Read 8.4-8.5

Exam Monday 7:30 A.M

chp 6,7 only

No H.W due this week

Chapter 8
Rotational motion

Bring all of the ideas we have learned in previous 7 chapters together and apply them to rotational motion

Kinematic Equations
Forces
Energy
momentum

These concepts modified to deal with rotations

Apply "old" ideas to "new" problems

Some Definitions

<u>Rigid Body</u>: An object that has a definite unchanging shape

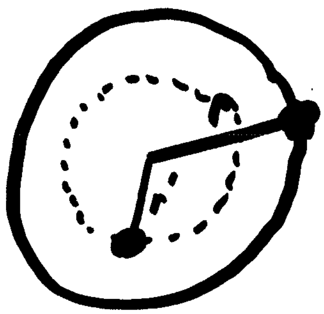
<u>Fixed axis of rotation</u>: A single non-changing axis around which the object rotates

<u>Translational motion</u>: movement of an object through space without rotation

<u>Rotational motion</u>: motion around an axis of rotation

can have both Translational and rotational motion at the same time

First Look at spinning wheel



$$V = \frac{\text{Distance}}{\text{time}} \qquad r' = \frac{r}{2}$$

$$V_{red} = \frac{2\pi r}{t}$$

$$V_{blue} = \frac{2\pi r'}{t}$$

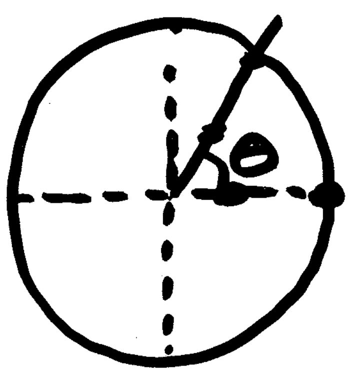
$$\frac{V_{red}}{V_{blue}} = \frac{2\pi r/t}{2\pi r'/t} = \frac{r}{r'}$$

$$= 2$$

red traveling twice as fast as blue

so 2 objects spinning at different distances from center have different velocities

what is constant for both objects?



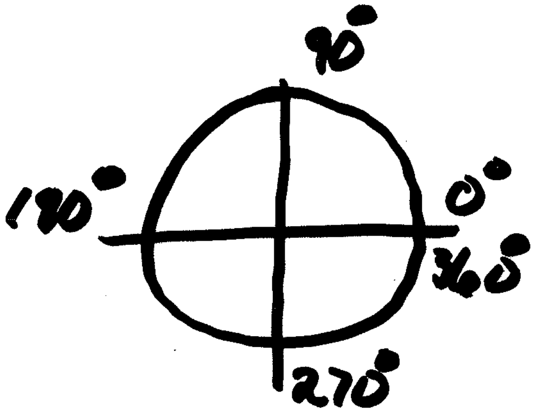
Have same change in angle

velocity = $\frac{\Delta x}{\Delta t}$

angular velocity = $\frac{\Delta \theta}{\Delta t} = \omega$ (omega)

* Greek letters often used for angular quantities

How to define Θ?



Degrees

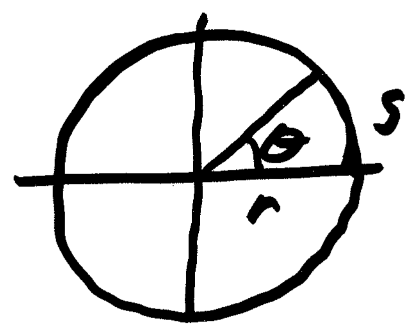
Degrees is a unit → 360° in a circle

Radians

$$\Theta = \frac{s}{r}$$

r = radius

s = arc length



around circle

$s = 2\pi r$

$$\Theta = \frac{2\pi r}{r} = 2\pi$$

2π radians in a circle

2π radians = 360°

units

$$\Theta = \frac{\text{length}}{\text{length}}$$

NO units

360° in a circle

2π radians in a circle $= 360^\circ$

45° How many radians?

$$\frac{45^\circ}{} \Big| \frac{2\pi \text{ rad}}{360^\circ} = \frac{\pi}{4} \text{ radians}$$

Velocity increases as one moves further from center of circle

linear velocity depends on r (distance from center of circle) and how fast wheel is spinning (ω)

$$v = \omega r$$

units

$$\frac{m}{s} = \frac{\cancel{\text{radians}}}{s} m$$

$$\frac{m}{s} = \frac{\text{degrees}}{s} m$$

linear velocity also related to period

$$\text{Velocity} = \frac{\text{Distance}}{\text{time taken}}$$

for 1 revolution

$$V = \frac{2\pi r}{T} = 2\pi r f$$

$$V = \omega r$$

$$\omega = \frac{V}{r} = \frac{2\pi r f}{r} = 2\pi f$$

$$\underline{\omega = 2\pi f}$$

angular velocity related to frequency

For rotations we can also have acceleration

linear acceleration $a_T = \frac{\Delta v}{\Delta t}$

angular acceleration $\alpha = \frac{\Delta \omega}{\Delta t}$

↑ alpha

$v = \omega r$

↑ linear velocity ↖ angular velocity

related

$\Delta v = \Delta \omega r$

$a_T = \frac{\Delta v}{\Delta t} = \frac{\Delta \omega r}{\Delta t} = \alpha r$

$$\underline{a_T = \alpha r}$$

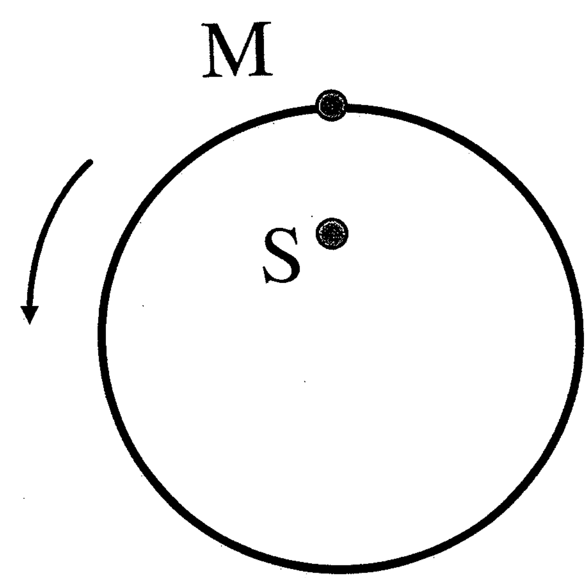
Note $a_c = \frac{v^2}{r} = \frac{\omega^2 r^2}{r} = \omega^2 r$

$$\underline{a_c = \omega^2 r}$$

$a = \sqrt{a_c^2 + a_T^2}$

Interactive Question

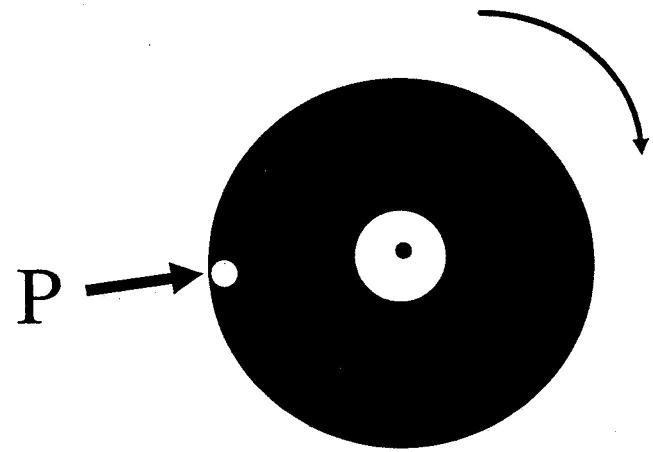
Steve (S) and his brother Mark (M) are riding on a merry-go-round as shown. Which of the following is true?

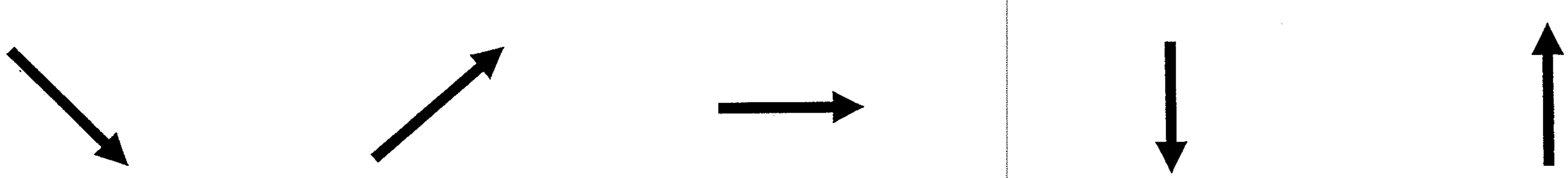


A) They have the same speed, but different angular velocities.
B) They have the same speed, and the same angular velocities
C) They have different speeds and different angular velocities.
D) They have different speeds and the same angular velocity

Interactive Question

The record playing on the turntable is rotating clockwise as seen from above. After turning it off, the turntable is slowing down, but hasn't stopped yet. The direction of the acceleration at point P is





A) B) C) D) E)

see very nice correspondence between linear variables and angular variables

linear		angular	
x	$\longleftrightarrow$	θ	(theta)
v	$\longleftrightarrow$	ω	(omega)
a	$\longleftrightarrow$	α	(alpha)

linear	angular
$x = x_0 + v_{av} t$	$\theta = \theta_0 + \omega_{av} t$
$v_x = v_{0x} + at$	$\omega = \omega_0 + \alpha t$
$x = x_0 + v_0 t + \frac{1}{2} a t^2$	$\theta = \theta_0 + \omega_0 t + \frac{1}{2} \alpha t^2$
$v^2 = v_0^2 + 2a\Delta x$	$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$
Need constant acceleration	Need constant angular acceleration