The University of British Columbia
MECHANICAL ENGINEERING 457 & 459

CAPSTONE DESIGN PROGRAM

STUDENT INSTRUCTIONS

2009-2010

Course Coordinator: **Mike Van der Loos, PhD**
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Course Website: http://www.vista.ubc.ca

Introduction

MECH 45X is the capstone design project course for UBC Mechanical Engineering. The course is designed to allow you to showcase the skills and abilities you have developed in your studies here and to give you an extensive supervised experience of designing a mechanical device to fill a real need. Our hope and expectation is that this experience will prepare you well to take on professional responsibilities once you graduate.

Our expectations for you in this course are high. Each project will be a full-fledged design project that you will do for a real client with real needs, and we expect you to deliver a working prototype by the end of the course. You will work toward this goal in teams of roughly four people and will exhibit a professional level of commitment. Along the way, you will follow a typical engineering design process. Although the scope of each project will vary, the overall expectation for you is that by the end of the course you will have gained experience in the following areas:

- Proper assessment of your client's needs,
- Developing the necessary project requirements and evaluation criteria,
- Proposing conceptual solutions,
- Proper analysis of your options and the selection of the most promising solution,
- Development of a detailed design including the necessary engineering analyses,
- Development of detailed engineering drawings of components that you will build,
- Selection of suitable manufacturing methods,
- Component and/or material procurement,
- Prototype construction,
- Prototype evaluation, and
- Technical communication of results (verbal and written).

Course Organization

Overall Organization

To help you reach your goals, we will place you in design teams within a larger organizational structure. In effect, you will be a member of a project team within a "company" that specializes in related projects. Each company will be headed by a faculty member who will serve as your supervisor (i.e., boss). You will choose or be assigned a client in the first days of the course. Your team will have access to an engineering consultant/mentor who will provide expertise in areas relevant to your particular project and be able to provide an industrial relevance and outside perspective on your project and on your work. As external resources to the teams, they are not supervisors. You will meet the industrial mentors several weeks into the course.

The faculty supervisors are:

Dr. Antony Hodgson
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Dr. Mike Van der Loos
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Dr. Nima Atabaki
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Dr. Elizabeth Croft
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Markus Fengler, P.Eng.
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Project Team Meetings

You will be expected to have regular meetings with your supervisor. These meetings are scheduled during the MECH 457 tutorial times. At these meetings, you will control the agenda – your job is to report on your progress, identify any problems or issues that you wish to discuss, assess your overall progress against your master plan, and propose activities for the coming week (subject to revision in the meeting). Prior to each meeting, you will prepare a brief memo covering the above items (use the MECH 328 agenda as a template; bullet point form is fine), along with an accounting for the hours each of the members of your team have worked that week. You will also bring your logbooks in for signing on a regular basis. Meetings will include partner project teams, if applicable, and the faculty supervisor. On occasion, the industry mentor may attend, but mentor meetings are generally to be held separately. It is imperative that students prepare for the meetings in a professional manner. Project teams will be assigned a particular room location for meetings, or may elect to meet elsewhere by prior arrangement.

Project Team Meetings: Tuesdays and Thursdays 2 - 4 PM (Terms 1 and 2)

During September, the following meeting rooms are allocated to the course:

09/15/2009	02:00 PM	04:00 PM	WOOD	B75
09/15/2009	02:00 PM	04:00 PM	WOOD	G53
09/15/2009	02:00 PM	04:00 PM	WOOD	G44

09/15/2009	02:00 PM	04:00 PM	WOOD	G65
09/17/2009	02:00 PM	04:00 PM	WOOD	B79
09/17/2009	02:00 PM	04:00 PM	FNH	20
09/17/2009	02:00 PM	04:00 PM	CEME	1206
09/17/2009	02:00 PM	04:00 PM	WOOD	B75
09/22/2009	02:00 PM	04:00 PM	WOOD	G44
09/22/2009	02:00 PM	04:00 PM	WOOD	G53
09/22/2009	02:00 PM	04:00 PM	WOOD	B75
09/22/2009	02:00 PM	04:00 PM	WOOD	G65
09/24/2009	02:00 PM	04:00 PM	SCRF	1024
09/24/2009	02:00 PM	04:00 PM	WOOD	B76
09/24/2009	02:00 PM	04:00 PM	WOOD	B79
09/24/2009	02:00 PM	04:00 PM	WOOD	G55

After this time, the room dedicated to MECH 457/9 for meetings and prototyping will be available full-time: RH 118. Room RH 102 is also available for the entire two terms from 2-4PM for this course.

