MEEN 363/502 – Dynamics and Vibration FALL 2007

Course Description: Application of Newtonian methods to model dynamic systems with ordinary differential equations; system of rigid bodies; solutions of models; interpreting solutions/performance measures; vibrations; energy methods.
Prerequisites: ENGR 221, MATH 308, MEEN 357 or CVEN 302 or registration therein, CVEN 305 or registration therein

Course Objectives: To introduce fundaments for modeling mechanical systems, to derive differential equations of motion (kinetics and kinematics), find (predict) the dynamic response of systems using mathematical analysis, and to provide knowledge for practice in understanding mechanical systems behavior.

Class Time: TR 12:45 -1:35 pm FERM 303, T 5:30-7:20 pm RICH 101
ACCESS the class web site (ME363 section 502) at **http://elearning.tamu.edu** using your neo-ID and password

Instructor: Dr. Luis San Andrés, ENPH 118, Phone - 845-0160, 862-4744, LsanAndres@mengr.tamu.edu
Office hours: T, R: 11:30 am -12:30 pm, T: 4:00-5:00 pm, or by appointment (phone call or e-mail in advance).
TA: Benjamin Gronemeyer: ENPH 426, W 3-4 pm, R: 4-5 pm

References: **Dynamics in Engineering Practice, 7th Edition (only)**, D.W. Childs, TAMU Bookstore
MEEN 363 Lecture Notes, D. Childs, download from http://elearning.tamu.edu
Engineering Mechanics, Vol. II: Dynamics, Meriam, J.L., and L. Kraige, 1992, J. Wiley Pubs., III.
Advanced Engineering Dynamics, Ginsberg, J.H., 1995, Cambridge University Press.
Theory of Vibration with Applications, Thompson, W.T., and Dahleh, M.D., 1993, Prentice Hall.
In addition, Dr. San Andrés distributes via e-mail and through the class web site (**webCT**) additional notes (appendices) and solution to problems & past exams in pdf format as they become available.

EXAM SCHEDULE:

	Topics	Exam covers Lecture Sets	Date	Time	Place
1	**Planar kinematics for particle motion**	1-4	09/06	6-8 pm.	**SCOATES 208**
2	**Planar kinetics of 1-DOF lumped mechanical systems**	5-12	09/27	6-8 pm.	**RICH 114**
3	**Planar kinetics of 2-DOF lumped mechanical systems**	13-17	10/11	6-8 pm.	**RICH 114**
4	**Planar kinematics for rigid links (mechanisms)**	19-22	10/25	6-8 pm.	**SCOATES 208**
5	**Planar kinetics of rigid bodies and elastic structures**	23-31	11/15	6-8 pm.	**RICH 114**
6	**Final Exam**	5-17, 23-35	12/12	8-10 am	**FERM 303**

Grading: Five partial exams and a comprehensive final exam. Exams cover material specified on the SYLLABUS and PERFORMANCE OBJECTIVES. Practice problems (recommended homework) assigned but **not** graded. No make-up exams will be given unless the student has an acceptable and verifiable excuse (see http://student-rules.tamu.edu/rule7.htm) and notified the lecture instructor in advance. (If instructor is not in his office leave a [phone or e-mail] message and return address or phone number).

Exam 1	10%	
Exams 2,3,4,5	60 %	(15 % each)
Quizzes(7%)+ Assignments (8%)=	15%	(MATLAB/MATHCAD/MS Excel Spreadsheets)
Final Exam	15%	(Final is neither optional nor will be waived)
	100%	

The course letter grade is assigned from your numerical grade based on TAMU policy; i.e., A = 100-90, B = 89-80, C 79-70, D = 69-60, F = 59-0. There is no "curve" for the exams, assignments or the class final grades.

Notes:

November 2: Last day for all students to drop course with no penalty (Q-drop).
All background material on prerequisites is the responsibility of each student (**See page 8 and webCT**).

MEEN 363 Class Syllabus FALL 2007

Texas A&M University, Department of Mechanical Engineering **CH**: Childs textbook, **L**: lecture Notes

