

USC Viterbi School of Engineering

AME 302 Dynamic Systems

Units: 3

Fall 2016

Lecture: Mon, Wed, Fri—1:00-1:50 pm

Discussion: Fri—10:00-11:50 am

Location: VHE 217 (lecture)/ SOS B2 (discussion)

Instructor: Dr. Inna Abramova

Office: TBD

Office Hours: Monday, Wednesday, 10:00 am-12:00 pm

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IT Help: USC Information Technology Services

<http://itservices.usc.edu/>

Hours of Service: Monday-Thursday: 8:00 am-7:00 pm,

Friday: 8:00 am-5:00 pm,

Saturday-Sunday: 1:00 pm-5:00 pm

Contact Info: consult@usc.edu, (213) 740-555

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: vectors and matrices, complex numbers, differential equations, Laplace transform, analytical solutions of 1st-order and 2nd-order differential equations
- Dynamic system representations: differential equations, transfer functions, state equations, block diagrams
- Modeling of mechanical, electrical, fluid and thermal systems
- Lagrange's equations for mechanical systems
- Modeling of combined or mixed dynamic systems, electro-mechanical systems
- System-Level analysis in time domain, free and forced response, transient and steady-state response, system stability
- Introduction to frequency-domain analysis
- Introduction to feedback control systems
- Utility of software packages MATLAB/SIMULINK and/or Wolfram Mathematica for modeling and simulation of dynamical systems; numerical solution of differential equations

Prerequisite(s): MATH 245

Co-Requisite (s): None

Concurrent Enrollment: None

Recommended Preparation: AME 309 or CE 309; AME 301 or CE 325

Course Notes

Class notes, assignments, handouts, and other class materials are downloadable from the Blackboard: <https://blackboard.usc.edu/>. Class announcements will also be posted on the Blackboard.

Required Readings and Supplementary Materials

Required Textbook:

William J. Palm III, "*System Dynamics*", 3rd ed. McGraw-Hill, 2014, 913 pp., ISBN: 978-0-07-339806-8

Supplementary Reading:

C.M. Close, D.K. Frederick, and J.C. Newell, "*Modeling and Analysis of Dynamic Systems*", Wiley, 3rd ed., 2002

R. S. Esfandiari and B. Lu, "*Modeling and Analysis of Dynamic Systems*", CRC Press, 2010

D.G. Luenberger, “*Introduction to Dynamic Systems: Theory, Models, and Applications*”, Wiley, 1979



R. L. Woods and K. L. Lawrence, “*Modeling and Simulation of Dynamic Systems*”, Prentice Hall, 1997

Description and Assessment of Assignments

Two midterm exams, 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.

Software MATLAB/Simulink or Wolfram Mathematica is required to do the project.

Grading Breakdown

Assignment	Points	% of Grade
10 Homeworks, 15 pts each	150	25
Project	60	10
Midterm 1	90	15
Midterm 2	90	15
Final Exam	210	35
TOTAL	 600 	100

Assignment Submission Policy

Weekly homework assigned, and due the following week.
The class project report is due December 02, 2016.

Additional Policies

Late homework receives **NO** credits.

A 90-min discussion session will be held each week, to address problem-solving, issues in lectures, homework problems, and the project.

Course Outline

1. Introduction to AME 302 (Refer to Chapter 1)
2. Mathematics Review (Refer to Chapter 2; handout)
 - Vectors and Matrices (handout)
 - Complex numbers (handout)
 - Ordinary differential equations; solving differential equations via the method of undetermined coefficients (Section 2.1, handout)
 - Laplace Transform & its properties; Initial Value theorem & Final Value theorem (Section 2.2, handout)
 - Inverse Laplace transform by partial fraction expansion (Section 2.4, handout)
 - Solution of differential equations via Laplace transform (Section 2.3, handout)
3. Mechanical Systems (Refer to Chapters 2, 3, 4, and 5)
 - 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 (Sections 4.1, 4.2, 4.4, 4.5)
 - Translational and rotational systems (Chapter 3)
 - Geared systems (Chapter 3)
 - Derivation of equations of motion (rigid body motion, single and multi-body systems, coupled translational and rotational systems) (Chapters 3 and 4)
 - Transfer function formulation (Sections 2.6 and 5.1)
 - State-space representation (Section 5.2)
 - Block diagrams (Section 5.1)
 - Energy methods and Lagrange's equations (optional) (Section 4.3, handout)
4. Electrical Systems (Refer to Chapter 6)
 - Basic elements and concept of impedance (Sections 6.1 and 6.3)
 - Passive circuit analysis (Section 6.2)
 - Active circuit analysis (Section 6.4)
5. System Analysis in Time Domain – Transient and Steady-State Response (Refer to Chapter 8)
 - Categories of system response
 - 1st-order systems (Section 8.1)
 - 2nd-order systems (Sections 8.2 and 8.3)
 - Higher-order systems
6. System-Level Analysis (Refer to Chapters 6, 9, and 10; handout)
 - Block diagrams with multiple inputs and multiple outputs
 - Electro-mechanical systems (Sections 6.5 through 6.7)
 - Feedback control systems (Chapter 10)

