USC Viterbi School of Engineering

AME 302 Dynamic Systems
Units: 3
Spring 2016
Lecture: Tue, Thu—9:30-10:50 am
Discussion: Fri—10:00-11:50 am

Location: MHP 106 (lecture)/ SLH 100 (discussion)

Instructor: Dr. Inna Abramova
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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
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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 1^{st}-order and 2^{nd}-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, 3^{rd} 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 April 29, 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
   - 1^{st}-order systems (Section 8.1)
   - 2^{nd}-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 1/11-1/17	Introduction Mathematics Review	Chapters 1 and 2; handout	
Week 2 1/18-1/24	Mathematics Review	Chapter 2; handout HW1 assigned	
Week 3 1/25-1/31	Mechanical Systems: modeling, fundamental principles, basic elements, translational motion	Chapter 4 (Sections 4.1, 4.2) HW2 assigned	HW1 due 1/26
Week 4 2/1-2/7	Mechanical systems: translational and rotational systems	Chapter 3 (Section 3.1) Chapter 4 (Sections 4.4, 4.5) HW3 assigned	HW2 due 2/02
Week 5 2/8-2/14	Mechanical systems: rotational systems	Chapters 3 and 4 HW4 assigned	HW3 due 2/09
Week 6 2/15-2/21	Mechanical systems: rigid body motion, multi-body systems, coupled translational and rotational systems	Chapters 3 and 4 HW5 assigned	HW4 due 2/16
Week 7 2/22-2/28	System modeling techniques: transfer function, state-space representation, block diagrams	Sections 2.6, 5.1, 5.2 HW6 assigned	HW5 due 2/24
Week 8 2/29-3/6	Midterm material review Project review **Midterm 1,** 3/03	Class Project assigned	HW6 due 3/03
Week 9 3/7-3/13	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 3/21-3/27	Electrical systems: passive and active circuits analysis	Chapter 6 (Sections 6.3, 6.4) HW7 assigned	
Week 11 3/28-4/3	System-Level analysis: modeling of combined systems Electromechanical systems	Handout Chapter 6 (Sections 6.5-6.7) HW8 assigned	HW7 due 3/29
Week 12 4/4-4/10	Midterm material review **Midterm 2,** 4/07		HW8 due 4/05
Week 13 4/11-4/17	Energy methods and Lagrange's Equations Feedback control systems	Section 4.3, handout Chapter 10 HW9 assigned	
Week 14 4/18-4/24	System analysis in time domain	Chapter 8 HW10 assigned	HW9 due 4/19
Week 15 4/25-4/29	System-Level analysis: stability, frequency response Course review for final exam	Chapter 9 handout	HW10 due 4/26 Class Project report due 4/29
FINAL	**Final Exam**		**5/10** **8:00 – 10:00 am**

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.htmlprovides 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.