Exam 2 Review

Physics 211
Syracuse University, Physics 211 Spring 2019
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Exam details

- 3 full-length questions; a few short-answer questions; a paragraph-length answer regarding the process of science
- You may bring notes: one side of a page, handwritten by yourself

Extra exam preparation

- Practice exam solutions posted
- Office hours today: 3-5 PM (Physics Clinic)
- Recitation tomorrow: **come prepared with questions**.
  - TA's will do a review in whatever format is best for you
  - They'd rather talk about what you want than anything they've prepared

Review: overview

- Newton's second law: $\sum \vec{F} = m\vec{a}$
  - Forces (left hand side) cause accelerations (right hand side)
  - Acceleration is not a force; it *results* from forces

- Newton's third law: Forces come in pairs. If A pushes on B, B pushes back on A with the same magnitude in the opposite direction.

- Forces are things you can feel:
  - Normal forces: one thing pushes on another
  - Gravity
  - Tension: a rope pulls on something
  - Friction: opposes things sliding
  - Acceleration is not a force: forces *cause* acceleration
  - "Centripetal force" is not a separate force: it describes one of the above

A few things about these forces: gravity

- On Earth: always acts downward with $F_g = mg$
- The acceleration of an object is *only* g if there are no other forces

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- This is only true on Earth. Elsewhere: all objects attract each other

$$F_g = \frac{Gm_1 m_2}{r^2}$$

- m_1 and m_2 are the masses of the two objects; r is the distance between their centers.
- $G = 6.67 \times 10^{-11} \mathrm{N} \cdot \mathrm{m}^2/\mathrm{kg}^2$
- This distance is measured between their centers (for planets)
- On Earth: $F_g = m_1 g = \frac{GM_e m_1}{r_e^2}$, so $g = \frac{GM_e}{r_e^2}$

A few things about these forces: tension

- Just the force exerted by a rope
- Always goes in the direction of the rope, and is the same throughout
- Can only pull; can never push
- Force is the same on both ends (Newton's 3rd law)
- **Tension is almost always something you will need to solve for, not something you know ahead of time**

A few things about these forces: normal forces

- Stops two things from moving through each other
- Always directed normal (perpendicular) to a surface
- Magnitude is as large as it needs to be to stop objects from "crossing" ($a_\perp = 0$)
- Newton's third law: if A pushes on B, B pushes back on A (the book problem)
- Can only push; can never pull (the frog-in-bucket problem)
- "Apparent weight": the normal force exerted by whatever you are standing on
- **Normal force is almost always something you will need to solve for, not something you know ahead of time**
  - $F_N = mg$ only if you're standing on a level surface and there are no other vertical forces: $F_N - mg = ma_y = 0$
  - That is often not true!

A few things about these forces: friction

Friction depends on a property of the surfaces called the coefficient of friction μ

- Roughly: "how sticky things are".
- Force of kinetic friction $= \mu_k F_N$
- Max force of static friction $= \mu_s F_N$
- Friction points in whichever direction opposes the tendency to slide
- Static friction *can* make objects move (cars, people walking)

Rotational motion

- "Uniform circular motion": object steadily moving in a circle
- Angular velocity: how fast does the thing turn? (RPM's, degrees per second, **radians per second**)
- Constant speed does *not* mean constant velocity or zero acceleration!

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- "How many force problems and how many circular motion problems will we have?"
- They're the same: circular motion just tells you that $a = \omega^2 r$. You do these problems in *exactly the same way.*

Rotational motion

- A rotating object has an *angular velocity* – how fast it's turning, measured in radians per second
- The tangential speed of a point on the object is given by $v_T = \omega r$
- The angular velocity is related to the time it takes to rotate by $\tau = \frac{2\pi}{\omega}$

If an object is traveling in a circle, you immediately know that its acceleration is $\omega^2 r$ or v^2/r toward the center.

Problem solving strategies (the important thing!)

- 1. Force diagrams ("Accounting")
  - Draw all forces and only forces (things you can feel)
  - Choose a pair of axes (tilted axes are sometimes helpful, like for things on ramps)
  - Break forces into components along these axes, if needed

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- 2. Newton's laws ("Physics")
  - Write down $\sum F = ma$ for each object in each direction. You can read this off your diagram. For instance:

$$\begin{aligned} T_1 \cos\theta - T_2 &= ma_x \\ T_1 \sin\theta - mg &= ma_y \end{aligned}$$

  - Forces (real things) go on the left side; acceleration goes on the right
  - Put in things you know about the acceleration
  - Different objects : different acceleration variables (are they related?)
    - Sometimes $a = 0$
    - Circular motion: $a_r = \omega^2 r = \frac{v^2}{r}$ toward the center

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- 3. Algebra ("Math")
  - Put in the stuff you have, solve for the stuff you need
  - Need at least as many equations as unknowns
  - "Systems of equations": solve by substitution

Properties of science

Science – as a means of seeking truth about nature – has a few fundamental properties:

- **Empiricism:** the ultimate authority is what we measure about the world around us, not what we think is true
- **Self-skepticism:** someone making a scientific claim should actively search for things that might prove themselves wrong
- **Universality:** the laws of nature apply in all places and times, and to all things (including humans)
- **Objectivity:** scientific ideas, or the evaluation of them, should be independent of any particular human perspective

Principles that come from these:

A model is only valid within the realm of data against which it has been checked.

- Precision: is the law of gravity valid to one part in a billion? One part in a trillion?

- Scope and scale: Is Newtonian mechanics valid for very fast things? Things as large as a galaxy? Things as small as an atom?

It's the duty of the claimer to search for experiments that they can do to possibly prove themselves wrong.

- These need to be diverse – see above

Cherry-picking data

In the modern era, people cherry-picking data (accidentally or deliberately) often:

- **Ignore potentially refuting evidence** instead of honestly examining it, focusing only on arguments *for* their claims
- **Focus only on a narrow scope of observations** but try to draw broad claims from them
- **Use a biased sample (intentionally or otherwise)**, ignoring inconvenient things like puddles
- **“Launder data” through statistics**, rather than incorporating both positive and negative results

Sample problems: elevator

A 100 kg person stands in an elevator. What is their apparent weight if the elevator is accelerating upward at 3 m/s^2?

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A 100 kg person stands in an elevator. What is their apparent weight if the elevator is accelerating upward at 3 $\mathrm{m/s^2}$?

- Sum of forces goes on the left, acceleration goes on the right
- Remember, apparent weight is the normal force applied by the thing you're standing on
- We know the acceleration; we don't know one of the forces $\rightarrow$ solve for it!

Sample problems: Mass on a string

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- This is the same idea as the last problem; we just know the acceleration in an indirect way
- 1 revolution per second $= 2\pi$ radians per second

Sample problems: Mass on a string

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A 2 kg mass hangs on a string 1m long, which is being spun in a vertical circle once per second. What is the tension force at the top of the arc?

- Remember, the acceleration goes toward the center of the circle: think about your signs!

Sample problems: Mass on a ramp

A block sits on a ramp inclined at an angle of 40 degrees. The coefficient of kinetic friction is 0.3. What is its acceleration?

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- Tilted coordinate axes
- Break gravity into components (remember how this goes!!)

Sample problems: your request!