1. Brief Course Description

The emphasis of this capstone design course is on analysis and design of manufacturing systems, cellular design, flexible manufacturing systems and manufacturing integration. It integrates knowledge gained from all required industrial engineering courses in the form of application to an industry sponsored system design project. The course is intended for students in their final semester of undergraduate studies.

2. Perquisites

INEN 314, INEN 416, and INEN 424.

“1.13 Prerequisites: It is the responsibility of the student to be sure that course prerequisites are met. All prerequisites must be listed in the appropriate catalog or schedule of classes. A student may register for a course for which he or she has not met the prerequisites only with the consent of the head of the department in which the course is offered. Failure to meet course prerequisites could result in a student’s being dropped from the class.”

(Excerpt from Texas A&M University Student Rules).

3. Teaching Team

Instructor
J. Eric Bickel, PhD
Assistant Professor
236B-Zachry Engineering Center
845-4347
ebickel@tamu.edu

Office Hours
Monday from 4-5 PM or by appointment. If you need to talk with me outside of office hours, please send an e-mail stating the specific problem or topic you wish to discuss. Out of respect for my family, please do not call my home. I will check my TAMU email regularly.

Teaching Assistant
Sera Kahruman
302D Zachry
845-4335
sera@tamu.edu

Office Hours
Tuesday - Thursday from 9:30 – 10:30 AM, or by appointment.

4. Educational Objectives

1. Learn to formulate and develop solutions for open-ended, real-life, large-scale problems
2. Learn and appreciate the concept of applying theory to practice
3. Learn, understand and practice professional and ethical responsibility
4. Improve written and verbal presentation & team working skills
5. The senior design experience aims at incorporating engineering standard and realistic constraints for the students while working on an industry sponsored project. Some of the engineering standards include:
   i. Economic analysis pertaining to
      a. design alternatives
      b. modeling and optimization
      c. cost estimation
      d. potential savings
   ii. Environmental analysis in the context of
      a. Impact on site selection for new facility
      b. Recycling and scrap disposal in a manufacturing system
      c. Evaluate alternatives for positive and negative environmental impact
   iii. Sustainability analysis
      a. Ability to sustain the proposed changes
      b. Funding strategies for new solutions
      c. Improving product lifetime and recyclability
   iv. Manufacturability analysis
      a. Evaluate the feasibility of the proposed processes
   v. Ethical issues
      a. Significance of non disclosure agreements
      b. Impact of proposed solutions for different constituencies of the organization – debt holders, stock holders, workers, customers
      c. ADA compliance issues
      d. Information sharing with different constituencies
   vi. Health and Safety analysis
      a. Evaluation of potential hazards
      b. Public safety, fire safety issues
      c. Ergonomic design consideration to minimize worker injuries
   vii. Social Issues
      a. Impact on community of the location of new facility
      b. Impact on worker morale on new management practices
      c. Diversity analysis
      d. Addressing grievance
   viii. Political issues
      a. Tax breaks from community for new facility
      b. Retraining people for new positions from eliminated positions
      c. Easy availability of resources
      d. Potential trade ties with friendly and hostile nations

5. Course Calendar

Lecture: M 8:00 – 8:50 AM (Zachry 340A)
Lab 1: M 9:10 AM – 12:20 PM (Zachry 340A)
Lab 2: M 12:40 PM – 3:50 PM (Zachry 340A)

Note: After the first two weeks, we will not meet during the lecture time, unless otherwise noted.

We will conform to the University Academic Calendar (http://www.tamu.edu/admissions/records/academic_calendar.html). Consideration for University Authorized Absences will be made. Please see http://student-rules.tamu.edu/ for the guidelines.
Out of respect for your professor and fellow students, please give advance notice of any absences if possible.

If a class needs to be canceled for any other reason, you will be notified at least 1 week in advance—if at all possible.

6. **Course Website**

All course material will be posted on the course website. [http://tamcam.tamu.edu/inen459/](http://tamcam.tamu.edu/inen459/)

7. **Handouts**

Handouts will be provided in class to supplement chapter material as needed.

