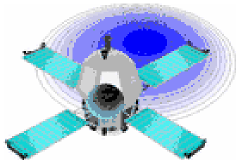
Colton Lecture 11, 10/11/07

Announcements

1. **No announcements yet**

Circular Motion



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

Same ______

Demo: Bicycle wheel

Radians: relate angles and distances
Circumference (aka 1 revolution):

Arc length "s":

Radian/degrees conversion:

Q4. Which angle is greatest:
a. 30 revolutions
b. 30°
c. 30 rad

Angular

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

Angular motion of the body vs. motion of a spinning **point**

Angular displacement $\Delta\theta$ vs distance s

Angular velocity ω vs speed v

Angular acceleration α vs acceleration a

Very Important: These all describe *tangential* motion

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

Kinematic equations

(constant *angular* acceleration)

$x \to \theta$
$v \to \omega$
$a \to \alpha$

Regular	Angular
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*:

$$x = x_0 + v_0 t + \frac{1}{2}at^2$$
$$v = v_0 + at$$
$$v^2 = v_0^2 + 2a(x - x_0)$$
$$v_{ave} = \langle v \rangle = \frac{v_i + v_f}{2}$$

For constant α:

$$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$$
$$\omega = \omega_0 + \alpha t$$
$$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$$
$$\omega_{ave} = \langle \omega \rangle = \frac{\omega_i + \omega_f}{2}$$

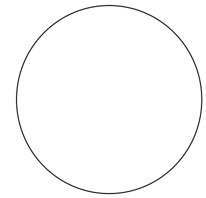
Hints:
1. Choose a direction for + angles, rotations.
2. Can use units of rev/sec, deg/sec or rad/s if you use them for each term in kin. eqns. (But rad/sec is safest!)

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.

How many revolutions will it turn before stopping?

How fast was a point on the rim initially going? What was its tangential acceleration?

Accelerations and forces in circular motion



Ball on string: Demo

Why does it move in a circle?

Whenever there is a **net force** there is ______________

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

direction:

Tangential (speed up/down) acceleration:

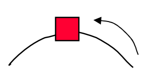
direction:

Total acceleration: combination (vector sum) of both

Applet: pendulum animation
http://stokes.byu.edu/pendulum_flash.html

An object traveling in the direction shown is *slowing down*

Q7. The centripetal acceleration at this instant is

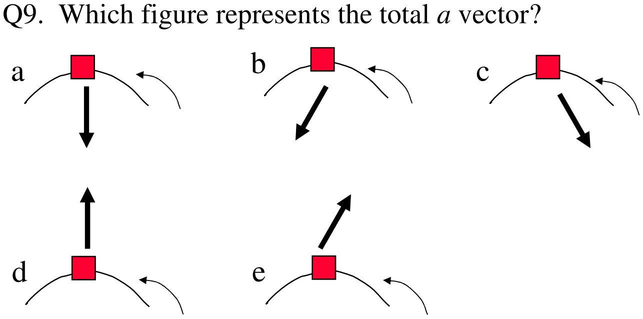


a. up
b. down
c. left
d. right
e. zero

Q8. The tangential acceleration at that instant is

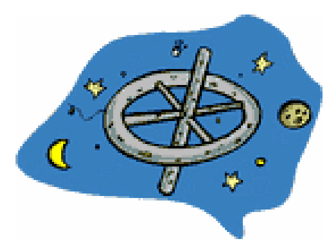
a. up
b. down
c. left
d. right
e. zero

Q9. Which figure represents the total *a* vector?



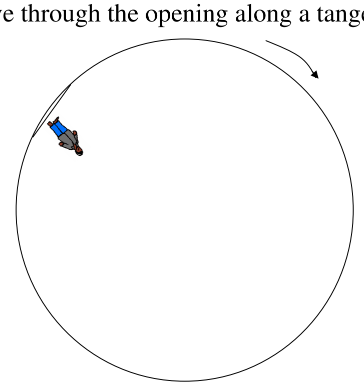
Space stations and artificial gravity.

