NΨ Capstone Design Syllabus

1. Course Overview

> **Design:** An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.
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> Engineering design integrates mathematics, natural sciences, engineering sciences, and complementary studies in order to develop elements, systems, and processes to meet specific needs. It is a creative, iterative, and open-ended process, subject to constraints which may be governed by standards or legislation to varying degrees depending upon the discipline. These constraints may also relate to economic, health, safety, environmental, societal or other interdisciplinary factors.
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> The engineering curriculum must culminate in a significant design experience … based on the knowledge and skills acquired in earlier work and it preferably gives students an involvement in team work and project management.
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> (*Canadian Engineering Accreditation Board Accreditation Criteria and Procedures 2017*, Canadian Council of Professional Engineers, sections 3.1, 3.4.4.3 and 3.4.4.4.)

The Engineering Science ECE Capstone Design course provides students – primarily those from the ECE Major – with an opportunity to integrate and apply the technical knowledge gained during their undergraduate education to the solution of a given real-world engineering design challenge. Students work in small groups, and have significant latitude to explore and reframe the given challenge.

There are no technical lectures or tutorials in Capstone Design; students are expected to have sufficient technical background that they can successfully address the design challenge with some minimal additional self-study.

The design challenge for the Engineering Science ECE Capstone Design is:

> Use the knowledge gained through your progress in Engineering Science, to develop an engineered product.

- The product must make use of ECE knowledge gained through your Engineeing Science education. This may include hardware, software, algorithmic, mathematical, and/or statistical analysis knowledge. In your project proposal, you must make clear why this is an engineering project.
- Your project *may* be a software-only project (eg. an app or web-app), but you must identify the algorithmic, mathematical, or statistical analysis components that make your project an engineering project. For example, a web-app that serves only a business or social purpose is not enough. A web-app that does that by performing an identifiably-engineered technical data analysis using algorithmic or statistical processes, or machine learning, to accomplish its purpose *would* be acceptable.

- Your project does *not* need to include original research, and may be an implementation of existing research, but in doing so, you must again identify what innovations make this an engineering project (ie. How you are applying the research to make it practical and available).
- Students are to work in teams of 2-4.
- Teams *must* send at least one member to each weekly studio session to report on progress. However, *all* team members are strongly encouraged to attend each weekly studio session, to review progress with the course instructors, discuss approaches, work as a team, and explore activities of other teams. As a collaborative project indicative of future career collaborations, individual participation matters. Individual participation in this manner is assigned 10% of the final course grade (see the policies and deliverables tables below). The primary goals of this participation are progress updates and consultation with instructors, and team collaboration, all in an efficient manner. Teams are encouraged and welcome to make use of the full studio time and location to perform active project development work each week. But alternately, by scheduling times with the instructors during each weekly studio slot, and holding short team update meetings while there, it is not necessary to attend for the full studio time slot.
- Each student is expected to maintain a journal notebook (paper or virtual), aka "lab notes", that logs project activities performed by that individual student.
- In addition to their team activities, each student is individually required to produce an individual Personal Experience Document.

2. Course Instructors

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Given the highly varying nature of upper year student schedules, in lieu of scheduled office hours students who desire additional contact time must make individual appointments with the Course Instructors. During the term the Course Instructors may announce one or more scheduled times and locations where individuals or groups of students may obtain additional contact.

3. Graduate Attributes

Having completed ESC472 Engineering Science ECE Capstone Design all student are expected to have demonstrated that they possess the abilities and understandings linked to the following CEAB graduate attributes[1]:

1 Further information on the CEAB Graduate Attributes can be found at:
http://www.engineerscanada.ca/files/w_Accreditation_Criteria_Procedures_2012.pdf

3.1.4 Design
3.1.5 Engineering tools
3.1.6 Teamwork
3.1.7 Communication skills
3.1.8 Professionalism
3.1.9 Impact of Engineering
3.1.10 Ethics and equity
3.1.11 Economics and project management
3.1.12 Lifelong Learning

4. Prerequisites

There are no formal prerequisites for Capstone Design beyond having completed the Engineering Science Foundation curriculum and one year of an Engineering Science Major. As part of their Foundation studies, all students in Capstone Design are expected to have engaged in the design of structures, circuits, software programs, socio-technical systems, and other forms of engineering. They are also expected to be familiar with engineering design as a distinct topic of study. Informal prerequisites include having completed laboratory experiments as part of a course, and the use of analytic and simulation tools such as Matlab and Labview.

