Western University
Department of Mechanical & Materials Engineering

MME 4487a — Mechatronic System Design

COURSE OUTLINE 2023–2024

CALENDAR DESCRIPTION:

An overview of electrical, mechanical, optical, and control technologies for system integration. Topics include: intelligent products and processes; design methodology; system modeling; sensors and actuators; microcontrollers; knowledge-based control.

COURSE INFORMATION:

Instructor: Michael D. Naish, PhD, P.Eng.
Room: ACEB 3470
Email: mnaish@uwo.ca

Timetable information is available at https://draftmyschedule.uwo.ca/

PREREQUISITES:

MME 2213A/B or MME 2234A/B, and ECE 3374A/B, or (ECE 2233A/B and ECE 2277A/B), or (ECE 2238A/B and ECE 2277A/B).

Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you will be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

ACCREDITATION UNITS:

Engineering Science = 40%, Engineering Design = 60%

TOPICS AND LEARNING OBJECTIVES:

Mechatronic system design strives to integrate mechanical, electronic, optical, and computer technologies in order to create "optimal" products and processes. Basic concepts and fundamental principles will be reviewed in this course. Students will develop the knowledge and skills necessary to adopt an interdisciplinary approach to mechatronic system design through the lectures, hands-on laboratory assignments, and a term design project. Specific topics and learning objectives include:

1. **Mechatronic System Design**
   The concepts of mechatronic systems, their primary components, and how they are designed in a systematic manner will be introduced at the beginning and reinforced throughout the course. In the end, students will be able to:
   a. Identify and explain the components and characteristics of a mechatronic system **KB4**
   b. Explain how intelligent products and systems are developed **KB4**
   c. Expand engineering design knowledge to encompass mechatronic design principles **KB4**
   d. Explain the role of sensors, actuators, control, and machine intelligence in product performance **KB4**
   e. Apply product design and systems engineering concepts to the development of a mechatronic system **D1, D2, D3, D4**
   f. Adapt mechanical designs into mechatronic designs **D1, D2, D3, D4**
2. **Microcontrollers**
   Microcontrollers are a key component of mechatronic systems, providing control and intelligence functionality. The structure of microcontrollers, how they are programmed, and how they are interfaced with external devices will be introduced and expanded upon throughout the course. In the end, students will be able to:
   a. Understand the architecture and organization of microcontrollers **KB4**
   b. Discuss how to integrate a programmable device into a smart product **PA2**
   c. Demonstrate the programming skills needed to write, modify, and implement code for an ESP32 microcontroller **PA2, ET2, ET3**
   d. Understand and demonstrate how to interface with analog and digital peripheral devices **KB4, PA2, ET2, ET3**
   e. Design, construct, and evaluate functional mechatronic systems **D2, D3, D4**
3. **Sensors and Actuators**
   Sensors provide critical information to a mechatronic system and actuators allow a system to affect the environment. At the end of this section, students will be able to:

a. Explain the operating characteristics and use of electrical and optical sensors **KB4**
b. Explain the operating characteristics and use of DC electromechanical actuators **KB4**
c. Select and integrate suitable sensors and actuators into a mechatronic design **PA1, PA2, PA3**
d. Construct and evaluate simple electronic circuits to interface with sensors and actuators **ET2, ET3**

4. Communication Systems

Several methods of wireless communications will be introduced. At the end of this section, students will be able to:

a. Explain the operating principles of wireless communication **KB4**
b. Assess simple wireless electronic (optical and radio-frequency) communication systems **KB4**
c. Implement wireless communication methods with a microcontroller **ET2, ET3**

5. Machine Control and Intelligence

Microcontrollers afford the opportunity to embed human knowledge into the operation of devices and enable them to behave in an intelligent manner. At the end of this section, students will be able to:

a. Explain how human knowledge can be represented by a digital computer **KB4**
b. Illustrate how human-like control and intelligence can be integrated into a mechatronic system using knowledge based systems, fuzzy logic, and artificial neural networks **KB4**

CONTACT HOURS: 2 lecture hours and 3 laboratory hours per week, half course. Note that the laboratory work includes individual self-study.

