3.003
Principles of Engineering Practice

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18 years AT&T Bell Laboratories
1st reliable telecom laser; 1st 1MB DRAM; metrology; semiconductor processing
18 years MIT
silicon microphotonics; solar cells; sensors; semiconductor processing

Educational mission: to create engineering curricula that teach science-to-systems and enable the student to function professionally in vertically integrated teams.
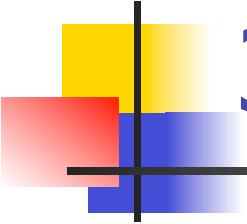
3.003 Purpose

To engage MIT freshmen in the full social, political, economic and technological dimensionality of engineering practice.

For the student to acquire

- Arrogance to encounter the unknown with some confidence of success,
- Humility to understand that success is rarely predetermined and always a collaborative venture,
- Ability to exercise global judgment,
- Ability to realize when a new way of thinking is required.
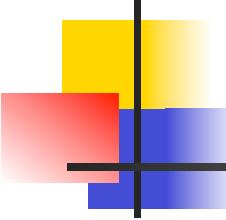
3.003 Vision

- instructors and lecturers are <u>coaches</u>
- students and instructors are one <u>community</u>
  - social gathering after every assignment
  - constant feedback
- all participants are dedicated to <u>continuous improvement</u> of the educational process
- our <u>commitment</u> to this community will be long term
- you will be a <u>success</u> in engineering practice
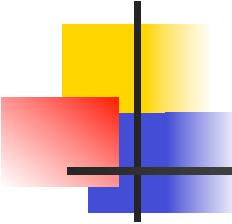
Course Structure

- Diverse and interdisciplinary instructors: <u>MIT Departments</u>: I, III, ESD, XXI (CMS); NYU (Department of Politics); <u>Industry</u>: IBM, New York Stock Exchange; <u>Government</u>: Department of Defense (DARPA), Massachusetts Department of Transportation.

- Instructors teach Principles

- Laboratories provide a constrained environment to practice.

- Projects provide an unconstrained opportunity for creative problem definition and solution.

- Project reviews by outside experts to validate team efforts.

- Writing instructor, Tom Delaney, Program in Writing and Humanistic Studies teaches communication skills and critiqued team submissions and presentations.

- Instructor lectures available on MIT World; a public website displays the best student work.
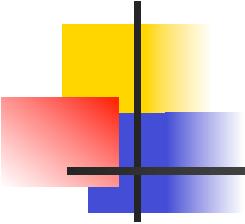
Curriculum by week

- one hour lecture and two hours lab per week
    - one hour lecture introduces reference materials and research methodology
    - laboratory exercises are project-based with a two week minimum duration
- teams of three students each execute a project
    - each project is supported by laboratory exercises and guest experts
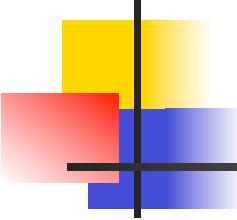
Office Hours

- This class involves 6 hours of homework.
- Each team will have one hour of coaching in communication skills available each week.
- Each team will have one hour of coaching in content (technical, social, economic, political) available each week.
- In addition to designated office hours, coaching sessions may be arranged by email.
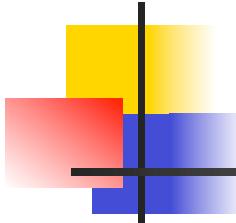
Grades

- *Team and Class Participation 10%*
- *Labs (4) and Lab Notebook 30%*
- *Case Studies (4 of 6) 20%*
- *Final Project 30%*
- *Communication Skills 10%*
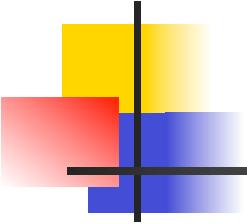
Case Studies 2010

- **The Ethical Engineer**
  - Individual writing sample

- **Big Infrastructure Engineering**
  - Advocacy Document and Presentation

- **Standards: Technology and Social Behavior**
  - The introduction of new technology

- **Solar Electricity Installations**
  - Building integrated systems

- **Energy Efficient Electronics**
  - Semiconductor materials and devices

- **Solar Electricity: Barriers to Adoption**
  - Efficiency, cost, unique attributes
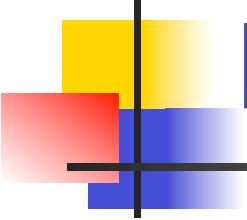
Project Execution

- One Project assignment is given and divided into parts for concurrent engineering by teams.

