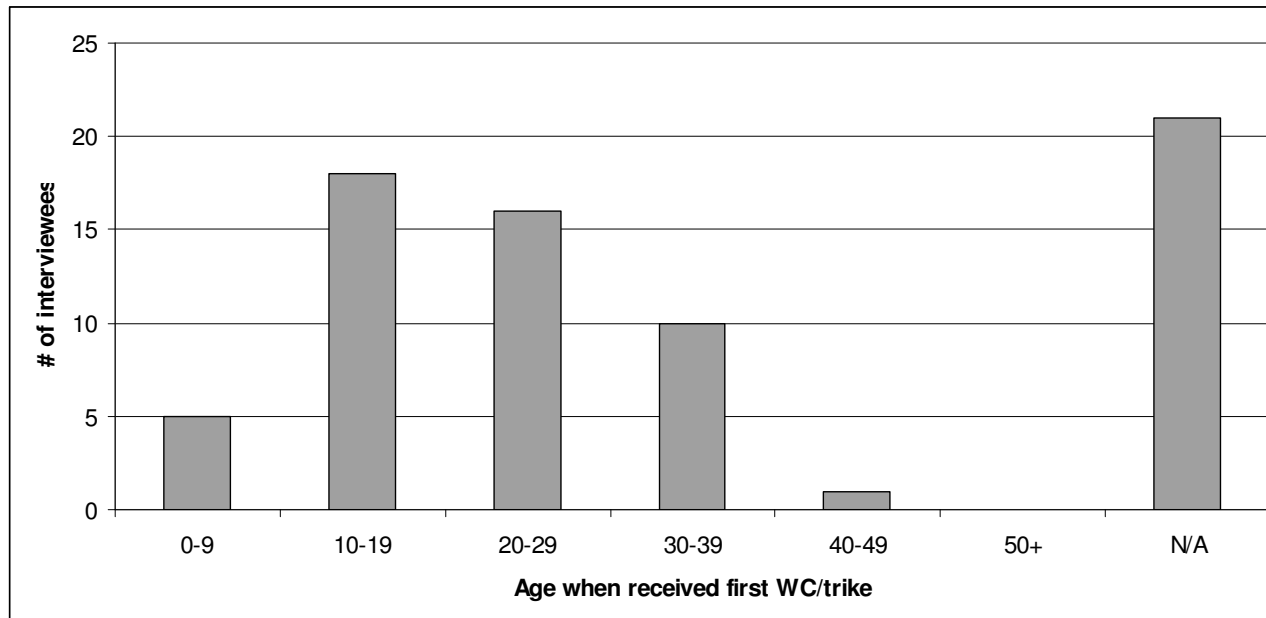
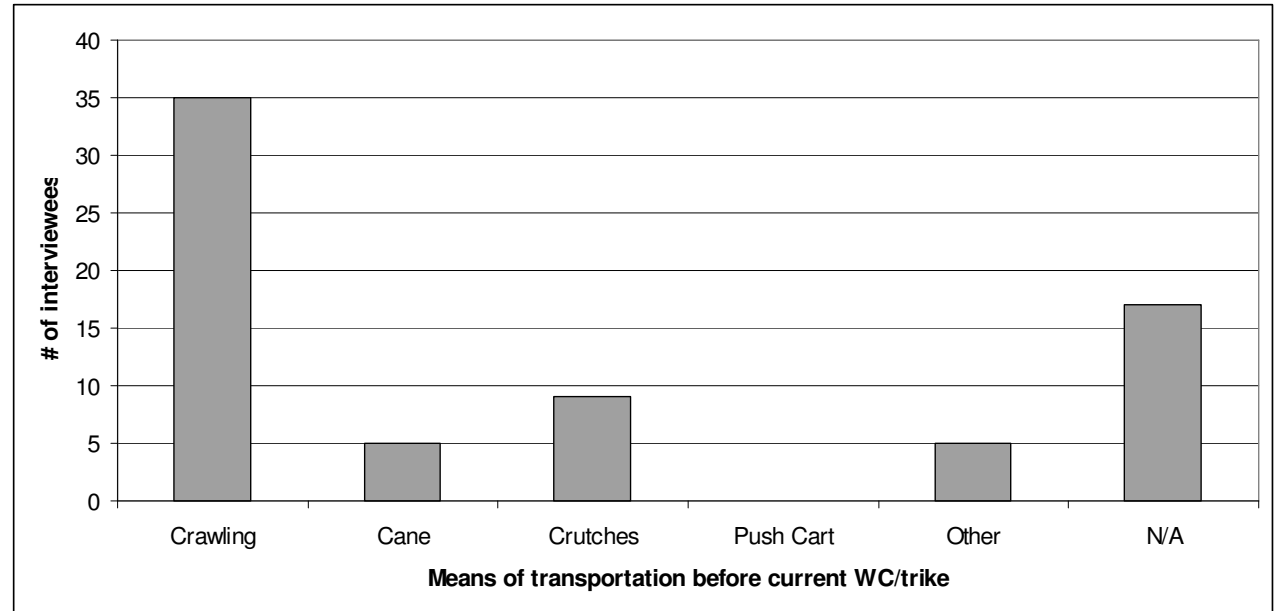
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TZ WHEELCHAIR ASSESSMENT

Opportunities for improved distribution/procurement

- 65% crawled on the ground before current mobility aid
- Mean age when acquired first mobility aid is 21
- In TZ, 2,000 people have a wheelchair, 30,000 to 50,000 need one.



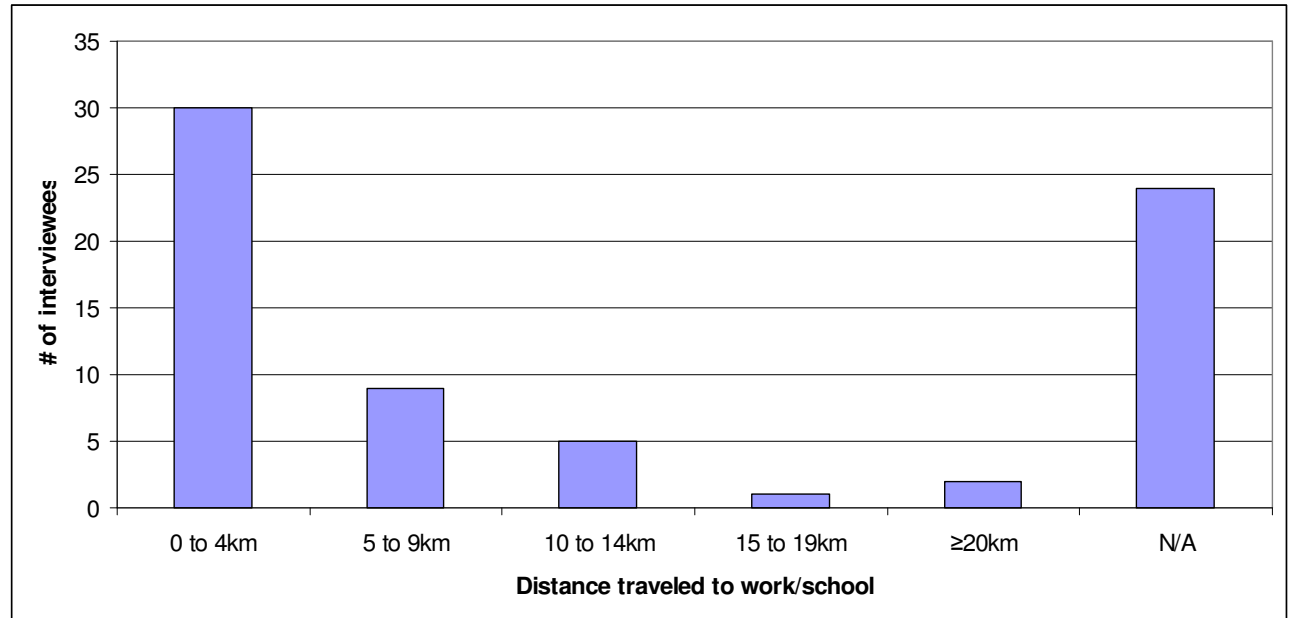
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TZ WHEELCHAIR ASSESSMENT

Opportunities to better serve user needs

- 36% interviewees traveling more than 5km per day
- Largest fraction of interviewees (37%) using a tricycle
- Tricycles much more common (75% of sales at APDK, Kenya)



Tanzanian public bus



Tanzanian-made trike



TZ WHEELCHAIR ASSESSMENT

Opportunity to design mobility aids to better serve users

Common mobility aids available in East Africa



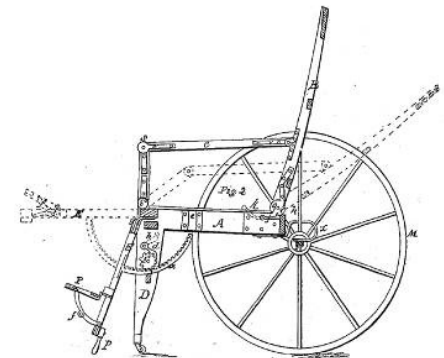
USA/Europe designed, African made



African designed, African made



USA designed, foreign made



First USA wheelchair patent
A.P. Blunt, et. all., 1869

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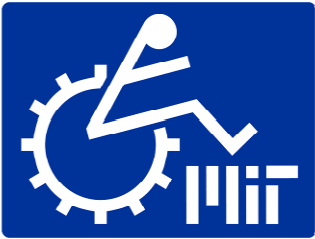


LEVERAGED FREEDOM CHAIR

A wheelchair designed specifically for developing countries



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WHEELCHAIR DESIGN IN DEVELOPING COUNTRIES

Established in 2007

Motivation: Engage many bright students in advancing wheelchair technology

Activities of students in the class:

- Use science and technology to improve the lives of others
- Learn the technical, social, and economic factors preventing appropriate wheelchair technology from being implemented
- Study engineering, business, and biomechanics theory in context of wheelchairs
- Work in teams, collaborating with developing country partners and wheelchair specialists, to design and prototype wheelchair technology
- Interact with faculty, professional, and community partners during guest lecturers
- Participate in summer fellowships in developing countries to implement class projects

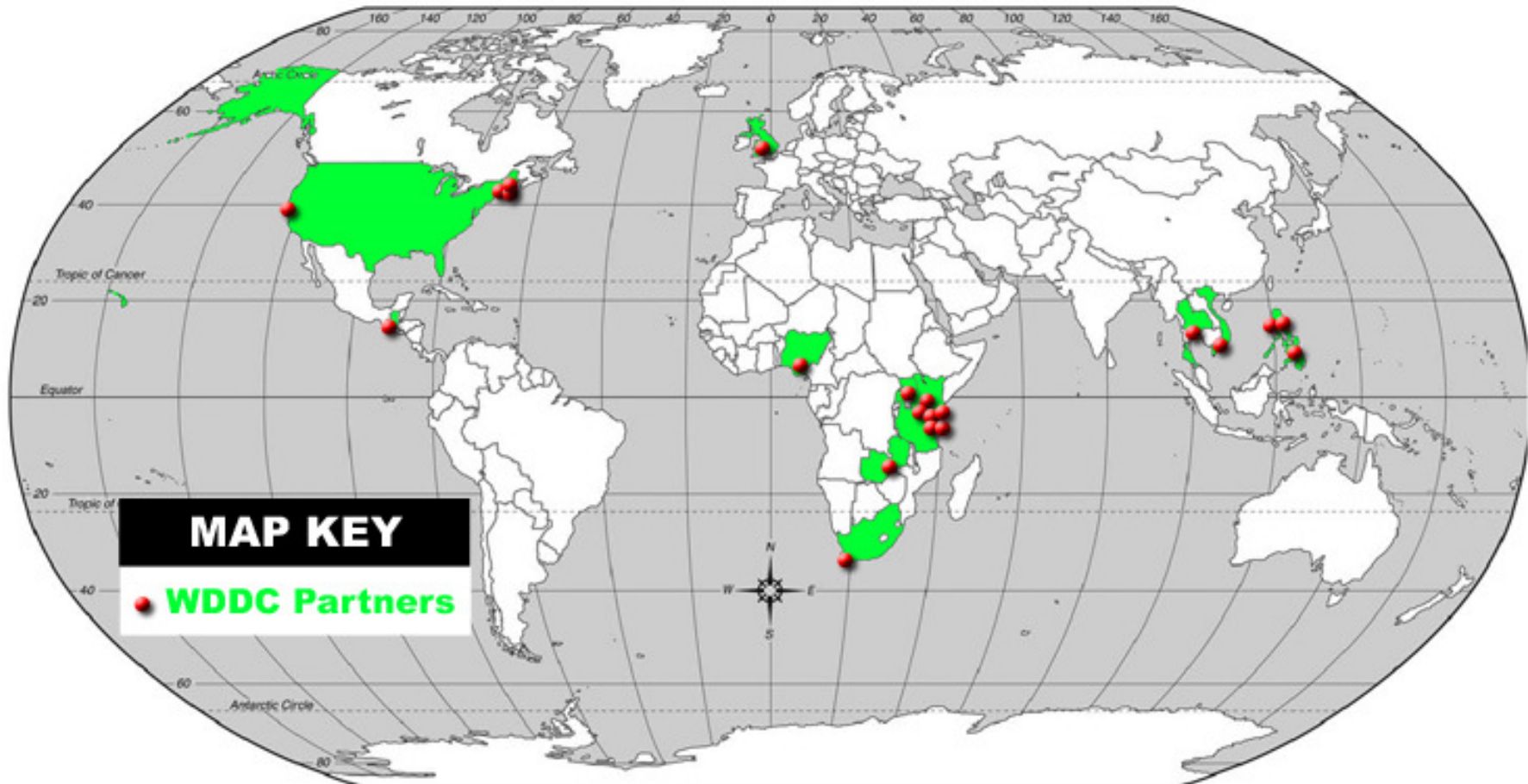


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PARTNER WORKSHOPS

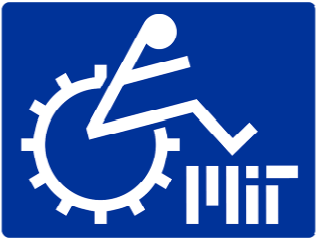
How class projects were defined



10 countries in Africa, Southeast Asia, and Central America

14 partner workshops

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SP.784 WHEELCHAIR DESIGN IN DEVELOPING COUNTRIES

Class project cycle

Disseminate



1. Define projects with workshops
(Aug-Sept)

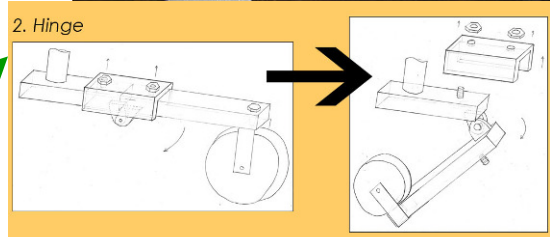
Collaborate



Wheelchair experts



Students
travel to
workshops



2. Develop ideas and prototype
(Feb-May)

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3. Test and implement (June-July)



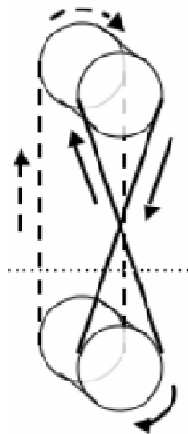
2007 CLASS PROJECTS

2-speed tricycle

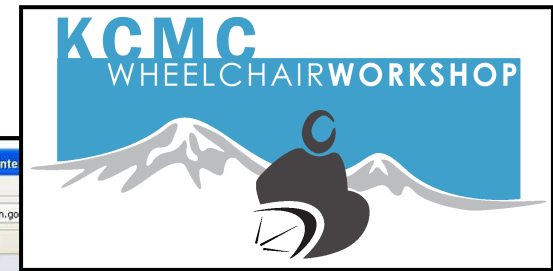


How it works

- Pedal forwards: you drive normally
- Pedal backwards: normal chain ratchets at wheel and figure-8 chain drives forward



Marketing strategies for workshops



How to Make a Web Site at an Internet Cafe!
Learn the basic principles of good Web site design, and get started with making a Web site, with no previous experience required!

Welcome!
Having a Web site can allow you to distribute information across the globe without leaving your seat—giving you the ability to disseminate information from one side of the globe to the other.

Chapters
0. About this Guide
1. Welcome
2. Importance of...

COMMON PROBLEMS FROM IMPROPER WHEELCHAIRS

BACK SUPPORT
It is crucial to get a wheelchair that has been fitted to your size and provide adequate back support. Chairs that do not properly support the back and trunk back pain.

SHOULDER INJURIES
Improper positioning of the wheelchairs wheels to your body and cause inflammation and pain in the muscles and tendons. This will severely damage the shoulder or make it unstable. Again it is important to have a well fit chair that positions the shoulders over the axle.

CONTRACTURES
Keeping limbs immobile can cause a stiffness to develop in the joints and you will be unable to straighten the affected limb. To prevent this, make sure that your wheelchair is and fits your size and has proper support for the legs, trunk and feet.

PRESSURE SORES
Pressure sores are open wounds that develop near bones such as the hip and seat bones. In these areas where there is little mobility, pressure builds up and blood cannot flow. This causes tissue in the area to die. If left untreated this tissue becomes infected and may lead to death.

QUESTIONS TO ASK YOUR WHEELCHAIR MANUFACTURER

- ✓ Will the wheelchair be adjusted to fit my body?
- ✓ Is there a pressure relieving cushion?
- ✓ Can I receive any training to learn how to use the wheelchair?
- ✓ Are spare parts and repairs available and what are their costs?
- ✓ How durable is this chair?
- ✓ How long will it last?
- ✓ How are the models different?
- ✓ Tell the manufacturers what you will be using the chair for and ask them what will be an appropriate purchase for those needs.
- ✓ Don't be afraid to ask questions. The employees are there to serve you.

For more information speak to your doctor, and visit a local wheel chair workshop.

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2008 CLASS PROJECTS

Tricycle Attachment



The Learning Desk



February 3, 2009



2009 PROPOSED PROJECTS

1. World-wide network to connect donors local workshops

Objectives:

- Connect funds from international donors to local workshops
- Compete with large-scale donation organizations

Project details:

- Assess donation capability, user need, and develop business model
- Minimal NGO required – **Maximize fund transfer**
- Inputs/outputs managed by donors and workshops through internet
- Workshops held accountable for confirming delivery of wheelchair

Delivery confirmation to donor



Foreign donor



Log on to network



Example: APDK

Donate to client



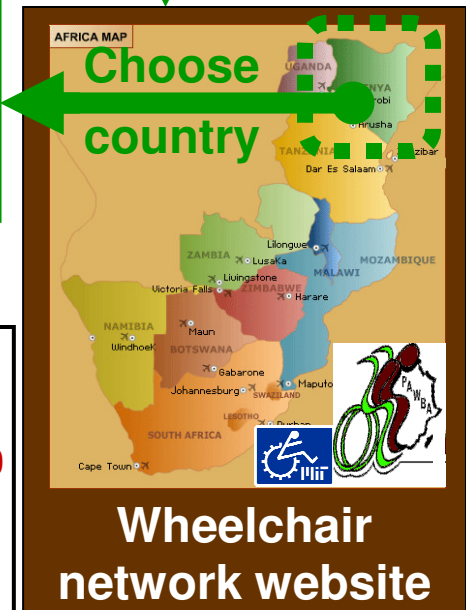
Client

Provided: \$50

Required: \$150

Bio:

David is a polio survivor from Busia, Kenya. He requires a tricycle...



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2009 PROPOSED PROJECTS

2. Low-cost tricycle attachment

Objective: Design a new tricycle attachment that costs ~\$50



Project details

- Low cost (~\$50)
- Stowable on wheelchair
- Optimize usage of bicycle parts
- Connects to both 3 and 4 wheelers made in partner workshops
- Gear ratio appropriate for local conditions (may use 2-speed trike from last year's class)

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2009 PROPOSED PROJECTS

3. Small businesses run from wheelchairs

Objective: Identify ways disabled people can buy their own mobility aid and use it to generate an income.



Ex) Mobility Care mobile phone credit seller chair



Ex) APDK retractable mobile phone tray

Project details

- Identify small business opportunities
- Develop business models for each wheelchair-based business
- Locate resources to allow people to buy own chairs
 - Micro loans
 - Pay-over-time plan from manufacturers
- Optimize usage of available materials and processes
- Work with mechanical engineers to prototype add-ons to wheelchairs to facilitate business

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2009 PROPOSED PROJECTS

4. Power-assisted tricycle

Objective: Design a human-powered/power-assisted tricycle



Project details

- Low cost (~\$300-\$500)
- Human-powered or power-assisted or combo (like a moped)
- Need to control engine and pedals at the same time
- Uses locally-available components and parts
- Can transport the user at ~10mph for 10 miles
- Uses a locally-appropriate fuel

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2008 PROPOSED PROJECTS

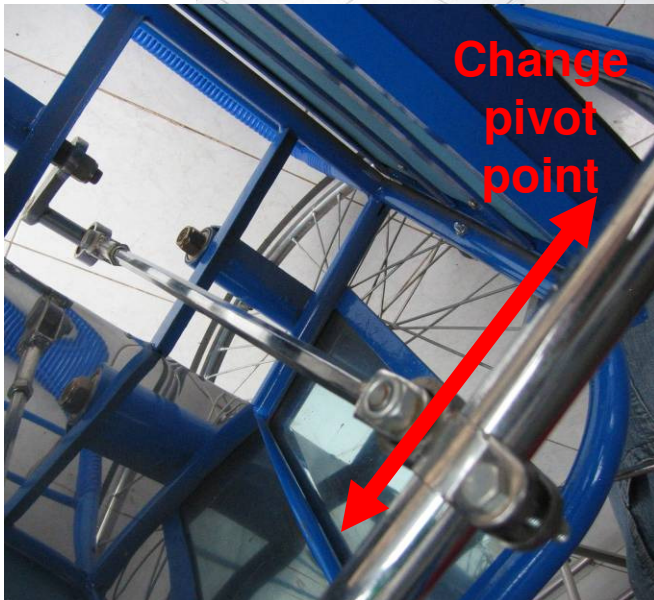
5. Adjustable gear ratio for Kien Tuong tricycles

Objective: Enable the Kien Tuong tricycle to change gear ratios on the fly



Project details

- Current tricycle only has one gear, but great steering/geartrain combo
- Kien Tuong would like a system to shift gears on the fly
- Can change gear ratio by moving pivot position
- Cannot add significant cost
- Made from local components



Cool steering linkage

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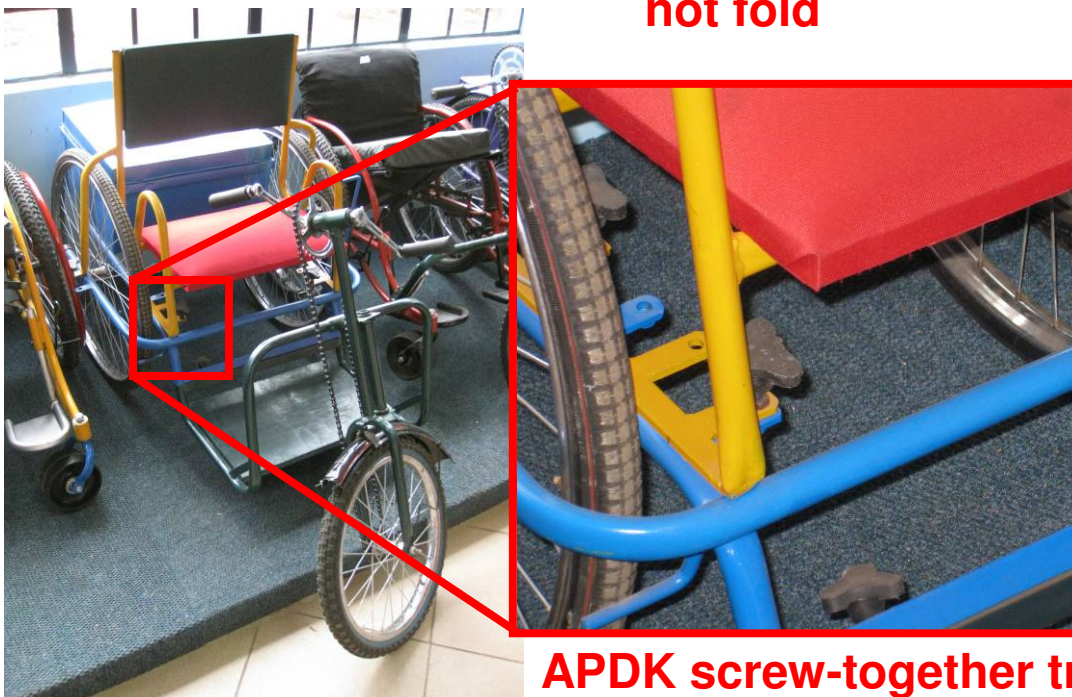
2008 PROPOSED PROJECTS

6. Flat-pack tricycle frame

Objective: Facilitate container shipments of tricycles



**Most trikes do
not fold**

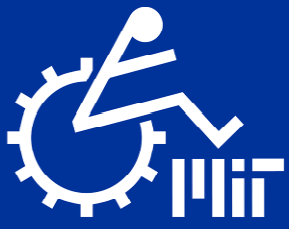


APDK screw-together trike

Project details

- Design a frame that can fold down flat for shipping
- Also make foldable for transport on busses
- Make frame light weight – not more than current trikes
- Optimize material usage for high strength, low weight
- Make adaptable for different trike designs (Kien Tuong, APDK)

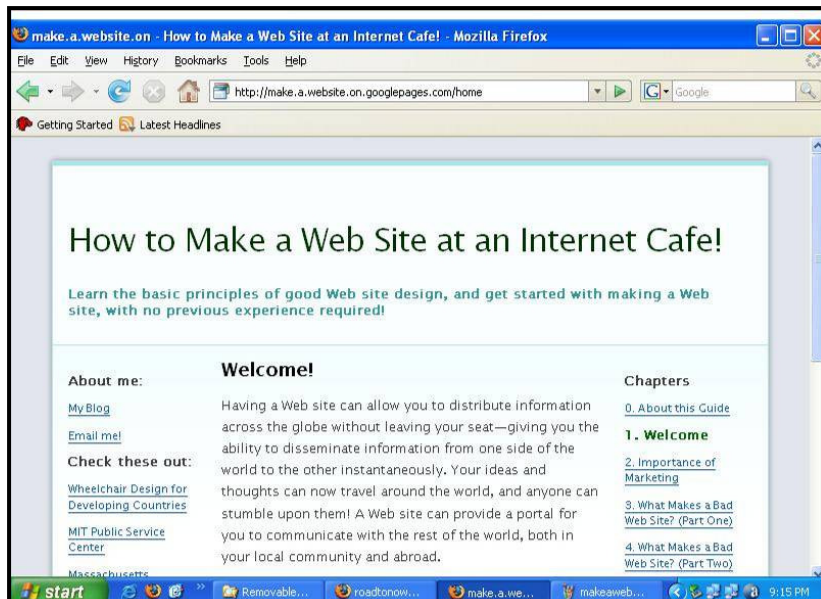
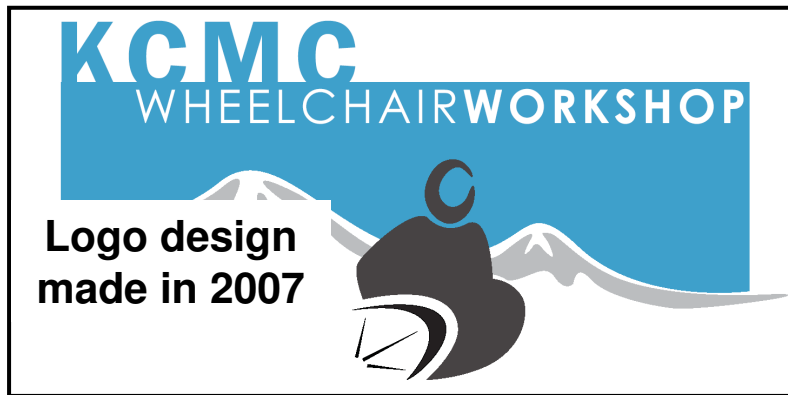
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2009 PROPOSED PROJECTS

7. Marketing and funding guide

Objective: Increase awareness of locally-made mobility aid products and help workshops write grants, gain funding



Project details

- Study other successfully marketed appropriate technology (ex. Treadle pump)
- Identify potential forms of media in Africa vs. USA
- Advertise to foreign donors
- Create materials for brochures, posters, TV, and radio
- Create websites that can be maintained by workshops (consider internet speed)
- Assemble a grant-writing guide to be used by local workshops

<http://make.a.website.on.googlepages.com>

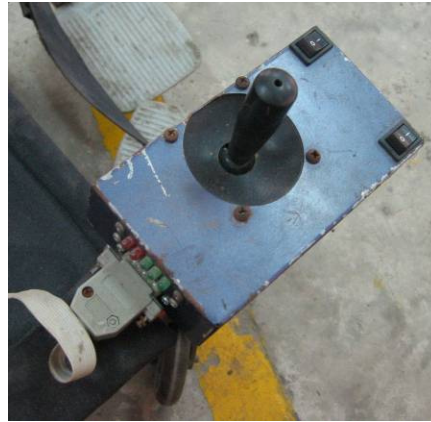
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2009 PROPOSED PROJECTS

8. Electrically powered wheelchair/scooter

Objective: Design an appropriate electric wheelchair/scooter



Wheelchair made
by Thaiwheel

Project details

- Use locally available motors and batteries
- Develop control system and user interface
- Small enough to use indoors, through doorways
- Possibly use solar power
- Low-cost (~\$300-500)



2009 PROPOSED PROJECTS

9. Sports wheelchairs and tricycles

Objective: Design new mobility aids purely for recreation



Freedom
Technology
Racer



Disacare sports
wheelchairs



OneOff Titanium
handcycle

Project details

- Wheelchairs for tennis or basketball
- Wheelchairs should conform to international competition standards
- Tricycles made for sport or commuting or possibly off-road
- All products made low-cost out of local materials
- Ideally produce jigs and production manuals for products



2009 PROPOSED PROJECTS

20. Your idea

Have an Idea?