TEXT: **Optional:** W. Bolton, *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering*, 7th Edition, Pearson Education, 2018. ISBN # 978-1292250977
Note: Students must purchase an *MME 4487 Lab Kit* through Western Engineering.

REFERENCES: Assigned Readings

UNITS: SI

EVALUATION: The course grade will be determined as follows:

Individual Laboratory Assignments (Total = 5)		
Assignment 1	*Begins week of Sept. 18, 2023*	5%
Assignment 2	*Begins week of Sept. 25, 2023*	5%
Assignment 3	*Begins week of Oct. 2, 2023*	5%
Assignment 4	*Begins week of Oct. 9, 2023*	5%
Assignment 5	*Begins week of Oct. 16, 2023*	5%
In-class Tests (Total = 2)		
Test 1	*Oct. 19, 2023*	10%
Test 2	*Nov. 16, 2023*	10%
Term Project		
Milestone 1	*Oct. 10, 2023*	5%
Milestone 2	*Oct. 23, 2023*	5%
Milestone 3	*Nov. 13, 2023*	5%
Milestone 4	*Nov. 20, 2023*	5%
Prototype and Demonstration	*Nov. 30, 2023*	10%
Group Design Report	*Due Dec. 8, 2023*	25%

The dates listed above are **tentative** and may be adjusted if needed. Marks will be assigned on the basis of method of analysis and presentation, correctness of solution, clarity and neatness.

COURSE POLICIES: All work submitted must be of professional quality. Material that is handed in dirty, illegible, or disorganized will be returned to the student for resubmission and the late submission penalty will take effect. An additional penalty of 10% may be deducted for poor grammar, incoherence or lack of flow in the written reports.

Laboratory sessions:

- Attendance at all laboratory sessions is mandatory.

- Students who arrive 20 min after the scheduled lab time without a legitimate reason, leave the lab early without permission from the TA, or miss the lab without a legitimate reason will receive a zero for the corresponding laboratory assignment.
- Students who miss a lab with academic consideration are required to contact the course instructor for further instructions. Failure to do so will result in a zero mark for that lab.
- The laboratory exercises are to be completed individually. The lab deliverables will be assessed online. Most items will be demonstrated to a TA, while some will also require an online submission. Plagiarism checks will be in place to ensure that each student submits original material. Work that is found to be unoriginal will result in a grade of 0 for the lab, in the first instance. Subsequent submissions of unoriginal material will result in more severe academic penalties.
- Assignments will be penalized by 10% of the available marks per day for late submission. Assignments submitted more than 5 days late will not be accepted.
- A minimum mark of 50% in each laboratory exercise, with a minimum average of 60% across all laboratory exercises is required to pass the course.

In-class tests:

- If a student misses a test, the test will not be rescheduled regardless of the circumstances for which the test was missed. The student must contact the instructor if unable to attend, and the instructor will decide whether to allow the reweighting of the test, where reweighting means the marks normally allotted for the test will be added to the other test.
- If a student is going to miss the test for religious reasons, they must inform the instructor in writing within 48 hours of the announcement of the test date or they will be required to write the test at the scheduled time.
- Missing the test without academic consideration will result in a grade of zero for the test.
- At least one of the two tests must be written in order to pass the course.

Project:

- Project teams will be formed by the third week of the term. Students must form a team with others in the same lab section.
- The default assumption is that everyone contributes equally to the team effort, and hence all students will receive the same grade for the project components. Each student will be asked to specify the contribution made by each member of the team, including themself. Team grades may be adjusted by up to 30% for each student based on self and peer evaluation. Students who provide limited contributions to the team effort may receive a failing project grade, irrespective of the how well the rest of the team does.
- A minimum of 60% must be obtained on the project in order to pass the course.