Capstone Design builds on the Praxis Approach to Engineering Design introduced in the Engineering Science Foundation Curriculum. Accordingly students are expected to be aware of this approach and to use it as the basis of their Capstone Design activities. Key features of this Approach include:

- Synthesizing multiple conceptions of "engineering" and "design" to **develop an individualized understanding of, and approach to the practice of "engineering design"**;
- E**xploring, questioning, and developing alternative perspectives on** the theory and practice of "engineering design";
- Taking responsibility for **integrating engineering design theory and practice**;
- Using **multiple modes** to represent and defend design decisions and concepts; and,
- **Demonstrating integrity** between engineering design as understood and as practiced.

The Praxis Approach has as core theoretical underpinnings the Perry Model of Intellectual and Ethical Development and the Kolb Learning Cycle. Students are encouraged to explore these models to better understand the philosophy of the Engineering Science Capstone Design course.

5. Resources

Capstone Design makes use of Quercus:

Quercus: `https://q.utoronto.ca`

There is no textbook for Capstone Design; any required readings will be made available electronically as the course progresses. Links to these readings will be made available on Quercus.

Students are required to develop functional, and as necessary non-functional, prototypes of their Capstone designs. To support these efforts, students will be reimbursed for their purchases and will have access to maker services. **To receive reimbursement or gain access to maker services, students must obtain prior approval from both the course instructors and from a designated authority.**

Students may also choose to engage in activities that have associated costs, for example having posters printed on large format paper or producing bound, colour copy reports, Students in Capstone Design are

expected to spend an amount similar to the cost of a textbook over the course of the term without expectation of compensation.

As much as possible, assessment will be structured so that the grade and the level of expenditure will not be correlated, allowing students to choose their own level of expenditure. Students should consult with the Course Instructors should they feel that the costs of the course are becoming excessive.

6. Activities

6.1. Design Studios ("Practical"; 3 scheduled hours per week)

Studios are designed as weekly opportunities for group work and consultation with the Course Instructors. Portions of certain Studios will be used for structured activities including discussions with subject matter experts, possibly presentations by guest speakers, demonstrations, and class discussions.

Design studio times for the 2020 course session are Mondays 12:00pm - 3:00pm in MY360, from Jan 6 2020 to Apr 6 2020.

During the Design Studios each team is expected to demonstrate facility with the "Economics and project management" graduate attribute by – at a minimum – providing the Course Instructors with an appropriate representation of their progress during the interstice between the previous Studio meeting. Teams who fail to provide to provide such a representation – or whose representation does not support the Course Instructors in providing feedback and guidance – may receive up to a 5% penalty on their Process deliverables.

6.2. Course Feedback

Over the course of the term, students may be requested to provide feedback on the course. This feedback may be solicited by the Division of Engineering Science or the Course Instructors. Any such feedback will be used to improve the course, during both this and future sessions. While students are not required to respond to the requests for feedback, they are encouraged to do so as their feedback can significantly improve both their course experience and that of future students. Should feedback be requested, student anonymity will be preserved unless the student explicitly chooses to share their identity with the Course Instructors.

