

ME 440 – Intermediate Vibrations

Spring 2009

Time: 9:30 – 10:45 AM [Tu, Th]
Location: 3349EH through Jan. 31, 3126ME afterwards
Instructor: Dan Negrut
Office: 2035ME
Phone: 608 890 0914
E-Mail: negrut@engr.wisc.edu
Course Page: learnuw.wisc.edu

Grader: Naresh Khude (khude@wisc.edu)

Office Hours:

Monday, 2 – 4 PM
Wednesday, 2 – 4 PM
Friday, 3 – 4 PM
Other times by appointment (please call or email to arrange)

Text: S. S. Rao, Mechanical Vibrations, 2004 (4th edition, book is on reserve at Wendt Library).

Prerequisites: ME340

Catalog Description: Analytical methods for solution of typical vibratory and balancing problems encountered in engines and other mechanical systems. Special emphasis on dampers and absorbers.

Course Objectives:

The purpose of the course is to develop the skills needed to design and analyze mechanical systems in which vibration problems are typically encountered. These skills include analytical and numerical techniques (e.g., finite element methods) that allow the student to model the system, analyze the system performance and employ the necessary design changes. Emphasis is placed on developing a thorough understanding of how the changes in system parameters affect the system response.

Course Outcomes: Students must have the ability to:

1. Derive the equations of motion of single and multi-degree of freedom systems, using Newton's Laws and energy methods.
2. Determine the natural frequencies and mode shapes of single and multi-degree of freedom systems.
3. Evaluate the dynamic response of single and multi-degree of freedom systems under impulse loadings, harmonic loadings, and general periodic excitation.
4. Apply modal analysis and orthogonality conditions to establish the dynamic characteristics of multi-degree of freedom systems.
5. Generate finite element models of discrete systems to simulate the dynamic response to initial conditions and external excitations.

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Grades will be based on your performance on written homework and examinations. All homework and exam scores will be maintained on the Learn@UW course website. This will allow you to monitor your performance and see aggregate scores for the rest of the class, which can give you a continuous idea of your performance in relation to the rest of the class. Should you have questions about your score, please contact me. Policies regarding grading and turning in your homework:

1. *Score-related questions about homeworks and exams must be raised prior to the next class period after receiving the score.*
 2. *If homework that you turned in appears not to be graded (missing) on the Learn@UW course website please point that out to me within one week after the return of the corresponding set of graded homeworks. It is a good practice to save your homeworks so that I will be able to update the grade to give you full credit for your work.*
 3. *Please do not drop homework in my department mail box*
 4. *Homework is due at the beginning of each lecture*
 5. *Two homeworks with the lowest score will be dropped when computing the final homework average*
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Percentage participation to the final grade shall be distributed in the following manner:

Homework+Projects	=	40%
Exam I	=	20%
Exam II	=	20%
Exam III	=	20%
TOTAL		100%

Textbook reading assignments will be assigned prior to each class. You are asked to read the material, take notes and be prepared to participate in classroom activities. The Microsoft PowerPoint notes used in class will be posted online.

Homework: Problems will be assigned regularly during the semester. All assigned homework will be collected at the beginning of class on the due date. No late homework will be accepted. Homework solutions should be *neat and well organized*. All necessary diagrams and calculations must be clearly shown. The total point count for the assignment is the average of the points of the problems in that assignment, where each problem is graded on a 0-10 score. Your final score for each assignment will be between 0-10, based on how many points the solutions you provide accumulate.

Exams: Exams will include short-answer questions and problems. The best way to prepare for exams is to participate in class, learn the fundamental concepts, and practice homework and example problems from lecture and the text. Each exam will be scored on a scale of 1 to 100. One day prior to each midterm exam, at 7:15PM, a one to two hour review is offered for those interested. The location of this review session will be announced later.

Disability requests: I must hear from anyone who has a disability that may require some modification of seating, testing or other class requirements so that appropriate arrangements may be made. Please see me after class or during my office hours.

Complaints: If you have a complaint regarding the course and if you are unsatisfied with the response of the instructor, then you should contact the Chair of the Department of Mechanical Engineering. The Chair's office is in 3650ME, and an appointment to see the Chair can be made by contacting the Department Office at 608 263-5372.

