To atoms and beyond!

Physics 211
Syracuse University, Physics 211 Spring 2021
Walter Freeman

May 13, 2021

Announcements

Extra office hours and reviews ahead of the exam, held on the class Zoom or in Physics Building basement room B126

- Friday, 8:45 AM - 10:45 AM
- Next Monday, 9AM - 1PM
- Next Tuesday, 9AM - 1PM

Homework 10 is short and posted now; it is due Sunday end of day.

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The paper:

- Due at the latest May 21 (no extensions past this)
- Earlier submissions will get a little extra credit
- We are not picky about title, format, etc. – whatever you do, do it well

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There are two times when people will be able to take the exam: May 19 (Wednesday) 8AM-10AM and May 20 (Thursday) 3PM-5PM. If you need a time different from these for an exceptional emergency, please let me know well in advance; we may be able to accommodate this.

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I have gotten some emails about things like this and will hopefully catch up tonight.

Resonance

We've learned that a cavity – like a violin string or organ pipe – can contain *normal modes of vibration*, with specific frequencies.

Let's set stuff on fire again and explore this...

The power of mechanics

The things we've studied in this class are more powerful than you think.
If you call up a chemist, she'll tell you the approximate force law between two noble gas atoms:

$$F(r) = \frac{\alpha}{r^{12}} - \frac{\beta}{r^6}$$

Put this into a computer and let it go:

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Put this into a computer and let it go:

We can understand freezing, melting, and boiling just with $\vec{F} = m\vec{a}$!
... we can even get the ideal gas law for free along the way!

The rest of physics

The other disciplines of physics are variants on what you've learned already:

- Electromagnetism (PHY 212) introduces a new force – just another $\vec{F}$
- All you'll do in that class is apply the work-energy theorem and so on to this new force
  - Light is just a particular manifestation of that force
- Statistical mechanics uses statistics to understand $\vec{F} = m\vec{a}$ acting on a great many particles at once
- Relativity mixes up space and time, changing the coordinates on us
- Quantum mechanics mixes up "particle" and "wave"

Each of these disciplines is supported by a "three-legged stool":

- Theory: understanding principles and using pen and paper to study them in simple situations (this class)
- Experiment: designing tests for these principles and building machines to carry them out (221)
- Computation: using computers to simulate those principles in more complicated situations and study their consequences (my field and class in the fall)

Two invitations

Like what you've done here? We have multiple options for you to study more physics!

You could get a physics minor. This involves:

- Physics 211 (you have this now!)
- Physics 212 (you will probably take this next semester!)
- Four more classes at the 300 level of your choice. For instance:
  - Biophysics: the physics of living things – how do cells do what they do?
  - Cosmology: the history and future of the Universe!
  - Astrophysics
  - Computational physics (my class in the fall – all of you are qualified!)
  - Modern physics (quantum mechanics, relativity, atoms)
  - Waves and vibrations: light and sound
  - Advanced laboratory
  - ... and others I'm forgetting!

Two invitations

... or maybe you want to be a physics major! (Come to the dark side – we have both cookies and the cheat-codes to the Universe!)

Bachelor of Arts

This degree program prepares you for jobs in industry, and is also a great double major option with engineering, computer science, education, and all sorts of things:

- Physics 211/212
- 300-level class on modern physics (quantum mechanics, relativity, atoms – the good stuff!)
- 300-level lab class
- 5 more elective classes (astrophysics, computational physics, biophysics, cosmology... lots of stuff)
- 30 physics credits total (you have four, plus four if you took AST101)

Bachelor of Science

This degree program prepares you for the most technically demanding industry jobs, as well as graduate study in physics or related fields.
It is also a good double major option for other STEM fields, in particular engineering (there are overlaps in the required classes)

- Physics 211/212
- 300-level class on modern physics (quantum mechanics, relativity, atoms – the good stuff!)
- 300-level lab class
- Rigorous courses in computational physics, electromagnetism, quantum mechanics, thermodynamics, and others
- 39 physics credits total (you have four now!)

Two invitations

If you've done reasonably well in this course, and have strong communication skills, Physics 211 wants to offer you a job!

We're always looking for good people to work for us as coaches in future years. Want to help next year's class, have fun, earn some money, and get a job that looks great on your resume?

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Come talk to us!

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"All science is either physics or stamp collecting." (E. Rutherford)

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"Poets say science takes away from the beauty of the stars – mere globs of gas atoms. Nothing is "mere". I too can see the stars on a desert night, and feel them. But do I see less or more? The vastness of the heavens stretches my imagination – stuck on this carousel my little eye can catch one-million-year-old light. A vast pattern – of which I am a part... What is the pattern, or the meaning, or the why? It does not do harm to the mystery to know a little about it. For far more marvelous is the truth than any artists of the past imagined!"

–Richard Feynman, from *Lectures on Physics*

Thanks for a wonderful semester!