ENGG*3490 Introduction to Mechatronic Systems Design

01

Winter 2020
Section(s): C01

School of Engineering
Credit Weight: 0.75
Version 1.00 - January 05, 2020

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1 Course Details

1.1 Calendar Description

This course covers the design of mechatronic systems, which are synergistic, combinations of components and controls drawn from mechanical engineering, electronics, and computer engineering. The course covers the following areas: (1) modeling of mechatronic systems (mechanical, electrical/electronic systems) and understanding their behaviour, (2) sensing and measurement including a variety of mechatronics sensors (fundamentals and applications), (3) actuators specific to mechatronics including motors and drivers (fundamentals and applications), (4) basic microcontroller programming as well as sensor/actuator integrations, and (5) control and its applications in mechatronics.

Pre-Requisites: ENGG*2340, ENGG*2450
Co-Requisites: ENGG*3410

1.2 Course Description

This course covers an introduction to mechatronics systems. Mechatronics, in general, is involved with mechanical, electrical and computer systems. Recently, mechatronics have found a variety of applications in many fields especially in the automation and manufacturing industries. In this course, you will learn about mechatronics systems: how are they designed and controlled. We will cover programmable logic controller (PLC), review and modeling of mechatronic systems, sensing and measurement, sensors and applications, actuators and their applications, modeling and control of electric motors (dc and ac), as well as stepper and servo motors. You will learn important concepts such as analog/digital or digital/analog conversion. Microprocessors and microcontroller structures will be introduced and discussed. As well, some control techniques for mechatronic systems will be introduced, and finally mobile robotic systems and their recent advances will be reviewed. By the end of the

term, you should have a good understanding of design, modeling and control of mechatronic systems. This course contains theory and practical applications of those systems. More importantly, the course has hands-on and practical projects which provide you with great skill sets required to succeed in your career. This course covers the following topics:

1. Introduction to mechatronic systems: basics
2. Sensors and instrumentation
3. Modeling of Mechatronics systems
4. Response
5. Actuators and Motors
6. Microprocessor and microcontroller
7. Programmable logic controller (PLC)
8. Control

1.3 Timetable

Lectures

Lectures:

Tuesday	4:00 pm–5:20pm	MCKN, 121
Thursday	4:00 pm–5:20pm	MCKN 121

Laboratory:

Monday	12:30PM - 02:20PM	THRN 2307
Friday	9:30am - 11:20am	THRN 2307
Friday	12:30pm - 2:20pm	THRN 2307

* labs start the week of January 13

1.4 Final Exam

Final Exam: 30%

08:30AM - 10:30AM (2019/04/14), Room TBA on Webadvisor

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2 Instructional Support

2.1 Instructional Support Team

Instructor:	Mohammad Biglarbegian Ph.D., P.Eng.
Email:	mbiglarb@uoguelph.ca
Telephone:	+1-519-824-4120 x56248
Office:	THRN 2339
Office Hours:	By appointment
Lab Technician:	Kevin Dong P.Eng.
Email:	kdong@uoguelph.ca
Telephone:	519-824-4120 x53729
Office:	RICH 2506

2.2 Teaching Assistants

Teaching Assistant:	Benjamin Dyer
Email:	bdyer@uoguelph.ca
Office Hours:	TBA/By appointment

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3 Learning Resources

3.1 Required Resources

Course Website (Website)

Course material, news, announcements, and grades will be regularly posted to the ENGG*3490 Courselink site. You are responsible for checking the site regularly.

Required Resources (Other)

Students are expected to attend all the lecturers. Students are responsible for whatever material is taught in the class. Note that the textbook may not have all the material taught in the class.

There is no single textbook that can cover all the material taught in a Mechatronics course in general, simply because Mechatronics is multidisciplinary. The following book is a great source:

“Mechatronics: A Multidisciplinary Approach”, W. Bolton, 6th edition, Prentice Hall, 2015.

3.2 Recommended Resources

Recommended Resources (Textbook)

"Applied Mechatronics", A. Smaili, F Mrad, Oxford University Press, 2008. "Programmable Logic Controllers", Frank D. Petruzella, 3/E, McGrawHill, 2005. "Mechatronics", Dan S. Necsulescu, Prentice Hall, 2002.

"Principles of Robot Motion", H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki and S. Thrun, MIT Press, Boston, 2005

"Principles and Applications of Electrical Engineering", by G. Rizzoni, McGraw-Hill, 5th edition, 2007. "Electric Machinary Fundamental", by S. J. Chapman, McGraw-Hill, 5th edition, 2011.

"Programmable Logic Controller", J. R. Hackworth, F. D. Hackworth, Jr., 4th edition, Prentice Hall, 2004.

3.3 Additional Resources

Additional Resources (Other)

Lecture Information: Students should attend the classes and make their own notes.

Lab Information: The handouts for all the lab sessions are within the lab section. All types of resources regarding tutorials, links to web pages can be found in this section.

Homework: Download the homeworks according to the schedule given in this handout. All the solutions will be posted as indicated.

