



ENGG*4480 Advanced Mechatronic Systems

Design

01

Winter 2024

Section(s): C01

School of Engineering

Credit Weight: 0.75

Version 3.00 - January 24, 2024

1 Course Details

1.1 Calendar Description

The course is a follow up to the introductory mechatronics course and aims at covering advanced topics that are necessary in developing mechatronic systems. Topics include: signal conditioning and filtering for mechatronics system including advanced filters such as Kalman filters; important/advanced electronic circuits for mechatronics systems; microcontroller interfacing and programming; design and development of motion control for mechatronics systems including PLC; introduction of integrated complex mechatronics systems: concept, structure, and applications. Through a design project, students will use and apply these concepts in building a complex mechatronics system with advanced features.

Pre-Requisites: ENGG*3490

Restrictions: Non-BENG students may take a maximum of 4.00 ENGG credits.

1.2 Course Description

The aim of this course is to design and implement a mechatronic system using the knowledge and experience you have gained from ENGG*3490, which demonstrated the basics of sensors and actuators as well as a variety of mechatronic systems. For this course, the laboratories and project will be completed in groups of three to four people. Groups will be tasked with designing, building, and running their own experimental setup based on advanced single board computer system and control or estimation theory. Successful setups may be used in future course offerings.

1.3 Timetable

Lectures

T/TH: 8:30am - 9:50am, THRN 2313

Laboratory

F: 2:30 pm - 5:20 pm, THRN 2307

1.4 Final Exam

Final exam: No final exam

2 Instructional Support

2.1 Instructional Support Team

Instructor:	Mohammad Al Janaideh PhD, P. Eng
Email:	maljanai@uoguelph.ca
Telephone:	+1-519-824-4120 x56455
Office:	RICH1505
Office Hours:	T: 10:00-11:00 am
	TH: 2:00-3:00 pm

2.2 Additional Support

Laboratory Coordinator: Kevin Dong, Email: kdong@uoguelph.ca

TA: Michael Pumphrey, Email: mpumphre@uoguelph.ca

3 Learning Resources

3.1 Required Resources

Course Website (Website)

Course material, news, announcements, and grades will be posted regularly to the ENGG*4480 Courselink site. You are responsible for checking the site regularly.

3.2 Recommended Resources

Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering (Textbook)

- The Design of High-Performance Mechatronics, 3rd edition R. Schmidt, G. Schitter, A. Rankers, J. Van Eijk, IOP, 2020.
- Mechatronics: An Integrated Approach, by Clarence W. De Silva, 2004,

- Introduction to Mechatronics - Measurement Systems, David Alciatore, 2018.

3.3 Recommended Resources

Other recommended resources (optional) are as follows:

- Information on single board computer systems: <https://www.raspberrypi.org/>
- Online electronics shop: sparkfun.com; digkey.ca

3.3 Additional Resources

Lecture Information: **Some parts** of the lectures notes are posted on the web page. The reason that only some parts are posted is to ensure that students attend the classes to learn the material. Note that the posted lectures on the webpage **may NOT** have all of the material taught in the class. Students should attend the classes and make their own notes.

Assignments: Assignments will cover lecture material and theory taught in the class. They will be completed individually. No late assignments will be accepted.

Miscellaneous Information: Other information related to estimation theory will also be posted on the course web page.

4 Learning Outcomes

4.1 Course Learning Outcomes

By the end of this course, you should be able to:

1. Design and implement mechanical parts on mechatronic systems
2. Address safety concerns of mechatronic systems as well as during the fabrication process
3. Sensor and actuator implementation on advanced single board computer (SBC)
4. Use of a variety of sensors and how to use them as input devices for a mechatronics system
5. How to achieve higher accuracies by combining more than two different sensors
6. Understand the basics of estimation theory
7. Understand the basics of machine intelligence
8. Manipulate mechatronic systems and obtain relevant measurement data for engineering purposes
9. Reflect upon professional skills and prepare for post-graduation
10. Hone communication skills through written and oral reports.

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome
1	Knowledge Base	6, 7
1.4	Recall, describe and apply program-specific engineering principles and concepts	6, 7
3	Investigation	3, 4, 5
3.3	Analyze and interpret experimental data	3, 4, 5
4	Design	1, 8
4.5	Develop and refine an engineering design solution, through techniques such as iteration, simulation and/or prototyping	1, 8
7	Communication Skills	10
7.1	Identify key message(s) and intended audience in verbal or written communication as both sender and receiver	10
7.3	Construct the finished elements using accepted norms in English, graphical standards, and engineering conventions, as appropriate for the message and audience	10
9	Impact of Engineering on Society and the Environment	2
9.1	Analyze the safety, social, environmental, and legal aspects of engineering activity	2
12	Life Long Learning	9
12.1	Identify personal career goals and opportunities for professional development	9

5 Teaching and Learning Activities

5.1 Lecture

Topics:

1. Electrical elements [review].

Topics:

2. Mechanical elements [review].

Topics:

3. MEMS accelerometers: design and interface.

Topics:

4. Piezo accelerometers: design and interface.

Topics:

5. Smart actuators

Topics:

6. State space modeling

Topics:

7. State space control

Topics:

8. Motion Control

5.2 Lab

Topics:

Check lab schedule on CourseLink.

