Gravitation

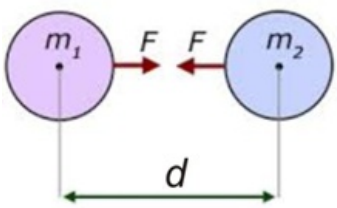
Gravitation and Universal Law of Gravitation

Q.1 What is Gravitation force?

A force that attracts any objects with mass. Every object is pulling on every other object in the entire universe, is called Gravitational force.

Q.2 Define universal law of gravitation? Name the scientist who gave this law?

The Universal law of Gravitation states that any two bodies having mass attract each other with force directly proportional to the product of their mass and inversely proportional to the square of distance between them. The force acts along the line joining the centres of the objects.



$$F \propto \frac{m_1 m_2}{d^2}$$

Therefore $F = \frac{G m_1 m_2}{d^2}$

Here, G is Universal gravitational constant = $6.673 \times 10^{-11} N m^2 kg^{-2}$. The value of G was found out by Henry Cavendish. Isaac newton gave this law.

Q.3. What is importance of Gravitational force?

Importance of Gravitational Force:

- It binds us to Earth.

- Moon revolves around Earth due to gravitational force. Planets revolve around Sun due to gravitational force.

- Tides in seas are caused due to gravitational force of moon on earth.

Q.4 What is value of gravitational force, if masses of objects are large?

If masses of object are large, Gravitational force will be more.

Q.5 What is value of gravitational force, if distance between two objects is more?

If distance between two objects is more, force exerted will be less and vice versa.

Q.6 What is value of gravitational constant G?

G is Universal gravitational constant = $6.673 \times 10^{-11} N m^2 kg^{-2}$

Q.7 Which force is responsible for moon revolving round the earth?

Gravitational force is responsible for moon revolving around the earth.

Q.8 Give the formula for gravitational force between two bodies of masses M and m kept at a distance d from each other.

The formula for gravitational force between two bodies of masses M and m kept at a distance d from each other:

$$F = \frac{GMm}{d^2}$$

Here, G is Universal gravitational constant = $6.673 \times 10^{-11} N m^2 kg^{-2}$. The value of G was found out by Henry Cavendish.

Q.9 What type of force is involved in the formation of tides in the sea?

Tides in seas are caused due to gravitational force of moon on earth.

Q.10 Which force is responsible for holding the solar system together?

Gravitational force by Sun is responsible for holding the solar system together.

Q.11 What name has been given to the force with which two objects lying apart attract each other?

Gravitational force has been given to the force with which two objects lying apart attract each other.

Q.12 State two application of universal law of gravitation?

Two application of universal law of gravitation:

• Moon revolves around Earth due to gravitational force. Planets revolve around Sun due to gravitational force.

• Tides in seas are caused due to gravitational force of moon on earth.

Q.13 What happens to gravitational force between two objects when the distance between them is doubled?

The gravitational force between two objects is inversely proportional to the square of distance between them.

$$F \propto \frac{1}{d^2}$$

When the distance between them is doubled then Gravitational force will become one – forth.

Q.14 What happens to gravitational force between two objects when the distance between them is halved?

The gravitational force between two objects is inversely proportional to the square of distance between them.

$$F \propto \frac{1}{d^2}$$

When the distance between them is halved then Gravitational force will become four times.

Free fall bodies, Air resistance

Q.15 What is meant by term free fall'?

The earth attracts objects towards it due to gravitational force. When an object moves such that only gravitational force of earth acts on it, it is said to do "Free Fall".

Q.16 Derive the expression for attraction force of Earth on object close to its surface?

When an object is near the surface of earth, the distance between object and centre of the earth will be equal to the radius of earth (i.e. R_E) because the distance of object is negligible in comparison of the radius of earth.

Therefore,

$$F = \frac{GM_E m}{R_E^2}$$

Therefore

$$F = m\left(\frac{GM_E}{R_E^2}\right)$$

Therefore

F = mg …(i)

Where, $g = \left(\frac{GM_E}{R_E^2}\right)$

g = acceleration due to gravity. Value of $g = 9.8 m/s^2$

Q.17 Does the acceleration produced in a freely falling body depend on the mass of the body?

No, the acceleration produced in a freely falling body does not depend on the mass of the body because gravitational acceleration $g = 9.8 m/s^2$ is constant.

Q.18 Define gravitational constant. What is the S.I unit of gravitational constant?

G is universal gravitational constant = $6.673 \times 10^{-11} N m^2 kg^{-2}$. The value of G was found out by Henry Cavendish. S.I Unit of gravitational constant is $N m^2 kg^{-2}$.

Q.19 What is meant by the term uniform motion?

When an object moves with constant velocity, such motion is called uniform motion.

Q.20 What is the meant by the term ‘accelerated motion’?

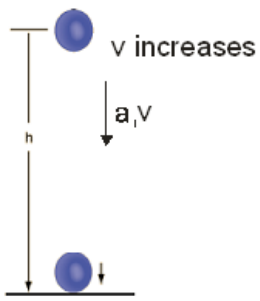
When an object moves with increasing velocity, motion is called accelerated motion.

Q.21 What do you mean by the term ‘retarded motion’?

When an object moves with decreasing velocity, motion is called retarded motion.

Q.22 Derive the expression for acceleration of free falling body, when an object is released from top?

When an object is released from top, it falls down due to gravitational force of earth. As force acts downwards, acceleration ‘a’ would be in downward direction. As object is moving downwards and acceleration is also in downward direction, velocity increases. So when an object is released from top, it does accelerated motion (increasing velocity).



Calculation of acceleration ‘a’:

According to Newton’s 2nd Law

F = ma

Therefore

$$a = \frac{F}{m}$$

From equation (i)

Therefore

$$a = \frac{mg}{m}$$

Therefore

a = g = $9.8 m/s^2$

Thus acceleration acted on a falling object is equal to ‘g’ (acceleration due to gravity).

Q.23 During a free fall, will heavier objects accelerate more than lighter ones?

No, during a free fall, heavier objects will not accelerate more than lighter ones because acceleration does not depend on mass of object.

Q.24 Write the equations of motion for freely falling object?

We have studied three equations of motion.

v = u + at

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

These equations can be used to calculate the value of velocity, distance, etc by replacing ‘a’ by ‘g’. Now equations become:

v = u + gt

$$s = ut + \frac{1}{2}gt^2$$

$$v^2 = u^2 + 2gs$$

The value of ‘g’ is taken as positive in the case of object moving towards earth and taken as negative in the case of object is thrown in opposite direction of earth.

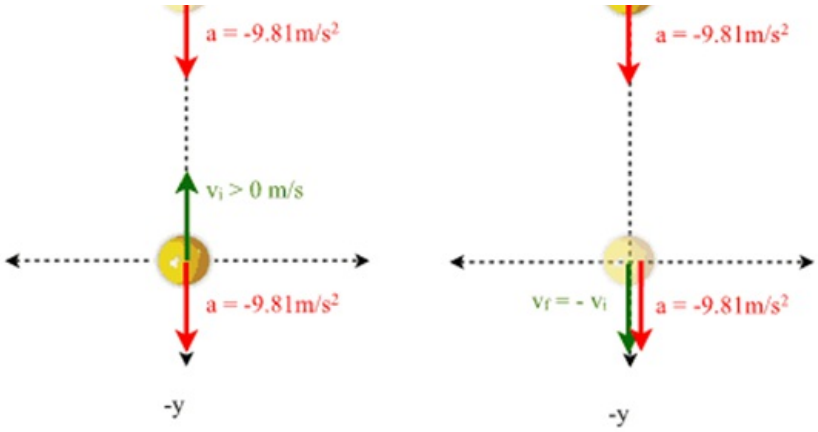
Q.25 Explain why, if a stone held in our hand is released, it falls towards the earth.

If a stone held in our hand is released, it falls towards the earth because of gravitational force. This force acts between earth and stone, that’s why it falls towards the earth.

Q.26 When we throw a ball upward in the air, for this case how can we calculate the value of velocity, distance and time?

If we throw a ball upward in the air, a gravitational force acts downwards on it. As force acts downwards, acceleration is in downwards direction. It means velocity will decrease with time and at one point, it becomes zero.

