WESTERN UNIVERSITY
FACULTY OF ENGINEERING
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

ECE3330A – CONTROL SYSTEMS

COURSE OUTLINE 2023-24

Description: This is an introductory course that focuses on the theory of linear control system design and analysis. The course emphasises the analysis of dynamic behaviour and the design of feedback control strategies to meet specific system performance criteria. Familiarity with Laplace transform and Bode plots is assumed.

Academic Calendar Copy: The concept of feedbacks; modelling of dynamic systems; characteristics of feedback control systems, performance of control systems in time and frequency domains; stability of feedback systems; control system analysis and design; using root locus and frequency response techniques.

Contact Hours: 3 lecture hours, 5 laboratory sessions, 3 hours each, 0.5 course.

Antirequisite: CBE 3310A/B

Prerequisites: Applied Mathematics 2270A/B and (ECE 2233A/B or MSE 2233A/B)

Unless you have either the requisites for this course or written special permission from your Dean to enrol 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.

CEAB Academic Units: Engineering Science 75% Engineering Design 25%

Textbook (Required): N. S. Nise, Control Systems Engineering, 6th, 7th or 8th Ed., Wiley.

Software (Required): Matlab and Simulink including Control Systems and Simscape toolboxes

Recommended Reference:

1. G.F. Franklin, J.P. Powell and A. Emani-Naeini, Feedback Control of Dynamic Systems, Fourth Ed., Prentice Hall, 2002.
2. R.C. Dorf and R.H. Bishop, Modern Control Systems, Ninth Edition, Addison Wesley, 2000.

GENERAL LEARNING OBJECTIVES

Knowledge Base	D	Use of Engineering Tools	D	Impact on Society and the Environment	
Problem Analysis	D	Individual and Team Work		Ethics and Equity	
Investigation		Communication		Economics and Project Management	
Design	D	Professionalism		Life-Long Learning	

Notation: **I –**The instructor will introduce the topic at the level required. It is not necessary for the student to have seen the material before. **D –** There may be a reminder or review, but the student is expected to have seen and been tested on the material before

taking the course. **A –** It is expected that the student can apply the knowledge without prompting (e.g. no review)**a/b**, where **a** is the cognitive level (1: Remember, 2: Understand, 3: Apply) at which the attribute is assessed and **b** is the academic level (1: Beginner, 2: Intermediate, 3: Advanced) at which the attribute is assessed.

Topics:

1. Introduction to Control Systems and Mathematical Modeling of Dynamic Systems
   - Examples of control systems
   - Concept of feedback
   - Elements in control systems
   - The design process
   - Physical system modeling
   - Laplace transform review
2. Time Response
   - Poles, zeros, and system responses
   - First-order systems
   - Second-order systems
   - The relationship between 's'-plane root location and transient response
3. Multiple Systems Representation
   - Block diagrams and block diagram simplification
   - Signal-flow graph
   - Mason's rule
4. Stability
   - Concept of stability
   - Routh-Hurwitz stability criterion
   - Steady-state error
   - Sensitivity
5. Root Locus Analysis
   - Concept of root locus
   - Rules in the construction of root locus
   - Analysis of control systems using root locus
6. Frequency Response Analysis and Design
   - Bode diagrams
   - Gain and phase margins
   - Frequency domain performance specifications
   - Stability tests in frequency domain
   - Lead-lag compensator designs

Specific Learning Objectives:

1. At the end of topic 1, students should be able to:

- Identify the basic elements in a feedback control system, including labs;	PA1,ET1
- Sketch the block diagram representation of a DC motor system;	PA2
- Convert time-domain functions to s-domain by using Laplace Transform;	PA1,PA2
- Write system transfer functions from block diagram representations;	PA2

2. At the end of topic 2, students should be able to:

- Calculate the time constant of a first-order system;	PA2
- Determine the rise time, percent of overshoot, and settling time of a second-order system;	PA1,ET2 KB3
- Distinguish the steady-state from the transient responses of a dynamic system;	PA2
- Relate the transient responses of a dynamic system to the pole location in the s-plane	PA2

