ELEN 4310/EECE 5310

Fall 2018

ELEN 4310/EECE 5310– Control Systems

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| **Instructors:** | Dr. Susan Schneider  Office: HH 217 Phone: 288- 7178  Mailbox: 47  e-mail: susan.schneider@marquette.edu |
| **Office Hours:** | Office hours for SCS posted on her office door and listed in D2L course site.  Other hours available by appointment. |

**Required Course Materials:**

Textbooks:

* Richard C. Dorf and Robert H. Bishop, Modern Control Systems, 13th ed., 2017, Pearson Education, Inc., Hoboken NJ, USA.
* Choose and check out a SECOND Control Systems textbook from the MU Library

Recommendations – any later edition of the following texts

* Benjamin C. Kuo, Automatic Control Systems
* Katsuhiko Ogata, Modern Control Systems
* Norman C. Nise, Control Systems Engineering (6th edition available online)
* Gene F. Franklin, J. David Powell, Abbas Emami-Naeini, Feedback Control of Dynamic Systems
* OER textbooks examples – to be used as/if needed
* Wikibooks contributors, Control Systems, Wikibooks, The Free Textbook Project, 26 July 2018, 13:25 UTC, <https://en.wikibooks.org/w/index.php?title=Control_Systems&oldid=3446330> [accessed 9 August 2018]
* Karl Johan Åström and Richard M. Murray, Feedback Systems: An Introduction for Scientists and Engineers, Feedback Systems web site, 18 November 2016, <http://www.cds.caltech.edu/~murray/amwiki/index.php?title=Second_Edition>, [accessed 10 August 2018].

Software:

* MATLAB and SIMULINK
  + Available by arrangement of Marquette University
  + Download by starting from <http://www.marquette.edu/its/help/matlab/>
* Microsoft Office (Word, Excel, PowerPoint)
  + software available for purchase via ITS website for MU students
* Internet access for
  + course D2L site and
  + internet resources

Suggested Supplies: 3 ring binder, engineering grid paper, storage media (flash drive, D2L locker, other).

**Attendance:** The College of Engineering Absence Policies and Procedures states that "attendance is mandatory for every exercise of a course in which a student is registered. Excessive absences may result in lower grades." In this course, attendance is expected for all sessions. Excessive unexcused absences (5 or more) will result in an instructor initiated “Withdrawal for Absence”. See also Marquette’s Attendance policy at <http://bulletin.marquette.edu/undergrad/academicregulations/#attendance>.

For the purpose of this class, attendance will be monitored by a **combination** of the following methods:

(1) occasional in-class “roll call”,

(2) participation in group/individual learning tasks in class

(3) appearance at all regularly scheduled tests,

(4) submission of all homework and/or projects on their regularly scheduled due dates.

All missed exams, homework and projects will be counted as absences unless the student has consulted with the instructor in person within 24 hours of the due date.

**Academic Integrity** – Students are expected to follow the Honor Pledge:

The Honor Pledge states:

* I recognize the importance of personal integrity in all aspects of life and work.
* I commit myself to truthfulness, honor, and responsibility, by which I earn the respect of others.
* I support the development of good character, and commit myself to uphold the highest standards of academic integrity as an important aspect of personal integrity.
* My commitment obliges me to conduct myself according to the Marquette University Honor Code.

Refer to <http://www.marquette.edu/provost/integrity-index.php>. and <http://bulletin.marquette.edu/undergrad/academicregulations/> for more information about how academic integrity is defined and recognized at Marquette University.

**Professional Attitude:**

You are expected to conduct yourself in a professional manner. This means that you will come to class on time and prepared to participate. You will do the reading in a timely manner. You will start work on all reading and homework assignments as soon as they are given to you.

**Collaboration Policy – when you may work with others:**

When working on assignments, some of your best learning may actually occur as you help others. Bear in mind, however, that assignments are meant to reflect your work. All tests will reflect only your own work.

• You may work together with others when you *work on homework assignments and projects*.

• You will *CREDIT all people with whom you consult and any other sources you use (textbooks, Web, etc.) in the appropriate section of your assignment work*.

