

Chapter 7: Circular Motion

_____ - Spin about an axis located within the body
Example:

_____ - Spin about an axis located outside the body.
Example:

Example: Explain why it feels like you are pulled to the right side of the car when going around a left-handed turn?

- Angular acceleration arises when a spinning object is speeding up or slowing down its spin. (Example: A car tire as a car is speeding up) WE WILL NOT BE TALKING ABOUT THIS TYPE OF ACCELERATION IN THIS UNIT
- _____ acceleration () has to do with the fact that the _____ of an object is always changing even if the speed of the spin is not. (Example: Earth's orbit around the sun)
- _____: (v units:) When an object is going around in the circle, it has a linear velocity that is tangent to the circle at the location of the object. Since the tangential velocity is always changing directions, the object must be accelerating. We call this centripetal acceleration.
- An object moving in circular motion is inherently accelerating (centripetal acceleration) because it is constantly changing direction. It must therefore have a net force continually acting on it. We call this net force the _____.
- The centripetal force (which is the net force which causes circular motion) always points toward _____.

Example: A car rounds a curve while maintaining a constant speed. Is there a net force on the car as it rounds the curve? Explain.

Equations for Centripetal Acceleration:

If an object is traveling in a _____ there MUST be a _____ on that object causing a _____.

One equation for Centripetal Acceleration:

Where a_c = centripetal acceleration (m/s^2)
 v = linear/tangential velocity (given in m/s)
 r = radius (in meters)

_____ (T): The time it takes for an object to complete one full rotation or revolution.
(Remember: 1 revolution or rotation = $360^\circ = 2\pi$ radians)

Another equation for Centripetal acceleration:

Where a^c = centripetal acceleration (m/s^2)

T is the period or the time it takes for one revolution. (in seconds)

r = Radius of spin (in meters)

Example: A child 1.35 m from the center of a merry-go-round is moving with a period of 2.0 minutes. What is her centripetal acceleration in m/sec^2 ?

Example: On a day when the roads are icy, the coefficient of friction between a typical tire and the pavement is 0.200. What is the maximum speed a car can make a turn of radius _____?

- Roads can be banked (or tilted), to reduce the need for friction to make a turn.

Example: A daredevil drives a motorcycle on a loop the loop track. What is the slowest he can go and still make it? Remember: mg is constant, but the normal force varies with the speed.

Example: If the man and the motorcycle have a combined mass of 350 kg, what is the normal force at the bottom of the ramp?

Gravitational Field & Gravitational Force:

- The gravitational force is an _____ force between two _____.
- Gravity is a _____ force. The masses don't need to be in contact with each other to cause attraction.

What goes up must come back down:

Why? _____ But why?

- Jumping with a large backpack on is a lot harder than jumping with a small backpack on. Why?
 - Gravity must have something to do with the _____ (ie. Backpack)
- Dropping an object on Earth is different than dropping that same object on the moon.
 - The object will fall to the ground in both scenarios, but the rates are different. Why?
 - The moon is less _____ than the Earth, so falling (caused by gravity) must be directly related to the mass of one object (the Earth or the moon) causing a second object (an apple, a ball) to fall.
- What about distance between the two masses?
 - It turns out, the gravitational force _____ with distance, but not linearly.
 - If you double the distance between two objects the force of gravity between them decreases by a factor of 4.
 - If you quadruple the distance between two objects, the force of gravity decreases by a factor of 16!
 - This is the inverse square law:

So what is gravity?

Gravity is the force of attraction between two masses.

Where $G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2$ (The Universal Gravitation Constant)

M_1 and M_2 = The masses of the two objects in kg

r = the distance between the two objects in meters

Example: He is obviously attracted to her. But, how much force of attraction is there? Assume: His mass = _____, Her mass = 52 kg, and separated by 0.75 m

Example: Determine the force of gravitational attraction between the earth ($m = 5.98 \times 10^{24} \text{ kg}$) and a 70. kg physics student flying in an airplane _____ ft (12,000 m) above the surface of the Earth (radius of Earth = $6.3781 \times 10^6 \text{ m}$).

Field Force:

- Gravity is a _____ force, meaning the two masses will attract each other even when they aren't in _____ with each other.
- This force of attraction will cause the masses to _____ towards each other.
- Masses create gravitational fields around themselves. Any other _____ in that gravitational field will experience a _____ of attraction.
- It is this gravitational field that causes gravity to be able to act at a distance on other masses.

Calculating Gravitational Fields:

Where

g = gravitational field

$G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2$ (The Universal Gravitation Constant)

M_1 = mass of the object CREATING the field (kg)

r = the distance from the center of the object creating the field to the point you are looking at (m)

Units:

Example: Calculate Earth's Gravitational Field. $M_{\text{Earth}} = 5.98 \times 10^{24} \text{ kg}$ and radius of Earth = $6.3781 \times 10^6 \text{ m}$

Example: A satellite is halfway between the Earth and the moon. What is the net gravitational field at that location. ($M_{\text{Earth}} = 5.98 \times 10^{24} \text{ kg}$; $M_{\text{moon}} = 7.36 \times 10^{22} \text{ kg}$; $r_{\text{earth-moon}} = 3.8 \times 10^8 \text{ m}$)

What does a gravitational field of 0.0109 N/kg mean?

- Any object placed at that location will accelerate towards the Earth at 0.0109 m/s^2 regardless of its mass.
- It will also let us calculate the force of gravity on any object placed at that location using $F = mg$

$$F_{\text{gravity}} = \frac{GM_1m_2}{r^2} \quad F_{\text{gravity}} = mg$$

Example: Back to the satellite: If a 150 kg satellite is placed in orbit halfway between the Earth and the moon, what will the force of gravity be on the satellite?

Example: The satellite is in orbit around the Earth (instead of floating off in a straight line towards Jupiter). What is the magnitude/strength of the centripetal force?

Example: Explain why a ball launched at _____ km/sec will go into orbit.

Example: Jupiter's moon Io orbits Jupiter once every 1.769 days and is at a distance of 4.217×10^8 m from Jupiter. What is the mass of Jupiter?

Calculating the speed of a satellite: (wait for the boxed equation...)

v = tangential velocity of satellite (m/s)

$G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$

M = mass (kg) of planet being orbited

r = radius (m) of orbit

= (radius of planet + height of satellite above planet's surface)

Example: A satellite orbits Earth at a speed of 8500 m/s. Which picture correctly depicts the direction of the velocity?

Calculating the Period of a Satellite: (wait for the boxed equation...)

T = period (sec), time to orbit planet once

$G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$

M = mass (kg) of planet being orbited

r = radius (m) of orbit

= (radius of planet + height of satellite above planet's surface)

Example: Earth has a mass of 5.97×10^{24} kg while the moon has a mass of 7.4×10^{22} kg. If the moon is 3.8×10^8 m away, what is the moon's (a) velocity, (b) period?

How do the tides work?

What we already know:

Picture of Earth w/ high tides:

The new part:

Spring Tides:

Neap Tides: