Foundations of Physics III

Fall 2019; 10:20 A.M. MWF Physics 211 PEngel 167

Instructor:

Name: Dr. Tom Kirkman
Office: PEngel 132/6 Phone: 363–3811 email: tkirkman@csbsju.edu
Office Hours: by appointment Drop-by Informal Office Hours: 7:30 A.M. – 5:30 P.M.

Required Texts:

- *University Physics*
  by Hugh D. Young, Roger A. Freedman (Pearson, 14th edition, 2016)
  Chapters: 12, 14–16, (17, 18), 33–36
- *Six Ideas That Shaped Physics: Unit T — Some Processes are Irreversible*
  by Thomas A Moore (McGraw-Hill, 2017 3nd edition)
  Chapters: T1–T10
- `http://www.physics.csbsju.edu/211/`

Grading:

Your grade will be determined by averaging six scores: total homework score, three exam scores, and the final exam score (which is double-counted). Assigned homework is due at the beginning of the next class period. Late homework is discouraged but often accepted. You may use a single-sided $8\frac{1}{2}$" $\times$ 11" "formula sheet" to assist you on the exams. The formula sheet should be limited to formulas and definitions—no worked examples. Exam dates are: September 18 (Wednesday), October 23 (Wednesday), and December 6 (Friday). If informed in advance, I may be able to accommodate exam conflicts. The final exam will be comprehensive and have a structure similar to the other exams, but proportionally longer. The final exam has been scheduled for 1:00 P.M. Thursday, December 12.

Lab:

You should probably also be registered for PHYS 332: Intermediate Lab, although that is an entirely separate course, with no direct connection to this course.

Questions:

There is no such thing as a dumb question. Questions during lecture do not "interrupt" the lecture, rather they indicate your interests or misunderstandings. I'd much rather clear up a misunderstanding or discuss a topic of interest than continue a dull lecture.

Remember: you are almost never alone in your interests, your misunderstandings, or your problems. Please help your classmates by asking any question vaguely related to physics. If you don't want to ask your question during class, that's fine too: I can be found almost any time in my office (PEngel 132/6) or the nearby labs. Drop in any time!

Topics:

Catalog: Thermodynamics and waves. Kinetic theory and the laws of thermodynamics are developed from a mechanical point of view. Temperature, entropy and heat engines. Wave phenomena (sound and light) are developed from a unified point of view. Geometrical optics. Prerequisites: 200, concurrent registration in MATH 239. Fall.

This course covers the two remaining sections of classical physics: waves and thermodynamics. Both topics are closely connected to quantum mechanics and hence "modern physics". Quantum mechanics involves the discovery that the objects we called particles in 191 act (in part) like waves and historically thermodynamics provided the first evidence for "quantum" behavior. Both of these topics are also closely connected to practical devices: telescopes, microscopes, refrigerators and engines of all sorts.

As always a big part of physics is mathematics. In 191 differential equations ($F = m\frac{d^2x}{dt^2}$) played the central role. In 200 integral equations (like Gauss's law and Ampere's law) were central. In this course, you'll find complex numbers provide the simplest way to describe waves and vector spaces (which you'll be learning about in Linear Algebra) will be applied to find Fourier series. Additionally we'll use some simple combinatorics to describe the statistical mechanics which underlies thermodynamics.

You will have noticed that our usual textbook (UP) is being augmented this semester with Unit T from *Six Ideas that Shaped Physics* (Moore). Unit T is the sixth idea in Moore's sequence, and so it relies a bit on material you will cover next semester: quantum mechanics. As a result you'll have to take on faith a main result of quantum mechanics: that, for example, a particle's possible energy — instead of being continuous — must fall in a countable set of possible values ('states'). While we could derive many of the needed results assuming continuous energy possibilities (i.e., in the classical approximation), the discrete list of states we'll be using is both more accurate and easier (once you get used to these odd quantum ideas). The singularly important result we gain from using Moore is the Boltzmann Factor:

$$\text{Probability} \propto e^{-E/k_B T}$$

This result is needed on page one of most any branch of modern physics.