Tips for success:

- You are responsible for all material posted online and discussed in class. Class attendance is highly encouraged. Attention to the events happening in each lecture will ensure your understanding of the topics and will allow you to gain the most from the course.
- While every student works at a different level, it is the effort placed in each requirement that ultimately leads to success. Your interest in the course, participation in class by asking relevant questions, and talking to the instructor during office hours will all contribute to your successful completion of the assignments, labs, test, and project. Such behavior is highly encouraged.
- It is your responsibility to determine what is required of you. If you miss a lecture, it is your responsibility to find out what was discussed and what instructions were given regarding assignments, laboratory sessions, or exams.
- Plan to arrive to class and to the lab a few minutes early. Lectures will start promptly, and immediate attention will be required from the start.

CONSULTATION HOURS: By appointment

ENGLISH: In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests and examinations for the improper use of English. Additionally, poorly written work with the exception of final examinations may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

ATTENDANCE: All classes, laboratories, and tutorials are mandatory unless otherwise stated. Any student who, in the opinion of the instructor, is absent too frequently from class or laboratory periods in any course, will be reported to the Dean (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Dean, the student will be debarred from taking the regular examination in the course.

RELIGIOUS ACCOMMODATION: Students should consult the University's list of recognized religious holidays, and should give reasonable notice in writing, prior to the holiday, to the Instructor and an Academic Counsellor if their course requirements will be affected by a religious observance. Additional information is given in the Western Multicultural Calendar.

CHEATING: Students must write their reports and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. University policy states that cheating, including plagiarism, is a scholastic offence. The commission of a scholastic offence is attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning.

All required papers may be subject to submission for textual similarity review to commercial plagiarism-detection software under license to the University for the detection of plagiarism. All papers submitted will be included as source documents on the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between the University of Western Ontario and Turnitin.com (http://www.turnitin.com).

Scholastic offences are taken seriously and students are directed to the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following Web site: http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf

Note that, unless a particular assignment or deliverable explicitly states otherwise, the use of generative artificial intelligence tools and apps is strictly prohibited. This includes ChatGPT and other AI writing and coding assistants. The use of generative AI in this course may be considered use of an unauthorized aid, which is a form of cheating.

SSD: Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 661-2111 x 82147 for any specific question regarding an accommodation.

NOTE: The above topics and outline are subject to adjustments and changes as needed. Students who have failed an Engineering course (i.e., < 50%) must repeat all components of the course. No special permissions will be granted enabling a student to retain laboratory, assignment or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted for grading by the student in subsequent years.

August 29, 2023

STATEMENT ON GENDER-BASED AND SEXUAL VIOLENCE

Western is committed to reducing incidents of gender-based and sexual violence and providing compassionate support to anyone who has gone through these traumatic events. If you have experienced gender-based or sexual violence (either recently or in the past), you will find information about support services for survivors, including emergency contacts, here. To connect with a case manager or set up an appointment, please contact support@uwo.ca.

INSTRUCTIONS FOR STUDENTS UNABLE TO WRITE TESTS OR EXAMINATIONS OR SUBMIT ASSIGNMENTS AS SCHEDULED

If, on medical or compassionate grounds, you are unable to write term tests or final examinations or complete course work by the due date, you should follow the instructions listed below. You should understand that academic relief will not be granted automatically on request. You must demonstrate to your department (or the Undergraduate Services Office) that there are compelling medical or compassionate grounds that can be documented before academic relief will be considered. Different regulations apply to term tests, final examinations and late assignments. Please read the instructions carefully.

A. *GENERAL REGULATIONS & PROCEDURES*

1. All first-year students will report to the Undergraduate Services Office by submitting the Academic Consideration Request Form, for all instances.

