

Physics 105 Class 11

CIRCULAR MOTION

Complicated motion of rotating body:

Different r , v , a 's for different parts

Same _____

Angles and distance relations are simple using *radians*

Circumference

Arc length "s"

Radian/degrees conversion

Revolutions, turns

P1. Which angle is greatest: 30 rev, 30° , 30 rad?

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Angular

displacement $\Delta\theta=$

average velocity $\langle\omega\rangle=$

average acceleration $\langle\alpha\rangle=$

Angular motion of a body and motion of a **point**

Angular displacement $\Delta\theta$ vs distance s

Angular velocity ω vs speed v

Angular acceleration α vs acceleration a

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What if it's a rolling object?

How far does the center of a wheel go in N revolutions (**no slipping**)?



How fast is the car (or wheel center) going if the wheels move with ω (**no slipping**)?

What is the acceleration of the car (or wheel center) if the wheels accelerate with α (**no slipping**)?

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Angular kinematic equations

(constant acceleration)

$$\omega = \omega_o + \alpha t$$

$$\Delta\theta = \frac{1}{2}(\omega_o + \omega)t$$

$$\Delta\theta = \omega_o t + \frac{1}{2}\alpha t^2$$

$$\omega^2 = \omega_o^2 + 2\alpha\Delta\theta$$

Hints for using the angular kinematic equations

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.
3. You must end up with units of radians if you want to use the equation $s=r\theta$, $v=r\omega$ and $a=r\alpha$

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Friction slows down a spinning top with angular deceleration of 2 rad/s^2 . It was initially spinning at 50 rad/s .

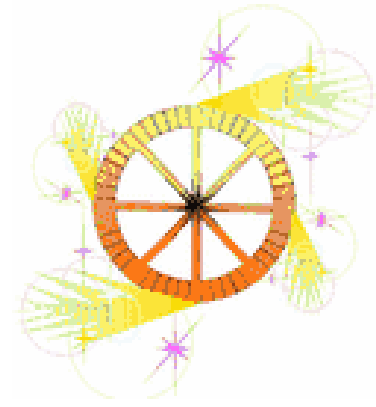


How many revolutions will it turn
stopping?

before

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P2. What constant angular acceleration (radians/sec²) is necessary to get a 20 cm diameter grinding wheel to rotate 100 radians from rest in 8 seconds?



P3. What was the average angular velocity during the 8 seconds?

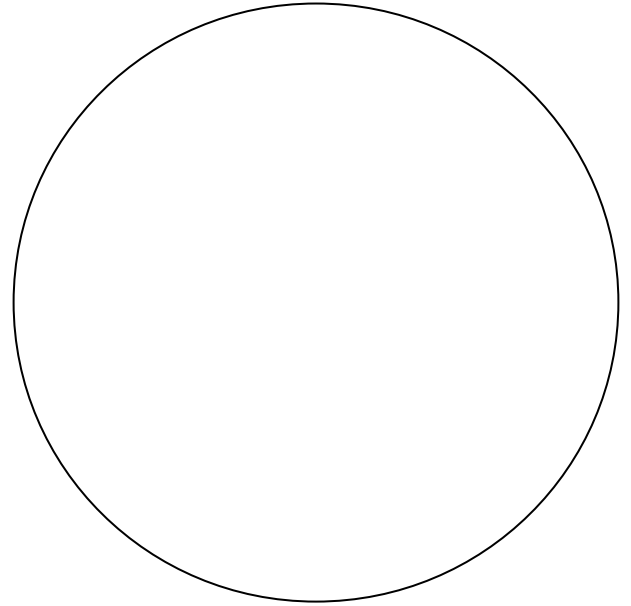
What is the final angular velocity?

What is the speed of a point on the rim at this velocity?

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Accelerations and forces in circular motion

Why does the ball move in a circle?



Whenever there is a **net force** there is _____

Centripetal (turning) acceleration:
direction:

Tangential (speed up/down) acceleration:
direction:

Total acceleration:

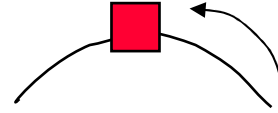
Newton's 2nd Law:

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

P4. The centripetal acceleration at this instant is

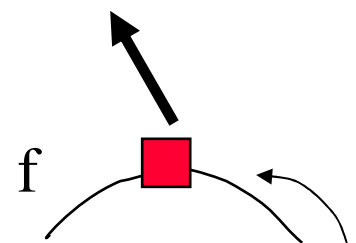
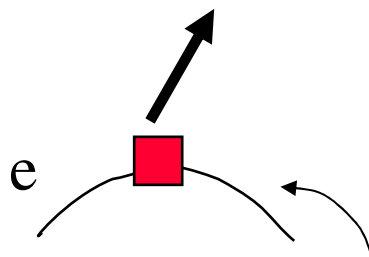
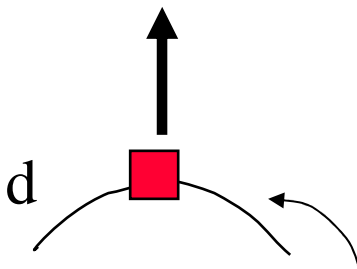
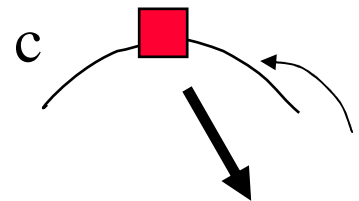
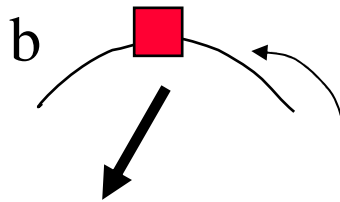
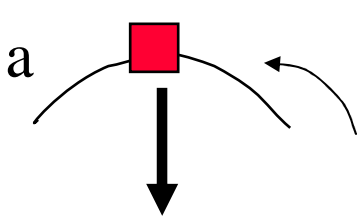
1. up
2. down
3. left
4. right
5. zero