3. At the end of topic 3, students should be able to:

- Reduce a complex block diagram to a single block diagram and obtain equivalent transfer function	PA2,PA3 KB4
- Convert block diagram to signal-flow graph	PA1
- Obtain transfer function of a complex system using one formula	PA3

4. At the end of topic 4, students should be able to:

- Sketch the typical responses from stable, critically stable, and unstable systems	PA2
- Apply the Routh-Hurwitz criterion to determine the stability region of a control system	PA3, KB3

5. At the end of topic 5, students should be able to:

- Explain the concept of root locus	PA1
- Apply four main rules in constructing a root locus for a given system, including labs and MATALB	PA2, ET2, KB4
- Analyze the effect of the control system gain on the system performance using root locus	PA2, PA3

6. At the end of topic 6, students should be able to:

- State the frequency domain specifications for a feedback control system	PA1
- Perform the stability test in frequency domain	PA2, KB3
- Distinguish a phase-lead compensator from a phase-lag compensator	D2,D3
- Synthesize a phase-lead or a phase-lag compensator for a given dynamic system	D2,D3

Evaluation:

		Maximum Penalties (*)	
Course Component	Weight	English	Presentation
Assignments	0%	NA	NA
Laboratory	15%	0%	0%
Quiz (2 quizzes)	30%	5%	NA
Final Examination	55%	5%	5%

To obtain a passing grade in the course, a mark of 50% or more must be achieved on the final examination as well as on the laboratory. A final examination or laboratory mark < 50% will result in a final course grade of 48% or less.

Assignments: Assignments are posted on course online portal. Although, Assignments will not be used as a means of student's assessment in the course, Assignments provide important information that complements the learning experience and enrich student's understanding of each topic. Students must use Assignments as a tool for evaluating their knowledge and understanding of each topic. Solutions to selected number of questions (not all questions) in each Assignment will be posted about one week after each Assignment is posted.

Laboratory: The laboratory consists of five laboratory exercise including an introduction to Matlab and Simulink and four additional laboratory exercises. Each exercise includes a pre-lab work that must be completed prior to attending the lab. Each students must complete pre-laboratory work individually and submit (upload) the work as one single PDF file to the student's dedicated drop box on OWL prior to each lab session. See also Late Submission Policy.
Students will work in a group of two that must remain the same throughout the semester. Each student in the group

must attend all posted laboratory exercises. During each laboratory exercise, each group must complete each part of the exercise and **show the results to the TA before advancing** to the next part. It is the group's responsibility to make sure that the TA has seen the results before closing the computer screen or advancing to other part of the laboratory exercise. The TA will ask the group questions related to the completed part and assign a mark to the group.
The mark for each lab exercise is based on (1) pre-lab work, and (2) demonstrating the results obtained in each laboratory exercise and answering questions following the completion of each part.
The amount of time required to successfully complete each lab is inversely proportional to the amount time dedicate to the preparation for the pre-lab. It is expected from students to dedicate sufficient time and effort to prepare for each lab session prior to attending the laboratory. The TA will not be able to extend the time required for the lab session. Students who cannot complete their lab exercise within the allocated time will receive partial mark given to the pre-lab work, if submitted in advance, and the portion of the exercise completed.
If one of the students in a group is either absent or more than one hour late for the respective lab session, the remaining group is still required to complete the lab exercise within the allocated time. In this case, the mark for the students who are absent from the lab will be subject to 40% penalties unless the student has provided necessary documentations through Undergraduate Office.

Quiz: There are **two quizzes** throughout the semester. These quizzes will be held during the lecture hours. The date for the quizzes will be announced at **least 1 week in advance** of each quiz on the course website. The quizzes are **closed-book** and may include multiple choice and/or questions requiring calculations.
If a student misses any of the three quizzes, **the quiz will not be rescheduled**. The student who has missed a quiz must follow guidelines in Academic Consideration for Student Absence to provide necessary documentation. The department will decide whether to allow the reweighting of the quiz, where reweighting means the marks normally allotted for the quiz will be added to the final exam. If no reasonable justification for missing the quiz is provided, then the student will receive a mark of zero for that quiz.
If a student is going to miss a quiz for religious reasons, they must inform the undergraduate office in advance otherwise they will be required to write the quiz.