Acronyms below: M: mass, K: stiffness, C: damping, ODE: ordinary differential equation, EOM: equation of motion, SEP: static equilibrium position, DOF: degree of freedom, FBD: free body diagram, CE: characteristic equation, CME: Principle of Conservation of Mechanical Energy

wk	dates	Lecture Material (subject to revision)	Topic/ Reading Assignment
		PART 1. PLANAR KINEMATICS OF PARTICLES	**PART 1**
1	08/28 Tues day	**Class description**: Syllabus, Policies, Grading, Exam, etc. **L1.** Particle kinematics in a plane using Cartesian coordinates. Review of vector and matrix algebra. Coordinate transformations: relationships between components of a vector in two coordinate systems. Example: projectile motion. **L2.** Particle motion in a plane using polar coordinates. Radial and tangential unit vectors and their time derivatives. Components of velocity and acceleration vectors in polar coordinates. Examples of coordinate transformations: polar to Cartesian or vice versa.	**CH 2.1 thru 2.7** **Lecture Set L1-L4** (39 pages)
2	09/04	**L3.** Particle motion in a plane using path coordinates. Path radius of curvature, normal and tangential unit vectors and their time derivatives. Components of velocity and acceleration vectors in path coordinates. Examples of coordinate transformations: path to Cartesian or polar or vice versa. **L4.** Expressing motion in different coordinate systems: moving between Cartesian, polar and path coordinates. Physical units: conversions & understanding.	**Exam 1: 09/06** **Scoates 208 (L1-L4)**
		PART 2. PLANAR KINETICS OF LUMPED MASS SYSTEMS	**PART 2**
2	09/06	**L5.** Newton's Laws for particle kinetics and equivalence to change in linear momentum = linear impulse. Drawing free body diagram (FBD) and identifying forces acting on system mass (M). Derivation of Mechanical Work = Conservation of Mechanical Energy (CME) Principle. Example of motion with constant acceleration. Learning use of energy integral substitution. Mechanical stiffness element (K): Selection of coordinate system. Derivation of fundamental EOM for mass-spring (M-K) system. Solution of ODE to arbitrary initial conditions: system free and constant force responses. Concept of natural frequency. Review of physical units.	**(1 DOF systems)** **CH 3.1 thru 3.2d** **Lecture Set L5-L8** (41 pages)
3	09/11	**L6.** Derivation of EOM from CME: kinetic + potential energy = Work. Definition of static equilibrium position (SEP) and finding small amplitude motions (perturbation) about SEP. EOM including external (non-conservative) forces. Necessary condition for static stability (K>0). **L7.** Examples of simple M-K systems and interpretation of physical responses. Nonlinear EOM for simple pendulum and linearization for small amplitude motions: evaluation of natural frequency. Mechanical viscous damping element (C): constitutive relationship for energy dissipation element. Derivation of fundamental EOM for mass-spring-damper (M-K-C) system. Solution of ODE for arbitrary initial conditions: system free and constant force response. The concept of damped natural frequency and viscous damping ratio. Review of physical units. Necessary condition for dynamic stability (C>0). Types of system responses: underdamped, overdamped and critically damped. **L8.** Transient (1) response of simple M-K-C systems. Forced response including effect of initial conditions. Superposition of solutions: homogeneous + particular: formulas for forcing functions of the forrn = $c + at + b\,t^2$.	**CH 3.1 thru 3.2d** **Lecture Set L9-L12** (35 pages)
4	09/18	**L9.** More Transient Response (2) Solutions - Base excitation **L10.** Transient Response (3) Solutions - Base excitation: Ramp loading **L11.** Harmonic Excitation: solution to equation of motion = transient + permanent or steady-state components. Definition of system frequency response. Effect of excitation frequency and damping ratio on amplitude (amplification factor) and phase lag of steady-state response. Regimes of operation, the concept of system resonance. EOM for M-K-C system with harmonic base excitation. System response to harmonic base excitation. Effect of excitation frequency and damping ratio on amplitude (amplification factor) and phase lag of steady-state response. Regimes of operation. Example of road excitation on simple vehicle dynamics	**CH 3.3a**
5	09/25	**L12.** EOM for M-K-C system due to rotating imbalance. Physical nature of imbalance, magnitude of excitation force and its importance in rotating system dynamics. System response to mass imbalance. Effect of excitation frequency and damping ratio on amplitude (amplification factor) and phase lag of steady-state response. Interpretation of regimes of operation. Example of application to reduce vibration amplitude in a mechanical structure. Pulleys: EOMs and equations of constraint. Applications to M-K-C systems. **App G. Important design and operation issues/questions applying frequency response functions in simple M-K-C mechanical systems.**	**Exam 2: 09/27** **RICH 114** **(L5-L12)**