This policy means that you can, and are encouraged to, form study groups and work out problems together “on the board”.  **Each student will individually write up this work for submission; there must be no written or electronic exchange of information.**

**On the Use of Digital Devices and Internet Study Resources**

* Digital devices may not be used for non-course related activities during lectures (Internet browsing, texting, facebooking, tweeting, instagramming, snap chatting, etc.). These activities prevent you from engaging with the class, and it will distract other students.
* Internet Study Resources such as online tutoring, homework help or solutions manuals may be a valuable learning tool IF USED PROPERLY. Do NOT use these resources to substitute for your own efforts; you may NEVER directly copy them as if they are your work. You may, however, consult these resources to provide reassurance and/or reinforcement and/or remembrance so that you can successfully complete your work ON YOUR OWN. Don’t forget to credit resources.

**Assistance:**

Students with disabilities may be entitled to accommodations and/or academic adjustments designed to give them equal access to the university's resources. The procedures guiding the accommodations process are detailed at the Office of Disability Services website <http://www.marquette.edu/disability-services/procedure.shtml> or by contacting the Office of Disability Services at 414-288-1645 or by e-mail at [ods@marquette.edu](mailto:ods@marquette.edu). The Office of Disability Services is located in the 707 Building, Room 503. If approved for accommodations, the student will receive a letter from ODS describing the accommodations; the student must then deliver this letter to the instructor within one week of the start of the semester. Student will work together with the instructor to incorporate the accommodations as needed.

**Due Dates and TIMES:**

The tentative due **dates** for all homework and some of the project work are listed on the master schedule for this class, posted on D2L (Content: Course Information: Master Schedule).

• All project reports are due electronically in the required format to the D2L dropbox no later than (NLT) 5:00 p.m. on the scheduled due date.

• All homework is due electronically **as a PDF** to the D2L dropbox NLT 5 pm on the scheduled due date.

**Late Policy and Makeup Work Policy:**

Late work is work that you failed to complete in a timely manner. Consult with the instructor as soon as you become aware of anything that will preclude you from completing your work on time. Significant penalties will be applied to any work submitted after the due date. In all cases, late work will no longer be accepted one week after the original due date.

For homework/projects – Homework and projects will not be accepted after the due date without **prior** permission of the instructor. The instructor *may* allow make-up work for *excused* absences when the student notifies the instructor at least one day in advance.

For exams - If a student knows they will be unable to take an in-class exam on the scheduled date, arrangements for an alternate date **prior** to the scheduled exam date must be made with the instructor. No make-up exams will be given except in extreme circumstances.

***IMPORTANT NOTICE –***

***All documents submitted by the students in this class are considered to be public documents and may be used for instructional purposes.*** These documents include but are not limited to homework, and project reports.

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| **Grading:** | pts |
| Homework (10 @ 10 pts) | 100 |
| Control Project  (preliminary reports @ 50 pts, final report @ 100 pts, project prototype @50 pts) | 200 |
| Exams (2 @ 100 pts) | 200 |
| Final Exam (150 pts) | 150 |
| total | 650 |

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|  | qpa | Undergraduate Grade Scale | **Graduate Grade Scale** |
| A | 4 | [94-100] | [95-100] |
| A- | 3.67 | [91-94) | [92-95) |
| B+ | 3.33 | [87-91) | [89-92) |
| B | 3 | [84-87) | [86-89) |
| B- | 2.67 | [81-84) | [83-86) |
| C+ | 2.33 | [77-81) | [80-83) |
| C | 2 | [74-77) | [77-80) |
| C- | 1.67 | [71-74) | [74-76) |
| D+ | 1.33 | [67-71) |  |
| D | 1 | [63-67) | [70-74) |
| F | 0 | Below 63 | Below 70 |
|  |  | [a-b) => a ≤ x < b |  |

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**ELEN 4310/ EECE 5310 – Tentative** Topic Scheduling

**Fall 2018**

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|  | Topic | Reading | Tentative Dates | *Tentative*  *hw due date* |
| 1,2 | Introduction | Chapter 1 | 8/30 | *8/31, 9/7* |
| 3 | Mathematical Models of Systems | Chapter 2 | 9/4 – 9/13 | *9/14* |
| 4 | Feedback Control System Characteristics | Chapter 4 | 9/18 – 10/2 | *9/21* |
| 5 | Performance of Feedback Control Systems | Chapter 5 | *9/28* |
| 6 | Stability of Linear Feedback Systems | Chapter 6 | *10/5* |
|  | EXAM 1 |  | 10/4 |  |
| 7 | Root Locus | Chapter 7 | 10/9 – 10/25 | *10/26* |
| 8,9 | Design of Feedback Control Systems | Chapter 10 | 10/30 – 11/20 | *11/9, 11/20* |
|  | EXAM 2 |  | 11/8 |  |
| 10 | Robust Control | Chapter 12 | 11/27-11/29 | *11/30* |
|  | Design Project Presentations & Demos |  | 12/4, 12/6  12/6 |  |
|  | 5th Annual EECE Design Project Poster Session & Demos |  |  |