- Write it down and we will include it when projects are chosen



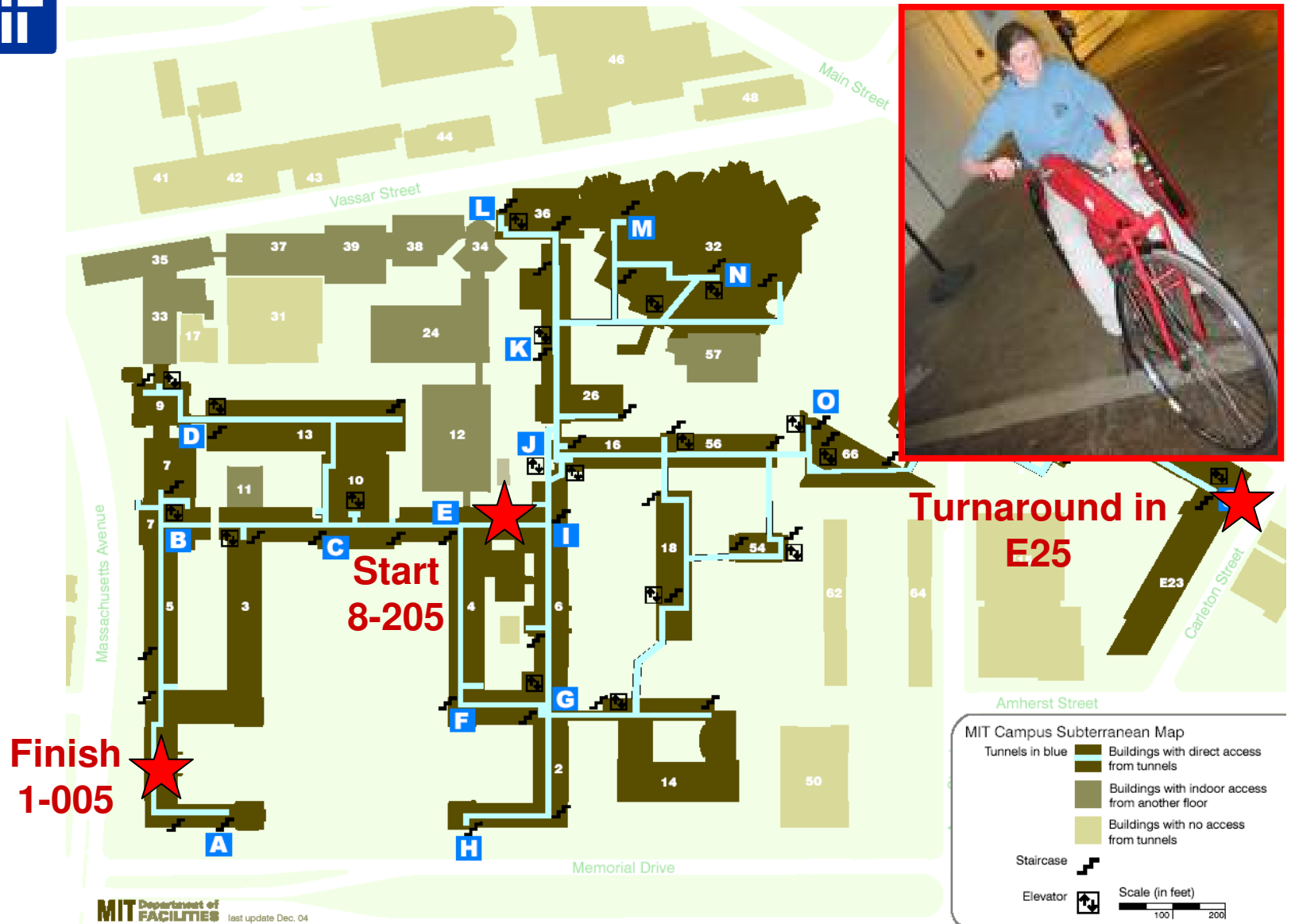
HOMEWORK

Due at beginning of next class

- Pick your top 5 projects
 - Projects will be ranked by popularity
 - Project teams formed next Tuesday 2/9
- Readings (posted on course website)
 - International Society of Prosthetics and Orthotics (ISPO): “Wheelchair” article
 - Whirlwind Wheelchair International: “Proposal to develop standards for wheelchair provision services” article
 - A. Winter: “Assessment of wheelchair technology in Tanzania”



NEXT CLASS Wheelchair relay race



February 3, 2009



PROPOSED CLASS PROJECTS FOR 2009

10. Folding 3-wheeler

Objective: Modify the popular African-made three-wheeler to collapse like a 4-wheeled wheelchair



Project details

- Design a system to fold the rear wheels in closer to the frame
- Utilize bicycle parts and other local materials
- Cannot add significant weight or manufacturing cost to the chair
- Can use in conjunction with front wheel coupling developed in last year's class.
- Has to fit in the trunk of a car or in a bus



2009 PROPOSED PROJECTS

11. Wheelchair modifications for women

Objective: Design wheelchair accessories specifically for women's needs



Project details

- Enable user to easily get down to the floor
- Carry children
- Carry supplies/ groceries/water
- Removable to reduce weight
- Low-cost (~\$20)
- Made from local components

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2009 PROPOSED PROJECTS

12. Small business assessment plan

Objective: Improve practices and efficiency of local workshops and identify supplemental income generating activities



APDK Kenya makes 200 wheelchairs per month, whereas most local shops make 10-20



Wheelchair workshops have the capacity to produce products like pedal-powered grinders and charcoal presses

Project details

- Create a general assessment system to optimize local wheelchair builders for their region
- Investigate the local market – clients, funders, materials, labor skill, etc.
- Determine whether to build wheelchairs locally, import from larger African manufacturers, or import from Asia
- Identify supplemental income sources from related products, such as charcoal compactor or pedal grinders

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2009 PROPOSED PROJECTS

13. Curriculum to teach wheelchair prescription

Objective: Design a short course to train wheelchair prescribers



Project details

- Develop a curriculum to teach people how to prescribe wheelchairs for different disabilities
- Offer different levels of training (similar to PADI)
- Make prescriber also salesman for products
- Train prescribers so they can be posted far away from workshop, as to utilize central manufacturing
- Write for people with english as a second language
- Class to be taught by wheelchair technicians

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2009 PROPOSED PROJECTS

14. Creating testing methods and instruments

Objective: Design protocols and instruments to test the appropriateness of wheelchairs in developing countries



