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 system performance criteria. Familiarity with Laplace transform and Bode plots is assumed.

Instructor: Mehrdad R. Kermani, Ph.D., P.Eng.
ACEB 3450, 519-661-2111 ext. 81260, e-mail: mkermani@eng.uwo.ca

Consultation Hours: Monday and Thursdays 12:00-1:00PM

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, 1 laboratory hour, 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 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.

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


Recommended Reference:

GENERAL LEARNING OBJECTIVES

<table>
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<tr>
<th>Knowledge Base</th>
<th>2/2</th>
<th>Use of Engineering Tools</th>
<th>Impact on Society and the Environment</th>
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<tbody>
<tr>
<td>Problem Analysis</td>
<td>3/2</td>
<td>Individual and Team Work</td>
<td>Ethics and Equity</td>
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<td>Investigation</td>
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<td>Communication</td>
<td>Economics and Project Management</td>
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<td>Design</td>
<td>1/2</td>
<td>Professionalism</td>
<td>Life-Long Learning</td>
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</table>

Notation: 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 and Learning Objectives:
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
   - Nyquist (polar) plots
   - 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;
   - Sketch the block diagram representation of a DC motor system;
   - Convert time-domain functions to s-domain by using Laplace Transform;
   - Write system transfer functions from block diagram representations

2. At the end of topic 2, students should be able to:
   - Describe the advantages of a closed-loop system over an open-loop system;
   - Calculate the time constant of a first-order system;
   - Determine the rise time, percent of overshoot, and settling time of a second-order system;
   - Distinguish the steady-state from the transient responses of a dynamic system;
   - Relate the transient responses of a dynamic system to the pole location in the s-plane.

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
   - Convert block diagram to signal-flow graph
   - Obtain transfer function of a complex system using one formula
4. At the end of topic 4, students should be able to:
   - Sketch the typical responses from stable, critically stable, and unstable systems;
   - Apply the Routh-Hurwitz criterion to determine the stability region of a control system;
   - Modify the Routh-Hurwitz test to test for minimum settling time criteria.

5. At the end of topic 5, students should be able to:
   - Explain the concept of root locus;
   - Apply four main rules in constructing a root locus for a given system;
   - Analyze the effect of the control system gain on the system performance using root locus.

6. At the end of topic 6, students should be able to:
   - Draw Nyquist plots from the dynamic model of the system;
   - Convert a Nyquist plot to a Bode diagram graphically;
   - Determine the gain and phase margins of a feedback control system graphically;
   - State the frequency domain specifications for a feedback control system;
   - Perform the stability test in frequency domain using Nyquist criteria.
   - Distinguish a phase-lead compensator from a phase-lag compensator;
   - Synthesize a phase-lead or a phase-lag compensator for a given dynamic system;

Evaluation:

<table>
<thead>
<tr>
<th>Course Component</th>
<th>Weight</th>
<th>English</th>
<th>Presentation</th>
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</thead>
<tbody>
<tr>
<td>Course Laboratory</td>
<td>20%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Assignments</td>
<td>0%</td>
<td>0%</td>
<td>NA</td>
</tr>
<tr>
<td>Quiz (2 quizzes)</td>
<td>20%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Final Examination</td>
<td>60%</td>
<td>5%</td>
<td>0%</td>
</tr>
</tbody>
</table>

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 distributed either during lecture hours or via course online portal.

Laboratory: The laboratory consists of four exercises. Each exercise includes a pre-lab work that must be completed prior to attending the lab. 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. The mark for each lab exercise is based on (1) pre-lab work, and (2) a lab report submitted following the completion of each exercise. Pre-laboratory work must be completed individually but the lab report is group submission (i.e., one submission per each group including all signed individual pre-laboratory works).

All reports must be submitted online on student’s dedicated drop box on OWL.

Pre-lab work must be signed by the lab TA (Teaching Assistant) at the beginning of each lab session. It is the group responsibility to make sure that the pre-lab work is signed by the TA. The amount of time required to successfully complete each lab is inversely proportional to the amount time dedicate to the preparation of 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.

Group reports (one per group) must be submitted for each lab exercise within one week from the day the lab was conducted. If one of the students in a group is either absent or more than one hour late for the respective lab session, the group may still submit reports using results obtained by the other group member. In this case, the mark for the said student will be subject to 30% penalties unless the student has provided necessary documentations through Undergraduate Office.
Quiz: There will be two in-class quizzes throughout the semester. The date for the quizzes will be announced at least 1 week in advance of each quiz. The quizzes are closed-book test and necessary equations are provided. Non-programmable calculators are allowed during the quizzes.

Final Examination: Final examination is closed book exam. Necessary equations are provided. Non-programmable calculators are allowed. (check https://studentservices.uwo.ca/secure/Exams/)

Late Submission Policy: Late submissions for those assignments with specified deadline are not accepted. Late submission policy for Lab reports will be specified in the Laboratory Regulations posted on the OWL. It is the student’s responsibility to make sure reading and complying with these regulations.

