

# Systems Design 553

## Advanced Dynamics

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### Objectives:

The principal goal of this course is to increase your understanding of dynamics to the point that real-world problems can be analyzed and solved. Following a short review of particle kinematics and dynamics, the three-dimensional motion of rigid bodies and multibody systems will be covered, as well as an introduction to the important energy-based methods of mechanics (most notably Lagrange's equations). By the end of the course, you will be able to analyze and understand the dynamics of complex mechanical systems such as suspensions, satellites, robotic manipulators, human movement, vehicles, and mechanisms.

**Instructor:** Prof. John McPhee (mcphee@uwaterloo.ca)  
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**Required Textbook:** *Advanced Engineering Dynamics, 2nd edition*, by J.H. Ginsberg

**Lectures:** Tuesdays@2:30-3:50 p.m.  
(E5-6127) Fridays@12:30-1:50 p.m.

**Consultation:** Tuesdays at 3:50-4:50, or send me an email and we'll set up a time

**Tutorial:** Fridays@2:00-2:50 p.m.  
(E5-6127)

**Evaluation:** Assignments = 25 %  
Midterm Exam = 30 %  
Final Exam = 45 %

## Coverage:

**Weeks 1-6: Kinematics of Particles and Rigid Bodies.** Review of vectors and particle dynamics, curvilinear coordinates, rotating reference frames, 3-d rotations. *Chapters 1 to 4 of textbook, Problem Sets 1-3, Midterm.*

**Weeks 7-9: Dynamics of Particles and Rigid Bodies.** Systems of particles, angular momentum, inertial properties of rigid bodies, Newton-Euler equations of motion, impulse-momentum and work-energy principles, multibody systems, gyroscopic effects. *Chapters 5 and 8 of textbook, Problem Set 4.*

**Weeks 10-12: Analytical Mechanics.** Generalized coordinates, degrees of freedom, constraints, virtual displacements and virtual work, Hamilton's principle, Lagrange's equations, Gibbs-Appell equations. *Chapters 6 and 7 of textbook, Problem Set 5.*

## Additional References:

- [1]. *Principles of Dynamics, 2nd ed.*, D.T. Greenwood, Prentice-Hall, 1988.
- [2]. *Intermediate Dynamics*, E.J. Haug, Prentice-Hall, 1992.
- [3]. *A Treatise on Analytical Dynamics*, L.A. Pars, Oxbow Press, 1979.
- [4]. *Methods of Analytical Dynamics*, L. Meirovitch, McGraw-Hill, 1970.
- [5]. *Classical Mechanics, 2nd ed.*, H. Goldstein, Addison-Wesley, 1980.
- [6]. *The Variational Principles of Mechanics*, C. Lanczos, Univ. of Toronto Press, 1970.
- [7]. *Computer-Aided Analysis of Mechanical Systems*, P. Nikravesh, Prentice-Hall, 1988.
- [8]. *Computer-Aided Kinematics and Dynamics of Mechanical Systems, Volume I: Basic Methods*, E.J. Haug, Allyn and Bacon, 1989.
- [9]. Introductory texts on dynamics by e.g. Hibbeler or Beer and Johnston.

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