MEEN 363(501) Dynamics and Vibrations

REQUIRED OR ELECTIVE: Required course

COURSE DESCRIPTION: Application of Newtonian and energy methods to model dynamic systems with ordinary differential equations; system of rigid bodies; solutions of models; interpreting solutions/performance measures; vibrations; energy methods. Three credits (2-2).

TEXTBOOK: *Dynamics for Engineering Practice* by Dara Childs, 2008, John Wiley & Sons Custom Publishing

PREREQUISITES: MEEN 221, MATH 308, co-requisite MEEN 357 or CVEN 302 or registration therein

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COURSE LEARNING OUTCOMES: At the end of this course, students should be able to demonstrate the following knowledge and skills:

1. Use coordinate transformations to determine the components of a vector in two orthogonal coordinate systems.
2. Determine the velocity and acceleration vector for a point in 2D space using Cartesian, polar, and path coordinates and be able to use coordinate transformations to move from one coordinate definition to another.
3. Develop, state, and analyze the equations of motion (EOM) for particles and planar motion of rigid bodies using Newton's force and moment equations. This skill involves the following steps: (i) Select appropriate coordinates, (ii) Draw free-body diagrams including reaction forces and moments due to weight, linear springs, and linear dampers.
4. Understand "degrees of freedom" and be able to state how many degrees of freedom in an example.
5. Know how to derive the EOM for motion that is either about an arbitrary position or about equilibrium
6. Develop and analyze equations of motion for 1DOF particle and rigid-body examples using the work-energy principle.
7. Know the definitions and physical implications for the following terms: natural frequency (damped and undamped), damping ratio, period (damped and undamped), logarithmic decrement.
8. Know how to find the time response of a second-order linear vibration equation with an external force, including homogenous and particular solutions.
9. Understand frequency-response functions (amplitude and phase) for 1DOF examples including external harmonic excitation, base excitation, and excitation due to a rotating imbalance.
10. Be able to recognize and state kinematic constraint relationships between coordinates and use the knowledge in reducing degrees of freedom.
11. Be able to derive equations of motion for MDOF vibration systems including particles and rigid bodies from Newton's force and moment equations.
12. Understand undamped modal analysis and use it to produce an uncoupled modal model for 2DOF examples.
13. Be able to develop and produce a time-transient solution for a 2DOF example using modal analysis. Examples include particles and rigid bodies in planar motion.
14. Understand planar kinematics and be able to use it in analyzing 2D kinematic mechanisms.
15. Understand and be able to apply the rolling-without-slipping kinematic constraint.

16. Be able to develop models for planar mechanisms, torsional trains, and structures
17. Be able to write in full sentences a problem statement and procedure for showing analysis towards a solution.

TOPICS COVERED:

Week 1: Description of vector position and time derivatives in Cartesian, polar and path coordinates.
Week 2: Coordinate transformations: motion examples expressed in different coordinate systems.
Week 3: Newton's laws, constant acceleration, spring forces, 1DOF undamped vibration, natural frequency, equilibrium, forced excitation, pulleys and kinematic constraints. The simple pendulum and linearization. Energy dissipation, viscous damping, damping ratio, damped natural frequency, transient response solutions.
Week 4: Harmonic force and base-motion excitation, governing equation and steady-state solution. Excitation due to a rotating imbalance, governing equation and steady-state solution.
Week 5: Two-degree-of-freedom (2DOF) vibration problems; spring-mass and double-pendulum examples. Eigenanalysis for 2DOF systems. Uncoupling equations of motion using modal coordinates.
Week 6: Solving for free and forced motions using modal coordinates
Week 7: Equations for rigid body velocity and acceleration. Rolling without slipping: constraint and engineering applications
Week 8 &9: Planar kinematic examples solutions via geometry, polar coordinates, and two-coordinate system relations. Kinematic analysis of mechanisms
Week 10&11: Mass inertia properties, Force and moment equations of motion. Kinetic energy of a rigid body. The compound pendulum. Compound-pendulum/spring-connection. 1 DOF Torsional Example .
Week 12: General motion/rolling-without-slipping examples.
Week 13 &14: MDOF Torsional trains. MDOF structure examples with beam & bar elements. Calculation of natural frequencies and mode shapes
Weeks 15. 2DOF Planar motion examples

CLASS/LABORATORY SCHEDULE: Two, 50 minute sessions plus one 100 minute evening time slot per week, taught in lecture format. Around five group (no more than 5 members) projects assigned that require computer analysis (either Matlab or spread sheet solutions) and written technical reports. Five group quizzes before a major exam. Five (2 hour) evening exams plus a final exam (2 hour).

CONTRIBUTION TO MEETING REQUIREMENTS OF CRITERION 5:

Subject	Semester hrs	Subject	Semester hrs	Subject	Semester hrs
Mathematics		Engineering Science	3	General	
Basic Science		Engineering Design			

RELATIONSHIP OF COURSE TO PROGRAM OUTCOMES:

	ABET Program Outcome		ABET Program Outcome
x	a. ability to apply knowledge of mathematics, science and engineering		f. understanding of professional and ethical responsibility
	b. ability to design and construct experiments, and analyze and interpret data	x	g. ability to communicate effectively (written form mainly)
	c. ability to design a system, component, or process to meet desired needs within realistic constraints		h. education to understand the impact of engineering solutions in a global, economic, environmental, and societal context
x	d. ability to function on multi-disciplinary teams	x	i. recognition of the need for, and an ability to engage in life-long learning
x	e. ability to identify, formulate and solve engineering problems		j. a knowledge of contemporary issues
		x	k. ability to use the techniques, skills and modern engineering tools necessary for engineering practice

Prepared by : Dara Childs. **Updated by: Luis San Andrés** Date: January 15, 2009