5.3 Important Note

The class schedule may be subject to change. Please refer to the most recent syllabus or outline available online.

5.4 Other Important Dates

Monday, January 8: Classes commence

ENGG4480 first lecture is on Tuesday, Jan 9. In-person.

Lectures: Tuesday -Thursday: 8:30 - 9:50 AM

Monday, February 19, Winter Break -- No Classes Scheduled This Week.

Friday, February 29: Project plan presentation and progress (in the classroom)

Friday, March 29: Holiday -- No Classes Scheduled. Classes rescheduled to Monday, April 8.

Friday, April 4: last lecture.

Friday, April 5: project presentation in the lab.

Friday, April 12: final project report (via course link)

6 Assessments

The submission deadlines for all assessments have been posted online (CourseLink). Please refer to the CourseLink page for ENGG*4480 for the latest deadlines.

6.1 Marking Schemes & Distributions

Name	Scheme A (%)
Labs (Group)	5
Exam 01	20
Project	55
Exam 02	20
Total	100

6.2 Assessment Details

Labs (Group) (5%)

Learning Outcome: 3, 4, 6, 8, 10

Lab 1 - Arduino Intro / Sensor Calibration

Lab 2 - Speed Control of Motor

Exam 01 (20%)

Date: Tue, Feb 13, 8:30 AM - 9:30 AM, Classroom

Learning Outcome: 1, 6, 7

Exam 01, 2024-02-13, 8:30 AM - 9:30 AM

Project (55%)

Learning Outcome: 1, 2, 3, 4, 5, 6, 7, 8, 10

Mobile robot design

Exam 02 (20%)

Date: Thu, Mar 28, 8:30 AM - 9:30 AM, Classroom

Learning Outcome: 1, 6, 7

Exam 02, 2024-03-28, 8:30 AM - 9:30 AM

6.3 Project

- **Project Description and Plan: presentation in the classroom and a brief report (up to five pages), Feb 27 and Feb 29)**

The description of the project with all the necessary details will be posted on Courselink. This course project requires you to design and build a Mechatronics system based on your selection. The proposed system should include mechanical design, fabrication, actuators, sensors, and microcontroller (Control design). The objective of the proposed system should be identified and get approval before starting work on the project.

- **Project Rules**

1. Each group consists of 4~5 people (max. 5).
2. There is no late policy for the final demo. The late demonstration is **not** acceptable. Each group needs to demonstrate their project (whatever they have done by the deadline).

- **Project Milestones**

The project includes:

1. **Project Description and Objective:** This requires each group to present the project's idea and objectives and the block diagram of the system's main components.
2. **Project structure and mechanical design:** This requires each group to show the proposed mechanical structure of the mechanical structure, show the CAD, and process the fabrication using a 3D printer.
3. **Components selection:** Each group must (i) determine the motor specifications

(maximum torque, maximum speed, and power) to be suitable for the mechanical design. (ii) determine necessary sensors and the types of measured signals. (iii) the microcontroller should be selected.

4. **Modelling and Control Design:** In this stage, the mathematical model of the proposed system should be obtained and used to design a PID controller to achieve the desired tracking performance. Simulate the system using MATLAB/SIMULINK.
5. **Implementation and Experimental test:** This milestone includes the implementation of the proposed controller using a microcontroller and experimental test.

- **Project Submission**

In addition to the individual milestone reports, each group needs to submit the following.

1. **Experimental Demonstration in the Lab (April 5):** Each group needs to run and test the mobile robot.
2. **Final Report (April 12):** The final report should include the following chapters
 - Section 1: Introduction (Background, system applications, project description).
 - Section 2: Mechanical Design and Fabrication.
 - Section 3: Components Selection.
 - Section 4: Modeling and Controller Design.
 - Section 5: Experimental Test Results.
 - Section 6: Conclusion.

Report deliverables will be marked based on the requirements detailed in the Report Deliverables Section. All reports are to be submitted on time. The design will be scored such that the best design in each category will receive the highest mark for that respective category.

