The purpose of the Engineering Physics Capstone design course is to pull together knowledge students have gained in their physics and engineering classes into one significant design experience.

It should incorporate a variety of issues that engineers typically face:

i. design
ii. prototyping
iii. creativity
iv. working with a customer base
v. documentation
vi. teamwork
vii. economics

NOTE: Revised schedule on course web page - no class meeting next Friday Sep 30th.
Cosmic rays are thought to be created by supernovas, and have energies which range from $10^{12}$ eV all the way up to $10^{21}$ eV and beyond. When these cosmic rays hit the upper atmosphere, they produce showers of particles. A primary constituent of these showers are particles called muons (essentially a heavy copy of the electron), with mean energy of approximately 5 GeV. The muons have a short lifetime of about 2 microseconds. Study of such showers is an active area of research in Particle Astrophysics, and yet simplified versions of such studies are interesting, and provide an excellent tool to introduce the public - particularly middle and high school age children - to the wonder and potential of science.

This project involves the design and construction of a cosmic ray detection system. The system will be comprised of at least two subsystems, each of which can operate independently, as well as have their results correlated. The intent is to design a full cost-effective system that could be installed in a central Ohio high school, and operated by interested teachers and their students.
How does this project address the capstone goals?

i. design: choice of configuration, materials, etc

ii. prototyping: seems feasible given the timescale of 20 weeks

iii. creativity: what sort of experiments might be possible? How complicated of a design would be appropriate for the target audience

iv. working with a customer base: both teachers and students (high school and/or middle school)

v. documentation: both of the design and how to use the end product

vi. teamwork: ME/EE/CSE/Systems/Materials/etc

vii. economics: want the most cost effective solution
Last year the capstone project was predetermined, and the capstone teams were chosen by the instructor. This year we will experiment with a different approach:

i. Provide a list of projects that can be selected from

ii. Allow *some* self-selection of teams

iii. We want the teams to have ~4 students. With 15 (16?) students doing the course capstone this gives use 3-4 teams with 3-5 students per team.

iv. Different teams can do the same project, but we will need to coordinate these efforts in a ways that makes appropriate use of resources.
Portable Cosmic Ray Shower

Design a portable cosmic ray detector which uses some illumination method for visualizing actual detected cosmic rays. The detector would be stationed in the atrium of the PRB. It should be portable such that it is easily moveable to Smith Lab or local area schools for use in demonstrations.
Project #1 Details

A) Available components
   i) Scintillators and PMTs
   ii) DAQ and simple control software
   iii) PC

B) Deliverables
   i) Prototype (if not final system)
   ii) Schematics
   iii) Control software for data collection and display

C) Other
   i) Topics covered: cosmic rays, materials science, detector technology, control software, DAQ
   ii) Skills needed: mechanical, computer, electrical
**Development of a Miniature Water Cerenkov Cosmic Ray Detector**

Cerenkov radiation occurs when a charged particle passes through a medium at a speed greater than that of light in that medium. It can be used to detect cosmic ray particles such as muons and electrons. This project involves the development of a detector to illustrate this effect, as well as measure a variety of properties of the detected particles.


http://hawc.colostate.edu/work/
Project #2 Details

A) Available components
   i) Scintillators and PMTs
   ii) DAQ and simple control software
   iii) PC

B) Deliverables
   i) Prototype (if not final system)
   ii) Schematics
   iii) Control software for data collection and display

C) Other
   i) Topics covered: cosmic rays, materials science, detector technology, control software, DAQ
   ii) Skills needed: mechanical, computer, electrical
Design of a Inverted Pendulum Display

Design and implement an inverted pendulum, and build a display which indicates the relevant physics and control ideas. The basic idea is to design a system in which maintains the unstable equilibrium of an inverted pendulum in the upright position.

See:


2) [http://www.youtube.com/watch?v=Cd96_8iwP6s&NR=1](http://www.youtube.com/watch?v=Cd96_8iwP6s&NR=1)

2) [http://www.youtube.com/watch?v=p5umi2X3F-I](http://www.youtube.com/watch?v=p5umi2X3F-I)

Many possibilities here:
1) Rotary pendulum
2) “segway”-like pendulum
Project #3 Details

A) Available components
   i) Possible controller: Altera DAQ board
   ii) Access to machine shop

B) Deliverables
   i) Prototype (if not final system)
   ii) Schematics
   iii) Control software

C) Other
   i) Topics covered: nonlinear systems, control software, DAQ
   ii) Skills needed: mechanical, computer, electrical
Design simple user interface to freely available data collected by the Fermi Gamma Ray Space Telescope, which can be used in high schools and middle schools in central Ohio. The Fermi Telescope is about a satellite which launched in 2008. It is scheduled to continue taking data for 2 more years with a possible option for an additional 5 years. ALL of the good photon data is available online, but access to the data requires the use of sophisticated software packages. Design an interface to the data which allows visualization of pulsars, Gamma ray bursts, the sun, moon, etc.
Project #4 Details

A) Available components
   i) Fermi data
   ii) Access to experts in data format

B) Deliverables
   i) Prototype (if not final system)
   ii) Control software for data collection and display
   iii) Maps which can be overlaid on the current night sky

C) Other
   i) Topics covered: physics of gamma rays, analysis software
   ii) Skills needed: computer
Project #5

**Football Positioning System**

Design a system which will allow the real-time determination of the speed and position in 3D of a football on a football field (or other properly instrumented environment). The purpose of this system is both practical - did the football actually cross the goal line - as well as educational - how does the trajectory of a thrown (or kicked) football differ from simple projectile motion predictions.

See:


2) [http://www.kokes.net/imufootball/imufootball.htm](http://www.kokes.net/imufootball/imufootball.htm)

3) [http://www.youtube.com/watch?v=TYd3y0A5J7Y](http://www.youtube.com/watch?v=TYd3y0A5J7Y)
Project #5 Details

A) Available component: None, through some free software exists for already existing images (e.g. OpenVC and Kinect)

B) Deliverables
   i) Prototype (if not final system)
   ii) Schematics
   iii) Control software for data collection and display

C) Other
   i) Topics covered: projectile motion, detector technology, control software, DAQ, visualization software
   ii) Skills needed: mechanical, computer, electrical
Next Steps

i. Choose project
   a) Review projects over the weekend. Check out links and do some additional investigation. **Choose a project based on interest.** Don’t worry about whether you have the skills now to do a particular project
   
   b) Email me a ranked list of what project(s) you like - do this by Sunday afternoon.
   
   c) Indicate if you are interested in working with other specific teammates... though this may not work depending on the project

ii. Projects and teams will be set over the weekend.

iii. Discuss project with team on Monday and Wednesday (maybe) of next week (during class and outside of class)
   
   a) Try to divide into manageable sub-projects
   
   b) Think about scheduling and who will do what
   
   c) At some point need to consider costs (assume budget of < $500/team)

iv. Begin to write up a project proposal