		Syllabus - continued	
w	**Dates**	**Lecture Material (subject to revision)**	**Topic/ Reading Assignment**
		PART 2. PLANAR KINETICS OF LUMPED 2-DOF SYSTEMS	**PART 2**
5	**09/27**	**L13** EOMs for 2-DOF mechanical M-K-C systems including base excitation. Free body diagrams (FBDs), selection of coordinates, and establishment of forces for mechanical elements connecting masses. Application of Newton's 2nd Law. Expressing EOMS in matrix form. Derivation of nonlinear EOMs for double pendulum.	**(2 DOF systems)** **CH 3.5** **Lecture Set L13-L17** (74 pages)
6	**10/02**	**L14.** Eigenanalysis of free response of 2-DOF undamped mechanical systems. Fundamental response function and derivation of system characteristic equation (CE). Solving CE: Eigenvalues (natural frequencies) and eigenvectors (mode shapes) of system, physical interpretation of natural frequencies and mode shapes. Transformation of coordinates to modal space via modal matrix of eigenvectors and uncoupling of system EOMs. **L15.** Transient response of 2-DOF undamped mechanical systems. Prediction of system transient (free) response using modal (natural) coordinates. Transformation to physical space. Examples of analysis and interpreting solutions (system responses). Examples of systems with rigid body motions: interpretation of null or zero natural frequency. Insights into the analysis of systems with viscous damping: lightly damped systems and systems with proportional damping. The concept of modal damping ratio. Application to the analysis of a 2-DOF system response after collision. **L16.** Transient response of 2- DOF M-K-C system with proportional damping. Example of usage of modal coordinates – Collision problem	**CH 3.5**
7	**10/09**	**L17** Forced periodic response of 2-DOF undamped mechanical systems. Steady state solution to harmonic force excitation using (a) modal coordinates and (b) direct substitution. Interpretation of regimes of operation: below, around and above natural frequencies. Effect of excitation frequency on amplitude (amplification factor) and phase lag of steady-state response. Insights into the forced periodic response of 2-DOF systems with viscous damping. **Examples: vibration absorber**	**Exam 3: 10/11** **RICH 114** **L13-L17**
		PART 3. PLANAR KINEMATICS OF RIGID BODIES	**PART 3**
7	**10/11**	**L19** Introduction to rigid body motion in a plane. Concept of rigid body. Rotation about a fixed axis and angular velocity vector. Vectors expressed relative to fixed coordinate system *(X, Y)* and coordinate system *(x, y)* attached to rigid body. Transformation of coordinates. Time derivatives of unit vectors in rotating coordinate system *(x, y)*. Derivation of velocity and acceleration vectors in two coordinate systems. Derivation of equations for velocity and acceleration vectors for two material points in rigid body. Geometrical interpretation of vector terms forming velocity and acceleration vectors. Example of application to pulley system.	**CH 4.1 thru 4.6** **Lecture Set L19-L23** (44 pages)
8	**10/16**	**L20** Rolling without slipping. Physical description of motion for wheels and gears. Fundamental constraint: geometrical development and visual demo. Derivation of equations for velocity and acceleration of material points in a rolling wheel: geometric-differential approach and vector analysis approach. Examples or rolling inside and outside of curved surfaces.**L21**. Planar kinematics of mechanisms: geometric-differential approach and vector analysis to determine velocity and acceleration of desired material points. Identifying constraints and DOF in linkage problems.	**CH 4.1 thru 4.6**
9	**10/23**	**L22-23.** Examples of three-bar mechanism, slider-crank mechanism, etc. Examples using polar coordinates for vector and acceleration definitions Dr. San Andres away	**Exam 4: 10/25** **Scoates 208 L19-L22**

