1. **MEE321 – Mechanical Vibrations**

   Fall 2017

   Course (catalog) description

   Oscillatory motion, free vibration of single degree freedom systems, harmonically excited vibration, vibration under general forcing conditions, two or more degrees of freedom systems, and generalized eigenvalue problems. In addition to lecture, the course has scheduled laboratory sessions.

   Long description In this course we will model and analyze oscillatory motion in systems. We will begin with deriving the equation of motion for a spring-mass-damper system, a model representation of single degree of freedom vibration. Intuition for how the stiffness and damping affects system response to external inputs will be developed through simulation, analyses and representative examples from engineering. Real-world examples will be explored to appreciate how vibration analysis can be used to avoid anomalies in architecture and engineering. Laboratory sessions will complement theoretical concepts where students will understand how to measure system properties experimentally and perform vibration related analyses.

   Course objectives On completing this course, the student will be able to:

   - Identify and locate single degree-of-freedom systems in simple machines (e)
   - Experimentally determine system properties such as natural frequency and damping (b, d, g, k)
   - Analyze systems with multiple degrees of freedom (a, e)

2. **Prerequisites:** MEE 211, MEE 212, and MATH 336.

3. **Credit and contact hours:** 3 Cr. hrs. Contact hours is one 160 minutes lectures/week

   Meeting times

   Tue, Thu 9:30p–10:45p EB 221

4. **Instructor:** Sachit Butail

   EB 148
   Office hours: Mon 10a–12p, Thu 3:00–4:30p, or by appointment
   sbutail@niu.edu
   (815) 753-9987

5. **Teaching assistants:** Kiran Maridi (KM) and Hari Boddeeti (HB)

   EB 253 (KM, HB)
   Office hours: Mon, Fri 3–5p (KM), Mon, Wed 2–4p (HB)
   Z1798573@students.niu.edu (KM), Z1817537@students.niu.edu (HB)

6. **Textbook(s) and/or other required materials:**

   Engineering Vibration (4th Edition)
   Daniel J. Inman
   Publisher: Pearson

7. **Specific Course Information:**

   i. **Homeworks:**

   There will be seven homework assignments as part of this course due as per schedule (Table 1). You are encouraged to collaborate on these, however, the work you submit should be entirely your own. In case of a late submission, 10% of maximum marks will be docked for every additional day; after three days no marks will be awarded. Copying homework, first offense will get you 0 points on the homework; second offense will get you 0 points on the homework and -1% on the final grade; third and subsequent offense will get you 0 points on the homework and -5% on the final grade.

   ii. **Reading Assignments:** Reading assignments should be completed before the start of the week in order to get maximum advantage from the lectures. A question will be posted on blackboard to test your understanding of the reading material.

   iii. **Quiz/Exams:**

   There will be seven online quiz, one mid-term exam, and one Final exam as per the Schedule (1). The quiz will be administered via Blackboard; you will be allowed a single attempt within a 12 hour period starting 8am on the day of the quiz. The quiz will not be rescheduled. Collaboration of any form is not permitted during quiz/exams. You may only refer to your notes and homework during the quiz.

   iv. **Lab:** We will have four lab sessions in this course. The labs will consist of data acquisition, frequency analysis, and vibration measurement. This will be group work, but you must turn in your own lab report *online*. See Schedule (1) for the weeks when labs will be held.

   v. **Grading:**

   - Homework Assignments (best 6 out of 7): 20%
   - Quiz (best 6 out of 7): 20%
   - Labs: 20%
   - Mid-semester exam: 20%
   - Final exam: 20%

   vi. **Note:**

   - Students who are enrolled in the honors section are expected to complete a group project that will count towards 20% of their grade. Please contact me as soon as possible to get started.
   - It is your responsibility to check your scores on Blackboard periodically. Scores will only be updated for the most recent homework/quiz/project/exam.

