MCEN4043: SYSTEM DYNAMICS - FALL 2017
COURSE DESCRIPTION

Credits/Contact Hours: 3 credits hours, 2 hours lecture and 2 laboratory hours

Instructor: Dr. Francisco Castro Office: AEC 215
Phone: 970-248-1564 castrof@colorado.edu

Class Sessions: AEC 204 TR 11:00-11:50am

Laboratory Sessions: AEC 123 M or W 9:00-10:50am

Textbook: System Dynamics by William J. Palm III, 3rd Edition

Software/Hardware:

MATLAB is required: installed on AEC computers. License is available for CU students.
Calculator

Course Prerequisites:

MCEN3043: Dynamics
MCEN3017: Circuits and Electronics
This is a required course

Course Objectives

This class will allow students to define a system and a dynamic system. Students will be able to identify the input and output of a system, as well as the appropriate units used for mechanical, fluid, thermal, and electrical systems. The class will include developing and applying modeling templates for mechanical, fluid, thermal, and electrical systems. Mathematical tools such as the Laplace transforms for initial condition and forced transient problems, transfer functions, the inverse Laplace transforms, and Fourier series will be introduced to analyze the transient response of dynamic systems. At the end of the class, students will be able to analyze harmonic forcing and response of dynamic systems, analyze and design coupled discrete systems and apply numerical methods for solving ODEs.

Learning Objectives

- Define a system and a dynamic system. Identify the input and output of a system. Classify systems. Identify the appropriate units used for mechanical, fluid, thermal, and electrical systems.
- Develop and apply modeling templates for mechanical, fluid, thermal, and electrical systems.
- Compute Laplace transforms for initial condition and forced transient problems.
- Compute transfer functions.
- Compute inverse Laplace transforms to analyze the transient response of dynamic systems.
- Analyze harmonic forcing and response of dynamic systems.
- Analyze and design coupled discrete systems.
- Apply numerical methods to the solution of ODEs.
- Become proficient with Simulink.
- Elaborate Bode plots.

Student Outcomes for ABET Accreditation

- Student Outcome a: an ability to apply knowledge of mathematics, science, and engineering
- Student Outcome e: an ability to identify, formulate, and solve engineering problems
- Student Outcome k: an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

SYLLABUS

1. Introduction
    a. System Dynamics: Definitions
    b. Linear Models
2. Solution Methods for Dynamic Models
    a. ODEs
    b. The Laplace Transform
    c. Response Types and Stability
    d. Transfer Functions
    e. Numerator Dynamics
3. Modeling of Rigid-Body Mechanical Systems
    a. Translational Motion
    b. Rotation About a Fixed Axis
    c. Equivalent Mass and Inertia
4. Spring and Damper Elements in Mechanical Systems
    a. Spring Elements
    b. Energy Methods
    c. Damping Elements
5. Transient Response and Block Diagram Models
    a. State-Variable Models
    b. MATLAB ode functions
    c. First-Order Systems
    d. Block Diagrams
6. Electrical and Electromechanical Systems
    a. Electric Circuits
    b. Electric Motors
7. Fluid and Thermal Systems
    a. Fluid Systems
    b. Thermal Systems
8. System Analysis in the Time and Frequency Domains
    a. Frequency Response
    b. Introduction to Fourier Series
    c. Filtering
9. Introduction to Feedback Control Systems
    a. Closed-Loop Control
    b. The PID Control Algorithm

GRADING

Four different aspects will be used to obtain the final grade.

No late assignments allowed unless extraordinary circumstances.
If this happens, inform as soon as possible, before it is due.

Class attendance is expected and highly recommended.

1. Quizzes: 5%

Requires individual work.
Given during class (5-10min) or D2L. There are randomly performed.
Focused on concepts rather than numerical problems.
If given in class, quizzes are closed books/notebooks and no calculators.
No cell phones allowed.

2. Homework: 15%

Requires individual work but discussion among colleagues is encouraged.
Ten (10) sets of homework will be assigned on Wednesdays and they will be due a week later.
Focus on concepts and numerical problems.
Lowest score will be dropped.

3. Laboratory: 10%

Ten (10) sets of laboratory sessions will be performed.
Matlab software.
Lowest score will be dropped.

