ENAE 646 ADVANCED DYNAMICS
SPRING 2017 SYLLABUS

DEPARTMENT OF AEROSPACE ENGINEERING, UNIVERSITY OF MARYLAND
LAST UPDATED: DECEMBER 19, 2016

Description

This course introduces the principles and methods for formulating and analyzing mathematical models of aerospace systems using Newtonian, Lagrangian, and Hamiltonian formulations of particle and rigid body dynamics. Additional topics include applied dynamical systems, geometric mechanics, and symmetry and reduction. 3 credits. *Prerequisite:* ENAE301 or equivalent.

Instructor

Dr. Derek A. Paley
3150 Glenn L. Martin Hall, 301-405-5757, `dpaley@umd.edu`
Office Hours: Walk-in or by appointment

Lectures

Tu, Th 11:00–12:15 in JMP 2216

Required Textbooks (all books and references are on reserve at EPSL)

[1] H. Goldstein, C. Poole & J. Safko, *Classical Mechanics.* Addison Wesley, 3rd ed., 2001.
[2] N. Kasdin & D. Paley, *Engineering Dynamics: A Comprehensive Introduction.* Princeton University Press, 2011. (Errata available at `cdcl.umd.edu`.)

Additional References

[3] J. Guckenheimer & P. Holmes, *Nonlinear Oscillations, Dynamical Systems, and Bifurcations of Vector Fields*, Springer, 7th printing, 2002.
[4] E. Hairer, C. Lubich, & G. Wanner, *Geometric Numerical Integration*, Springer, 2nd ed., 2006.
[5] L. Hand & Finch, *Analytical Mechanics*, Cambridge University Press, 1998.
[6] J. Marsden & T. S. Ratiu, *Introduction to Mechanics and Symmetry*, Springer, 2nd ed., 1999.
[7] R. Murray, Z. Li, & S. Sastry, *A Mathematical Introduction to Robotic Manipulation*, CRC Press, 1994.
[8] L. Perko, *Differential Equations and Dynamical Systems*, Springer, 2001.
[9] A. Rao, *Dynamics of Particles and Rigid Bodies*, Cambridge University Press, 2006.
[10] S. Strogatz, *Nonlinear Dynamics and Chaos*, Westview, 1994.

Grading

Your final grade will be based on homework assignments (30%), a final take-home exam (30%), a midterm take-home exam (20%), a project (20%), and attendance and participation.

Policies

You are encouraged to collaborate on the homework assignments, but you must turn in original work. You may not copy the homework solutions from other students, past or present. Collaboration is not permitted on the midterm exam or final exam. Collaboration is not permitted on the project, except with permission of the instructor (though this is rare). Assignments and exams will not be accepted after the deadline, except with permission of the instructor.

Course Materials

Course materials will be available through the Elms website, `http://elms.umd.edu`.

Course Outline

I. *Review of Newtonian mechanics*
   a. Mathematical preliminaries
   b. Particle kinematics and kinetics
   c. Relative motion and rigid-body dynamics

II. *Methods of analytical mechanics*
   a. Generalized coordinates and constraints
   b. Variational principles and Lagrange's equations
   c. Hamiltonian dynamics
   d. Canonical transformations and Poisson brackets

III. *Introduction to nonlinear dynamics*
   a. Symplectic integrators
   b. One-dimensional flows and maps
   c. Bifurcation theory
   d. Phase-plane analysis

Project

The project will consist of an oral presentation to the class and a written report provided to the instructor. The oral presentation should be approximately 10–15 minutes long and should summarize your project in a way that is accessible to the entire class. The written report should be 5–10 typed pages and should contain reference citations, relevant mathematical calculations, computer simulations, etc.

You are free to choose a topic for your project according to your interest. The project should make use of, or build on, a topic from advanced dynamics. *Your project may complement your current research but it should not be a repeat of something you have already done in your research.* Possible project types include the following:

An **application project** applies the theory of advanced dynamics to an application of interest. This type of project could involve a problem that you define and study by (1) modeling as a dynamic system, (2) finding the equations of motion, (3) integrating the equations of motion by hand or in Matlab (producing animations if possible).

An **advanced topic project** investigates an advanced-dynamics topic that goes beyond what we have studied in class. This could be completely independent work or it may involve reading, understanding and being able to explain the results of a paper from the literature or a topic from a textbook in the references list.

Project deadlines

1. *Project topic* due at the start of the first class after spring break (March 28)
2. *Oral presentation* held during one of the last two days of class (May 9, May 11)
3. *Written report* due at the start of the last class (May 11)