8. **Project Evaluation**

There will not be any homework or exams. Instead you grade will be based on the following:

**Team Based**
- Weekly Assignments/Updates: 10%
- Website: 5%
- Project Proposal: 10%
- Midterm Presentation: 10%
- Final Report: 15%
- Final Presentation: 10%
- Client Feedback: 15%

**Individual**
- Individual Notebook: 10%
- Individual Performance: 15%

You are to form groups of 3-4 students. Groups are not evaluated against one another. Instead, each group is evaluated based on the results of its own project. In most cases we do not have specific things that we look for in specific projects. Instead, we look for sound problem definition and analysis methods and the application of fundamental industrial engineering techniques in the solution of the identified problems.

One aspect of the senior design that students often find puzzling is "whom to please." That is, should groups seek to satisfy the requirements of the course instructors or the industrial clients. The answer is, of course, both. Keep in mind, however, that the expectations of the instructors and the company are often different. The company is generally interested in getting a new perspective on the problems addressed in the projects and identifying potential areas for cost savings. The instructors are interested in the development of a sound project plan and the application of sound industrial engineering techniques in the execution of that plan. Both are interested in complete documentation of the process.

Each member of the team will receive the same base score for all group activities.

At the end of the course, I will ask you to provide feedback on the contributions of each group member and a self-evaluation. In addition, I will ask for client feedback regarding team and individual performance. I will also provide my personal assessment of your individual
contributions. These evaluations will be used to determine your score on the Client Feedback and Individual Performance dimensions.

9. Letter Grades

Total points will map to letter grades according to the following schedule:

- A = 90% or greater
- B = 80% to < 90%
- C = 70% to < 80%
- D = 60% to < 70%
- F = < 60%

The professor reserves the right to adjust final scores by “curving” or some other method. However, these changes will never lower your grade. It is my hope that everyone will earn an A! However, poor performance will result in a poor grade—indeed, independent of your “need” for a particular grade.

10. Attendance

You are expected to attend all lectures and meetings arranged by your team. This includes meetings with Professor Bickel, the TA, and your client.

Failure to attend or tardiness at client meetings is extremely unprofessional and will be accounted for in your final grade.

11. Project Team Member Roles and Responsibilities

Each team will consist of 3-4 members. You may select your team with the following caveats: (1) you need to put together a team with a broad range of skills, this may not result by forming a team of your close friends and (2) Dr. Bickel reserves the right to add or subtract team members as dictated by the total number of students and projects.

Each team member is responsible for writing and delivering presentations and reports, performing all project required tasks, keeping the notebook and website up to date, attending meetings, and generally being an asset to your team.

The project manager is also responsible for:

- Coordinating all written documents/oral presentations, assigning tasks to team members, and being the primary interface with the client in terms or project organization.
- Being the primary point of contact for setting up meetings with the faculty mentor.
- Arranging discussions with Dr. Bickel.

Note: the project manager may delegate this authority to another individual, but is ultimately responsible for these tasks.

Everyone is expected to act professionally at all times. This is especially true when visiting client sites. Your project manager should ask you what dress code is appropriate. Under no circumstances are you to wear shorts, hats, sandals/flip-flops, or inappropriate t-shirts while visiting a client. Your failure to comply with this request will negate your ability to further participate in your project.
When visiting client sites ask them to cover their safety guidelines and fully comply with these. **Violation of client safety procedures will negate your ability to further participate in your project.**

### 12. Important Dates

<table>
<thead>
<tr>
<th>Date</th>
<th>Milestone</th>
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<tbody>
<tr>
<td>28 August 2005</td>
<td>First Day of Class</td>
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<tr>
<td>30 August</td>
<td>Team Selection and Project Preference</td>
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<tr>
<td>31 August (9 AM)</td>
<td>Project Assignment and Weekly Meeting Time Announced (by email)</td>
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<tr>
<td>01 September</td>
<td>Deadline to Contact Client/Faculty Mentor and Arrange First Meetings</td>
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<tr>
<td>05 – 08 September</td>
<td>Kick-Off Meeting with Client</td>
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<tr>
<td>15 September (by 5 PM)</td>
<td>Draft Project Proposal Due</td>
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<tr>
<td>23 September (by 5 PM)</td>
<td>Project Proposal Due</td>
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<tr>
<td>02 October</td>
<td>Project Notebook and Webpage Review</td>
</tr>
<tr>
<td>23 October</td>
<td>Mid-Term Project Presentations</td>
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<td>06 November</td>
<td>Project Notebook and Webpage Review</td>
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<tr>
<td>22 November</td>
<td>Final Reports Due</td>
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<tr>
<td>27 November</td>
<td>Final Presentation Practice</td>
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<tr>
<td>04 December</td>
<td>Project Notebook and Webpage Review</td>
</tr>
<tr>
<td>04 December</td>
<td>Final Presentations</td>
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<tr>
<td>11 December</td>
<td>Corrected/Modified Final Report Due</td>
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### 13. Learning Environment

**Asking Questions**

It is vital that if, during a discussion, there is something you do not understand or the explanation is poor, PLEASE stop me and ask questions.

**Treating Each other with Respect**

In order to develop a safe learning environment, I expect everyone to be treated with respect and dignity. Failure to do so will negate your ability to attend lecture and/or lab.


After you graduate and enter the workforce your boss will expect that you have been educated. In the “real world” there are no make up exams or partial credit. Therefore, cheating will hurt you in the long run. I expect everyone to follow the Aggie Honor Code, which states:

**“An Aggie does not lie, cheat or steal or tolerate those who do.”**

All suspected violations of the Aggie Honor Code will be referred to the Administration for adjudication according to the Honor Council Rules and Procedures ([http://www.tamu.edu/aggiehonor/](http://www.tamu.edu/aggiehonor/)).

### 15. The Z203 and Z304 Facilities

Z203 and Z304 are state of the art classroom and has been designed and constructed in part with student supplied funds. We ask that you treat this facility with great respect and aid in keeping it clean and functioning.
When you leave at the end of class, please make certain to take all personal effects with you. We would ask that you not leave notes, newspapers, etc on the tables or on the floors. Kindly police your work area and dispose of all trash in the waste receptacles that are provided.

16. Americans with Disabilities Act (ADA) Policy Statement

The Americans with Disabilities Act (ADA) is a federal antidiscrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact the Department of Student Life, Services for Students with Disabilities in Room 126 of the Koldus Building, or call 845-1637.

17. About Your Instructor


I have worked at Sandia National Labs in both Albuquerque, New Mexico, and Livermore, California, where I performed research in robotics and combustion. I worked as a decision analyst at Pacific Northwest Laboratories in Richland, Washington, where I analyzed processes to treat nuclear waste.

During graduate school and after, I worked for Strategic Decisions Group (www.sdg.com), where I was a Senior Engagement Manager. At SDG, I applied decision analysis techniques to the most important decisions facing some of the world’s largest corporations. I have worked in North America, South America, Europe and Asia. Industries included metals, building services, biotech, commodity and specialty chemicals, energy trading and marketing, insurance, oil and gas, power generation and transmission, printing and publishing, and packaging. In most cases I worked directly with CEO/CFO/COO, executive vice president, vice president, or business unit head.

My research interests include:
- Efficient modeling of dependence
- Personal and corporate risk preference
- Application of decision analysis to oil and gas drilling decisions
- Modeling hurricane risk and developing optimal evacuation timing for commercial assets
- Combination of expert forecasts
- Building uncertainty into large scale system models
- Applications of maximum entropy
- Auditing and scoring of expert forecasts
- Application of decision analysis to sport; especially baseball
ABET ANALYSIS FOR INEN 459

INEN Student Outcomes
A. An ability to apply knowledge of mathematics, science, and engineering.
B. An ability to design and conduct experiments, as well as to analyze and interpret data.
C. An ability to design a system, component, or process to meet desired needs.
D. An ability to function on multi-disciplinary teams.
E. An ability to identify, formulate, and solve engineering problems.
F. An understanding of professional and ethical responsibility.
G. An ability to communicate effectively.
H. The broad education necessary to understand the impact of engineering solutions in a global and societal context.
I. A recognition of the need for, and an ability to engage in life-long learning.
J. A knowledge of contemporary issues.
K. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.


