VIBRATION: THEORY AND LABORATORY, ME4410 (Section 14420)

I. GENERAL INFORMATION

Text: **Lecture Notes Package**, Updated version Fall 2004, by R. A. Ibrahim.
You are encouraged to purchase the classical book of *Mechanical Vibrations* by J. P. Den Hartog, which may be ordered from Dover Publications, Inc., 31 East 2nd Street, Mineola, N.Y. 11501. This book offers physical insight of mechanical vibrations encountered in industrial applications.

Instructor: Professor Raouf A. Ibrahim, Room #2119 Engineering, Tel.# 577-3885,
E-mail: ibrahim@eng.wayne.edu
Class Meeting & Place: 3:30PM-5:20 Monday & Wednesday, 0269 Manoogian.
Lab Experiments will be conducted in room 1325 Engrg. Bldg.
Office Hours: 2:00 - 3:00 PM Monday & Wednesday, Room 2119 Engineering.
Help Session will be held every Friday 3:00 - 4:00 PM, Conference Room 2145 Engrg. Bldg.
Prerequisites: ME3400, MAT2150 or 2350, ENG3050, computer programming, **Complex Algebra and Differential Equations**

II. COURSE SYLLABUS

1. Overview of Mechanical Vibration: Can a Mechanical Engineer afford to ignore mechanical vibration and resonance in the design of mechanical components?

2. Free Vibration of SDoF Systems: Equations of motion, natural frequency, energy method, effective mass, viscously damped free vibration, logarithmic decrement, Coulomb damping.

EXAM 1 covers items 1 and 2. (**40 points**)

3. Harmonically Excited Vibration, Forced harmonic vibration, rotating balance, whirling of rotating shafts, support motion, vibration isolation, energy dissipation, equivalent damping, structural damping, vibration measuring instruments.

Lab I. Whirling of Shafts Experiment:

Pre-lab Report (5 points) **Lab Report I (10 points)**

EXAM 2, covers item 3+ experiments I&II (**50 points**)

Design Project (**10 points**) due date to be announced

4. Systems with Two Degrees of Freedom, Normal modes and natural frequencies, concept of principal coordinates, coordinate coupling, forced harmonic vibration, vibration absorbers, vibration dampers.

Lab III. Two Degree-of-Freedom Torsional Vibration Experiment:

Pre-lab report (10 points) **Lab report IV (10 points)**

EXAM 3 covers item 4 and Experiment II (60 points) will be held on Monday Dec. 20 at 3:00PM-5:00PM.

Each Lab Experiment will be allocated for one week. Half of the class will conduct the experiment On Monday meeting; while the other half will attend a Video presentation related to the experiment. The following Wednesday meeting the two groups will switch. The attendance is important to participate in discussion, questions and answers. It is not possible under any circumstances to arrange a special lab for those who miss both lab meetings.
On Monday of the Lab meeting the pre-lab report will be collected from the two groups.

III. GRADING POLICY AND REMARKS

Total points = Exams (40+50+60) +Lab Reports (5+10+10+10) + Design Project (10) =**195**, the sum of your credit points/**175** = your grade%

A: 92 and above; A$^-$: 89 – 91; B$^+$: 86 – 88; B: 82 – 85; B$^-$: 79 – 81; C$^+$: 76 – 78; C: 72 – 75; C$^-$: 69 – 71; D$^+$: 66 – 68; D: 62 – 65; D$^-$: 59 – 61; E: less than 59

IV. Important Remarks

1. No project will be accepted after the designated time or in my mailbox.
2. Make up exams will not be permitted.
3. Homework Problems will not be graded. Third of the homework problems will be solved in the class. The complete solutions will be posted in the Science Library.
5. You have the right to complain against the fairness of your lab report or Exam grades within one week from the day they are returned back to you.
6. Each student is responsible for collecting his/her graded items on the day they are returned, uncollected items will be left in the classroom. Please ask one of your colleagues to collect it for you if you are not planning to attend the class.
7. Pre-lab reports are due on the day of lab meeting. Pre-lab assignment will be given once the theory of the related lab is covered.

V. Student Conduct

It is the responsibility of each student to adhere to the principles of academic integrity. Academic integrity means that a student is honest with him/herself, fellow students, instructors, and the University in matters concerning his or her educational endeavors. Thus, a student should not falsely claim the work of another as his/her own, or misrepresent him/herself so that the measures of his/her academic performance do not reflect his/her own work or personal knowledge. In this regard, cheating will not be tolerated. Cheating includes (but is not limited to) any communication (written or oral) during examinations and sharing of work, such as using the same models or computer programs or copying work. All homework and projects must be an individual effort unless specifically noted. **STUDENTS WHO CHEAT ON ANY ASSIGNMENT OR DURING ANY EXAMINATION WILL BE ASSIGNED A FAILING GRADE FOR THE COURSE.** Therefore avoid all appearance of improper behavior! Students who witness cheating should report the incident to the instructor as soon as possible. Students are also welcome to discuss any concern related to cheating with Dr. Ronald Gibson, Chair of Mechanical Engineering Department.

VI. Policy on withdrawal

Please note that the LAST day to drop a class with a tuition refund is September 20, 2004.
Also note that the College of Engineering DOES NOT ALLOW Withdrawal from courses after the FIFTH week of classes except under exceptional circumstances. FAILING of a class is NOT an acceptable excuse for withdrawal after the 5th week.

VII. Policy on deferred grades

Note that a grade of 'I' should only be assigned if the student IS NOT currently failing the class and if there is NOT a substantial quantity of work yet to be completed. An 'I' grade MUST be made up within one year of assignment of the grade.

Overall Course Goals: Students who successfully complete ME4410 will be able to:

- understand the characteristics of undamped and damped free and forced vibrations and the role of resonance in the design of mechanical systems;
- analyze and solve free and forced vibration responses of two-degree-of-freedom systems with emphasis on minimizing or absorbing vibration; and
- use symbolic manipulation and numerical computations to solve and to design mechanical systems.

Specific Learning Objectives: Letters in brackets refer to the BSME Program Objectives A – J. Numbers in brackets refer to the methods of evaluation, with 1 = Homework; 2 = Exams; 3 = computer and design projects and competitions; 4 = Presentations; and 5 = Pre-lab and Laboratory Reports).

Students who successfully complete ME 4410 will be able to:

- understand the main characteristics of undamped and damped free and forced vibration of SDOF systems and the physical meanings of phases in the responses [A, B, C, D; 2, 3];
- calculate natural frequencies and free vibration responses of SDOF systems by using free-body diagram and Newton's second law, and energy method [A, B, C, D; 2, 3];
- understand the role of resonance in the design process of mechanical systems [A,C,D, 1,2,3];
- understand the main characteristics of free and forced vibration and the concepts of coupling, modal ratio, principal coordinates of TDOF systems [A, B, C, D; 2];
- understand the basic concepts in measuring and analyzing whirling of shafts, critical speeds, and effects of boundary conditions on the critical speeds [A, B, C, D, E, G, H; 2, 3, 5];
- learn basic skills for measuring free and forced time and frequency response characteristics of coupled torsional two-DOF systems [A, B, C, D, E, G, H; 2, 3, 5];
- learn basic skills in design of vibration absorbers and techniques in identifying system parameters of TDOF systems [A, B, C, D, E, G, H; 2, 3, 5].

Relationship of Course to Program Educational Objectives:

Strongly related to the BSME Program Educational Objectives that successful students will:

- be able to understand scientific principles and apply them to the practice of mechanical engineering [A];
- be able to communicate effectively [B];
- possess the problem-solving skills, background, and confidence necessary to educate themselves continually throughout their careers [C];
- be able to apply computers as tools for engineering [D];
- be able to apply the basic principles of measurement, data analysis, and design of experiments, learned through "hands-on" laboratory experience [E];
- be able to develop creative solutions to engineering problems [G];
- be able to work well as part of a team [H];

Related to the BSME Program Educational Objectives that successful students will: