ME 4189 Structural Vibrations (Elective)

Catalog Description: ME 4189 Structural Vibrations (3-0-3)
Prerequisites: ME 3015 System Dynamics and Control, ODE, Linear Algebra
Single and multi-degree-of-freedom systems as well as continuous systems are analyzed for their vibrational response characteristics using both exact and approximate methods.

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

Topics Covered:

1. Free vibration of 1-DOF systems (modeling, energy methods, damping)
2. Forced harmonic excitation of 1-DOF systems (frequency response functions, resonance, rotating unbalance, base excitation and isolation, whirling of shaft/rotor systems, transducers, viscous and structural damping)
3. General free and forced response of 1-DOF systems; impulse and step response, convolution, shock spectrum, response to periodic excitation through use of Fourier series, computer calculation of system response including time integration
4. Free vibration of 2-DOF systems (natural frequencies, natural modes, beating phenomenon, dynamic and static coupling, Lagrange's method, generalized forces, relative and absolute coordinates)
5. Forced harmonic excitation of 2-DOF systems (impedance matrix, dynamic vibration absorber)
6. Multi-DOF systems (symmetry of mass and stiffness matrices, free vibration - eigenvalues and eigenvectors, modal matrix, orthoganality of eigenvectors, decoupling the equations of motion, modal, proportional/Rayleigh damping models, approximate methods, degenerate and rigid body modes)
7. Forced excitation of Multi-DOF systems (modal analysis, harmonic excitation, frequency response functions, computer solutions for free and forced response)
8. Approximate analysis of continuous systems (kinetic and potential energy functions for continuous systems, assumed modes method, free and forced response)
9. Simple continuous systems (normal modes and waves on strings, vibration of rods, and beams)

Course Outcomes:

Outcome 1: To teach students to model and analyze free and forced vibration of single and multi-degree-of-freedom lumped element systems

1.1 Students will demonstrate the ability to set up appropriate equations of motion for 1, 2 and Multi-DOF systems using both Newton’s laws and energy/Lagrangian methods.
1.2 Students will be familiar with normal modes and be able to find the normal modes and natural frequencies associated with Multi-DOF vibrational systems.
1.3 Students will be able to solve for the free vibration of Multi-DOF systems subject to given initial conditions.
1.4 Students will be able to determine the forced response of Multi-DOF systems for a wide variety of forcing conditions including rotating unbalance, base excitation, harmonic and general-periodic forcing, impulsive and shock excitation.
1.5 Students will demonstrate a knowledge of both structural and viscous damping models, and will be able to include damping into analyses of free and forced response.
1.6 Students will demonstrate the ability to solve free and forced vibration problems using a computer and to make use of computer resources such as software packages in the solution of vibration problems.

Outcome 2: To introduce students to the modeling and analysis of continuous vibrational systems including approximate solution methods.

2.1 The students will be able to derive the partial differential equation of motion and associated boundary conditions for simple continuous systems such as strings, rods, or beams.
2.2 The students will be able to obtain "exact" natural frequencies and natural modes for these systems.
2.3 Students will be able to express the free and forced response of simple continuous systems in terms of normal modes.
2.4 The students will be acquainted with one or more approximate methods for determining system modes and natural frequencies.

Outcome 3: To teach students how to apply these principles and analytical tools in the design of engineering systems and devices.

3.1 The students will demonstrate an ability to design effective vibration isolation systems and must demonstrate an understanding of the tradeoffs inherent in isolator designs.
3.2 Students will demonstrate an ability to design dynamic vibration absorbers as well as demonstrating an understanding of the uses, advantages, and disadvantages of vibration absorbers.
3.3 The students will demonstrate their ability to apply the principles of vibration analysis in the design and re-design of machinery and structures.
3.4 The students will be able to apply their knowledge of forced vibration to the design of electromechanical systems such as loudspeakers, seismometers, and accelerometers.

Correlation between Course Outcomes and Program Educational Outcomes.

ME 4189												
	Mechanical Engineering Program Educational Outcomes											
Course Outcomes	a	b	c	d	e	f	g	h	i	j	k	l
Course Outcome 1.1	X				X						X	X
Course Outcome 1.2	X				X						X	X
Course Outcome 1.3	X				X						X	X
Course Outcome 1.4	X				X						X	X
Course Outcome 1.5	X				X						X	X
Course Outcome 1.6	X				X						X	X
Course Outcome 2.1	X				X						X	X
Course Outcome 2.2	X				X						X	X
Course Outcome 2.3	X				X						X	X
Course Outcome 2.4	X				X						X	X
Course Outcome 3.1	X				X						X	X
Course Outcome 3.2	X				X						X	X
Course Outcome 3.3	X				X						X	X
Course Outcome 3.4	X				X						X	X

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