7. Grading Policies

7.1. Composition of Final Grades

Category	Definition	Min.	Max.
Product	Final deliverables and accompanying descriptions. Examples include design and analysis documents, budget planning, product prototypes, etc. Product deliverables focus on answering the question "**What is the design?**"	30%	45%
Process	Process deliverables frame, explain, and justify the product. Examples include problem definitions, stakeholder needs assessments, multi-criteria decision making, success/failure assessments, proposed future changes, etc. Process deliverables focus on answering the question: **Why is this an example of credible engineering design?**"	30%	45%

Category	Definition	Min.	Max.
Reflection	Reflection deliverables demonstrate individual changes in knowledge, practice, or attitude. They may also be used to plan future activities. Reflection deliverables focus on answering the question "What did you, as an engineering designer, obtain from this design course and throughout your undergraduate experience?"	15%	
Participation	Participation in the weekly Design Studio class sessions	10%	

The deliverables associated with a design activity can be broken down into four categories: Product, Process, Reflection, and Participation. To provide students with the flexibility to pursue their own learning goals, in Capstone Design each student team is able to select what percentage of their overall grade is allocated to two of those categories, and to define the specific deliverables within those categories.

Due Date	Deliverable	Type	Description	Submit
2020-01-13 @2400	Project Proposal	Process/10	1-2 page proposed project description plus team member bios.	Team
2020-01-20 @2400	Initial Feasibility Study	Process/- Product/-	Detailed and researched evaluation of project problem space and potential solutions. Goal is to prove project feasibility in the timeframe of the course by giving detailed descriptions of the system components/interfaces, designated owners for tasks within the group, budget and materials, reasonable timelines, etc. Also looking for justification of chosen design criteria/constraints towards making the product useful for the stated objective of the project by the group. The teaching team should be able to know exactly what each group member aims to accomplish in their product by the end of the semester with no ambiguity.	Team
2020-02-03 @2400	Final Feasibility Study	Process/20 Product/10	Students will be given an opportunity to revise the initial Feasibility Study based on feedback.	Team
Ongoing	Weekly Presentations, Progress Reports	Process /50 Product /30	Every week following the submission of the Feasibility Study, students will present their ongoing progress on their projects. The product portion of this mark is optional if student teams define demo-able product milestones in their Feasibility Study.	Team
2020-04-24 @2400	Demo, Final Release, and Post- Mortem Report.	Process /20 Product /60	Two-part supervised and take-home exam delivered in person and electronically to the Course Instructors.	Team

Due Date	Deliverable	Type	Description	Submit
Demo within 2020-04-14 2020-04-28				
2020-04-24 @2400	Personal Experience Document	Reflection/100	Take-home exam delivered physically and/or electronically to the Course Instructors. Should include: • The contents of each student's engineering notebook. • An individual Personal Experience Document authored by each student. The Personal Experience Document is where you reflect on how this project as consolidated in a real-world manner, your experiences in engineering school, both theoretical and practical. For example, this can include reflections on: • How the technical knowledge you gained in Eng Sci was applied to this project, and may be applied to your future career projects. • How the engineering processes and philosophies that you learned in Eng Sci was applied to this project, and may be applied to your future career projects. • How collaboration with teammates and domain experts can benefit a project. • How collaboration with teammates can sometimes lead to challenges, and how these challenges can be dealt with to create mutually beneficial results. • The technological, financial, organizational, and personal risks involved in projects. • What it means to understand and embrace failure in projects. • What you learned (both good and bad) about how team projects progress while working on this and other projects in Eng Sci. • Similar topics from projects outside of Eng Sci that you've worked on (entrepreneurial, social, volunteer, etc). • What IS engineering? How is it different than other related fields? What is its relation to science and society? • What you like and dislike about the field of engineering? The Personal Experience Document can take any form (document, website, diary, manga, video, CV/resume, etc). What we are after is the communication of understanding and meaningful reflection about what you've been doing for the past few years, and where you want to take it. The contents of this document will not be shared with your classmates or team members. You are free to be open and honest. However, this is not the place to simply vent. Discussions about team challenges should be	Individual

Due Date	Deliverable	Type	Description	Submit
			thoughtful and meaningful. Demonstrate that you have learned from the challenges and an understanding that you will encounter them repeatedly in your career.	
Ongoing	Design Studio	Participation/ 100	Participation in the weekly Design Studio class sessions. This is an interactive course. Interactive with your teammates. Interactive with your instructors. Interactive with other teams. Engineering collaboration throughout your career will involve regular meetings and conferences with teammates, bosses, other teams, other organizations, etc. Get used to it.	Individual

Additional details will be released at a reasonable point in time prior to each deliverable's due date.

