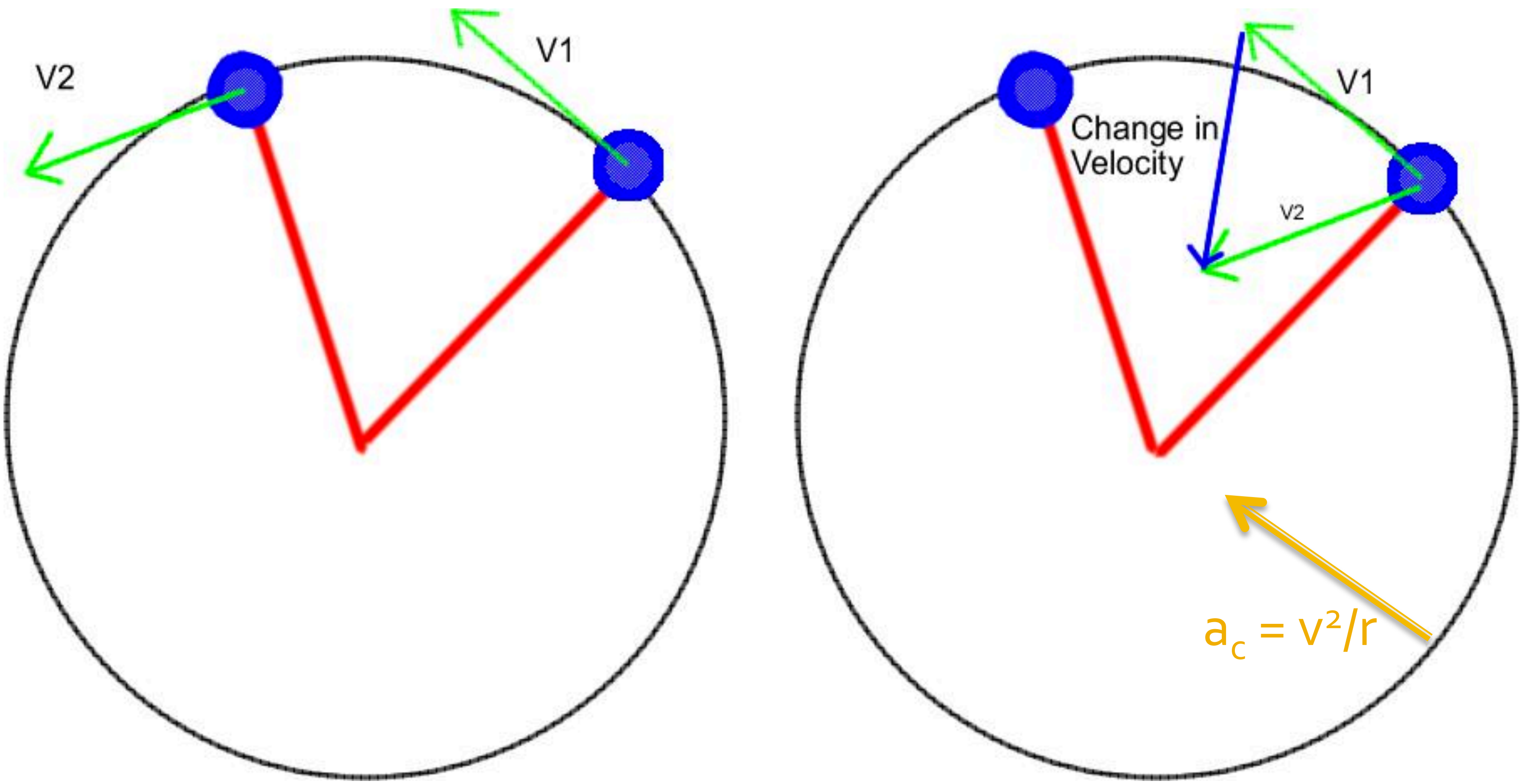
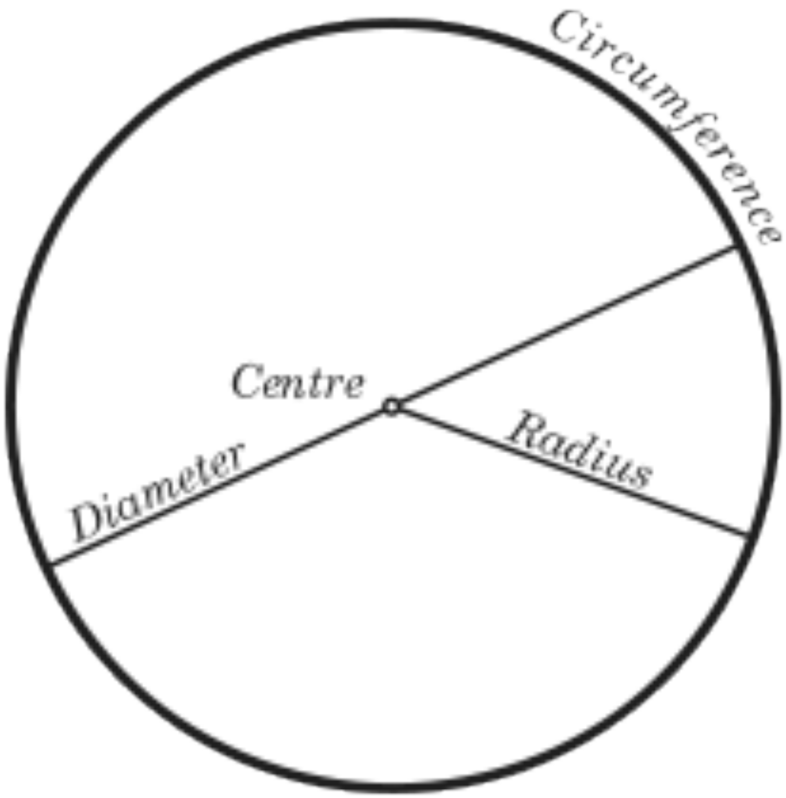
College Physics I: 1511 Mechanics & Thermodynamics