		Syllabus - continued	
w	**Dates**	**Lecture Material (subject to revision)**	**Topic/ Reading Assignment**
		PART 4. PLANAR KINETICS OF RIGID BODIES (1 DOF)	**PART 4**
10	**10/30**	**L24.** Rigid body: inertia properties (center of mass and mass moments of inertia): development of equations. Parallel axis formula and restrictions to its application. Example: determining mass center and moment of inertia of a mass assembly. Steps in procedure. Use of published Tables containing useful mass properties **L25.** Motion of a rigid body on a plane: derivation of force and moment EOMs in Cartesian coordinates. Vector analysis. Reduced forms for the moment EOM: about mass center, about fixed point in inertial space. Applications. 1-DOF torsional vibrations: definition of torsional stiffness, natural frequency, and similitude to response of 1-DOF M-K-C system. Fixed axis rotation: simple rotor on bearings, pulleys connected by belts, gear transmission.	**CH 5.1 thru 5.5** **Lecture Set 24-27** (35 pages)
11	**11/06**	**L26.** Kinetic energy of rigid body in planar motion (translation and rotation). Examples of fixed axis rotation: derivation of equations from CME: rotor on bearings, torsional vibrations, pulleys connected by belts. **L27.**Nonlinear EOMs for compound pendulum, including damping: FBDs, application of force and moment equations. EOM derived from CME. Equilibrium and small amplitude motions about SEP, stable and unstable configurations. Example: Nonlinear EOMs for a swinging plate. **L28.**Nonlinear EOMs for compound pendulum connected to (linear) spring and viscous damper: FBDs, application of force and moment equations, geometric nonlinearities at linear element (K, C) connections, linearization of EOM about SEP. EOM derived from CME. Preload in spring elements. Finding natural frequencies and motions for bars and plates connected to springs and dampers.	**CH 5.5 a-c**
12	**11/13**	**L29** Rigid body motion with prescribed acceleration of pivot support point: FBDs, application of force and moment equations. Equations for reaction forces, interpretation of results. **L30**. Motion of cylinders rolling w/o slipping. FBDs, identification of forces and rolling constraint, derivation of EOM. Definition of Coulomb (dry friction) forces. When will the cylinder slip and not roll? EOM derived from CME. EOM for imbalanced cylinder rolling down an inclined plane, oscillations of a half cylinder on a flat plane: prediction and measurement of natural frequency. **L31.**More examples of rolling motion: cylinder restrained by spring, cylinder rolling inside a concave surface: FBDs, identification of forces and rolling constraint, derivation of EOM, linearization and identification of natural frequency. EOM derived from CME. Example: pulley assembly connected to spring element.	**CH 5.6 a-d** **Lecture Set 28-31** (25 pages) **Exam 5: 11/15** **RICH 114** **L23-L31**
		PART 5. PLANAR KINETICS FOR MULTI-BODY SYSTEMS	**PART 5**
13	**11/20**	**L32.**Torsional vibrations of rotating assemblies. Methods to estimate mass moments of inertia from oscillating assemblies. Motion of disks connected with flexible shafts: FBDs, identification of elastic moments, derivation of multiple DOF EOMs, eigenvalue analysis and determination of natural frequencies and mode shapes. Interpretation of natural modes of motion. **Thanksgiving 11/22-23**	**5.6c** **Lecture Set 32-35** (28 pages)
14	**11/27**	**L33.** Lateral vibrations of mass connected to an elastic beam. Brief review of lateral deflections of elastic beams. Definition of lumped stiffness (K) for cantilever beam. Derive EOM for mass supported at beam end: identification of system natural frequency. Analysis for development of beam stiffness matrix from force/moment relationships to beam displacement/rotation. Applications to building and bridge frames – 2DOF problems - eigensolutions **L34. 2DOF examples:** vehicle suspension system, rotor-bearing system, rolling w/o slipping. FBDs, identification of constraints and reaction forces, geometric approach to derive mechanism kinematics, derivation of EOMs from rigid body force and moment equations. Eigenanalysis – natural frequencies and interpretation of mode shapes.	**CH 5.6 b-d**
15	**12/04**	**L35. Nonlinear 2DOF systems:** A swinging bar supported by cord, a double compound pendulum. FBD, identification of constraints and reaction forces, derivation of nonlinear EOMs from rigid body force and moment equations, matrix form for numerical evaluation, linearization for small amplitude motions about SEP. **Closure.**	**CH 5.6 d, CH 5.8** **Last day of class, Tuesday 12/04**
16	**12/12**	**Wed, DECEMBER 12, 8-10 am FINAL Exam Content: L5-L17, L23-L35**	**FINAL EXAM** **FERM 303**

D. Childs textbook and lecture notes are mandatory for the class. I also recommend a few reference books, very valuable to help you in further understanding the class material. Attendance and attention to the lectures are **mandatory** for success.

Attendance to lectures is NOT mandatory, except for Quizzes. There will be no make up quizzes under any unjustified circumstance. For justification of absences see http://student-rules.tamu.edu/rule7.htm

About lectures

The class focuses on the dynamic response of mechanical (structural) systems. The lectures convey the fundamentals for system modeling and analysis, give you simple examples of system analysis and responses, and provide you with useful information for the design and troubleshooting of mechanical systems. There ARE significant amounts of subject material mentioned in the lectures **that are NOT** in the class handouts.

The instructor uses profusely overheads in class. The lecture presentations browse through the notes and DO not cover all details. The instructor will present and work out relevant (simple) examples in class. **The lecture time is too short to attempt to work complicated problems. You must do this on your own along with fellow students.**

Reading assignments

The syllabus lists the portions of the textbook and instructor's class handouts (lecture notes) that you must read and study prior to coming into class. I cannot force you to read the material ahead of time, yet you will soon discover the benefit of preparing in advance**. Past students successfully completing the class (A grade) noted that reading the textbook helped them to attain good grades.** The textbook includes a number of tips (procedural steps) for appropriate application of the knowledge learned.