**~~~~ Details on Grade Items ~~~~**

**Homework**:

Each student is expected to honestly attempt all assigned problems prior to the beginning of in-class discussion. Group work (either small group or class discussions) will focus on the homework. At the conclusion of discussion, each student will then complete and submit individual write-ups of the solutions to that assignment’s problem. Homework will be scored using the homework rubric for the course (posted on D2L).

Additional -

* Homework MUST BE NEAT, or they will not be graded. Homework should be neatly handwritten.
* Homework MUST be completed on 8½" X 11" paper - preferably on engineering grid paper.
* Student’s name, the course number and assignment type/number must be legibly printed in the upper right hand corner on the first page of all homework assignments.
* Student’s name (only) must appear in the urh corner of each page of the homework.

***Submitting the homework:***

Homework will be turned in only as electronic copy. After writing up your homework (by hand), scan your pages to produce a \*.pdf document. The \*.pdf is to be submitted to the appropriate D2L dropbox no later than 5 pm on the due date.

* Use the following file name format: <lastName>\_*HW\_<num>.pdf* for your electronic submission. *Example: Schneider\_hw\_4.pdf.*
* You can use the MultiFunctionDevice (aka the printer/scanner you use for Printwise) to create a (multipage) pdf that you email to yourself. Or, you can use a smartphone/tablet scanner app (test out the best lighting, height above, etc.) to produce the pdf.
* Incorporate MATLAB results (graphs) into your homework by printing a hardcopy of the MATLAB work, insert these pages into the appropriate location in your handwritten homework and then scan. Or, locate a free pdf aggregator application that will allow you to combine two pdfs.

**Exams**

**TWO** in-class exams will be given during the semester. While each exam will focus on the chapters listed below, each exam covers all the preceding course material because the nature of this course is inherently cumulative. Since each topic builds upon the next, each exam will also be cumulative in nature.

EXAM DATES:

Exam 1, Thursday, October 4

Exam 2, Thursday, November 8

**FINAL EXAM –** Cumulative final exam **–** Thursday, December 13, **8:00 am – 10 am**

***2018 ABET Outline***

**ELEN 4310 (EECE 150) ‑- Control Systems**

3 credit course, meeting the equivalent of three 50 minute class periods per week.

**Course Material:**

Richard Dorf and Robert Bishop, Modern Control Systems, 13th ed., Prentice Hall, 2017

MATLAB: Available at http://www.marquette.edu/its/help/matlab/ (no cost to Marquette Students)

**Course Description:**

Review of continuous-time linear systems. Modeling, analysis, solutions, and simulation of systems. Stability of systems. Time-domain system analysis. Time-domain design of lead/lag and PID controllers. Root-locus technique. Frequency-domain system analysis including Nyquist, Bode, and Nichols analysis and relative stability. Frequency-domain design of lead/lag and PID controllers.

**Prerequisites:** ELEN 3020 Linear Systems with a minimum grade of C.

**Elective** course in the Electrical Engineering program.

**Contribution to Professional Component**: Engineering Science 50%

Engineering Design 50%

**Course Goals:**

This course is designed to give senior and graduate students the ability to analyze and design control systems, to analyze, design, and simulate control systems using computers, and to implement control algorithms in analog circuitry.

**Course Objectives:**

*By the end of this course you should be able to:*

* Represent linear systems with transfer functions, block diagrams, and signal flow graphs; and to transform a system from one representation to another.
* Model linear translational and rotational mechanical systems.
* Model Operational Amplifier circuits.
* Determine the stability of transfer functions.
* Determine the response of linear systems to inputs, including steady state error.
* Recognize step response characteristics of second order systems, and approximate step responses of higher order systems.
* Apply the root locus technique
* Analyze frequency domain characteristics of systems, including phase and gain margins from Bode plots.
* Design controllers using P, PI, PD, PID, Phase-Lead, Phase-Lag, Lead-Lag controllers, including the characteristics and impacts of each controller.

**Contribution to Program Objectives:** partial fulfillment of criterion 3 objectives A, C, E, G, and K.