THE UNIVERSITY OF BRITISH COLUMBIA

FACULTY OF APPLIED SCIENCE (Engineering)

ELEC 391: Electrical Engineering Design Studio II **Updated**: Jan, 2023

Contact Information:

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1. Calendar Entry

ELEC 391: Engineering Design Studio II (6) [2-6-2*]

Introduction to project management. Problem definition. Design principles and practices. Implementation techniques including circuit design, software design, solid modelling, PCBs, assembling, and packaging. Testing and evaluation. Effective presentations.

Pre-requisite: One of {CPEN 291, ELEC 291, ELEC 292} and two of {ELEC 301, ELEC 341, ELEC 311, ELEC 342}.
Co-requisite: None.

2. Course Structure

The 13-week term comprises 5 instruction weeks, 1 reading week (Mid-Term Break), 6 tutorial weeks, and 1 final evaluation week. There is no final exam.

All lectures are held in person and are recorded when resources permit. Tutorials may be held in person or online. During the evaluation week there are no classroom hours. During the 5 instruction weeks, all 4 classroom hours are devoted to technical instruction. During the 6 tutorial weeks, 2 classroom hours are devoted to student-led tutorials.

Students register for 6 lab hours per week but may attend any available lab hours. During scheduled lab hours, TAs and technical support staff are available for consultation and to supply physical resources. Students are provided 24/7 access to the lab but technical support is not provided outside of scheduled lab hours. There are no office hours outside of scheduled lab hours.

Evaluations take place during scheduled lecture and lab hours. When student teams are made up of students registered in different lab sections, those students may have their final demonstration scheduled outside of their registered lab hours. Those students are expected to resolve any time conflicts so they can attend their final demonstration.

3. Course Motivation

This course satisfies the 3rd year design studio requirement of a BASc in Electrical Engineering.

The project provides an opportunity to exercise skills obtained in the following 3rd year courses.

- ELEC 341 – System & Control
- ELEC 301 – Electronic Circuits
- ELEC 342 – Electro-Mechanical Energy Conversion and Transmission
- ELEC 311 – Electromagnetic Fields and Waves

Pre-requisite knowledge is applied toward the design of an electro-mechanical control system. The design is documented in a technical design report. Lectures and tutorials provide the necessary design and prototyping background to design and implement the design project, which is demonstrated live.

4. Course Learning Outcomes

By the end of the course the students should be able to:

A. Formalize an Engineering Design Project in terms of Requirements, Constraints and Goals (RCGs).
   - Derive product and component specifications based on project requirements and constraints. (GA 4.3)
   - Identify and mitigate risks that impact the project design process. (GA 11.3)

B. Apply Scientific Theory and Engineering Design Principles to optimally satisfy the RCGs.
   - Evaluate system / sub-system design alternatives to identify the best solution based on the project requirements. (GA 4.4)
   - Implement the product design using best practices. (GA 4.5)
   - Compare experimental measurements with theory / simulation tools to justify design decisions. (GA 3.4)
   - Evaluate a curated list of course references to address personal knowledge gaps. (GA 12.3)

C. Evaluate demonstrated level of success in satisfying the RCGs.
   - Collect product data using state of the art tools to assess performance specifications. (GA 5.1)
   - Verify their product design based on the project requirements including tolerances or confidence levels. (GA 2.4)

D. Effectively deliver results using written and verbal communication techniques.
   - Document the project design in sufficient detail to allow an undergraduate engineer to reproduce the results. (GA 7.2)
   - Justify the most significant design decisions through an oral presentation. (GA 7.3)

E. Work effectively in a team environment.
   - Create and follow a team plan that meets the course project milestones. (GA 6.3)
   - Impartially assess individual and peer contributions to the project tasks. (GA 6.2)
   - Formulate a team charter that promotes equitable contribution of all team members. (GA 10.3)

F. Identify and mitigate safety hazards to both product developers and end-users.
   - Identify hazards associated with prototyping equipment and implement appropriate risk mitigation steps. (GA 8.2)
   - Identify how the design impacts health, safety and productivity in the context which it is deployed. (GA 9.1)

5. Course Content

<u>Section I – Project Description & RCGs (4 Lecture Hours)</u>

- Mini-Project Specifications
- Team Project Specifications
- Team Formation & Peer Review Policy
- Introduction to Requirements, Constraints & Goals

<u>Section II – Design Tools (8 Lecture Hours)</u>

- SolidWorks – Designing & Modelling Mechanical Parts & Assemblies
- Simscape – Simulating Linear & Non-Linear Mechanical Dynamics
- MultiSim & UltiBoard – Designing Analog Circuits & PCBs

- WinCupl – Designing Digital PLDs

Section III – Engineering Design & Prototyping (8 Lecture Hours)

- Sensors & Actuators
  - Encoders
  - Decoders & Programmable Logic Devices (PLDs)
  - Current & Voltage Drivers
  - DC, Servo & Stepper Motors
- Mechanisms
  - Fasteners & Rigid Connections
  - Joints & Sliding Surfaces
  - 3D Printing
- Gears & Robotics
  - Gear Configurations
  - Gear-Motors
  - Simulation Models
  - Direct & Inverse Kinematics
  - Path Planning
- Design Report
  - RCGs
  - Detailed Design
  - Verification

6. Course Activities

The course has 3 activities, each allocated approximately 4 weeks to complete.