The instructor will post on the class web site additional study material, released to your attention as the semester progresses. This material will consist of additional lecture notes (pdf files), and solutions to specific problems. You are responsible for checking frequently the web site for important messages, material and updates from your Lecturer.

Exam grades:

Exams will be promptly graded and returned to students. Solution Keys will be posted outside Lecturer's office (glass cabinet). Students will have ONE WEEK to revise an exam grade (after exam is returned to students). Revisions requesting more partial credit WILL NOT BE acknowledged. Only major shortcoming in grading, including incorrect addition of partial marks or grading will be acknowledged.

The grader will make an effort to READ your solution to problems in an exam. Correct usage of English language with explanations of procedures using **full sentences** will make a large portion of your partial grade. Worked problems that show a jargon of numbers without definitions and procedures will MERIT a LOW grade, even if the (numerical) answer should be correct.

Homework (recommended problems) assignments

The list of recommended problems will be posted on the class web site (http://elearning.tamu.edu), updated weekly and after each major exam. The problem statements are also listed in your course textbook.

The class web site will also include a number of worked problems. All documents are pdf files and some include video (avi) clips. The worked problems posted will be **REMOVED** after each major exam.

Practice or recommended problems (sets) will be assigned as the semester progresses. The course textbook includes the problem sets for each chapter. Your instructor may also post the problem statements on the course web site. The recommended problems are NOT graded, but they are good practice for the exams. It cannot be emphasized enough that the way to learn how to work problems is to work problems. Use the given answer (if known) only to determine that

your strategy, your procedure, and your numerical computations are correct. Working backwards from the answer will not teach you the engineering method, or the principles involved in the problem.

Complete solutions to (recommended) HOMEWORK problems **will NOT** be posted. Partial solutions, i.e. answers, **MAY be** released. Students should take advantage of office hours to obtain help in developing clear procedures for solution of problems and to improve their understanding of class materials. The instructor will not solve problems for you during office hours; instead he will aid you learn an engineering method for problem solving.

Schedule for computational assignments (group work – not individual – 5 members maximum – three minimum)

There will be at least eight (FOUR) graded computational assignments. The schedule – announcement and completion - will be posted on the class web site (http://elearning.tamu.edu). The assignments account for 8 % of your final grade.

See Format for Technical Memorandum for presentation of assignments. English style and grammar will be graded.

Students may use MATHLAB, MATHCAD, MAPLE, Visual Basic, or other computational software. A MATLAB Manual is available at the course web site, and you can download it to make your own copies. The assignments and due dates will be posted in the class web site. Dr. San Andrés will also release via e-mail pdf files detailing the solution to typical problems/projects.

Quizzes: Quizzes will be given on TUESDAY before each major exam (total = 6 quizzes) at the END of the late afternoon recitation. **Group work** is encouraged but students must work without disturbing other groups. **ONLY one quiz per group** will be accepted. Neatness in the quiz presentation and English will be graded. **A group is three or more students, maximum six.** The quizzes account for 7 % of your final grade.

If you miss a quiz you will get a zero, unless you have an official University excuse. There will be no make up quizzes.

The class TA will grade the quizzes and computational assignments and return them to you within a week.

MEEN 363 - Dr. Luis San Andrés More Policies

About plagiarism: As commonly defined, plagiarism consists of passing off as one's own ideas, words, writings, etc., which belong to another. In accordance with this definition, you are committing plagiarism if you copy the work of another person and turn it in as your own, even if you should have the permission of that person. Plagiarism is one of the worst academic sins, for the plagiarist destroys the trust among colleagues without which knowledge and learning cannot be safely communicated. If you have any questions regarding plagiarism, please consult the latest issue of the Texas A&M University Student Rules, under the section "Scholastic Dishonesty."

The textbook, homework assignments, problem sets, lecture notes, exams and handouts (appendices) used in this course are copyrighted. Because these materials are copyrighted, you do not have the right to distribute them freely, unless the author expressly grants permission. Note that (any) material downloaded from the www may be copyrighted. In all cases acknowledge the source of your information. Furthermore, passing as your own computer assignments/projects prepared by former students is NOT acceptable and will automatically bring you into disciplinary action by TAMU.

Americans with Disabilities Act (ADA) Policy Statement

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact the Department of Student Life, Services for Students with Disabilities, in Room B118 of the Koldus Building or call 845-1637.

Texas A&M University complies with the Americans with Disability Act. For this course, that means specifically that I will cheerfully work with identified students to provide appropriate alternative settings for tests and quizzes.