Final Examination: Closed book exam from all covered topics. Necessary equations are provided. Non-programmable calculators are allowed. (check https://studentservices.uwo.ca/secure/Exams/). Final Examination in this course will be conducted in person, unless decided otherwise.

Late Submission Policy: Late submissions for pre-laboratory work or other course deliverables are not accepted. It is the student's responsibility to make all on-line submissions have been done properly and the uploaded files are free of errors.

Use of English Policy: 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 the final examination 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.

All work will be marked first for content after which a penalty not to exceed the maximum shown above may be applied for lack of proficiency in English and/or presentation.

Attendance: Any student who, in the opinion of the instructor, has not engaged sufficiently in class lectures and/or is absent too frequently from laboratory will be reported to the Dean (after due warning has been given). On the recommendation

of the department, and with the permission of the Dean, the student will be debarred from taking the regular final examination in the course.

Academic Consideration for Student Absence: Students will have up to two (2) opportunities during the regular academic year to use an on-line portal to self-report an absence during the term, provided the following conditions are met: the absence is no more than 48 hours in duration, and the assessment for which consideration is being sought is worth 30% or less of the student's final grade. Students are expected to send an email to the instructor within 24 hours of the end of the period of the self-reported absence. You **do not need to receive the instructor's acknowledgment** for the self-reporting absence. Students are not able to use the self-reporting option in the following circumstances:

- for exams scheduled by the Office of the Registrar (e.g., December and April exams)
- absence of a duration greater than 48 hours,
- assessments worth more than 30% of the student's final grade,
- if a student has already used the self-reporting portal twice during the academic year

If the conditions for a Self-Reported Absence are not met, students will need to provide a Student Medical Certificate if the absence is medical, or provide appropriate documentation if there are compassionate grounds for the absence in question. Students are encouraged to contact their Faculty academic counselling office to obtain more information about the relevant documentation.

Students should also note that individual instructors are not permitted to receive documentation directly from a student, whether in support of an application for consideration on medical grounds, or for other reasons. All documentation required for absences that are not covered by the Self-Reported Absence Policy must be submitted to the Academic Counselling office of a student's Home Faculty.

For Western University policy on Consideration for Student Absence, see
Policy on Academic Consideration for Student Absences - Undergraduate Students in First Entry Programs
and for the Student Medical Certificate (SMC), see:
http://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf.

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.

For more information concerning Students Unable to Write Tests , see Western Engineering Guidelines at:
https://www.eng.uwo.ca/files/undergraduate/Instructions-for-students-unable-to-write-tests-or-exams-.pdf

Cheating and Plagiarism: Students must write their essays 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 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 read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, in the relevant section of the Academic Handbook:
http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf

Important Considerations:
To ensure the best experience for both you and your classmates, please honour the following rules of etiquette:

- please **"ARRIVE"** to class on time
- please do not use your cell phone during the class
- Keep in mind the different cultural and linguistic backgrounds of the students in the course.
- Be courteous toward the instructor, your colleagues, and authors whose work you are discussing.
- Be respectful of the diversity of viewpoints that you will encounter in the class and in your readings. The exchange of diverse ideas and opinions is part of the scholarly environment. "Flaming" is never appropriate.
- Be professional and scholarly in activities related to this course.

Note that disruptive behaviour of any type during classes is unacceptable. Students found guilty of disturbing a class may be subject to disciplinary measures under the Code of Student Conduct.

Policy on Repeating All Components of a Course: Students who are required to repeat an Engineering course 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 by the student for grading in subsequent years.

Internet and Electronic Mail Policy: Students are responsible for regularly checking their Western e-mail and notices posted on the course web site and making themselves aware of any information that is posted about the course.

Accessibility: 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 519-661-2111 ext. 82147 for any specific question regarding an accommodation.

Support Services: Office of the Registrar, http://www.registrar.uwo.ca/
Student Development Centre, http://www.sdc.uwo.ca/
Engineering Undergraduate Services, http://www.eng.uwo.ca/undergraduate/
USC Student Support Services, http://westernusc.ca/services/

Students that are in emotional/mental distress should refer to Mental Health @ Western, http://www.uwo.ca/uwocom/mentalhealth/, for a complete list of options about how to obtain help.

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