2. If you are an upper year student and you are missing a test/assignment/lab or examination you will report the absence by submitting Academic Consideration Request Form. Absences worth LESS THAN 10% of your mark, will be processed by your department office. If your course work is worth 10% OR MORE of your final grade, your request will be processed by the Undergraduate Services Office.

3. Check the course outline to see if the instructor has a policy for missed tests, examinations, late assignments or attendance.

4. Documentation must be provided as soon as possible. If no one is available in your department office or the Undergraduate Services Office, leave a message clearly stating your name & student number and reason for your call. The department telephone numbers are given at the end of these instructions.

5. If you decide to write a test or an examination you should be prepared to accept the mark you earn. Rewriting tests or examinations or having the value of a test or examination reweighted on a retroactive basis is not permitted.

B. *TERM/MIDTERM TESTS*

1. If you are in first year and you are unable to write a midterm/term test, contact the Undergraduate Services Office, SEB 2097 PRIOR to the scheduled date of the test.

2. If you are an upper year student and you are unable to write a midterm/term test, inform your instructor PRIOR to the scheduled date of the test and request relief through the Academic Consideration Request Form. If the instructor is not available, leave a message for him/her at the department office. If the test is worth LESS THAN 10% of your mark, your request for relief will be processed by your department office. If the test is worth MORE THAN 10% of your final grade your request for relief will be processed by the Undergraduate Services Office.

3. Be prepared to attach supporting documentation to the Department Chair and/or the Undergraduate Services Office through the online form (see next page for information on documentation).

4. Discuss with the instructor if and when the test can be rescheduled. The approval of the Chair or the Undergraduate Services Office is required when rescheduling midterm/term tests.

C. *FINAL EXAMINATIONS*

1. If you are unable to write a final examination, contact the Undergraduate Services Office PRIOR TO THE SCHEDULED EXAMINATION TIME to report your absence using the Academic Consideration Request Form and request permission to write a Special Final Examination. If no one is available in the Undergraduate Services Office, leave a message clearly stating your name & student number.

2. Be prepared to provide the Undergraduate Services Office with supporting documentation (see next page for information on documentation) the next day, or as soon as possible (in cases where students are hospitalized). The following circumstances are not considered grounds for missing a final examination or requesting special examinations: common cold, headache, sleeping in, misreading timetable and travel arrangements.

3. In order to receive permission to write a Special Examination, you must obtain the approval of the Chair of the Department **and** the Associate Dean and in order to apply you must submit an "Application for a Special Exam" form. The Undergraduate Services Office will then notify the course instructor(s) and reschedule the examination on your behalf.

   PLEASE NOTE: **It is the student's responsibility to check the date, time and location of the Special Examination.**

D. *LATE ASSIGNMENTS*

1. Advise the instructor if you are having problems completing the assignment on time (**prior** to the due date of the assignment).
2. Be prepared to submit the Academic Consideration Request Form and provide documentation if requested by the instructor (see reverse side for information on documentation).
3. If you are granted an extension, establish a due date. The approval of the Chair of your Department (or the Assistant Dean, First Year Studies, if you are in first year) is not required if assignments will be completed prior to the last day of classes.
4. i) Extensions beyond the end of classes must have the consent of the instructor, the department Chair and the Associate Dean, Undergraduate Studies. Documentation is mandatory.
   ii) A Recommendation of Incomplete Form must be filled out indicating the work to be completed and the date by which it is due. This form must be signed by the student, the instructor, the department Chair and the Associate Dean, Undergraduate Studies.

E. *SHORT ABSENCES*

If you miss a class due to a minor illness or other problem, check your course outlines for information regarding attendance requirements and make sure you are not missing a test, laboratory or assignment. Cover any readings and arrange to borrow notes from a classmate.

F. *EXTENDED ABSENCES*

If you are absent more than one week or if you get too far behind to catch up, you should consider reducing your workload by dropping one or more courses. (Note drop deadlines listed below). You are strongly encouraged to seek advice from your Academic Counsellor in the Undergraduate Services Office.

