Announcements - 8 Oct 2009

1. **Exam 2 results**
   a. Scores:
      i. 75th percentile =
      ii. 50th percentile (median) =
      iii. 25th percentile =
   b. Exams will be returned soon (Monday), pick them up in usual place (boxes near N357 ESC)
   c. Solutions will be posted on website soon (Monday)

2. Like last time, if you have questions on the exam:
   a. Look over your own exam.
   b. Look over the posted solutions, see if you can figure out why you got the problems wrong.
   c. If you can't figure things out on your own, come talk to me (or TAs)

3. While you're waiting for class to start, see if you can fill in the steps to Dr. Colton's guide (next page) in your own words.

Momentum Review

Equations

Definition: $\vec{p} = m\vec{v}$

Conservation Law: $\sum \vec{p}_{before} = \sum \vec{p}_{after}$ (if no…)

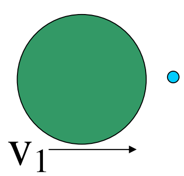
"Impulse equation": $\vec{F}_{net}\Delta t = \Delta\vec{p}$

Dr. Colton's Guide: How to Solve Conservation of Momentum Problems

1. Draw…
2. Draw in…
3. Use…
4. Divide into separate…
5. Fill in…
   i. One term in equation for…
6. Be careful with…
7. If it's an elastic collision, use…
   → how do you know if collision is elastic?

Demo problem:
Elastic collision between very large and very small mass

Bowling ball and a marble. Marble is at rest.



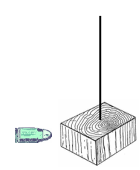
If $v_{\text{bowling ball final}} \approx v_{\text{bowling ball initial}}$,
what does velocity reversal equation imply about $v_{\text{marble final}}$?

Demo: "Velocity amplifier"

Multi-step problems

→ Collision followed by something else

"Ballistic pendulum". A bullet of mass *m* and speed *v* embeds in a block of wood of mass *M* hanging from a string. How high do they rise?



How not to do: $\frac{1}{2}mv^2 = (m+M)gh$

How to do:

1. **Collision part: *p* is conserved** (but KE is not!)
   i. This gets you the velocity right after the collision
2. **Motion part: Energy is conserved** (but *p* is not!)
   i. This gets you the height based on velocity

This is similar to HW 10-1!

Answer: $h = \left(\frac{m}{m+M}\right)^2 \frac{v^2}{2g}$

Center of Mass

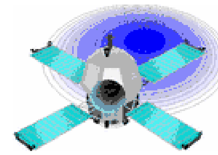
What is the center of mass?

What forces can change the motion of the center of mass?

How does the center of mass move?

Demos: Foam object, CO_2 rocket

Circular Motion



Demo: Bicycle wheel

Complicated motion of rotating body:
Different r, v, a's for different parts

But same ______________________

From warmup: Which has greater linear speed, a horse near the outside rail of a merry-go-round or a horse near the inside rail?

a. outside horse
b. inside horse
c. both the same

Do revolutions relate to angles?

Question: Which angle is greatest:

a. 30 revolutions
b. 30^o
c. 30 radians

Definition of radian:

How many radians in one circumference?
How many radians in 360°?

→ I will not give you these conversion factors on exam!

How many radians in an arc of length "s"?

→ I will give you this equation on exam

What is angular speed? (aka angular velocity)

Clicker quiz: The symbol ω, used for angular velocity, is pronounced:

a. "al-pha"
b. "double-you"
c. "gam-ma"
d. "om-e-ga"
e. "pi"

From warmup: Which has greater angular speed, a horse near the outside rail of a merry-go-round or a horse near the inside rail?

a. outside horse
b. inside horse
c. both the same

Angular quantities

displacement $\Delta\theta$
average velocity ω_{ave} =
average acceleration α_{ave} =

Angular motion of the whole object vs. motion of a spinning **point**

Angular displacement $\Delta\theta$ vs "distance around circumference", *s*

Angular velocity ω vs tangential speed *v*

Angular acceleration α vs tangential acceleration *a*

Very Important: *Tangential* motion!

Also very important: You must use radians if you want to use those equations

Kinematic equations (for constant *angular* acceleration)

Substitutions: $x \to \theta$, $v \to \omega$, $a \to \alpha$

Regular kinematic	Angular kinematic
Definition: $v_{ave} = \langle v \rangle = \frac{\Delta x}{\Delta t}$	$\omega_{ave} = \langle \omega \rangle = \frac{\Delta \theta}{\Delta t}$
Definition: $a_{ave} = \langle a \rangle = \frac{\Delta v}{\Delta t}$	$\alpha_{ave} = \langle \alpha \rangle = \frac{\Delta \omega}{\Delta t}$
For constant *a*:	For constant α:
$x = x_0 + v_0 t + \frac{1}{2} a t^2$	$\theta = \theta_0 + \omega_0 t + \frac{1}{2} \alpha t^2$
$v = v_0 + at$	$\omega = \omega_0 + \alpha t$
$v^2 = v_0^2 + 2a(x - x_0)$	$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$

Guidance:
1. Pretend a problem involves regular distances & velocities, and figure out how you would solve it
2. Then use the corresponding angular equations

Note: I will not give you the angular kinematic equations on exam

Worked Problem: Friction slows down a 5 cm diameter spinning top with angular deceleration of 2 rad/s^2. It was initially spinning at 50 rad/s.