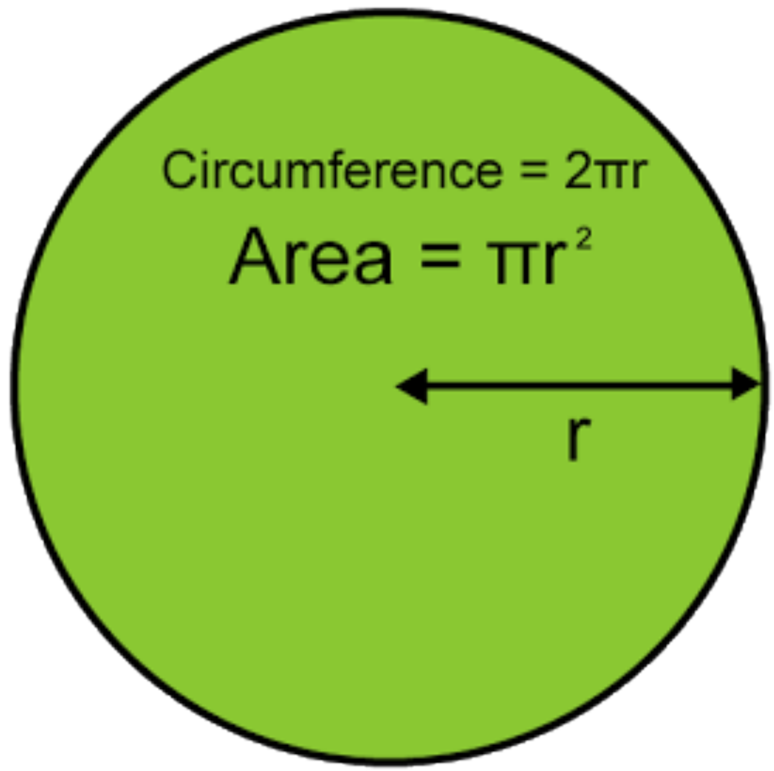
Professor Jasper Halekas
Van Allen Lecture Room 1
MWF 8:30-9:20 Lecture

