Physics 3: Modern Essentials

Carnegie Mellon University — Department of Physics
33.211, 33.213 — Fall 2020
Version 1.1

Lecturer: Professor Reinhard Schumacher — Wean Hall 8406
email: schumacher@cmu.edu web: http://www.cmu.edu/physics/people/faculty/schumacher.html
office hours: via Zoom, at times to be announced

Class Times: Monday, Tuesday, Wednesday, Friday (Online only) 9:20 – 10:10 a.m.

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

Supplemental Texts: (For supplemental reading on the same topics at a similar level)
Introduction to Special Relativity, R. Resnick, Wiley (1968)
Spacetime Physics, E. F. Taylor and J. A. Wheeler, Freeman (1992)
101 Quantum Questions, K. Ford, Harvard Press (2012)

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 Relativity (also touching upon General Relativity) and Quantum Physics. 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 will learn which quantities in mechanics are relative between observers and which quantities are invariant for all. Energy and momentum conservation remain crucial in Relativity but will be formulated anew. 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 will learn why quantum theory is necessary and come to appreciate the intellectual paradigm shift inherent in the modern quantum view of nature. Again, the concepts are sometimes challenging, but the mathematical formalism will be straightforward. The course will nevertheless be quantitative, involving the algebraic and numerical solution of many problems. The class will therefore improve your skill 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 that you may take in electricity and magnetism and in quantum theory. It leads most directly into Quantum Physics (33.234), which will develop a more formal treatment of quantum mechanics.

Online Learning, Class Recordings, and Other Online Resources:

The Canvas website is https://canvas.cmu.edu/courses/18256 (via the QR Code on first page). It will be used for announcements, score keeping, scheduling information, the weekly homework assignments, and practice exams.

This class will be conducted entirely online, with no in-person component. Class sessions will be "synchronous" and recorded via Zoom so that students in this course can watch or re-watch past class sessions. Breakout rooms, if used, will not be recorded. The recordings will be available and archived on Canvas soon after each class session. The instructor appreciates questions and discussion during class, especially if something was said that is unclear to you or something was written incorrectly on the board! To make this work well, we wish all students to have their cameras on during lectures and discussions, in particular when asking a question. During our class meetings, please keep your mic muted unless you are sharing with the class. You can use the "chat" window within Zoom: that works for asking questions, but the instructor may not see what you type immediately, even if you use the "raise hand" feature (available when the Zoom participant list is pulled up). We may therefore ask for volunteers to serve as "chat" monitors to alert the instructor.

The fine print: Please note that you are not allowed to share these recordings. This is to protect your FERPA rights and those of your fellow students. Per University policy: "Recordings of course sessions are provided solely for educational use by students enrolled in the course and may not be distributed to any other person or posted on the internet without the express written permission of the course instructor." Furthermore: "No student may record any classroom activity without express written consent from the course instructor. If you have (or think you may have) a disability such that you need to record or tape classroom activities, you should contact the Office of Disability Resources to request an appropriate accommodation."

The textbook for the course has recently gone out of print (summer 2018), but it is still available online from various sources. Get yourself a copy as soon as possible.

Quizzes, Exams, & Grades:

There will be weekly quizzes, usually based on the current assignment or on examples from the previous lectures. The quizzes will typically occur on Fridays, with the aim to see whether you are keeping up with the course. They will be timed: 20 minutes will be the nominal time allotted, with an extra 10 minutes allotted to complete scanning or picture-taking and uploading them to Canvas. Work the problems on clean paper, by hand, legibly, with neatly labeled diagrams and structured algebra, as appropriate. (People in remote time zones will have the option to complete a quiz with respect to their local time.)

There will be three one-hour exams during the semester and a three-hour final exam. The hour exams will be given online and be available for any 60-minute block of time with a given 24-hour period. Photograph or scan your handwritten pages and upload them to Canvas by the given deadline. You may use the textbook during the exams, and you may use handwritten class notes and your handwritten problem sets. 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 that will be used in determining the course grades are:

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

Letter grades will be computed from your overall numerical score at mid-semester and again 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 with 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 readings and written problems. Doing the assignments, especially *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 assigned problems indicate the *minimum* level of achievement expected of all students.

Generally, homework dealing with the ongoing week's concepts will be due on **Fridays**, uploaded to Canvas. Written solutions will later 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. Turn in the assignments on time! 20% credit per day will be deducted for late work, and zero credit will be given after the solutions are posted. Tip: review your returned work and the posted solutions each week, even the problems that were not graded in detail. Test problems will be similar to the homework problems.

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 in algebra or in classical physics is weak, 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 (Fridays), so that you have time to think about the questions and absorb the concepts that you don't grasp right away.

Extra Help:

You are encouraged to discuss with the instructor any problems you may have with the course material. One way is to use the Zoom Office Hours (times to be announced and subject to change). Our plan is to have group sessions – first come, first served – where you might be helped by listening to a discussion with another student in the class, or even by being asked to explain something you already understand to someone else in the session.

Also, we will be using "Piazza" for class discussions. The system is set up to getting you help fast and efficiently from classmates and the instructor. Rather than emailing questions to the teaching staff, try first posting your questions on Piazza.
Find our class page at: https://piazza.com/cmu/fall2020/33211/home

In addition, the Physics Department will offer a Physics Assignment Tutoring Hall/Help ("PATH") site for help with homework problems in any 200+ level physics course. It would be staffed by competent upper-class undergraduate physics majors and is open for business nearly every evening of the week throughout most of the semester. Departmental emails will announce when this is available.

Taking care of yourself. *Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress. If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. Counseling and Psychological Services (CaPS) is here to help: call 412-268-2922 and visit their website at http://www.cmu.edu/counseling/. Consider reaching out to a friend, faculty or family member you trust for help getting connected to the support that can help.*

If you or someone you know is feeling suicidal or in danger of self-harm, call someone immediately, day or night:

CaPS: 412-268-2922
Re:solve Crisis Network: 888-796-8226
If the situation is life threatening, call the police:
On campus: CMU Police: 412-268-2323
Off campus: 911

If you have a disability and are registered with the Office of Disability Resources, I encourage you to use their online system to notify me of your accommodations and discuss your needs with me as early in the semester as possible. I will work with you to ensure that accommodations are provided as appropriate. If you suspect that you may have a disability and would benefit from accommodations but are not yet registered with the Office of Disability Resources, I encourage you to contact them at access@andrew.cmu.edu.

If you have questions about this or your coursework, please let me know.

Course Schedule: The *tentative* schedule for the semester: (Version 1)

Week	Ending	Topics covered	Assigned Reading (Chapter-Section)
1	Sept. 4	Newtonia. Einstein's Postulates of Special Relativity	1-1, 1-2
2	Sept. 11	Simultaneity, Lorentz Transformation, Time Dilation, Length Contraction, Velocity Addition, Invariant Intervals	1-3, 1-4
3	Sept. 18	Spacetime Diagrams, Doppler Effect, Famous "Paradoxes"	1-5, 1-6
4	Sept. 25	Relativistic Momentum and Energy	2-1, 2-2
Friday	**Oct. 2**	**9:10 am EXAM I** (Coverage: Weeks 1-4)	
5	Oct. 2	Energy-Mass Equivalence, Relativistic Kinematics	2-3, 2-4
6	Oct. 9	A Glimpse of General Relativity	2-5
7	Oct. 16	Quantization of Charge and Energy, Blackbody Radiation	3-1, 3-2
-	Oct. 16	(Mid-semester Break; No Classes)	
8	Oct. 23	Quantization of Light: Photoelectric Effect	3-3
-	Oct. 23	(Random Break; No Classes)	
Friday	**Oct. 30**	**9:30 am EXAM II** (Coverage: Weeks 5-8)	
9	Oct. 30	Quantization of Light: X-Rays, Compton Effect	3-4
10	Nov. 6	Atomic Spectra, The Atomic Nucleus	4-1, 4-2
11	Nov. 13	The Bohr Model of Hydrogen	4-3
12	Nov. 20	X-Ray Spectra, Franck-Hertz Experiment, deBroglie Hypothesis	4-4, 4-5, 5-1
13	Nov. 24	The Wave Nature of Particles	5-2, 5-3
-	Nov. 25-27	(Thanksgiving Break; No Classes)	
Friday	**Dec. 4**	**9:30 am EXAM III** (Coverage: Weeks 9-13)	
14	Dec. 4	Uncertainty Principle, Wave Particle Duality	5-4 thru 5-7
15	Dec. 11	The Schrödinger Equation	Ch. 6 Selections
-	**T.B.A.**	**FINAL EXAM, time T.B.A.** (Coverage: comprehensive) The Final Exam must be taken at the scheduled date and time.	

Next Step: The Quantum Physics course (33.234)!