CLARKSON UNIVERSITY

**Department of Mechanical and Aeronautical Engineering**

Spring Semester 2005 AE/ME 455 Mechanical Vibrations

## LEARNING OBJECTIVES FOR FINAL EXAM

These should serve as your "roadmap" in studying for the exam. They are a statement of what I expect from the students taking this course. If it is mentioned here it may be on the exam. If it is not mentioned here, it will not be on the exam.

1. You should understand the meaning of and be able to provide a concise definition of the following terms as they apply to mechanical vibrations analysis: *discrete parameter or lumped parameter system, degrees of freedom, distributed parameter or continuous system, linear and/or nonlinear vibrations, deterministic and/ or nondeterministic vibrations, free and/ or forced vibrations, damped and/ or undamped vibrations.*

2. You should understand and be able to apply the force-relative displacement relationship for springs, the torque-relative twist relationship for shafts and torsional members, the force-relative velocity relationship for linear viscous dampers and the torque-relative angular velocity relationship for torsional dampers. You should be able to determine equivalent spring stiffnesses and equivalent damping coefficients for various combinations of springs (series and parallel) and various combinations of dampers (series and parallel).

3. You should be able to apply conservation of linear momentum and conservation of angular momentum (Newton's Second Law/D'Alembert's Principle/Dynamic Equilibrium) to get equations of motion for single degree of freedom mechanical systems with translational (or rectilinear) and rotational (or angular) motion.

4. You should be able to write the elastic stored (potential) energy of a spring or a torsional member and the kinetic energy of a mass or a rotating element. You should be able to use conservation of energy for conservative systems ( the *energy method)* to obtain the equation of motion for single degree of freedom mechanical systems.

5. You should be able to obtain the equivalent spring stiffness for linear elastic beams loaded in various ways, given the beam formulae, Young's Modulus and second moment of the cross-sectional area of the beam about its neutral axis. You should be able to determine the equivalent spring stiffness of beams combined with springs.

6. For undamped free vibration of single degree of freedom, linear mechanical systems, you should be able to determine the undamped natural frequency and the displacement, velocity and acceleration of the system mass as a function of time. You should be able to determine amplitude and phase angle of the motion given the initial conditions (initial excitation).

7. For damped free vibration of single degree of freedom, linear mechanical systems, you should be able to determine the undamped and damped natural frequencies. You should be able to determine the damping factor (or damping ratio). You should be able to distinguish between overdamped, underdamped and critically damped vibrations and be able to determine the displacement, velocity and acceleration of the system mass as a function of time. You should be able to determine amplitude and phase angle of the motion given the initial conditions (initial excitation). You should be able to use information about the amplitude decay to characterize system damping for underdamped systems.

8. For forced vibration of single degree of freedom, linear mechanical systems, both undamped and damped, you should be able to determine the equation of motion when force- or displacement-based excitations are applied. You should be able to determine both transient and

steady state responses -displacements, velocities and accelerations as a function of time for harmonically excited systems. You should understand the difference between *harmonic, periodic* and *nonperiodic* motion and/or excitation. You should be able to determine the frequency response - both amplitude and phase shift - for harmonically excited systems. You should be able to describe the meaning of *resonance* in words or using graphs and equations. You should be able to determine transmitted forces for vibration isolation or base excitation problems.

9. If I give you a simple periodic function with period $\tau$ (graphical representation), you should be able to write down an expression for the Fourier Series representation of the function. You should be able to obtain an analytic expression for the periodic function on the required interval and set up integrals for the Fourier coefficients. You will not be required to evaluate difficult integrals on the test.

10. Given the Fourier series representation for a periodic excitation, you should be able to obtain the steady state response for a single degree-of-freedom mechanical system to that periodic excitation.

11. Given the strength of an impulse excitation, you should be able to obtain the response of a single degree of freedom system to that impulse excitation. You should also be able to obtain the response to a sequence of impulses using superposition.

12. You should be able to obtain the differential equations of motion for a two degree-of-freedom system and you should be able to express them in matrix form.

13. You should understand and be able to give a brief explanation of the following terms related to two degree-of-freedom systems: *natural modes, natural frequencies, normal modes, elastic coupling, inertial coupling, principal coordinates.*

14. You should be able to determine the natural frequencies for a two degree-of-freedom system, given the system properties.

15. You should be able to determine the normal mode ratios and the normal modes of vibration for a two degree-of-freedom system, given the system properties.

16. You should be able to sketch mode shape diagrams for a two degree-of-freedom system and find the location(s) of the node(s).

17. You should be able to obtain the principal coordinates for a two degree of freedom system once the natural frequencies and normal mode ratios have been determined using other appropriate coordinates.

18. You should be able to determine the particular solution (or steady state response) of a two degree of freedom system to a simple harmonic excitation.

19. You should be able to solve problems like those given in homework assignments and discussed as examples in class, including computation of numerical answers and proper use and statement of units of computed quantities.