Review: Uniform Circular Motion

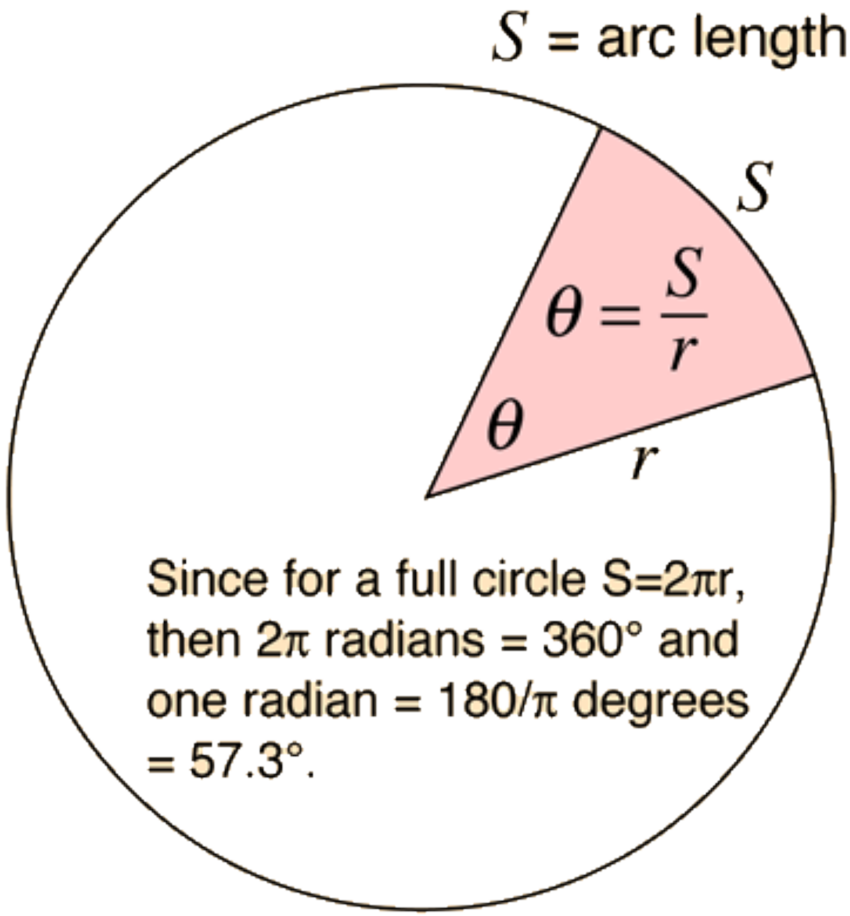


Review: Circles

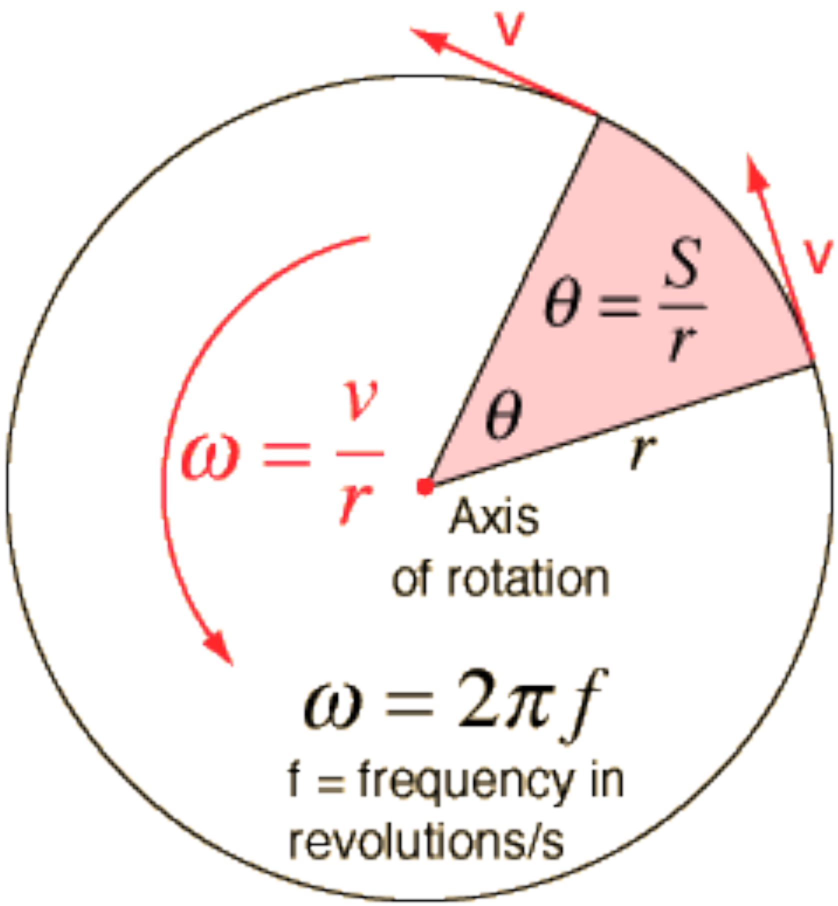




Rotational Quantities I: Angle



Rotational Quantities II: Angular Velocity



Tangential velocity

$$\langle V_T \rangle = s / \Delta t$$

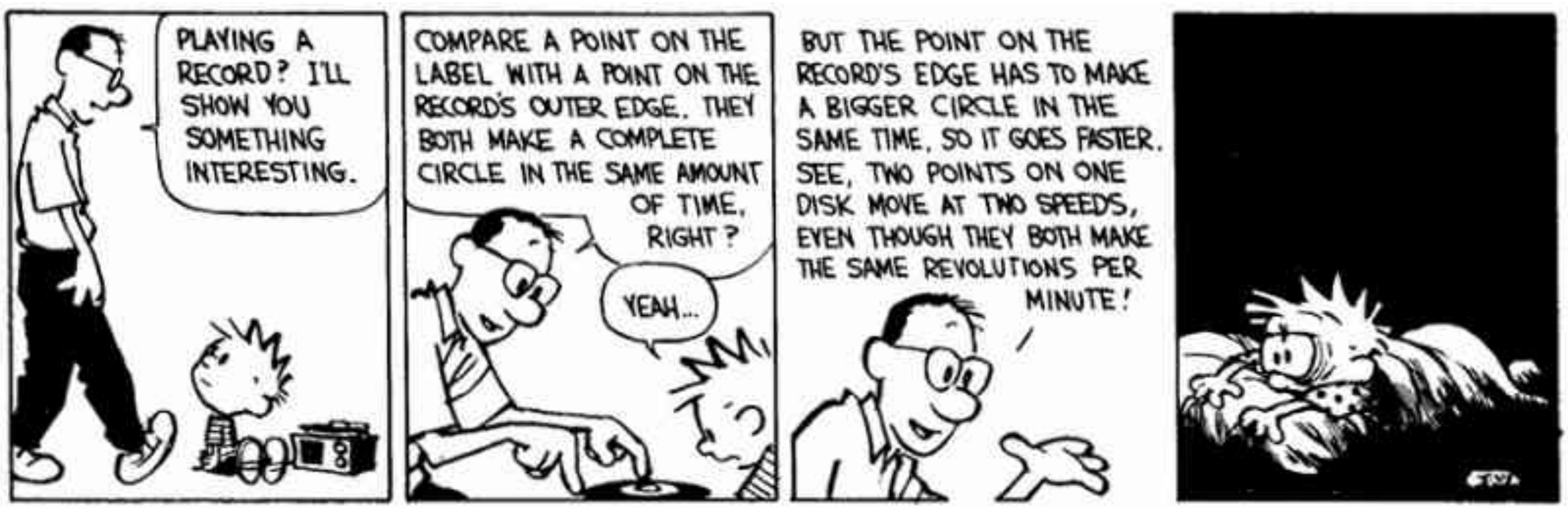
but $s = r \Delta \theta$

so $\langle V_T \rangle = r \Delta \theta / \Delta t$

define $\langle \omega \rangle = \Delta \theta / \Delta t$

$$\langle V_T \rangle = r \langle \omega \rangle$$

Tangential Vs. Angular Velocity



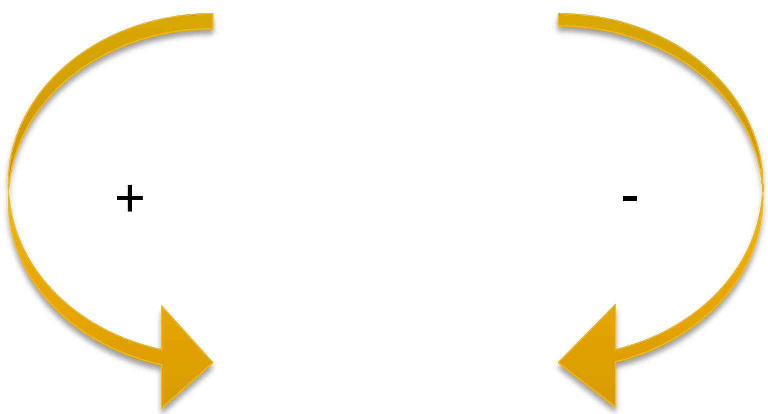
Tangential Velocity Vs. Angular Velocity

- Tangential velocity is the velocity of a body in the direction of the tangent to a circle
  - Tangential velocity (SI Unit: m/s) depends on the radius of the motion