Double drum tester



Imported wheelchair

Project details

- All tests have to low-cost and made from local materials
- Modify double-drum test for rough-road testing
- Test max user weight for chairs
- Use tests to determine appropriateness of donated chairs
- ISO certify locally made chairs
- Test bearings for life under harsh conditions (wet, mud, sand, dust, etc)

February 3, 2009



2009 PROPOSED PROJECTS

15. Organizational and logistical improvements

Objective: Optimize the logistics of workshop production and improve product quality



Stock material at APDK

Project details

- Track manufacturing quality and customer satisfaction by using serial numbers to trace product defects back to the workers
- Implement a computerized stock room and purchasing system
- Purchase in bulk to lower unit cost of components
- Outsource fabrication of some components to specialty shops
- Apply lean manufacturing techniques

DAGE workshop





2009 PROPOSED PROJECTS

16. Optimized tricycle biomechanics

Objective: Improve functionality, comfort, and efficiency of tricycles.



Aligned or opposed hand cranks?



WDDC 2-Speed design

Project details

- Upper body motion with highest sustainable power output
- Gear ratio for different terrains
- Best configuration of hand grips
- Best rake angle for stability vs. comfort
- Appropriate, supportive seating
- Simplified production



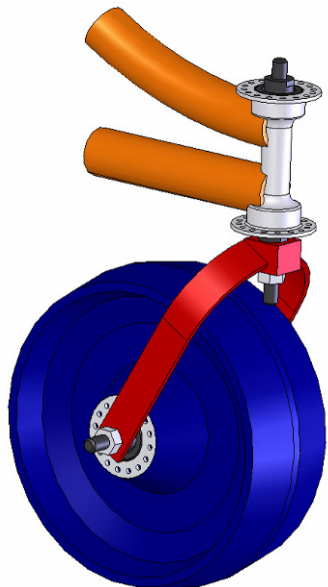
2009 PROPOSED PROJECTS

17. Component and material optimization

Objective: Find best components and materials to reduce weight, improve serviceability, extend life, and lower cost.



Available materials



Castor barrel-bike hub concept

Project details

- How can bicycle components be used more effectively in wheelchairs?
- What components are available
- How could they be used differently
- Life and durability
- Cost savings of replacement



2009 PROPOSED PROJECTS

18. Welding jig and symmetric frame design

Objective: Decrease manufacturing time with better, more repeatable welding jigs and simplified frame designs.



Current Whirlwind jig with separate left and right sides

Project details

- Assess current process time and manufacturing steps
- Identify bottlenecks in production
- Find unnecessary frame complexity
- Tolerance stack-up and mitigation
- Simplified frame prototype
- Jig design prototype
- Process plan for making frames



2009 PROPOSED PROJECTS

19. Tricycle frame jig and production manual

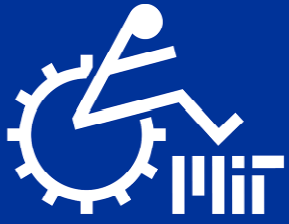
Objective: Design jig to hold tricycle components during welding and make a production manual to teach other workshops to make tricycles.



**Tricycle frame production,
APDK Nairobi**

Project details

- Understand tricycle building process
- Design to avoid tolerance stack-up mitigation
- Accommodate bending errors
- Calculate process complexity and time
- Produce a simplified frame prototype
- Produce a jig design prototype

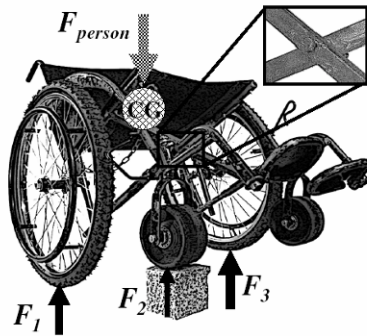


2009 PROPOSED PROJECTS

20. Workshop manual

Objective: Teach safe manufacturing practices

Mechanical Principles of Wheelchair Design



Amos Winter

Graduate Student, Department of Mechanical Engineering
Massachusetts Institute of Technology

Ralf Hotchkiss

Chief Engineer
Whirlwind Wheelchair International

This manual is free to anyone. Please photocopy and distribute.

Example: Manual to teach mechanical engineering principles

Project details

- Consider language, literacy, and cost of printing
- Demonstrate unsafe practices in workshop
- Describe manufacturing processes
- Explain tolerance stack-up mitigation, bending errors
- Introduce lean manufacturing principles

February 3, 2009



2009 PROPOSED PROJECTS

21. Break design

Objective: Improve reliability and safety of breaks



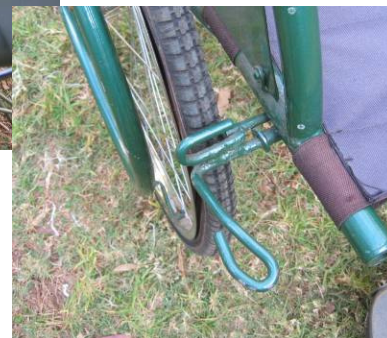
**Reverse
break**



**Break
lever**



**Drum
break**



**Flip
break**

Project details

- Examine existing bike breaking systems
- Calculate stopping requirements
- Understand road surfaces
- Consider manufacturing cost/complexity and tire wear
- Prototype break for both tricycles and wheelchairs