EC.721 Wheelchair Design in Developing Countries
Spring 2009

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WHEELCHAIR DESIGN IN DEVELOPING COUNTRIES

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

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

**Manufacturing:**

**Parts:** African wheelchairs and bicycle components
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

February 3, 2009
<table>
<thead>
<tr>
<th>Week #</th>
<th>Tuesday</th>
<th>Thursday</th>
<th>Assignments</th>
<th>Milestones</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (2/2)</td>
<td>Introduction to wheelchairs in developing countries and review of potential projects</td>
<td>Wheelchair/Trike relay race around campus</td>
<td>Readings about wheelchair usage and distribution, Review projects</td>
<td></td>
</tr>
<tr>
<td>2 (2/9)</td>
<td>2007 summer fellow presentations on last year's projects</td>
<td>Designing wheelchairs for the developing world and deterministic design process</td>
<td>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</td>
<td></td>
</tr>
<tr>
<td>3 (2/16)</td>
<td>Alison Hynd speaking from the PSC about summer fellowships</td>
<td>Choose project teams</td>
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<tr>
<td>4 (2/23)</td>
<td>Monday schedule</td>
<td>Guest Speaker: Joost Bonsen</td>
<td>Reading from HBS case study “Note on Marketing Strategy”</td>
<td></td>
</tr>
<tr>
<td>5 (3/2)</td>
<td>Abdullah and Daniel speaking to class</td>
<td>Abdullah and Daniel speaking to class</td>
<td>Encouraged to visit 2.007 lecture, 3/8 - Encouraged to visit 2.007 lecture</td>
<td>Strategy presentations, time TBD</td>
</tr>
<tr>
<td>6 (3/9)</td>
<td>Material science/ mechanics of materials/welding with Mike Tarkanian</td>
<td>Wheelchair role-play</td>
<td>Encouraged to visit 2.007 lecture</td>
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<tr>
<td>7 (3/16)</td>
<td>Manufacturing processes and strategies</td>
<td>Results from Tanzanian Wheelchair Foundation Study</td>
<td>Reading about different appropriate and inappropriate technologies</td>
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<tr>
<td>8 (3/23)</td>
<td>Spring break</td>
<td>Spring break</td>
<td></td>
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<tr>
<td>9 (3/30)</td>
<td>Material science/ mechanics of materials/welding with Mike Tarkanian</td>
<td>Power output test up ramp in basement</td>
<td>Encouraged to visit 2.007 lecture</td>
<td></td>
</tr>
<tr>
<td>10 (4/6)</td>
<td>Manufacturing processes and strategies</td>
<td>Product design and critique of existing wheelchair designs</td>
<td>Reading from Mastering the Machine</td>
<td>Concept presentations, time TBD</td>
</tr>
<tr>
<td>11 (4/13)</td>
<td>Watch “Murderball” in class</td>
<td>Finish “Murderball” and watch parts of “Emanuel's Gift”</td>
<td>Write short comment on the two movies, discuss portrayal of disability, mobility, public perception</td>
<td></td>
</tr>
<tr>
<td>12 (4/20)</td>
<td>Guest speaker: Ralf Hotchkiss Talking about his career and designing wheelchairs</td>
<td>Guest speaker: Ralf Hotchkiss Talking about his career and designing wheelchairs</td>
<td>Project work</td>
<td>Most critical module (MCM) presentations, time TBD</td>
</tr>
<tr>
<td>13 (4/27)</td>
<td>Guest Speaker: Prof. David Gordon Wilson Human-powered machines</td>
<td>Guest Speaker: Rory McCarthy Handcycle design and racing</td>
<td>Reading on wheelchair user image</td>
<td></td>
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<tr>
<td>14 (5/4)</td>
<td>Project work</td>
<td>Project work</td>
<td>Project work</td>
<td>Poster and presentation for MIT Museum on Sat, 5/9</td>
</tr>
<tr>
<td>15 (5/11)</td>
<td>Project work</td>
<td>Project work</td>
<td>Project work</td>
<td>Final presentation of project with a working prototype, time TBD</td>
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</tbody>
</table>
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)
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 ever year

- Opportunities for cross-cultural, collaborative exchange of ideas

- World-wide recognition of MIT draws attention to wheelchair issues

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

Innovation
- 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

Courtesy of Whirlwind Wheelchair International. Used with permission.

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PERSONAL MOTIVATION TO IMPROVE WC TECHNOLOGY
Summer 2005: Assessment of WC technology in Tanzania

Supervision organizations
• Tanzanian Training Center for Orthopedic Technologists, Moshi, TZ
• Whirlwind Wheelchair International, San Francisco, USA

Interview locations

Map courtesy of CIA.

Parties interviewed

Wheelchair users

Wheelchair workshops

Wheelchair advocacy groups

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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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• 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.
• 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)

TZ WHEELCHAIR ASSESSMENT
Opportunities to better serve user needs

Distance traveled to work/school

<table>
<thead>
<tr>
<th>Distance</th>
<th># of interviewees</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 4km</td>
<td>30</td>
</tr>
<tr>
<td>5 to 9km</td>
<td>10</td>
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<tr>
<td>10 to 14km</td>
<td>5</td>
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<tr>
<td>15 to 19km</td>
<td>2</td>
</tr>
<tr>
<td>≥20km</td>
<td>2</td>
</tr>
<tr>
<td>N/A</td>
<td>1</td>
</tr>
</tbody>
</table>

Tanzanian-made trike

Tanzanian public bus

Photo courtesy of Brother Rewd on Flickr.

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TZ WHEELCHAIR ASSESSMENT
Opportunity to design mobility aids to better serve users

Common mobility aids available in East Africa

USA/Europe designed, African made

Photos removed due to copyright restrictions.
Chair by Free Wheelchair Mission, with plastic lawn chair as seat.

USA designed, foreign made

African designed, African 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

Photos courtesy of MIT M-Lab.

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**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 lectures
- Participate in summer fellowships in developing countries to implement class projects
PARTNER WORKSHOPS
How class projects were defined

10 countries in Africa, Southeast Asia, and Central America
14 partner workshops

Figure by MIT OpenCourseWare.

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Class project cycle

1. Define projects with workshops (Aug-Sept)

2. Develop ideas and prototype (Feb-May)

3. Test and implement (June-July)

Collaborate

Wheelchair experts
Courtesy of Whirlwind Wheelchair International. Used with permission.

Students travel to workshops

Disseminate
2-speed tricycle

How it works

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

 Courtesy of Mario Bollini. Used with permission.

Marketing strategies for workshops

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Courtesy of Shirley Fung. Used with permission.
2008 CLASS PROJECTS

Tricycle Attachment

The Learning Desk

Photos courtesy of MIT M-Lab.

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