

# CLASSICAL MECHANICS

PHY 401

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Text: Fowles, G. R. and Cassiday, G. L., Analytical Mechanics, 7<sup>th</sup> Ed., Thomson Brooks/Cole, 2005.

## I. Course Description

Newtonian mechanics is studied rigorously using advanced mathematical and numerical techniques. Topics treated include kinematics, dynamics, harmonic oscillations, central forces, many particle systems, rigid bodies, Lagrangians, and Hamiltonians. Scientific programming is used extensively in problem solving.

## II. Course Objectives

1. To develop fundamental concepts in mechanics more rigorously as needed for further study in physics, engineering and technology.
2. To apply advanced mathematical and computational techniques to complex problems.
3. To contribute to the development of the student's thinking process through the understanding of the theory and application of this knowledge to the solution of practical problems.

## III. Course Outline

1. Newtonian Mechanics in One Dimension(Ch. 2)  
Newton's laws and inertial systems. Simple applications of Newton's laws. Constant applied force. Position-dependent forces. Time-dependent force. Velocity-dependent force.  
Homework 1: 2.2, 2.5, 2.12, 2.16, C2.1, and [additional problems HW 1](#)
2. Oscillations (Ch. 3)  
Linear restoring force: Harmonic motion. Damped harmonic motion. Forced harmonic motion.  
Homework 2: 3.3, 3.5, 3.7, 3.10, 3.12, 3.18, 3.19 (parts a & b), C3.1

Test 1

TBA

3. General Motion of a Particle in Three Dimensions (Ch. 4)  
General principles. Potential energy function in three-dimensional motion: the del operator. Projectile motion. The harmonic oscillator in two and three dimensions. Motion of charged particles electric and magnetic fields. Constrained motion of a particle.  
Homework 3: 4.1, 4.3, 4.5, 4.8, 4.17 (graph the path), 4.18, 4.19
4. Noninertial Coordinate Systems (Ch. 5)  
Accelerated coordinate systems and inertial forces. Rotating coordinate systems. Dynamics of a particle in a rotating coordinate system. Effects of Earth's rotation. The Foucault Pendulum.  
Homework 4: 5.2, 5.5, 5.8, 5.10, 5.13, 5.15, 5.16, 5.21

5. Gravitation and Central Forces (Ch. 6)

Gravitational force between a uniform sphere and a particle. Kepler's laws of planetary motion. Potential energy in a gravitational field. Energy equation of an orbit in a central field. Orbital energies in an inverse-square field. Effective potential. Orbital transfers: gravitational boost and braking.

Homework 5: 6.1,6.6,6.10,6.13 and [additional problems HW 5](#)

Test 2

TBA

6. Lagrangian Mechanics (Ch. 10)

Hamilton's variational principle. Generalized coordinates. Lagrange's equations of motion for conservative systems. Generalized momenta. Ignorable coordinates. Forces of constraint.

Lagrange multipliers. Generalized forces. Hamilton's equations.

Homework 6: 10.4,10.6,10.11,10.12,10.13,10.14 (each problem is worth twice the usual value)

7. Mechanics of Rigid Bodies (Ch. 8)

Center of mass of a rigid body. Rotation about a fixed axis. Calculation of moment of inertia.

The physical pendulum. Laminar motion of a rigid body. Center of percussion.

Homework 7: 8.3,8.6,8.11,8.18,8.20 and [additional problems HW 7](#)

8. Dynamics of System of Particles (Ch. 7)

Center of mass and linear momentum of a system. Angular momentum and kinetic energy of a system. Motion of two interacting bodies. Collisions. Oblique collisions and scattering.

Motion of a body with variable mass: rocket motion.

Homework 8: 7.4, 7.5,7.7,7.10,7.15,7.17,7.25, and 7.26

Final Exam

II. Assessment of Student Performance

1. Tests (30 points)

2. Final exam (35 points)

3. Homework problems and computer program (35 points)

Homework problems are due one week after the corresponding chapter has been completed in the lectures unless otherwise noted. Late homework will not be accepted (each homework problem is worth up to .33 points toward the final grade). Homework should be handed in an ordered and neat presentation; points will be deducted for lack of these.

The computer program is due three weeks after it is assigned (the program is worth up to 5 points towards the final grade).

Grading Scale	
Final Score	Letter Grade
92.5 - 100	A
89.5 - 92.4	A-
86.5 - 89.4	B+
82.5 - 86.4	B
79.5 - 82.4	B-
76.5 - 79.4	C+
72.5 - 76.4	C

69.5 – 72.4	C-
66.5 – 69.4	D+
59.5 – 66.4	D
0 – 59.4	F

### III. Attendance

Students are expected to attend class. No makeups will be given unless there is an emergency situation. In that case students are expected to contact the instructor no later than 24 hours after the test or exam; otherwise they will be given a zero grade for the missed evaluation.

### IV. Bibliography

Arya, A. P., "Introduction to Classical Mechanics," 2<sup>nd</sup> Ed., Prentice Hall, 1998.

Walker, J. "Halliday and Resnick Fundamentals of Physics," 8th Ed., J. Wiley & Sons, 2007.

Taylor, J. R., "Classical Mechanics," University Science Books, 2005.

Thornton, S. T. and Marion, J., "Classical Dynamics of Particles and Systems," 5th Ed., Thomson-Brooks/Cole, 2004.

Serway, R. A., "Physics for Scientists and Engineers," 7<sup>th</sup> Ed., Thomson-Brooks/Cole, 2008.

Spiegel, M. R., "Theoretical Mechanics," Schaum's Outline Series, McGraw Hill, 1992.

Young, H. D. and Freedman, "University Physics," 11th Ed., Pearson/Addison-Wesley, 2004.