Academic Integrity Statement

Aggie Honor Code: ***"An Aggie does not lie, cheat, or steal, or tolerate those who do."***

Upon accepting admission to Texas A&M University, a student immediately assumes a commitment to uphold the Honor Code, to accept responsibility for learning and to follow the philosophy and rules of the Honor System. Students will be required to state their commitment on examinations, research papers, and other academic work. Ignorance of the rules does not exclude any member of the Texas A&M University community from the requirements or the processes of the Honor System. For additional information please visit: www.tamu.edu/aggiehonor/

On all course work, assignments, and examinations at Texas A&M University, the following Honor Pledge shall be preprinted and signed by the student:

"On my honor, as an Aggie, I have neither given nor received unauthorized aid on this academic work."

About office hours:

The purpose of office hours is to encourage individual interaction between the students and the instructor. The instructor is available to discuss not only questions related to the course, but other issues where he can help as a professional engineer, educator and researcher. Please take advantage of office hours. To utilize this time efficiently, students should prepare by organizing questions in advance.

I am willing to help you at times other than office hours without an appointment. However, just like you, I have responsibilities other than MEEN 363 (teach other classes, direct graduate student research, write proposals and technical papers, organize laboratories, voluntary work for ASME, etc.) I must budget certain times to meet those responsibilities. My weekly work schedule is posted outside my office. Please do not be offended if I am in the office but cannot meet with you.

The use of e-mails for communication with your instructor is acceptable. I usually receive three types of e-mail messages:

a) a request to schedule a meeting at other times than office hours,
b) questions related to the impending take-home quiz due (say) next day,
c) questions related to the study material for an exam.

I reply promptly to all messages (usually within the next working hour if I am in town).

If you cannot find me in my Campus Office, please call me at 862 4744. I spend 50+ hours/week at the Turbomachinery Laboratory (corner of FM2818 and George Bush Dr) where I conduct research and manage an excellent team of engineers performing experimental and computational work serving the needs of industrial sponsors.

MAKE UP CLASSES : when will the instructor be absent?

I have scheduled my attendance to several technical Conferences this FALL Semester. I will announce the exact date of my absences at least two weeks in advance. Make up recitations for lost classes will be scheduled within a week and be conducted at night time (between 6 p.m. to 8 p.m.).

Aug 29-Aug 31	Honeywell Turbocharging Technologies, Los Angeles, CA
Sept 12 (W)	Int. Turbomachinery Symposium, Houston
Oct 20-27	CIBIM8, Cusco, Peru
Nov 7-10	Congreso Latinoamericano de Turbomaquinaria, Veracruz, Mexico
Nov 18-24	Singapore (tentative)

Prerequisites for MEEN 363:

ENGR 221: Conservation Principles in Engineering
Statics and Newton's Laws of Particle Motion Conservation of Linear and Angular Momentum.
Principles of Work and Energy (Potential and Kinetic), Impulse and Momentum/Collision of particles

MATH 308: Differential Equations:
Solution of Linear Ordinary Differential Equations (operator or Laplace transform methods).
Systems of differential equations. Basic Theory of complex numbers. Conversion from Cartesian to polar coordinates.

MEEN 357: Engineering Analysis for MEs (concurrent)
Basic knowledge of computing languages (MATLAB).
Methods for numerical solution of systems of algebraic equations and (non)linear differential equations, and including evaluation of matrix eigenvalues/eigenvectors

OTHER things you should know:
Vector Algebra and Calculus. Complex numbers
Matrix Algebra including evaluation of determinants and solution of systems of linear algebraic equations.
Correct use of SI and U.S. Customary units: Conversion skills and equivalence of units.

AND LAST BUT NOT LEAST: DESIRE AND WILL TO LEARN!
See course webct site for a comprehensive description of pre-requisites for this course

OTHER IMPORTANT INFORMATION YOU SHOULD KNOW:

Mathematical procedures and analysis in assignments and exams will be regarded as erroneous if physical units are handled incorrectly. The least we can expect from conscientious students (potential mechanical engineers) is the correct usage and conversion of physical units and the ability to estimate the right order of magnitude of an answer to an engineering problem.

Refer to a math textbook and refresh your knowledge on the analytical solution of linear ordinary differential equations. This material is your sole responsibility since you learned it on a prior class (MATH 308).

In my experience, common sense is a must for a successful engineering career!

Dynamics is a historically difficult subject. Your success depends on you working the homework assignments, understanding the problem statements and following a logical method to achieve a solution, and explaining the nature of the results obtained (to fellow students if possible). Furthermore, absolute mastery on the handling of physical units and conversions (SI & US systems) is necessary to succeed in the class.

