Life Science Physics I

Spring 2021 Block A | Physics 105 | PEngel 173

Instructor:

Name: Dr. Tom Kirkman `tkirkman@csbsju.edu`
Office: PEngel 136/132 Phone: 363–3811
Drop-by Informal Office Hours: 7:30 A.M.–5:30 P.M.

Texts:

- *College Physics* by OpenStax College Chapters: 1–16
- *Laboratory Manual for Life Science Physics I*
- `http://www.physics.csbsju.edu/105/`

Grading:

Your grade will be determined by averaging six scores: overall homework score, lab score, two exam scores, and the final exam score (which is double-counted). Homework should be completed (`WebAssign`) by midnight on the following class day. Homework questions answered after the class deadline are assessed a 15% penalty; request online an automatic "extension" to submit late homework. Note: the messaging feature within WebAssign does not actually reach me; use email for asynchronous contact. The exams include both multiple choice and numerical problems (see the online examples). You may use an unannotated 'Course Guide' to assist you on the exams. Exam dates are: February 1 (Monday), February 9 (Tuesday), and February 18 (Thursday).

Lab:

You must be registered in one of the lab sections required for this course. Labs meet in the afternoon. Time in lab is limited so prepare for each lab by reading the lab manual *before* lab. Pre-lab exercises (on Canvas) must be turned in one hour before the beginning of lab. Your completed electronic lab report must be turned in at the end of the lab. Read the INTRODUCTION to the Laboratory Manual ASAP. Note that the first lab is entirely online.

Good lab skills are the key to success in science. Almost certainly your first job in science will not resemble an exam: with lots of pencil pushing on made-up problems; rather it will most resemble lab: where you use equipment to collect data on real—less than perfect—objects.

Advice:

- In this COVID year, a day in class corresponds to a week or more of the semester class. I fear that this pace will be impossible to sustain unless you aggressively read each day's text assignment before lecture. Again: 'lecture' will largely be devoted to working problems rather than an expository re-hash of the textbook, so if you haven't wrestled with the material before class, the class 'lecture' may be meaningless to you.
- Particularly this year much of the learning has to occur outside of class, so you must be brave enough to **ask questions** when things don't seem to make sense. I want to particularly encourage you to ask questions **during class**, as others undoubtedly share your questions. You can, of course, also ask questions privately by arraigning a zoom or by stopping by my office.
- In addition to the textbook and your instructor, other on-campus aids are available: tutors and the Math Skills Center. On-line resources like he Khan Academy have also proven useful.
- For more than a century science students have struggled in physics classes. Much good advice has been written on how to adjust your study style for the more math-heavy sciences like physics. I've collect lots that good advice on the class web site.
- Cheating during COVID-related on-line learning has frequently been in the news. It's pretty easy to think of ways around the rules I'll enforce. The strongest deterrent is your personal integrity and the understanding that failure to learn today will have consequences in the future. (Hollywood seems to have an animus against mathematics. In several time-travel movies the star tells her high school math teacher, e.g., *Peggy Sue Got Married*, 'I happen to know that in the future I will have no use for algebra'. If you don't already know that that's false, you will after this course.) Empirical studies show that, on average

at least, cheating hurts you. Check out the video by Professor McKay (at `umich.edu`) reporting on some of this work. Do note that, during an exam, both giving aid and taking unauthorized aid are academic violations. (On the other hand, I do encourage collaboration on homework and labs.)

Catalog Course Description

An introduction to mechanics and thermodynamics emphasizing applications to biological systems. Topics include Newton's laws of motion, equilibrium, torques, forces, conservation principles, work, energy, power, rotating systems, oscillations, temperature, heat transfer, laws of thermodynamics, fluid statics and dynamics. Intended for non-majors. Algebra and trigonometry are needed. Recommended: MATH 115 or equivalent high school mathematics.

MCAT Topical Coverage

MCAT Topics	Content Category
Translational Motion	4A
Force	4A
Equilibrium	4A
Work	4A
Energy	4A
Periodic motion	4A
Fluids	4B
Gas phase	4B
Thermodynamics	5E

Student learning outcomes

After successful completion of this course, students will be able to

- solve numerical problems involving motion, fluids, and thermodynamics;
- understand the basic physical concepts of motion, fluids, and thermodynamics;
- analyze and interpret data from simple physics experiments.

The 'Course Guide' is a detailed list of learning outcomes.

Topics:

This course covers the discoveries of Isaac Newton (1642–1727) and the founders of thermodynamics (e.g., Sadi Carnot (1796–1832), James Joule (1818–1889), William Thomson, 1st Baron Kelvin, (1824–1907), James Clerk Maxwell (1831–1879), Willard Gibbs (1839–1903), and Ludwig Boltzmann (1844–1906)) which are the foundation of the science and technology that transformed the animal powered world of Newton into the mechanized world of today.

To quote the Soviet mathematician V.I. Arnold (1937–2010): "Newton's fundamental discovery, the one which he considered necessary to keep secret and published only in the form of an anagram, consists of the following: *Data aequatione quotcumque fluentes quantitae involvente fluationes invenire et vice versa*. In contemporary mathematical language, this means: It is useful to solve differential equations."

This course will focus on applying Newton's laws of motion to three situations: (A) motion with a constant applied force, (B) motion in a circle at constant speed, and (C) oscillatory motion. Clearly these three situations are a small subset of real life motions. Please realize that Newton's laws explain all motions, but we need additional mathematical tools to apply them to more complicated situations.

While differential equations are inherently about change, quantities that are *conserved* (constant) even as the common-sense quantities associated with the motion vary provide simple ways of understanding motions. In this course we will use the conservation of (A) energy, (B) linear momentum, and (C) angular momentum. (An analogy: when a log burns initially we have wood and oxygen and finally we have hot gases and ash. Everything seems changed. But there is a great unifying principle behind this apparent change: the number of carbon atoms stayed the same during the reaction.)

Of thermodynamics V.I. Arnold wrote: "Every mathematician knows it is impossible to understand an elementary course in thermodynamics."

On a more hopeful note, Einstein wrote: "A theory is the more impressive the greater the simplicity of its premises, the more different kinds of things it relates, and the more extended its area of applicability. Therefore the deep impression that classical thermodynamics made upon me. It is the only physical theory of universal content which I am convinced will never be overthrown"