Table 2: Important dates

Item	Date	Mark	Excellent (90-100%)	Good (80-89%)	Satisfactory (70-79%)	Needs Improvement (0-69%)
Project Milestones and Progress: (a) presentation	Feb 27 and Feb 29	15%	Comprehensive and well-organized report. Clearly presents objectives,	Well-structured with minor room for improvement. Presents objectives,	Adequate structure but lacking in detail and clarity. Some important	Lacks organization, detail, or key components. Fails to demonstrate

(in the classroom) (b) a brief report (up to 5 pages) Slides and report to be submitted via Courselink			methodology, and results.	methodology, and results.	components may be missing.	an understanding of the task.
Project test (in the lab) THRN 2307	April 5 (11:30-1:20 pm)	65%	Outstanding performance in the competition. Demonstrates exceptional problem-solving and innovation.	Strong performance with room for improvement. Applies solid problem-solving and innovation skills.	Adequate performance but with notable shortcomings. Demonstrates basic problem-solving and innovation skills.	Poor performance in the competition. Lacks problem-solving skills and innovation
Final Report (via Course link)	April 12	20%	Exceptional depth, structure, and clarity. Thoroughly covers all aspects of the project.	Well-structured, but minor improvements needed. Adequately covers project components.	Adequate structure but lacks detail and clarity. Some critical components are missing.	Poorly structured, unclear, and lacking detail. Fails to cover critical aspects of the project.

6.4 Important Note

While you are encouraged to discuss with other classmates on problems in the class, there is zero tolerance for plagiarism or copying. A grade of 0% will be assigned to an exam if it is copied or plagiarized by any means. Potential cases of academic misconduct will be put forward for formal investigation by the College of Engineering and Physical Sciences.

7 Course Statements

7.1 Course Grading Policies

Missed Assessments: If you are unable to meet an in course requirement due to medical, psychological, or compassionate reasons, please email the course instructor. See the undergraduate calendar for information on regulations and procedures for Academic Consideration:

http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08_ac.shtml

Accommodation of Religious Obligations: If you are unable to meet an in course requirement due to religious obligations, please email the course instructor at the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations:

http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08_accomrelig.shtml

Passing grade: You must pass both the laboratories and midterm section, as well as the project portion, in order to pass the course. For example, obtaining 40/40 on the project but 20/60 on the rest of the course will result in an overall failure of the course. In this example, a final grade of 49/100 will be earned in the course.

Late Submissions: Late submissions without a pre approved reason will **not** be accepted.

7.2 Relationships with other Courses & Labs

Previous Courses:

ENGG*3490: Introduction to Mechatronic Systems Design (basic concepts)

ENGG*3640: Microcomputer Interfacing (data acquisition)

ENGG*4460: Robotic Systems (modeling and design of complex mechatronic systems)

8 School of Engineering Statements

8.1 Instructor's Role and Responsibility to Students

The instructor's role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on Courselink but these are not intended to be stand-alone course notes. Some written lecture notes will be presented only in class. During lectures, the instructor will expand and explain the content of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and labs.

8.2 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and lab sessions. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

8.3 Lab Safety

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.

9 University Statements

9.1 Email Communication

As per university regulations, all students are required to check their e-mail account regularly: e-mail is the official route of communication between the University and its students.

9.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. The grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals

<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml>

Graduate Calendar - Grounds for Academic Consideration

<https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml>

Associate Diploma Calendar - Academic Consideration, Appeals and Petitions

<https://www.uoguelph.ca/registrar/calendars/diploma/current/index.shtml>

9.3 Drop Date

Students will have until the last day of classes to drop courses without academic penalty. The deadline to drop two-semester courses will be the last day of classes in the second semester. This applies to all students (undergraduate, graduate and diploma) except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in their respective Academic Calendars.

Undergraduate Calendar - Dropping Courses

<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml>

Graduate Calendar - Registration Changes

<https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml>

Associate Diploma Calendar - Dropping Courses

<https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.shtml>

9.4 Copies of Out-of-class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

9.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required; however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to make a booking at least 14 days in advance, and no later than November 1 (fall), March 1 (winter) or July 1 (summer). Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time.

For Guelph students, information can be found on the SAS website
<https://www.uoguelph.ca/sas>

For Ridgetown students, information can be found on the Ridgetown SAS website
<https://www.ridgetownc.com/services/accessibilityservices.cfm>

9.6 Academic Integrity

The University of Guelph is committed to upholding the highest standards of academic integrity, and it is the responsibility of all members of the University community—faculty, staff, and students—to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff, and students have the responsibility of supporting an environment that encourages academic integrity. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not

relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

Undergraduate Calendar - Academic Misconduct

<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml>

Graduate Calendar - Academic Misconduct

<https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml>

9.7 Recording of Materials

Presentations that are made in relation to course work - including lectures - cannot be recorded or copied without the permission of the presenter, whether the instructor, a student, or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

9.8 Resources

The Academic Calendars are the source of information about the University of Guelph's procedures, policies, and regulations that apply to undergraduate, graduate, and diploma programs.

Academic Calendars

<https://www.uoguelph.ca/academics/calendars>

9.9 Illness

Medical notes will not normally be required for singular instances of academic consideration, although students may be required to provide supporting documentation for multiple missed assessments or when involving a large part of a course (e.g.. final exam or major assignment).
