



Queen's University  
Mechanical Engineering

McLaughlin Hall  
Kingston, Ontario, Canada

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## Capstone Design – Experience with Industry Based Projects

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First CDIO Annual Conference  
June 7 to 8, 2005  
Queen's University, Kingston



### Mechanical Engineering at Queen's

- 1<sup>st</sup> year physics, chemistry, math, drafting
  - 2<sup>nd</sup> and 3<sup>rd</sup> year courses in thermodynamics, fluid mechanics, solid mechanics, dynamics
- } *common*

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- 2<sup>nd</sup> year courses in materials and manufacturing which include 12 weeks of machine shop
  - 3<sup>rd</sup> year courses in machine design, electronics, statistics, and automatic controls
  - business, humanities and social science courses
  - 4<sup>th</sup> year tech electives plus **capstone design project**

**First, perspective on where engineering education starts**

**EMC**

**High school engineering outreach courses must be hands-on**

**5 days of lectures, tutorials, labs and working together on mobile robots**



**EMC**

**Hands-on is important, counter the negative view that university is about sitting in a classroom for 4 years**



**Engineering education is about hands-on labs**



**But this only addresses the engineering science component, what about design ?**

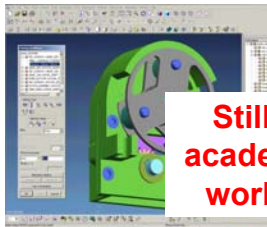
**2<sup>nd</sup> year introduction to manufacturing**



**12 week course in machine shop practice, what are the tools and what can they do ?**

**3<sup>rd</sup> year introduction to design, build, test, admire (CDIO)**

**DBT a pump in 12 weeks (elective)**



**Still viewed (by some) as an academic exercise, when do we work on "real" engineering ?**



**Competition Teams – now this is real**



**But this are student driven (led) and only involve about 20 % of the students ... and very expensive**

The screenshot shows the website for the Faculty of Applied Science, Mechanical and Materials Engineering at Queens University. The page is titled "Team Project - Conceive and Design" and includes an "Overview" section. A large orange banner with the text "real engineering projects for everybody" is prominently displayed. The navigation menu on the left includes links for Mech 460, Homepage, Assessment, Budgets, Companies, Lectures, Posters, Projects, Useful Link, MECH 462, Search, and Back. The main content area describes the course's goal of preparing students for real engineering work through team projects.



## MECH 460 – Conceive and Design (2004)

- required 1 term (12 week) course for 130 students
- 32 projects with 4 students per project
- 28 were industry based (4 were vehicle team based)
- doesn't have the implement component, a paper design only for most projects (with some exceptions)

### Comments

- provides the "senior year team design experience" that is required in CEAB guidelines
- **students are allowed to select their own groups**



## MECH 462 – Implement and Operate (2005)

- continuation of MECH 460
- elective 1 term (12 week) course for 56 students (about 40% of the MECH 460 class)
- 14 projects with 4 students per project
- 10 were industry based (4 vehicle team based)

### Comment

- elective nature provides flexibility, can drop those projects (and students) who don't work out
- means you don't expend resources on students who have no intention of becoming engineers

## MECH 460 Listing of Industrial Projects (2004)

Company	Project
ASK Science	Autonomous Fish
Bosal Canada	Manufacture of Muffler Boxes
Continental Conveyor	Seal Cartridge Assembly
Decoma Autosystems	Xenon Automotive Headlamp
Energy Depot	Integrated Solar Energy
Enerworks	Photovoltaic Powered Pump
Fuel Cell Research Centre	Fuel Cell Powered Golf Cart
Goodyear	Rubber Material Handling
Hydrogenics	Polymer Electrolyte Fuel Cells
Kilmarnock	Machine Noise Suppression
Knorr Brake	MCL Actuator Brake Seals
KTH Shelburne	Inspection of Stamping Operations
MCW Custom Energy	Variable Air Volume Systems
Millennium Biologix	Tube Roller
Muskoka Renewables	Automated Solar Tracker

Size of company varies from 1 employee (consultant) to job shop with 10 employees to manufacturing facility with 1500 employees

- no fee charged, company covers expenses when over
- \$200/project MECH 460
- \$1,000/project MECH 462

Niagara Prosthetics #1	The Niagara Foot
Niagara Prosthetics #2	The Prosthetic Pylon
Northern Cables	Ventilation Assessment
Pennsafe	Safety Snap Hook Design
Procter & Gamble #1	Clay Material Handling
Procter & Gamble #2	Reject Verification Optimization
Pump House Museum	Steam Turbine Demo Unit
Samui Corp	Bicycle Trailer Design
Shorewood Packaging	Auxiliary Driven Oscillator
Superior Wind	Self-Erecting Wind Tower
Transformix Engineering	Underwater Camera
Van Rob Stampings	Wire-feed Speed in Arc Welding
Waterstick Paddles	Performance Canoe Paddles



## MMO Budget Guidelines

Item	Budget
Adjunct faculty for course coordination	\$15,000
Administrative staff	\$5,000
One person project	\$500/project
Two person project	\$1200/project
Three person project	\$3500/project
Average project expense	\$1500/project

- cost is \$50,000 (CAD), MMO grant makes it possible
- Materials and Manufacturing Ontario (MMO), awards grants to underwrite industry project expenses
- valid expenses include travel, supplies, materials and administrative salaries




## Assessment for MECH 460 Design Project

Item	Mark
Letter of Intent	0
Design Notebook	5
Weekly Progress Memo	10
Oral Presentations (two, progress and poster)	10
Design Proposal Report	10
The Poster	10
Final Design Report	50
Industry client assessment	5
Thank you letter to industry client	0


