USC Andrew and Erna Viterbi School of Engineering

AME302 Dynamic Systems

Sp 2020 — TuThur — 2-3:20pm online

Instructor	Professor Ben Yang Phone: (213) 740-7082; Email: bingen@usc.edu
Lecture	Tuesday and Thursday, 2-3:20 pm, online with Blackboard
Office Hours	Tuesday and Thursday, 9:30 am – 11:30 am, online with Blackboard

TA	Mr. Haowen Liu Email: haowenl@usc.edu
Office Hours	Monday and Friday: 3-4:30 pm, online with Blackboard
Discussion Session	To address issues in lectures, homework and project, and to answer questions from students. Location and time: THH 101 & online, 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: William J. Palm III, System Dynamics, 3rd ed. McGraw-Hill, 2014.
ISBN: 978-0-07-339806-8

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

Grading Breakdown

Two 80-min Midterm Exams (@18% each)	36%
Project	10%
Homework (11 sets of problems)	26%
Final Exam (120 min)	28%
Total	100%

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.

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)

2. Mathematics Review (Refer to Chapters 3)
   - 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 2, 4 and 10 of the Textbook)
   - 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 (Section 10.1)
   - Lagrange's equations (optional, handout)

4. Electrical Systems (Refer to Chapter 6)
   - Introduction
   - Basic elements and concept of impedance (Sections 6.1 and 6.3)
   - Transfer functions and state equations (Section 6.2)
   - Passive circuit analysis (Section 6.2)
   - Active circuit analysis (Section 6.3)

5. Thermal and Fluid Systems (Refer to Chapter 7)
   - 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
   - Transfer function formulation and system response via MATLAB (Sections 2.10 and 4.7, and handout)
   - State representation via MATLAB (Section 5.3 and handout)
   - Solution of Differential equations via MATLAB (Section 5.4)
   - Block diagram and SIMULINK (Sections 5.5, 5.6, 6.9 and 7.9)

7. Transient and Steady-State Response (Refer to Chapter 89)
   - Categories of system response
   - 1^{st}-order systems (Section 8.1)
   - 2^{nd}-order systems (Sections 8.2 and 8.3)
   - Higher-order systems
   - Numerical solution of nonlinear systems via R-K method (Handout, optional)

8. System-Level Analysis
   - Block diagrams with multiple inputs and multiple outputs
   - Electro-mechanical systems
   - Feedback control systems
   - Stability
   - Frequency response

Course Schedule: Weekly Breakdown

Important Dates			
	02/25/2021	Midterm Exam 1 (80 min)	
	04/08/2021	Midterm Exam 2 (80 min)	
	04/30/2021	Project report due by 11:59 pm, PT	
	05/06/2020	Final Exam (120 min)	

Week	Date	Materials Covered/Exams	Comment
1	1/19	Introduction & complex numbers	
	1/21	Math review – Differential equations Handout #1	
2	1/26	Math review – Laplace transform	HW 1
	1/28	Inverse Laplace transform	
3	2/2	Inverse Laplace transform	HW 2
	2/4	Solution of differential equations by LT	
4	2/9	Mechanical systems: fundamental principles and basic elements Handout #2	HW 3
	2/11	Mechanical systems: free body diagrams	
5	2/16	Mechanical systems: Transfer functions,	HW 4
	2/18	Mechanical systems: rigid bodies; pulleys and disks	
6	2/23	Mechanical systems: rotors and robots	HW 5
	2/25	Midterm Exam 1	Monitored by TA
7	3/2	Mechanical systems: wheels and pendulums	
	3/4	Mechanical Systems: shafts and rotor systems	
8	3/9	Geared systems	HW 6
	3/11	Block diagrams, three types of block diagrams;	Project assignment
9	3/16	Block diagrams for multi-input-multi-output systems;	HW 7
	3/18	State representation	
10	3/23	State representation: two special cases; time-domain block diagrams;	HW 8
	3/25	System response in time domain: introduction and 1st-order systems, Handout #3	
	3/26	Discussion Session: Introduction to SIMULINK	By TA, on Friday
11	3/30	Time response of 2nd-order systems	HW 9
	4/1	Time response of higher-order systems	

12	4/6	Electrical systems: Basic elements, impedance, Kirchhoff's laws	
	4/8	**Midterm Exam 2**	Monitored by TA
13	4/13	Electrical systems: Loop analysis and node analysis	HW 10
	4/15	State representation for electric systems; electromechanical systems;	
14	4/20	Combined systems; feedback control systems Liquid-level systems	HW 11
	4/22	Thermal systems	
15	4/27	System response in frequency domain	HW 11 due
	4/29	Stability , Class review	
	4/30	**Project report due by 11:59 pm PT (Friday)**	Submit online
	5/6	**Final exam: Thursday, 2 - 4 pm**	Monitored by TA

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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