Due to the gravitational force, the ball takes U-turn and reaches to ground with same speed with which it was thrown up. As object is moving downwards and acceleration is also in downward direction, velocity increases.



Note: We have studied three equations of motion.

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

These equations can be used to calculate the value of velocity, distance, etc by replacing 'a' by 'g'.

The value of 'g' is taken as positive in the case of object moving towards earth and taken as negative in the case of object is thrown in opposite direction of earth.

Q.27 What is the S.I Unit of gravitational acceleration?

S.I Unit of acceleration is m/s^2.

Q.28 What is usual value of the acceleration due to gravity of earth?

The usual value of the acceleration due to gravity of earth is $g = 9.8\, m/s^2$.

Q.29 Is the acceleration due to gravity of earth 'g' a constant?

Yes, The acceleration due to gravity of earth 'g' a constant.

Q.30 What do you understand by Air resistance?

All objects of different shape, size and mass should take same time to fall through same distance. But practically it is observed that two objects of different mass hit the ground at different times due to different air resistance on them.

Q.31 What factors affecting Air resistance?

Factors affecting Air resistance:

1. More the mass, lesser the effect of air resistance.

2. More the surface area of object, more the effect of air resistance.

Q.32 Define the variation of in the value of Gravitational acceleration ‘g’?

Variation in the value of ‘g’:

• As we go at large heights, g decreases.

• Since, earth is not a perfect sphere rather it has oblique shape. Therefore, radius at the equator is greater than at the poles. Since, value of ‘g’ is reciprocal of the square of radius of earth, thus, the value of ‘g’ will be greater at the poles and less at the equator.

• Geography of earth is different at different locations such as mountains, plains, oceans. This causes variation in value of g.

Mass and Weight

Q.33 Define mass of an object?

Mass is the quantity of matter present. The mass of a body is always constant and does not change from place to place. Mass has no direction and thus it is scalar quantity. The S.I unit of mass is kg. Mass can be measured using beam balanced.

Q.34 Define weight of an object?

Weight of an object is the gravitational force applied by the earth on that object.

$W = m \times g$

The weight of a body changes from place to place, depending on mass of object.

Since weight always acts vertically downwards, therefore, weight has both magnitude and direction and thus it is a vector quantity. The S.I unit of weight is Newton. Weight can be measured using spring balance.

Q.35 What is the differences between mass and weight ?

Mass	Weight
1. Mass is the quantity of matter present	1. Weight of a body is the gravitational force applied by the earth on that object.
2. The mass of a body is always constant and does not change from place to place.	2. The weight of a body changes from place to place, depending on mass of object.
3. Mass has no direction and thus it is scalar quantity.	3. Weight always acts vertically downwards, therefore, weight has both magnitude and direction and thus it is a vector quantity.
4. The S.I unit of mass is kg	4. The S.I unit of weight is Newton
5. Mass can be measured using beam balanced	5. Weight can be measured using spring balance.

Q.36 What is weight on the surface of moon?

Mass of an object is same on earth as well as moon. But weight is different.

$$\frac{Wt.\ of\ body\ on\ Earth}{Wt.\ of\ body\ on\ Moon} = \frac{\frac{GM_E m}{{R_E}^2}}{\frac{GM_M m}{{R_E}^2}} = \frac{M_E}{{R_E}^2}\frac{{R_M}^2}{M_M}$$

Where M_E is mass of earth = $6\times10^{24}kg$

R_E is radius of earth = $6.37\times10^{6}m$

M_M is mass of moon = $7.36\times10^{22}kg$

R_M is radius of moon = $1.74\times10^{6}m$

$$= \frac{(6\times10^{24}kg)}{(6.37\times10^{6}m)^2}\frac{(1.74\times10^{6}m)^2}{(7.36\times10^{22}kg)}$$

Therefore

$$\frac{Wt.of\ body\ on\ Earth}{Wt.of\ body\ on\ Moon} \simeq 6$$

Therefore W t of body on earth = 6 (Wt. of body on moon)

Or W t. of body on moon = $\frac{1}{6}$ (Wt. of body on earth)

Q.37 Why weight is a Vector quantity?

Weight always acts vertically downwards, therefore, weight has both magnitude and direction and thus it is a vector quantity.

Q.38 Does mass of an object change from place to place?

No, The mass of a body is always constant and does not change from place to place.

Q.39 What is the relation between mass and weight of an object?

Weight of an object is the gravitational force applied by the earth on that object.

The relation between mass and weight of an object is:

W = m × g

Where

W = Weight of object

M = mass of object

g = Gravitational acceleration

The weight of a body changes from place to place, depending on mass of object.

Q.40 What is S.I Unit of Weight?

S.I Unit of weight is :Newton

Circular Motion & Gravitational Force and Thrust and Pressure

Q.41 Define Circular Motion?

In circular motion, a force must act on body as its direction of velocity changes. This force is called Centripetal force.

• When moon revolves around earth in circular path, gravitational force of earth provides the centripetal force to moon for circular motion.

• When planets revolve around Sun, gravitational force of Sun provides the centripetal force to planets.

Q.42 Define thrust and Pressure?

Thrust: Force exerted by an object perpendicular to the surface is called thrust.

Pressure: Pressure is defined as thrust or force per unit area on a surface.

$$\text{Pressure} = \frac{Thrust}{Area}$$

$$SI\ unit\ of\ pressure = \frac{N}{m^2} = Nm^{-2} = Pascal\,(Pa)$$

Since, pressure is indirectly proportional to the surface area of the object, so, pressure increases with decrease in surface area and decreases with increase in surface area.

Q.43 Name the quantity whose one of the units is Pascal (Pa)?

Pressure is the quantity whose one of the units is Pascal (Pa).

Q.44 Derive the unit of pressure?

Pressure is defined as thrust or force per unit area on a surface.

$$\text{Pressure} = \frac{Thrust}{Area}$$

$$SI\ unit\ of\ pressure = \frac{N}{m^2} = Nm^{-2} = Pascal\,(Pa)$$

Q.45 What name is given to ‘thrust per unit area’?

Pressure name is given to ‘thrust per unit area’.

Pressure in Fluid ,Buoyancy & Buoyant Force and Archimedes Principle

Q.46 What type of Materials are fluids?

Anything that can flow is called Fluid like liquid and gases.

Q.47 Define Pressure in fluid?

Molecules of fluid move around and collide with walls of vessel. Thus fluids apply pressure on walls. Fluids exert pressure in all directions.

Q.48 With help of two examples define Buoyancy & Buoyant Force?

Fluid applies an upward force on a solid which is partially or fully submerged in liquid. This phenomenon is called buoyancy (Upthrust) and applied upward force is called buoyant force.

Experiment - 1:

Take a empty bottle and float it on water. If we push it down in the water partially or fully and then release, bottle suddenly jumps upward. This is because the water applies an upward force on bottle.

Experiment- 2:

Hang a rubber string. Attach a stone to the rubber string. String will elongate. Submerge the stone in water - filled bucket. The elongation in string decreases.

This happens due to upward buoyant force of water.

Q.49 Define archimedes' principle?

When an object is fully or partially submerged in a liquid, buoyant force acts on it in upward direction. Its value is equal to weight of liquid displaced.

For example, suppose an object is partially submerged in a liquid and the mass of displaced liquid is 1.5 kg. Then

Buoyant force applied on the object (F) = Weight of liquid displaced = mg

= (1.5) (9.8) = 14.7 N

Archimedes principle has many uses. It is used in designing ships, submarines, air balloons etc.

Q.50 In which direction does the buoyant force on an object due to liquid act?

Upward direction does the buoyant force on an object due to liquid act.

Q.51 What is the other name of buoyant force?

The other name of buoyant force is upthrust.

Q.52 What is upthrust?

Fluid applies an upward force on a solid which is partially or fully submerged in liquid. This force is known as upthrust force or buoyant force.

Q.53 Name the principle which gives the magnitude of buoyant force acting on an object immersed in a liquid.

Archimedes principle the name of principle which gives the magnitude of buoyant force acting on an object immersed in a liquid.

Q.54 What is the scientific name of the 'upward force' acting on an object immersed in a liquid?

The scientific name of the 'upward force' acting on an object immersed in a liquid is buoyant or upthrust force.

Q.55 What is meant by term 'buoyancy'?

Fluid applies an upward force on a solid which is partially or fully submerged in liquid. This phenomenon is called buoyancy (Upthrust).

Q.56 Define thrust and its unit?

Force exerted by an object perpendicular to the surface is called thrust. And its S.I unit is Newton.

Q.57 A mug full of water appears light as it is under water in the bucket than when it is outside water. Why?

Water applies buoyant force on mug in upward direction under water, and then total force is loss of weight of mug. That's why a mug full of water appears light as it is under water in the bucket than when it is outside water.

Q.58 What happens to the buoyant force as more and more volume of a solid object is immersed in a liquid?

When does the buoyant force become maximum?

The buoyant or upthrust force increases as more and more volume of a solid object is immersed in a liquid. When object is fully immersed in water the buoyant force becomes maximum.

Q.59 Define buoyant force. Name two factors on which buoyant force depends.

Fluid applies an upward force on a solid which is partially or fully submerged in liquid. This phenomenon is called buoyancy (Upthrust) and applied upward force is called buoyant force.

Two factors on which buoyant force depends:

- Volume or shape of object.
- Density of fluid in which object is immersed.

Density and Relative Density

Q.60 What is density and its S.I unit?

The density of a substance is the mass of a unit volume of the substance.

$$Density = \frac{Mass}{Volume}$$

Every material has its own density. The SI unit of density is kilogram per metre cube (kg m^{-3}).

Q.61 Make the table of different densities of different material.

Material	Density (kg / m^3)
Aluminum	2,700
Blood	1,600
Brass	8,600
Copper	8,900
Gold	19,300
Iron	7,800
Lead	11,300
Mercury	13,600
Platinum	21,400
Silver	10,500
Steel	7,800
Water	1,000

Q.62 What is meant by the term 'Relative density'? Give its S.I Unit.

The relative density of a substance is the ratio of the density of a substance to the density of water.

$$\text{Relative density} = \frac{\text{Density of a substance}}{\text{Density of water}}$$

Since relative density is a ratio of similar quantities, it has no unit.

Q.63 The upward push of water on submerged object, give the name of force?

Buoyant or upthrust force acts in upward direction when an object is submerged in water.

Q.64 Write the common unit of density?

g/cm^3 is the common unit of density.

Q.65 What is the value of relative density of water?

1 is the value of relative density of water.

Q.66 The relative density of mercury is 13.6. What does this statement mean?

This statement means that mercury is 13.6 times heavier than water in equal volume.

Q.67 Why does a block of wood held under water rise to the surface when released?

A block of wood held under water rise to the surface when released because density of wood is less than water and which substances have less density than fluid, they floats.

Q.68 The density of a body is 800 kg/m^3. Will it sink or float when dipped in a bucket of water? (Density of water = 1000 kg/m^3).

Body will float when dipped in a bucket of water because density of body is less than density of water.

Q.68 What is the difference between density and relative density?

Differences between density and relative density:

Density	Relative Density
1. The density of a substance is the mass of a unit volume of the substance.	1. The relative density of a substance is the ratio of the density of a substance to the density of water.
2. Formula: $\text{Density} = \frac{\text{Mass}}{\text{Volume}}$	2. Formula: $\text{Relative density} = \frac{\text{Density of a substance}}{\text{Density of water}}$
3. The SI unit of density is kilogram per metre cube (kg m $^{-3}$).	3. Relative density is a ratio of similar quantities, it has no unit.

Q.69 An iron nail sinks in water but it floats in mercury. Why?

An iron nail sinks in water but it float in mercury because density of water (1,000 Kg/m^3) is less than density of iron (7800 Kg/m^3) ,that's why iron nail slink in water, Whereas Density of iron is less than density of mercury (13,600 Kg/m^3), that's why iron nail float in mercury.

Q.70 Steel sinks in water but a steel boat floats. Why?

Steel sinks in water because steel's density is more than water's density. Whereas steel boat traps lots of air that's why average density is less than density of water that's why it floats on water.

Q.71 Two balls of 1 kg each are placed with their centres 1 m apart, then they attract each other with force. Calculate the force ($G = 6.67 \times 10^{-11}\ Nm^2 / kg^2$)

Given : masses of two balls

$m_1 = 1kg$

$m_2 = 1kg$

and distance $r = 1m$

According to law of gravitation

$$F = \frac{G \times m_1 \times m_2}{r^2}$$

$$F = \frac{6.67 \times 10^{-11} \times 1 \times 1}{(1)^2}$$

$F = 6.67 \times 10^{-11}\ N$

Q.72 Calculate the force of gravitation due to earth on a ball of 1 kg mass lying on ground. (mass of earth = 6×10^{24} kg; Radius of earth = 6.4×10^3 km; and $G = 6.67 \times 10^{-11}\ Nm^2/kg^2$)

Given :

Mass of ball $m = 1kg$

Mass of earth $M = 6 \times 10^{24}\ kg$

Radius of earth $R = 6.4 \times 10^3\ km = 6.4 \times 10^3 \times 1000 = 6.4 \times 10^{-6}$

Gravitation Constant $= 6.7 \times 10^{-11}\ Nm^2/kg^2$

Then, Force according to law Gravitation

$$F = G \times \frac{Mm}{R^2}$$

$$F = \frac{6.7 \times 10^{-11} \times 6 \times 10^{24} \times 1}{(6.4 \times 10^6)^2}$$

$$F = \frac{6.7 \times 6 \times 10^{-11} \times 10^{24}}{(6.4)^2 \times 10^{12}}$$

$$F = \frac{6.7 \times 6 \times 10}{(6.4)^2}$$

F= 9.8 N

Q.73 The mass of the earth is 6×10^{24} kg and that of the moon is 7.4×10^{22} kg. If the distance between the earth and the moon be 3.84×10^{5} km. Calculate the force exerted by the earth on the moon. (G = 6.7×10^{-11} Nm^2 kg^{-2})

Given :

Mass of earth M = 6×10^{24} kg

Mass of moon m = 7.4×10^{22} kg

Distance d = 3.8×10^{5} km

= $3.8 \times 10^{5} \times 1000$ m

= 3.84×10^{8} m

Gravitation Constant G = 6.7×10^{-11} Nm^2 kg^{-2}

then force according to gravitation law

F = $G \times \frac{Mm}{d^2}$

F = $\frac{6.6 \times 10^{-11} \times 6 \times 10^{24} \times 7.4 \times 10^{22}}{(3.84 \times 10^{8})^2}$

$\frac{6.6 \times 6 \times 7.4 \times 10^{-11} \times 10^{24} \times 10^{22}}{(3.84)^2 \times 10^{16}}$

F = 2.01×10^{20}

Q.74 Calculate the value of acceleration due to gravity on the surface of the moon

(Given : Mass of the moon = 7.4×10^{22} g ; Radius of moon = 1740 km ; G = 6.7×10^{-11} Nm^2/kg^2)

Given : Gravitational constant G = 6.7×10^{-11} Nm^2/kg^2

Mass of the moon ; M = 7.4×10^{22} kg

Radius of the moon R = 1740 km

= 1740×1000 m

= 1.7×10^{6} m

The formula of Gravitation acceleration

g = $G \times \frac{M}{R^2}$

$g = \frac{6.7\times10^{-11}\times7.4\times10^{22}}{(1.74\times10^{6})^2}$

$g = 1.63\ m/s^2$

Q.75 To estimate the height of a bridge over a river, a stone is dropped freely in the river from the bridge. The stone take 2 seconds to touch the water surface in the river. Calculate the height of the bridge from the water level ($g = 9.8\ m/s^2$)

Given :

Initial velocity of stone, u = 0

Time taken t = 2s

Gravity acceleration $g = 9.8\ m/s^2$

Then height from 2nd equation of motion

$h = ut + \frac{1}{2}gt^2$

$h = 0 \times 2 + \frac{1}{2} \times 9.8 \times 4$

h = 19.6 m

Q. 76 What is the weight of a 1 kg mass on the earth? ($g = 9.8\ m/s^2$)

Given :

mass (m) = 1 kg

gravity acceleration $g = 9.8\ m/s^2$

then weight w = mg

$= 9.8 \times 1$

= 9.8 N

Q.77 If mass of an object be 10 kg. What is its weight? ($g = 9.8\ m/s^2$)

Given :

mass of an object m = 10 kg

gravity acceleration $g = 9.8\ m/s^2$

then weight w = mg
$= 10 \times 9.8 = 98$ N

Q.78 The weight of a body is 50 N. What is its mass? (g = 9.8 m/s^2)

Given :

weight w = 50 N

gravity acceleration = 9.8 m/s^2

w = mg

50 = m × 9.8

m = $\frac{50}{9.8}$ = 5.102 kg

Q.79 If the weight of a body on the earth is 6N. What will it be on the moon?

