ME 340 AL1 / ZJ1: Dynamics of Mechanical Systems
Fall 2023

Instructor: Alexander F. Vakakis, avakakis@illinois.edu
Office hours (in 3003 MEL): *Tuesday 12noon-1pm,* and *Thursday 12noon-1pm*

Lectures: *10-10:50pm Monday, Wednesday, Friday, 4100 Sidney LuMEB*

Course website: Log into https://canvas.illinois.edu/ to access the course website

Teaching Assistants (All TAs' office hours will be at the TA-Study rooms at LL of LuMEB)

Josh Tempelman (*), jrt7@illinois.edu,	Office hours: *Wednesday 4-5pm, Friday 4-5pm*
Liyuan Zhang, liyuan3@illinois.edu	TBA
Zhengtao Xu, zx8@illinois.edu,	Office hours: *Wednesday 5-7pm*
Mikayel Aramyan, mikayel2@illinois.edu	TBA
Hyungsoo Kang, hk15@illinois.edu,	Office hours: *Friday 7-9pm*
Alireza Askarian, askaria2@illinois.edu,	Office hours: *Thursday 4-5pm, Friday 5-6pm*

(*) Lead TA for our session.

Grader: Terry Taegyeong Kim

Textbook (recommended but not required): *Modeling and Analysis of Dynamic Systems*, by R.S. Esfandiari and B. Lu, CRC Press, 2014 or 2018 editions. Reserved for ME340 at Grainger Reserves.

Also another relevant textbook is *Engineering Dynamics: A Comprehensive Introduction*, by N.J. Kasdin and D.A. Paley, Princeton Univ. Press, 2011. This is also reserved for ME340 at Grainger Reserves.

Accommodations for Disabilities: To obtain disability-related accommodations for this class, students with disabilities are advised to contact the instructor and the Division of Rehabilitation-Education Services (DRES) (http://www.disability.illinois.edu/) as soon as possible. To contact DRES, you may visit 1207 S. Oak St., Champaign (Hours: 8:30am to 5pm, M-F), call 333-1970, or email disability@illinois.edu.

Equity and Diversity: This is an equal opportunity classroom environment. We value the diversity represented by the participants in this course. Our diversity is a primary source of ideas and perspectives. As you work through the course, practice using this diversity to your advantage.

Grading: In-class Quizzes: 5%, Midterm1: 15%, Midterm2: 15%, Final Exam: 30%
Homeworks: 25%, Labs: 10%

Grading Policy:

In each class there will be a short quiz (typically of about 5 minutes), which should be taken within the allocated time; at the end of the semester your 3 quizzes with the least grades will be dropped from your quiz grading.

In addition, there will be a weekly homework assignment which will be posted on the course website on Mondays, with your solutions being due a week later in class. Note that due to logistical constraints and in fairness to your fellow students *no late homeworks will be accepted unless there is a serious (e.g., medical or family) reason*; also once the homework solutions are posted on the course website on the date when the homework is due, no more homeworks will be accepted. You are encouraged to collaborate with your fellow students in the homework assignments, however you should only hand in your own *original* homework.

Regarding the exams, in fairness to your fellow students no makeup exams will be given (unless there is a serious reason). Evidence of plagiarism in an exam will be dealt with seriously.

Exams: Midterm 1: *Wednesday, September 27, 7-9pm, room 2100 LuMEB*
Midterm 2: *Wednesday, November 8, 7-9pm, room 2100 LuMEB*
Final Exam: *TBA*

Please mark your calendars with these dates and plan accordingly, since due to logistical constraints and in fairness to your fellow students *no conflict exams will be given*; the only possible exceptions could be for serious reasons (e.g., in case of a medical reason the necessary medical certifications need to be provided to the instructor).

Lab Assignments (Dr. Daniel J. Block, d-block@illinois.edu, is supervising the ME340 labs): Information and instructions are available at http://coecsl.ece.illinois.edu/me340/. The labs will be held bi-weekly starting the week of September 11. Please come prepared and familiar with that week's lab handout material. Specific questions regarding the lab exercises should be addressed to your individual TA.

Lab Handouts, Prelabs and Lab Reports are at, http://coecsl.ece.illinois.edu/me340/labhandouts.htm. There is a Prelab assignment to be completed before you attend the first lab. The Prelab assignment can be downloaded at http://coecsl.ece.illinois.edu/me340/Lab1_handout.pdf. If needed, Matlab® and/or Mathematica® can be downloaded at https://webstore.illinois.edu/.

The Lab schedule is as follows:

Week of	
Aug 21	No Lab
Sept 4	No Lab Labor Day
Sept 11	ME 340 Lab #1
Sept 25	ME 340 Lab #2
Oct 2	ME 340 Lab #3
Oct 9	ME 340 Lab #4
Oct 23	ME 340 Lab #5
Nov 6	ME 340 Lab #6
Nov 20	(Thanksgiving)
Nov 27	ME 340 Lab #7

ME340: Objectives

ME 340 covers dynamic modeling and analysis of mechanical components and systems. By the end of the course you should be able to do a variety of tasks, including:

- Create dynamic models of single- and multi-degree-of-freedom mechanical components and systems.
- Perform time-domain and frequency-domain analyses of linear time-invariant systems.
- Be familiar with important topics in mechanical engineering such as resonance, natural frequency and mode shape, and be able to design basic vibration/shock isolation systems
- Apply basic principles to linearize nonlinear systems.
- Use Lagrangian dynamics to model a dynamical system.
- Model a system using state (phase) space representation.
- Perform dynamical analysis in the time and frequency domains
- Be able to apply Laplace transforms to study the dynamics of discrete models of mechanical systems
- Be able to apply Fourier series to study time-periodic responses of discrete models of mechanical systems, and understand the notion of frequency and its role in dynamics
- Use MATLAB/Simulink to model and analyze the response of single- and multi-degree-of-freedom dynamical systems.

ME340: Topics to Be Covered

INTRODUCTION TO DYNAMICAL SYSTEMS

- Physical and mathematical models of dynamical systems
- Basic classification of dynamical systems – Linear versus nonlinear systems
- Examples

MODELING

- Elements of physical systems, and principles of conservation
- Free-body diagrams and Newton's 2^{nd} Law: Equations of Motion
- Translational and rotational systems
- Analytical dynamics: Principle of virtual work, Lagrange's equations of motion

REPRESENTATION AND SIMPLIFICATION

- State or phase space representation
- Linearization of nonlinear systems

SINGLE-DEGREE-OF-FREEDOM SYSTEMS: INPUT/OUTPUT RESPONSES

- Free and forced responses- time constants, damping ratios, dynamic overshoot
- Convolution (Duhamel's) integral
- Laplace transforms, transfer functions and stability analysis
- Frequency response, complex analysis, resonance; vibration absorber
- Fourier series analysis and introduction to Fourier transforms
- Applications to mechanical systems

MULTI-DEGREE-OF-FREEDOM SYSTEMS: MODAL ANALYSIS

- Matrix representation
- Modal analysis: natural frequencies, mode shapes and modal damping ratios
- Frequency responses and resonances
- Applications to shock and vibration isolation