You are standing on a space station that rotates you at speed v_{rot} so that the **normal force** is N=9.8 m/s^2.
You feel OK!



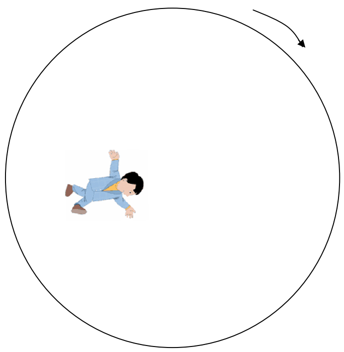
Q10. A large trapdoor opens under you to the outside. What happens, from the point of view of an astronaut outside the space station?

a. You "float" motionless above the opening
b. You move through the opening along a radial direction
c. You move through the opening along a tangential direction



Q11. The spaceship is rotating clockwise. If it is a big cylinder, 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.



What happens when you reach the other side?

Swing ball in vertical circle

Demo: ball on string

Where is tension the greatest/least?

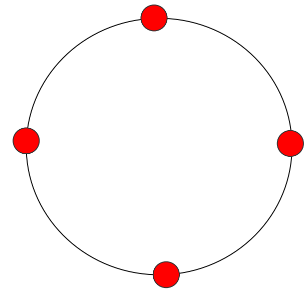
Find T as a function of v, at four points on circle:

Top

Right

Bottom

Left:

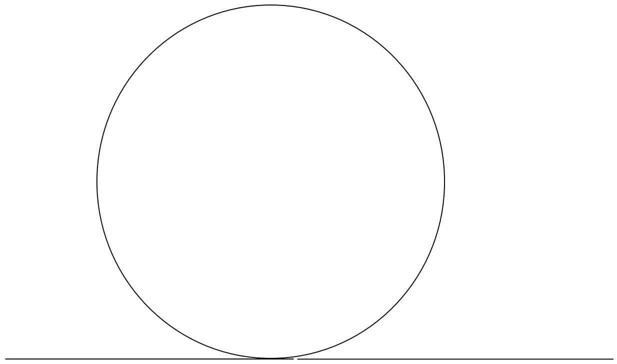


General hints for forces on objects moving in a circle:

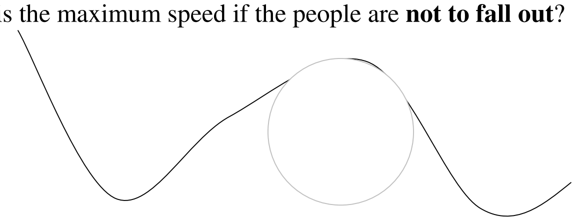
1. Choose + radial direction toward center (along a_c)
2. Draw FBD of object showing only real forces (don't treat a_c as a force)
3. Write $\sum F_{\text{radial}} = ma_c = m\frac{v^2}{r}$ and/or $\sum F_{\text{tangential}} = ma_t = mr\alpha$

Roller coasters problems

You design a roller coaster so that people feel normal forces (seat forces) of at most five × a person's normal weight: N=5mg The tightest loop has a radius of 20 m. What is the maximum speed the roller coaster should go at the bottom of the loop?



For the top of an *outside* curve, radius of 8 m, and **no seatbelts**, what is the maximum speed if the people are **not to fall out**?

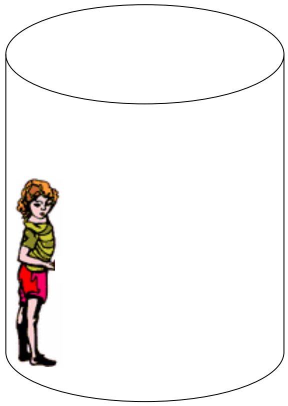


Key concept: When the people are *about to fall out*, the normal force is ______________.

Angular velocity of **earth**: Speed on surface: 1000 mi/hr. Why don't we fly off?

Floor-dropping ride

If the coefficient of friction is μ, what minimum speed v must you be going before the floor is removed?



Video: Man on wall