Given :

weight on earth = 6N

gravity acceleration g = 9.8 m/s^2

Since gravity acceleration on moon = $\frac{gravity\,acceleration\,on\,earth}{6}$

g_{moon} = $\frac{g_{earth}}{6}$

then weight on moon = $\frac{weight\,on\,earth}{6}$= $\frac{6}{6}$ = 1 N

Q.80 Calculate the force of gravitation between two objects of masses 50 kg and 120 kg respectively kept at a distance of 10 m from one another. (Gravitational constant G = 6.7 × 10^{-11} Nm^2 kg^{-2})

Given :

Mass of bodies M = 120 kg

m = 50 kg

Distance r = 10 m

then gravitational force according to law of gravitation is

F = $\frac{GMm}{r^2}$

= $\frac{6.67\times10^{-11}\times12\times5\times100}{100}$= 6.67 N

Q.81 What is the force of gravity on a body of mass 150 kg lying on the surface of the earth? (Mass of earth = 6×10^{24} kg; Radius of earth = 6.4×10^{6}m ; G = 6.7×10^{-11} Nm^2/kg^2)

Given :

mass of a body m = 150 kg

mass of earth M = 6×10^{24} kg

radius of earth r = 6.4×10^{6} m

The force according to law of gravitation

$F = \frac{6.7\times10^{-11}\times6\times10^{24}\times150}{(6.4\times10^{6})^2}$

$F = \frac{6.7\times10^{-11}\times6\times10^{24}\times150}{6.4\times6.4\times10^{6}\times10^{6}}$

$F = \frac{6.7\times6\times150\times10^{13}}{6.4\times6.4\times10^{12}}$

F= 14.72 × 10 N

Q.82 The mass of sun is 2×10^{30} kg and the mass of earth is 6×10^{24} kg. If the average distance between the sun and the earth be 1.5×10^{8} km. Calculate the force of gravitation between them.

Given :

mass of sun M = 2×10^{30} kg

mass of earth m = 6×10^{24} kg

Average distance r = 1.5×10^{8} km

= $1.5 \times 10^{8} \times 1000$ m

= 1.5×10^{11}m

then gravitation force

$F = \frac{GMm}{r^2}$

$= \frac{6.67\times10^{-11}\times2\times10^{30}\times6\times10^{24}}{(1.5\times10^{11})^2}$

$= \frac{6.67\times2\times6\times10^{43}}{1.5\times1.5\times10^{22}}$

$= \frac{80.076\times10^{21}}{2.25}$ = 3.57×10^{22} N

Q.83 A piece of stone is thrown upwards. It reaches the maximum height in 3 sec. If the acceleration of

the stone be 9.8 m/s^2 directed towards the ground. Calculate the initial velocity of the stone with which it is thrown upwards.

Given :

Final velocity V = 0 m/s

Gravity acceleration g = 9.8 m/s^2

time t = 3 sec

Then the calculate of initial velocity u from 1st equation of motion

V = u + gt

0 = u + 9.8 × 3

u = – 29.4 m/s

Negative sign shows direction of initial velocity is opposite the gravity acceleration.

Q.84 A stone falls from a buildings and reach the ground 2.5 s later. How high is the building ?

(g = 9.8 m/s^2)

Given : Initial velocity u = 0 m/s

gravity acceleration g = 9.8 m/s^2

height of building h = ?

time t = 2.5 sec

from 2nd equation of motion

h = ut + $\frac{1}{2}gt^2$

$h = 0 \times 25 + \frac{1}{2} \times 9.8 \times 2.5 \times 2.5$

h = $\frac{1}{2}$× 9.8 × 2.5 × 2.5

h = 61.25 × 2= 30.625 m

Q.85 A stone is dropped from a height of 20 m

(i) How long will it take to reach the ground?

(ii) What will be its speed when it hits the ground? (g = 10 m/s^2)

Given :

Height h = 20

Initial velocity u = 0m/s

gravity acceleration g = 10 m/s^2

(i) Time to reach the ground from 2nd equation of motion

$h = ut + \frac{1}{2}gt^2$

$20 = 0 \times t + \frac{1}{2} \times 10 \times t^2$

$20 = 5t^2$

$t^2 = \frac{20}{5} = 4$

$t = \sqrt{4} = 2$ sec

(ii) Speed when it hits the ground t = 2sec from 1st equation of motion

V = u + gt

= 0 + 10 × 2 = 20 m/s

Q.86 A stone is thrown vertically upwards with a speed of 20 m/s. How high will it go before it begins to fall ? (g = 9.8 m/s^2)

Given :

Initial velocity u = +20 m/s

Find velocity = 0 m/sec

Gravity acceleration g = 9.8 m/s^2

Distance s = ?

From 3rd equation of motion

$V^2 - u^2 = 2as$

$0^2 - (+20)^2 = 2 \times 9.8 \times s$

$+ 400 = 2 \times 9.8 \times s$

$s = \frac{-400}{2 \times 9.8} = -20.4$ m

Negative sign shows direction of displacement and gravity acceleration are opposite direction.

the distance = 20.4 m

Q.87 A force of 20 N acts upon a body whose weight is 9.8 N. What is the mass of the body and how much is its acceleration? (g = 9.8 m/sec^2)

Given :

Weight of the body w = 9.8 N

mass of the body m = ?

gravity acceleration g = 9.8 m/sec^2

Force act on it F = 20 N

then mass of the body

W = mg

m = $\frac{w}{g}$

m = $\frac{9.8}{9.8}$= 1kg

then acceleration F = ma

20 = 1 × a

a = 20 m/s^2

Q.88 A stone resting on the ground has gravitational force of 20 N on it. What is the weight of the stone? What is its mass?

Given :

Weight of the stone = 20 N

gravity acceleration g = 9.8 m/s^2

w = mg

20 = m × 9.8

m = $\frac{20}{9.8}$= 2.04 kg

Q.89 An object has mass of 20 kg on earth. What will be its (i) mass, and (ii) weight on the moon?

(g on moon = 1.6 m/s^2)

Given : Mass on earth m = 20 kg

Gravity acceleration g = 1.6 m/s^2

(i) Mass of moon = 20 kg

Mass is a constant quantity

(ii) Weight on the moon w = mg

= 20 × 1.6 = 32 N

Q.90 How much would a 70 kg man weight on the moon? What would be his mass on the earth and on the moon? (Acceleration due to gravity on moon (1.63 m/s^2)

Given :

Mass of man, m = 70 kg

Gravitation acceleration, g = 1.63 m/s^2

then mass on moon = 70 kg (constant everywhere)

then weight w = mg

W = 70 × 1.63

W = 114.1 N

Q.91 The acceleration due to gravity at the surface of the moon is 1.67 ms^2. If radius of moon is 1.74 × 10^6 m. Find the mass of the moon Given G = 667 × 10^{-11} Nm^2 kg^{-2}.

Given :

Gravity acceleration on moon g = 1.67 ms^{-1}

Radius of the moon R_m = 1.7 × 10^6 m

then mass of moon = $M_m = \frac{9R_m}{G}$

$= \frac{1.67\times(1.74\times10^6)^2}{16.67\times10^{-11}}$

$= \frac{1.67\times1.74\times1.74\times10^{12}}{6.67\times10^{-11}}$

= 7.58 × 10^{22} kg

Q.92 An astronaut on the moon measures the acceleration due to gravity and finds it to be 1.67 ms^{-2}. He knows that the earth is about 80 time more massive than the moon.