- Angular velocity is the rate at which the angle of a body with respect to a set of coordinate axes changes
  - Angular velocity (SI Unit: rad/s) does not depend on the radius of the motion

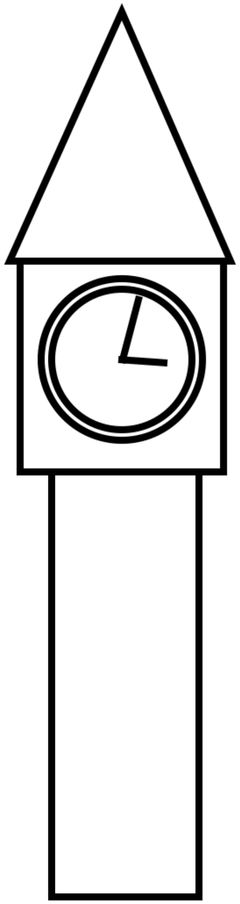
Important Convention

- Angles and angular velocities are defined as positive if they are counter-clockwise, negative if they are clockwise



Concept Check

BIG BEN and a little alarm clock both keep perfect time. Which minute hand has the bigger angular velocity ω?



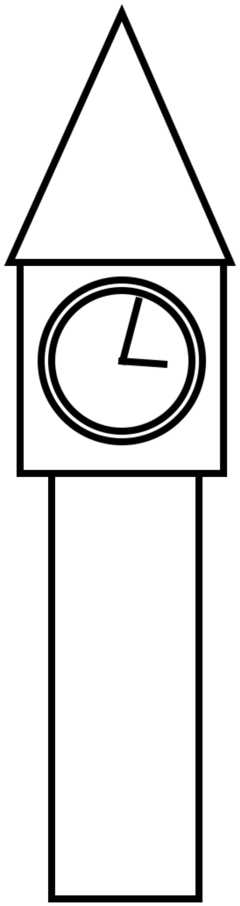
A) Big Ben

B) little alarm clock

C) Both have the same ω

Concept Check

BIG BEN and a little alarm clock both keep perfect time. Which minute hand has the bigger angular velocity ω?



