ENGG*3490 Introduction to Mechatronic Systems Design

Winter 2019
Section(s): C01

School of Engineering
Credit Weight: 0.75
Version 1.00 - January 06, 2019

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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-Requisite(s): ENGG*2340, ENGG*2450
Co-Requisite(s): 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
9. Robotics: mobile robots

1.3 Timetable

Lectures

Lectures:

Tuesday	4:00 pm–5:20pm	CRSC 116
Thursday	4:00 pm–5:20pm	CRSC 116

Laboratory:

Tuesday	8:30am - 10:20am	THRN 2307
Wednesday	8:30am - 10:20am	THRN 2307
Friday	8:30am - 10:20am	THRN 2307

1.4 Final Exam

Final Exam: 30%

08:30AM - 10:30AM (2019/04/09), 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 Assistant(s)

Teaching Assistant: Amit Patel
Email: apatel21@uoguelph.ca
Office Hours: TBA/By appointment

Teaching Assistant: Freeman Mak
Email: fmak@uoguelph.ca
Office Hours: TBA/By appointment

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3 Learning Resources

3.1 Required Resource(s)

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 Resource(s)

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 Resource(s)

Additional Resources (Other)

Lecture Information: **Only some supplementary parts** of the lectures notes might be posted on the web page. The reason is to ensure that students attend the classes to learn the material. 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(s)
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

5 Teaching and Learning Activities

5.1 Lecture

Topic(s): Background and Review

Topic(s): Electrical/Electronic Systems & Modeling with Applications
Reference(s): Class lectures

Topic(s): Mechanical Systems Modeling
Reference(s): Class lectures

Topic(s): System response
Reference(s): Class lectures

Topic(s): Principles of sensing

Reference(s): Class lectures

Topic(s): Sensors
Reference(s): Class lectures

Topic(s): Actuators and Motors
Reference(s): Class lectures

Topic(s): PLC
Reference(s): Class lectures

Topic(s): Control concepts
Reference(s): Class lectures

Topic(s): Control design: state space
Reference(s): Class lectures

Topic(s): Mobile Robots and Application
Reference(s): Chapter 3

Topic(s): Mobile Robot Motion Planning
Reference(s): Chapter 8

Topic(s): Estimation (not mandatory)
Reference(s): Class lectures

5.2 Lab

Topic(s): 1 Introduction to Lab Equipment, Safety Training, Course Project, and Group Formation
Due Week 2

Topic(s): Lab 1: Sensor Measurements
Due Week 3

Topic(s): Lab 2: Stepper Motors
Due Week 4

Topic(s): Project Work Period, questions/answers regarding project/course

Topic(s): Project Milestone: Integration of Sensors with Arduino
Due Week 6

Topic(s): Project Work Period, questions/answers regarding project/cours

Topic(s): Project Milestone: Loading Station Base Completed
Due Week 10

Topic(s): Project Milestone: All Machining Completed
Due Week 11

Topic(s): Project Milestone: Final Demonstrations
Due Week 12

5.3 Other Important Dates

Monday, January 7, 2019: First day of class
Monday, February 18, 2019: Winter study week
Friday, March 8, 2019: drop date – 40th class
Friday, April 5, 2019: last day of classes

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6 Assessments

6.1 Assessment Details

Lab 1 (7.5%)
Learning Outcome(s): 1

Lab 2 (7.5%)
Learning Outcome(s): 2

Project Milestones (9%)
Learning Outcome(s): 3

Final Project (34%)
Learning Outcome(s): 4

Final Project Report (12%)
Learning Outcome(s): 5

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

6.2 Final Project

Final Project

The final project is due on week 12 (week of March 25):

- March 26 for Tuesday Labs
- March 27 for Wednesday Labs
- March 29 for Friday Labs

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

Final Project marking Scheme

The project demonstration will be marked out of 34. The mark breakdown depends on the following
categories: (1) design (18 marks), (2) performance (12 marks), and (3) speed of sorting (4 marks).

Design (18 marks)
The first category is broken down into 4 subcategories as outlined below:
Relevance to Mechatronics Design: 6 marks
Conformance to Dimensions specifications: 4 marks
Footprint of the Mechanism: 4 marks
Quality of Design machining: 4 marks

Performance (12 marks)
This category relates to efficiency of the sorting mechanism. At the end of sorting, each mug should have
3 nuts that belong to this container category. For every container, an inspection will be performed at the
end of sorting to count the number of nuts and their types. For every nut that does not belong to a specific
container a total of 1 mark will be deducted. For example if a sorting mechanism places 3 correct nuts in
container 1 (3 steel small), 2 correct in container 2 (2 brass medium and 1 brass large), 2 correct in
container 3 (2 brass large and 1 nylon large), and 2 correct in container 4 (2 nylon large and 1 brass medium); a total of 3 marks will be deducted and the groups' grade in this category will be 9/12. An empty container results in 3 marks deduction for this container. Also, at the end of sorting for every container having 2 or 4 nuts (of any combination) will result in 1 mark deduction. Every container having 1 nut or 5 nuts as opposed to 3 will result in 2 marks deduction. If the sorting of all 12 nuts is done correctly, a full mark of 12/12 is guaranteed in this category.

Speed (4 marks)
The third category depends on speed of sorting.
- For groups that scored 12/12 in performance, a full mark of 8/8 in speed will be awarded to the group
that completes the "correct" sorting in the fastest time. The group that requires the longest time to
correctly sort 12 nuts will receive a mark of 2/4 in this category. The mark for all other groups (that
successfully completed category 2) will be spanned linearly between 2/4 and 4/4.
- All groups that fail to score 12/12 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/12)*(4)*(recorded speed of the group/speed of fastest group in the pool).

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

Final Design Report (Due Date: April 5)
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. Your final report is
worth 10 marks.

Project marking
The project demonstration will be marked out of 34. The mark breakdown depends on the following
categories: (1) design (18 marks), (2) performance (12 marks), and (3) speed of sorting (4 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

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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.

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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

9.3 Drop Date

Courses that are one semester long must be dropped by the end of the fortieth class day; two-semester courses must be dropped by the last day of the add period in the second semester. The regulations and procedures for course registration are available in the Undergraduate and Graduate 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

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.

More information can be found on the SAS website
https://www.uoguelph.ca/sas

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
