Department of Mechanical Engineering

ME433-Vibration Analysis

Technical Elective

Catalog Description: **ME 433 (3 0 3)**

An introduction to the fundamental theory of mechanical vibrations. Undamped and damped systems with single and multiple degrees of freedom, transient vibration, vibrations of continuous media, and analog and numerical methods.

Prerequisites: Mech 236 – Dynamics
Math 222-Differential Equations

Textbook(s) Materials Required:

1. William J. Palm, Mechanical Vibration, 1st Ed., J. Wiley, 2007.
2. Software: MATLAB, Math Works, Inc.

Reference(s) (Not Required):

1. William T. Thomson, Theory of Vibration with Applications, 4th Ed., Nelson Thornes Ltd., 2003.

Course Supervisor: Prof. Ben Serico

Pre-requisite by topic

1. Calculus
2. Ordinary differential equations
3. Force balance
4. Dynamics

Course Objectives[1]:

1. To develop the students skills in analyzing the vibration behavior of mechanical systems under different types of loading. (A, B, C)
2. To develop student analytical skills in the evaluation of dynamic characteristics of single –degree and multi-degree systems. Including the determination of natural frequencies and mode shapes. (A, B, C)
3. To develop the students skills in evaluating time response of systems under both free and forced conditions. (A, B, C)
4. To develop the students ability to evaluate the frequency response of systems driven by harmonic excitations. (A, B, C)
5. To provide the student with some knowledge of basic principles of design of vibration absorbers and isolators. (A, B, C,D,E)

Topics[2] :

1. Basic vibration and concepts of stiffness and damping (least squares method).

(3 hrs)
2. Differential equation of motion derived directly from Newton's laws. (6 hrs)
3. Free response of damped and undamped systems having single degree of freedom (6 hrs)
4. Harmonic response of systems having one degree of freedom including resonance. (6 hrs)
5. 1-DOF systems response to non-harmonic forcing functions. (6 hrs)
6. Design systems to eliminate or reduce the effects of unwanted vibration. (3 hrs)
7. Use Matrix methods for analysis for equations of motion and analysis. (3hrs)
8. Vibration measurement and testing, hardware and measurement of response. (3 hrs)
9. Vibration of systems that cannot be described adequately with lumped-parameter Modes. (3 hrs)
10. Applications of MATLAB to finite element analysis. (3 hrs)

Evaluation Method:
1. Quizzes
2. Exam
3. Homework

Schedule: Lecture Recitation: 3 hours, per week

Professional Component: Engineering Science

Program Objectives Addressed: A, B, C, D, E

Course Outcomes[3] :

Objective 1
1.1 Students will develop models of spring elements and damping elements and apply least square methods. (1,2,3) (a,e,k)
Objective 2
2.11. Students will demonstrate an ability to apply work energy methods for problems involving force, displacement, and velocity. (1,2,3) (a,c,e,k)
2. 2. Students will use software to solve some exercises (1,2,3) (a,e,k)
2. 3. Students will demonstrate the ability to property apply the mechanical energy equation to a variety of physical systems. (1,2,3,4) (a,c,e,h,k)
Objective 3
3. 1. Students will demonstrate an ability to compute the damped, natural frequencies, the logarithmic decrement, the time constant, and the damping factor, and determine whether or not the system is stable. (1,2,3) (a,e,h,k)
Objective 4
4.1. Students will demonstrate an ability to determine the resonance frequency and peak response.(1,2,3) (a,c,e,h,k)
4.2. Students will demonstrate the ability to analyze the displacement and transmitted force of system having base excitation, rotating unbalance, or rotor shaft vibration. (1,2,3)(a,c,e,h,k)
Objective 5

5.1 Students will apply the Fourier series method and the Laplace transformation method to obtain to obtain the response of a linear system. Also, expressed in matrix form. (1,2,3) (a,c,e,h,k)
5.2 Students will identify the modes of a system and compute its natural frequencies. (1,2,3) (a,c,e,h,k)
5.3 Students will study ways to reduce unwanted vibration and the equipment used for collecting response data. (1,2,3) (a,c,e,k)

Prepared by: Serico **Date: September 29, 2006**

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[1] Capital Letters in parenthesis refer to the Program Objectives of the Mechanical Engineering
Department. Listed in Sec 2 d Tables B-2-9, B-2-12. Table B-2-8 links Program Objectives with the ABET a-k Criterion.
[2] Topi**c** numbers in parenthesis refer to lecture hours. (three hours is equivalent to 1 week)
[3] Outcome numbers in parenthesis refer to evaluation methods used to assess the student performance. Lower case letters in parenthesis refer to ABET a-k outcomes.