A) Big Ben

B) little alarm clock

C) Both have the same ω

Big Ben:

$$\omega_B = 2\pi \text{ rad} / 60 \text{ s}$$

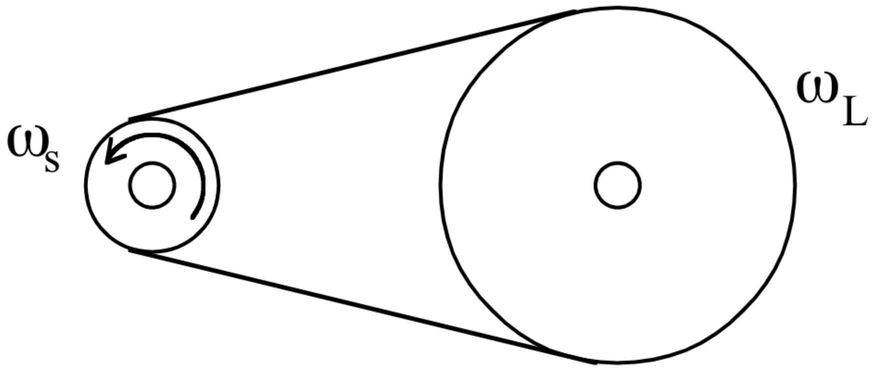
Little Clock:

$$\omega_C = 2\pi \text{ rad} / 60 \text{ s}$$

$$\boxed{\omega_B = \omega_C}$$

Concept Check

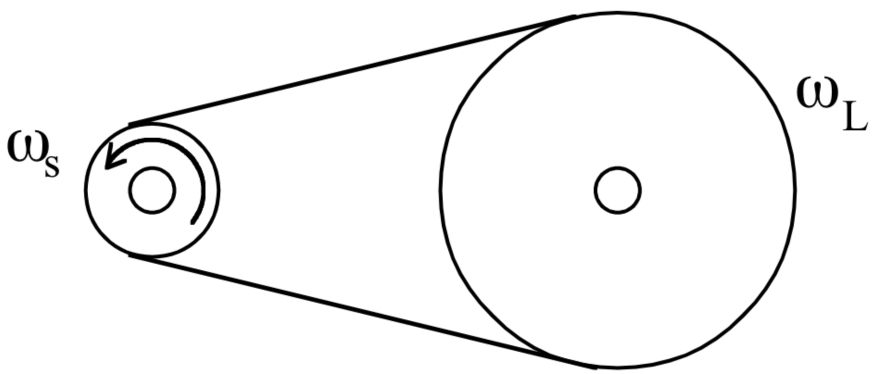
A small wheel and a large wheel are connected by a belt. The small wheel is turned at a constant angular velocity ω_s. How does the magnitude of the angular velocity of the large wheel ω_L compare to that of the small wheel?



A: $\omega_s = \omega_L$ B: $\omega_s > \omega_L$ C: $\omega_s < \omega_L$

Concept Check

A small wheel and a large wheel are connected by a belt. The small wheel is turned at a constant angular velocity ω_s. How does the magnitude of the angular velocity of the large wheel ω_L compare to that of the small wheel?



A: $\omega_s = \omega_L$

B: $\omega_s > \omega_L$

C: $\omega_s < \omega_L$

Bicycle:

Big wheel has angular velocity ω_L

$$\Delta\theta = \omega_L \cdot t$$

$$s_L = r_L \Delta\theta_L = r_L \omega_L \cdot t$$

since belt connects two wheels

$$s_s = s_L$$

$$s_s = r_s \Delta\theta_s = r_s \omega_s \cdot t$$

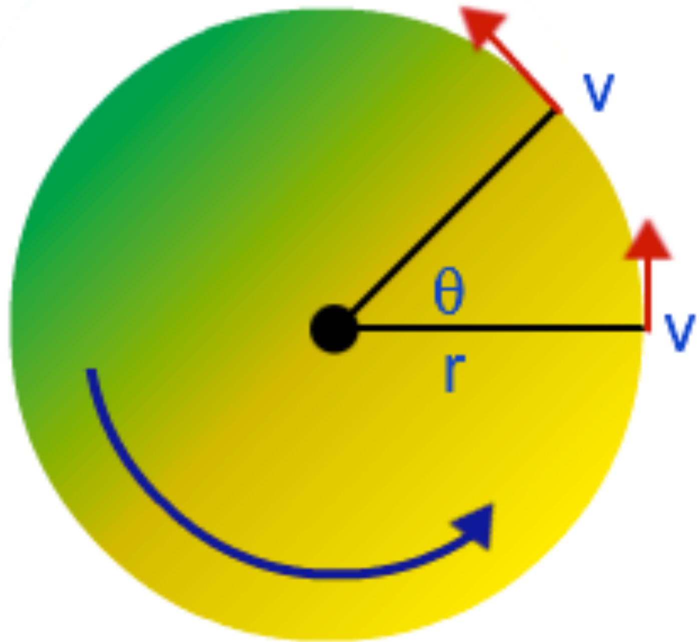
so: $r_L \omega_L \cdot t = r_s \omega_s \cdot t$