What is his estimate of the radius of the earth to that of the moon? ($g = 9.8\ m/s^2$)

Given :

Gravity acceleration on moon a = 1.67 m/s^2

Gravity acceleration on earth g = 9.8 m/s^2

From formula of gravity acceleration

on earth $g = \frac{GM}{R^2}$ . . . (1)

On moon $a = \frac{GMm}{R_m^2}$ . . . (2)

From equation (1) & (2)

$$\frac{a}{g} = \frac{GMm/R_M^2}{GM/R^2} = \frac{MmR^2}{MR_M^2}$$

$$\frac{R^2}{R_M^2} = \frac{M}{Mm} \cdot \frac{a}{g}$$

$$\frac{R}{Mm} = \left(\frac{M}{Mm} - \frac{a}{g}\right)^{1/2}$$

$$= \left(80 \times \frac{1.6}{9.8}\right)^{1/2} = 3.69$$

Q.93 A force of 100 N is applied to an object of area $2m^2$. Calculate the pressure

Given :

Force F = 100N

Area A = $2m^2$

then pressure = $\frac{Force}{Area}$

$= \frac{100N}{2m^2} = 50N/m^2$ (or 50 Pa)

Q.94 A rectangular wooden block has mass of 4 kg the length, breath and height of the wooden block are 50 cm, 25 cm and 10 cm respectively. Find the pressure on the table top.

(a) When the wooden block is kept with its surface measuring 50 cm × 25 cm on the table

(b) When the wooden block is kept with its surface measuring 25 × 10cm on the table

Given :

Mass of wooden block m = 4kg

gravity acceleration = 10 m/s^2

the weight W = m × g = 4 × 10 = 40 N

(a) Force F = 40 N

area a = 50cm × 25 cm

a = $\frac{50}{100}$m × $\frac{25}{100}$ m

a = 0.5m × 0.25 m

a = 0.125 m^2

then pressure = $\frac{Force}{Area}$ = $\frac{40}{0.125}$ = 320 Nm^{-2}

(b) Force F = 40 N

Area A= 25 cm × 10 cm

= $\frac{25}{100}m \times \frac{10}{100}m$

= 0.25m × 0.1 m

= 0.025 m^2

Pressure = $\frac{Force}{Area}$ = $\frac{40}{0.25}$ = 1600Nm^{-2}

Q.95 What force acting on an area of 0.5 m^2 will produce a pressure of 500 Pa?

Given :

Area A = 0.5m^2

Pressure = P = 500 Pa

then force = pressure × area

= 500 × 0.5 = 250N

Q.96 An object of weight 200 N is floating in a liquid. What is the magnitude of buoyant force acting on it.

The magnitude of buoyant force is equal to weight of liquid displaced by the object.

Q.97 The density of gold is 19 g/cm^3. Find the volume of 95 gm of gold.

Given : Density of gold r = 19 g/m^3

mass of gold m = 95 g

then volume

$D = \frac{m}{V}$

V = $\frac{m}{D} = \frac{95}{19}$

V = 5 cm^3

Q.98 What is the mass of 5m^3 of cement of density 3000 kg/m^3?

Then mass of cement

D = $\frac{m}{V}$

m = D × V

= 3000 × 5 = 15000 kg

Q.99 What is the density of a substance of 100 g and volume 10 cm^3?

Given volume of substances = 10 cm^3

mass of substance = 100 g

then density D = $\frac{m}{v} = \frac{100}{10}$

D = 10 g/cm^3

Q.100 5 kg of material 4 occupy 20 cm^3 whereas 20 g of material B occupy 90 cm^3. Which has the greater density : A or B? Support your answer with accelerations.

Given : for material

mass m = 5kg = 5 × 1000g = 5000 kg

Volume V = 20 cm^3

then density D = $\frac{m}{v}$

D = $\frac{5000}{20}$ = 250g/cm^3

for material B

mass m = 20 kg = 20 × 1000 = 20000 g

Volume V = 90 cm^3

Density D = $\frac{m}{V}$

D = $\frac{20000}{90}$= 222.2 g/cm^3

A has higher density.

Value Based Questions : -

Q.1 If the distance between two masses is increased by a factor of S, by what factor would the mass of one of them have to be altered to maintain the same gravitational fore would this be an increase or decrease in the mass?

Gravitation constant = G

Let M and m be the masses of two object.

and distance between them = d

then gravitation force

$F = \frac{GM_m}{d^2}$ …. (1)

If the distance between two masses is increased by 5 time , then d' = 5d

Now gravitation force –

$F^1 = \frac{GM_m}{(5d)^2}$

$F^1 = \frac{GM_m}{25d^2}$ … (2)

To maintain the same gravitational force, the mass should be increased by 25 times

$F^1 = \frac{GM25m}{25d^2}$

$F^1 = F$

Q.2 Universal law of gravitation states that every object exerts a gravitation force of attraction on every other object. If this is true, why don't we notice such forces ? Why don't the two objects in a room moves towards each other due to this force?

Gravitation force acts between two object, in order to notice this it is necessary that one of the object should have large mass as compressed to the other. But two objects in a room have not such large mass. So we can not notice the gravitational force between them.

Q.3 Suppose a planet exist whose mass and radius both are half those of the earth. Calculate the acceleration due to gravity on the surface of this plant.

Given gravitation constant

G =
$6.67\times10^{-11}Nm^2kg^{-2}$

Mass and radius both are half those of the earth

Mass of planet
$M=\frac{(5.98\times10^{24}kg)}{2}$

Radius of planet
$R=\frac{(6.4\times10^{6}m)}{2}$

Then gravitation acceleration of plannet –

$G=\frac{GM}{R^2}$

$G=\frac{6.67\times10^{-11}\times5.98\times10^{24}\times4}{(6.4\times10^{6})^2\times2}$

$G=\frac{6.67\times5.98\times4\times10^{13}}{6.4\times6.4\times2\times10^{12}}$

$G=\frac{6.67\times5.98\times4\times10}{6.4\times6.4\times2}$

$G=1.9484\times10=19.5N$

Q.4 A stone and the earth attract each other with an equal and opposite force. Why then we see only the stone falling towards the earth but not the earth rising towards the stone?

We see only the stone falling wards the earth but not the earth rising towards the stone because mass of stone is very low as compared to the earth's mass . Hence earth's acceleration is very law as compared to stone's acceleration. So stone falls forwards the earth.

Q.5 The value of a g at six distances A, B, C, D E and F from the surface of the earth are found to be $3.08m/s^2$,
$9.23m/s^2,0.57m/s^2,7.34m/s^2,0.30m/s^2$ and
$1.49m/s^2$ respectively. Arrange these value of g according to the increasing distances from the surface of the earth (keeping the value of g nearest to the surface of the earth first.

Formula of gravitational acceleration

$G=\frac{GM}{R^2}$

Therefore
$G\propto\frac{1}{R^2}$ …. (1)

As increase the distant from the earth's surface value of g is decreased

So arrangement –

$9.23m/s^2,7.34m/s^2,3.08m/s^2,1.49m/s^2,0.57m/s^2,^2,0.30m/s^2$

1 Mark Questions

Q.1 Define thrust.

Q.2 State a condition for an object to float when placed on the surface of water.

Q.3 A coin sinks when placed on the surface of water. Give reason.

Q.4 State and define SI unit of pressure.

Q.5 How is pressure related to the thrust exerted on a surface?

Q.6 Why do buildings have wide foundation?

Q.7 How does the density of fluid affect the magnitude of buoyancy acting on an object immersed in it?

Q.8 State Archimedes principle.

Q.9 Give two applications of Archimedes principle.

Q.10 Give the SI unit of relative density.

Q.11 Relate relative density of a substance to its density.

Q.12 Density of a solid is $7.5\ g/cm^3$. What is its relative density?

Q.13 State the SI unit of buoyancy.

Q.14 School bags have broad straps.

Q.15 Dams have broad foundation.

Q.16 It is easier to cut an apple with sharp edge of knife.

Q.17 A mug appears lighter inside water.

Q.18 A solid exerts pressure of 20 Pa on a surface of 2 m^2. Find its weight.

Q.19 Relative density of an object is 1.35. Will it float or sink in water?

Q.20 Mark the direction of weight of the body and upthrust acting on it, in the following diagram:

Q.21 "A coin sinks in water because upthrust acting on it is greater than its weight." Is the statement correct? If not, correct it.

Q.22 An object is put one by one in three liquids having different densities. The object floats with 1/9, 2/11 and 3/7 parts of their volumes outside the liquid surface in liquids of densities d1, d2 and d3 respectively. Arrange the densities in ascending order of their magnitude.

Q.23 An object weights 10 N in air. When immersed fully in water, it weights 8 N. Find the weight of liquid displaced by the object.

Q.24 State the principle of floatation for an object of weight W immersed in a fluid.

Q.25 Relate the SI unit of density with its CGS unit.

Q.26 A crumpled sheet of paper falls down faster than a plane sheet, Why?

Q.27 A body is immersed once in each of the following media:
mustard oil
water
glycerine
petrol
In which ease will there be maximum apparent loss of weight and why?

Q.28 Differentiate between force and thrust.

Solutions

1. Force acting perpendicular to a surface is called thrust.

2. A body will float if its density is less than that of water.

3. The coin sinks as its density is greater than water.

4. Pressure is defined as thrust per unit area. The unit of pressure is Pascal. One pascal is the pressure exerted when 1 N force acts as a surface area of $1m^2$.

5. Pressure = Thrust/Area

6. Buildings have wide foundations to reduce the pressure on ground. Since larger the area, lesser will be the pressure.

7. Weight of fluid displaced = ρgV where ρ is the density. Hence, buoyant force increases with increasing density of fluid.

8. Archimedes Principle: When a body is immersed fully or partially in a fluid, it experiences an upward force that is equal to the weight of the fluid displaced by it.

9. It is used in (i) designing ships and (ii) submarines.

10. Relative density has no units.

11. $\text{Relative density} = \frac{\text{Density of substance}}{\text{Density of water}}$

12. Relative density $= \frac{\text{Density of substance}}{\text{Density of water}}$

$= \frac{7.5}{1} = 7.5$

13. Newton.

14. Pressure = Force/Area.

Broad straps have greater area and therefore exert lesser pressure.

15. Greater the area, less is the pressure exerted. The broad base of dams reduce pressure on the ground.

16. Sharp knives have very small area on which the force acts. Hence , pressure is much more and can easily cut an apple.

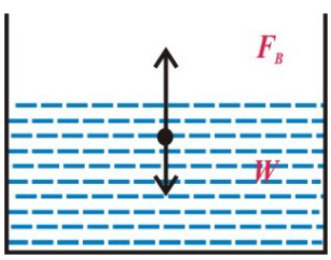
17. The mug appears lighter as the buoyant force acting in the upward direction reduces the effective weight of the mug when placed in water.

18. Weight = Pressure X Area

= 20 X 2 = 40 N.

19. As relative density is greater than 1 , the object will sink.

20.



F_B = Buoyant force

W = Weight of object

21. The statement is wrong. The correct statement will be " A coin sinks in water because upthrust acting on it is less than its weight".

22. $\frac{1}{9} = 0.11\,;\, \frac{2}{11} = 0.18\,;\, \frac{3}{7} = 0.43$

There are the volume outside of liquids of densities d1, d2, d3 respectively. This means buoyant face is maximum for d3 and minimum for d2. As buoyant force is proportional to density, d1< d2<d3.

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23. Weight of object in air = 10 N

Weight of object in fluid = 8 N

Therefore, Loss of weight = (10 - 8) N = 2 N

Buoyant force = Loss of weight = 2 N

---

24. Archimedes Principle states when a body is immersed fully or partially in a fluid, it experiences an upward force that is equal to the weight of the fluid displaced by it.

---

25. $1000\,\mathrm{kg}/m^3 = 1g\,m/cm^3$

---

26. Air resistance on sheet of paper will be more then the crumpled sheet as its surface area is greater. The net force acting on it is nearly zero so it moves down slowly.

---

27. Glycerine has highest density so maximum apparent loss will be seen when body is immersed in glycerine.

---

28. Force can have any direction, but thrust is that force which is acting perpendicular to a surface.

2 Marks Questions

Q.1 An object is suspended with a string which gets stretched. When the object is completely immersed in water, the extension of thread decreases. Explain why it happens.

Q.2 (a) State the principle on which the working of a hydrometer is based.

(b) A sharp knife is more effective than a blunt knife. Why ?

Q.3 What happens when:

(a) Buoyant force exerted by the fluid is greater than the weight of the body?

(b) Buoyant force exerted by the fluid is equal to the weight of the body?

Q.4 Why are railway tracks laid on large sized concrete sleepers? Explain.

Q.5 An object of 40 N weight when immersed in water losses 10 N weight. Will the object float or sink? Why?

Q.6 Two blocks, one of iron and other of wood are immersed in water at same depth. Which one will come upward. Why?

Q.7 Define relative density of a substance. Relative density of silver is 10.8. The density of water is 1000 kg/m^3. What is the density of silver in SI units?

Q.8 Which will exert more pressure 100 kg mass on 10 m^2 or 50 kg mass on 4 m^2 ? Give reason.

Q.9 (a) Explain why a truck or a motor bus has much wider tyres ?

(b) Why do we feel lighter when we swim?

Q.10 Account for the statement "Camel walks easily on sand but it is difficult for a man to walk on sand though a camel is much heavier than a man".

Q.11 Differentiate between density and relative density.

Q.12 Lead has greater density than iron and both are denser than water. Is the buoyant force on a lead object greater than, or lesser than or equal to the buoyant force on an iron object of the same volume?

Explain your answer giving reason.

Q.13 Explain why sheet of paper falls slower than a coin under gravity through air.

Q.14 Give one example each where the same force acting on

(a) a smaller area exerts a larger pressure,

(b) a larger area exerts a smaller pressure

Q.15 Why does a nail sink in water but a piece of cork floats on it?

Q.16 State Archimedes' principle. Write two applications of this principle.

Q.17 A body of mass 20 kg is placed on a $2m^2$ area. Find the pressure exerted.

Q.18 An iron ball weights 11 kg in air and 8 kg when immersed in water. Find its relative density.

Q.19 Thrust of 'F' N is exerted on area 2A and thrust of '3F' N is exerted on area A/2. Find the ratio of pressure exerted.

Q.20 A boy lying on a mattress, stands up on it. He observes that the mattress is now depressed deeper down. Why does this happen?

Q.21 What are fluids? How does upthrust exerted by a fluid on an object immersed in it vary with density of fluid?

Q.22 Big trucks and tractors have broad tyres. Why?

Q.23 An iron nail sinks in the water. But a ship made of iron floats on water. Why?

Q.24 A bag of cotton weighs 10 kg and occupies a volume of 2 m^3. Find its density. Express this density in CGS. unit.

Solutions

1. The buoyant force exerted by a fluid is equal to the weight of fluid displaced. As a body is lowered in a fluid ,more is the fluid displaced, more is the buoyant force. This buoyant force is maximum when a body is completely immersed in a fluid , The extension of thread keeps decreasing as the net force deceases.

---

2. (a) Archimedes Principle : When a body is immersed fully or partially in a fluid, it experiences an upward force that is equal to the weight of the fluid displaced by it.

(b) A sharp knife has a smaller area of cross section on which force acts. Thus pressure on sharp knife is more and it is more effective than a blunt knife.

$$\text{As , Pressure} \alpha \frac{1}{area}$$

---

3. (a) The body rises to the surface of fluid.

(b) The body floats.

---

4. Railway tracks are laid on area on large sized concrete slabs to increase the area on which the weight of train will act and hence decrease pressure on the ground.

---

5. The object will sink as weight of object is greater than the buoyant force.

---

6. The wood block will come up because density of wooden block is less than water, where as iron has greater density than water.

---

7. Relative density is defined as the ratio of density of substance to that of water.

$$10.8 = \frac{\text{Density of silver}}{1000}$$

$$\text{therefore Density of silver} = 10.8 \text{ X } 10^3 \text{ kg}/m^3$$

---

8. $P1 = \frac{100}{10} = 10$ Pa.

$P2 = \frac{50}{4} = 125$ Pa.

The second mass will exert greater pressure.

---

9. (a) Bus or truck have wider tyres as they carry heavier loads. To reduce pressure on the ground, the tyres are kept wider.

(b) We feel lighter when we swim due to the buoyant force. Our apparent weight is actual weight.

10. Camels are much heavier than men but due to their wide feet the pressure exerted on sand is much less, making it easier for them to walk on it.

11. Density is defined on mass per unit volume. Its unit kg/m^3.

Relative density is the ratio of density of substance to that of water. It is a unit less quantity.

12. Buoyant force depends on the volume of fluid displaced. It a lead and iron object having same volume are immersed in water, both will experience the same buoyant force.

13. A sheet of paper has greater surface area, therefore air resistance is more , so it falls slower.

14. (a) A man standing on h is feet

(b) A man lying down

15. The density of cork is less than water whereas nail has greater density. So cork floats while nail sinks.

16. Archimedes Principle states when a body is immersed fully or partially in a fluid, it experiences an upward force that is equal to the weight of the fluid displaced by it.

Application :

1) Designing of ships, submarines

2) Lactometers

17. $\text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{20 \times 10}{2} = 100\ Pa.$

18. $\text{Relative Density} = \frac{\text{weight of object}}{\text{Loss of weight in water}}$

$= \frac{11}{11-8} = \frac{11}{3} = 3.07$

19. $P_1 = \frac{F}{2A}$

$P_2 = \frac{3F}{A/2} = \frac{6F}{A}$

$\frac{P_1}{P_2} = \frac{F/2A}{6F/A} = \frac{1}{12}$

Ratio is 1 : 12

20. The mattress is depressed deeper when the boy stands as pressure increase when area on which the weight acts becomes smaller. As pressure $\alpha \frac{1}{area}$; the pressure on the mattress increases.

21. Fluids are matter that can flow i.e. liquids and gases.

upthrust = weight of fluid displaced

= volume of body × density of fluid × acc. due to gravity.

Greater the density, greater will be the upthrust.

22. Bus or truck have wider tyres as they carry heavier loads. To reduce pressure on the ground, the tyres are kept wider.

23. A body sinks if its weight is greater than the buoyant force on it like the nail.
The ship has a large volume immersed in water. So , buoyant force is equal to its weight. So the ship floats.

24. Density $= \frac{\text{Mass}}{Vol.} = \frac{10kg}{2m^3}$

$= \frac{10 \times 1000\ gm}{2 \times 100 \times 100 \times 100\ cm^3}$

$= \frac{1}{200}\ g/cm^3$

3 Marks Questions

Q.1 Define pressure and state its SI unit. The dimensions of a metallic cuboid are 30 cm x 20 cm x 15 cm and its mass is 30 kg. If the acceleration due to

Q.2 (a) Do all bodies immersed in a given fluid experience the same buoyant force? Explain.

(b) A 100=cm^3 block has a mass of 395 g. Find its relative density. (Density of water = 1 g/cm^3)

Q.3 What is meant by buoyancy? Why does an object float or sink when placed on the surface of a liquid?

Q.4 (a) State the SI units of Thrust and Pressure.

(b) In which situation we exert more pressure on ground when we stand on one foot or on both feet? Justify your answer.

Q.5 Describe a simple activity to prove that objects of density less than that of the liquid float on it.

Q.6 The volume of a bag of mass 1250 g is 150 cm^3. If this bag is put on water, will it float or sink? Justify your reply. Also, find the volume of water displaced by this bag.

Q.7 A hollow plastic ball is taken to the bottom of a trough of water and released there.

(a) What happens to the ball?

(b) Give reason for this phenomenon.

Q.8 State any two daily life phenomena which are based on Archimedes' principle. Discuss the role of Archimedes' principle in industry and defense.

Q.9 A box has dimensions 15 cm x 20 cm x 25 cm. Calculate pressure exerted by box if it is rested on a surface at

(a) 15 cm x 20 cm face

(b) 20 cm x 25 cm face

(c) 15 cm x 25 cm face, given mass of box = 20 kg. Arrange the pressure in ascending order of their magnitude.

Solutions

1. Pressure is defined as thrust per unit area. Its unit is Pascal.

$$\text{Pressure} = \frac{F}{A} = \frac{mg}{Area} = \frac{30 \times 10}{\frac{20}{100} \times \frac{15}{100}} = 10^4 Pa.$$

---

2. (a) Buoyant force experienced by a body depends on volume of body immersed and the density of the fluid. If the volume of the immersed part of bodies is same, they will experience the same force.

(b) $\text{Density of block} = \frac{m}{V} = \frac{395}{100} = 3.95\, g/cm^3$

$$R.D. = \frac{Density of block}{Density of water} = \frac{3.95}{1} = 3.95$$

---

3. Buoyancy is the upward force experienced by an object placed in a fluid.

An object floats or sinks when placed on water depending the net force. If the weight is less than buoyant force it will float, and if more then it will sink.

---

4. (a) SI unit of Thrust is Newton and of pressure is Pascal.

(b) We exert more pressure on ground when we stand on one feet than when we stand on both feet because pressure is inversely proportional to the area on which the thrust acts.

---

5. Take a block of wood and iron of same volume and put then in a liquid. It is seen that wood floats while iron black sinks. It we find the density of wood it is less than the liquid while that of iron is more. Thus, it is proved that objects having less density than liquid float on it.

---

6. $\text{Density} = \frac{1250}{150} = 8.33\, g/cm^3$ since the density of bag is greater than water it will sink.

Volume of water displaced = volume immersed x density of water

$= 150 \times 1 = 150\, cm^3.$

---

7. (a) When the ball is released it rises to the surface.

(b) The reason being buoyant force is greater than its weight, so there is a net force in the upward

direction.

8. (1) Floating of boat

(2) Rising of helium filled balloon in air.

In industry Archimedes principle helps in testing purity of materials and designing ships and submarines

9. (a) $P_a = \frac{20 \times 10}{\frac{15}{100} \times \frac{20}{100}} = 6666.67\ P_a$

(b) $P_b = \frac{20 \times 10}{\frac{20}{100} \times \frac{25}{100}} = 4000 P_a$

(c) $P_c = \frac{20 \times 10}{\frac{15}{100} \times \frac{25}{100}} = 5333.33 P_a$

Therefore, $P_b < P_c < P_a$

5 Marks Questions

Q.1 (a) State two factors on which the magnitude of buoyant force acting on a body immersed in a fluid depends.

(b) Will buoyant force exerted by a liquid increase if its volume is increased?

(c) Name the devices based on Archimedes' principle.

Q.2 State Archimedes' principle. How will you verify it experimentally?

Q.3 What is upthrust? What are the quantities that can vary upthrust? How does it account for the floating of a body? When a partially immersed body is pressed down a little, what will happen to the upthrust?

Solutions

1. (a) The two factors on which the buoyant force depends is density of liquid, and volume of immersed body.

(b) Yes.

(c) Lactometer , Hydrometer

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2. Archimedes Principle states that when a body is immersed fully or partially in a fluid, it experiences an upward force that is equal to the weight of the fluid displaced by it.

Experimental verification of Archimedes Principle :

Tie a block by a string and suspend it on the a spring balance. Measure the weight of block say W1.
Take an overflow flask and a measuring cylinder. Fill the overflow jar to the brim with water. Gradually immerse the block into the water . As the block goes inside the water, water will overflow to the measuring jar. Read the weight of block now say W2 .

Measure the water overflowed.

Calculate the weight of water by using formulas= $\rho \times V \times g$,where ρ is density of water, V the volume of water overflowed, g the acceleration due to gravity.
You will find that the loss in weight (W1- W2) is equal to weight of water displaced.

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3. The upthrust can vary by changing volume of body immersed or density of fluid.The upward force exerted by a fluid is called upthrust. Due to upthrust the apparent weight of the body can vary. It the upthrust is equal to the weight of the body, the body will float. When a partially immersed body is pressed down, upthrust increase

Previous Year's Questions

1 Mark Questions

Q.1 The relative density of a substance is greater than 1. What does it signify?

[CBSE2013]

Sol. If the relative density of a substance is 1 it denotes that the substance will sink in water. Since, Relative density of water = 1 and the substances having relative densities greater than 1 can sink in water.

Q.2 Arrange the following in the increasing order of their relative densities. Iron, Air, Water

[CBSE, 2012]

Sol. The increasing order of the relative densities is **Iron > Water > Air**

Q.3 When we jump into a swimming pool, we feel lighter. Why?