- One solution will be submitted per team. All members of the team receive the same project grade.

- Teams will complete four project stages during the term.
  - Plan; Initial Findings; Solution Consistency among Teams; Final Presentation to Panel of Experts

- The final deliverables are:
  - 20 minute presentation (5-10 slides), during which all workgroup members must speak.
  - Two days later, edited slides and a final two-page report.
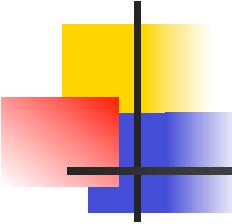
Principles of Engineering

- Understand *ethical practice* in terms of absolutes, context and the possible.
- Be able to *communicate* with a purpose targeted to an audience.
- Be aware of the *constraints* of public, private and academic practice.
- Be able to apply fundamental *science to system* applications.
- Be able to execute at all levels of design: *problem definition, estimation, figure-of-merit, rules-of-thumb and 'sanity checks'.*
- Be able to execute total system *design for sustainability*.
- Be aware of *robust manufacturing* design: performance, constraints, variation, process capability.
- *Practice through team projects: problem definition, information acquisition, data analysis, tradeoff plots, optimization.*
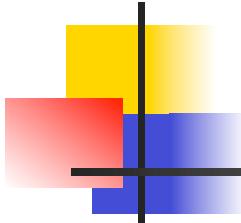
Principles from Communication

Perception is Reality
Communicate understanding, misunderstanding or nothing.

- **Prose**
  - Style: clear, compact
- **Lab Reports**
  - Message: structure, accuracy, content
- **Project Reports**
  - Synthesis and Advocacy: B-I-R-A-C
- **Presentations**
  - Purpose and Audience
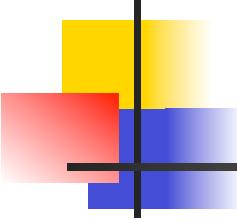
Principles from Speakers

The wise person learns from everyone.

- **Professor Fred Salvucci**
    - Boston Transportation
- **Professor William Uricchio**
    - Communication Media
- **Professor Gene Fitzgerald**
    - Solar Energy Infrastructure
- **Professor Randy Kirchain**
    - Design for Sustainability
- **Professor Christopher Weaver**
    - Big Engineers and Society
- Marshall Carter (NYSE); Alan Benner (IBM)
- DOE, IBM
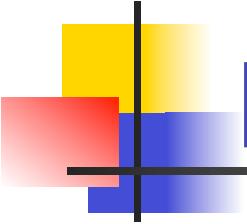
# Principles from Labs

- ## Lab #1 Refractive Index
  - Research is not complexity.

- ## Lab #2 Communications
  - Prose, Lab Report, Presentation
  - Video to Japanese colleagues

- ## Lab #3 Speed of Light
  - Encountering an ultimate parameter.

- ## Lab #4-xx Solar Energy
  - Solar Cell Design and Processing

- ## Field Trip to Solar Module Production Facility
 - Yield, efficiency and cost
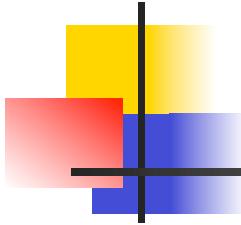
Principles from Projects

- Project #1

  Engineering the Future of Solar Electricity
  - Drivers, Barriers, Solutions
- Project #1A Plan
  - PentaChart
- Project #1B
  - Progress Report
- Project #1C
  - Consistency Check
- Project #1D
  - Final Report to Distinguished Panel
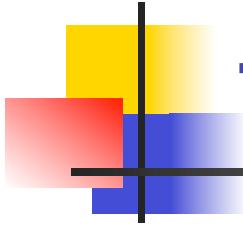
The Ethical Engineer

1. What kind of a person am I?

2. What kind of a situation is this?

3. What does a person like me do in a situation like this?
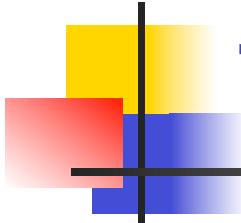
The Solar Cell

1) Principles of operation
2) Relevant performance metrics
3) Design for performance
4) Design for manufacturing
5) Design for application
6) What scale of production is consistent with (6)?

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