Department of Electrical & Computer Engineering
Concordia University

ENGR 290: Introductory Engineering Team Design Project

Fall 2018

Lectures: Tuesdays and Thursdays: 4:15 pm – 5:30 pm; Location: FG B060

Tutorials: Section FA: Mondays, 5:45 pm – 7:35 pm; Location: H 613
Section FB: Mondays, 2:15 pm – 4:05 pm; Location: H 540

Instructor: Dr. Rastko Selmic (rastko.selmic@concordia.ca)

Office Hours: Mondays and Wednesdays: 1:00 pm – 2:00 pm; Location: EV5.169

Lab Instructor: Dmitry Rozhdestvenskiy (dmitry@ece.concordia.ca); Location: H851-2

Teaching Assist.: Reza Babazadeh (r_babaza@encs.concordia.ca)
Neshat Elhamifard (ne.elhamifard@gmail.com)

URL: http://users.encs.concordia.ca/~rselmic/engr290

Description:
The introductory team design project introduces students to teamwork, project management, engineering design for a complex problem, technical writing and technical presentation in a team environment. Students work in teams and each team designs and builds a prototype defined by the Department. Students present their design and demonstrate that their design works in a competition at the end of the term. The students are also introduced to the basic principles of mechanics including the description of translational motion, rotational motion, forces and moments, work and energy, and they build a mechanical prototype to which the electronics and software are then added. A significant team project is required in this course.

Note: All written documentation must follow the Concordia Form and Style guide. Students are responsible for obtaining this document before beginning the project.

Topics:
- Introduction to Engineering Team Design Project
- Vectors and Matrices, Vector Calculus, Vector Functions, Motion on a Curve, Gradient, Curl, and Divergence, Surface Integrals
- Forces, Equilibrium, Free-Body Diagrams
- Motion of a Point, Angular Motion
- Force, Mass, and Acceleration
- Planar Kinematics and Dynamics of Rigid Bodies
- Rotational Motion & Equations of Motion of a Hovercraft

- Introduction to Fluid Mechanics, 1D Incompressible Flow, Continuity and Bernoulli's Equation
- Propulsion, Work, Energy
- Energy and Momentum in Rigid Body Dynamics
- Three-dimensional Kinematics and Dynamics of Rigid Bodies
- Open-Loop Control vs. Feedback Control
- Sensors

Objectives and Course Learning Outcomes (CLOs) – Upon successful completion of the course, students will be able to:

1. Solve physics problems of classical mechanics/dynamics and fluid mechanics.
2. Decide between engineering designs in a principled fashion using quantitative justification.
3. Implement a detailed design and prototype of an electromechanical system (hovercraft).
4. Apply simulation, when appropriate, to evaluate design options.
5. Contribute toward meeting the shared goals of an engineering team.
6. Resolve conflicts and disagreements with respect and logical, ethical reasoning.
7. Communicate design process and results in presentations and reports geared towards a specialized audience.
8. Execute the responsibilities of an engineering team member with integrity and competence.
9. Manage the schedule, work breakdown, and basic costs of a small-scale engineering project.
10. Identify new subject topics necessary for project success that had not been covered in prior courses.

Prerequisites: ENCS 282; ENGR 213, ENGR 233

Text: A. Bedford and W. Fowler, *Engineering Mechanics, Statics & Dynamics*, 5th edition, Pearson, Prentice Hall, Upper Saddle River, New Jersey, 2008, ISBN-10: 0-13-614225-7, ISBN-13: 978-0-13-614225-6.

Reference Books:

1. R.L. Mott and J.A. Untener, *Applied Fluid Mechanics*, 7th edition, Pearson Education, Inc., 2015, ISBN-10: 0-13-255892-0, ISBN-13: 978-0-13-255892-1
2. P. Kosky, R. Balmer, W. Keat, and G. Wise, *Exploring Engineering: An Introduction to Engineering and Design*, 4th Edition, Elsevier Science & Technology, 2015, ISBN-10: 0-12-801242-0, ISBN-13: 978-0-12-801242-0.
3. J. Dally, *Introduction to Engineering Design*, College House Enterprises, LLC, Knoxville, Tennessee, 2014, ISBN-13: 978-1-935673-14-9
4. D.G. Zill, *Advanced Engineering Mathematics*, 6th Edition, Jones & Barlett Learning, 2018, ISBN-13: 978-1-284-10590-2

Recommended Software: MATLAB

Other Course Material:

Homework, assignments, suggested problems, and other required course material will be distributed either during the lectures in classroom or posted on the Moodle system.

Tutorials:
In the scheduled tutorials, suggested problems will be solved and students' questions will be answered.

Grading Scheme:
Each student will be awarded a letter grade based on the following weighting of grades:

Evaluation Tool	Weight	Indicator
Homework & Quizzes	10%	
Midterm Exam	25%	
Assignment #1	5%	
Assignment #2	5%	
Interim Presentation	5%	DE-1, DE-2, CO-4, EPM-3
Demonstration	10%	DE-4, ITW-4
Competition	20%	DE-4, ITW-4
Final Report	15%	DE-1, DE-3, CO-1, EPM-3
Peer Evaluation	5%	ITW-1, ITW-2, ITW-3

The date for the midterm examinations will be announced in due course of time.

Homework:
Homework will provide hands-on experiences related to the theoretical concepts covered in the class. Homework should be submitted before the start of the lectures. No late homework will be accepted. Some homework may require computer simulations using MATLAB. In case of a simulation assignment, please plot your results and submit your documented (commented) source code.

Quizzes:
Short 15-minute quizzes will follow homework submissions to monitor students' learning. Quizzes will be held in class prior to the lecture after the submission of the homework.

Assignments:
Assignments will consists of one or more challenging problems that require modeling, theoretical solution, possible MATLAB simulation, and analysis. Problems will be related to practical issues facing with the design project.

Laboratory:
Lab coordinator: Mr. Dmitry Rozhdestvenskiy, (H851-2, dmitry@ece.concordia.ca)
The laboratory is located at H933. You must attend only the lab section you are registered in.

Design Project:
The goal of the project is to design and build a functioning radio-controlled hovercraft that can follow a specified course. This is a team project where students will form teams of three (3) people and will design, analyze, simulate, build and test a prototype of a hovercraft. This prototype will enter a competition in which all groups will have to successfully fly the hovercraft through a maze. The final score in the competition will be equal to $S = k/(T \cdot P \cdot (1 + D))$ where S is the score, T is the time (in minutes) that it takes the vehicle to exit the maze, $P > 0$ is the number of components (fans and servo motors) used in the design, D is the final distance (in meters) from the target that the craft comes to a rest, and k is the scaling factor equal for all teams.

Interim Presentation:
Student teams will give technical presentations describing the specifications, options analysis, proposed design, and interim development progress of their hovercraft. Students will prepare presentation slides. The interactive presentation will give an opportunity for teams to answer questions and get feedback from the instructors and their peers.

Demonstration:
During the lectures students will demonstrate that their hovercraft performance and basic tasks. Teams will need to briefly and informally discuss the prototype development, validation testing, and subsequent modifications.

Competition:
Teams will race their hovercrafts on a specified course. Innovative and creative designs will gain extra points.

Final report and documentation:
The final report will incorporate prior work the Interim Presentation, with an opportunity to improve these topics based on feedback. The report will also cover the detailed modeling and design process, validation testing, competition results, and a self-evaluation of the project's management. Documentation of lab work, meeting minutes, test results, and research citations must be included.

Peer Evaluations:
Private peer evaluations will be submitted recommending weighted scores for each team member based on contributions, professionalism, and engineering ethics.

Course Schedule:
The following course schedule is subject to change based on the class performance. Homework and quiz schedule is tentative and will be discussed in class.

Week	Topics	Comments
Week 1	Introduction to Engineering Team Design Project (Dally et al.)	
Week 1	Vectors and Matrices	

Week 2	Vector Calculus, Vector Functions, Motion on a Curve	HW #1 assigned
Week 2	Gradient, Curl, and Divergence, Surface Integrals	
Week 3	Forces, Equilibrium, Free-Body Diagrams, Moments (Ch. 3, Ch. 4, Bedford & Fowler)	HW #1 due, HW #2 assigned Project Teams formed
Week 3	Motion of a Point, Angular Motion (Ch. 13, Bedford & Fowler)	Quiz #1
Week 4	Newton's Law and Momentum Methods (Ch. 14, Ch. 16, Bedford & Fowler)	HW #2 due, HW #3 assigned
Week 4	Planar Kinematics of Rigid Bodies (Ch. 17, Bedford & Fowler)	Quiz #2
Week 5	Rotational Motion & Equations of Motion of a Hovercraft	HW #3 due, Assignment #1 assigned
Week 5	Introduction to Fluid Mechanics (Mott & Untener)	Quiz #3
Week 6	1D Incompressible Flow, Continuity and Bernoulli's Equation	HW #4 assigned
Week 6	Propulsion, Work, Energy (Ch. 15, Bedford & Fowler)	
Week 7	Review	HW #4 due
Week 7	**Midterm Exam**	
Week 8	Energy and Momentum in Rigid Body Dynamics (Ch. 19, Bedford & Fowler)	Assignment #1 due
Week 8	Planar Dynamics of Rigid Bodies (Ch. 18, Bedford & Fowler)	Assignment #2 assigned
Week 9	Three-dimensional Kinematics and Dynamics of Rigid Bodies (Ch. 20, Bedford & Fowler)	
Week 9	Three-dimensional Kinematics and Dynamics of Rigid Bodies (Ch. 20, Bedford & Fowler)	
Week 10	Interim Presentation	Slides due, presentations in class
Week 10	Interim Presentation	Presentations in class
Week 11	Sensors	
Week 11	Open-Loop Control vs. Feedback Control	
Week 12	Demonstration	Assignment #2 due
Week 12	Demonstration	
Week 13	Competition	
Week 13	Competition	Final Report Due (Nov 29)

Expectations of Originality Form:
The students are required to review, complete, and submit the Expectations of Originality form: https://www.concordia.ca/encs/students/sas/expectation-originality.html

Graduate Attributes:
This course emphasizes and develops the following CEAB (Canadian Engineering Accreditation Board) graduate attributes and indicators:

Graduate Attribute	**Indicator**	**Level**	**CLO**
DE – 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.	DE-1. Define the objective DE-2. Idea generation and selection DE-3. Detailed design DE-4. Validation and implementation	Intermediate	1, 2, 3
ITW – Individual & Teamwork: An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.	ITW-1. Cooperation and work ethics ITW-2. Practical and conceptual contributions ITW-3. Initiative and leadership ITW-4. Delivering results	Intermediate	5, 6
CO – Communication Skills: An ability to communicate complex engineering concepts within the profession and with society at large. Such abilities include reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.	CO-1. Writing process CO-4. Oral presentation	Intermediate	7
EPM – Economics & Project Management: An ability to appropriately incorporate economics and business practices including project, risk and change management into the practice of engineering and to understand their limitations.	EPM-3. Project planning and implementation	Introductory	9

Bellman's Principle of Optimality:
An optimal policy has the property that whatever the initial state and the initial decisions are, the remaining decisions must constitute an optimal policy with regard to the state resulting from the first decision.

“If you don't do the best with what you have happened to have got, you will never do the best with what you should have had.”