In Dynamics there are no small errors, a sign mistake could lead to catastrophic failures in actual applications, an incorrect conversion of physical magnitudes could mean enormous energy losses or worse yet, incredible expectations. To err is human; the mistake arises from our inability to correct the wrongs!

MEEN 363 – Dynamics and Vibrations
GLOBAL PERFORMANCE OBJECTIVES

IMPORTANT: Comprehensive Performance Objectives are available at course web site (http://elearning.tamu.edu)

Planar kinematics for particle motion: Student should be able to use Cartesian, polar and path-coordinate kinematics to define the velocity and acceleration components of a material point in motion. Student will learn to use coordinate transformations to shift back and forth between the three coordinate systems (Cartesian, polar and path). Student should be able to mathematically differentiate functions of time and space coordinates to determine desired functional forms.

Physical modeling of particle dynamics (1 DOF): You should be able to identify the fundamental components of mechanical systems into generalized lumped mass (inertia) M, stiffness K, damping C elements. Determine the degrees of freedom and/or the constraints present on the system. Establish the equivalence of Kinetic and Potential (Strain) Energies in Conservative systems. You should be able to derive the fundamental equations governing the motion of lumped-parameter (1 DOF and 2 DOF) mechanical systems in general plane motion. Fundamental knowledge of the kinematics and kinetics of planar rigid body motion: rectilinear motion and rotational motion about a rigid axis. Concepts of relative velocity and acceleration should be mastered.

Mathematical Modeling of 1 DOF mechanical systems: Student should be able to determine analytically the dynamic response (Solutions) of 1DOF systems described by the linear ODE $\{M\ddot{X} + C\dot{X} + KX = F(t)\}$ and given initial conditions. Be able to explain the concept of natural frequency ωn. Determine the free (transient) response to initial conditions and the dynamic response to Impulse and Step loads. Be able to discuss the concepts of transient and steady state responses, and the effect of viscous damping ratio (and logarithmic decrement) on the amplitude and decay speed of system response. Derive the dynamic response to periodic (harmonic) external forcing functions and discuss about the regimes of operation: below, close to, or above its natural frequency. Be able to obtain the Frequency Response Function (FRF) for sustained periodic excitations and explain the effects of system parameters and frequency on the Amplitude of motion and Phase lag. Use FRF for appropriate design considerations and reliable operation of vibrating systems.

Mathematical Modeling of 2 DOF mechanical systems: Student should be able to derive the EOMS for 2- or M-DOF lumped parameter systems. You should be able to linearize the EOMs about an equilibrium or operating point and determine the linear system of ODEs: $[M]\{\ddot{X}\}+[C]\{\dot{X}\}+[K]\{X\}=\{F(t)\}$. For undamped 2-DOF systems Student should be able to determine analytically the eigenvalues and eigenvectors of $\omega^2[M]\{\varphi\}=[K]\{\varphi\}$. Be able to explain the concept of modal (natural) coordinates and mode shapes. Student should be able to use the transformation $\{X\}=[\Phi]\{\eta\}$ to uncouple the EOMS in physical coordinates and determine (analytically) the free and forced response of 2-DOF systems to arbitrary initial conditions, step and periodic loads.

Numerical Modeling of mechanical systems: Student should be able to use computational software to solve linear and nonlinear algebraic and differential equations describing the motion of 1- or M-DOF systems. You should be able to apply knowledge gained in MEEN 357 to select appropriate numerical techniques with due consideration for time steps and procedures (algorithms) ensuring accurate, numerically stable, and cost efficient system response. Student should be able to interpret numerical calculations (predictions) to explain system behavior (motion), identify possible failure mechanisms due to excessive amplitudes of motion or reaction forces, etc.

RECOMMENDED FORMAT for PRESENTATION of GRADED COMPUTATIONAL ASSIGNMENTS:

MEEN 363 Technical Memorandum (TM)

TO: MEEN 363 Students
FROM: Class instructor
Subject: Writing Technical memos
Date: August 27, 2007

SUMMARY OF THIS MEMO

This memorandum explains (and demonstrates) how to write a technical memorandum (*TM*). *Webster's* defines a memorandum as a "*usually brief communication written for interoffice circulation . . . a communication that contains directive, advisory, or informative matter*". Adding the adjective "*technical*" implies a certain degree of structure both in format and content. A *TM* is a concise and well written communication approximately three to six pages long[1] that:

defines a task,
specifies the objectives of the task,
identifies and outlines a solution method and/or an experimental procedure,
reports and discusses the results of implementing the solution and/or the estimated parameters from the measurements, and
provides conclusions and recommendations.

