

Circular Motion

Centripetal Acceleration

- Velocity
 - Vector quantity -
 - Change in direction causes a change in velocity, even

- **Uniform circular motion** - motion of an object in a circle with a

- Velocity =

- The distance around a circle is the
- Period is the time it takes to make one cycle around the circle.

- Average velocity :

- Objects moving at different radius in the same period will have

- In circular motion, the direction of the velocity is
- The direction of the velocity is tangential to the
- Average acceleration is the

- Acceleration =

- The change in velocity is towards the
- **The acceleration is towards the**
- The object is accelerating just because it

- Objects moving in a circular path, at a constant speed, experience an acceleration which is directed

- $a_c =$

- Constant acceleration (constantly changing direction)

- $v_c =$

- $a_c =$

- Note that the velocity and acceleration are not

Centripetal Force

- Newton's 1st Law : objects in motion tend to stay in motion, with the same speed and direction, unless acted
- Objects tend to keep going in the
- It takes a net force to
- **Centripetal force** - a physical force pushing or pulling an object towards the

- Road provides friction causing the car
- If there was a patch of ice, the car would go
- Inertia would keep it moving in a

- $F_c =$

- $F_c =$

- The centripetal force is in the same direction as the acceleration, towards the

Critical Velocity

- Lowest velocity required to keep an object from dropping out of a "loop-the-loop"

- $F_c =$

- $ma_c =$

- $a_c =$

-

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1. A carnival clown rides a motorcycle down a ramp and around a "loop-the-loop." If the loop has a radius of 18m, what is the slowest speed the rider can have at the top of the loop to avoid falling?

2. A 75 kg pilot flies a plane in a loop. At the top of the loop, where the plane is completely upside-down for an instant, the pilot hangs freely in the seat and does not push against the seat belt. The air speed indicator reads 120 m/s. What is the radius of the plane's loop?

5. I rode the *Gravitron* at the fair (and didn't get sick)! On this ride, you stand against the inside of a drum that rotates around. When you get going fast enough, they drop the floor and you don't fall because the centripetal force causes friction. The friction is balanced by your weight and you don't fall down, even if you didn't say your prayers last night! Suppose this carnival ride has a 2.5 m radius and rotates 1.1 times each second. Find the speed of a rider, the centripetal acceleration of a rider, and the coefficient of friction that is needed to keep the riders from slipping. Describe what causes this acceleration.

Simple Harmonic Motion Universal Gravitation

Simple Harmonic Motion

- Vibration about an equilibrium position with a restoring force that is proportional to the
- It is a back-and-forth motion over
- A force causes the motion to continue
- Equilibrium position is when the object
- A spring vibrating is SHM. The restoring force is the
- Pendulum swinging is SHM. The restoring force is
- Velocity is
 - acceleration is
 - displacement is
 - balanced forces - inertia keeps
- Velocity is
 - acceleration is
 - displacement is
 - Net force is

Pendulum

- A mass, called a bob, attached to a string
- Swings side to side -
- Restoring force is the
- Angle of swing should be
- The period is based on the length of the
-
- $l =$
- $T =$
- $T^2 =$
- $g =$
- Note that the mass of the bob is not a factor in calculating

Mechanical Resonance

- Application of small forces at regular intervals to a vibrating object causes the size (amplitude) of the
- The time interval between applying the force must be the same as the

- This is how you keep the
- Soldiers do not march
-

Universal Gravitation

- Newton studied the planets and
- He proposed a
- Attractive force that exists between all objects in the
- Law of

- $F =$

- Inverse

- $F :$
- $G :$
□ $G =$
- d : distance between the centers of the
- m_1 : mass of
- m_2 : mass of

- Henry Cavendish measured the universal gravitational constant by measuring the
- Using this constant, they were able to calculate the

- Calculating the mass of the Earth!
- $F_W =$

- $F =$

- $m_{\text{you}}g =$

- $m_{\text{earth}} =$

- $m_{\text{earth}} =$

- Objects orbiting the Earth:

- $F_c =$

-

-

-

- $F_c =$

-

-

-

-

Kepler's Laws

- Tycho Brahe -

- Believed Earth was the

- Recorded the exact position of the planets and the

- Johannes Kepler -

- 45 years before

- Believed in a sun-centered

- Worked as Brahe's

- Used Brahe's data to formulate the following

- Kepler's 1st Law

- Paths of the planets are ellipses, with the

- Kepler's 2nd Law

- An imaginary line from the sun to a planet sweeps out equal areas

- Planets move faster when closer to the sun and slower

- Kepler's 3rd Law

- The square of the ratio of the periods of any two planets revolving about the sun is equal to the cube of the ratio of their

-

- T :

- r :

6. The mass of an electron is 9.1×10^{-31} kg. The mass of a proton is 1.7×10^{-27} kg. They are about 1.0×10^{-10} m apart in a hydrogen atom. What gravitational force exists between the proton and the electron of a hydrogen atom?
7. Two satellites of equal mass are put into orbit 30 m apart. The gravitational force between them is 2.0×10^{-7} N.
- What is the mass of each satellite?
 - What is the initial acceleration given to each satellite by the gravitational force?
8. Two large spheres are suspended close to each other. Their centers are 4.0 m apart. One sphere weights 980 N. The other sphere has a weight of 196 N. What is the gravitational force between them?

9. If the centers of the Earth and the Moon are 3.9×10^8 m apart, the gravitational force between them is about 1.9×10^{20} N. What is the approximate mass of the moon?
10. A satellite is placed in a circular orbit with a radius of 1.0×10^7 m, and period of 9900 sec. Calculate the mass of the Earth. Hint: gravity supplies the needed centripetal force for such a satellite. Scientists have actually measured the mass of Earth this way.
11. If you weight 637N on Earth's surface, how much would you weigh on the planet Mars? (Mars has a mass of 6.37×10^{23} kg and a radius of 3.43×10^6 m.)

12. Magellan, the first planetary spacecraft to be launched from a space shuttle, took pictures of Venus. During the spacecraft's fifth orbit around Venus, Magellan traveled at a mean altitude of 361 km. If the orbit had been circular, what would Magellan's period and speed have been?

13. At what distance above the Earth would a satellite have a period of 125 minutes?

14. A pendulum has a length of 1.00 m. What is its period on Earth? What is its period on the moon where acceleration due to gravity is 1.63 m/s^2 ?

15. What is acceleration due to gravity on a planet where a pendulum with a length of 0.55 m has a period of 1.3 sec?

Fluids

Fluids

- Matter that flows and does
- Liquids and
- Very little resistance to a change in shape when
- Ideal Fluids - no internal friction
- Fluids exert

Pressure

- Force of particles when they collide with the

■ Pressure =

■ $P =$

■ Symbol =

■ Units =

■ $1000 \text{ Pa} =$

■ $1 \text{ atm} = 101 \text{ kPa} =$

■ Area Circle =

Bernoulli's Principle

- As the velocity of a fluid increases, the pressure exerted by
- Mass of fluid flowing into the pipe must be the same as the mass of

■ As the area decreases, the fluid must flow faster.

■ Helps

■ $Mass_{in} =$

■

■ $m =$

■

■ $V =$

■ A_{in}

■ $Velocity = v =$

■ $A_{in}v_{in}$

■ $A_{in}v_{in} =$

■ $Area \times velocity (in) =$

■ $Flow\ rate =$

■ $Flow\ rate =$

■ $Flow\ rate =$

■ $Flow\ rate\ is\ how$

■ $When\ the\ river\ is\ shallow\ or\ narrow,$

■ $When\ the\ river\ is\ deep\ or\ wide,$

Pascal's Principle

■ Any change in pressure applied to a confined fluid, at any point, is transmitted

■ Used in

■ A type of

■ $P =$

Pressure Below a Fluid

■ Pressure below a fluid is caused by the weight of the fluid. (pressure at the

■ $F_w =$

■ $P =$

■ Density :

■ $P =$

■ $P =$

■ $P =$ (Pressure at the bottom of the pool!)

■ is the density of the fluid (

■ $g =$

■ h is the height of the

■ Pressure is dependent on the density of the fluid and the height

■ Pressure does not matter how big or small the swimming pool is, just how

■ You are under pressure from the air above you - 101,000 Pa - weight of the

■ Density of water :

■

■

■

■ Density =

Buoyancy

■ Buoyant Force - force of a fluid pushing up on an object

Depends only on the weight of the f

$F_{buoy} =$

$F_{buoy} =$

is the density of the fluid!

$F_{\text{buoy}} =$

Weight of fluid displaced - Not

■ The buoyancy is caused by the greater pressure (force) of the fluid

■ Archimedes Principle - helps

An object immersed in a fluid is buoyed up by a force equal to the weight of the

Force pushing up on the object depends on the

■ To determine if an object will sink, float (suspend), or rise up you have to determine the

$F_W >$

$F_W =$

$F_W <$

■ Objects immersed in water appear to weigh less. That is because the buoyant force is

■ $0 = F_{\text{apparent}}$

■ $F_W =$

16. How tall must a column of mercury, $\rho = 13600 \text{ kg/m}^3$, be to exert a pressure equal to the atmosphere?

17. A dog, with 4 legs, whose paw has an area of 12.0 cm^2 , has a mass of 8.0 kg . What average pressure does the dog exert while standing?
18. A rowboat, mass 42.0 kg , is floating on a lake.
- What is the size of the buoyant force?
 - What is the volume of the submerged part of the boat?
19. A hydraulic lift has a large piston of 20.00 cm diameter and a small piston of 5.00 cm diameter. How much force is required to lift a $1,785 \text{ kg}$ car?

20. A piece of metal weighs 75.0 N in air and 60.0 N in water. What is the density of the metal?
21. A river barge with vertical sides is 20.0 m long and 10.0 m wide. If it floats 3.00 m out of the water when empty. When loaded with coals, the water is only 1.00 m from the top. What is the weight of the load of coal?
22. During an ecology experiment, an aquarium half filled with water is placed on a scale. The scale reads 195 N.
- A rock weighing 8 N is added to the aquarium. If the rock sinks to the bottom of the aquarium, what will the scale read?
 - The rock is removed from the aquarium, and the amount of water is adjusted until the scale again reads 195 N. A fish weighing 2 N is added to the aquarium. What is the scale reading with the fish in the aquarium?

23. A bargain hunter purchases a "gold" crown at a flea market. After she gets home, she hangs it from a scale and finds its weight to be 7.84 N. She then weighs the crown while it is immersed in water and the scale reads 6.86 N. Is the crown made of pure gold? The actual density of gold is $19.3 \times 10^3 \text{ kg/m}^3$.
24. Each second, $5,525 \text{ m}^3$ of water flows over the 670 m wide cliff of the Horseshoe Falls portion of Niagara Falls. The water is approximately 2.0 m deep as it reaches the cliff. Estimate its velocity at that instant.

25. A water hose 2.50 cm in diameter is used by a gardener to fill a 30.0 L bucket (1 L = 1000 cm³). The gardener notices that it takes 1.00 min to fill the bucket. A nozzle with an opening of cross sectional area 0.500 cm² is then attached to the hose. Over what horizontal distance can the water be projected?