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PH 352-2G & PH 352L-T6: Modern Physics II
Spring Semester 2014

Time and location:
PH 351-2G (Lecture): Tuesdays & Thursdays 5:00 – 6:15 PM (CH 394)
PH 351L-T6 (Lab): Mondays 5:45 – 8:35 PM (CH 470)

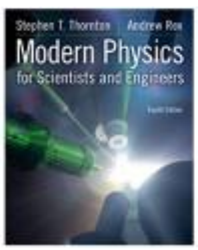
Instructor and office hours:

Dr. Aaron Catledge, catledge@uab.edu	Friday 4:00-5:00 PM in CBSE G89 Tues/Thurs 4:00-5:00 PM in CH 306
(205) 934-8143 or (205) 934-3693	(Other times by appointment)

Teaching Assistants and office hours:

Zack Lindsey, zack@uab.edu CH 460 (email 1st)	Office Hours: Wednesdays 11:00AM-12:00PM (Other times by appointment)
Alex Skinner, askinner@uab.edu CH 350	Office Hours: Wednesdays 11:00AM-12:00PM (Other times by appointment)

Required Textbook:



Modern Physics for Scientists and Engineers
Thornton & Rex, 4th Ed., 2013
Publisher: Brooks/Cole, Cengage Learning
ISBN10: 1-133-10372-3
ISBN13: 978-1-133-10372-1

Other Books and Resources Suggested:

Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles (2nd Edition) *J. Eisberg & R. Resnick* *Wiley*	**Modern Physics** (3rd Edition) *K. S. Krane* *Wiley*

Catalog Description: Atomic, molecular, and solid-state physics; semiconductors, lasers and nanotechnology; nuclear and particle physics; general relativity and cosmology. Emphasis on the use of quantitative reasoning to solve modern physics problems. Writing and scientific ethics assignments based on laboratory experiences. Lecture and laboratory.

Prerequisite: PH 351 & 351L *or* equivalent.

Last Day to Add/Drop: January 13th

Last Day to Withdraw: March 31st

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

Related UAB 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. Students will demonstrate a working knowledge of physics-related technical and laboratory skills including data analysis, and scientific writing.

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

Additional Quantitative Literacy (QL) Learning Objectives:
By successfully completing this course a student should be able to:

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(28) Evaluate the reasonableness of modern physics assumptions through computations using arithmetic, algebra and calculus, in the appropriate units of measurement *(**Addresses QL Learning Outcome 3.1**)*.

(29) Translate back and forth between verbal and mathematical descriptions of modern physics problems *(**Addresses QL Learning Outcome 3.1**)*.

(30) Construct and interpret tables, graphs and schematic representations of relationships among physical systems and modern physics concepts *(**Addresses QL Learning Outcome 3.2**)*.

(31) Use quantitative methods to solve problems and advance arguments in modern physics *(**Addresses QL Learning Outcome 3.4**)*.

(32) Analyze and interpret computational and/or experimental data and draw conclusions about modern physics hypothesis *(**Addresses QL Learning Outcome 3.4**)*.

(33) Write laboratory reports that communicate quantitative information to a modern physics readership *(**Addresses QL Learning Outcome 3.6**)*.

Additional Writing Learning Objectives:

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

(34) Write laboratory reports that communicate quantitative information to a modern physics readership *(**Addresses Writing Outcome 2.1**)*.

(35) Write laboratory reports that acknowledge used external sources in an ethical manner *(**Addresses Writing Outcome 2.3**)*.

(36) Write laboratory reports that demonstrate competence in scientific writing in English *(**Addresses Writing Outcome 2.4**)*.

(37) Write laboratory reports according to standards of peer-reviewed journal publications in Physics *(**Addresses Writing Outcome 2.5**)*.

Additional Ethics & Civic Responsibility Learning Objectives:

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

(38) Write laboratory reports with ethical acknowledgement of used sources *(**Addresses ECR Outcome 4.1**)*.

(39) Adopt high ethical standards in the conduction of laboratory activities, including: (i) Rejection of plagiarism; (ii) Acceptance of legitimate data only; (ii) Acknowledgement of used sources *(**Addresses ECR Outcome 4.1**)*.