It is often necessary to include an informal appendix (sometimes handwritten) containing the data, sample calculations, etc. to support statements made in 4 and 5. Description of the various parts of a TM follow.

HEADING

The heading should follow the format of this memo. The tech memo must be dated. (All correspondence, analysis, etc. should be dated.) The heading of a memo contains parts for "TO", "FROM", and "SUBJECT". The TO part identifies the recipient of the memo by name and title, i.e. Dr. San Andrés or responsible TA. The FROM part identifies you by name and course/section number; e.g., Joe Studious, Student. The SUBJECT part is equivalent to a title and tells what the memo is about as completely and concisely as possible.

EXECUTIVE SUMMARY

Concisely define the task in terms of the objectives of the assignment and specify any restrictions/constraints. Summarize the major findings, conclusions and difficulties found. Sound engineering practice demands a precise usage of technical terms and short sentence structure. This is not an introduction; do not give a lot of background and motivation. The recipient of the TM is knowledgeable about your work and you do not need to explain to him/her why you are doing it. You must explain exactly what you are going to do, but you do not need to give the motivation for the project. (The total length of this section should not exceed 200 words).

METHOD

Describe the method you used to solve the problem (theoretical, experimental, or both) including any major assumptions, derivation of important equations, and/or experimental procedures. Describe the physics of the problem, show assumptions for the physical model and the governing equations of motion, including boundary and initial conditions. Provide a concise nomenclature to follow.

This section almost always requires some sketches or drawings, i.e. figures. The main text should always refer to the figures before they appear. The writer needs to explain the items depicted with attention to trends and important characteristics. Figures should be referred in the text in ascending number and accompanied by meaningful and explanatory captions. Figures with multiple curves should have clear symbols (and keywords) differentiating them.

[1] Type font should be maximum 11 points, 1 ½ spaces and with 1 inch margins in 8 ½ by 11 inch pages.

PROCEDURE

Here you must describe in a logical manner the procedures for analysis, exact or numerical, for example. Provide statements on the validity of the solution procedure highlighting advantages or shortcomings. For numerical solutions, you must provide statements on the accuracy, convergence and stability of the results.

RESULTS and DISCUSSION

All results are to be presented in the units of actual measurement or calculation, either English or SI, with final values in alternative units given in parenthesis.

Present the calculated results in a form best suited to help the reader understand their significance in light of the stated objectives. This will usually be graphs or curves, supplemented by tables highlighting identified (measured) or calculated values. Present all of the significant findings of the study and explain any important observations, trends, or limitations. Discuss how these observations (results) will lead to your final and important conclusions.

CONCLUSIONS

Always state your conclusions. Conclusion must address the purpose of the assignment. Some students (and professionals) do not want to risk making erroneous conclusions so they waffle on stating conclusions. For example, they may list several possible conclusions, but leave it up to the reader to choose one. You are educated and qualified to *analyze* the data (results) and draw conclusions from it. As a future engineer, your boss will think enough of your qualifications to pay you a good salary, and he/she expects conclusions and sound recommendations. The only exception is the case in which the data does not support a conclusion; and in this exceptional case, the method used is inadequate for the purpose and you should so state.

REFERENCES

List all references in your main text according to the ASME format, see:
http://www.asme.org/Publications/ConfProceedings/Author/References_2.cfm
In general, references must contain the authors' names (last-first initial), year of publication, title, journal or periodical name, volume and page numbers. All material found on internet sites must be clearly acknowledged, including any graphs copied.

FINAL NOTES:

Your main report MUST NOT include a copy of your computer program. In particular, inserting MAPLE or MATLAB printouts is NOT allowed. A computer program OUTPUT may be included as an APPENDIX and must contain detailed text or comments for any reader to understand your important work.

Figures and Tables should always be inserted AFTER text citing them. In particular, Figures and Tables must contain COMPLETE captions, i.e. descriptive titles (full senetences). Labels in Figures (X,Y axes) must display appropriate physical units, for example, X: distance [meter], Y: acceleration [meter/s^2]. Point deductions will be taken for incomplete figures and tables.

Most technical papers and reports are written in the third person, i.e. they are impersonal. Phrases like "We did" or "I have found," etc. Incidentally, avoid writing with passive voice and in the past tense, it is bad English!

from ***The Elements of Style***, by W. Strunk and E.B. White:
"Vigorous writing is concise. A sentence should contain no unnecessary words, a paragraph no unnecessary sentences, for the same reason that a drawing should not have unnecessary lines and a machine no unnecessary parts. This requires NOT that the writer makes all his sentences short, or that he avoids all detail and treats his subjects only in outline, but that every word tells."