Exam 2 Review

Physics 211
Syracuse University, Physics 211 Spring 2015
Walter Freeman

March 23, 2016

Announcements

- Exam 2 next Tuesday
- Homework 5 due Friday
- Recitations held as normal next week

Exam details

- 4 questions (+ possible extra credit)
- More symbolic problems (no numbers) than before
- Please arrive a bit early if at all possible
- If possible please don't bring backpacks to make life easier on proctors
  - We're just trying to help you, and don't want to trip over and fall
- Bring a calculator of any type and pencils
- Reference sheet: prepared today, posted tonight, provided for you on exam

Extra exam preparation

- Practice exam posted
  - Solutions posted Friday after recitations
- Office hours today: 1:30-3:30 PM (Physics Clinic)
- If there's demand I'll be back at 6
- Office hours tomorrow: 10-12 AM (Physics Clinic)
- Review session Friday, 1-4 PM, location TBA
- Review session Saturday, 4-7 PM, Stolkin Auditorium
  - Lots of people have been Facebook-messaging me cellphone pictures of work with questions; please do this!
- There is a huge amount of help available to you: use it!

Review: overview

Two main topics:

- Newton's second law:
  - Relates force to acceleration
  - Force diagrams
  - Circular motion: $a = \omega^2 r = v^2/r$ toward center
  - We did this before break; make sure you brush up on it!
  - We'll focus on it here
- Conservation of momentum:
  - Useful for collisions, explosions
  - Conservation of angular momentum (from Tuesday)

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
- 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

$$-mg = ma_y \text{ : only if } \sum F_y = -mg!$$

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

$$-mg = ma_y \text{ : only if } \sum F_y = -mg!$$

- 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)

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 the ground

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!

$$a = \omega^2 r = \frac{v^2}{r} \text{ toward the center of the circle}$$

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!

$$a = \omega^2 r = \frac{v^2}{r} \text{ toward the center of the circle}$$

- "How many force problems and how many circular motion problems will we have?"

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!

$$a = \omega^2 r = \frac{v^2}{r} \text{ toward the center of the circle}$$

- "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

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

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

- 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

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
- 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
- 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

Sample problems: elevator

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

Sample problems: elevator

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

- Sum of forces goes on the left, acceleration goes on the right
- We know the acceleration; we don't know one of the forces $\rightarrow$ solve for it!

Sample problems: Mass on a string

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 bottom of the arc?

Sample problems: Mass on a string

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 bottom of the arc?

- This is the same idea as the last problem; we just know the acceleration in an indirect way

Sample problems: Mass on a string

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?

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?

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?

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

Two masses of 1 kg and 1.1 kg hang from either side of a massless pulley. What is their acceleration?

Sample problems: Atwood's machine

Two masses of 1 kg and 1.1 kg hang from either side of a massless pulley. What is their acceleration?

- Separate force diagram for each object
- How do the accelerations relate?

Sample problems: momentum

- This week's homework:
  - Problem 1: momentum in 2D, multiple objects
  - Problem 7: momentum in 2D, vectors
  - Problem 4: momentum plus kinematics (do it in steps!)
  - Problem 3: angular momentum

Sample problems: your request!