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 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, is absent too frequently from class, laboratory, or tutorial periods 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.

Absence Due to Illness or Other Circumstances: Students should immediately consult with the instructor or department Chair if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented (see the attached “Instructions for Students Unable to Write Tests or Examinations or Submit Assignments as Scheduled”). The student should seek advice from the instructor or department Chair regarding how best to deal with the problem. Failure to notify the instructor or department Chair immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

For more information concerning medical accommodations, see the relevant section of the Academic Handbook: http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_medical.pdf

For more information concerning accommodations for religious holidays, see the relevant section of the Academic Handbook: http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_religious.pdf

Missed Quiz: The quizzes will not be rescheduled for those who miss either of two quizzes. Students must follow the Instructions for Students Unable to Write Tests and provide documentations to their department within 24 hours of the missed test. The department 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 final exam. If no reasonable justification for missing the test can be found, then the student will receive a mark of zero for the test.

If a student is going to miss either of two quizzes for religious reasons, they must inform the instructor in writing within 48 hours of the announcement of the quiz date or they will be required to write the quiz.
Missed Lab: Students who are either absent or more than one hour late for their respective lab session can submit a report using results obtained by other student(s) in the group. However, the report will be subject to 30% penalties unless the student has provided necessary documentations to support the reason for his/her absence/delay through Undergraduate Office. The missed lab session cannot be rescheduled.

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 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 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

Use of Electronic Devices: Students may use laptops, tablet computers, or smart phones only to access the course OWL site during lectures and tutorials. No other electronic devices may be used at any time during lectures, tutorials, or examinations.

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 the course web site (https://owl.uwo.ca/portal/) 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.

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.
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.

NEW: Requests for Academic Consideration using the Self-Reported Absence Form

If you experience an unexpected illness or injury or an extenuating circumstance (48 hours or less) that is sufficiently severe to temporarily render you unable to meet academic requirements (e.g., attending lectures or labs, writing tests or midterm exams, completing and submitting assignments, participating in presentations) you should self-declare using the online Self-Reported Absence portal. This option should be used in situations where you expect to resume academic responsibilities within 48 hours or less.

Each student will be allowed a maximum of two self-reported absences between September and April and one self-reported absence between May and August. Self-reporting may not be used for final exams or assessments (e.g. midterm exams, tests, reports, presentations, or essays) worth more than 30% of any given course.

For full instructions about the Self-Reporting System refer to the Academic Calendar: http://westerncalendar.uwo.ca/PolicyPages.cfm?PolicyCategoryID=1&Command=showCategory&Keywords=report&SubHeadingID=32&SelectedCalendar=Live&ArchiveID=#SubHeading_322

A. GENERAL REGULATIONS & PROCEDURES (other than self-reported absences)

1. All first year students will report to the Undergraduate Services Office, SEB 2097, for all instances.

2. If you are an upper year student and you are missing a test/assignment/lab or examination that is worth LESS THAN 10% of your mark, you should report to your department office to request relief. If your course work is worth MORE THAN 10% of your final grade, you will report to the Undergraduate Services Office, SEB 2097.

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 (other than self-reported absences)

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. 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, you should report to your department office to request relief. If the test is worth MORE THAN 10% of your final grade you will report to the Undergraduate Services Office, SEB 2097 to request relief.

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

4. Discuss with the instructor if and when the test can be rescheduled. N.B. The approval of the Chair or the Undergraduate Services Office is required when rescheduling midterm/term tests.
C. **FINAL EXAMINATIONS (cannot be self-reported)**

1. If you are unable to write a final examination, contact the Undergraduate Services Office PRIOR TO THE SCHEDULED EXAMINATION TIME to 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 sign a "Recommendation for a Special Examination Form" available in the Undergraduate Services Office. 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 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 2019 Western Academic Calendar available at www.westerncalendar.uwo.ca.

Self-Reporting Absences:
http://westerncalendar.uwo.ca/PolicyPages.cfm?PolicyCategoryID=1&Command=showCategory&Keywords=report&SubHeadingID=322&SelectedCalendar=Live&ArchiveID=#SubHeading_322

Absences Due to Illness:
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_12

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/forms/smc.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 13, 2019
Full courses and full-year half course (i.e. “E”, “Y” or no suffix) September 13, 2019
Second term half course (i.e. “B” or “G”) January 14, 2020

Drop Deadlines:
First term half course (i.e. “A” or “F”) November 12, 2019
Full courses and full-year half courses (i.e. “E”, “Y” or no suffix) November 30, 2019
Second term half or second term full course (i.e. “B” or “G”) March 7, 2020

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

Revised 08/01/19