

Engineering Problem Solving I

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Abstract

This course introduces the student to a multifaceted engineering problem-solving and design paradigm. Lectures provide students with the opportunity to develop and demonstrate specific problem-solving skills; faculty-directed project team sections provide an opportunity for the student to become familiar with open-ended engineering problems/design and their solutions.

Course Format

This 3-credit course consists both of a lecture and a faculty-directed project/activity component each having equal student contact (1.5 hours). The lecture meets twice weekly (Tuesday and Thursdays) with each of the four 100-student sections for 11 weeks (22 meetings). Completing the lecture portion of the course four weeks before the end of the semester allows the students more time to devote to the project section component of this course. Two faculty members are responsible for the lecture component of the course, each teaching two sections of 50 to 100 students. Approximately 6-7 sessions are used for homework collection, handback, and discussion. Five quarter-time graduate teaching assistants support the lecture component.

Twelve project sections each meet over the course of the entire semester. Each of the six faculty members assigned to teach these are assigned two coordinated sections. Scheduling is such that each single 33-student section can meet individually for one hour per week, as well as an additional hour jointly with the other section taught by the same instructor on an "as needed" basis. Rooms are reserved for Mondays, Wednesdays and Fridays, allowing for this flexibility. Two quarter-time graduate teaching assistants support each project instructor.

Course Philosophy and Content

The general philosophy of this course is to use it as a vehicle to introduce the student to a structured engineering design problem-solving paradigm and common elements such as the

one adapted from our text, *Engineering Fundamentals & Problem Solving* (see Figure 1). As such, one objective is to provide students with a "road map" on how engineers typically go about solving problems, an idea of what specific skills may be important and why, and a realization of what typically characterizes and differentiates engineering from other disciplines. Table 1 is a list (by no means comprehensive) of what typically constitutes specific common and generic elements of engineering problem solving. Lecture problems focus on application of skills by individual students as applied to problem "analysis", skills typically incorporated in one or more of the 10 design process steps shown in Figure 1, while the project sections focus more on using common elements in the context of the comprehensive design paradigm.

The lectures are arranged in content "modules". The specific content is selected based upon several criteria, including its "genericness", importance, and instructor needs and preferences. The concept is that one or more modules can be replaced by the responsible instructor(s) teaching the course depending on changing needs. This aspect is designed into the course to foster its sustainability. It addresses the critical need to introduce new skills and ideas

The initial lecture content and schedule is made up of six modules. The primary purpose of the companion project/activity section is to provide the students with opportunities to become familiar with the 10-step structured design process (Figure 1) through practice and application of common elements (Table 1). In the companion project/activity sections, the students work in small groups of 3-5 students depending on individual faculty needs. This component of the course is not designed to be a "lab" for the lecture section, but an independent section having activities that are coordinated around the overall coarse 10 steps shown. Included is a requirement for oral and written reports. Projects and activities are selected by the faculty and, in some cases, by the students themselves in conjunction with faculty input. In all cases, they are appropriate for freshman students of diverse and limited background. They also do not rely on overly specialized skills, but utilize common elements of problem solving. Effective use is made of the students' innate problem-solving skills and "street smarts" in creative problem solving.

Sustainability Issues and Failure Modes

For this course to be successful it must meet several criteria. First, it must be implementable from a logistical standpoint. Large classes are generally not scalable from small ones, in the same way that one cannot simply scale up a breeze to a tornado. Course size related issues

that can drain the faculty interest and energy include trying to identify exam times and locations for such a large number of students, scheduling specialized tutorial sessions outside of regular lecture, and even collecting and dispersing homework. Grading exams may also become problematic if they are to be returned in a timely manner. Experience with large classes shows that they are never simply just "over" when scheduled during the term but may require several late exams, make-up work, and special needs requirements all exacerbated by this large size. Travel to attend a meeting can become especially difficult especially if no other faculty members are prepared to fill in.

Secondly, the course must be perceived by both the students and the faculty as being valuable (and fun) without being overly burdensome. The content must be meaningful and adequate, but not overwhelming. Care was taken to balance the need for meaningful content without overworking either the students or the faculty. Thirdly, the course must be taught by more than a "select" group of faculty each and every year. That is, no College faculty should expect to not teach this course. There are a number of reasons for this. Rotation can minimize burnout. Second, it keeps the faculty aware of the nature of our "raw" material. Thirdly, it is important to have institutional memory, and this memory needs to be distributed as widely as possible. Without common institutional experiences and memory it becomes difficult to continuously change and improve our curriculum. Fourth, the project component has to "feed" on projects requiring a more or less continuous supply of new ideas. Fifth, a cadre of experienced EPSI instructors would allow relatively easy substitution of faculty in case that is required (due to retirement, travel needs, sickness, *etc.*). Sixth, it is fair.

Lastly, a related issue has to do with the overall structure of the course and addresses problems of continuity of content and purpose. The faculty had to arrive at a reasonably similar vision and philosophy about the nature of the course (*i.e.*, they had to buy into it) before any of the details could be worked out. Although the first year required a nine-month planning period when the entire teaching team met weekly, this course was designed to be essentially "self-actuating". That is, the faculty members assigned to teach this course are able to do so with minimal communication and coordination among themselves.

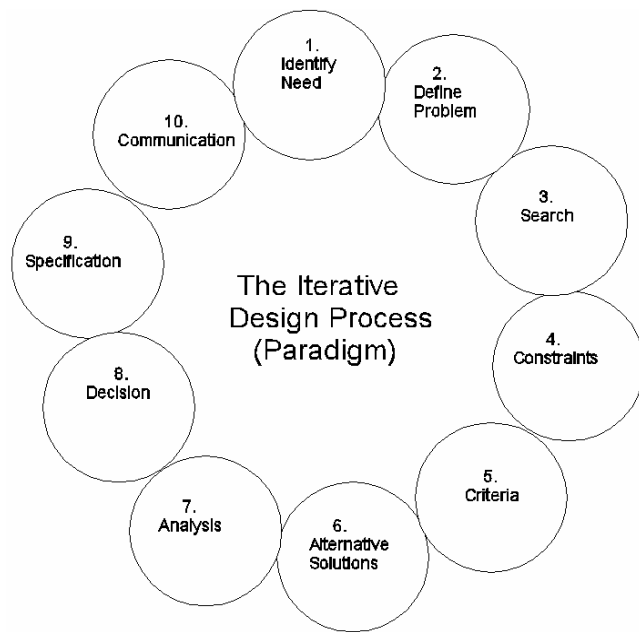


Figure 1. 10-step Engineering Design Process

Table 1. Common Elements of Engineering Problem Solving

1. *Design Paradigm/Creative Problem Solving/Generic Engineering*
2. *Information Gathering/Searching*
 - Experimental
 - Library and human resources
3. *Modeling*
 - Mathematical description
 - Visualization
4. *Problem-solving Tools*
 - Computers
 - Statistics
 - Numerical methods
 - Graphical analysis
5. *Communication*
 - Graphical
 - Oral presentation
 - Written assignment
 - Specialized tools (e.g., PowerPoint)
6. *Societal Interfaces*
 - Scheduling
 - Public interaction
 - Ethics
 - Sustainability
 - Life-cycle assessment
7. *Engineering Economics*
 - Cost comparison
 - Cost/benefit analysis
8. *Teamwork, Leadership*
 - Team building