A. An ability to apply knowledge of mathematics, science, and engineering.

Outcome Definition

Students are able to apply general principles, theories, concepts, and/or formulas from calculus, differential equations, linear algebra, statistics, probability, engineering sciences, and systems engineering to conduct industrial engineering analyses of a diversified range of problems.

Course Experience

Students are required to use a variety of tools and techniques in their projects. The specific skills vary depending on the nature of the project, but they draw on the knowledge gained from previous courses. Some of the topics in which knowledge of mathematics, science and engineering is applied are shown below:

- Engineering economic analysis
- Flow analysis of manufacturing systems
- Manufacturing processes: description, selection, and applications
- Calculation of machine and manpower requirements

Evaluation Method: The students are evaluated on the approach that they take to the problem, their use of proper analysis methodologies, and the overall results that they obtain. The components include project design review, final presentation and report.

B. An ability to design and conduct experiments, as well as to analyze and interpret data.

Outcome Definition
Students are able to conduct a statistical study of a given situation. They should be able to define the problem, determine the constraints, design the experiment, collect data, perform required analysis and interpret the results. They should be able to apply the fundamental principles of experimental design: replication, randomization and local control – each principle playing an important role in the development of a significance test. Students should be able to determine variation caused by random variation and a systemic effect.

Course Experience

The students have to identify the data requirements and methods for data gathering. They have to perform analysis of the measured data for accuracy and relevance, and determine how to use the data and develop strategies while dealing with missing data. Depending on the project requirements, they have to design and conduct experiments and perform sensitivity analysis to test their solutions.

Evaluation Method: design review, final report, presentation.

C. An ability to design a system, component, or process to meet desired needs.

Outcome Definition

Students are able to integrate different types of knowledge and skills to design a system or a process consisting of multiple components working together as a whole. Students have an appreciation for the design process including the blend of analysis and creativity, the requirement for satisfying multiple, perhaps conflicting objectives, the trait of lacking a single correct answer, and the need for an iterative type approach.

Course Experience

The steps of the scientific method can be reformulated as follows when we consider specifically the engineering design process: (1) define the problem; (2) analyze the problem; (3) generate alternative designs; (4) evaluate the alternatives; (5) select the preferred design; and (6) implement the design. The six steps of the engineering design process recast into the following process for conducting the capstone design project:

- Define the objective of the project
- Specify primary and support activities to be performed
- Determine the interaction between activities
- Determine requirements for all activities
- Generate alternative strategies
- Evaluate strategies
- Select a strategy
- Implement the strategy
- Maintain and adapt the strategy
- Redefine the objective. This takes place according to a life cycle consisting of three phases: (1) objectives; (2) plan; (3) implementation.
Evaluation Method: project proposal, design review, notebooks, final report and presentation.

D. An ability to function on multi-disciplinary teams.

Outcome Definition

Students have the understanding and ability to associate together in the development, improvement, or rationalization of work or activity that requires the knowledge of several subject areas or fields of study.

Course Experience

Students are required to work on an industry sponsored project as part of this course. In order to promote the team approach, groups of three to four students are allowed for each project. The students typically organize such that each team member has a different strength (strong communicator, good software skills, detail oriented, etc.). The selection of the project is up to the students, although it requires the approval of the instructor.

Each team is required to attend a 150-minute lab session per week and/or visit the sponsor for project related activities.

Evaluation Method: project and team’s self evaluation.

E. An ability to identify, formulate, and solve engineering problems.

Outcome Definition

Students are able to recognize opportunities for applying industrial engineering tools to improve operational aspects of complex production, distribution, and service systems. They can define and formulate the important elements of an industrial engineering problem in a concrete, quantitative language of engineering and mathematics. Furthermore, students are able to apply engineering, statistical, and mathematical methods to analyze the problem formulations and develop appropriate solutions that improve the operation of the system.