Company Activities

Each project-sponsoring company is expecting to meet with the student project teams on a regular basis. It is suggested that a formal meeting be held in the second week of the course, at the Design Reviews mid-term, and once at the end of each term. These meetings will be scheduled by the student teams. In addition, the company liaisons understand that student teams may contact them as needed via phone or email in between formal meetings.

Class Activities (Thursdays, 4:00-5:00 PM, DEMP 310)

The capstone design program is an opportunity to further explore the design process that you were formally taught in your second and third year design courses (MECH 2 and MECH 328). Formal instruction on the design process will therefore not be given to the class during the lecture portion of MECH 45X. Instead, the weekly lectures will feature the following (see VISTA calendar):

- **Case studies** by industry-based engineers on how the design process works in a company, usually focusing on a specific project. These lectures will provide you with a better understanding what your professional expectations should be for the coming years.
- **In-class review (ICR)** by teams, supported, if desired, by a PPT slide or two. Each team will have 2-5 minutes to tell about the most significant event of the week, or challenge faced. How was the knee replacement operation you witnessed at VGH? Did your prototype survive the drop-test? How did the field trip to the islands turn out? You get the idea. The goal of this session is to have a reality check on where each team is in the process. Half of the teams will present on consecutive Thursdays: ICPR-1 and ICPR-2. There will be 2-3 sessions per term.
- **Team-sharing presentations.** Each team will present one thing they learned during the past month that is of possible use to the whole class. This can be a new program to generate GANTT charts, the best place to buy fasteners in Vancouver, the best source of apps for the Arduino PIC, the best brown-rice sushi restaurant within 2 km of campus, etc. Each team must post the item on the VISTA discussion board.
- One lecture slot per month is currently not scheduled.

IMPORTANT: The in-class peer reviews and the team-sharing presentations will count as part of the presentation portion of the team mark.

Communication

General:

Communication between project teams, supervisors, clients, and engineering mentors will be done primarily through phone, email and VISTA. The VISTA site for MECH 457 will contain secure folders for each project group to store various files and allow for online review and discussion. The folders will only be available to the project team and supervisors. As you explore the website, you will see a calendar highlighting key milestones in the course, an on-line technical communication resource, procedures for ordering materials and using the machine shop, design tips with links to on-line catalogues and standards associations, and a link to the Canadian Engineering Design Network (CDEN). The CDEN network is a means to assist all Canadian engineering schools with resources in area of engineering design. Look through the site and visit often as more universities (including UBC) become active in the network.

Term-1 start-up and project selection:

The website contains a list of all the proposed projects submitted by various clients. BEFORE the Thursday, Sept. 10 Team-meeting time (2PM), review the projects and discuss them with instructors and classmates, with the goal of using the Thursday meeting time to ask informed questions to aid in project selection. Fill in the "Team Selection Quiz" on VISTA and select your top four choices from 1 (highest) to 4, before Sunday, Sept. 13 at midnight. The quiz will automatically be closed at that time. If you have any special requests relating to team formation or project choice, please email the course coordinator, Mike Van der Loos, by the same time. Emails received after the deadline will not be considered. On Monday, Sept. 14, the instructors will match students up with as close to their top project choices as possible. By noon on Tuesday, Sept. 15, the team formation and project selection will be finalized and posted on VISTA. Note that we will strive to be as egalitarian as possible and give each student a project ranked highly. When you select your top 4 projects, you should be able to eagerly embrace working on any of them for the remainder of the year.

