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EC.721 Wheelchair Design in Developing Countries  
Spring 2009

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# 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

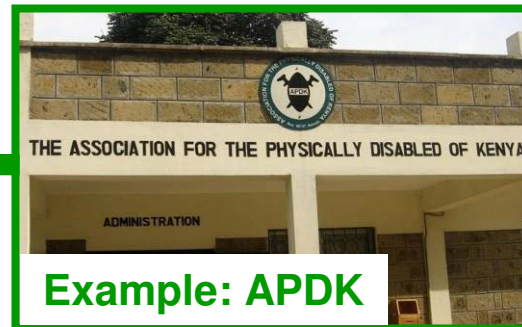


Foreign donor



Figure by MIT OpenCourseWare.

Log on to network



Example: APDK

Donate to client



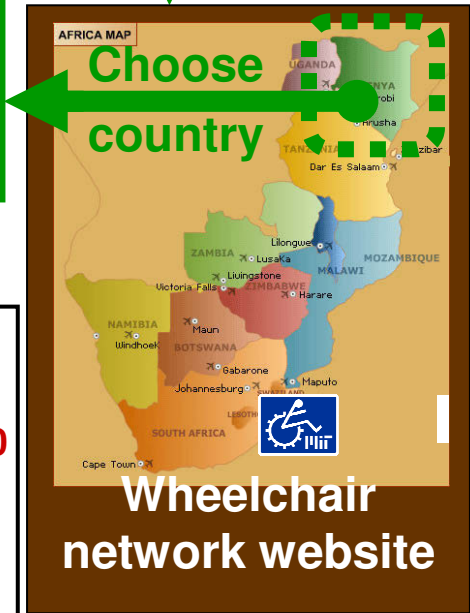
**Client**

**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

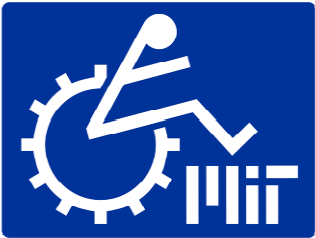


Photos courtesy of MIT M-Lab.

### 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

Photos courtesy of MIT M-Lab.

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## 2008 PROPOSED PROJECTS

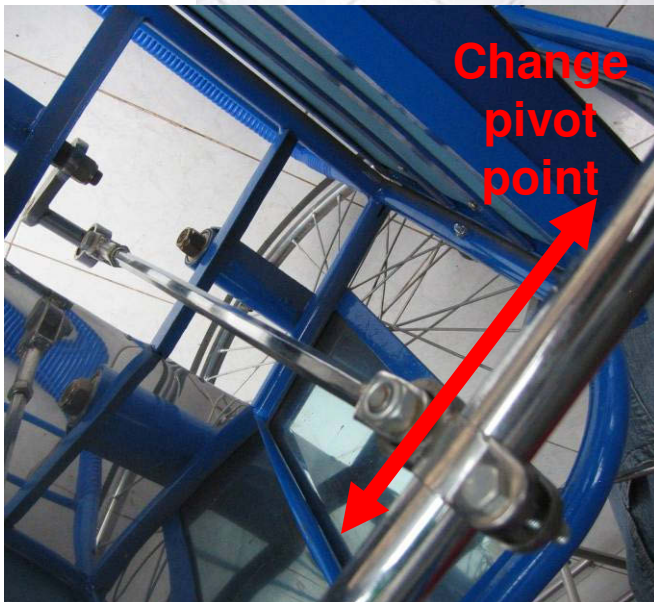
### 5. Adjustable gear ratio for Kien Tuong tricycles

**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

Photos courtesy of MIT M-Lab.

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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)

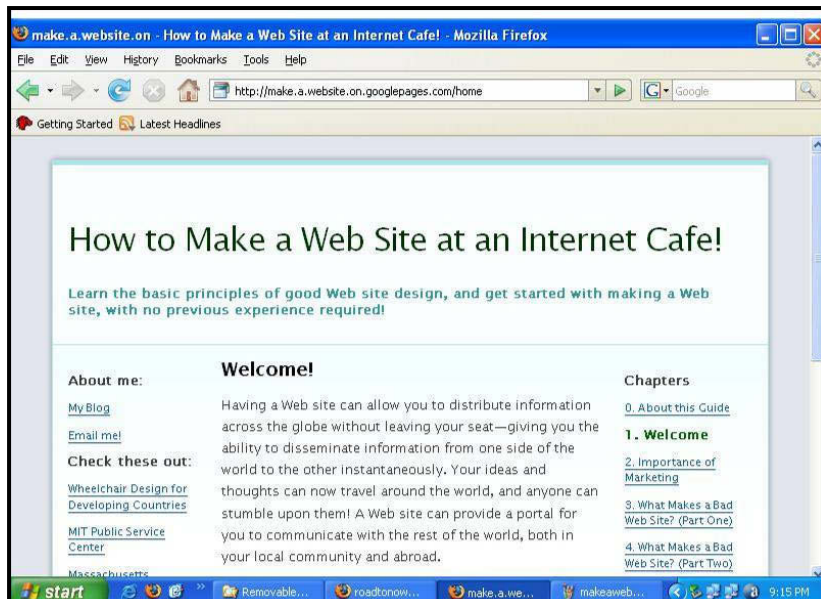
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## 2009 PROPOSED PROJECTS