1. How many revolutions will it turn before stopping?

"Translated problem": Friction slows down a block, a = -2 m/s^2. It was initially travelling at 50 m/s. How far will it go before stopping?

2. How long will that take?

3. How fast was a point on the rim initially going?

Answers: 99.47 revs, 25 s, 1.25 m/s

Centripetal vs. Tangential

Ball on string: Demo

Is the ball accelerating?

Speeding up/slowing down: acceleration is ___________________

What if the ball is not speeding up/slowing down?

Centripetal (turning) acceleration: $a_c = \frac{v^2}{r}$

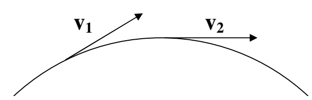
Direction? _____________

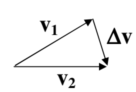
(hint: think of the direction of the tension force)

Bottom line:
If circular motion, then there is centripetal acceleration produced by the net inward/outward forces.

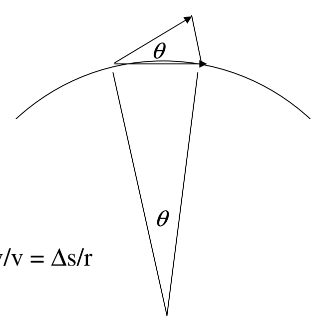
This acceleration (v^2/r) goes on the **right hand side** of N2

Derivation:





$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$



Similar triangles: Δv/v = Δs/r

Magnitude: $a = \frac{(v\Delta s/r)}{\Delta t} = \left(\frac{v}{r}\right)\frac{\Delta s}{\Delta t} = \frac{v^2}{r}$

Direction of centripetal acceleration? ______________
→ call that positive

From warmup: A ladybug sits on the outer edge of a merry-go-round that is turning around counter-clockwise without speeding up or slowing down. In what direction is the friction force that sticks the ladybug to the merry-go-round?

a. clockwise
b. counter-clockwise
c. inward
d. outward

From warmup: Ralph is confused about centripetal and centrifugal forces. When he is in a car which is turning to the left, he feels a force pushing him to the right. But the textbook says that the actual force is pushing him to the left. Can you explain this to him? What is he feeling during the turn?

Answer from the class:

Worked Problem:
You swing a ball (mass m) in a vertical circle with a string; its speed is constant (v) through the whole circle. (a) What is the tension at the lowest point? (b) At the highest point?

(a) Picture:

Equation:

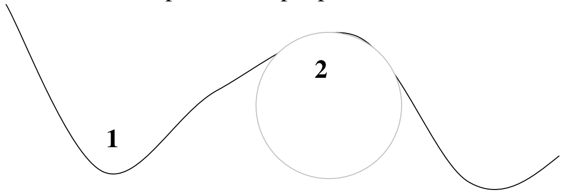
(b) Picture:

Equation:

Answers: $mg + mv^2/r$, $mg - mv^2/r$

Unsafe roller coasters (no seatbelts)

For the top of an *outside* curve (pt 2), radius of curvature = 8 m, what is the maximum speed if the people are **not to fall out**?



What's the difference between pt 1 and pt 2?

Free-body diagrams:

What happens to normal force at pt 2 as speed increases?
→ Just as people fall out, the normal force is ______________.

Question: Angular velocity of **earth** (1 rev/24 hours, convert to rad/s) gives speed at Provo = 792 mph! Why don't we fly off?

Answer: 8.854 m/s

Space stations and "artificial gravity"

You are standing on a 50 m radius space station that rotates at just the right speed so that the **normal force** is

$N = m \times 9.8\ m/s^2$.

Your usual normal force = mg, so this feels "normal"! ☺

What direction do your feet face?

How fast are you traveling? (m/s)

How fast is the station rotating? (revolutions per minute)

Answers: 22.14 m/s, 4.23 rpm

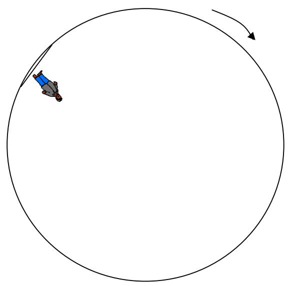
Clicker quizzes (if time)

Now a large trapdoor opens under you to the outside. What happens, from the point of view of an astronaut outside the space station?

a. You hang motionless above the opening

b. You move through the opening and proceed in a radial direction

c. You move through the opening and proceed in a tangential direction



The spaceship is rotating clockwise. If it's a hollow cylinder as shown, what can you do to "float" to the other edge, right through the *center* of the cylinder?

a. Jump pushing straight "up"

b. Run clockwise just right and push straight "up"

c. Run counterclockwise just right and push straight "up"

d. Can't be done.