Miscellaneous Information: Other information related to Mechatronics are also posted on the web page.

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4 Learning Outcomes

4.1 Course Learning Outcomes

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

1. Learn how to work with sensors; learn how to acquire data; learn how to calibrate sensors.
2. Learn how to work with actuators and micro-controllers; learn to connect sensors and actuators to micro-controllers; learn to program micro-controllers.
3. Learn how plan a project; learn how to integrate a project components;
4. Learn how to prototype and execute a mechatronics design project; learn how to

troubleshoot; learn how to deliver a project.

5. Learn project reporting and engineering communication.
6. Learn how to design, solve problems, and perform data analysis for mechatronics systems.

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome
2	Problem Analysis	1, 2, 6
2.3	Construct a conceptual framework and select an appropriate solution approach	1
2.4	Execute an engineering solution	6
2.5	Critique and appraise solution approach and results	2
4	Design	3, 4
4.1	Describe design process used to develop design solution	3
4.4	Evaluate alternative design solutions based on problem definition	4
7	Communication Skills	5
7.1	Identify key message(s) and intended audience in verbal or written communication as both sender and receiver	5

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5 Teaching and Learning Activities

5.1 Lecture

Topics: Background and Review

Topics: Electrical/Electronic Systems & Modeling with Applications
References: Class lectures

Topics: Mechanical Systems Modeling
References: Class lectures

Topics: System response
References: Class lectures

Topics: Principles of sensing
References: Class lectures

Topics: Sensors
References: Class lectures

Topics: Actuators and Motors
References: Class lectures

Topics: PLC
References: Class lectures

Topics: Control concepts
References: Class lectures

Topics: Control design: state space
References: Class lectures

Topics: Mobile Robots and Application
References: Chapter 3

Topics: Mobile Robot Motion Planning
References: Chapter 8

Topics: Estimation (not mandatory)
References: Class lectures

5.2 Lab

Topics: 1 Introduction to Lab Equipment, Safety Training, Course Project, and Group Formation
Due Week 2

Topics: Lab 1: Sensor Measurements
Due Week 3

Topics: Lab 2: Stepper Motors
Due Week 4

Topics: Project Work Period, questions/answers regarding project/course

Topics: Project Milestone: Integration of Sensors with Arduino
Due Week 6

Topics: Project Work Period, questions/answers regarding project/cours

Topics: Project Milestone: Loading Station Base Completed
Due Week 10

Topics: Project Milestone: All Machining Completed
Due Week 11

Topics: Project Milestone: Final Demonstrations
Due Week 12

5.3 Other Important Dates

Monday, January 6, 2020: First day of classes
Monday, February 17, 2020: Winter study week
Friday, April 3, 2020: drop date
Friday, April 3, 2020: last day of classes

* labs start the week of January 13

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6 Assessments

6.1 Assessment Details

Lab 1 (8%)
Learning Outcome: 1, 1, 1, 1

- Introduction to labs as well as Lab 1 will be done on the week of Jan. 13
- Lab 1 report due: week of January 27

Lab 2 (8%)
Learning Outcome: 2

- Lab 2 will be done on the week of Jan. 27
- Lab 2 report due: week of Feb. 10

Project Milestones (4%)
Learning Outcome: 1, 1, 1, 1, 1, 1, 3

Final Project (35%)
Learning Outcome: 1, 1, 1, 4

- Please see pages 8 -12 for details, milestones, and deadlines.

Final Project Report (15%)
Learning Outcome: 5

- Please see pages 12 for details and the deadline.

Final Exam (30%)
Learning Outcome: 1, 1, 1, 1, 1, 6
08:30AM - 10:30AM, 2019/04/09, Room TBA on Webadvisor

6.2 Final Project

Final Project

The description of the project with all the necessary details will be posted on the Courselink.

Project description

For the course project, you are required to design and build an autonomous mobile robot that is capable of navigating a maze. The maze, which we call it also 'environment' is composed of several obstacles (both static and dynamic). Building includes mechanical design and fabrication of the robot as well as mounting microcontrollers and on-board sensors. Please visit the course webpage on the Courselink for information about the maze and all the dimensions.

The robot should be able to start from a known starting point, 'start', identify the environment and navigate through the maze until it reaches a 'goal'; the location of 'goal' is also known.

Note 1: Each group consists of 5~6 people (max. 6). Each group **must** contain **at least** one mechanical student due to shop policies. It is also **recommended** that your group include one ES&C or Computer student if possible.

Note 2: There is no late policy for the final demo. Late demonstration is not acceptable. Each group needs to demonstrate their project (whatever they have done by the deadline).

