

WESTERN UNIVERSITY  
FACULTY OF ENGINEERING  
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

**ECE3330A – CONTROL SYSTEMS**

**COURSE OUTLINE 2017-18**

**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.  
TEB 367, 519-661-2111 ext. 81260, e-mail: [mkermani@eng.uwo.ca](mailto:mkermani@eng.uwo.ca)

**Consultation Hours:** Tuesdays and Thursdays 2:30-3:30PM

**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, 4 x 3 laboratory hours, 0.5 course.

**Antirequisite:** CBE 3310A/B or the former CBE4410A/B

**Prerequisites:** Applied Mathematics 2415, 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, 6<sup>th</sup> or 7<sup>th</sup> Ed., Wiley, 2009-10.

**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	2/2	Use of Engineering Tools	1/2	Impact on Society and the Environment	
Problem Analysis	3/2	Individual and Team Work		Ethics and Equity	
Investigation		Communication		Economics and Project Management	
Design	1/2	Professionalism		Life-Long Learning	

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:

Course Component	Weight	Maximum Penalties (*)	
		English	Presentation
Course Laboratory	25%	10%	20%
Assignments	0%	10%	10%
Midterm Examination	25%	5%	5%
Final Examination	45%	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 distributed either during lecture hours or via course online portal.

**Laboratory:** The laboratory component consists of four exercises including pre-lab design work that will be posted on OWL. A schedule of the laboratory sections will also be posted on OWL. A student's laboratory mark is determined by the teaching assistant's evaluation of (1) the written pre-lab work and (2) a demonstration of the required results by the student, and (3) a lab report submitted following completion of each lab session.

**Midterm Examination:** 2-hour, closed book exam. Necessary equations are provided. No programmable calculators are allowed. Date, time, and location of the midterm exam will be announced in class and on OWL.

**Final Examination:** Closed book exam. Necessary equations are provided. No programmable calculators are allowed. (check <https://studentservices.uwo.ca/secure/Exams/> )

**Late Submission Policy:** Late submissions for assignments are NOT accepted. Late submission policy for Lab reports will be specified in the Laboratory Regulations posted on the course web site.

**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, 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/handbook/appeals/accommodation\\_medical.pdf](http://www.uwo.ca/univsec/handbook/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/handbook/appeals/accommodation\\_religious.pdf](http://www.uwo.ca/univsec/handbook/appeals/accommodation_religious.pdf)

**Missed Midterm Examinations:** If a student misses a midterm examination, the exam will not be rescheduled. The student must follow the Instructions for Students Unable to Write Tests and provide documentation 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 midterm 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 the midterm examination for religious reasons, they must inform the instructor in writing within 48 hours of the announcement of the exam date or they will be required to write the exam.

**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](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 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.

**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. (SEE THE 2017 UWO ACADEMIC CALENDAR).

**A. GENERAL REGULATIONS & PROCEDURES**

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 exam that is worth MORE THAN 10% of your final grade, you will report to the Undergraduate Services Office, SEB 2097. Otherwise, you will report to your department office to request relief.
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 TESTS**

1. If you are in first year and you are unable to write a 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 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 MORE THAN 10% of your final grade you will report to the Undergraduate Services Office, SEB 2097 to request relief. Otherwise, you will report to your department office 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 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 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, 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.

**N.B. 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 Associate Dean 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. 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.

## 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 may want to seek advice from the academic counsellor in your Department or Ms. Karen Murray in the Undergraduate Services Office, if you are in first year.

## 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 2017 Western Academic Calendar available at [www.westerncalendar.uwo.ca](http://www.westerncalendar.uwo.ca).

Absences Due to Illness: <http://westerncalendar.uwo.ca/2017/pg117.html>  
Academic Accommodations for Students with Disabilities: <http://westerncalendar.uwo.ca/2017/pg118.html>  
Academic Accommodations for Religious or Holy Days: <http://westerncalendar.uwo.ca/2017/pg119.html>  
Course Withdrawals: <http://westerncalendar.uwo.ca/2017/pg157.html>  
Examinations: <http://westerncalendar.uwo.ca/2017/pg129.html>  
Scheduling of Term Assignments: <http://westerncalendar.uwo.ca/2017/pg135.html>  
Scholastic Offences: <http://www.westerncalendar.uwo.ca/2017/pg111.html>  
Student Medical Certificate: [http://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/medicalform.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf)  
Engineering Academic Regulations: <http://www.westerncalendar.uwo.ca/2017/pg1442.html>

**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.

### **Drop Deadlines:**

First term half course (i.e. "A" or "F"):	November 5, 2017
Full courses and full-year half courses (i.e. "E", "Y" or no suffix):	November 30, 2017
Second term half or second term full course (i.e. "B" or "G"):	March 7, 2017

### **Contact Information:**

Undergraduate Services Office:	SEB 2097	Telephone: (519) 661-2130	E-mail: <a href="mailto:engugrad@uwo.ca">engugrad@uwo.ca</a>
Dept. of Chemical and Biochemical Engineering & Green Process Engineering:	TEB 477	Telephone: (519) 661-2131	E-mail: <a href="mailto:cbeugrad@uwo.ca">cbeugrad@uwo.ca</a>
Dept. of Civil and Environmental Engineering:	SEB 3005	Telephone: (519) 661-2139	E-mail: <a href="mailto:civil@uwo.ca">civil@uwo.ca</a>
Dept. of Electrical and Computer Engineering, Software Engineering & Mechatronics Engineering:	TEB 279	Telephone: (519) 661-3758	E-mail: <a href="mailto:eceugrad@uwo.ca">eceugrad@uwo.ca</a>
Dept. of Mechanical and Materials Engineering:	SEB 3002	Telephone: (519) 661-4122	E-mail: <a href="mailto:mmeundergraduate@uwo.ca">mmeundergraduate@uwo.ca</a>