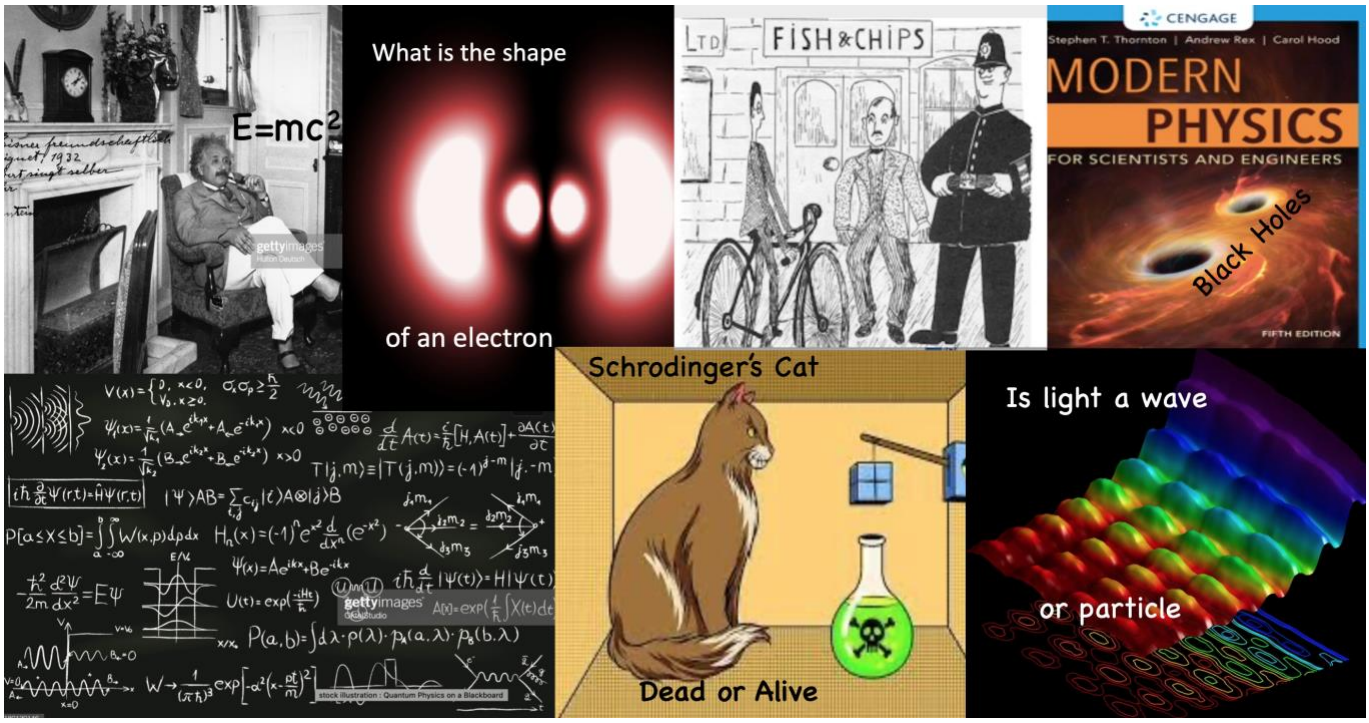
PHYS 2620
Modern Physics
Syllabus
Summer Session I-II 2022
Instruction mode
Online (Synchronous)
Updated May 9, 2022

Start Date: Monday May 23, 2022 – End Date: Friday July 8, 2022
Class Time MTW 1:00 – 3:15 and TR 1:00 – 3:15



