PS 303 – Modern Physics
Embry-Riddle University
Fall 2009

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Required texts:	*Twentieth Century Physics*, by Reynolds
	Men who made a new physics, by Cline
Supplementary texts:	*Modern Physics, 3rd edition*, by Thornton and Rex
	Modern Physics, 2nd edition, by Krane
"Hyperphysics"	`http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html`

Point system:

1 final project	200 points	200
3 tests	200 points each	600
120 problems	1 point each	120
10-15 quizzes	2-4 points each	40
10 short reports	5 points each	50
	TOTAL	1010

Grading scale:

A	900 –
B	750 – 899
C	600 – 749
D	500 – 599

IMPORTANT NOTE

Listening to lectures is not enough (*you retain only 10% of what you hear* …). All processes of learning are somehow connected to active participation, and the learning of physics is no exception. Therefore, it is imperative that you work diligently at your own desk (… *80% of what you practice* …). However, this does not mean that you should only work alone. I encourage you to form study groups and collaborate with your classmates (… *and 90% of what you teach to others!*).

Course Description: Modern concepts in physics. Topics include special relativity, physical optics, wave-particle duality, the uncertainty principle, elementary quantum mechanics, atomic and molecular structure, and nuclear reactions. **Prerequisites**: PS 219 or PS 250; MA 345 recommended

Learning Outcomes:

1. Define: Interference and diffraction, the Born postulates, physical constraints on a wave function and its derivatives, the probability of finding a particle in a given region of space from a known wave function, wave packets and photons, the momentum operator, the energy operator, the Hamiltonian, the normal Zeeman effect, proper time, proper length, nuclear fission and fusion, Einstein's postulates of the special theory.
2. Discuss: The failure of the Galilean transformations, Einstein's two postulates, the photoelectric effect, Compton scattering, the de Broglie hypothesis, the wave-particle duality of light and matter, the Heisenberg indeterminacy principle, the one-dimensional square barrier and its application to tunneling, the Pauli exclusion principle.
3. Solve Problems In: Special theory of relativity, relativistic momentum and kinetic energy, the total relativistic energy, wavelengths of material bodies, the expectation values of the Schrodinger equation in one dimension and three dimensions for a particle in a box and for the simple harmonic oscillator, for a free particle, and the normalization of wave functions.
4. Use: Both orbital and spin angular momentum and their magnetic moments, the total angular momentum to study interactions among electrons of the same atom as well as with external electric and magnetic fields.
5. Derive: The Lorentz contraction, time dilation, the energy of the hydrogen atom from the Born postulates, the solutions of the Schrodinger equation in one dimension.
6. Evaluate: Absorption and emission energy using energy level diagrams and employ the selection rules.
7. Calculate: Energy level diagrams of a particle in a potential well, a simple harmonic oscillation and hydrogen-like systems.
8. Demonstrate: Very basic understanding of elementary nuclear physics, lasers, superconductivity, electron spin and nuclear magnetic resonance.

RULES

1. Arrive on time; depart on time.
2. Take notes, and bring calculator to each class.
3. No eating, no cell phones.

Final Project

15-20 page research paper.
Due Date: Mon 23 Nov.

Tests

One-hour; closed book; closed notes.
Tools: pen or pencil, calculator, Codata sheet, periodic table.
Dates: Mon 21 Sep, Fri 30 Oct, Mon 7 Dec.

Problems

120 problems; must be neat and stapled.
Due Dates: approximately 10 due per week.
Graded on completeness, correctness and effort.

Quizzes

Take-home *and* in-class (first 5 minutes of class – be prepared!).
Tools: pen or pencil, scientific calculator.

Short Reports

Due dates: each Wednesday (2 Sep – 2 Dec).
200-word summary of each chapter in Cline.
One page, typed. Ten maximum.

All assignments are due at the *beginning* of class on the due date, after which they will be considered late and the score will be reduced by 50%. After the beginning of the *next* class period, they will not be accepted.

Code of Behavior

In order for learning to take place, we all must act with civility (formal politeness) and respect (polite consideration, courtesy) toward each other. My responsibilities include coming to class prepared and on time, and evaluating you in a fair and impartial manner. Your responsibilities include coming to class prepared and on time, not disrupting the class (for example, talking without being called on, eating, reading newspapers, sleeping, shuffling papers, talking on cell phones, etc.), and treating your fellow students as colleagues (see the Student Handbook). Violations of this code can result in your removal from the class.

General study habits

Repetition is critical for creating long-term memories. A good method for learning is the following sequence: read, listen, write, re-read, re-write, practice, and review. The textbook should be read THREE times: read once before class, read deeply (at least) once after class, and once as a review. In addition, you do not read textbooks as you would the newspaper. You must work through the examples, all mathematical steps should be confirmed, and you should write notes in the margins (it is your book, you can write in it!).