(40) Discuss contemporary issues such as the role of science in society, the contribution of Physics to the development of clean energy sources, the principles and safety issues related to nuclear power, nuclear weapons, nanotechnology, etc *(**Addresses ECR Outcome 4.2**)*.

(41) Develop a sense of the broad cultural and gender diversity of the practitioners of science, including the basic cultural background of key scientists in Modern Physics. *(**Addresses ECR Outcome 4.2**)*.

(42) Work effectively as part of a group or team of students with diverse cultural, racial, intellectual, and educational backgrounds *(**Addresses ECR Outcome 4.4**)*.

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

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Course Grade:

Problem Sets	30%
Average of In-Class Tests	35%
Laboratory Participation	5%
Laboratory Notebook	5%
Laboratory Reports	20%
Major Field Test (MFT)	5%

• **Laboratory Notebook**. Every student will maintain an ***individual*** laboratory notebook. This notebook will be reviewed periodically by the teaching assistants and graded at the end of the semester according to the lab notebook rubric.

• **Laboratory Participation**. In every lab session students will be asked to complete certain activities. Completed activity sheets returned to the teaching assistants will document a student's engagement and participation in the laboratory. A student's score in this participation component will scale linearly with the number of activities he or she completed (from **zero** for no activities completed to **5%** for all activities completed).

• **Laboratory Reports**. Following several experiments students will create a written scientific document reporting their findings. These laboratory reports will be prepared according to guidelines and standards provided by the instructor and the teaching assistants. Guidelines will vary from one report to another, including whether they are ***group*** or ***individual*** exercises. The final value of this grade component will correspond to the average score of the reports. Reports will be graded according to a written scientific communications rubric.

• **Problem Sets**. 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 yet been posted
- 0 credit after solutions have been posted

• **Three In-Class Tests**. Non-cumulative closed book tests during regular lab periods.

• **Physics Major Field Test (MFT)**. 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 and exams.

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Personal Class Notes. Most of the material covered and the concepts developed in this course require mathematical derivations. In order to maximize their opportunities for meaningful understanding of course content, students are *strongly encouraged* to maintain a well organized set of personal notes. These notes should include the derivations carried out in class and the development of their own understanding of the material. Students are strongly advised *against* relying exclusively on the notes provided by the instructor. Many students seeking to learn the course material in depth find it helpful to develop their own notes or to annotate the notes provided by the instructor.

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

Test & Exam Dates (This is TENTATIVE and therefore subject to change):

- **Test 1:** **Monday, February 3; 5:45-8:00 PM**
- **Test 2:** **Monday, March 10; 5:45-8:00 PM**
- **Test 3:** **Monday, April 14; 5:45-8:00 PM**
- **Major Field Test:** **Thursday, April 24; 4:15-6:45 PM**

Special accommodations: Please contact Dr. Catledge for an appointment to discuss special accommodations.

Web learning resources: Lectures, assignments, and class information will be available through the Blackboard Learn system: https://www.uab.edu/bblearn/.

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Topical Outline

1. Schrödinger's Theory of Quantum Mechanics Applied to Simple Potential Wells

a. Review of Schrödinger's Theory
b. Solution for Infinite Square-Well Potential
c. Solution for Finite Square-Well Potential
d. Solution for the Harmonic Oscillator Potential
e. Solution for 3D Infinite Potential Well

2. Schrödinger's Theory of Quantum Mechanics 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

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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

Laboratory Experiments

(Tentative)

1. The Franck-Hertz Experiment
2. Scattering of Plane Waves & Wave Packets by Steps and Barriers *(Computational)*
3. Bound States in 1D Potential Wells *(Computational)*
4. Trapping of Probability Density in Multi-barrier Potentials *(Computational)*
4. Zeeman Effect
6. Absorption Spectroscopy I – *Extinction Coefficient of Liquid Samples*
7. Absorption Spectroscopy II – *Beer's Law and Molar Absorbtivity of a Sample*
8. Nuclear Magnetic Resonance
9. Blackbody Spectrum
10. Electron Diffraction