Intermediate Modern Physics: PH 354 (UA)

Spring Semester 2009

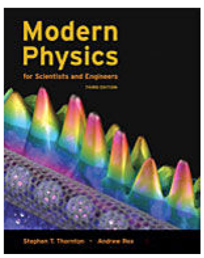
Time and location:
Tuesdays & Thursdays 5:30 – 6:45 PM (Gallalee 328)

Instructors and office hours:

Dr. Renato Camata, camata@uab.edu — Tuesdays & Thursdays 4:30-5:30 PM
CH 306, (205) 934-8143 — (Other times by appointment)
http://www.phy.uab.edu/~rcamata/PH352.html

Dr. Richard Tipping, rtipping@bama.ua.edu — Mondays & Thursdays 9:00-10:30 AM
334 Gallalee Hall, (205) 348-3799 — (Other times by appointment)

Required Textbook:



Modern Physics for Scientists and Engineers
Thornton & Rex, 3rd Ed., 2006
Publisher: Thomson-Brooks/Cole
ISBN: 0534417817
ISBN13: 9780534417819

Textbook Errata: http://modern.physics.virginia.edu/Book/errata3.html

Other Books and Resources Suggested:

Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles (2nd Edition) *J. Eisberg & R. Resnick* *Wiley*	**Modern Physics** (2nd Edition) *K. S. Krane* *Wiley*

Catalog Description: Atomic, molecular, solid-state physics; quantum mechanics, lasers and nanotechnology. Theoretical and experimental studies to understand observable properties of matter in terms of microscopic constituents.

Prerequisite: PH 351 & 351L (UAB) *or* equivalent.

Last Day to Withdraw with "W": March 25

Course Activities: This course will comprise lectures, classroom discussions, and written problem-solving exercises assigned by the instructor (problem sets).

Related core learning outcomes: Students successfully completing this course will demonstrate knowledge of fundamental concepts in quantum mechanics, statistical physics and general relativity and will be able to apply this knowledge to solve problems in elementary particles, nuclear, atomic and molecular physics, as well as solids.

Course learning objectives:

By successfully completing this course a student should be able to:

(1) Define the overall framework of Schrödinger's Theory of Quantum Mechanics.
(2) Compare and contrast the Bohr Model of the atom and the atomic model based on Schrödinger's Theory of Quantum Mechanics.
(3) Solve Schrödinger's Equation for the Coulomb Potential (Z=1).
(4) Explain the Angular Momentum and Intrinsic Spin in the hydrogen atom.
(5) Explain Magnetic effects in the hydrogen atom.
(6) Delineate the solution of Schrödinger's Equation for multi-electron atoms.
(7) Explain Spin-Orbit Coupling in own words as well as using diagrams.
(8) Present the Quantum Physics Perspective of the Periodic Table of the Elements.
(9) Define the overall framework of Classical Statistical Physics.
(10) Compare and Contrast Classical and Quantum Statistics.
(11) Explain in own words the Fermi-Dirac and the Bose-Einstein Distributions.
(12) Compare and Contrast the Fermi-Dirac and the Bose-Einstein Distributions.
(13) Command elementary quantum methods in the description of molecules and solids, including semiconductors, and superconductors.
(14) Explain the principle of operation of the laser.
(15) Define the discoveries that led to the Modern Physics view of the atomic nucleus.
(16) State and distinguish the nuclear forces and processes.
(17) Argue how the foundational knowledge of the nucleus explains radioactive dating, nuclear fission, nuclear fusion, and other nuclear reactions.
(18) Discuss the role of particle accelerators in Modern Physics discoveries.
(19) Describe the fundamental interactions of Physics.
(20) Explain in own words the basic tenets of the Standard Model of elementary particles.
(21) Classify known/predicted elementary particles within the framework of the Standard Model.
(22) State the basic tenets and at least **4** experimental tests of General Relativity.
(23) Explain in own words how General Relativity predicts Black Holes and Gravity Waves.
(24) Present the experimental cosmological evidence for the evolution of the universe.
(25) Argue how hot, inflationary big bang models can account for cosmological observations.

Measurement of learning outcomes. Documented completion of problem sets, in-class tests and the Major Field Test will be used to measure attainment of learning objectives.