Using two books has the disadvantage of mixing two notations and writing styles. I think you'll enjoy Moore's writing style; instead reading like an encyclopedia, he clearly is enthusiastic about how these big ideas shaped physics and the world. Usually living with two notations amounts to learning to "equivalence" different letters that are used to represent the same quantity. For example, after a quick check of the books on my shelf I found the following notations used for torque: τ, N, M (from moment), Q, and T. However UP and Moore have a more serious disagreement: the same letter is used to represent opposite quantities! UP writes the first law of thermodynamics as:

$$\Delta U = Q - W \tag{19.4}$$

whereas Moore writes this same law as

$$\Delta U = Q + W \tag{T1.1}$$

that is Moore and UP define the work W oppositely. We will follow Moore in class (and in homework and exams!), but you should know that most of the world uses the historical (but odd) definition of *work* found in UP.

Schedule

Class		Date	UP	Topics	6 Ideas
1	M	Aug 26	12.1–3	pressure, buoyancy	
2	W	Aug 28	12.4–6	continuity, Bernoulli	
3	F	Aug 30	14.7–8	SHM made complex	
4	M	Sep 2	15.1–3	waves	
5	W	Sep 4	15.4–6	speed & superposition	
6	F	Sep 6	15.7–8	standing waves	
7	M	Sep 9	16.1–3	sound, dB	
8	W	Sep 11	16.4–7	pipes, interference, beats	
9	F	Sep 13	16.8–9	Doppler, Mach	
10	M	Sep 16		Fourier superposition	
11	W	Sep 18	12,14–16	**Exam I: fluids & waves**	
12	F	Sep 20	33.1–3	index of refraction, Snell	
13	M	Sep 23	33.4–7	dispersion, polarization, Huygens	
14	W	Sep 25	34.1–2	mirrors	
15	F	Sep 27	34.3–4	lenses	
Free Days: Monday, Tuesday					
16	W	Oct 2	34.5–8	optical instruments	
17	F	Oct 4	34	more geometrical optics	
18	M	Oct 7	35.1–2	interference, 2-slits	
19	W	Oct 9	35.3–4	phase & intensity; thin films	
20	F	Oct 11	35.4–5	Michelson	
21	M	Oct 14	36.1–2	diffraction: edge & single slit	
22	W	Oct 16	36.3–5	intensity: N slits	
23	F	Oct 18	36.6–8	circular apertures, Bragg	
24	M	Oct 21	36	more wave optics	
25	W	Oct 23	33–36	**Exam II: optics**	
26	F	Oct 25	17.5–6	$Q = mc\Delta T$	
27	M	Oct 28	17.4 & 7	thermal expansion, transfer	
28	W	Oct 30		thermal energy	T1
29	F	Nov 1		macrostates & microstates	T2
30	M	Nov 4		thermal contact, irreversibility	T3
31	W	Nov 6		entropy & temperature	T3
32	F	Nov 8		Boltzmann & partition function	T4
33	M	Nov 11	18.3	KE molecular theory	T5
34	W	Nov 13		diatomic gases, equipartition	T5
35	F	Nov 15		Maxwell-Boltzmann	T6
36	M	Nov 18		photon gas, blackbody	T6
37	W	Nov 20		adiabatic & other paths	T7
38	F	Nov 22		ΔS	T8
39	M	Nov 25		heat engines	T9
Thanksgiving Break: Wednesday–Friday					
40	M	Dec 2		refrigerators, Carnot	T9
41	W	Dec 4		climate change	T10
42	F	Dec 6		**Exam III: thermal physics**	
43	M	Dec 9		Review	
	R	Dec 12	ALL	**Final Exam** (1:00 P.M.)	ALL

Links to Institutional Policies:

- Course Attendance policy
  `www.csbsju.edu/academics/catalog/academic-policies-and-regulations/courses/class-attendance`
- Statement on accommodations for students with disabilities
  `www.csbsju.edu/student-accessibility-services/information-for-faculty/syllabus-statement`
- Academic Misconduct and Plagiarism
  `www.csbsju.edu/academics/catalog/academic-policies-and-regulations/rights/academic-misconduct`
- Sexual Misconduct
  `www.csbsju.edu/human-rights/sexual-misconduct/sexual-misconduct-policy`
- Title IX policy
  `www.csbsju.edu/joint-student-development/title-ix`