PHYSICS III: Modern Essentials

Carnegie Mellon University — Department of Physics
33.211, 33.213 — Fall 2014
Version 1.0

Lecturer: Professor Reinhard Schumacher Wean Hall 8406 412-268-5177
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office hours: I am usually in my office; drop in when you want, call to ensure I am there.

Class Times: Monday, Wednesday, Friday Doherty Hall 1112 9:30 – 10:20 a.m.
Tuesday Doherty Hall 1212 9:30 – 10:20 a.m.

Required Text:

Modern Physics, 6th Ed., P. A. Tipler & R. A. Llewellyn, Freeman (2012)
ISBN-13: 978-1-4292-5078-8

Supplemental Texts:

Introduction to Special Relativity, R. Resnick, Wiley (1968) (on reserve in the E&S library, optional supplement for the Relativity part of the course)

Spacetime Physics, E. F. Taylor and J. A. Wheeler, Freeman (1992) (on reserve in the E&S library, optional supplement for the Relativity part of the course)

101 Quantum Questions, K. Ford, Harvard Press (2012) (on reserve in the E&S library, optional supplement for the Quantum Physics part of the course)

Goals of the Course:

This course is required for students of physics, but is open to anyone who wants to become familiar with some of the key concepts underlying virtually all of modern physics. We will study Special (and touch upon General) Relativity and Quantum Physics, which began development in the early 20th century. The first part of the course (mini-course 33.213) will be on Relativity, covering relativistic kinematics and dynamics, but not electricity and magnetism. You should learn which quantities in mechanics are relative between observers and which quantities are invariants for all. The necessary mathematics is simple but the concepts challenge our everyday intuition. The second part of the course will take a broad look at quantum phenomena. You should learn about the need for quantum theory and appreciate the paradigm shift intrinsic to modern quantum theory. Again, while the concepts are challenging, the mathematical formalism will be minimal. Nevertheless, the course will be quantitative, involving the algebraic and numerical solutions of many problems. The class will therefore improve your skills in thinking through and solving intriguing physics problems. It is definitely possible to develop reliable intuition for relativistic and quantum physics, and this course should get you off to a

good start. It will prepare you for later classes you may take in electricity and magnetism and in quantum theory. It leads directly into the Quantum Physics course (33.234), which will begin with a more formal treatment of quantum mechanics.

Websites:

The Blackboard website is http://www.cmu.edu/blackboard. It will be used for announcements, score keeping, scheduling information, the weekly homework assignments, and previous exams. Please check it often. The textbook has its own accompanying website that has supplemental information. It is at www.whfreeman.com/tiplermodernphysics6e/. Please test these sites and let us know of any problems you encounter.

Quizzes, Exams, & Grades:

There will be weekly quizzes, usually based on the current assignment or on examples from the previous lectures. The quizzes will usually occur during the Friday class sessions, so be on time and be prepared.

There will be three one-hour exams during the semester and a three-hour comprehensive final exam. The hour exams will be given during regular class times in the usual lecture hall. They will be closed-book exams with no electronic devices permitted. *No make-up exams will be given.* If you cannot take an exam for any reason, tell the instructor beforehand, but very few excuses will be accepted for missing an exam. The weighting factors which will be used in determining the course grades are:

Three hour exams 3×10%	= 30%
Final exam	= 35%
Quizzes	= 20%
Assignments	= 15%

Letter grades will be computed from your overall numerical score at mid-term and at the end of the semester. We will drop your lowest assignment score and lowest quiz score, but not the lowest exam score. Grades will be computed on an absolute scale, not on a curve. Therefore, you are not in competition with your fellow students, but only with yourself and the material. The final letter grades for the course will be determined by the following approximate scale: A > 87%; B 75–87%; C 60–75%; D 50–60%; R < 50%. In borderline cases, based on the instructors' perception of your work, we will consider diligent lecture attendance, class participation, and consistency of performance throughout the semester.

