USC Andrew and Erna Viterbi School of Engineering

AME302 Dynamic Systems

Fall 2017 — MWF — 1:00-1:50pm

Instructor	Professor Ben Yang Office: OHE 400F; Phone: (213) 740-7082; Email: bingen@usc.edu
Meeting	Monday, Wednesday and Friday, 1:00-1:50 pm, ZHS 163
Office Hour	Monday & Wednesday 10:30 am -12 noon

TA	Mr. Sichen Yuan Office: VHE 202; Email: ysichen@usc.edu
Office Hour	TBD
Discussion Session	Held by TA, to address issues in lectures, homework, and project, and to answer questions from students. Location and time: SLH 100, 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 Midterm Exams (@15% each)	30%
Project	10%
Homework	30%
Final Exam	30%
Total	100%

Description of Assignments

Two midterm exams, 12 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.

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

"Assignments" -- homework 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: A Weekly Breakdown

Important Dates			
	09/29/2017	Midterm Exam 1	
	11/13/2017	Midterm Exam 2	
	12/04/2017	Project report due	
	12/13/2017	Final Exam	

Week	Date	Materials Covered	Homework
1	8/21	Introduction & math review	
	8/23	Math review – Complex analysis	
	8/25	Math review – Laplace transform	HW 1
2	8/28	Math review – Properties of LT	
	8/30	Math review – Inverse Laplace transform	
	9/1	Math review – Partial fraction expansion	HW 2
3	9/4	**Labor Day, university holiday, no class**	
	9/6	Math review – Partial fraction expansion	
	9/8	Solution of differential equations by LT	
4	9/11	Mechanical systems: fundamental principles	HW 3
	9/13	Mechanical systems: basic elements	
	9/15	Mechanical systems: free body diagrams	
5	9/18	Mechanical systems: Transfer functions	HW 4
	9/20	Mechanical systems: Pulleys and disks	
	9/22	Mechanical systems: Rigid bars and rotors	
6	9/25	Mechanical Systems – Block diagrams	HW 5
	9/27	Mechanical Systems - Geared systems	
	9/29	**Midterm Exam 1**	**Monitored by TA**
7	10/2	Mechanical Systems – State representation	
	10/4	Simplification of block diagrams	HW 6
	10/6	Construction of block diagrams for mechanical systems	Project assignment
8	10/9	Block diagrams for multi-input-multi-output systems	
	10/11	Time-domain block diagrams	HW 7
	10/13	Introduction to SIMULINK	**Presented by TA**
9	10/16	Electrical systems: Basic elements	
	20/18	Electrical systems: impedance	HW 8

	10/20	Electrical systems: Kirchhoff's law	
10	10/23	Electrical systems: Loop analysis	
	10/25	Electrical systems: Node analysis	HW 9
	10/27	Electrical systems: Active elements	
11	10/30	Electro-mechanical systems	
	11/1	Electro-mechanical systems	HW 10
	11/3	Electro-mechanical systems	
12	11/6	System-level analysis	
	11/8	System-level analysis	HW 11
	11/10	System-level analysis	
13	11/13	System-level analysis	
	11/15	Thermal and fluid systems	HW 12
	11/17	**Midterm Exam 2**	**Monitored by TA**
14	11/20	Discussion on Project	By TA
	11/22	**Thanksgiving recess, no class**	
	11/24	**Thanksgiving recess, no class**	
15	11/27	Thermal and fluid systems	
	11/29	Thermal and fluid systems	
	12/1	Course review -- Last lecture	HW 12 due
	12/4	**Project report due by 5 pm (Monday)**	
	12/13	**Final exam: Wednesday, 11 am -1 pm**	

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.