[Board, 2011]

Sol. When we jump into a swimming pool, we feel lighter because upthrust acting upon us from the bottom. So, our apparent weight is less than actual weight and we feel lighter.

Q.4 State a condition for an object to float when placed on the surface of water.

[CBSE (CCE), 2010]

Sol. To make an object float, its weight should be less than the buoyant force acting on it i.e. weight of body (W) < Buoyant force.

Q.5 A coin sinks when placed on the surface of water. Give reason.

[CBSE (CCE), 2010]

Sol. Since coin is made up of metal, it has greater density than water. So, when it is placed

on the surface of the water it sinks.

2 Marks Questions

Q.6 Give a brief description about why bottom of dams are broad?

[CBSE, 2013]

Sol. Since, Pressure is the force acting on per unit area.
Pressure = force / area. As area would increase the pressure will decrease.
As dams need to store large reserves of water and they have to withstand the high pressure of the water stored in it. Therefore, the base areas of the dam should be broad enough to hold the dam in position.

Q.7 A woman walking on a wooden floor wearing high-heels can damage the floor by making small dimples in the floor since her weight is concentrated on such a small area (the tip of the high heel). If the woman weighs 60 N and the tip of the high heel is 1 cm^2, what will be the pressure exerted on the floor by her high heels?

[Board, 2013]

Sol. Given,

Weight of the woman = 60 N,
Area A = 1 cm^2 = 1/10000 m^2
Since, Pressure = F / A
= 60 × 10000N/m^2
= 6 × 10^5 Pa
Therefore, the pressure exerted on the floor by high heels of the woman is 6 × 10^5 Pa.

Q.8 Explain why camel walks easily on a sandy surface than a man in spite of the fact that a camel is much heavier than a man.

[CBSE 2013]

Sol. Since, **Pressure = Force/ Area, so Pressure α 1/ area.**
This implies that with the increase in area the pressure decreases. Camel have padded feet they cover larger surface area on sandy surface and apply less pressure.

Q.9 The density of turpentine at 293 K is given as 870 kg/m^3. Identify and write the name of substances that sink in turpentine at the same temperature.

[Board, 2012]

S.No.	Substance	Density kg / m^3
1.	Wood	690
2.	Ice	920
3.	Rubber	970
4.	Paraffin wax	900
5.	Cork	240
6.	Bone	1850

Sol. The substances that would sink in the turpentine oil are ice, rubber, paraffin wax and bone. This is because the densities of these four from the table are more than the

turpentine oil.

Q.10 Why does an army tank rest upon a continuous chain?

[Board, 2012]

Sol. An army tank being very heavy there are chances of the tanks sinking in the ground. To avoid this, they are rested upon a continuous chain which applies less pressure on the ground as they increase the surface area of the tank.

Q.11 (i) Define relative density of a substance.

(ii) The density of iron is 7.8×10^3 kg / m^3 and that of water is 10^3 kg / m^3. Find the relative density of iron.

[Board, 2012]

Sol. (i) Relative density of a substance is the ratio of the density of the substance to the density of water.

Relative density of a substance = Density of the substance / Density of water

(ii) Given,

Density of iron = 7.8×10^3 kg / m^3

Density of water = 10^3 kg / m^3

Relative density of iron = $\frac{7.8 \times 10^3}{10^3} = 7.8$

Q.12 Why is it difficult to hold a bag having a strap made of a thin and strong string?

[Board, 2012]

Sol. If the strap of a bag is thin, then the weight of the bag will fall over a small area of the shoulder which will produce high pressure and person carrying the bag will have a painful shoulder.

Q.13 Give reason:

(a) An iron nail floats on mercury, but sinks in water.

(b) Tractors have broad tyres.

[Board, 2012]

Sol. (a) Density of iron is more than that of water so iron nails sinks in it, whereas the density of mercury is more than that of iron. So, the iron nail floats on it.

(b) Tractors have broad tyres as more surface area would exert less pressure and when these tyres would run on soft grounds they will not lapse in them.

3 Marks Questions

Q.14 (a) State the unit of relative density.
(b) Find relative density of iron.
(Given, density of iron 8500 kg m^{-3} and density of water 1000 kg m^{-3}).

[CBSE, 2013]

Sol. (a) Since, the relative density is ratio of the densities, it has no unit.

(b) Relative density of iron $= \frac{\text{Density or iron}}{\text{Density of water}} = \frac{8500\ \text{kgm}^{-3}}{1000\ \text{kgm}^{-3}} = 8.5$

Q.15 Verify Archimedes principle of buoyancy with an activity. For the activity you are provided with a piece of stone, a rubber string and a container filled with water.

[Board, 2013]

Sol. **Procedure:**

(i) Tie the piece of stone at one end of a rubber string.
(ii) Swing the stone by holding the string.
(iii) Due to weight of the stone, the string experiences elongation. Note this elongation.
(iv) Now, gradually dip the stone in the container filled with water.

Observation:

(i) As the stone is deliberately lowered in water, the elongation of the string decreases.
(ii) No further change observed after the stone was fully immersed in water.

Inference:

The maximum loss in the weight of the object takes place when the piece of stone is fully immersed and after that no more weight loss would be observed.

Q.16 (a) Do all bodies immersed in a given fluid experience the same buoyant force? Explain.
(b) A 100 cm^3 block has a mass of 395 gm. find its relative density. (Density of water = 1 gm / cm^3)

[Board, 2012]

Sol. (a) No. As all bodies do not have same volume, the buoyant force experienced by the bodies will not be the same in the given fluid. As the volume of the solid in the fluid will increase the buoyant force will also increase.

(b) Given,
Density of block = Mass / Volume = 395 / 100 = 3.95 gm / cm^3.
Density of water = 1 gm / cm^3
Relative density of the block = Density of the block / Density of water
= 3.95 / 1
Relative density of the block = 3.95

Q.17 (a) 'Lactometers are used to determine the purity of a sample of milk'. State the principle on which this instrument is based on.

(b) Write two factors on which the buoyant force acting on a body when immersed in a liquid depends.

[Board, 2012]

Sol. (a) Lactometers are based on Archimedes principle.
According to the Archimedes principle:
Upthrust acting on an object = Weight of liquid displaced by the object

(b) Two factors on which the buoyant force acting on a body when immersed in a liquid depends are:
(i) Volume of object immersed in the liquid.
(ii) Density of the liquid.

Q.18 A solid body of mass 150 g and volume 250 cm^3 is placed in a jar containing water. Will it float or sink in water? [Density of water is 1 g/cm^3.]

[CBSE, 2010]

Sol. Given,
Mass of the body, m = 150 g,
Volume of the body, V = 250 cm^3

$$\text{Density of the solid, } d = \frac{\text{Mass of the body}}{\text{Volume of the body}} = \frac{m}{V}$$

$$= \frac{150\ g}{250\ cm^3}$$

$$= 0.6\ g/cm^3$$

The density of solid body ($0.6\ g/cm^3$) is less than the density of water (1 g/cm^3). Therefore, it will float on water.

Q.19 When you immerse an empty plastic bottle in a bucket of water, it comes above the surface of water. Why does this happen? How can it remain immersed in water and why?

[CBSE 2010]

Sol. In an empty bottle, upward force (upthrust) is greater than the weight of bottle, therefore it comes above the surface.

For keeping the bottle completely immersed, upward force (upthrust) should be either less or equal to the weight of bottle. Therefore, if external force greater than upthrust is applied on the bottle is will immerse in the water.

5 Marks Questions

State the laws of floatation
Why is it easier to swim in sea water than in river water?
Explain the reason, why cork floats in the water whereas an iron nail sinks.
[Board, 2014]

Sol. According to the **Archimedes' principle:**
When a body is partially or wholly immersed in a liquid, it undergoes upthrust or buoyant force which is equal to the weight of liquid displaced by the body.

Laws of floatation:

(1) Object floats: When the weight of the object is equal to or less than the buoyant force applied on the body, it floats.

(2) Object sinks: When the weight of the object is not equal to the buoyant force applied on the body, it sinks.

Sea water has more density than river water because of the presence of salts in it. So sea water exerts higher buoyant force than river water on the same object. Therefore, it is easier to swim in sea water.

Cork floats in the water whereas an iron nail sinks because the density of cork is less than water whereas the density of nail is higher than water.