### 7. Marketing and funding guide

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



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

### 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

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Courtesy of Shirley Fung. Used with permission.





## 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)

Photos courtesy of MIT M-Lab.

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## 2009 PROPOSED PROJECTS

### 9. Sports wheelchairs and tricycles

**Objective:** Design new mobility aids purely for recreation



Disacare sports wheelchairs

Photo removed  
due to copyright restrictions.

Freedom  
Technology  
Racer

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due to copyright restrictions.

See <http://www.oneoffhandcycle.com/images/riders/full/9.jpg>

OneOff Titanium  
handcycle

### Project details

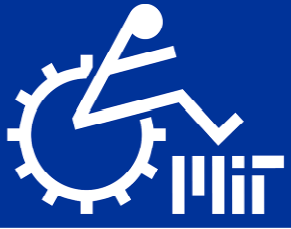
- Wheelchairs for tennis or basketball
- Wheelchairs should conform to international competition standards
- Tricycles made for sport or commuting or possibly off-road
- All products made low-cost out of local materials
- Ideally produce jigs and production manuals for products

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## Have an Idea?

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



## HOMEWORK

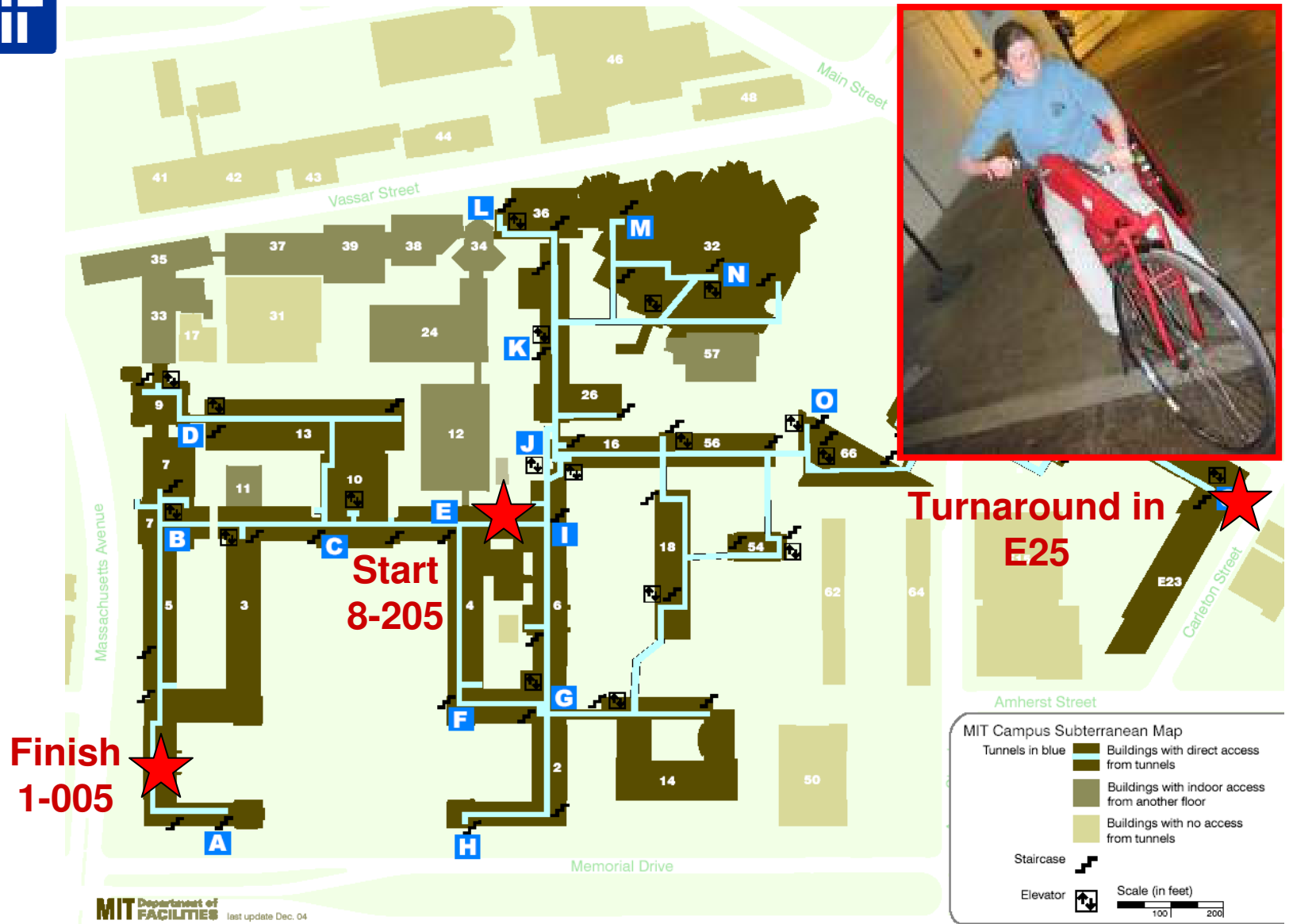
Due at beginning of next class

- 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”

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# NEXT CLASS Wheelchair relay race



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## 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



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## 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

Photos courtesy of MIT M-Lab.

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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**

#### 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

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

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## 2009 PROPOSED PROJECTS

### 13. Curriculum to teach wheelchair prescription

**Objective:** Design a short course to train wheelchair prescribers

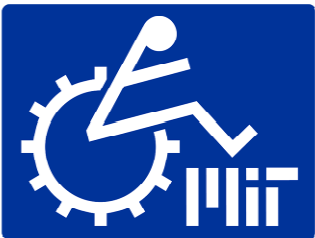


#### Project details

- 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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Photos courtesy of MIT M-Lab.



