EP/EMA 545 – Spring 2013
Mechanical Vibrations

Course Home Page: Engineering Moodle Courses: https://courses.moodle.wisc.edu
Lecture notes, homework and solutions will be posted on course web site.

Instructor:

Prof. Matt Allen
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Office Hours: T 9:15-10AM, 2-3PM, W 2-3PM, or by appointment

Grader: (available by appointment if needed)
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Prerequisites:
EMA 202 or 221, EMA 304 or 306, Math 223

Required Textbook: Mechanical and Structural Vibrations: Theory and Applications, Jerry H. Ginsberg, 1st Edition, Wiley, 2001.

Evaluation:

- **Weekly Homework sets** – Problems assigned weekly and typically due on Thursday. Late homework will not be accepted unless prior arrangements have been made with the instructor. Consulting with your peers is allowed so long as it is done responsibly.
    - If you are ill or otherwise unable to turn in an assignment, contact Prof. Allen immediately by phone or email to make arrangements to turn the assignment. Late homework will not be accepted unless prior arrangements have been made.
- **Exams (2)**
    - Two in-class exams, each approximately one hour long.
    - The instructor will also give occasional 5-min pop-quizzes focusing on very fundamental concepts, which will be graded for homework credit.
- **Design Project**
    - Work in groups of two and turn in a short but high-quality written report with handwritten calculations in the appendix.
- **Final Exam**
- Grades in the course will be based on the following weighting:
    - Homework Sets 30%
    - Exams 40%
    - Design Project 10%
    - Final Exam 20%

Academic Misconduct:
The instructor takes dishonesty very seriously. Cheating will not be tolerated, whether on exams, quizzes or homework. If there is reasonable evidence that you have cheated on a homework assignment, the instructor reserves the right to give you negative credit for the assignment up to three times the value of the assignment. (Score = –3*value of assignment.) Serious infractions will be handled through the designated university channels.

Online course description:
General theory of free, forced, and transient vibrations; vibration transmission, isolation, and measurement; normal modes and generalized coordinates; method of matrix equation formulation and

solution. The application of theory and methods to the analysis, measurement and design of dynamic systems.

General Topic Areas Covered:

- Equations of Motion for Discrete Vibratory Systems
- Transient Response of Single-Degree of Freedom (SDOF) Systems
- Steady State Response to Harmonic Excitation
- Modal Analysis of Multi-Degree-of-Freedom (MDOF) Systems
- Harmonic Excitation of MDOF Systems
- Vibration of Continuous Systems: The Ritz Method

Miscellaneous

Please inform me within the first two weeks of class of any specific days during the semester that may conflict with your religious observances, so I can make alternate arrangements for you.

Matlab

Many of the homework assignments require a computer package such as Matlab to complete. Matlab is available in all CAE computer labs. You can also purchase a student version for around $100 to install on your personal computer. Alternatively, there are a few clones of Matlab which may provide enough functionality to meet the needs of this course. These are compared in the following and in many blogs and websites:
http://www.webcitation.org/6BbWqerg3
The most notable for laptop/desktop computers seem to be:
Octave – www.octave.org
Freemat – www.freemat.org
Python with SciPy - http://en.wikipedia.org/wiki/SciPy
For Android:
Addi – https://play.google.com/store/apps/details?id=com.addi
Octave - https://play.google.com/store/apps/details?id=com.octave&hl=en

TENTATIVE **Semester Schedule:**

*** NOTE: All of the dates below are approximate.** The instructor reserves the right to adjust the schedule!

Date*	**Week**	**Topic** (*Book sections*)	**Due Dates**
1/22	1	Introduction, Review of Newton-Euler EOM (*1.1-1.4*)	
1/24		Numerical solution methods, Harmonic Functions (*2.1*)	
1/29	2	Intro – Solutions to EOM, Beating	
1/31		Free Response: Underdamped/Overdamped (*2.2*)	**HW #1 due**
2/5	3	Forced Response (*2.3*)	
2/7		Finish Forced Response (2.3)	**HW #2 due**
2/12	4	MSA OUT (IMAC) Video Lecture RF Switch Example, Aircraft Engine Example	
2/14		MSA OUT (IMAC) – Lab Demo (John Dreger)	**HW #3 due**
2/19	5	Frequency Response (*3.1, 3.2.1, 3.3*)	
2/21		**Exam #1** (Ch. 2, SDOF Time Response)	
2/26	6	Base Excitation, examples	*(Assign Design Project)*
2/28		Damping (3.2) Resonance (3.3) Stress in Springs (notes)	**HW #4 due**
3/5	7	Rotating Imbalance (*3.4*) Force Transmissibility (*3.6*)	
3/7		Intro to Fourier Series (3.7)	**HW#5 due**
3/12	8	FFT for Periodic Excitation (3.7.5) Fourier Transform, DFT/FFT, Aliasing	
3/14		FFT for Transient Excitation (3.8.2), Accelerometer (3.7.6), Examples	**HW#6 due**
3/19	9	MDOF EOM, Large Deformation & Linearization, Gravity Stiffness & Stiff Spring Approx	**DP analysis due**
3/21		Additional examples	**HW #7 due**
3/26-28		**Spring Recess** (Mar 23-31)	
4/2	10	MDOF Solution, Shuttle Example	
4/4		**Exam #2** (SDOF System Response)	**HW #8 due**
4/9	11	MDOF Systems – Intro to Eigenproblem (4.1-4.2)	**DP due** (Monday 5PM)
4/11		MDOF Systems – Orthogonality, Normalization (4.2.2)	**HW#9 due**
4/16	12	Examples: Free Response, Transient Response, Damping	
4/18		Modal Transformation – (4.3), 3DOF Example and Matlab, (done by video) (do after close fn's next time)	**HW #10 due**
4/23	13	Close Nat. Freqs. (4.2.5-6), Rigid Body Modes Frequency Response using Modal Coordinates	
4/25		Freq. Domain TF (5.1), Vibration Absorber (5.3)	
4/30	14	Introduction to Power Balance & Lagrange Methods (1.5)	
5/2		Ritz Method (6.1), Sound from a rod excited axially	**HW #11 due**
5/7	15	Examples Continued	
5/9		Aircraft Modes using Ritz, Aeroelasticity Example, Review for Final, Nonlinear Vibration	**HW #12 due**
5/16		**Final Exam: Thurs. May 16, 10:05AM - 12:05PM**	