- Stability (handout)
- Frequency response (Chapter 9)

7. Modeling and Simulation with software: MATLAB/SIMULINK and Wolfram Mathematica (Refer to Chapter 5, and handouts)

- Transfer function formulation and system response with MATLAB (Sections 2.10 and 4.7, and handout) and with Mathematica (handout)
- State representation with MATLAB (Section 5.3 and handout) and with Mathematica (handout)
- Solution of Differential equations with MATLAB (Section 5.4) and with Mathematica (handout)
- Block diagram and SIMULINK (Sections 5.5, 5.6, and 6.9)

8. Thermal and Fluid Systems (optional, time-permitting; refer to Chapter 7)

- Fluid capacitance and fluid resistance
- Liquid-level systems
- Thermal capacitance and thermal resistance
- Dynamic models of thermal systems

Course Schedule: A Weekly Breakdown

	Topics/Daily Activities	Readings and Homework	Deliverable/ Due Dates
Week 1 8/22-8/28	Introduction Mathematics Review	Chapters 1 and 2; handout	
Week 2 8/29-9/4	Mathematics Review	Chapter 2; handout HW1 assigned (08-31)	
Week 3 9/6-9/11	Mechanical Systems: modeling, fundamental principles, basic elements, translational motion	Chapter 4 (Sections 4.1, 4.2) HW2 assigned (09-07)	HW1 due 9/07
Week 4 9/12-9/18	Mechanical systems: translational and rotational systems	Chapter 3 (Section 3.1) Chapter 4 (Sections 4.4, 4.5) HW3 assigned (09-14)	HW2 due 9/14
Week 5 9/19-9/25	Mechanical systems: rotational systems	Chapters 3 and 4 HW4 assigned (09-21)	HW3 due 9/21
Week 6 9/26-10/02	Mechanical systems: rigid body motion, multi-body systems, coupled translational and rotational systems	Chapters 3 and 4 HW5 assigned (09-28)	HW4 due 9/28
Week 7 10/03-10/09	System modeling techniques: transfer function, state-space representation, block diagrams	Sections 2.6, 5.1, 5.2 HW6 assigned (10-05)	HW5 due 10/05
Week 8 10/10-10/16	Midterm material review Project review Midterm 1, 10/12	Class Project assigned (10-14)	HW6 due 10/12
Week 9 10/17-10/23	Modeling & Simulation with Software Electrical systems: fundamentals	Sections 2.10, 4.7, 5.3-5.6, and handout Chapter 6 (Sections 6.1, 6.2)	
Week 10 10/24-10/30	Electrical systems: passive and active circuits analysis	Chapter 6 (Sections 6.3, 6.4) HW7 assigned (10-26)	
Week 11 10/31-11/06	System-Level analysis: modeling of combined systems Electromechanical systems	Handout Chapter 6 (Sections 6.5-6.7) HW8 assigned (11-02)	HW7 due 11/02
Week 12 11/07-11/13	Midterm material review Midterm 2, 11/09		HW8 due 11/09
Week 13 11/14-11/20	Energy methods and Lagrange's Equations Feedback control systems	Section 4.3, handout Chapter 10 HW9 assigned (11-14)	
Week 14 11/21-11/27	System analysis in time domain	Chapter 8 HW10 assigned (11-21)	HW9 due 11/21
11/23-11/27	Thanksgiving recess		
Week 15 11/30-12/4	System-Level analysis: stability, frequency response Course review for final exam	Chapter 9 handout	HW10 due 12/02 Class Project report due 12/02
FINAL	Final Exam		12/14 11:00 am – 1:00 pm

Statement on Academic Conduct and Support Systems

Academic Conduct

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Section 11, *Behavior Violating University Standards* <https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions/>. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, <http://policy.usc.edu/scientific-misconduct/>.

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the *Office of Equity and Diversity* <http://equity.usc.edu/> or to the *Department of Public Safety* <http://capsnet.usc.edu/department/department-public-safety/online-forms/contact-us>. This is important for the safety whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. *The Center for Women and Men* <http://www.usc.edu/student-affairs/cwm/> provides 24/7 confidential support, and the sexual assault resource center webpage sarc@usc.edu describes reporting options and other resources.

Support Systems

A number of USC’s schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the *American Language Institute* <http://dornsife.usc.edu/ali>, which sponsors courses and workshops specifically for international graduate students. *The Office of Disability Services and Programs* http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, *USC Emergency Information* <http://emergency.usc.edu/> will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.