Letter Grades: After each exam, you will be informed of the letter grade you would receive based on that exam alone. Final letter grades will be based on the total score accumulated on homework and exams throughout the semester using the following scale:

<u>Score</u>	<u>Grade</u>
≥94	A
87-93	AB
80-86	B
73-79	BC
66-72	C
55-65	D

Tentative Schedule for ME 440

Intermediate Vibrations

Spring Semester 2009

TEXTBOOK: *Mechanical Vibrations*, 4th ed. by S. S. Rao

COURSE INSTRUCTOR: Dan Negrut, Rm. 2035B ME Bldg., 890-0914, negrut@engr.wisc.edu

Date	Study Assignment	Topics Covered	HW
Jan. 20	1.1 – 1.6	Basic Concepts, Classifications, Procedures	1.79
Jan. 22	1.7 – 1.9	Spring, Mass, and Damping Elements	9,N
Jan. 27	1.10	Harmonic Motion, Complex Algebra, Fourier Series	1.34, 1.66
Jan. 29	1.11	Fourier Series, Complex Representation	1.68
Feb. 3	2.1 – 2.2	Review of Single DOF Systems: Deriving EOMs	2.35, 2.45, 2.69
Feb. 5	2.2, 2.6	IVPs, Transient Response	2.106, 2.108, 2.109
Feb. 10	2.6	Coulomb Friction, Logarithmic decrement; Applications	2.62, 2.111
Feb. 12	2.3	Pendulum Systems; Torsional Vibration; Energy Methods	2.71, 2.80
Feb. 17	2.5	Energy Methods; Rayleigh's Method and Applications	2.73, 2.82
Feb. 19	3.1 – 3.5	Review of Single DOF Systems: Harmonic Excitation	3.25, 3.50
Feb. 24		Exam 1¹	
Feb. 26	3.6 – 3.7	Harmonic Excitation: Rotating Unbalance, Design Problem Engine Mounts	3.30, 3.56
Mar. 3	3.8 – 3.11	Harmonic Excitation: Base Excitation, Beating Phenomena	3.35, 3.36
Mar. 5	4.1 – 4.3	Nonharmonic Excitation: General Periodic Excitation	3.40, 3.51
Mar. 10	4.4	Nonharmonic Excitation: Impulsive Forces, Convolution Integral	4.2, 4.6
Mar. 12	4.5 – 4.6	Nonharmonic Excitation: Convolution Integral, Superposition	4.23, 4.24
March 14 – 22, Spring Recess			
Mar. 24		Impulse Loading – Response Spectrum, Dynamic Load Factor	4.32, 4.35
Mar. 26	5.1 – 5.2	Two DOF Systems: Natural Frequencies and Mode Shapes	5.1, 5.4
Mar. 31	5.3 – 5.4	Two DOF Systems: Natural Frequencies and Mode Shapes, MATLAB	5.5, 5.8
Apr. 2	5.4	Two DOF Systems: Coupling, Matrix Notation	5.42
Apr. 7		Exam 2²	
Apr. 9	5.5	Two DOF Systems: Decoupling of EOMs, Principal Coordinates	5.28, 5.38
Apr. 14	6.8 – 6.10, 6.12	Modal Analysis: Natural Frequencies and Mode Shapes, MATLAB	No HW assigned, Expo Week
Apr. 16	6.13	Modal Analysis: Free Response of Undamped and Underdamped Systems	6.22, 6.54
Apr. 21	Lecture Notes	Tuned-Mass Dampers in Buildings (Prof. Engelstad)	No HW assigned
Apr. 23	6.14 – 6.16	Multi-DOF Systems: Forced Response and Lumped Mass Modeling	6.60, 6.61, 6.62
Apr. 28	6.14 – 6.16	Multi-DOF Systems: Lumped Mass Modeling	6.74, 6.80
Apr. 30	6.7	Lagrange's Equations	6.34, 6.43
May 5	Chapter 6	Examples (Lumped Mass, Lagrange's Equations, Forced Response) and Course Evaluation	
May 7		Exam 3³	

Final Exam: 2:45 pm - 4:45 pm, Wednesday, May 13th, 2009

¹ Review session held on Mo, Feb. 23. Time: 7:15 PM, room 3126ME

² Review session held on Mo, Apr. 6. Time: 7:15 PM, room 3126ME

³ Review session held on Wd, May 6. Time: 7:15 PM, room 3126ME