Course Grade:

Problem Sets	45%
Average of In-Class Tests	50%
Major Field Test	5%

- **<u>Problem Sets.</u>** Problem sets featuring a variety of activities to foster learning will be regularly assigned by instructor. Activities must be completed and turned in by the due date.
  Policy regarding late Problem Set without proper justification:
  - ½ credit while solutions have not been discussed in class
  - 0 credit after solutions have been discussed in class

- **Three In-Class Tests.** Non-cumulative closed book tests during regular class periods (Tests 1 & 2) or during final exam week (Test 3) (75 min).

- **The Physics Major Field Test**. Assessment of overall physics knowledge through a standardized test designed and scored by the Educational Testing Service. This test will take the place of a final exam. Full 5% credit toward grade given for a good-faith effort on the test.

Student collaboration policy. Guidelines regarding student collaboration will be provided for each Assigned Activity and Problem Set:

- Open Exchange of Ideas: In general, students are encouraged to discuss concepts, assigned problems, and engage in lively exchange of ideas.
- Independent Work: Specific problems and activities will be assigned for students to ***complete independently***. The purpose is that each student can be confident that he or she has acquired the desired knowledge in specific topics.

Copying and verbatim rendering of solutions from other students ***are not appropriate***. These practices constitute violation of the University honor code and may result in academic disciplinary action including dismissal from the degree program. Collaboration among students ***is not allowed*** during tests.

Letter grades will be assigned according to the following table:
(All calculated grades will be rounded up to the nearest 0.1%.)

88.0% to 100% inclusive	**A**
76.0% to 87.9% inclusive	**B**
63.0% to 75.9% inclusive	**C**
50.0% to 62.9% inclusive	**D**
0.0% to 49.9% inclusive	**F**

Turning in all assigned work is a necessary condition for an **A** grade

Important Dates:

- **Test 1:** **Tuesday, February 10; 5:30-6:45 PM**
- **Test 2:** **Thursday, March 12; 5:30-6:45 PM**
- **Test 3:** **Tuesday, May 5, 7:00-8:15 PM**
- **Major Field Test:** **TBA**

Special accommodations:
Please contact Dr. Camata or Dr. Tipping for an appointment to discuss special accommodations.

Topical Outline

1. **Schrödinger's Theory of Quantum Mechanics**
    a. Schrödinger's Wave Equation
    b. Expectation Values
    c. Solution for Infinite Square-Well Potential
    d. Solution for Finite Square-Well Potential
    e. Solution for 3D Infinite Potential Well
    f. Solution for the Harmonic Oscillator Potential
    g. Barriers and Tunneling

2. **Schrödinger's Theory Applied to the Hydrogen Atom**
    a. Solution of Schrödinger's Equation for Coulomb Potential (Z=1)
    b. Quantum Numbers
    c. Orbital Angular Momentum and Intrinsic Spin
    d. Magnetic Effects
    e. The Hydrogen Energy Spectrum and Probability Distributions

3. **Many-electron Atoms**
    a. Solution of Schrödinger's Equation for Coulomb Potential (Z>1)
    b. Survey of Multi-electron Effects
    c. Spin-Orbit Coupling
    d. The Periodic Table of the Elements: The Quantum Physics Perspective

4. **Statistical Physics**
    a. Review of Classical Statistical Physics (Equipartition, Maxwell-Boltzmann Dirtr.)
    b. Quantum Statistics
    c. The Fermi-Dirac Distribution
    d. The Bose-Einstein Distribution

5. **Molecules and Solids**
    a. Molecular Bonding
    b. Principles of Lasers
    c. Structural Properties of Solids
    d. Thermal and Magnetic Properties of Solids
    e. Superconductivity

6. **Semiconductor Theory and Devices**
    a. Band structure of solids
    b. Theory of Semiconductors
    c. Semiconductor Devices (Photovoltaics, FETs, ICs, lasers)
    d. Nanotechnology

7. **The Atomic Nucleus**
    a. Nuclear Forces

    b. Nuclear Processes
    c. Radioactive Dating
    d. Nuclear Fission and Fusion

8. **Elementary Particles**
    a. Fundamental Interactions
    b. Conservation Laws and Symmetries
    c. The Standard Model
    d. Beyond the Standard Model

9. **General Relativity**
    a. The Principle of Equivalence
    b. Tests of General Relativity
    c. Gravitational Waves
    d. Black Holes

10. **Cosmology**
    a. Observational Evidence for the Evolution of the Universe
    b. Big Bang Models
    c. The Age of the Universe
    d. The Future of the Universe