Course Syllabus
EE3261 – Classical Control Systems
Electrical and Computer Engineering
Spring 2018

Instructor Information
Instructor: Wayne Weaver, PhD, Associate Professor
Office Location: 236 EERC
Telephone: Office – (906)487-1461
E-mail: wwwweaver@mtu.edu
Office Hours: 1) Mondays, 11a-12a, EERC 236
2) Thursdays, 11a-12a, EERC 236
3) By appointment
4) Drop by EERC 236 anytime. If Dr. Weaver’s door is open, he will answer your questions.

Laboratory Instructor Information
Instructor: TBD
E-mail: TBD
Office Hours: TBD

Course Identification
Course Number: EE3261-R01, L01, L02, L03, L04, L05
Course Name: Classical Control Systems
Course Location: EERC 229
Class Times: MW: 9:05am – 9:55 pm
Prerequisites: EE3160 – Linear Systems and Control

Course Description/Overview
Mathematical formulation of control problems (both transfer function and state-variable descriptions); analysis of feedback control systems (stability, transient performance, steady-state error, sensitivity, etc.); design using frequency response, root locus, state-variable methods; analog and digital simulation and computation; and experiments with physical systems.

Disclaimer: I may change this syllabus and course schedule at any time according to my judgment as to what is best for the class. Any changes will be declared ahead of time in class.
**Course Learning Objectives**

1. A mastery of the analysis of feedback control systems, including determining stability, transient performance, and steady-state error. The student should also have a mastery of the relationship between closed loop poles and system performance.

2. A mastery of control system design using proportional, derivative, and integral control.

3. A mastery of the use of the root locus design methodology. The student should be able to use root locus to design proportional control, add zeros to influence transient behavior, and apply root locus to selecting general control parameters.

4. A mastery of frequency domain design of lead compensators.

5. Application of control system implementation using operational amplifier circuits.

**Course Resources**

**Course Website**
- Canvas: https://mtu.instructure.com

**Required Course Text**

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**Other Useful Reference Texts**
- *Feedback Control Systems*, by Phillips and Parr
- *Basic Control System Engineering*, by Lewis and Yang
- *Automatic Control Systems*, by Kuo
- *Modern Control Systems*, by Dorf
- *Modern Control Engineering*, by Ogata
- *Design of Feedback Control Systems*, by Stefani, Savant, Shahian, Hostetter
**Grading Scheme**

**Class Grading**

<table>
<thead>
<tr>
<th>Letter Grade</th>
<th>Percentage</th>
<th>Grade points/credit</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&gt;92%</td>
<td>4.00</td>
<td>Excellent</td>
</tr>
<tr>
<td>AB</td>
<td>88% – 92%</td>
<td>3.50</td>
<td>Very good</td>
</tr>
<tr>
<td>B</td>
<td>80% – 88%</td>
<td>3.00</td>
<td>Good</td>
</tr>
<tr>
<td>BC</td>
<td>78% – 80%</td>
<td>2.50</td>
<td>Above average</td>
</tr>
<tr>
<td>C</td>
<td>70% – 78%</td>
<td>2.00</td>
<td>Average</td>
</tr>
<tr>
<td>CD</td>
<td>68% – 70%</td>
<td>1.50</td>
<td>Below average</td>
</tr>
<tr>
<td>D</td>
<td>60% - 68%</td>
<td>1.00</td>
<td>Inferior</td>
</tr>
<tr>
<td>F</td>
<td>&lt;60%</td>
<td>0.00</td>
<td>Failure</td>
</tr>
</tbody>
</table>

I: Incomplete; given only when a student is unable to complete a segment of the course because of circumstances beyond the student’s control. A grade of incomplete may be given only when approved in writing by the DEAN.

X: Conditional, with no grade points per credit; given only when the student is at fault in failing to complete a minor segment of a course, but in the judgment of the instructor does not need to repeat the course. It must be made up within the next semester in residence or the grade becomes a failure (F). A (X) grade is computed into the grade point average as a (F) grade.