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 1(a): Important dates

Item	Assigned / Start	Due / Finish	Mark
Project	Jan 7	March 16 for Monday labs	35

		March 20 for Friday labs	
Final Design Report	---	March 23 for Monday labs March 27 for Friday labs	15

Table 1(b): Project Completion Intermediate Milestones

Milestones	**Due by / Finish**	**Mark**
Interfacing Sensors and Actuators	Feb 24 for Monday labs Feb 28 for Friday labs	2
All machining parts done	March 9 for Tuesday labs March 13 for Friday labs	2

Project marking

The project demonstration will be marked out of **35**. The mark breakdown depends on the following categories: (1) design (**10%)**, (2) performance (**17%**), and (3) speed (**8%**).

Design (12%)

The first category is broken down into three subcategories as outlined in the table below.

Table 3: Design category Marks Weighting

Subcategory	Weight
Relevance to Mechatronics Design	4
Conformance to Dimensions specifications	2
Quality of Design – machining	3
Circuitry Quality (neat, clean)	1

Relevance to Mechatronics Design: ENGG*3490 main emphasis is one mechatronics design and full mark will be given if all the sensors are fully utilized. Justification for using all the sensors needs to be mentioned and reflected in the final report. For every sensor that is neither suitably used nor any acceptable justification provided one mark will be deducted.

Conformance to Dimensions specifications: groups should design their robot to conform to the dimensions between maximum 25 cm to maximum of 12 cm.

Quality of Design – machining: Your final robot should be a product of systematic application of a well thought out design process that meets the project requirements. Your final design should reflect this fact and hence poorly machined parts or subsections of the mechanism that are products of “last minute” tweaking to ensure the objective is met will not be looked at favorably during the final evaluation. Your design should demonstrate that considerable time has been allocated to the implementation of the predefined design process. Also, your final product should reflect the fact that time was spent in the machine shop to ensure the integrated sorting mechanism is robust and was not put together in a rush to meet the competition deadline. Poorly-machined or integrated parts in your final design will result in mark deduction in this subcategory.

Circuitry Quality: you should also do a great job with circuity layout and make sure all the connections and wirings are done neatly and nicely. It is important not to just have a functional electronic system, but also a product that looks professional.

Performance (17%)

This category relates to efficiency of the autonomous system. At the end of completion, robot should get to the final goal position while not having any collisions with the walls or obstacles.

For a robot that gets from start to goal without any collisions, a full mark of 17/17 is guaranteed in this category. Every time the robot hits a wall 3 marks, collides with a static obstacle 2 marks (for each obstacle) and dynamic obstacle 1 mark will be deducted. Partial marks will be given if a robot could not finish the task completely, i.e., if the robot finishes roughly x% of the course, then (x/100)*17 marks will be given.

Speed (8%)

The third category depends on speed of the robot for navigating the environment from start to goal.

- For groups that scored 17/17 in performance, a full mark of 8/8 in speed will be awarded to the group that completes the maze perfectly (no collision etc.) in the fastest time. The group that requires the longest time to navigate the entire maze will receive a mark of 4/8 in this category. The mark for all other groups (that successfully completed category 2) will be spanned linearly between 8/8 and 4/8.

- All groups that fail to score 17/17 in performance will be placed in a separate poll for evaluation for speed. They will be ranked based on speed of sorting and their mark in this category will be calculated as

(mark in performance/17)*(8)*(speed of fastest group in the pool/recorded speed of the group).

6.3 Important Note

While you are encouraged to discuss with other classmates about the labs or project, there is zero tolerance for plagiarism or copying. Cases of academic misconduct will be reported.

6.4 Project Report

Report Deliverables

Final Design Report

The purpose of this report is to communicate the progress leading up to your group's resulting design. It will detail your design specifications, explaining calculations and analyses that ensure that your final design meets specifications. It should also include all microcontroller program code and a description of the logic you used to separate and sort the nuts. Any further testing, simulation, and results should be detailed and discussed. In addition, this report will also include changes to budgetary and scheduling plans. While the report should be comprehensive and include all the necessary information, it should not exceed **10 pages**. Appendices and codes are not counted toward the 10 page limit. Both hard and soft copies are required for submission. Reports should be submitted to the TA and are due by 5:30 pm on March 28th. Reports that are not submitted by 5:30 pm on March 28th will not receive any marks.

6.5 Important Note regarding final exam

Final exam is closed-book, closed-notes. A formula sheet will be provided in the exam.

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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: In order to pass the course, you must obtain a grade of 50% or higher in total.

Lab Work: You must attend and complete all laboratories. If you miss a laboratory due to grounds for granting academic consideration or religious accommodation, arrangements must be made with the teaching assistant to complete a makeup lab.

Late Lab Reports: Late submissions of lab reports will **not** be accepted.

7.2 Relationships with other Courses & Labs

Previous Courses:

ENGG*2340: Systems, first-order, 2nd order systems, signals
ENGG*3450: Fundamentals of DC and AC circuits, KVL, KLC

Courses:

ENGG*3410: Control systems, feedback, etc.

Follow-on Courses:

ENGG*4480: Advanced Mechatronics
ENGG*4030: Manufacturing System Design
ENGG*4480: Advanced Mechatronic Systems Design

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 book their exams at least 7 days in advance and not later than the 40th Class Day.

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