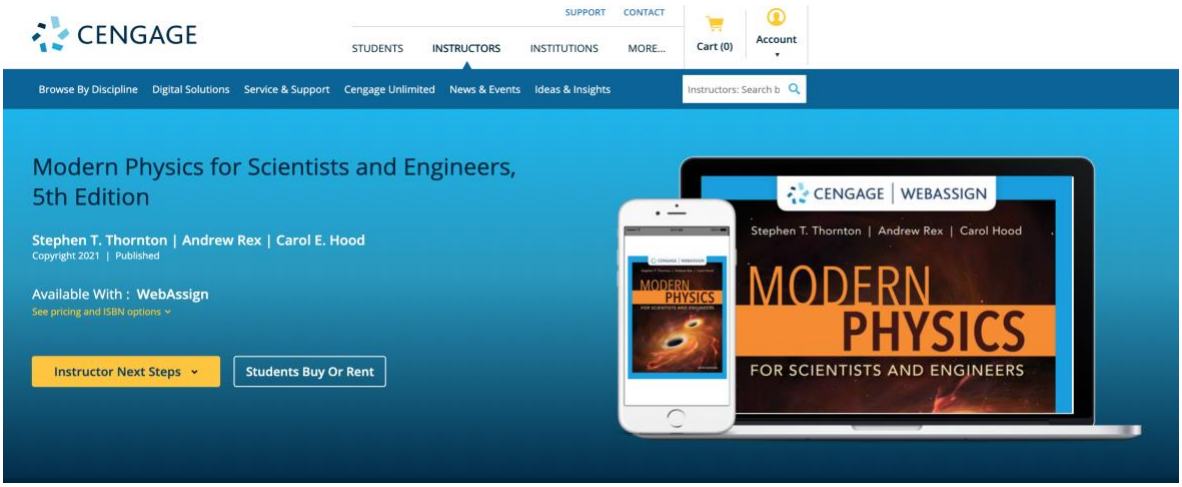
For registration details on Summer Session go to the link summer session home For course details see below

- **Course Overview:** Physics 2620 is a comprehensive study of modern physics that emphasizes concepts and problem solving. Modern physics generally means the breakthroughs in special relativity and quantum mechanics during the early 1900's. This course includes that part of classical physics that failed to explain certain well-known experiments. In the late 1800's classical physics consisted of Newton's Laws, Maxwell's equations, and thermodynamics. As these failures became more worrisome to prominent scientist, new ideas began to emerge and special relativity and quantum physics were born. This course is about the emergence of special relativity, quantum physics and the Schrodinger equation and application of the latter to new phenomena.

- **Synchronous Lectures*, Quizzes and Exams:** There are 40 lectures on MTWRF offered online. There is no penalty for missing an occasional online lecture. Lectures by the course instructor are automatically video/audio recorded for replay if you happen to miss a lecture or want to play it again. You can take it from anywhere in the world where you have a fast internet connection and a laptop or desktop computer. **Quizzes which are given on Tuesday of Thursday must be taken with unmuted video on Zoom on the given date and time on the calendar**. If you miss the quiz due to a daily job or doctor supported medical reasons, you must take the makeup offered at 7:00 pm on the same day. The midterm and final must be taken at the scheduled time. There are also selected video/audio vignettes of special topics and problem solving by the lead author of the textbook to help you learn the conceptual aspects of the material and problem solving which are both important components of learning physics.

  *Students who have other commitments such as a full time work schedule during lecture time may request permission from the instructor to take the class self-paced (asynchronously), but must meet the deadlines for homework, quizzes, and exams.

- **Required Textbook:** Modern Physics for Scientists and Engineers, Stephen T. Thornton, Andrew Rex, and C. Hood, ed 5. Hard cover edition ISBN: 978-1-337-91945-6, Loose-leaf edition ISBN: 978-1-337-91956-2.
  After you register for the course and after I publish it on Collab, you will be able to access all course materials including the digital textbook on Collab. WebAssign and the textbook publisher Cengage are paired with Collab. Just click on the button Cengage (WebAssign) and you will automatically have access to WebAssign and the digital textbook. If you stay registered in the course up until the add/drop period, your UVa student fee account will automatically be billed $82.35. This price may vary. When you order your materials from the bookstore or web, you will choose Inclusive Access. This includes the digital textbook , Cengage, and access to webassign. This is a great savings. The hardcover, softcover or loose-leaf edition textbook may be ordered from the UVa Cavalier bookstore if desired. https://uvabookstores.com/textbooks.asp or call 800-759-4667 but a higher price.