$$\Rightarrow r_L \omega_L = r_s \omega_s$$

$$\Rightarrow \omega_s = \frac{r_L}{r_s} \omega_L \boxed{> \omega_L}$$

Bicycle Gears

Rotational Quantities III: Angular Acceleration



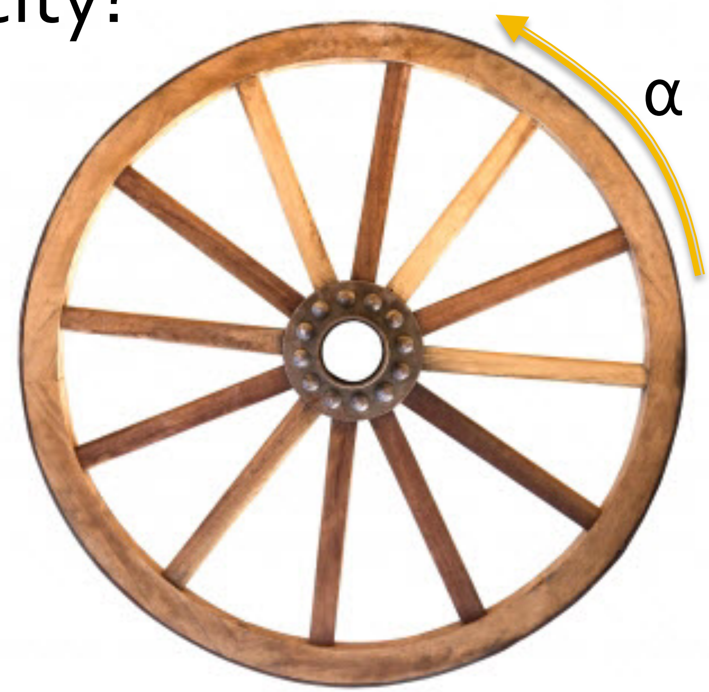
$$\text{Average angular acceleration} = \frac{\text{Change in angular velocity}}{\text{Elapsed time}}$$

$$\bar{\alpha} = \frac{\omega - \omega_o}{t - t_o} = \frac{\Delta\omega}{\Delta t}$$

SI Unit of Angular acceleration: radian per second per second (rad/s^2)

Concept Check

- A wheel starts from rest and undergoes an angular acceleration of 4 rad/s^2. After 5 s, what is its angular velocity?

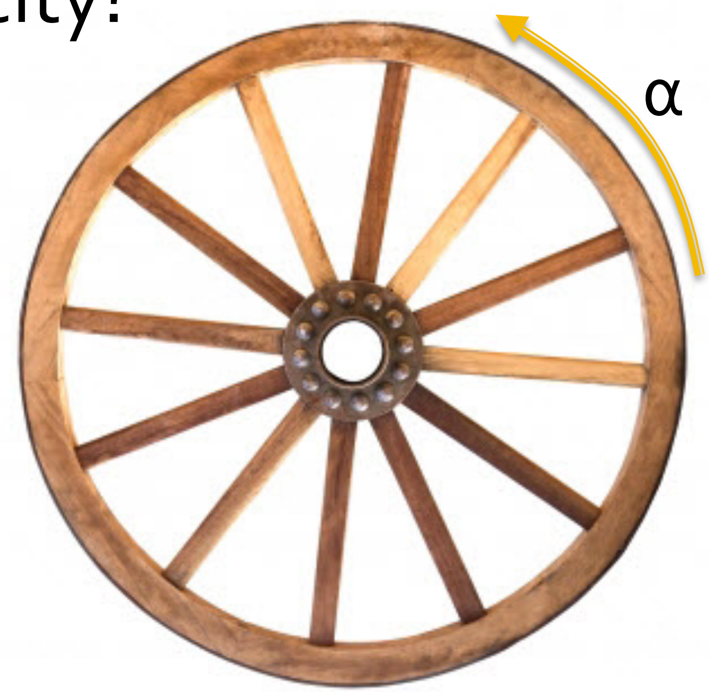


A. 10 rad/s
B. 20 rad/s
C. 40 rad/s
D. 5 rad/s
E. 0 rad/s

Concept Check

- A wheel starts from rest and undergoes an angular acceleration of 4 rad/s². After 5 s, what is its angular velocity?

A. 10 rad/s
B. 20 rad/s
C. 40 rad/s
D. 5 rad/s
E. 0 rad/s



$$\alpha = \Delta w / \Delta t$$

$$= (w - w_0) / \Delta t$$

$$\Rightarrow \quad w - w_0 = \alpha \Delta t$$

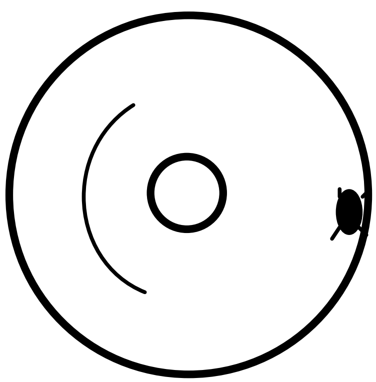
or $$w = w_0 + \alpha \Delta t$$

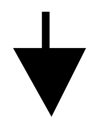
$$= 0 + 4 \cdot 5$$

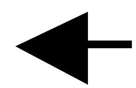
$$= \boxed{20 \text{ rad/s}}$$

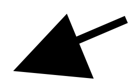
Concept Check

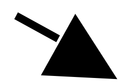
A ladybug is clinging to the rim of a spinning wheel which is spinning CCW very fast and is slowing down. At the moment shown, what is the approximate direction of the ladybug's total acceleration?



A) 

B) 

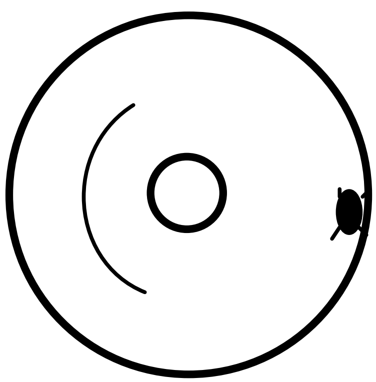
C) 

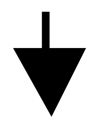
D) 

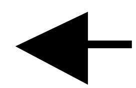
E) None of these

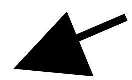
Concept Check

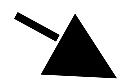
A ladybug is clinging to the rim of a spinning wheel which is spinning CCW very fast and is slowing down. At the moment shown, what is the approximate direction of the ladybug's total acceleration?



A) 

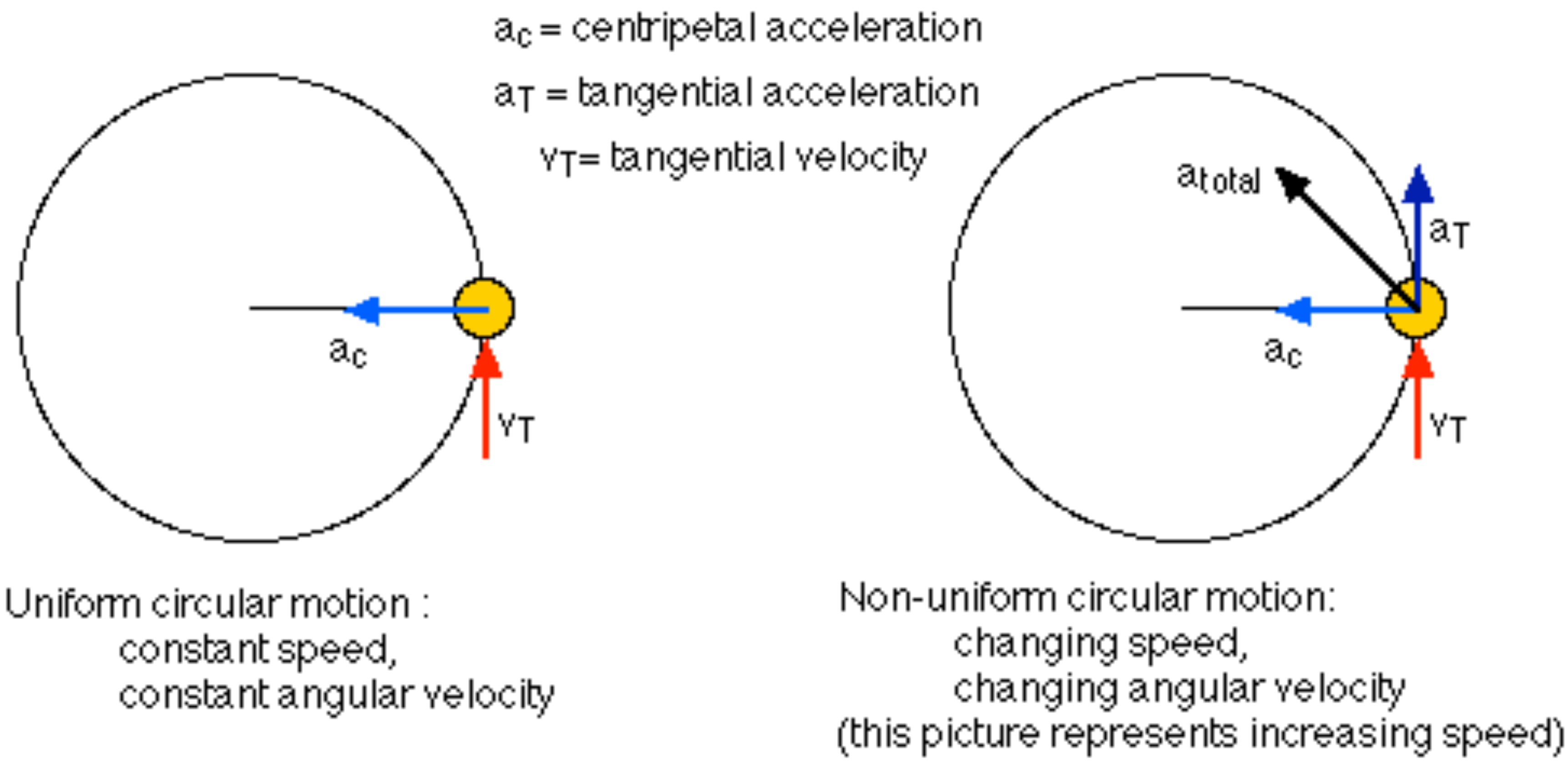
B) 