Course Experience

A large component of the design project is understanding the critical issues about the problem, extract the relevant problem, and determining how to setup and solve this problem. Often, the industry contact describes the problem from their own business perspectives and jargons. The group has to identify the underlying problem, formulate the problem, and develop strategies to solve the problem.

Evaluation Method: project proposal, design review, website, final report and presentation.

F. An understanding of professional and ethical responsibility.

Outcome Definition

Students are able to demonstrate that they have an understanding of professional and ethical responsibility. They can make informed ethical choices and possess knowledge of the industrial
engineering professional code of ethics. They can demonstrate ethical and professional behaviors in dealing with peers, faculty and industry sponsors.

Course Experience

The students interact with the sponsors on a regular basis. They are forced to deal with issues including making and keeping appointments, providing regular feedback and progress reports, dealing with individuals at different levels of the organization, signing and abiding by non-disclosure agreements. All of these directly relate to their professional and ethical responsibilities as engineers.

Evaluation Method: final report, feedback from sponsor.

G. An ability to communicate effectively.

Outcome Definition

Students are able to convey knowledge of or information about a particular topic by using language, skills (approach), and verbal or communication channels (media).

Course Experience

This course provides a rich experience for the students to present their projects verbally and in writing. The groups write a project proposal describing the problem and the approach to be taken after consulting with the sponsor, faculty advisor, and discussing with team members. They perform a midterm design review describing the problem and the current project status. They write a final report and give an oral presentation of their findings at the end of the semester. They also develop a project website with all the relevant information, and maintain an individual notebook documenting their participation in the activities.

Evaluation Method: project proposal, design review, final report and presentation, website, notebooks.

H. The broad education necessary to understand the impact of engineering solutions in a global and societal context.

Outcome Definition

Students are able to show that they can interpret the technical solutions in both a societal (more micro context) and global (more macro context).

Course Experience

Depending on the project, the students have to describe the societal and/or global impact of their proposed solution. The idea is to make them think beyond the narrow focus of the problem description and consider possible implications of their approach in the positive and negative contexts. Some of the general impacts that are considered are:

- Reduction of waste
• Increase productivity
• Better workplace environment
• Ergonomic considerations
• Environmental effects

Evaluation Method: final report and presentation.

I. A recognition of the need for, and an ability to engage in life-long learning.

Outcome Definition

Students have the appreciation for life-long learning, as well as the ability to use information-seeking tools to acquire new knowledge that enables industrial engineers to remain competent during their professional lives, in the presence of continuous demands posed by an increasing trend of scientific and technological developments.

Course Experience

In the course the students often encounter areas or topics that they have not been exposed to in their courses. They are required to learn about these areas and research potential solutions. It is rare that they can conduct a project by relying solely on their previous knowledge. So they are forced to learn on their own during the project and recognize that this is an important aspect of their careers.

Evaluation Method: final report.

J. A knowledge of contemporary issues.

Outcome Definition

Students show that they are aware of and respect contemporary issues in industrial engineering and other areas such as humanities and social sciences. They demonstrate the ability to evaluate socio-economic, political and environmental implications of proposed technical solutions.

Course Experience

In the course the students often encounter environmental and governmental restrictions and political issues while working on a sponsored project. Some of these are contemporary issues and students have to read more about the issues and develop solutions keeping these constraints in mind.

Evaluation Method: final report.

K. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Outcome Definition
Students have knowledge of state-of-the-art computerized procedures for decision-making including, but not limited to, simulation, spreadsheet analysis, database management, and general-purpose computer languages. Students also are able to engage in an industry-based or industry-related industrial engineering design experience.

Course Experience

Depending on the project requirements, the students have to use computerized tools for data capture, analysis, problem formulation and solving. They also have to learn to use specific software tools being used by a sponsor.

Evaluation Method: design review, final report and presentation.