1. Mini-Project (Individuals)
2. System Design (Partners)
3. System Integration (Teams of 4)

Mini-Project

Students individually develop 2 elementary systems:

1. Software System (Mechanism & System ID)
2. Hardware System (Digital & Analog Circuits)

All software tools must be mastered but minimal design work is required to complete the Mini-Project. Successful completion demonstrates the necessary background to participate in the Team Project.

The Mini-Project comprises a live presentation and a brief document containing screen-captures, which is graded Pass/Fail. The deadline is approximately 4 weeks into the course, and coincides with the add/drop deadline for all UBC courses. Any student that does not successfully complete the Mini-Project by the deadline will not be added to a group and will work individually on an extended Written Design Report if they decide to remain in the course.

After receiving a Passing grade on the Mini-Project, a student is added to the Team of their choice. Teams are made up of 4 members who work together to complete the Team Project.

System Design

Each Team of students divides into 2 pairs of students. Each pair assumes responsibility for 1 System. Each student assumes responsibility for 1 Sub-System.

1. Software System (Controller)
   i. System Design & Identification Sub-System
   ii. Controller Sub-System

2. Hardware System (Electric Circuits)
    i. Analog Circuit Sub-System
    ii. Digital Circuit Sub-System

A design document and proof-of-concept prototype is prepared for each Sub-System. The proof-of-concept is demonstrated during live Progress Meetings scheduled approximately 8 weeks into the course.

Any student that is not part of a Student Team due to a late Mini-Project submission must complete both Sub-System designs from 1 System. One Sub-System design will be due approximately 8 weeks into the course, and the second will be due at the end of the course.

System Integration
The entire Team works together to integrate all sub-systems into a working prototype. The prototype is demonstrated during live Final Demonstrations scheduled in the last week of the course.

System integration details and a formal test procedure to measure system performance is provided in a Power-Point presentation. A duty roster identifying individual contributions is also provided.

The quality of the prototype is evaluated during the Final Demonstration based on the following criteria.

- Completeness
- Implementation Quality & Reliability
- User Interface
- Development History
- Extra Features

7. Assessment Policies

- Attendance at all lectures and labs is optional.
- Attendance at demonstrations is mandatory and may only be excused under special circumstances. All Team members must attend the Team demonstration.
- Demonstrations take place in the lab during scheduled hours.
- All graded documentation is submitted on Canvas.
- Passing the Mini-Project earns a grade that reduces over time.
- Students are added to a Team only after they have passed the Mini-Project.
- Students are allocated a fixed amount of time during live demonstrations. It is the responsibility of the student to use that time effectively.
- All grades earned during live demos are final, and ineligible for “Review of Assigned Standing” according to UBC policy.

8. Assessment

The following is the weighting of all assessed components:

- Mini-Project (Control Sys) 10% (pass / fail)
- Mini-Project (Electric CCT) 10% (pass / fail)

- Sub-Sys Report (Individual) 30%
- Sub-Sys Report (Partner) 10%
- Final Demonstration 35%
- Slide Deck 5%

Mini-Project
The deadline is approximately 4 weeks into the course.
Document of screen captures is submitted on Canvas and is graded Pass/Fail.
Demonstration is graded Pass/Fail.
The grade is applied to the individual.

System Design
The deadline is approximately 8 weeks into the course.
Document is submitted on Canvas and is graded according to a posted rubric.
Students may opt-out of weighted sum grading if there was minimal contribution from partner.

System Integration
The deadline is the final week of the course.
Slide Deck is submitted on Canvas. Slide deck and live demonstration are graded according to a subjective assessment of quality and completeness.
Individual duty roster is submitted on Canvas. Team grade is scaled to reflect individual contributions.

Any disagreement between team members regarding individual contributions is resolved by a meeting with the instructor where individual students show physical evidence of individual contributions.

9. Texts and Bibliography (including any required materials)

- Course notes and various resources are provided on Canvas. These include:
  - Software tutorials and examples
  - FAQs about software tools
  - Links to department resources such as component and service order forms

- There is no text for this course. It exercises technical content from pre-requisite courses.

- A budget is provided to each student group to purchase components, materials and services from the department. Any additional resources requirements are the responsibility of the students. No materials or components are explicitly prohibited, but any Off-the-Shelf components that impact the design content of the project may have an associated impact on the grade.

10. Senate Policy on Academic Concession – Academic Calendar statement:

Please refer to the Senate policy on Academic Concession:
http://www.calendar.ubc.ca/vancouver/index.cfm?tree=3,48,0,0

Students should report any requests for in-term concession at the following site and then follow up with their instructor:
https://academicservices.engineering.ubc.ca/form-request-for-academic-concession-in-term-work/

11. University Policies

UBC provides resources to support student learning and to maintain healthy lifestyles but recognizes that sometimes crises arise and so there are additional resources to access including those for survivors of sexual violence. UBC values respect for the person and ideas of all members of the academic community. Harassment and discrimination are not tolerated nor is suppression of academic freedom. UBC provides appropriate accommodation for students with disabilities and for religious, spiritual and cultural observances. UBC values academic honesty and students ae expected to acknowledge the ideas generated by others and to uphold the highest academic standards in all of their actions. Details of the policies and how to access support are available here.