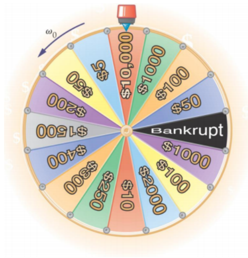
PRACTICE	LABS	TESTS
	Roller Coaster Lab (Due Tues. 3/19)	Unit 12 Test Friday (3/29/19)

UNIT 12

Rotational Motion and Equilibrium



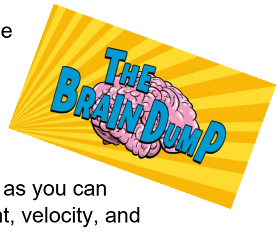
12.1	Describing Angular Motion
12.2	Rolling Motion and the Moment of Inertia
12.3	Torque
12.4	Static Equilibrium

Describing Rotational Motion

12.1	I can describe, interpret, and solve problems involving angular motion.

UNIT 12 IN CLASS PROBLEMS

You have learned how to describe the motion of an object by its displacement, velocity, and acceleration.



1. In 60 seconds, write as much as you can remember about displacement, velocity, and acceleration.

Describing Motion θ

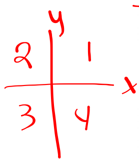
Quantity	Linear	Angular
Position	*x*	θ
Speed / Velocity	*v*	ω
Acceleration	*a*	α

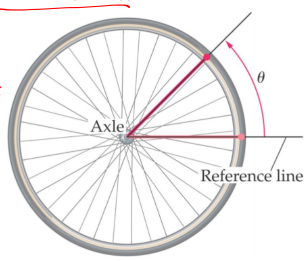
Angular Position, Velocity, and Acceleration

Definition of Angular Position, θ

θ = angle measured from reference line

SI unit: radian (rad), which is dimensionless





Angular Position, Velocity, and Acceleration

Sign Convention for Angular Position

By convention:

$\theta > 0$ counterclockwise rotation from reference line

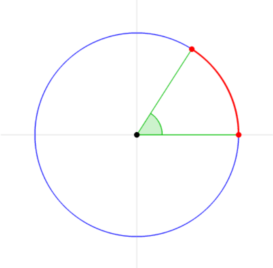
$\theta < 0$ clockwise rotation from reference line

Degrees and revolutions:

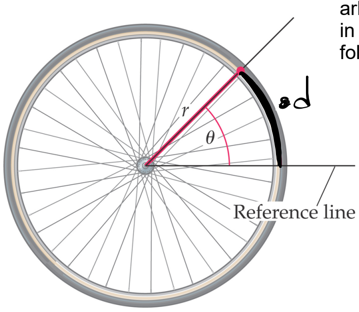
$$1 \text{ rev} = 360°$$

Angular Position, Velocity, and Acceleration

- While common units for measuring angles are the degree (°) and revolution (rev), the most convenient unit for angle measurements in scientific calculations is the radian (rad).
- As the figure indicates, the radian is the angle for which the length of a circular arc is equal to the radius of the circle.



Arc Length



The arc length, *s*, for an arbitrary angle, *θ*, measured in radians is given by the following relation:

$$\boxed{d = r\,\theta}$$

$d = r \cdot 2\pi$

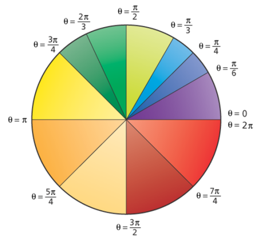
$C = \pi d$

$\frac{C}{d} = \pi$

Angular Displacement

Revolutions, Degrees, and Radians

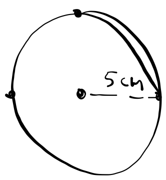
$$\boxed{1 \text{ rev} = 360° = 2\pi \text{ rad}}$$



EXAMPLE How Many Degrees?

How many degrees correspond to 1 radian?

$$1 \cancel{\text{rad}} \times \frac{360°}{2\pi \cancel{\text{rad}}} = 57.3°$$



$d = 2r$

Angular Speed and Velocity

Angular Velocity is defined as the change in angular position divided by the time required to make the change.

$$\boxed{\omega = \frac{\Delta\theta}{\Delta t}}$$

Units – (rad/s)

Angular Velocity

The 1909 Looff Carrousel, in Spokane's Riverfront Park, is on the National Register of Historic Places and is one of America's most beautiful and well preserved hand-carved wooden carrousels.

Angular Velocity

An average ride on the carrousel runs for 3.5 minutes and the carrousel makes 17.5 revolutions during that time.

a) What is the angular displacement for one ride?

$\theta = 17.5 \text{ rev} \times \frac{2\pi \text{ rad}}{1 \text{ rev}} = 35\pi \text{ rad} = 110 \text{ rad}$

b) What is the angular velocity of the carrousel in rad/s?

$\omega = \frac{\Delta\theta}{t} = \frac{110 \text{ rad}}{3.5 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ s}}$

$= 0.52 \frac{\text{rad}}{\text{s}}$

Angular Acceleration

Angular Acceleration is defined as the change in angular velocity divided by the time required to make the change.

$$\boxed{\alpha = \frac{\Delta\omega}{\Delta t}}$$

Units – (rad/s^2)

UNIT 12 IN CLASS PROBLEMS

2. Convert the following angles to radians. 37°, 90°
3. Convert the following angles to degrees.

   π/6 rad, 1.5π rad
4. An antique long-playing (LP) phonograph record rotates clockwise at $33\frac{1}{3}$ rpm (revolutions per minute). What is its angular velocity in radians per second?
5. As you start riding a bicycle, the wheels begin at rest and have an angular acceleration of 2.3 rad/s^2. What is the angular speed of the wheels after 3.8 s?

UNIT 12 IN CLASS PROBLEMS

1. Convert the following angles to radians. 37°, 90°

$37° \times \frac{2\pi \text{ rad}}{360°} = 0.65 \text{ rad}$ 　 $90° = \pi/2 \text{ rad} = 1.6 \text{ rad}$

2. Convert the following angles to degrees.

   π/6 rad, 0.70 rad, 5π rad

$\pi/6 \text{ rad} \times \frac{360°}{2\pi \text{ rad}} = 30°$ 　 $1.5\pi \text{ rad} = 270°$

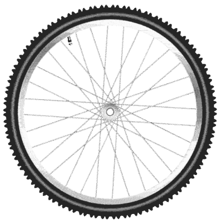
UNIT 12 IN CLASS PROBLEMS

3. An antique long-playing (LP) phonograph record rotates clockwise at $33\frac{1}{3}$ rpm (revolutions per minute). What is its angular velocity in radians per second?

$\frac{-33\frac{1}{3} \text{ rev}}{\text{min}} \times \frac{2\pi \text{ rad}}{1 \text{ rev}} \times \frac{1 \text{ min}}{60 \text{ s}} = -3.49 \text{ rad/s}$

UNIT 12 IN CLASS PROBLEMS

4. As you start riding a bicycle, the wheels begin at rest and have an angular acceleration of 2.3 rad/s^2. What is the angular speed of the wheels after 3.8 s?



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

$$2.3\ \text{rad/s}^2 = \frac{\omega_f - 0}{3.8\ \text{s}} \qquad \omega_f = 8.7\ \text{rad/s}$$