7.2. Team Grades

When working in teams, students are expected to divide workload in an equitable fashion. The nature of the division is up to the team members, and does not require that all members work the same hours or produce identical volumes of work. Team members are expected to follow practices of good teamwork and to comport themselves as professionals. **Students are also expected to report any difficulties with regards to teamwork to the Course Instructors as soon as possible during the term**; failure to report such difficulties may result in the instructional team being unable to address student concerns.

By default, members of a team receive an identical grade on team assignments, except for the Personal Experience Document. **The Course Instructors may adjust the grade distribution within a team based on solicited, confidential feedback.**

7.3. Late Penalties

Due dates have been selected such that course workload is spread out over the term and that sufficient time is available to provide formative feedback prior to the submission of summative assignments. Assignments that are submitted late will be subject to a cumulative penalty, as outlined in the respective assignment descriptions.

7.4. Support and Accommodation

Students with diverse learning styles and needs are welcome in this course. Students who have a disability or health consideration that may require accommodations are both encouraged and welcome to approach the Course Instructors as soon as possible. **Should accommodations be necessary, by University of Toronto policy students are required to contact the Accessibility Services Office**.

8. Policies

Students in Capstone Design are expected to comport themselves professionally and to exercise common sense[2]. They are also expected to be familiar with, and act according to, the following University policies, guidelines, and interpretations:

- Code of Behaviour on Academic Matters
- Code of Student Conduct
- Academic Integrity
- Petitions and Appeals
- University of Toronto Inventions Policy
- University of Toronto Policy on Official Correspondence with Students

8.1. Instructional Materials and Copyright

Students are prohibited from recording or otherwise reproducing any copyrighted materials associated with ESC472 Capstone Design unless they obtain prior permission from the copyright holder. Unless otherwise indicated, tangible instructional materials (e.g. assignments, slides, handouts, etc.) developed by the Course Instructors are released under a Creative Commons license that permits the sharing of the materials, so long as attribution is made, no financial remuneration is asked, and any derivative works are similarly licensed. Tangible instructional materials developed by other parties are assumed to be copyright of those parties unless otherwise indicated.

Intangible instructional materials, in particular spoken or presented content, are assumed to be copyright of those providing the materials, including the Course Instructors.

8.2. Public Disclosure

Students agree that by taking this course all submitted deliverables may be used for teaching and learning purposes, in this or subsequent courses, or to support research into improving engineering education. Any such use will confirm to the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans. **Students who are concerned about the intellectual property ramifications of potential disclosure must notify the Course Instructors prior to the end of the 2020 academic session.** Students who have questions about the University of Toronto Inventions Policy should inquire with the Course Instructors

8.3. Turnitin

Students agree that by taking this course all required papers may be subject to submission for textual similarity review to Turnitin.com for the detection of plagiarism. All submitted papers will be included as source documents in the Turnitin.com reference database solely for the purpose of detecting plagiarism of such papers. The terms that apply to the University's use of the Turnitin.com service are described on the Turnitin.com web site. The intellectual property of all students submitting to Turnitin.com is protected by the licensing agreement between the University of Toronto and iParadigms. This agreement further ensures that student papers submitted to Turnitin.com will not be used for commercial purposes.

[2] Students are encouraged to consult with the Course Instructors any time that they are uncertain as to whether an activity or decision would be unprofessional or would indicate a lack of common sense.