## 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

Photo removed due to copyright restrictions.

[http://www.ercwm.pitt.edu/RERCWM\\_Res/RERC\\_Res\\_DDT/RERC\\_Res\\_DDT\\_D1/DDT\\_D1.html](http://www.ercwm.pitt.edu/RERCWM_Res/RERC_Res_DDT/RERC_Res_DDT_D1/DDT_D1.html)



Imported wheelchair

Photo courtesy of MIT M-Lab.

#### 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)

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## 2009 PROPOSED PROJECTS

### 15. Organizational and logistical improvements

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



Stock material at APDK

DAGE workshop



Photos courtesy of MIT M-Lab.

### 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

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## 2009 PROPOSED PROJECTS

### 16. Optimized tricycle biomechanics

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



**Aligned or opposed hand cranks?**



**WDDC 2-Speed design**

Photos courtesy of MIT M-Lab.

### 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

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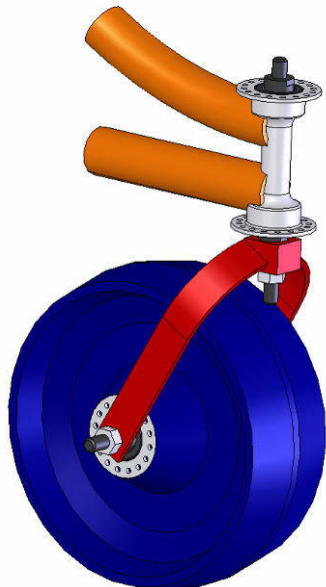
## 2009 PROPOSED PROJECTS

### 17. Component and material optimization

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



Available materials

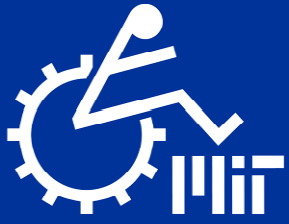


Castor barrel-bike hub concept



## 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**

Photos courtesy of MIT M-Lab.

### 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

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## 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.



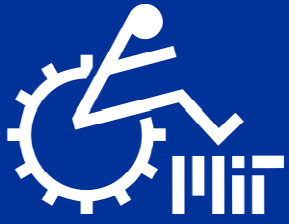
**Tricycle frame production,  
APDK Nairobi**

Photos courtesy of MIT M-Lab.

### 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

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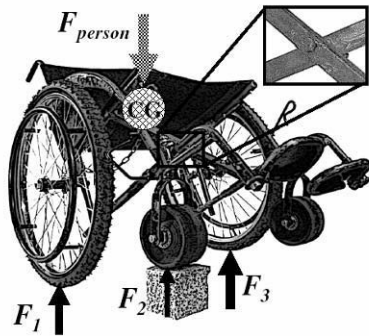


## 2009 PROPOSED PROJECTS

### 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

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## 2009 PROPOSED PROJECTS

### 21. Brake design

**Objective:** Improve reliability and safety of breaks



**Reverse  
brake**



**Brake  
lever**



**Drum  
brake**



**Flip  
brake**

### Project details

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

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