Students who do not submit their projects by the deadline will be placed on a project of the instructors' choice.

In forming teams, we will strive to maximize team diversity to the extent that we can, given project rankings, to increase the opportunity for divergent thinking styles on each team to lead to highly creative designs. We will not fulfill special requests to be teamed up with a particular other student because you happen to be friends. We will gladly accept special requests on the basis of demonstrable diversity (e.g., Myers-Briggs assessments).

Project Selection Deadline: Before midnight, Sunday, September 13, 2009

The first team meeting with the faculty supervisor will be held on Tuesday, Sept. 15, in one of the meeting rooms reserved for the course.

Deliverables and Evaluation

You will be evaluated in multiple ways in four main categories (the 4 Ps): Proposal, Process, Product and Presentation.

Proposal: You must produce a proposal that is acceptable to yourselves, to your client, and to your supervisor, all of whom must sign off on it before you may proceed. You should involve your mentor in this phase as well.

Process: To do well in this course, you must be determined to work steadily. This is necessary not only because you have regular progress review meetings nor because there are numerous milestones to meet and items to submit for evaluation, but because physical resources such as technician and shop time are limited. Therefore, to explicitly encourage steady, focused work, part of your mark will be based on your cumulative progress. You are expected to put in 100 hr per term per team member, which implies that you need to be working on the project for roughly 8 hr per week.

Product: You will be judged not only on the prototype itself, but also on the drawings and models that you make of it. We will solicit feedback from your client, which will be included in the overall evaluation.

Presentation: You will present not only your final design, but numerous short reports along the way, for example, a discussion of the state of the art, a technical issue summary (from reference materials), a technical analysis, a discussion of manufacturing options, a presentation of conceptual models, economic &/or ergonomic &/or ethical &/or social impact analyses, etc. There will also be two marked and peer-reviewed design presentations, one per term, to the class.

End of Course Celebration: To celebrate your hard work and to show off your capabilities, we will have a formal conference at the end of the course during the exam period. Second and third year students will be invited, as will all your clients and technical consultants, along with potential employers. Friends and family will be welcome, and the public will be invited as well.

Mark Sharing: As in MECH 328, team work often involves the risk of some members not pulling their weight or not allowing certain team members to make their own contribution. We will therefore use the iPeer on-line peer review process in each term as a way of addressing some of these issues.

Report and presentation dates are posted on the course VISTA website. For each of the deliverables, there is a document in the "Assignments" folder on VISTA. A summary:

Project Selection	**Midnight, Sunday, September 13, 2009**
Proposal	**4PM, Monday, October 5, 2009**
Reference Report	**4PM, Monday, October 19, 2009**
Concept Presentations	**Team meeting times, Nov. 5 & 7, 2009**
Conceptual Alternatives Report	**4PM, Monday, November 9, 2009**
CFP Report	**4PM, Monday, November 30, 2009**
Milestone: Choosing a Concept	**Friday, January 8, 2010**
Technical Analysis Report	**4PM, Monday, January 25, 2010**
Prototype Build Presentations	**Team meeting times, March 6 & 8, 2010**
Test Protocol Reviews	**Team meeting times, March 23 & 25, 2010**
Final Report	**4PM, Monday, April 19, 2010**
Design Celebration	**In the Term 2 exam period, TBD**

Marking Rubric

Your mark will be composed of the following elements. Further information on each of these elements is provided on-line. The team design mark (95%) will be multiplied by an individual participation score. The individual logbook content mark will then be added to it to determine each student's overall mark. Team design mark components 1-8:

1. Proposal: Problem Statement, Requirements & Specifications: 10%
   You will demonstrate that you have assessed the client's/user's needs and translated that into an appropriate set of engineering requirements.
2. Reference materials exercise: 5%
   You will be asked to obtain reference items relevant to your project from a variety of sources (e.g., patents, technical articles) and explain how these items can support your design effort.
3. Analysis of conceptual alternative: 10%
   In your report, you will present your estimates for the value of your principal conceptual alternatives, paying special attention to explaining the physical principles behind your estimates and the associated uncertainties.
4. Critical Function Prototype (CFP) building and testing: 10%
   You will explicitly consider the manufacture of one or more key components in your design that is critical to success and that you are at this stage the least sure of being able to design. The report will include your design, the results of prototype testing and lessons learned.
5. Formal technical analysis: 10%
   For your key performance variable, you will present details of the method you used to estimate performance and how you optimized that performance through more detailed analysis and testing in your report.
6. Assessment of prototype and prototype testing: 25%
   You will present your prototype and any testing results to your client and your supervisor. They will offer an assessment of how well you have achieved your original goals.
7. Final report: 10%
   This report is primarily for your client. The report should include the assessment of the prototype, any revised designs, and recommendations for commercial development.
8. Presentations: 15%
   You will receive a mark from instructors, clients, mentors and peers present in the audience. Two oral presentations will be scheduled – one in the fall and one in the spring.

Individual participation multiplier: approximately 80% to 120% (a-c below). Using the above 95% as a starting point:

a. Class attendance and participation -5% to +5% (individual)
   The participation will be reviewed by your supervisor.
b. Logbook presentation -5% to +5% (individual)
   In addition to design content of the logbook (see #9 above), a mark will be given at the end of Term 2 for format, neatness and overall presentation quality.
c. Peer evaluation, approximately -10% to +10% (individual)
   In each term , iPeer will be used to ask each student about the relative contributions of the others on the team. Instructors reserve the right to make adjustments beyond the ±10% range.

Logbook content: 5%. This is an individual, not a team design mark component. Your logbook will be evaluated for content as part of the design component of the mark.

Resources

Textbook

We recommend that each team have access to a copy of ***Product Design and Development***, by **Karl Ulrich** and **Steven Eppinger 2008,** to guide you through the overall design process. Selected chapters are included on the VISTA website for this course.

Consultation with Faculty

As mentioned earlier, you will have weekly meetings with your instructor. You should also use your connections with other faculty in the department and elsewhere as resources.

Technician Resources

Machine Shop Instructor: Markus Fengler, mfengler@mech.ubc.ca, KAIS 1190C, 827-5655
Instrumentation Shop Supervisor: Glenn Jolly, gjolly@mech.ubc.ca, KAIS 1220, 822-4530

Each team will have access to assistance from these technicians to assist with completion of the project, with the cost coming out of the team budget. We encourage you to plan ahead for how you will use this time – remember that the shop gets increasingly busy toward the end of the terms.

Drawings must be submitted for any work done by workshop technicians. All drawings must be submitted to Markus Fengler for scheduling and allocation. Unsuitable drawings will be returned for correction and revision. Work will not start until suitable drawings have been submitted. Each drawing must be approved and signed by the project supervisor.

Student Shop Time

Students are encouraged to do project work in the shop on their own, as equipment and safety permit. Both access to the student shop and to the main machine tools (milling machine and lathes) are likewise scheduled.

NOTE: Any student using the machine shop must first obtain insurance and complete the shop orientation session. Insurance can be obtained through the Mechanical Engineering Department.

Funds

Each project team will be allocated $750. These funds are available for either materials or components and may be released from the internal account in three ways: (1) as reimbursements upon presentation of receipts (reimbursed at the end of Term 2 in a lump sum to each team), (2) as charges for materials available through our shop, or (3) by ordering parts or supplies using our department's purchasing process. You may have additional funds at your disposal from your sponsor. All expenditures must be approved by the team's faculty supervisor.

APSC 496 Option

If you are interested in teaming up with EECE students in one of the medical/rehab projects, please consult the APSC 496 document, and visit: http://designubc.wordpress.com/apsc-496/
Projects with the -496 suffix are appropriate for either MECH 45X or APSC 496. You will receive the same credit in each, and the project will feature the same milestones and marking rubric.