AME 453: ENGINEERING DYNAMICS

SPRING 2011

Instructor: Eva Kanso Associate Professor of Aerospace and Mechanical Engineering University of Southern California, Los Angeles, CA 90089 office: 214 Rapp building (RRB), email: kanso@usc.edu, phone: 213 821 5788 url: http://www-rcf.usc.edu/~kanso/

Course Description: This course focuses on *classical dynamics*, that is, the study of motion of interacting bodies. The topics to be covered range from the motion of a single particle to systems of particles and rigid bodies with particular emphasis on rotations in three-dimensional space.

Pre-requisites: Dynamics AME 301 and basic knowledge of ordinary differential equations.

List of topics: The following is a tentative outline of the topics to be covered.

- 1. Newtonian Dynamics of Particles (~3 weeks)
 - Inertial frames. Kinematics of a Particle. Cartesian and curvilinear coordinates systems.
 - Integrable and non-integrable constraints.
 - Balance laws. Conservation of linear and angular momenta. Work and power.
 - Conservative forces. Constraint forces.
 - Introduction to dynamical systems tools and concepts of equilibria and stability.
- 2. Rigid Body Motion (\sim 4 weeks)
 - Rotation tensors, Euler and Rodrigues representations of rotation tensors
 - Kinematics of a rigid body: angular velocity and acceleration, corotational basis
 - Moment of Inertia Tensors. Angular momentum. Rotational Kinetic Energy
 - Eulers equations of motion and their stability. Poinsot Construction.
- 3. Lagrangian Mechanics (~ 4 weeks)
 - Lagrange's equations of motion.
 - Generalized coordinates. Generalized momenta. Generalized forces.
 - Conserved quantities. Ignorable coordinates and symmetries. Noether theorem.
 - Introduction to nonlinear and Lyapunov stability.

The ideas will be illustrated through examples such as the motion of planar, spherical and double pendula, particles on rotating surfaces, rolling and sliding disks and spheres, etc.

References: I will provide you with my set of notes but it is also useful to consult the following classic texts and web resources (some cover more material than we do in this class so don't be alarmed):

- Your textbook for AME 301
- Hand L. & Finch J., Analytical Mechanics
- Goldstein H., Poole C. & Safko J., Classical Mechanics
- Ginsberg, J.H., Advanced Engineering Dynamics
- Arnold, V.I., Mathematical methods of classical mechanics
- Landau, L.D. & Lifshitz, E.M., Mechanics
- Lecture notes of Prof. David Tong of the University of Cambridge: http://www.damtp.cam.ac.uk/user/tong/dynamics.html
- Lecture notes of Prof. Masahiro Morii of Harvard University: http://www.hepl.harvard.edu/~morii/phys151/lectures/

Homework assignments: There will be weekly homework sets assigned every Wednesday and due the following Wednesday. The purpose of the problem assignments is to help you understand the material and communicate your knowledge in writing. It is not necessary that you type your solution but write it in a neat and legible way.

Class projects: In addition to the weekly homework sets, I would like to assign two or three "open-ended" projects that require you to model, simulate, and analyze a system of particles or rigid bodies using the techniques we developed in class. The projects will be chosen as the semester progresses and will involve that you work together in teams. A 1-2 pages (double spaced, 12pt font, 1 inch margins) description of your results should be submitted for each project. Your main findings and computer animations will be discussed and shown in class.

Office hours: Monday 2:30-4pm and Thursday 9-11am (my office in 214 Rapp building)

Grading: Grades will be based on the following categories:

Categories	Weight
Homework assignments	25%
Projects	15%
Class Participation	10%
Mid-term Exam	20%
Final Exam	30%