BU ENG ME 413 Machine Design

Fall 2010

COURSE INFORMATION SHEET – ALL SECTIONS

(COURSE SYNOPSIS: First part of the Mechanical Engineering capstone design sequence. Static and dynamic failure analysis, including fatigue; load analysis; and factors of safety. Machine elements including fasteners, bearings, and other power transmission elements. Engineering design (product realization) process including customer requirements and problem definition, creativity and conceptual design, feasibility and decision analyses. Cognitive styles and group dynamics. Oral and written communication. Start of capstone design project.)

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Textbooks: Dieter, G.E. and L.C. Schmidt, Engineering Design, 4th ed., McGraw-Hill, 2009.

Juvinall, R.C. and K.M. Marshek, Fundamentals of Machine Component Design, 4th ed., Wiley, 2006.

Computation Notebook RR 77255 (Green cover, quad 5 to 1", UPC: 070972772557)

Lumsdaine, E., M. Lumsdaine, and J.W. Shelnutt, Creative Problems Solving and Engineering Design, McGraw-Hill, 1999. (Recommended)

Recommended shop manual: Machinery's Handbook, 27th ed., Industrial Press, 2004 (Contact Joe Estano for ordering information at a special reduced price.)

(Note: These same textbooks will also be required for ME 414.)

Grading: Guidelines:

Structural Failure Analysis and Machine Elements (35%)	
Homework and pop-quizzes (Individual, collaboration on HW OK **if identified**)	10%
Midterm test (Individual)	10%
Final Exam (Individual)	15%
Capstone Project (46%)	
Review of Previous Capstone Project (Individual)	3%
Design Review Meetings (Individual grading)	3%
Project Proposal – Customer requirements/specifications (Group)	15%
Conceptual Design Progress Report I (Group)	2%
Conceptual Design Progress Report II (Individual)	3%
Preliminary Design Proposal – Concept Eval. & Feas. (Group)	20%
General Professional Development (Individual) (19%)	
Participation, Design Journal, Shop, Professional Society	9%
Oral Presentations	10%

Note on required special evening class for all sections for Midterm Test: On Thursday, October 21, 2010, 8-10 p.m., we will have the Midterm Exam for all sections. Please plan ahead to be available at this time. If you have a scheduled BU activity until 9 p.m., such as band or orchestra, you will be able to take the test 9-11 p.m. You must arrange this ahead of time. A make up exam will be given only for very extenuating circumstances. It must be arranged for before the test date. We will not have class during regular times that Wednesday and Thursday.

Note on engineering ethics and plagiarism: As an engineer, you will be expected by other engineers and the public to conduct your self in all professional undertakings according to the professional ethics of engineering. During the spring semester, engineering ethics will be studied in some depth in ME 414. However, since you will be expected to include the consideration of engineering ethics in your capstone designs, which are started during this semester, a copy of the Code of Ethics of Engineers as was promulgated by the Accreditation Board for Engineering and Technology (ABET) is included in this course information packet.

Plagiarism is a violation of all professional ethics codes as well as your College's Code of Student Conduct. Plagiarism is the undisclosed use of another's work as your own, without or even with that person's permission. If without that person's permission, this is the additional crime of intellectual property theft. Unless explicitly stated otherwise, such as "group" reports or the special note under homework, below, all of the work you submit for this course is expected to be done individually. This explicitly includes, but is not limited to, the midterm test, the final exam, CAD drawings identified by you as only your work (e.g., as "designer" or "drawn by"), and the Progress Report on Capstone Conceptual Design II due on November 15th or 16th involving the generation and evaluation of alternative conceptual designs. Plagiarizers will be prosecuted.

Note on homework: Applying theory to real parts is a different skill from learning the physics behind the theory. and the best way to learn the application is through practice, feedback, and improvement based on this feedback. Homework is a crucial step in the process. Before each class, read the sections in the textbook(s) assigned in the syllabus. Then do the homework when assigned. In your projects, use your knowledge of analysis to verify and optimize your designs.

Although there may be several sources of help, we recommend that you start by trying the homework on your own. The problem with any other approach is that you may not clearly determine what you do and do not understand, and may not learn the material well enough to use it in design, or on a test. If you need help, the course staff is available during office hours. If you use other sources of help, including – but not limited to – fellow students, previous solution sets, or solution manuals in electronic, written or other form, you must state at the beginning of your solution for each homework problem what sources of help you used. If you do this, it will not affect your homework grade, which will be based on the quality of your effort. Receiving help on any homework problem and not acknowledging it, is plagiarism and will subject you to possible action by the College's Student Conduct Committee. Please, do not put yourself at risk for this painful embarrassment.

The machine element homework will be based on Juvinall and Marshek, and should be handed in according to a standard homework format (see below). It will be graded on a 0 – 3 scale, based on the quantity and quality of your effort, and is worth up to 10% of the term grade. It will usually be due one week after assignment. If it is not submitted on time, without an acceptable excuse, you will receive no credit for it. If you will not be in class on the due date, send it in with another student, leave it with the receptionist in the Mech Department Office and ask to have it put in the instructors mail box, FAX it to the Department (617-353-5866) addressed to the instructor, or send by regular mail (postmarked by due date).

Doing the assigned problems is the best way to keep up with the class material.

Note on pop-quizzes: Some very short pop quizzes in class may be used to improve the effectiveness of the lectures. They will count as part of your homework grades.

Note on design journal: The engineering design journal is A PERSONAL LOG/DIARY/JOURNAL of the students HANDWRITTEN CALCULATIONS, DRAWINGS, AND NOTES THAT IS TO BE MAINTAINED THROUGHOUT THE COURSE. You should maintain in the notebook a COMPLETE record of your activities related to your capstone project: notes of project group meeting, notes from research related to projects (e.g., interviews, library or internet work, experimentation and testing), development of your design concepts, and analyses. All analyses related to your project should be referenced in the journal. Hand calculations should be done directly in the journal. Computer analyses should be included as problem statements, explanations, and numerical results, with reference to the full analysis contained in a notebook to be appended to the journal or as an appendix in a formal written report. Although it may sound silly, keep the journal with you at all times to record useful ideas that come when least expected, such as those that crop up and wake you from a sound sleep.

Many good ideas are lost because they were are written down right away. Every page should be numbered, dated and signed. The Journal will be collected periodically through the semester for grading, as well as at the end of the course. (See the attached Check Sheet for Design Journal Use.)

Note on peer evaluations: There will be written peer evaluations at various points during the semester. These confidential evaluations, done by all members of a design team, are a way of providing feedback to both the course instructors and the individual students on how well individuals are functioning as members of teams. These evaluations will affect the "group" portion of your individual course grade.

The capstone projects are too large for one or even two individuals to carry the load. Although teamwork can be difficult at times, it can also be very rewarding. The following is a quote from a recent former student, following graduation. You might note this team almost melted down in the middle of the first semester, but with the course staff's help ended up with an excellent product and experience – and won the best project award that year.

My experience working on my design team for AM413/414 has left me very eager to work in a team-oriented environment. Prior to that experience, I loathed team projects, and I preferred to work by myself without having to constantly explain myself. This was how I felt when the senior design project started, but over the course of the year I learned to appreciate the value of working in a team, and I think I greatly improved my ability to communicate and cooperate with teammates. Also, I felt very comfortable assuming a leadership position on my team and assuming managerial responsibility. I think I did a good job of recognizing and utilizing the strengths of each one of my teammates. I would like to have more opportunities to work in teams, and, hopefully, I will be given the chance to manage some of those teams.

Note on team leaders: Each team must select a different team leader for each major segment of the design project. The name of the team leader for each project segment must appear on the cover page of the written report for that segment.

Note on professional designs and prototypes: The key reason for doing a capstone project is to learn, by practice, what goes into producing a reliable, effective, and economically attractive commercial product. Even if some parts of a project, such as motors, will be purchased off the shelf, you will have to do specialized design of individual parts and integration into an overall system in order to be successful. Please also note that the model or prototype developed for your project is the property of your customer (or the ME Department if you have no identified customer). It is to be left with your customer (or the Department) on completion of the project. By accepting the project proposed by your customer, you enter into an implicit contract to produce the product. The customer will have been waiting all year for your product, and may well have sought it elsewhere if you had not agreed to supply it. So there is a cost to your customer even if he/she has not paid money. In addition to being of use to your customer, prototypes are important to the Department to show to future students as well as to our accreditors and other visitors.

Note on shop practice and manufacturing: Although it is not the goal of this course to turn you into a crackerjack machinist, designs which are hard to

fabricate are expensive, if not useless. Therefore, proper shop practice, and the attention to detail it entails, is an important part of the course. The ME Department's technicians, Joe Estano, David Campbell, and Bob Sjostrom, are excellent machinists and an outstanding resource for the success of your project. Take advantage of their knowledge and experience (preferably well before the last minute!)

Note on ASME International (American Society of Mechanical Engineers): Being an engineer is being part of a profession. One of the advantages and responsibilities of being part of a profession is membership in a professional society. As part of your training as a professional in this course, **you are required to become a member of at least one approved professional society**. As mechanical engineering students, we recommend that you join ASME and, hopefully, participate in the activities of the BU student section. If you want to belong to a professional society other than ASME, please check with your course instructor.

Note on professional registration: Professional registration is required in most application areas where engineers have direct contact with the public and are involved in projects that directly affect public welfare. Registration is a three step process: (1) successfully passing the Fundamentals of Engineering (FE) Exam; (2) working in a responsible engineering position for some length of time (usually on the order of four years); and then (3) successfully passing the Professional Engineering (PE) Exam in your specialty area. Even if you are not planning on becoming a registered professional engineer, passing the FE exam can be the edge you need for getting your first job offer.

The FE exam is a general exam covering all aspect of the generally accepted background for engineering. It is at the B.S. level, and most students, who take it, do so towards the end of their senior year. The Mechanical Engineering Department at Boston University has had a policy of subsidizing one-half of the cost of the exam (total cost around $200) for any department senior who takes the exam and reports his/her grade back to the department. More details about the exam will be made available to you at the start of the spring semester through ME 414 and ASME. However, even in ME 413 sign conventions and other aspects of the solution of structural analysis problems will be consistent with those used on the FE exam.

Make-ups: Make-up tests will be given only under extreme circumstances. They must be arranged for well in advance of the scheduled exam.

Final Exam: There will be a final exam in this course. Its date will be announced as soon as it is available from the University registrar. **Do not make travel plans for a date prior to the end of exam week, until you know the dates of all your final exams, confirmed by your instructors.**

Drop Date: Thursday, October 7, 2010 (no "W" on record).

Withdrawal: Friday, November 5, 2010 (with a "W" on record). **NO WITHDRAWALS WILL BE ALLOWED AFTER NOVEMBER 5TH.**

Incomplete: Incompletes will be permitted only for very extenuating circumstances. They must be arranged for before the end of classes.

Facilities: You will have 24/7 card access to the ME Senior Computational Design Lab (SCUDLab), ENG 114; to the shop project area, ENG B07; and to the Engineering Computation Lab (ECL), EMB 125 – except for times when regularly scheduled classes meet in ECL. If your Tarrier Card does not work in these labs, please see the receptionist in the ME office. Please keep these facilities neat and clean for the benefit and safety of other users and to reduce the chances of attracting small furry creatures. Remember that a cluttered workspace is more likely to be a hazardous workspace. Please note that the facilities are meant only for students in the ME Department and pay attention to security issues. Do not leave the laboratory doors unlocked. The software available in the SCUDLab includes:

- Algor
- Ansys
- Comsol
- Matlab
- MS Office
- MS Project
- Solidworks
- Pro-E Wildfire

INSTRUCTORS' STATEMENT OF COURSE OBJECTIVES:

What is this course all about? What will I learn? How will I use this subject in my future engineering work?

From this course you will learn how to combine 'art' and 'science' in a way that can produce a device that can effectively solve a problem, whether well specified or not.