P5. The tangential acceleration at this instant is

6. up
7. down
8. left
9. right
10. zero

P6. Which figure represents the total acceleration vector?

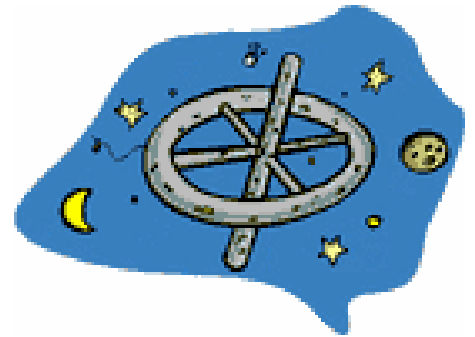


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Space stations and artificial gravity

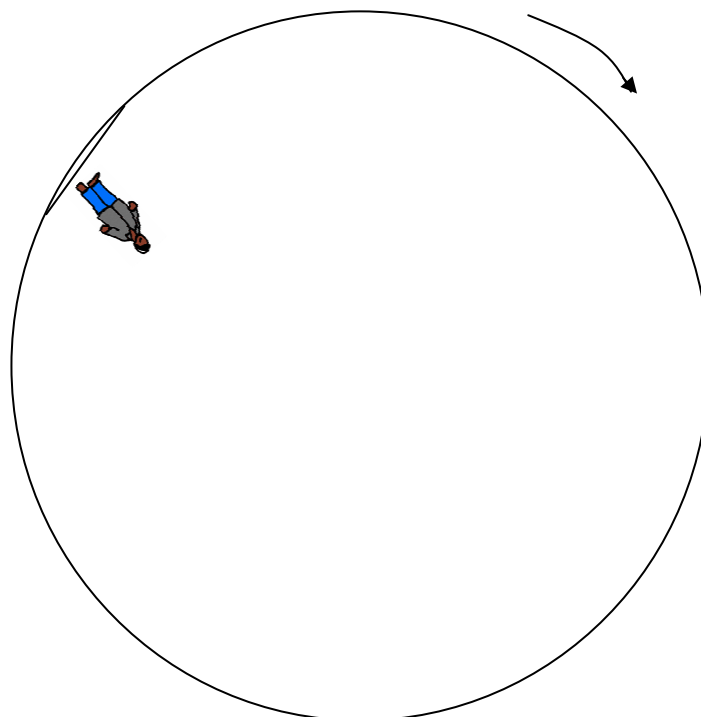
You are standing on a space station that rotates you at speed v_{rot} so that the **normal force** is $N=9.8 \text{ m/s}^2$.

You feel OK!



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

1. You “float” motionless above the opening
2. You move through the opening along a radial direction
3. You move through the opening along a tangential direction



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Swing ball in vertical circle

Where is tension the greatest/least?

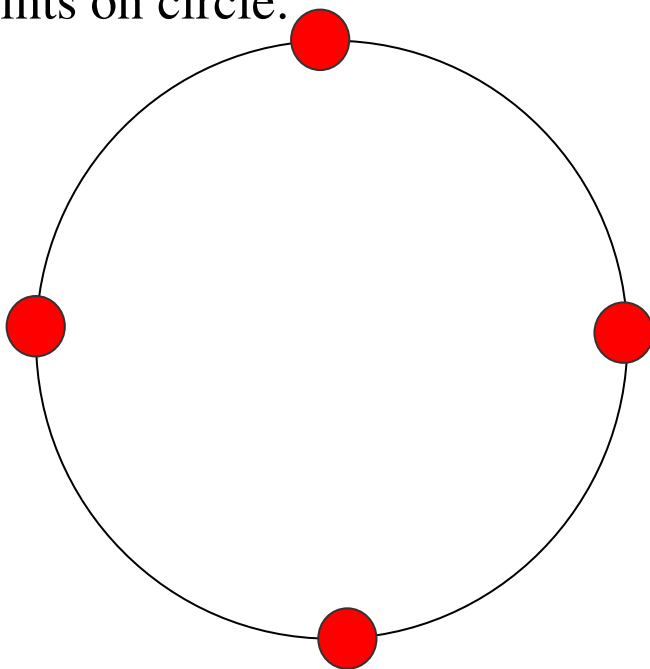
Find T as a function of v , at four points on circle:

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)

$$\sum F_{\text{radial}} = ma_c = m \frac{v^2}{r}$$

3. Write and/or $\sum F_{\text{tangential}} = ma_t = mr\alpha$

Water in pail

Minimum speed: when the water is about to fall out, the normal force of the bucket on the water is _____, and the force of gravity alone turns the water, so $mg =$ _____

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HOMEWORK HINTS: