1. Department, Course Number, and Course Title:

MECHANICAL ENGINEERING

ME 411 VIBRATIONAL ANALYSIS I

2. Designation:

Required	☐	Elective	☑
Lower Division	☐	Upper Division	☑

3. Course Description: Analysis of free and forced vibrations with and without damping, systems with several degrees of freedom, vibration isolation, mechanical transients, torsional vibrations, natural frequency computation techniques, finite element analysis software.

4. Prerequisites: CE/ME 320 (Dynamics I), MATH 215 (Differential Equations).

5. Text and Materials: Theory of Vibration with Applications, William T.Thomson, and Marie Dillon Dahleh, 5th Ed., Prentice-Hall, 1998.

6. Course Objectives: Seniors in M.E. will learn and understand concepts and principles, and methods of analysis, in mechanical vibrations. They will apply these concepts, principles, and methods to design.

Course Outcomes

- Ability to set up the governing equations of motion for single and two degree of freedom systems.
- Ability to calculate the natural frequencies for single and two degree of freedom systems, and the normal modes for two degree of freedom systems.
- Ability to apply the energy method to calculate the natural frequency of a single degree of freedom system.
- Ability to apply Rayleigh's method to account for the effect on natural frequency of distributed mass.
- Ability to determine the steady-state harmonic response for single and two degree of freedom systems
- Ability to determine the transient and shock response for single and two degree of freedom systems using the convolution integral and the Laplace transform.
- Understanding of the workings of vibration measuring equipment.
- Elementary understanding of the finite element method, and ability to use commercial FEM software.
- Ability to perform modal analysis for two degree of freedom systems.
- Awareness of the complexities and limitations of linear vibration analysis.
- Ability to apply concepts and methods of analysis form mechanical vibrations to design situations.

7. Topics Covered: (in Order of Presentation)

- Free vibration of a single degree of freedom (SDOF), undamped, linear system; conservation of energy; free vibration of a SDOF, viscously damped, linear system; Coulomb damping; instructions for using finite element software such as MSC/PATRAN and NASTRAN.
- Response of a SDOF, linear system, to harmonic excitation; design applications: rotating unbalance, transmitted forces and vibration isolation, support motion; vibration measuring instruments; energy dissipated in a SDOF, viscously damped system during sinusoidal steady-state vibration; structural damping; Coulo mb damping; superposition principle; response to periodic forces
- Response to aperiodic forces, transient vibrations; impulse response; convolution integral; step response; system response by the Laplace transform method; design by shock response spectrum.
- Two degrees of freedom (TDOF) systems; free vibration of an undamped TDOF system; coupled coordinates; steady-state response of a TDOF, undamped system, to sinusoidal forces; design of vibration absorber; general response of an undamped system; response of a viscously damped system

8. Class Schedule:

Number of Sessions per week:	2
Duration of each session:	1 hour 40 minutes

9. Contribution of course to meeting the professional component:

This course is part of the 25 units of upper division technical electives required for the mechanical engineering program.

Engineering Science	2 units
Engineering Design	2 units

10. Relationship of course to program objectives:

This course relates to the program objectives by contributing to the following measurable outcomes at the level indicated for all engineering graduates:

Knowledge outcomes:

- an ability to apply knowledge of mathematics, science, and engineering (abet a)
- a knowledge of computer aided design and simulation software
- a knowledge of measurement and manufacturing techniques
- a knowledge of how mechanical engineering integrates into inter-disciplinary systems

Skill outcomes:

- an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability (abet c)
- an ability to communicate effectively (abet g)
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (abet k)
- an ability to think in a logical sequential process

Attitudes Outcome:

- an understanding of responsibility and accountability

11. Prepared by: Stephen F. Felszeghy 05/2005