Final course review

Physics 211
Syracuse University, Physics 211 Spring 2015
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April 28, 2015

Announcements

- No recitation tomorrow due to my review
- Turn in your homework/extra credit in your TA's mailbox
- Final review schedule:
  - TODAY, 2-5, Sims 337
  - Wednesday, 10-4, Physics 208
  - Thursday, 9-3, Physics 202
  - Weekend TBA?

Final exam format

- 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**
- One standard sheet of paper, double-sided, **handwritten**

First, a pitch

Want to get paid to be a Physics 211 coach next year?

Like to teach your peers?

Earned at least a B+ in this course, or a B with my recommendation?

Prof. Lisa Manning is teaching a class on peer coaching next fall
Ask either of us for details, or see the flyer on the course website

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:

$$
\begin{aligned}
s(t) =& s_0 + v_0 t + \frac{1}{2} a t^2 \\
v(t) =& v_0 + at \\
v_f^2 - v_0^2 =& 2a\Delta x
\end{aligned}
$$

- 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 frog-and-table problem

A frog jumps horizontally off of a table of height h and lands a horizontal distance d away. What was its initial speed?

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: $F_{\text{fric,static,max}} = \mu_s F_N$, $F_{\text{fric,kinetic}} = \mu_k F_N$
  - Elastic: $F = -k\Delta x$
  - Gravity (Earth): $F = mg$ downward
  - Gravity (general): $F = \frac{Gm_1 m_2}{r^2}$
  - Tension: A rope pulls on both ends

Force diagrams

- 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

Uniform circular motion

- 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: forces

A book rests on a slope at angle θ. What coefficient of static friction is required to make it stick?

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 pendulum of length L is drawn back to an angle θ and released. How fast is it going when it reaches the bottom?

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

Sample problem: momentum

The hobbits-on-Onondaga problem from Exam 3:

Merry and Pippin are sledding on the frozen surface of Lake Onondaga, which is quite close to a frictionless surface. Each of them plus his sled has a mass of 30 kg, but Merry also carries a stone that weighs 5 kg. They are both traveling east at 2 m/s, right next to each other; Merry is north of Pippin. Merry throws his stone to Pippin, who catches it; the initial velocity of the stone is 5 m/s due south. Treat north as the positive $y-$axis and east as the positive $x-$axis.

Use conservation of momentum when:

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

Rotation

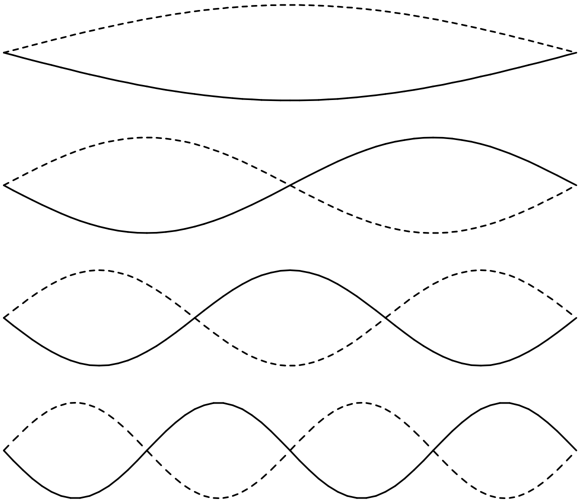
Many ideas here, most analogous to translational motion:

- Torque plays the role of force: $\tau = F_\perp r = F r_\perp$
- Moment of inertia plays the role of mass: $I = \lambda m r^2$
- $\vec{F} = m\vec{a} \to \tau = I\alpha$: "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:



Fundamental: $f_1 = \frac{c}{2L}$

2nd harmonic: $f_2 = 2f_1$

3rd harmonic: $f_3 = 3f_1$

4th harmonic: $f_4 = 4f_1$

Final reminders

- Huge amounts of extra review available (20-ish hours); use it
- Get some rest during finals week and take care of yourselves
- Practice exam solution sets will be posted after the extra credit is in
- If you're affected by the Calc 2/Physics exam scheduling nonsense, tell SU!

Beyond mechanics

What else is there in physics?

- Electrodynamics: electricity, magnetism, light
- Thermodynamics: heat, pressure, gases, temperature, phase changes
- Condensed matter: crystals, the structure of matter
- Quantum mechanics: atoms, very small things, chemistry
- Astrophysics and cosmology: what is the Universe and where is it going?
- Biophysics

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- Biophysics
- Computational physics (my course for Fall 2015)

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