You will become familiar with methodologies that have been used successfully by your predecessors to develop products, inventions, machines, mechanical systems: i.e. IDEAS THAT MATERIALIZE INTO FORM and ACTUALLY WORK! This course may, for the first time, make you realize that you now have a sufficient arsenal of science principles, theories and laws that needs now only to be combined with the intrinsic talents that you process and/or that need polishing in order for you to gain confidence that you can make a contribution as an engineer to solving humanity's needs and wants.

How does an engineering problem get solved? Is there only one method for conceiving, designing, building, testing, manufacturing and putting into service a 'solution' to a real human-need problem? What are the step(s) in a successful design process? Where does my engineering education enter the process? How do I communicate my solutions to my colleagues as well as the public? What are my responsibilities to the public with regards to safety, cost, environmental impact, and value?

All of these topics will be discussed during this course.

Engineering Science Part of This Course

Please keep in mind that the coverage of strength of materials, failure analysis, and machine elements constitutes about 1/3 of the course and of the grade. Consider it as a way for you to polish these skills. The feedback from former students who have taken the FE exam is that this course is very helpful in preparing them for that exam: "Thanks for encouraging me to take the exam, I'm happy I took it. It has come up in a few of my interviews, so companies are clearly interested in it." Keep up with the reading material and assigned work. Read the assigned material at least twice – once before the class and then again after the class is taught. Do not fall behind with the homework – it is the best way to understand the material taught in class.

Transitional Nature of This Course

Our goal is to help you make the transition from the academic learning environment to the professional working environment. This includes learning a systematic approach to mechanical design. But, to learn techniques you must practice them, first on simpler problems and then on more complex ones. This is why we pace you through the various stages of the design process, rather than letting you build the first idea that occurs to you. Please be patient and bear in mind that, in this way, both your learning of the process and the final product you achieve will be improved.

Documentation and Communication

Another major difference between this course and other courses is the importance attached to documentation and presentation of what you have done. Much of your previous education has

been aimed at your personal learning. An engineer almost never works alone, and clear communication is critical – with customers, supervisors, assistants, and fellow team members. **In this course, as in the working world, you must give as much thought to how you communicate your work as you do on the work, itself. Both format and content matter.**

Questions

We have seldom heard "stupid" questions in a classroom or office. If you have a question, which you cannot answer after a moment's serious reflection, ask it!!! Chances are, you are not the only one with this question. The answer to a single question sometimes provides a key insight and makes all the difference between success and failure..

BU ENG ME 413
Machine Design
Prof. DiBella
Prof. Hauser
Prof. Isaacson

Fall 2010
(All Sections)

COURSE SYLLABUS
(8/9/10)

(NOTE: In Reading: D = Dieter, J = Juvinall, L = Lumsdaine)

September

2/8 Introduction; Review of Info Sheet and Syllabus; Engineering design process ("product realization process"); Nature and scope of capstone project; Request for capstone project ideas.
Assignment of critical review of previous capstone project and report.
Sign up for shop and SCUDLab orientation immediately; some sessions may be today. Sign up sheets are posted outside ENG B07. Orientation sessions will be limited to about 10 students and last one hour. Please note that the class period next Tuesday can be used for this shop meeting, but you should sign up in advance. If you cannot sign up in advance, try to come to one of the shop sessions anyway. Joe may let you in. It always pays to be nice to your support staff. You must come to one of the shop sessions or lose credit.
Program Outcomes Assessment.
(Reading: J: Ch. 1; D: Ch. 1 & Sect. 9.3; L. Ch. 1)

7 Shop meetings

9/13 Shaft assemblies and components; Geometric tolerance and fits; Report format.
(Reading: J: Ch. 17; D: Sect. 8.6; Handout on fits and tolerance on website)

14/15 **Individual written and oral (~3 min.) reports on good and bad aspects of old capstone project and report.**
Bring transparencies explaining your comments.
Candidate capstone project ideas due.

16/20 Safety factors, Modeling loads, and Buckling.
Written report skills: Engineering analyses.
Bring final report from previous year's capstone project to lecture.

(Reading: J: Ch. 2 & Sects. 5.10-5.15 & 6.11-6.12; D: Sects. 10.2 & 14.1, 14.4&14.7; L: pp. 136-143)

21/22 Stress & Strain review.
(Reading: J: Chs. 3 & 4)

23/27 Stress & Strain review + Failure analysis – Static Stress.
Candidate capstone projects list distributed to class through website on 9/27.
(Reading: J: Ch. 6)

28/29 Failure analysis – Impact.
(Reading: J: Ch. 7)

30/4 Failure analysis – Fatigue ("Purely alternating" or "Completely reversed").
(Reading: J: Sects. 8.1-8.8

October

1 **CDO Fall Career Fair at GSU, 11 a.m. – 3 p.m.**

4 **Team project choice prioritized list due by e-mail to Prof. Isaacson**

5/6 Failure analysis – Fatigue (continued).

7/12 Customer requirements, Quality Function Deployment (QFD), House of Quality.
NOTE: Tuesday follows Monday schedule.
(Reading: D: Ch. 3; L: Ch. 7 & App. A)

8 **Finalize capstone projects and teams (through website)**.

13/14 Written and Oral Report Skills.
Cognitive styles and Team dynamics
(D: Ch. 4 & Sect. 9.3; L: Ch. 4 & pp. 121-135, 144-147)

18/19 **Capstone project team meetings on customer requirements.**

***21 Midterm test (Individual – Loading, stress, strain, impact, fatigue).**
NOTE: ALL SECTIONS ON THURSDAY, 10/21, 8-10 P.M. – If you have a BU conflict until 9 p.m., you may take the test 9-11 p.m., but you must contact Prof. Isaacson at least 2 weeks prior to the test.
No regular lectures on 10/20 & 21.

25/26 Generation of design concepts; Functional decomposition; Morphological charts
(Reading: D: Chs. 5 & Sects. 6.1-6.6; L: Ch. 6 & 8)

27/28 Evaluation of design concepts – feasibility analysis.
(Reading: D: Sects. 7.3-7.3.1; L: Ch. 9&10)

November

1/2 **Capstone Project Proposals due (Team oral and written reports – Problem definition, customer requirements, house of quality, reasons for weights in QFD, design objectives, engineering specifications, Gantt chart).**
Design journal grading.

Peer evaluations.
(Choose new team leaders)

3/4 Evaluation of design concepts – matrix methods for weighing alternatives (Pugh);
Failure analysis – Fatigue ("Fluctuating").
(Reading: J: 8.9-8.17; D: 7.3.2; L: Ch. 11)

8/9 **Progress Report on Capstone Conceptual Designs I (Team written report on functional decomposition)**
Capstone project team meetings for feedback on project proposal reports.

10/11 Failure analysis – Fatigue ("Fluctuating", continued).

15/16 Failure analysis – Fatigue ("Fluctuating", end)
Machine elements – Screws & Fasteners (start).
Progress Report on Capstone Conceptual Design II (Individual written reports – morphological chart, and one candidate concept with pros and cons).
(Reading: J: Ch. 10)

17/18 Machine elements – Screws & Fasteners (continued).

22/23 Machine elements – Screws & Fasteners (end); Bearings (start).
Capstone project team meetings – updates on conceptual designs.
(Reading: J: Sects. 13.1-13.2, Ch. 14)

29/30 Machine elements – Journal bearings and Rolling element bearings
(Reading: J: Ch. 14)

December

1/2 Machine elements – Rolling element bearings.
Program assessments.
Peer evaluations.

6/7 **Capstone Project Preliminary Design Proposals due (team oral and written reports – Team functional decomposition, morphological chart, three best candidate concepts, feasibility analysis for each, Pugh matrix weighing of alternatives, and choice of best candidate preliminary design**).
Design journal grading.

8/9 **Capstone project team meetings – Feedback on presentations and proposed preliminary designs.**
10 F**inal homework due for all sections on 10th at noon in ME office**

FINAL EXAM DURING EXAM WEEK