8. **Specific goals for the course:**

   Coverage of ABET Outcomes:

   a. an ability to apply knowledge of mathematics, science, and engineering

   b. an ability to design and conduct experiments, as well as to analyze and interpret data

   d. an ability to function on multidisciplinary teams

   e. an ability to identify, formulate, and solve engineering problems

   g. an ability to communicate effectively

k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

9. **Topics covered:** The topics will be covered in the following order and can be found with the same name in the textbook. Please read relevant chapters in the textbook before attempting homework assignments

   - Free vibration; harmonic motion; damping
   - Modeling and energy methods; stiffness
   - Measurement; stability
   - Harmonic excitation of undamped and damped systems
   - Response to arbitrary input
   - Two degree-of-freedom model; eigenvalue analysis
   - Systems with more than two degrees of freedom

Accessibility Statement

If you need an accommodation for this class, please contact the Disability Resource Center as soon as possible. The DRC coordinates accommodations for students with disabilities. It is located on the 4th floor of the Health Services Building, and can be reached at 815-753-1303 (V) or drc@niu.edu. Also, please contact me privately as soon as possible so we can discuss your accommodations. The sooner you let us know your needs, the sooner we can assist you in achieving your learning goals in this course.

Academic Integrity

Please carefully go through `http://www.niu.edu/ai/students/`. Please discuss with me if you have doubts about what constitutes dishonesty, plagiarism, and cheating. You are responsible for your work!

Table 1: Schedule of classes. Reading assignments must be finished prior to coming to the lecture.

Date	Outcome	Reading assignments	Hwks	Labs	Quiz
8/29/17	Examples of oscillatory motion and damping in nature and engineering. Revise Ordinary differential equations (ODE)	Calculus II, Appendix A, 1.1			
8/31/17	Preliminaries on ODE and complex numbers				
9/5/17	Solutions of ODE, Alternative methods, MATLAB basics (bring laptop to lecture)	Appendix B, Lynda Tutorial, 1.9	1 due	1 (Mon-Thur)	
9/7/17	Solving ODE numerically, Euler versus Runge Kutta (bring laptop to lecture)				1
9/12/17	Free-body diagram to obtain equations of motion (EOM) for a mass-spring system.	1.2, 1.3			
9/14/17	Adding a damper to the mass-spring system				
9/19/17	Obtaining EOM using energy method	1.4	2 due	Lab 1 report due	
9/21/17	Lagrange's method to derive EOM				2
9/26/17	Stiffness of leaf, coiled, and helical springs, and arrangement of springs	1.5, 1.6, 1.8		2 (Mon - Thur)	
9/28/17	Vibration measurements and stability				
10/3/17	Harmonic excitation of undamped systems	2.1	3 due		
10/5/17	Beats and resonance, Numerical simulations				3
10/10/17	Harmonic excitation of damped systems	2.2, 2.3.2, 2.3.3			
10/12/17	Amplitude vs frequency, complex response and transfer function method			Lab 2 report due	
10/17/17	Review. Why did Tacoma Narrows fail?	Feldman, B. J. (2003). *The Physics Teacher*, 41(2), 92-96.		3 (Mon - Thur)	
10/19/17	Mid-term exam (Homeworks 1-3, Quiz 1-3, Lab 1-2)				MT
10/24/17	Base excitation	2.4, NASA Technical Paper 3556	4 due		
10/26/17	Solar Array induced disturbance in Hubble space telescope				4
10/31/17	Principle of superposition	3.1			
11/2/17	System response to impulse input				
11/7/17	System response to arbitrary input	3.2	5 due	Lab 3 report due	
11/9/17	Step response, simulations				5
11/14/17	Fourier series representation	3.3		4 (Mon-Thur)	
11/16/17	System response to periodic input, Numerical Simulations				
11/21/17	Using transforms to solve for systems responding to arbitrary inputs	3.4	6 due		
11/23/17	Thanksgiving Break				
11/28/17	Matrix Algebra	Appendix C, 4.1, 4.2			6
11/30/17	Two degree of freedom undamped systems, Eigenvalue problem				
12/5/17	Eigenvalue problem continued, Modal analysis (time permitting)	4.2, 4.3	7 due		
12/7/17	Review			Lab 4 report due	7
12/14/17	Final exam 10-11:50am (Homeworks 4-7, Quiz 4-7, Lab 3 and 4)				FE