

## 500.110 “What is Engineering?” Johns Hopkins University

### Course objectives:

To introduce engineering ideas, thoughts, and problem-solving to potential engineering students. Is engineering for them? If so, what field? Team-time-cost management projects, multi-parameter problems, problems without single correct solutions are emphasized. The course is intended to establish the framework within which engineers typically operate. Although the course is “field independent”, it does introduce students to problems and ideas from specific engineering disciplines.

### How the course is taught

#### What is learning?

Synthesizing theory and knowledge in order to solve problems: Not just theory out of context--the “what”. But also the “why”, “when”, and under what conditions the theory may be invoked to solve a problem. Learning is also discovering what doesn’t work.

“... a failed structure provides a counterexample to a hypothesis and shows us incontrovertibly what cannot be done, while a structure that stands without incident often conceals whatever lessons or caveats it might hold for the next generation of engineers.”  
Henri Petroski, *To Engineer Is Human*

#### What are its teaching strategies?

- 1) Contextual--give reason to understand a theory or calculation
- 2) Problems “out of the chapter”
- 3) Assignments that involve efficiency, cost, functionality, accuracy
- 4) Back-of-the-envelope problems: “Fermi questions”
- 5) Assignments without single, deducible, correct answers
- 6) Taking data and deducing the underlying physical principles
- 7) Hands on--laboratories, virtual laboratories, projects

#### How are students engaged?

–Topics are introduced by posing a problem

- Suppose we need to devise a robot that moves toward light. . .
- Suppose we want to separate fat from gravy for a Thanksgiving dinner. . .
- Suppose we want to bid on a tree as material for a toothpick factory. . .
- Suppose we need a bridge to support the weight of a car. . .
- Suppose we would like to deduce the period of a pendulum. . .

—Asking “Why”

- Why do we want to do this?
- Why do we care?
- Why digital instead of analog?
- Why binary instead of decimal?

–Asking “Why not?”

- Why not use Elmer’s glue (or a glue gun) on spaghetti bridges?
- Why not measure the weight of a single penny on a postal scale?
- Why not use titanium to build bridges?

–Asking “what?”

- What tools/principles can we use on this problem?
  - finding forces in members attached to a pin joint on a stationary structure
  - separating alcohol from water
  - improving the accuracy of a measurement
- What are the conditions under which XXXX will/will not work?
  - Can we have a stone lintel that spans 20 feet?
  - When will a model yield characteristics of its full-scale counterpart?
  - What does it mean if the mass entering a control volume does not equal the mass leaving a control volume?

–Giving examples and counter examples

–Giving reasons for each step in solving a problem (the solution is less important than the strategy for approaching it)

–Posing sub-problems, i.e., “What if. . .?”

–Relating to other fields

- mass conservation vs. Kirchoff’s laws
- heat flow vs. electron flow vs. particle diffusion (gradient transport)

### **What the course avoids**

–Presenting theories/calculations without context

–Using ambiguous or loosely defined terms

–Giving “plug and chug” problems (well, maybe occasionally)

–Presenting topics without placing them within a “bigger picture”

## **“What is Engineering?” In a nutshell**

### **From a fundamentals point of view:**

- 1) Dimensions, units, and their roles
- 2)  $\pi$  vs. 3.1416 and  $dx$  vs.  $\Delta x$
- 3) “Stuff” is conserved
- 4) Zero as a condition, e.g.,  $\sum forces = 0$
- 5) NAND gates rule the digital world

### **From a substantive point of view (lectures and lab for each topic):**

- 1) Strength/behavior of materials
- 2) Statics/structures
- 3) Uncertainty, statistics, measurement
- 4) Robotics
- 5) Digital logic/circuitry
- 6) Separation processes
- 7) Diffusion, heat transfer

### **From a “process” point of view, i.e., what an engineer does**

- 1) Communication
  - a) proposal presentation
  - b) development of assembly/construction plans
  - c) reporting and interpreting of laboratory results
  - d) research synthesis (written)
- 2) Project management
  - a) time/team management
  - b) design
  - c) construction
  - d) testing
- 3) Experimentation
  - a) measurement
  - b) application of principles
  - c) application of data
- 4) Tools
  - a) approximation
  - b) statistics
  - c) computer software
    - i) simulation
    - ii) spreadsheet/presentation
    - iii) graphics/drawing

### **From a project point of view**

- 1) Lectures in properties of materials
- 2) Materials testing lab (spaghetti, aluminum)
- 3) Lectures in statics and the theory of structures:

$$\sum F_x = 0, \quad \sum F_y = 0, \quad \sum F_z = 0, \quad \sum \tau = 0$$

- 4) Design a bridge to specification
- 5) Build it
- 6) Test it (in a public setting)

**Note: More details about “What is Engineering?”-- lectures, projects, labs, assignments--can be found at [www.jhu.edu/virtlab](http://www.jhu.edu/virtlab)**