100


- projects posted on website, students submit a letter to identify their 3 top choices and to “sell” their qualifications
- coordinator matches groups to projects
- each project has faculty supervisor and industry advisor




## Project Poster Session at End of Term

- organized like a job fair
- 3x4' poster to summarize project
- posters (and supporting oral presentation) marked by faculty *and* industry





## Pensafe safety hook



- prototyping example
- widget design
- sample GANTT chart

**Prototype on rapid prototyping machine in the ILC**

**MECH 462 PROJECT SCHEDULE** Schedule as of Jan 27, 2005

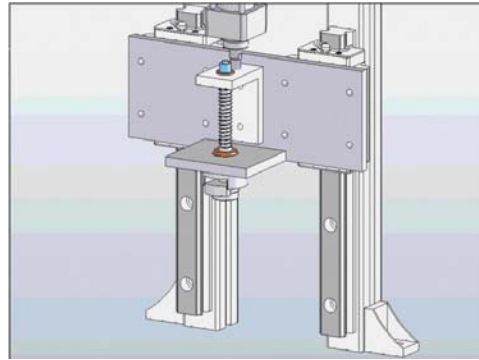
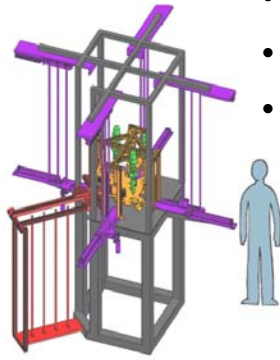
Task	Start	End
Material Requirements	Jan 27	Jan 27
Hook Body Design	Jan 27	Feb 3
Resilience	Jan 27	Feb 3
PEA (SICRWAK, ANSYS)	Jan 27	Feb 3
Keeper, Lever Redesign	Jan 27	Feb 3
Dynamic Load Analysis	Jan 27	Feb 3
Development of Testing	Jan 27	Feb 3
Final Prototyping	Jan 27	Feb 3
Final Progress Report	Jan 27	Feb 3
Written Progress Report	Jan 27	Feb 3
Keeper, Lever Manufacturing	Jan 27	Feb 3
Hook Body Manufacturing w/ ILC (ILC)	Jan 27	Feb 3
Final Prototype Testing	Jan 27	Feb 3
Hook Body Redesign	Jan 27	Feb 3
Hook Body Manufacturing w/ ILC (Final Body)	Jan 27	Feb 3
Final Prototype Testing	Jan 27	Feb 3
Final Oral Presentation	Jan 27	Feb 3





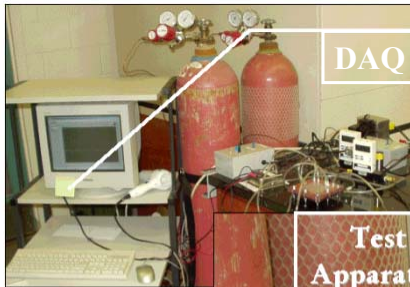
## Continental Conveyor cartridge assembly

- virtual prototyping example
- machine design
- automate a manual process

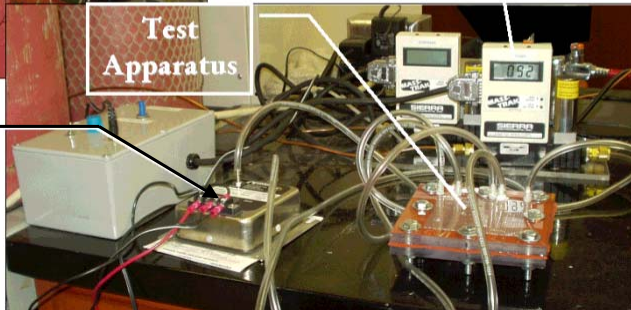


## Hydrogenics fuel cell test apparatus

- research example
- design and commission a test apparatus



Pressure transducer





**At end of term,  
students in MECH 462  
compete with students  
from Electrical and Civil  
for a cash prize from  
Procter and Gamble**

- oral presentation
- industrial application (30%)
- innovation (30%)
- resourcefulness (20%)
- mastery in discipline (20%)
- four judges from P&G



### **Some Problems**

- matching groups to projects
- budget control (student expenses)
- quality control (supervisor commitment)
- finding good projects (scope)

### **What makes a “good” project ?**

- company has no expectations
- challenging to students, but realistic in terms of finishing in 12 weeks



## Some Answers

- post more projects than required
- weekly memos (3<sup>rd</sup> party monitoring)
- **constant communication between faculty, industry and students**
- recycling of good projects
- industry advisor provides a mark
- students fill out same Queen's expense forms as used by the faculty



FACULTY OF APPLIED SCIENCE  
**Mechanical and Materials Engineering**



- Home
- Alumni
- Graduate
- Undergraduate
- Department
- Research
- People

### Team Project - Implement and Operate

**Mech 462**

#### Overview

The elective course MECH 462 enables team projects that started in MECH 460 to continue on to the implement and operate phases of the design cycle. However, new projects can be the subject of MECH 462 as long as they meet the design objectives of the course. Students can also change groups.

An engineering design report is prepared and defended, supported by a working prototype, physical mock-up or virtual model. Testing of a process or system can replace the building of a prototype. A weekly speaker series is planned that will feature topics related to design, project management, product costing, life cycle engineering, design for manufacturability, patents and intellectual property and technical entrepreneurship.



**MECH 462 students win 2005 P&G competition**

## Thanks, more details on the website.

Last updated: April 14, 2005