USC Andrew and Erna Viterbi School of Engineering

AME302 Dynamic Systems
Sp 2025 — TuThur — 2-3:20pm
Session 28713R

Instructor	Professor Ben Yang Office: OHE 412F, Phone: (213) 740-7082; Email: bingen@usc.edu
Lecture	Tuesday and Thursday, 2-3:20 pm, ZHS 163
Office Hours	Tuesday and Thursday (regular lecture dates), 4:30 am – 6:00 pm, at office Tuesday and Thursday (exam dates), 9:30 am – 11:00 am, online

TA	T.B.D
Office Hours	T.B.D.
Discussion Session	To address issues in lectures, homework and project, to introduce Simulink, and to answer questions from students on the coursework. Location and time: WPH B27, Friday 10 -11:50 am (starting from Week 2)

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
By the end of this course, the student should be able to

- model mechanical, electrical, fluid and thermal systems by a three-key procedure
- obtain system representations: transfer function formulations, state representations, block diagrams in the *s* domain and the time domain
- model electro-mechanical systems and feedback control systems
- determine free and forced response of 1st-order and 2nd-order systems
- compute time response and frequency response
- obtain numerical solutions of time-varying systems and nonlinear systems
- use MATLAB/SIMULINK in modeling and simulation of dynamic systems

Co-requisites: MATH 245
Recommended preparation: on the level of 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
Cambridge University Press, 2022. ISBN: 9781107179790

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

Grading Breakdown

Two 80-min Midterm Exams (@17% each)	34%
Project	15%
Homework (10 sets of problems)	25%
Final Exam (120 min)	26%
Total	100%

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

Description of Assignments
Two (2) midterm exams, ten (10) 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 open book and open notes and are given online.

Project Description
The project consists of several tasks, involving in modeling, analysis and numerical simulation of dynamic systems 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 soft-copy final report (in PDF format) and software codes that consist of MATLAB M-Files and SIMULINK model files.

Assignment Submission Policy
Weekly homework assigned, and most 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 and solutions, and project description are paperless. These documents are downloadable from the web https://brightspace.usc.edu/
You can get access to these 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

AME 302 Lectures Recorded on Zoom (Room ZHS 163)

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

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

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 (optional)

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
- 2nd-order systems
- Higher-order systems
- Numerical solution of nonlinear systems via R-K method (Section 7.4)

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
   - Steady-state response
   - Frequency response

Course Schedule: Weekly Breakdown

Important Dates			
	02/27/2025	Midterm Exam 1 (80 min)	Thursday
	04/03/2025	Midterm Exam 2 (80 min)	Thursday
	05/04/2025	Project report due by 11:59 pm, PT	Saturday
	05/08/2025	Final Exam (120 min)	Thursday

Week	Date	Materials Covered/Exams	Assignments
1	1/14	Introduction & complex numbers Reading: Chapter 1 and Section 2.3 of the text	
	1/16	Math review – Differential equations Reading: Sections 2.5 and 2.6	
		No Friday discussion session in the 1st week	
2	1/21	Math review – Undetermined coefficient method Reading: Section 2.6	HW 1 – 5 problems
	1/23	Math review – Laplace transform Reading: Section 2.4	
	1/24	1st Friday Discussion Session	By TA
3	1/28	Inverse Laplace transform Reading: Section 2.4	HW 2 – 6 problems HW 1 due
	1/30	Solution of differential equations by LT Sections 2.4 and 2.7	
	1/31	Friday Discussion Session	By TA
4	2/4	Mechanical systems: three-keys in modeling Reading: Sections 3.1 and 3.2	HW 3 – 5 problems HW 2 due
	2/6	Mechanical systems: translational systems Reading: Section 3.2	
	2/7	Friday Discussion Session	By TA
5	2/11	Mechanical systems: transfer functions Reading: Sections 2.7 and 3.2	HW4 – 5 problems HW 3 due
	2/13	Mechanical systems: rigid body systems	

		Reading: Sections 3.3 and 3.4	
	2/14	Friday Discussion Session	By TA
6	2/18	Mechanical systems: rigid body systems Reading: Sections 3.3 and 3.4	HW5 – 6 problems HW 4 due
	2/20	Mechanical systems: coupled translation and rotation, geared systems Reading: Sections 3.4 and 3.5	
	2/21	Friday Discussion Session	By TA
7	2/25	Block diagrams Reading: Section 3.6	
	2/27	**Midterm Exam 1 - online**	HW 5 due on 2/23
	2/28	Friday Discussion Session	By TA
8	3/4	Block diagrams: equivalent transformations Reading: Sections 3.6 and 6.2	Project assignment HW 6 – 7 problems
	3/6	State representation	
	3/7	Friday Discussion: MATLAB simulation	By TA
9	3/11	State representation; time-domain block diagrams Reading: Sections 3.7 and 6.5	
	3/13	Time response analysis of dynamic systems: general concepts, first-order systems Reading: Section 7.1	HW 7 – 7 problems HW 6 due
	3/14	Friday Discussion: Introduction to SIMULINK	By TA
10	3/18	No class & no office hours – Spring recess	
	3/20	No class & no office hours – Spring recess	
11	3/25	Time response analysis: second-order systems, steady-state response to harmonic excitations; numerical integration for time response Reading: Sections 7.1 and 7.3	
	3/27	Electrical systems: basic elements, impedance, Kirchhoff's laws Reading: Sections 4.1-4.2	HW 8 – 4 problems HW 7 due
	3/28	Friday Discussion Session	By TA
12	4/1	Electrical systems: loop analysis and node analysis, a branched circuit Reading: Sections 4.3 and 4.4	
	4/3	**Midterm Exam 2 - online**	
	4/4	Friday Discussion Session	By TA
13	4/8	Electrical systems: state representation Electromechanical systems, DC motors Reading: Section 6.3	HW 9 – 7 problems HW 8 due
	4/10	Feedback control systems, PID control Reading: Sections 8.1-8.3	
	4/11	Friday Discussion Session	By TA
14	4/15	PID control law; stability Reading: Sections 7.2 and 8.3	
	4/17	Feedback control systems: Routh criterion; steady-state error Reading: Section 7.2 and 8.4	HW 10 – 6 problems HW 9 due
	4/18	Friday Discussion Session	By TA
15	4/22	Fluid systems Reading: Sections 5.4-5.6	
	4/24	Thermal systems	

		Reading: Sections 5.1-5.3	
	4/25	Friday Discussion on the Project	By TA
16	4/29	Project tips, Q&A for the project	HW 10 due
	5/1	Class review for the final exam, Q&A for the project and final exam	Last lecture of the course
	5/2	Friday Discussion on the Project and Final Exam	By TA
Final Exam Week			
	5/4	**Project report due by 11:59 pm PT**	Online submission
	5/8	**Final exam: Thursday, 2 - 4 pm**	Online exam

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.

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