C) 

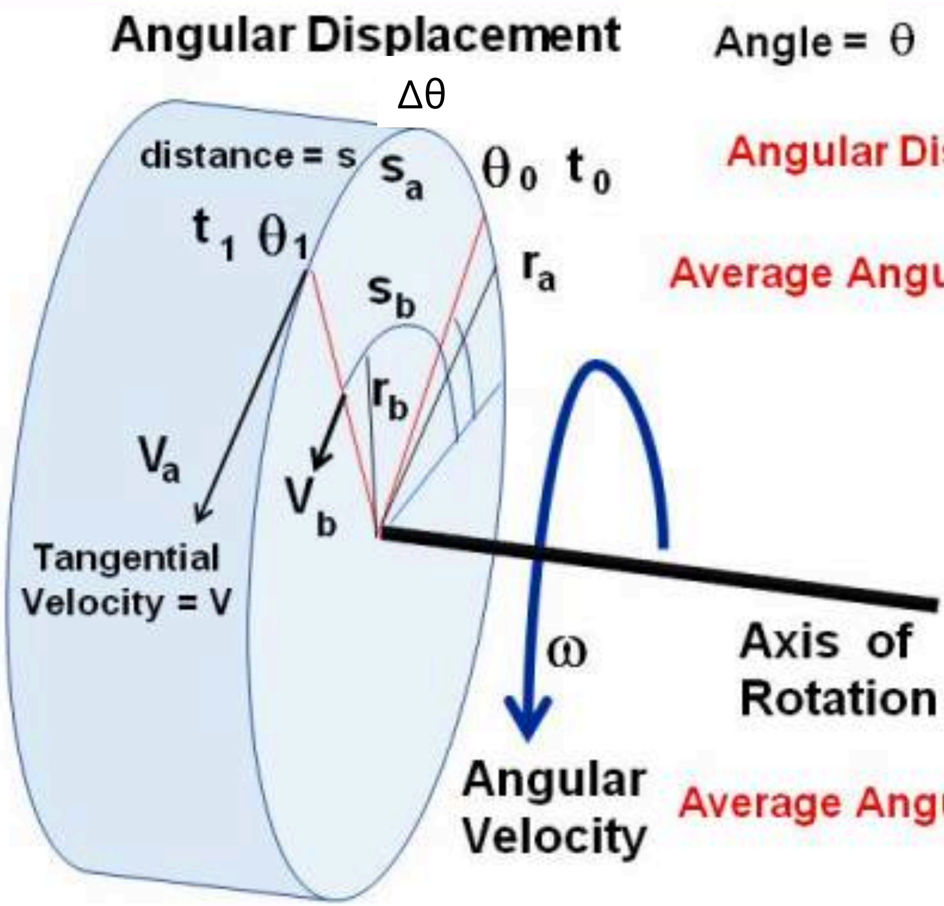
D) 

E) None of these

Centripetal and Tangential Acceleration



Angular Kinematic Variables



Angle = θ time = t radius = r

Angular Displacement $\Delta\theta = \theta_1 - \theta_0$

Average Angular Velocity $\omega = \dfrac{\theta_1 - \theta_0}{t_1 - t_0}$

Average Angular Acceleration $\alpha = \dfrac{\omega_1 - \omega_0}{t_1 - t_0}$

Angular Vs. Tangential Variables

Linear and Rotational Quantities

Linear	Type	Rotational	Relation (θ in radians)
S = x	displacement	θ	S = $x = R\theta$
v	velocity	ω	$v = R\omega$
$a_{\tan}$	acceleration	α	$a_{\tan} = R\alpha$