G. *DOCUMENTATION*

If you consulted an off-campus doctor or Student Health Services regarding your illness or personal problem, **you must provide the doctor with a Student Medical Certificate** to complete at the time of your visit and then bring it to the Department (or the Undergraduate Services Office). **This note must contain the following information: severity of illness, effect on academic studies and duration of absence. Regular doctor's notes will not be accepted; only the Student Medical Certificate will be accepted.**

In Case of Serious Illness of a Family Member: Provide a Student Medical Certificate to your family member's physician to complete and bring it to the Department (or the Undergraduate Services Office if you are in first year).

In Case of a Death: Obtain a copy of the death certificate or the notice provided by the funeral director's office. You must include your relationship to the deceased and bring it to the Department (or the Undergraduate Services Office if you are in first year).

For Other Extenuating Circumstances: If you are not sure what documentation to provide, ask the Departmental Office (or the Undergraduate Services Office if you are in first year) for direction.

Note: **Forged notes and certificates will be dealt with severely. To submit a forged document is a scholastic offence (see below).**

H. *ACADEMIC CONCERNS*

1. You need to know if your instructors have a policy on late penalties, missed tests, etc. This information may be included on the course outlines. If not, ask your instructor(s).

2. **You should also be aware of attendance requirements in some courses. You can be debarred from writing the final examination if your attendance is not satisfactory.**

3. If you are in academic difficulty, check out the minimum requirements for progression in the calendar. If in doubt, see your Academic Counsellor.

Calendar References: Check these regulations in your 2023 Western Academic Calendar available at www.westerncalendar.uwo.ca.

Absences Due to Illness:
https://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_135
Academic Accommodations for Students with Disabilities:
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_10
Academic Accommodations for Religious or Holy Days:
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_16
Course Withdrawals:
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=6&SelectedCalendar=Live&ArchiveID=#Page_75
Examinations:
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?PolicyCategoryID=5&command=showCategory&SelectedCalendar=Live&ArchiveID=
Scheduling of Term Assignments:
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=5&SelectedCalendar=Live&ArchiveID=#SubHeading_78
Scholastic Offences:
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_20
Student Medical Certificate:
https://www.eng.uwo.ca/files/undergraduate/student-medical-certificate.pdf
Engineering Academic Regulations:
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=4&SelectedCalendar=Live&ArchiveID=#Page_86

Note: These instructions apply to all students registered in the Faculty of Engineering regardless of whether the courses are offered by the Faculty of Engineering or other faculties in the University.

Add Deadlines:	First term half course (i.e. "A" or "F")	September 15, 2023
	Full courses and full-year half course (i.e. "E", "Y" or no suffix)	September 15, 2023
	Second term half course (i.e. "B" or "G")	January 16, 2024
***Drop Deadlines*:**	First term half course without penalty (i.e. "A" or "F")	November 13, 2023
	Full courses and full-year half courses without penalty (i.e. "E","Y" or no suffix)	November 30, 2023
	Second term half or second term full course without penalty (i.e. "B" or "G")	March 7, 2024

Contact Information:

Undergraduate Services Office:	SEB 2097	Phone: 519-661-2130	E-mail: engugrad@uwo.ca
Chemical & Green Process Engineering:	TEB 477	Phone: 519-661-2131	E-mail: cbeugrad@uwo.ca
Civil Engineering:	SEB 3005	Phone: 519-661-2139	E-mail: civil@uwo.ca
Computer, Electrical, Mechatronic Systems & Software Engineering	TEB 279	Phone: 519-661-3758	E-mail: eceugrad@uwo.ca
Integrated Engineering	ACEB 2410	Phone: 519-661-6725	E-mail: engceli@uwo.ca
Mechanical Engineering:	SEB 3002	Phone: 519-661-4122	E-mail: mmeundergraduate@uwo.ca