Circular Motion

IB Physics Content Guide

Big Ideas

- Objects moving in a circle are experiencing acceleration since the direction of the velocity is constantly changing
- If an object is moving at a constant speed in a circle, there is a net force directed toward the center of the circle
- It is useful to draw a free body diagram to determine what forces are present at a given position

1 – Defining Circular Motion

I can convert between angular displacement in revolutions and radians			
I can define and measure the period of circular motion			
I can calculate angular velocity in radians per second			
I can describe and calculate tangential velocity based on the angular velocity and radius			
I can determine the direction and magnitude of centripetal acceleration and centripetal force			

2 – Circular Motion in Force Fields

I can calculate the speed of an orbiting object based on the distance and mass of the object it's orbiting around			
I can describe the motion of a charged particle in a magnetic field			
I can use the magnetic force with circular motion to calculate the properties of a particle moving through a magnetic field			

3 – Orbits

I can describe Kepler's Three Laws of Planetary Motion			
I can use Kepler's 3rd Law to mathematically compare the period and radius of an orbit			

4 – Vertical Circular Motion

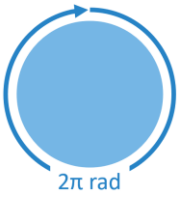
I can draw correctly proportioned free body diagrams for horizontal and vertical circular motion			
I can compare the forces on an object at different positions in vertical circular motion			
I can identify the combination of forces that make the net force that results in circular motion.			
I can determine the magnitude and direction of the forces needed to move in a vertical circle			

5 – Circular Motion Scenarios

I can draw and solve a problem when circular motion is produced by a normal force			
I can draw and solve a problem when circular motion is produced by a friction force			
I can draw and solve a problem when circular motion is produced by components of an angled tension force			

	Variable Symbol	Description	Unit
$F = ma$ $a = \frac{v^2}{r} = \omega^2 r = \frac{4\pi^2 r}{T^2}$ $v = \frac{2\pi r}{T} = \omega r$	F	Net Force (Centripetal)	[N]
	m	Mass	[kg]
	a	Acceleration (Centripetal)	[m/s^2] or [m s^{-2}]
	v	Linear Velocity	[m/s] or [m s^{-1}]
	ω	Angular Velocity	[rad/s] or [rad s^{-1}]
	r	Radius	[m]
	T	Period (Time per revolution)	[s]

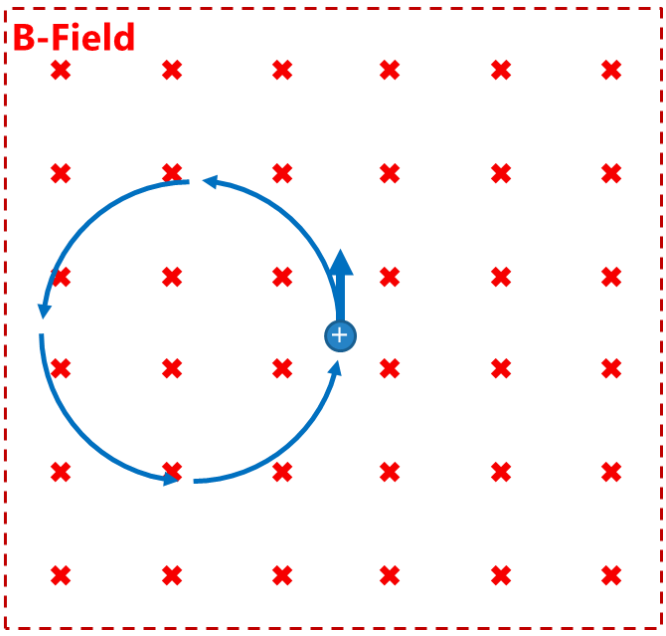
Defining Circular Motion

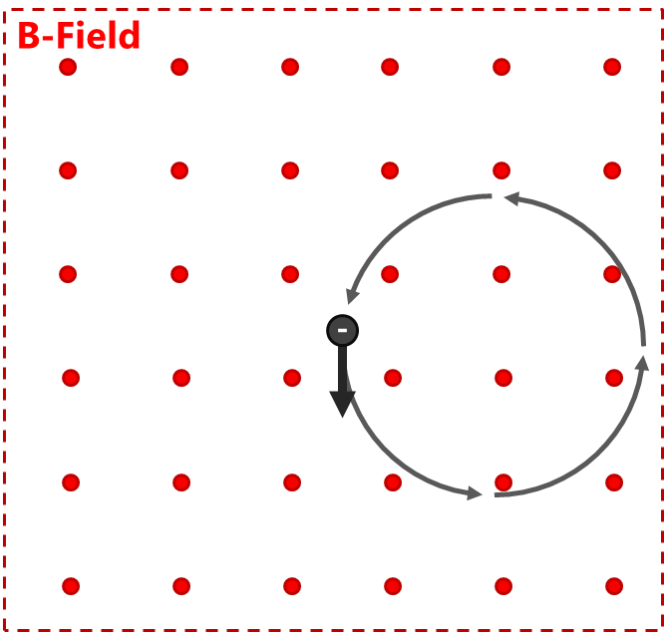


Period	T	[s]	Angular Velocity	ω	[rad s^{-1}]
Time per revolution			$\omega = \frac{2\pi}{T}$		

Circular Motion in Force Fields

Relationship between gravitational field strength and circular motion acceleration	g = a

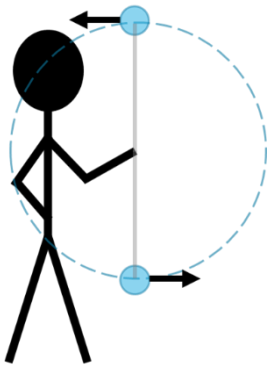
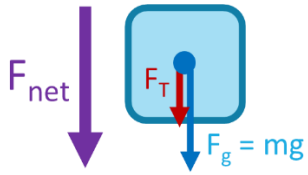
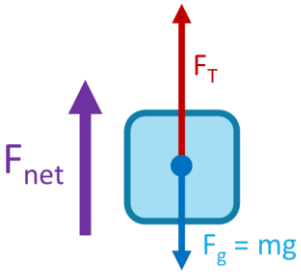




Orbits

Kepler's 1st Law	The orbit of every planet is an ellipse with the Sun at one focus.
Kepler's 2nd Law	A line drawn from a planet to the Sun sweeps out equal areas in equal times.
	Closer to the star = Planet is moving faster
Kepler's 3rd Law	A planet's orbital period is related to its average distance from the Sun
	$T^2 = \frac{4\pi^2}{GM} r^3$

Vertical Circular Motion

	Top: 	Bottom: 

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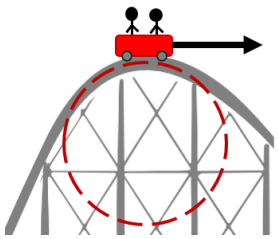
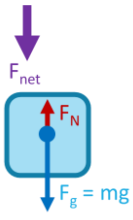
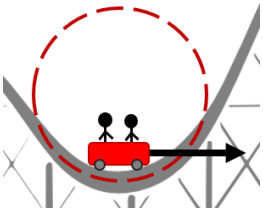
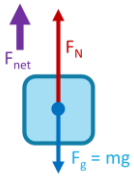
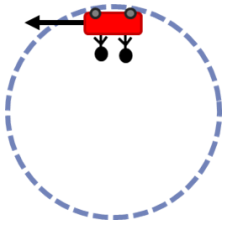
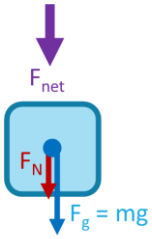
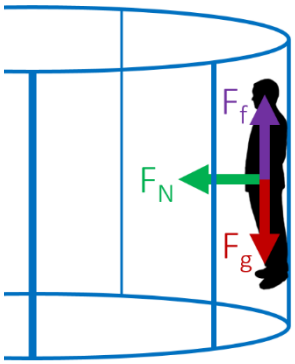
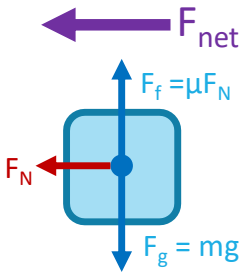
					

Circular Motion with Friction and Angles

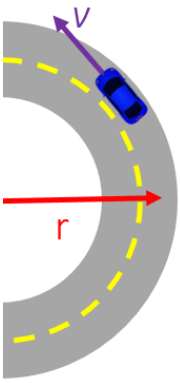


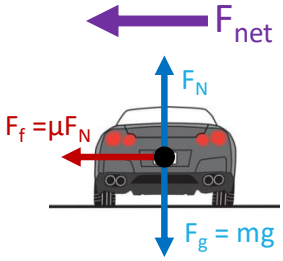


Relationships between variables:

$$F_f = F_g$$

$$F_{net} = F_N$$

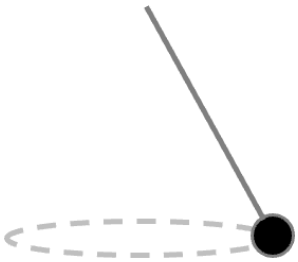


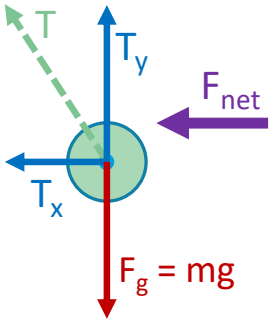


Relationships between variables:

$$F_N = F_g$$

$$F_{net} = F_f$$





Relationships between variables:

$$T_y = F_g$$

$$F_{net} = T_x$$