Assignments:

There will be weekly homework assignments, consisting of assigned readings and problems to be solved. Doing the written assignments, *i.e.* problem solving, is the single most important tool for learning the course material. However, you should feel free to discuss the assigned problems with your associates; in fact, it often helps to work in small groups. You should hand-write solutions on your own, legibly and understandably, because you need to fully grasp the material for yourself on quizzes and exams. The problems indicate the *minimum* level of achievement expected of all students.

Generally, homework dealing with the ongoing week's concepts will be collected on **Fridays** at the beginning of the lecture. Written solutions will be provided on the course website. A random subset of the problems will be graded in detail, and all problems will be checked to see if you made a serious effort to solve them. Since you won't know in advance which ones these are, do all problems fully. Please always go over your returned work and the solutions, simply because they will not all be graded in detail, and because the test problems will be similar to the previous homework problems. Turn in the assignments on time! 20% per day will be deducted for late work, and zero credit will be given after solutions are posted.

Since this is a ten-unit course and we meet in class for four hours per week, plan to spend about six hour per week outside of class. If your background is weak in algebra or in classical physics, you will need to spend more time. If you can't solve a problem within a reasonable time, say 30 minutes, ask an instructor or a fellow student for help. Also, start immediately on new assignments, so that you have time to think about the questions and to revisit concepts you don't grasp initially.

Extra Help:

You are encouraged to discuss with the instructor any problems you may have with the course material. Just use the email address given above, or even better, talk to him in person! In addition, the Physics Department offers an Upper Class Course Center (“PUCCC”) for help with homework problems in any 200+ level physics course. The Center is staffed by competent upper-class undergraduate physics majors and is open for business nearly every evening of the week throughout most of the semester. Just check the relevant postings.

Electronic Devices in Class:

Please be sure your mobile devices are silent at all times. You may use your laptop, silently, to make notes, but for no other purpose, and so that the screen does not distract you or others nearby. Audio or video recording is not permitted except with express consent of the instructor. Even in that case, recordings may not be further distributed or used for any purpose other than personal and educational.

Course Schedule: The *tentative* schedule for the semester:

Week	Ending	Topics covered	Assigned Reading (Chapter-Section)
1	Aug. 29	Newtonia. Einstein's Postulates of Special Relativity	1-1, 1-2
2	Sept. 5	Simultaneity, Lorentz Transformation, Time Dilation, Length Contraction, Velocity Addition, Invariant Intervals	1-3, 1-4
3	Sept. 12	Spacetime Diagrams, Doppler Effect, Famous "Paradoxes"	1-5, 1-6
4	Sept. 19	Relativistic Momentum and Energy	2-1, 2-2
Friday	**Sept. 26**	**9:30 am EXAM I** (Coverage: Weeks 1-4)	
5	Sept. 26	Energy-Mass Equivalence, Relativistic Kinematics	2-3, 2-4
6	Oct. 3	A Glimpse of General Relativity	2-5
7	Oct. 10	Quantization of Charge and Energy, Blackbody Radiation	3-1, 3-2
8	Oct. 15	Quantization of Light: Photoelectric Effect	3-3
-	Oct. 17	(Mid-semester Break; No Classes)	
Friday	**Oct. 24**	**9:30 am EXAM II** (Coverage: Weeks 5-8)	
9	Oct. 24	Quantization of Light: X-Rays, Compton Effect	3-4
10	Oct. 31	Atomic Spectra, The Atomic Nucleus	4-1, 4-2
11	Nov. 7	The Bohr Model of Hydrogen	4-3
12	Nov. 14	X-Ray Spectra, Franck-Hertz Experiment	4-4, 4-5
Friday	**Nov. 21**	**9:30 am EXAM III** (Coverage: Weeks 9-12)	
13	Nov. 21	The Wave Nature of Particles	5-1, 5-2, 5-3
14	Nov. 25	Uncertainty Principle, Wave Particle Duality	5-4 thru 5-7
-	Nov 26-28	(Thanksgiving Break; No Classes)	
15	Dec. 5	The Schrödinger Equation	Ch.6 Selections
-	**T.B.A.**	**FINAL EXAM, time and place T.B.A.** (Coverage: comprehensive) The Final must be taken at the scheduled date and time.	

Next Step: The Quantum Physics course (33.234)!