- **Course Topics**

Ch. 1 Classical Physics Review
Ch. 2 Special theory of relativity, Einstein's postulates, time dilation, contracted length, energy ...
Ch. 3 Particle and wave properties of matter, Planck's quantum and blackbody radiation, Photoelectric effect,…
Ch. 4 Classical atomic structure, Bohr model of atomic hydrogen, …
Ch. 5 De Broglie wavelength, Heisenberg uncertainty principle, wave functions …
Ch. 6 Schrodinger Wave equation, eigenvalues, square well potential, potential barriers, tunneling.…
Ch. 7 Application of Schrodinger equation, Hydrogen atom, quantum numbers, orbital motion and intrinsic spin.
Ch. 8 Periodic table. total angular momentum, and anomalous Zeeman effect.
Ch. 9 Maxwell velocity distribution, Fermi-Dirac statistics, and Bose-Einstein statistics
Ch. 10 Molecular bonding, spectra, lasers, and quantum entanglement
Ch. 12 Atomic nucleus, nuclear properties and forces, radioactivity, neutrinos, time dating using lead/carbon
Ch. 13 Nuclear physics, nuclear reactions, fission and fusion, reactors, and medical applications.
Ch. 14 Particle physics, accelerators, standard model, quarks, families of matter, and neutrino oscillations
Ch. 15 Astrophysics, stars, galaxies, gen. relativity, dark matter, and black holes

- **Prerequisites:** This particular course offering is appropriate for engineering students who have completed the sequence PHYS 1425 -2415 with Math 2310 at the University of Virginia and can be taken by science majors (including physics majors) who have taken various physics sequences: 2310-20 (no longer offered), or 1610-20 or 1710-20, and 2610, or possibly 2010-20 (with instructor permission). This course serves as a science/technical elective for engineering students. Visiting students should email the instructor (ral5q@virginia.edu) to discuss prerequisites for this class who have achieved at least a grade of C or better from physics courses equivalent to PHYS 2415 or 2610.

- **Online Course offered: PHYS 2620 4 cr-hr, Summer Session May 23, 2022 – July 01, 2022**

Lecture Sessions	MWF 1:00-3:15	Online (Zoom
Instructor:	Richard A Lindgren	ral5q@virginia.edu
	Research Professor of Physics	Office Physics Bldg.
Office Hours	TTH 7:00-8:00pm	Online (Zoom)
Discussion Sessions	TR 1:00-2:15	Online (Zoom)
Teaching Assistant	TBA	
Office Hours	MWF 7:00-8:00pm	Online (Zoom)

- **Lectures on Monday, Wednesday, and Friday**
  The course consist of approximately 40 lectures given on Monday, Wednesday and Friday. Two one-hour lectures are given on each day starting at 1:00 and 2:10 pm with a 10-minute break in-between lectures; Lectures will focus on developing the ideas surrounding the main physics concepts in each session, sometimes deriving important formulas (some of the time relying on you to derive the formulas). Many examples will be discussed in class including solving end of chapter problems. Several short videos on problem solving are also available on selected topics. The main objective is to teach you modern physics by making the lecture material interesting and exciting and have you to develop a working knowledge of solving problems in modern physics. We will cover the physics discussed in Chapters 2-14 omitting Chapter 11 and summarize Chapters 15 and 16. **Due to the pace of the course in such a short period of time and my own preferences for the material certain specialized topics in various chapters will be omitted, but this will not put your expertise of the subject matter at any disadvantage. Note that this is a 4 cr-hr course requiring more time than available in a single summer session I, II, or III. The course runs from the beginning of summer session I (May 23) and ends midway through summer session II (July 8).**

- **Problem solving, Discussion and Quizzes on Tuesday and Thursday**
  Additional examples of solving problems and discussion will be given on Tuesday starting at 1:00 pm and a discussion followed by a short quiz on Thursday starting at 1:00 pm The short quiz consisting of 3 - 5 numerical/conceptual problems will be about 30 minutes long. The quizzes will be part of your final grade.