**Grading Policy**

Grades will be based on the following:

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Percentage</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>15%</td>
<td>Lowest 3 scores will be dropped at end of semester</td>
</tr>
<tr>
<td>Laboratory*</td>
<td>20%</td>
<td>Lowest midterm score will be dropped</td>
</tr>
<tr>
<td>Midterm 1</td>
<td>30%</td>
<td></td>
</tr>
<tr>
<td>Midterm 2</td>
<td>30%</td>
<td></td>
</tr>
<tr>
<td>Final Exam</td>
<td>35%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

*A 50% laboratory grade is necessary for a passing course grade (regardless of all other grades)!!!

**Curve**

I will not be curving any grades in this class. I do reserve the right to adjust the grade scale down (in the students favor). Therefore it is possible that everyone can receive an A.

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Laboratory Procedures

- Descriptions of laboratory experiments will be available prior to the laboratory period, and pre-lab assignments may be included.
- A laboratory worksheet will be available at the beginning of some laboratory sessions with spaces to fill in key information and answers to specific questions. The completed worksheet must be submitted to the instructor and approved by the instructor before leaving the laboratory. Circuits and other apparatus should not be disassembled until approval is received. Your instructor may require that certain parts of the experiment be rechecked and corrected. Your instructor may also require submission of the pre-lab work with the worksheet.
- Some labs will require submittal of formal lab reports. Your lab instructor will inform you of what is required during the lab period. You may work with your lab partner on your report. If you choose to work alone on your report, do not give credit to your partner.
- Many experiments will include a DESIGN TASK that is described on the experiment sheet or described by the instructor.
- Lab reports are to be turned in electronically to Canvas in doc, docx or pdf format

Laboratory Grading (10 points per lab)

The final laboratory grade will be determined as follows:

- 90% - Individual Experiment Grades
- 10% - The instructor’s subjective evaluation of perseverance, initiative, and overall performance.

Individual lab grades:

- Pre-lab: 1 point
  - With instructor’s initials
- Lab procedure: 1 point
  - Successfully accomplishment of the experiment with all CORRECT circuit and simulations; obtain all the lab-required results.
- Report:
  - Title and summary: 1 point
    - Correct title and an informative summary or conclusion
  - Circuit design or block diagram: 1 point
    - The circuit or block diagram used in the experiment and a brief presentation on how to use this circuit or block diagram in the experiment.
  - Results: 3 points
    - Experimental results should be correct according for each setting. Provide enough information on how to get the parameters from your results. Plots and presentations should be clear.
    - Discussion and questions: 3 points
    - First, show the observations from the lab for each lab questions. Secondly, try to explain the observations from theoretical point of view. Note that even a guess can be an explanation of the
observations, although sometimes it needs to be further analyzed. Any innovation work or comments are welcome in this part.

- Late assignments
  - Not accepted

**Course Policies**

- Canvas will be the official form of communication from your instructor and should be checked multiple times in a day. You are responsible for being informed on course announcements.

- If you have a question, please post to the Canvas Discussion board and I will answer so everyone can see. If you are uncomfortable posting you can email me, but I will copy and respond via Canvas discussion board.

- When submitting your assignment, the submission instructions will be listed on the assignment details and need to be followed to receive credit. *Failure to follow the submission requirements will result in ZERO points assigned for the assignment.*

- All homework and lab assignments are due on the date and time indicated. Late assignments will not be accepted and will receive zero credit.

- Any medical or other acceptable excuses for missed assignments or exams must be adjudicated with Dr Weaver within 5 business days of the missed deadline.

- Cell phones, Blackberries, iPods, PDAs, or any other electronic devices other than calculators are not to be brought to the exams.

**Collaboration/Plagiarism Rules**

All assignments are expected to be done individually, unless otherwise instructed. Homework may be discussed with others, but all work submitted **MUST BE YOUR OWN.** Academic dishonesty is not acceptable, and will be documented and punished. Obey the course rules and the University’s Code of Policies and Regulations. **If you cheat, or plagiarize, any portion of any assignment, you will receive a failing grade in this course.**

**University Policies**

Academic regulations and procedures are governed by University policy. Academic dishonesty cases will be handled in accordance the University's policies.

If you have a disability that could affect your performance in this class or that requires an accommodation under the Americans with Disabilities Act, please see me as soon as possible so that we can make appropriate arrangements. The Affirmative Action Office has asked that you be made aware of the following:
Michigan Tech complies with all federal and state laws and regulations regarding discrimination, including the Americans with Disabilities Act of 1990. If you have a disability and need a reasonable accommodation for equal access to education or services at Michigan Tech, please call the Dean of Students Office, at 487-2212. For other concerns about discrimination, you may contact your advisor, department head or the Affirmative Action Office, at 487-3310

**Academic Integrity:** [http://www.studentaffairs.mtu.edu/dean/judicial/policies/academic_integrity.html](http://www.studentaffairs.mtu.edu/dean/judicial/policies/academic_integrity.html)

**Affirmative Action:**
[http://www.admin.mtu.edu/ao/](http://www.admin.mtu.edu/ao/)

**Disability Services:** [http://www.admin.mtu.edu/urel/studenthandbook/student_services.html#disability](http://www.admin.mtu.edu/urel/studenthandbook/student_services.html#disability)

**Equal Opportunity Statement:**
**Tentative Course Schedule**

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>MLK Day (No Class Monday) Introduction, Physical System Modeling</td>
<td>Chapter 1, Sections 2.4, 2.5, 2.6</td>
</tr>
<tr>
<td>2.</td>
<td>DC Motors, Block Diagram Reduction</td>
<td>Sections 2.8, 5.2</td>
</tr>
<tr>
<td>3.</td>
<td>Signal-Flow Graphs, Mason's Gain Formula, Analog controller implementation</td>
<td>Sections 5.4, 5.5</td>
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<td>Section 9.6</td>
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<tr>
<td>4.</td>
<td>Digital Simulation via State Models, Simulation with SIMULINK Stability</td>
<td>Sections 3.3, 3.4, Notes</td>
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<td>Section 6.1</td>
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<td>5.</td>
<td>Transient Performance Criteria</td>
<td>Sections 4.1-4.4</td>
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<td>Sections 4.5-4.8</td>
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<tr>
<td>6.</td>
<td>Steady-state error, polynomial inputs</td>
<td>Sections 7.1-7.2</td>
</tr>
<tr>
<td></td>
<td>Steady-state error, error constants, type number</td>
<td>Sections 7.3, 7.4</td>
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<td>7.</td>
<td>Disturbance rejection, Control amplitude criteria</td>
<td>Section 7.5, Notes</td>
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<tr>
<td></td>
<td>Root-locus, introduction and graphical techniques</td>
<td>Section 8.1-8.3</td>
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<tr>
<td>8.</td>
<td>Root-locus, rules of construction</td>
<td>Sections 8.4, 8.5</td>
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<td>Spring Break</td>
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<td>9.</td>
<td>Root-locus, examples, variations, using MATLAB</td>
<td>Section 8.6, Notes</td>
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<tr>
<td></td>
<td>Frequency response techniques, Bode plots</td>
<td>Sections 10.1, 10.2</td>
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<tr>
<td>10.</td>
<td>Gain and phase margins</td>
<td>Section 10.7</td>
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<tr>
<td>11.</td>
<td>The Nichols chart</td>
<td>Sections 10.9, 10.10</td>
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<td></td>
<td>Systems with Transportation Delay</td>
<td>Section 10.12</td>
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<tr>
<td></td>
<td>Ideal PD controller design, Practical PD</td>
<td>Section 9.3, Notes</td>
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<tr>
<td>13.</td>
<td>PID controllers</td>
<td>Section 9.4, Notes</td>
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<tr>
<td></td>
<td>Phase-lead controllers</td>
<td>Section 11.4, Notes</td>
</tr>
<tr>
<td>14.</td>
<td>Phase-lag controllers</td>
<td>Section 11.3, Notes</td>
</tr>
</tbody>
</table>

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