

Review and recap

Physics 211
Syracuse University, Physics 211 Spring 2017
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May 1, 2017

- Extra office hours and reviews ahead of the exam:
 - Today, 5-7, Physics Clinic
 - Wednesday, 10-4, Physics Clinic (with a break for lunch)
 - Thursday, 10-3:45, Physics Clinic (with a break for lunch)
 - Possibly Friday (will be announced by email)
 - Sunday, 7-9 PM, Stolkin Auditorium
- Come see me about exam corrections (if you had an excused absence last week) or anything else

- More questions, but less time-consuming
- Expect questions like:
 - “What concept could you use to solve this problem?”
 - “Write but do not solve a system of two equations that will let you find a and T ”
 - “Which of these equations would be useful here?”
- You may make **your own reference sheets**
- Two sides of a standard piece of paper, **handwritten**

Kinematics concepts

- First derivative of position is velocity; second derivative is acceleration
- Kinematics lets us connect acceleration, velocity, position, and time
- If \vec{a} is constant:

$$s(t) = s_0 + v_0 t + \frac{1}{2} a t^2$$

$$v(t) = v_0 + a t$$

$$v_f^2 - v_0^2 = 2a\Delta x$$

- These relations hold separately and independently in x and y
- Acceleration is g downwards **if and only if** an object is in freefall

Kinematics sample problem: the ball-and-table problem

A ball rolls off of a table of height h at speed v . How far does it go?

Use kinematics when:

- You need to connect some combination of position, velocity, acceleration, and time

Force concepts and Newton's second law

- Newton's second law relates the net force $\sum \vec{F}$ to the acceleration \vec{a} of the center of mass of an object
- If an object both rotates and moves, $\vec{F} = m\vec{a}$ gives you \vec{a} of the center of mass
- Newton's third law: forces come in pairs
- Some forces you should know about:
 - Normal forces: as big as they need to be
 - Friction: $F_{\text{fric,static,max}} = \mu_s F_N$, $F_{\text{fric,kinetic}} = \mu_k F_N$
 - Traction: a type of static friction, points in direction chosen by the vehicle
 - Elastic: $F = -k\Delta x$
 - Gravity (Earth): $F = mg$ downward
 - Gravity (general): $F = \frac{Gm_1m_2}{r^2}$
 - Tension: A rope pulls on both ends

- Draw all forces acting on the object, as vectors
- If you're going to care about torque, draw them where they act
- Gravity acts at the center of mass
- Draw these diagrams big enough that you can read them clearly and do trig

- If an object is traveling in a circle, you know its acceleration is $a_c = \omega^2 r = \frac{v_T^2}{r}$ toward the center
- Often this will “give you” the right side of $F = ma$, and let you conclude something about the left

Use Newton's second law when:

- You need to connect the forces on an object to its acceleration
- If you don't need \vec{a} directly, and don't care about time, maybe use energy methods instead?

Sample problem: the eraser in the tube

What angular frequency is required to make the eraser not fall?

The work-energy theorem and conservation of energy

- Work-energy theorem comes from the third kinematics relation
- Two formulations, one with potential energy and one without:
 - $KE_i + W_{\text{all}} = KE_f$
 - $KE_i + PE_i + W_{\text{other}} = KE_f + PE_f$
- Draw *clear* before and after snapshots
- Figure out work done in going from one to the other
- Work = $\vec{F} \cdot d\vec{s}$

Use energy methods when:

- You don't know and don't care about time
- You can account for the work done by all forces involved
- This is **not** true at the instant of a collision – use momentum instead

Sample problem: energy

A ball rolls down a hill of height h and across a table. How fast is it moving at the edge of the table?

Conservation of momentum

- In the absence of external forces, $\vec{p} = m\vec{v}$ is conserved
- This is a consequence of Newton's third law
- Collisions and explosions are short enough that external forces are small
- Momentum is a vector and is conserved separately in x and y

Use conservation of momentum when:

- You have a collision or explosion and need to connect the velocities before to the velocities after

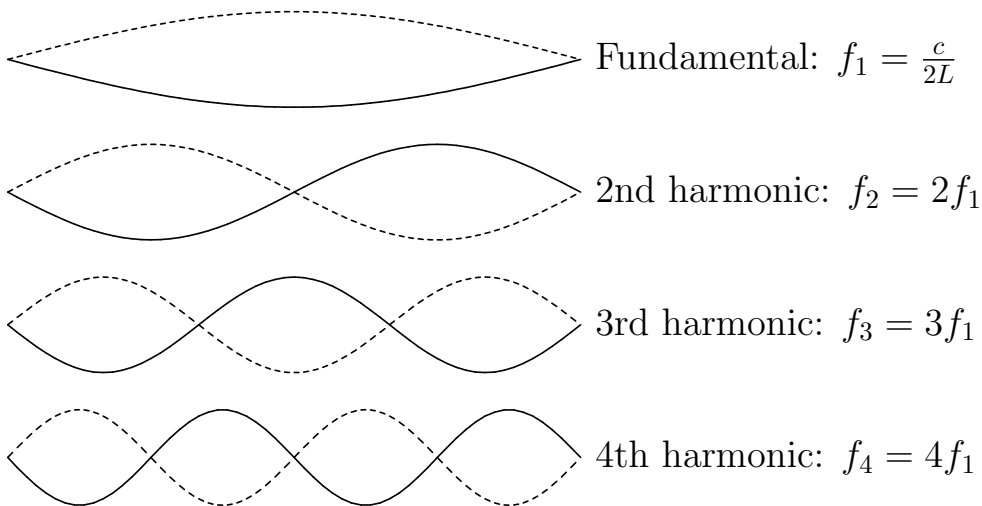
Many ideas here, most analogous to translational motion:

- Torque plays the role of force: $\tau = F_{\perp}r = Fr_{\perp}$
- Moment of inertia plays the role of mass: $I = \lambda mr^2$
- $\vec{F} = m\vec{a} \rightarrow \tau = I\alpha$: “Newton’s second law for rotation”
- Rolling motion is translation plus rotation: $v = \pm\omega r$, $a = \pm\alpha r$
- **You must think about the signs here**
- Rotational kinetic energy: $KE_{\text{rot}} = \frac{1}{2}I\omega^2$
- Angular momentum: $L = I\omega$

Static equilibrium problems

- Net torque is zero about any pivot
- Net force is zero (you may not need this)
- Torque due to any force applied **at** the pivot is zero

Standing waves in strings/tubes:



The relation between wavespeed, wavelength, and frequency:

$$c = f\lambda$$

Final reminders

- Huge amounts of extra review available; use it
- Get some rest during finals week and take care of yourselves
- If you're affected by the Calc/Physics exam scheduling nonsense, tell SU!

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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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 211) introduces a new force – just another \vec{F}
 - 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)

And, finally...

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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*