- **Homework**

Homework assignments will be posted on Collab and linked to WebAssign through Cengage. It is due twice a week at 11:59 pm on Tuesdays and Fridays. Because this course is at such a rapid pace you must keep up every day and not get behind or all is lost. Having you submit homework every few days will help you not get lost. Students are encouraged to discuss problems with others while completing homework assignments. You may also post a question on Piazza to get even faster turn-around from your TA, or your Professor or from other students. However, each student is required to work out the final solution on their own. Copying homework solutions is an honor violation. Homework extensions will be accepted up to a day or so but may require a penalty depending on the situation. If you have a medical excuse, send me some documentation and no penalty will be given. Solution to many of the problems are available on WebAssign and will be available to you after the deadline for submission. Office hours are held on Zoom by your Professor on Tuesday and Thursday from 7:00 PM to 8:00 pm to answer questions and by the TA on Monday, Wednesday, and Fridays (Time to be announced later).

- **Exams**
  Exams include one midterm exam, and one final exam. The midterm will be given on June 10 Thursday evening on Zoom from 7:00 pm to 8:15 pm. The midterm will be posted on WebAssign with approximately 20 questions. A practice exam will be posted to give you some practice taking a full exam on WebAssign and serve as review of the material. See Calendar for specific times of the quizzes and midterm. There could be some adjustment to the dates depending on our progress. All testing is open book, but obviously no searching the internet or communicating with others. All exams and quizzes are taken according to the rules set by the UVa honor code. Please review the code if you are not familiar with it. See next to last paragraph in these notes.

- **Solutions posted on WebAssign**
  Solutions to homework, quizzes, and midterm will be available on WebAssign. Practice midterm along with solutions will be provided a few days before midterm and final.

- **Videos: Mini lectures**
  There are short 5–10-minute mini-lectures that have been recorded by the lead author of the textbook for selected important material. You will find these lectures by clicking on a chapter number on the side bar of the screen. These video mini lectures are given by the lead professor who wrote the textbook and who taught this course for many years. These mini- lectures will help you. These lectures should start immediately on your computer.

- **WebAssign: Assignment platform for final, midterm, quizzes and homework**
  WebAssign will be used for taking the final, midterm, quizzes, and submitting homework. It allows for setting a time limit and dates for when the exam or homework is posted for future assignments. It also allows different kind of feedback conditions for the student as discussed below. The final is timed for 3 hours. The midterm is timed for 1 and 1/4 hour and quizzes are timed for 20-30 minutes or so. You have a 3-4 days in between each homework assignment. The quiz times and homework times are subject to change. You will have access to all assignments posted on WebAssign. There may be some instances where quizzes may be also posted on Collab or some other platform. If this happens, you will certainly be notified about the change.

- I have elected the Inclusive Access Program (also called Unlimited Cengage) that pairs WebAssign with the publisher and Collab. Just click on the Cengage (WedAssign) tab on Collab. This will give you access to WebAssign, the digital textbook, and other resources. You can still get familiar with WebAssign, but not the assignments, before class starts without access through Collab. Click on this link https://webassign.net/manual/WA_Student_Quick_Start.pdf

- **Types of problems**
  Assignments could have many different types of problems allowed in WebAssign. Possible types are numerical problems where you submit one answer with the correct number of requested sig. fig., multiple choice where you select one or more answers, fill in the blank, or may be even algebraic where steps are submitted to derive a formula. In our class I will focus mostly on numerical problems and multiple-choice questions

- **Significant figures (Sig. Fig.)**
  When solving problems or answering questions on WebAssign, you will be given to what accuracy a calculation is needed and how many significant figures (sig. fig.) are needed for a correct answer. If you give too little or too many sig. fig. your answer will be incorrect. You should do the calculation with intermediate steps holding as many sig. fig. as reasonable but certainly more than what is requested for the final answer. If you need 2 sig. fig. to get the right answer, you should hold the intermediate steps to at least 4 sig. fig. and sometimes more depending on the specific calculation

- **Units**
  Most problems assigned will require numerical answers that have units. The answer box will generally have the units given to you. You must enter the answer with the correct units

- **Answer feedback and resubmission**
  Depending whether you are working on an exam, quiz, or homework you will be given a chance to resubmit your answer. For example, if you submit your answer in the answer box, you will get either a green check mark (correct) or a red X (Incorrect). I may give you 6 chances for example to submit the answer again if it is a homework question to get it correct. I may allow a different number of times if it is a quiz or exam.

- **Lecture Slides:** All lecture slides original and annotated will be posted on Collab. The video/audio digital recordings of all the lectures will be available on Media Gallery after transferring from the Cloud to Collab.

- **Grading:** Your grade is based on several components, so no one component makes or breaks it.

	Weights
Final Exam	- 35%
Midterm	- 30%
Quizzes	- 15%
Homework	- 15%
Clickers.	- 5%
Total	100%

Final Exam: Open book 3 hr. exam. Approximately 40 multiple choice styles questions divided into 32 numerical and 8 conceptual questions. This breakdown is approximate.
Midterm: The midterm is an open book 1 ¼ hour exam which will be given during the discussion period on Thursday. There will be approximately 20 questions. The date on the calendar is approximate.
Quizzes: Quizzes will be given on Thursdays unless noted otherwise. Approximately **3-5** questions on each quiz.
Homework: Homework questions and problems will be selected from the end of chapter problems in the text. Problem numerical parameters are randomized, assigned, submitted, and graded through WebAssign. Homework is due Tuesday 11:59 pm and Fridays 11:59 pm. Homework help is available on Tuesday/Thursday Discussion, office hours by the instructor TR 7:00 pm – 8:00 pm and TA MWF (Time TBA). Additional time will be spent by the instructor on homework examples during Lecture and Discussion.

- **Students Disability Access Center (SDAC):** Students needing the services provided by the Students Disability Access Center (SDAC) will need to be certified by that office. The center is located at 400 Brandon Ave. P.O. Box 800760, Charlottesville, VA 22908-0760, Phone 434-924-5362, Email studenthealth@virginia.edu, Website **student health**

- **University Honor System:** An Honor Offense is defined in the link honor.virginia.edu/overview An honor offense would be any violation of the honor pledge, "On my honor, I pledge that I have neither given nor received help on this assignment." A pledged assignment means homework, exam, quiz, etc. or any written assignment that requires a grade unless otherwise noted. Your Professor can add to the pledge or document as he see fits. For example, an open book assignment means that you can only use your assigned textbook (digital or notebook versions) and

downloaded class slides. You cannot use notes compiled or summarized from other resources. I could change these rules if so desired. If I request you to take an exam with your video unmuted, then you are expected to do so. It could be considered an honor violation if you refused. If you knowingly obtain a copy of a future exam by accident or intent, I will consider that an honor violation. You should report such an incidence to your instructor. I am required to report any suspected violation of the honor code to the honor committee. If you are uncertain about any future action that you might commit, don't hesitate to contact me to ask for advice on whether or not it is an honor violation.

- **Important dates (Dates are expected to change by a day or so since these are 2021 dates)**

Online Registration opens on SIS : Mar 28, 2022 for UVa Grad Students
: Mar 29, 2022 for UVa Undergrad 3rd and 4th Year Students
: Mar 30, 2022 for UVa Undergrad 1stand 2nd Year Students
: Mar 31, 2022 for Visiting Students

For details on Online Registration go to the link Registration and Academic Procedures
First Online lecture: Monday May 23
No classes Monday: May 30,
No Classes Monday: July 4
Last day for dropping: June 10, 2022
No withdrawals after June 10, 2022.
Last day to change grade option: June 3
Midterm: Thursday June 16 1:00 pm
Last discussion session: Tuesday July 5 1:00 pm
Last lecture: Thursday July 7 1:00-2:00 pm
Course Review: Thursday July 7 2:10 pm
Final exam: Friday July 8 2:00 pm

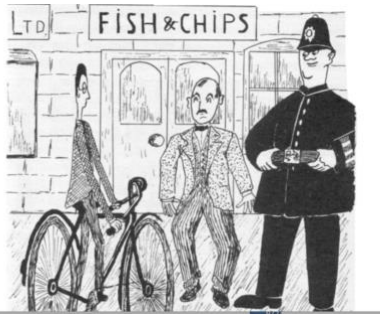
- **Additional reading and video resources:**

Modern Physics, Professor Michael Fowler's Notes
Professor Michael Fowler, Emeritus of the University of Virginia, has written a nice set of notes that cover most of the material in this course. It could help you if you read over his notes to obtain a different perspective of the material. These notes are somewhat older, but the subject has not changed. You can find his notes at Professor Fowler Notes

Modern Physics, Kenneth S. Krane, ed. 3
This book contains similar depth of material as Thornton, Rex, and Hood and written with a pedagogical emphasis from Physics Education Research studies. A balanced pedagogical approach examines major concepts first from a historical perspective, then through a modern lens using relevant experimental evidence and discussion of recent developments in the field. Extensive pedagogical tools aid in comprehension, encouraging students to think critically and strengthen their ability to apply conceptual knowledge to practical applications. Numerous exercises and examples reinforce fundamental principles.

