USC Andrew and Erna Viterbi School of Engineering

AME302 Dynamic Systems

Sp 2023 — TuThur — 2-3:20pm
Session 28713R

Instructor	Professor Ben Yang Phone: (213) 740-7082; Email: bingen@usc.edu
Lecture	Tuesday and Thursday, 2-3:20 pm, CPA 207
Office Hours	Tuesday and Thursday, 11:00 am – 12:30 pm, OHE 412F

TA	Mr. Yichi Zhang Phone: (213) 321-2923; Email: yichiz@usc.edu Also, Google Chat, a service embedded in the USC student email account
Office Hours	Monday and Wednesday: 10:30 am – 12 noon Location: BHE B14
Discussion Session	To address issues in lectures, homework and project, to introduce Simulink, and to answer questions from students. Location and time: WPH B27, Friday 10 -11:50 am

Course Description

Modeling of lumped parameter elements and systems; free and forced response of first and second order systems; design-oriented approach to dynamic systems. This course is suitable for undergraduate students in aerospace, bio, civil and mechanical engineering.

Learning Objectives

Math review: differential equations, Laplace transform and matrix theory
System representations: differential equations, transfer functions, state equations, block diagrams
Modeling of mechanical, electrical, fluid and thermal systems
Lagrange's equation for mechanical systems
Combined or mixed dynamic systems, electro-mechanical systems
Analytical solution of 1st-order and 2nd-order differential equations
Numerical solution of differential equations
Frequency and time response
Utility of software MATLAB/SIMULINK in modeling and simulation

Co-requisites: MATH 245
Recommended preparation: AME 309 or CE 309; AME 301 or CE 235.

Required Readings and Supplementary Materials

Textbook: Bingen Yang and Inna Abramova
Dynamic Systems: Modeling, Simulation, and Analysis
ISBN: 9781107179790

Class notes: Downloadable from the website https://blackboard.usc.edu/

Grading Breakdown

Two 80-min Midterm Exams (@16% each)	32%
Project	16%
Homework (11 sets of problems)	28%
Final Exam (120 min)	24%
Total	100%

All the exams, project reports, and homework will be submitted online through the AME302 website on Blackboard. Instructions on the online exams will be given in due course.

Description of Assignments

Two (2) midterm exams, eleven (11) sets of weekly homework problems, a project, and the final exam will be assigned and graded during the semester. The accumulated points that a student earned from all the assignments will be used to assign a grade for the student. The grading is curved. All the exams are of closed book and closed notes.

Project Description

The project consists of several tasks, involving in modeling, analysis and numerical simulation of a dynamic system found in engineering applications. Usage of the software MATLAB/SIMULINK is required for numerical simulation. To earn credits for the project, students must turn in a hard-copy final report and software code that consists of MATLAB M-Files and SIMULINK model files.

Assignment Submission Policy

Weekly homework assigned, and due the following week. A final report for the project is due near the end of the semester.

Additional Policies

Late homework receives **NO** credits.
Late project report receives **NO** credits.
A make-up midterm exam can be arranged with a Doctor's note
No make-up final exam can be arranged according to the University policy.

AME 302 Website

All the class notes, handouts, homework assignments and solutions, and project description are paperless. These documents are downloadable from the web https://blackboard.usc.edu/
You can get access to the course materials from the following directories or folders:

"Syllabus" -- course information
"Content" -- lecture notes and handouts, homework and solutions, midterm exam solutions, and project description

Course Outline

1. Introduction to AME 302 (Refer to Chapter 1 of the text)

2. Mathematics Review (Refer to Chapters 2)
   - Laplace transform & properties
   - Inverse Laplace transform by partial fraction expansion
   - Solution of differential equations via Laplace transform
   - Transfer functions of differential equations
   - Solution of differential equations via the method of undetermined coefficients (optional, handout)

3. Mechanical Systems (Refer to Chapters 3)
   - Three keys in modeling dynamic systems: (a) Fundamental principles; (b) models of basic elements; and (c) ways of analysis (synthesis)
   - Review of fundamental principles (Newton's laws) of mechanical systems
   - Inertia, spring and damping elements
   - Translational and rotational systems
   - Derivation of equations of motion (single and multi-body systems, coupled translational and rotational systems)
   - Transfer function formulation
   - State representation
   - Geared systems
   - Block diagrams
   - Lagrange's equations (optional)

4. Electrical Systems (Refer to Chapter 4)
   - Introduction
   - Basic elements and concept of impedance (Sections 6.1 and 6.3)
   - Transfer functions and state equations
   - Passive circuit analysis
   - Active circuit analysis

5. Thermal and Fluid Systems (Refer to Chapter 5)
   - Fluid capacitance and fluid resistance
   - Liquid-level systems
   - Thermal capacitance and thermal resistance
   - Dynamic models of thermal systems

6. Modeling and Simulation via MATLAB and SIMULINK (Refer to Chapter 3 and 6)
   - Transfer function formulation and system response via MATLAB
   - State representation via MATLAB
   - Solution of Differential equations via MATLAB
   - Block diagram and SIMULINK

7. Transient and Steady-State Response (Refer to Chapter 7)
- Categories of system response
- 1st-order systems (Section 8.1)
- 2nd-order systems (Sections 8.2 and 8.3)
- Higher-order systems
- Numerical solution of nonlinear systems via R-K method (optional)

8. System-Level Analysis (Refer to Chapters 7 and 8)
- Block diagrams with multiple inputs and multiple outputs
- Electro-mechanical systems
- Feedback control systems
- Stability
- Steady-state errors
- Frequency response (optional)

Course Schedule: Weekly Breakdown

Important Dates			
	02/23/2023	Midterm Exam 1 (80 min)	Thursday
	03/30/2023	Midterm Exam 2 (80 min)	Thursday
	04/29/2023	Project report due by 11:59 pm, PT	Saturday
	05/04/2023	Final Exam (120 min)	Thursday

Week	Date	Materials Covered/Exams	Comment
1	1/10	Introduction & complex numbers	
	1/12	Math review – Differential equations	
2	1/17	Math review – Undetermined coefficient method	HW 1
	1/19	Math review – Laplace transform	
	1/20	1st Discussion Session given by TA	
3	1/24	Inverse Laplace transform	HW 2
	1/26	Solution of differential equations by LT	
4	1/31	Mechanical systems: three-keys in modeling	HW 3
	2/2	Mechanical systems: translational systems	
5	2/7	Mechanical systems: transfer functions	HW4
	2/9	Mechanical systems: rigid body systems	
6	2/14	Mechanical systems: rigid body systems	HW4
	2/16	Mechanical systems: rotors, geared systems	
7	2/21	Block diagrams: three basic types	HW 6
	2/23	**Midterm Exam 1 - online**	
8	2/28	Block diagrams: equivalent transformations	
	3/2	Block diagrams in time domain; state equations	Project assignment
		Discussion Session: MATLAB simulation	By TA
9	3/7	State representation; numerical integration of state equations	HW 7
	3/9	Time response analysis: general concepts, first-order systems	

		Discussion Session: Introduction to SIMULINK	By TA
10	3/14	No class & no office hours – Spring recess	
	3/16	No class & no office hours – Spring recess	
11	3/21	Time response analysis: second-order systems, higher-order systems, simulation by MATLAB	HW 8
	3/23	Electrical systems: basic elements, impedance, Kirchhoff's laws	
12	3/28	Electrical systems: loop analysis and node analysis	HW 9
	3/30	**Midterm Exam 2 - online**	
13	4/4	Electrical systems: transfer functions, block diagrams, state representation	
	4/6	Active circuits; combined systems	
14	4/11	Electromechanical systems, DC motors	HW 10
	4/13	Feedback control systems: PID control law; stability analysis	
15	4/18	Feedback control systems: steady-state error, frequency response	HW 11
	4/20	Thermal systems	
16	4/25	Fluid systems	HW 11 due
	4/27	Class review	
	4/29	**Project report due by 11:59 pm PT**	Online submission
	5/4	**Final exam: Thursday, 2 - 4 pm, online**	

Statement for Students with Disabilities

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. Website and contact information for DSP: http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html, (213) 740-0776 (Phone), (213) 740-6948 (TDD only), (213) 740-8216 (FAX) ability@usc.edu.

Statement on Academic Integrity

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. *SCampus*, the Student Guidebook, (www.usc.edu/scampus or http://scampus.usc.edu) contains the University Student Conduct Code (see University Governance, Section 11.00), while the recommended sanctions are located in Appendix A.

Emergency Preparedness/Course Continuity in a Crisis

In case of a declared emergency if travel to campus is not feasible, USC executive leadership will announce an electronic way for instructors to teach students in their residence halls or homes using a combination of Blackboard, teleconferencing, and other technologies.

Created: 2022/11/29
Modified: 2023/01/09