PS 303 – Modern Physics
Embry-Riddle University
Fall 2013

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Required texts: *Twentieth Century Physics*, by Reynolds
Supplementary texts: *Schaum's Outlines – Modern Physics*, by Gautreau and Savin
From X-rays to Quarks, by Segre
Modern Physics, 3rd edition, by Thornton and Rex
Modern Physics, 2nd edition, by Krane
"*Hyperphysics*" http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html

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Percentage system:		*Grading scale*:	
1 final exam	20%	A	90% –
3 tests	60% (20% each)	B	75% – 89%
Problem sets	12%	C	60% – 74%
Quizzes, etc	8%	D	50% – 59%

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!*).

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* This syllabus incorporates all existing University policies, especially those sections of the *Student Handbook* pertaining to academic integrity, civility, and respect. *

Course Description: Modern concepts in physics including optics. Topics include refraction, diffraction, and scattering of electromagnetic radiation, special relativity, wave-particle duality, the uncertainty principle, quantum theory of atomic structure, X-rays, lasers, 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 Exam

Comprehensive; two-hour; closed book; closed notes.
Tools: pen or pencil, calculator, Codata sheet, periodic table.
Date: Tuesday, 10 Dec, 8:00 – 10:00.

Tests

One-hour; closed book; closed notes.
Tools: pen or pencil, calculator, Codata sheet, periodic table.
Dates: Mon 23 Sep, Fri 1 Nov, Wed 4 Dec.
Final exam will replace lowest test.

Problems

Approximately 8-10 problems each week; must be neat and stapled.
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.

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.

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.

Study Groups

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

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]. This is the most important component of coherence and full credit will not be given for any problem solution that does not contain such a description.
- 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.

PS 303 - Schedule - Fall 2013

day	date	TCP Reading	Supplementary	lecture topics
M	26-Aug	Preface, App A		intro, syllabus, epistemology (Popper), math (binomial)
W	28-Aug	1	Video 1	energy, momentum, quantum
F	30-Aug	2.1	Weinberg; YF 44.1-5	elementary particles
W	4-Sep	2.2	Video 2; Hyperphysics	charge, interactions, exchange particles, Heisenberg inequalities
F	6-Sep	App B	YF 39.2; Longo 3-2	Rutherford scattering
M	9-Sep	2.3	Video 3	spin, pe model
W	11-Sep	2.4	Video 4; YF 21.7, 22.7	magnetic moment, Pauli exclusion
F	13-Sep	2.5, 2.6	Quigg; Davies	color force, strong force, weak force
M	16-Sep	3.1-3.4	Video 5; YF 43.1-2	nuclear mass, charge, color, size
W	18-Sep	3.5, 3.6	Hyperphysics	spin, magnetic moment
F	20-Sep	App C	Bad Cigar; Stern*	Stern-Gerlach
M	23-Sep			Test #1
W	25-Sep	App D	Video 6; YF 39.5; PhD	Blackbody radiation
F	27-Sep	3.7, 3.8	YF 43.4	radioactivity, alpha decay
M	30-Sep	3.9	YF 43.3	beta decay
W	2-Oct	App E	Einstein 8	Photoelectric effect
F	4-Oct	4.1	Video 7; Bohren	atomic properties, dimensional analysis
M	7-Oct	4.2, App F	YF 39.3	Bohr model, reduced mass
W	9-Oct	4.3	YF 41.6	periodic table
F	11-Oct	4.4	YF 41.7; Moseley	Moseley's law
M	14-Oct	5.1, App G	Video 8; Wikipedia	introduction, time dilation, cosmic rays
W	16-Oct	5.2	YF 37.3, 37.4	length contraction
W	23-Oct	5.3	YF 37.5	Lorentz transformation
F	25-Oct	5.4	Simonetti*; Baez/Weiss*	twin paradox, etc.
M	28-Oct	5.5, 5.6	Video 9	more paradoxes, dynamics
W	30-Oct	5.6	YF 37.7, 37.8	more dynamics
F	1-Nov			Test #2

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day	date	TCP Reading	Supplementary	lecture topics
M	4-Nov	App H	Compton; Bragg; YF 38.3	Compton effect
W	6-Nov	6.1, 6.2	YF 38.4; YF pp1335-6	wave particle duality, dispersion
F	8-Nov	6.3, 6.4	YF 39.6	Heisenberg relations, Bohr's Complementarity Principle
W	13-Nov	7.1	YF 40.1	Schrodinger equation
F	15-Nov	7.2	YF 40.1	how to solve the Schrodinger equation
M	18-Nov	7.2	YF 40.2	special potentials
W	20-Nov	7.3	YF 41.2	symmetry and the Pauli principle
F	22-Nov	7.4	YF 40.1	free particles
M	25-Nov	7.5	Winter	quantum postulates
M	2-Dec	7.6	YF 41.1, 41.3	Schrodinger equation in 3D, review
W	4-Dec			Test #3