1. **MEE321 – Mechanical Vibrations**

   Spring 2018

   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
   Mon, Wed, Fri 1:00p–1:50p EB 221

   Laboratory times
   Refer to schedule and myniu, EB 253

4. **Instructor:** Sachit Butail

   EB 148
   Office hours: Mon 10a–12p, Wed 3:00–4:00p, 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, Tue 3–5p (KM), Tue, 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 below. 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. It is however, in your best interest to submit homeworks on time so that we can post solutions for review before tests/quiz. 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 below. The quiz will be administered via Blackboard; you will be allowed a single attempt within a 9 hour period starting 2 pm on the day of the quiz. You must take these on a computer (instead of a smartphone) to ensure that you see all equations properly. The quiz will not be rescheduled and no extensions will be given. 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. You have already selected your lab day (Mon, Tue, Wed, or Thu) when you registered for this course. Check that again. 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 below for the weeks when labs will be held.

   v. **Grading:**
   - Homework Assignments (best 6 out of 7): 20%
   - Online Reading Assignments: 5%
   - Online Quiz (best 6 out of 7): 20%
   - Labs: 20%
   - Mid-semester exam: 15%
   - 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

Wk	Mon	Wed	Fri	Reading assignment	Laboratory objective	Outcome
1		17-Jan	19-Jan	Appendix A and B, 1.1		What is vibration? Why do we care? Where will this course help? Examples of oscillatory motion and damping in nature and engineering. How do you analyze a vibrating system? Revise Ordinary differential equations (ODE), play with simulations on https://www.myphysicslab.com/index-en.html
2	22-Jan	24-Jan	26-Jan	1.2		Continue revising ODEs, alternative methods for solving ODEs such as Laplace transforms and numerical integration, MATLAB examples and sample codes. Free-body diagram (FBD) to obtain equations of motion (EOM) for a mass-spring system;
3	*29-Jan*	*31-Jan*	*2-Feb*	1.3	*To introduce the vibrations laboratory, LabVIEW software, and lab report procedures*	What happens to the system response when you add damping?
4	5-Feb	7-Feb	9-Feb	1.4		Obtaining EOM using energy method. Which problems are amenable to energy method vs FBD? Lagrange's equations
5	12-Feb	14-Feb	16-Feb	1.5, 1.6		What is the stiffness of leaf, coiled, and helical springs, and how does stiffness vary with arrangement of springs. How is vibration measured (precursor to Lab 2)?
6	*19-Feb*	*21-Feb*	*23-Feb*	1.8	*To find the damping ratio and natural frequency of a single degree of freedom cantilever beam under free vibration*	When does a system become unstable? Numerical simulations
7	26-Feb	28-Feb	2-Mar	2.1		Response of *undamped* systems to harmonic excitation. When do we observe beats, and resonance. Response of *damped* systems to harmonic excitation, what to expect? What are some important variables to measure?
8	5-Mar	7-Mar	**9-Mar**	2.2, 2.3.2, 2.3.3		Amplitude vs frequency, Complex response and transfer function method, Review, **Mid term exam (hw 1-3, lab 1-2, quiz 1-3)**
9	12-Mar	14-Mar	16-Mar			*Spring recess*
10	*19-Mar*	*21-Mar*	*23-Mar*	2.4, Feldman, B. J. (2003). *The Physics Teacher*, 41(2), 92-96.	*To create a plot of displacement magnitude versus the frequency ratio for a damping ratio caused by a rotating unbalance*	Case study of Tacoma Narrows bridge example; Base excitation, and how it is different from harmonic excitation.
11	26-Mar	28-Mar	30-Mar	NASA Technical Paper 3556, 3.1		Case study on Solar Array induced disturbance in Hubble space telescope; Recall Principle of superposition, What is the system response to an impulse input? And how can we use it to derive the system response to an arbitrary input. Step response
12	2-Apr	4-Apr	6-Apr	3.2, 3.3		Fourier series to approximate a periodic signal in terms of sines and cosines. Use it to derive system response to periodic input, Numerical Simulations
13	9-Apr	11-Apr	13-Apr	3.4, 3.8, Appendix C		Using transforms to solve for systems responding to arbitrary inputs. Stability to forced inputs. Multiple degree of freedom systems, look at examples of modes and mode shapes. Linear algebra basics (matrix multiplication, inverse of a matrix)
14	*16-Apr*	*18-Apr*	*20-Apr*	4.1, 4.2	*To detect modes in a single degree of freedom structure using impact testing*	Eigenvalue problem, Two degree of freedom undamped systems, EOM
15	23-Apr	25-Apr	27-Apr	4.3		Modal analysis
16	30-Apr	2-May		5.1, 5.2		Acceptable levels of Vibration, Vibration isolation
	9-May					**Final exam 12pm-1:50pm (hw 4-7, lab 3-4, quiz 4-7)**
	Legend	Homework due	Online quiz on Blackboard. 2 hour quiz available 2-11pm. No extensions.	*Laboratory this week*	**Exam on this day**	

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!