Modern Physics for Scientist and Engineers with Modern Physics by Douglas C. Giancoli, ed. 4
One textbook is not always enough. It always helps to have another textbook to look at for subjects which you may find confusing. It helps to have a different viewpoint. I also recommend Physics for Scientist and Engineers with Modern Physics by Douglas C. Giancoli, ed. 4, Vol. 3. You already may have access to it because Volumes I and II are used at the University of Virginia for the first two semesters of the physics series for Engineers, We will cover Chapters 36 to 42 and a little more. It was readily available in the Physics Library.

Mr. Tompkins in Wonderland (Paperback), George Gamow, Cambridge University Press, Reprinted 1994
In his dreams, Mr. Tompkins experiences some of the weird and counterintuitive phenomena of the theories of Relativity and Quantum Mechanics. Gamow uses the ingenious device of lowering the speed of light to 15 km/h and of raising the value of Planck's constant by many orders of magnitude in Mr. Tompkins dreams. As a result the story now embellishes the effects of relativity and quantum effects.



End of syllabus

Lecture	Time	Date	Day - Wk	PHYS 2620 updated May 9, 2022	Read Chapters	Quiz	Due 11:59
1	1:00	5/23/22	Mon - 1	Introduction - Classical Physics Review	1.1-1.6		
2	2:10	5/23/22	Mon - 1	Michelson-Morley exp, Einstein's postulates, Lorentz transformation	2.1-2.4		
	1:00	**5/24/22**	**Tue - 1**	**Problem Solving and Discussion**			
3	1:00	5/25/22	Wed - 1	Time dilation, length contraction, simultaneity	2.5		
4	2:10	5/25/22	Wed - 1	Addition of velocities, muon decay, twin paradox	2.6-2.8		
	1:00	**5/26/22**	**Thu – 1**	**Discussion and Quiz 1**		**Quiz 1**	
5	1:00	5/27/22	Fri - 1	Spacetime diagrams, invariants , relativistic Doppler Effect	2.9-2.10		
6	2:10	5/27/22	Fri - 1	Relativistic momentum and conservation of momentum	2.11-2.12		**HW01**
		5/30/22	Mon	**Memorial Day No Classes**			
	1:00	**5/31/22**	**Tue - 2**	**Solving and Discussion Problem**			
7	1:00	6/1/22	Wed - 2	Relativistic energy and the conservation of mass-energy	2.11 -2.12		
8	2:10	6/1/22	Wed - 2	Computations and binding energy	2.13		**HW02**
	1:00	**6/2/22**	**Thu - 2**	**Discussion and Quiz 2**		**Quiz 2**	
9	1:00	6/3/22	Fri - 2	X-rays, electron charge, line spectra, and quantization	3.1-3.4		
10	2:10	6/3/22	F- 2ri	Blackbody radiation, photoelectric effect	3.4-3.7		
11	1:00	6/6//22	Mon - 3	Compton Effect, pair production, pair annihilation	3.8-3.9		
12	2:10	6/6/22	Mon - 3	Models of the atom, Rutherford scattering	4.1-4.3		**HW03**
	1:00	**6/7/22**	**Tue - 3**	**Problem Solving and Discussion**			
13	1:00	6/8/22	Wed - 3	The Bohr model of the hydrogen atom, correspondence principle	4.3-4.5		
14	2:10	6/8/22	Wed - 3	Successes/failures, x-ray spectra, bremsstrahlung radiation, atomic	4.6-4.7		
	1:00	**6/9/22**	**Thu - 3**	**Discussion and Quiz 3**		**Quiz 3**	
15	1:00	6/10/22	Fri - 3	X-ray scattering, de Broglie waves, electron scattering: Quantum I	5.1-5.3		**HW04**
16	2:10	6/10/22	Fri - 3	Wave Motion, Waves or Particles: Quantum I	5.4-5.5		
17	1:00	6/13/22	Mon - 4	Uncertainty Principle Copenhagen, wave functions, particle in a box	5.6-5.8		
18	2:10	6/13/22	Mon - 4	Schrodinger equation, expectation values, and infinite square well	6.1-6.3		
	1:00	**6/14/22**	**Tue - 4**	**Problem Solving and Discussion**			
19	1:00	6/15/22	Wed - 4	Finite square well	6.4		
20	2:10	6/15/22	Wed - 4	2D infinite sq well potential and simple harmonic oscillator	6.5-6.6		**HW05**
	1:00	**6/16/22**	**Thu - 4**	**Midterm Exam on Zoom with unmuted video**		**Midterm**	
21	1:00	6/17/22	Fri - 4	Barriers and tunneling	6.7		
22	2:10	6/17/22	Fri - 4	Application/solution of the Schrodinger equation for hydrogen	7.1-7.2		
23	1:00	6/20/22	Mon - 5	Quantum numbers, magnetic effects, normal Zeeman effect	7.3-7.4		
24	2:10	6/20/22	Mon - 5	Intrinsic spin, energy levels, selection rules	7.5-7.6		**HW06**
	1:00	**6/21/22**	**Tue - 5**	**Problem Solving and Discussion**			
25	1:00	6/22/22	Wed - 5	Atomic structure, Pauli exclusion principle, periodic table	8.1		
26	2:10	6/22/22	Wed - 5	Total angular momentum and the anomalous Zeeman effect	8.2-8.3		
	1:00	**6/23/22**	**Thu - 5**	**Discussion and Quiz 4**		**Quiz 4**	**HW07**
27	1:00	6/24/22	Fri - 5	Maxwell's velocity distribution and equipartition theorem	9.1-9.3		
28	2:10	6/24/22	Fri - 5	Maxwell's speed distribution and classical and quantum statistics	9.4-9.5		
29	**1:00**	**6/25/22**	**Sat - 5**	**Molecular bonding and spectra**	10.1-10.2		
30	**2:10**	**6/25/22**	**Sat - 5**	**The neutron and nuclear properties**	12.1-12.2		
31	1:00	6/27/22	Mon - 6	Nuclear forces, nuclear stability, nuclear models	12.3-12.5		
32	2:10	6/27/22	Mon - 6	Nuclear models and radioactive decay	12.5 -12.6		
	1:00	**6/28/22**	**Tue - 6**	**Problem Solving and Discussion**			**HW08**
33	1:00	6/29/22	Wed- 6	Alpha, Beta, and Gamma decay	12.7		
34	2:10	6/29/22	Wed - 6	Naturally nuclides, dating and nuclear reactions	12.8,13.1-13.3		
	1:00	**6/3022**	**Thu - 6**	**Discussion and Quiz 5**		**Quiz 5**	
35	1:00	7/01/22	Fri - 6	Fission and fusion and nuclear physics applications	13.4-13.7		
36	2:10	701/22	Fri- 6	Particle physics, standard model, and fundamental interactions	14.1-14.3		**HW09**
		7/4/22	**Mon -7**	**Independence Day - No Classes**			
	1:00	**7/5/22**	**Tue - 7**	**Problem Solving, Discussion, and Quiz 6**		**Quiz 6**	
37	1:00	7/06/22	Wed- 7	Conservation Laws, quarks, and generations of matter	14.4-14.6		
38	2:10	7/6/22	Wed- 7	Stellar evolution, dark matter, and tenets of general relativity	15.1-15.3		**HW10**
39	1:00	7/7/22	Thu - 7	Test of general relativity, black holes, and gravitational waves	15.4-15.6		
40	2:10	7/7/22	Thu - 7	Review	Ch 2 - Ch 15		
	2:00	**7/8/22**	**Fri - 7**	**Final Exam 2:00 – 5:00 pm**	**Final Exam**	**Final Exam**	**Final Exam**