Notes

Taking notes during lecture is important – but you must review and re-copy those notes after class (within a few hours) for them to be useful. Notes that are never reviewed are less than worthless: they give you a false sense of security. It is important that you get into the habit studying every day.

Problem Solving

Solving problems is **critical** to your success in this course. An excellent method to prepare for the exams is to attempt problems at home in an exam-type environment. That is, once you have solved a group of problems, put aside the solutions and pretend that they are questions on an exam – attempt to solve them again, but without any help. Solve problems according to the following rules of coherence and readability:

- Describe *briefly*, but in clear and complete sentences, the basic principles used to solve the problem and explain the basic equations that are used in the solution [DO NOT simply rewrite the question].
- If a physical situation is discussed in the problem, draw an appropriate diagram.
- Identify in words, or by clear references to the diagram, all the symbols you use.
- Work through the problem symbolically, getting a simplified symbolic answer, and only substitute numbers (if appropriate at all) at the very end.
- If you obtain an explicit numerical solution, comment on whether the value you get is reasonable.
- Put boxes around your final answers.
- Write up the problem sets neatly.

Do not simply copy another student's work, and do not simply copy from the solutions manual, but I recommend that you form study groups and work together. This can help you through difficult sections and problems. I encourage you to discuss, argue, arm-wrestle, and finally master the problems. However, I expect you to write up your solutions individually, showing your own insights.

Study Groups

I strongly suggest that you form study groups. "For most individuals, learning is most effectively carried out via social interactions." (Ed Redish)

Final Project

Write a 15-20 page, typed, double-spaced, research paper on a topic of interest to you related to some aspect of modern physics. You must consult (and cite) at least 3 *written* references other than your textbook (i.e., actual books, at least one of which is from the ERAU library), and you must have a *significant* technical component. That is, you must include calculations in your report, at the level of the assigned problems. Note: a "calculation" can be either a numerical computation or an algebraic derivation.

To encourage you not to wait until the last minute, partial credit will be assigned for intermediate steps as follows:

Due dates:

1. Mon 28 Sep	title and abstract (3-4 descriptive sentences)	10 points
2. Mon 26 Oct	revised title and revised abstract outline (section titles with brief descriptions) [at least] one book reference from ERAU library [at least] one technical calculation (with explanation and relevance*)	20 points
3. Mon 9 Nov	revised title, abstract, outline, calculation 5-10 page draft	30 points
4. Mon 23 Nov	final version, journal article format (i.e., title, abstract, paper)	140 points

*What are the implications of this calculation? Why is this calculation relevant?

The audience for your paper should be your fellow students in this class. That is, they know all the modern physics that you know, but they don't know about the particular subject of your paper. This means that you don't need to derive quantities that we've derived in class, nor do you need to recapitulate any homework problems. But you should spell out in detail any physics that we have not learned in class.

Some reminders

1. Quoting an algebraic equation, and then plugging in numbers doesn't count as a calculation. It can *partially* count if the numerical value is germane to your argument.
2. Make your own equations, don't copy them as graphics. The resolution makes them hard to read.
3. Make sure you place references on quotes, figures, claims, and numbers.
4. Good calculations to make would be to confirm numerical values that a reference quotes.
5. Double space, 12-point font, one inch margins, Times New Roman font.
6. If you quote a long passage (a paragraph, say), set it apart and use single spaces.
7. The words must be your own. Do not plagiarize. If another author states it best, you can use that if you put his words in quotes and add a reference. However, stringing together lots of quotes does not look as if you put much thought into your writing.

You are not limited to the following, but here are some suggested topics.

Nuclear fusion
Nuclear fission
Positron emission tomography
Symmetry and invariance in physics
The role of the observer in the measurement process
Schrödinger's cat - myth and reality
The Einstein-Podolsky-Rosen paradox (then and now)
Quantum mechanics and hidden variables
Mathematical quantum mechanics: Operators, observables expectation values, the dispersion relation
Superconductivity
How macroscopic properties depend on microscopic properties (magnetism, heat capacity, heat conductivity)
Semiconductors
Experimental tests of special relativity
Paradoxes in special relativity
Ionizing radiation - what it is, where you find it, and radiation protection
Cosmic rays
The structure and evolution of stars
Big Bang relativity
The creation of the chemical elements - nucleosynthesis
Geo-neutrinos
Different fusion schemes
Nobel prize analysis
How did Schrodinger derive his equation?
Proton decay
The discovery of the neutron
Analysis of the Bohr, Kramers, Slater paper “The quantum theory of radiation,” 1927
Nuclear weapons
Electron degeneracy and white dwarfs
Neutron degeneracy and neutron stars
Casimir force