4. Exams: 70%

Exams 1 and 2:	TBA	15% each
Exam 3 and Final:	TBA	20% each

Books, notebooks and calculators may be allowed.
No cell phones allowed.
Length: 1-2 hours

PROPOSED SCHEDULE

WEEK	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
1	21-Aug **Lab1**	22 Introduction	23 **Lab1**	24 ODEs	25
2	28 **Lab2**	29 Laplace	30 **Lab2**	31-Aug **Hwk1** Laplace	1-Sep
3	4 **Lab3** Laplace	5 Laplace	6 **Lab3** Laplace	7 **Hwk2** Laplace	8
4	11 **Lab4**	12 Transfer Functions	13 **Lab4**	14 **Hwk3** Transfer Functions	15
5	18	19 **EXAM 1**	20	21 Rigid Body Dynamics	22
6	25 **Lab5**	26 Rigid Body Dynamics	27 **Lab5**	28 **Hwk4** Mechanical Systems	29-Sep
7	2-Oct **Lab6**	3 Mechanical Systems	4 **Lab6**	5 **Hwk5** Block Diagrams	6
8	9 **Lab7**	10 Block Diagrams	11 **Lab7**	12 **Hwk6** Block Diagrams	13 FALL BREAK
9	16	17 **EXAM 2**	18	19 Electrical Systems	20
10	23 **Lab8**	24 Electrical Systems	25 **Lab8**	26 **Hwk7** Fluid Systems	27
11	30 **Lab9**	31-Oct Fluid Systems	1-Nov **Lab9**	2 **Hwk8** Thermal Systems	3
12	6 **Lab10**	7 Time Domain	8 **Lab10**	9 **Hwk9** Time Domain	10
13	13	14 **EXAM 3**	15	16 Frequency Domain	17
14	20	21	22 THANKSGIVING BREAK	23	24
15	27	28 Frequency Domain	29	30-Nov **Hwk10** Feedback Control	1-Dec
16	4	5 Feedback Control	6	7 Feedback Control	8
17	11 **FINAL EXAM**	12	13	14	15

COURSE POLICIES: UNIVERSITY OF COLORADO - BOULDER

ACCOMMODATION FOR DISABILITIES

All faculty assume responsibility for ensuring that their individual courses and content are accessible to all students. Please utilize principles of Universal Design when creating new courses; otherwise, make appropriate alterations to existing material to accommodate students who require assistance. You may contact our Universal Instructional Design Consultant on the Academic Technology Design Team in the Office of Information Technology for more information by calling 303-735-4357 (5-HELP).

Faculty consultations with an Access Coordinator in Disability Services serve as an opportunity to provide clarity and guidance regarding the implementation of accommodations and working with students with disabilities. To request an appointment with an Access Coordinator, contact Disability Services at dsinfo@colorado.edu or 303-492-8671

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website (www.colorado.edu/disabilityservices/students). Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition or injury, see Temporary Medical Conditions under the Students tab on the Disability Services website and discuss your needs with your professor.

RELIGIOUS HOLIDAYS

It is the responsibility of every instructor to explain clearly her or his procedures about absences due to religious observances in the course syllabus so that all students are fully informed, in writing, near the beginning of each semester's classes. Campus policy regarding religious observances states that faculty *must* make reasonable accommodations for students and in so doing, be careful not to inhibit or penalize those students who are exercising their rights to religious observance. Faculty should be aware that a given religious holiday may be observed with very different levels of attentiveness by different members of the same religious group and thus may require careful consideration to the particulars of each individual case.

For more information on the religious holidays most commonly observed by CU Boulder students consult the online interfaith calendar.

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance.

See the campus policy regarding religious observances for full details.

CLASSROOM BEHAVIOR

Faculty and students should be aware of the campus Classroom and Course-Related Behavior policy which describes examples of unacceptable classroom behavior and provides information on how to handle such circumstances should they arise. Faculty are encouraged to address the issue of classroom behavior in the syllabus, and to understand their professional rights and duties. Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to

discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. For more information, see the policies on classroom behavior and the Student Code of Conduct.

SEXUAL MISCONDUCT, DISCRIMINATION, HARASSMENT AND/OR RELATED RETALIATION

The University of Colorado Boulder (CU Boulder) is committed to maintaining a positive learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct, discrimination, harassment or related retaliation against or by any employee or student. CU's Sexual Misconduct Policy prohibits sexual assault, sexual exploitation, sexual harassment, intimate partner abuse (dating or domestic violence), stalking or related retaliation. CU Boulder's Discrimination and Harassment Policy prohibits discrimination, harassment or related retaliation based on race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. Individuals who believe they have been subject to misconduct under either policy should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127. Information about the OIEC, the above referenced policies, and the campus resources available to assist individuals regarding sexual misconduct, discrimination, harassment or related retaliation can be found at the OIEC website.

HONOR CODE

The Boulder campus has an Academic Integrity Policy and a student Honor Code; individual faculty members are expected to familiarize themselves with its tenets and follow the approved procedures should violations be perceived. The campus has been working diligently to make this process work better and to provide guidance on 'gray areas' at the Honor Code website. All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the academic integrity policy. Violations of the policy may include: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, resubmission, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code Council (honor@colorado.edu; 303-735-2273). Students who are found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code Council as well as academic sanctions from the faculty member. Additional information regarding the academic integrity policy can be found at the Honor Code Office website.