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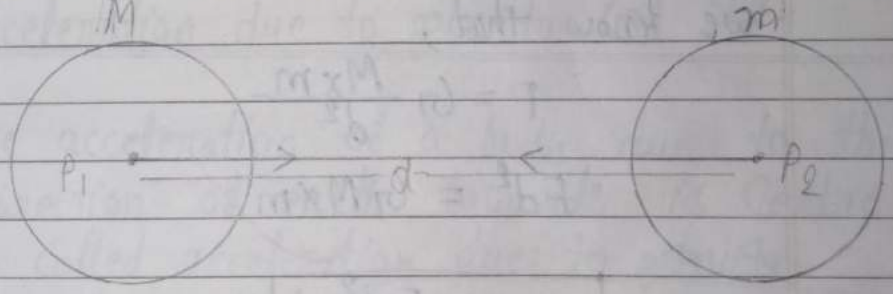
Science Notes K.V.S.

Class 9th

GRAVITATION

V.V.Imp. ## Universal Law of gravitation :-

Every object in the universal attracts every other object with a force which is Proportional to the product of their masses and inversely Proportional to the Square of the distance between them.



* The force between two objects is directly Proportional to the product of their masses.

$$F \propto M \times m \quad \text{——} (I)$$

* The force between two objects is inversely Proportional to the square of the distance between them.

$$F \propto \frac{1}{d^2} \quad \text{——} (II)$$

"In a gentle way, you can shake the world." –Mahatma Gandhi

Combining equation (I) and (II), we get

$$F \propto \frac{M \times m}{d^2}$$

or $$\boxed{F = G \frac{M \times m}{d^2}}$$

Universal gravitional Constant (G) :-

it is the force of attraction between the masses of 1 kg each kept at a distance of 1 m.

we know that,

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

$$Fd^2 = G M \times m$$

$$\boxed{G = \frac{Fd^2}{M \times m}}$$

* unit of $G = Nm^2/kg^2$
* Value of $G = 6.67 \times 10^{-11}$
* The value of G is find out by Henry Cavendish (1731 - 1810).

"Failure comes only when we forget our ideals and objectives and principles." - Jawaharlal Nehru

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Importance of the universal Law of Gravitation :-

i) The force that blinds us to the earth.
ii) The motion of the moon around the earth.
iii) The motion of planets around the Sun.
iv) The tides due to the moon and the Sun.

Free fall :- A body falling towards centre of the earth under the influence of gravitional pull alone is said to be freely falling body.

V.V.Imp

Acceleration due to gravity (g) :-

The acceleration of a body due to the direction of earth towards is Centre is called acceleration due to gravity.

We know that, (Relation betwn g and G)

$$F = ma$$

This acceleration is due to the force of gravity.

So, $F = mg$

We know from universal law of gravitation

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

"In a gentle way, you can shake the world." -Mahatma Gandhi

So, $mg = \frac{GMm}{R^2}$

$g = \frac{GM \times m}{m R^2}$

$$\boxed{g = \frac{GM}{R^2}}$$

Value of g :-

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

Radius of earth $= 6.4 \times 10^6$ m

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

$$g = \frac{6.67 \times 10^{-11} \times 6 \times 10^{24}}{(6.4 \times 10^6)^2}$$

$$g = \frac{6.67 \times 6 \times 10^{-11} \times 10^{24}}{40.96 \times 10^{12}}$$

$$g = \frac{40.02 \times 10^{13}}{40.96 \times 10^{12}}$$

$$g = 0.98 \times 10$$

$$\boxed{g = 9.8 \text{ m/s}^2}$$

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V.Imp.

Difference between G and g.

	g	G
1-	The acceleration of body due to the direction of earth towards is Centre is Called acceleration due to gravity.	1- it is the force of attraction between the masses of 1 kg each kept at a distance of 1 m.
2-	The acceleration of body when falling under gravitational pull of earth.	2- The gravitional force between bodies of unit mass each separate by unit distance.
3-	The value of $g = 9.8$ m/s	3- The value of $G = 6.67 \times 10^{-11} Nm^2/kg^2$
4-	The value of g is different at different Positions.	4- The value of G remains Constant every where.
5-	The g is zero at Centre of earth	5- The G is $6.67 \times 10^{-11} Nm^2/kg^2$ at center at earth.

Note:- i) The value of g decreases with height and depth.

ii) The value of g is more at Poles, less at equator.

"In a gentle way, you can shake the world." –Mahatma Gandhi

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equation of motion of a freely falling body:-

Acceleration 'a' is replaced by 'g'

$$V = u + gt$$

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

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

Mass:- it is the quantity of matter contained in a body. it is constant every where.

* it is Scaler quantity.
* its S.I. unit is Kg.

Weight :- weight of a body is the force with which the earth attracts a body.

we know that,

$$F = ma$$

$$F = mg$$

$$\boxed{W = mg}$$

* it is Vector quantity.
* its S.I. unit is N (Newton)

J.Imp.

* weight of object on moon = $\boxed{\frac{1}{6} \times \text{weight on earth.}}$

"Failure comes only when we forget our ideals and objectives and principles." – Jawaharlal Nehru

NCERT textbook page no. 134

Q.1 State the universal law of gravitation.

Ans Every object in the universal attracts every other object with a force which is proportional to the product of their masses and inversely proportional to the square of the distance between them.

Q.2 Write the formula to find the magnitude of the gravitational force between the earth and an 'object' on the surface of the earth.

Ans The mass of the earth and 'm' be the mass of an object on its surface. if 'R' is the radius of earth, then according to the universal law of gravitation Force (F) acting between the earth and the object is given by the relation.

NCERT textbook page no. 136

Q.1 what do you mean by free fall?

Ans A body falling towards centre of the earth under the influence of gravitional pull alone is called free fall.

Q.2 what do you mean by acceleration due to gravity?

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Ans The acceleration of a body due to the direction of earth towards is Centre is Called acceleration due to gravity.

Q. NCERT textbook Page no. 138

Q.1 what are the differences between the mass of an object and its weight?

Ans

	Mass	weight
1-	it is the quantity of matter Contained in a body. it is Constant every where.	1-weight of a body is the force with which the earth attracts a body.
2-	it is Scaler quantity.	2- it is Vector quantity.
3-	its SI unit is kg.	3- its S.I. unit is N.
4-	it is the measure of Inertia of the body	4- it is the measure of gravity.
5-	it only has magnitude	5- it has magnitude as well as direction.
6-	mass is Constant quantity	6-weight is not Constant quatity.

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Q.2 Why is the weight of an object on the moon 1/6th its weight on the earth?

Ans The weight of an object depends on 'g' acceleration due to gravity and the value of 'g' on earth and moon is not same.

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

The mass and Radius of the earth is more than the mass and Radius of the moon.

As. $W = GMm/R^2$ the weight of a body on the earth ~~is~~ 6 times more than the weight of a same body on moon.

Thrust :— The force acting on an object perpendicular to the surface is called Thrust.

Pressure :— $\frac{\text{Thrust}}{\text{Area}}$

Pressure :— Force (Thrust) acting on an unit area is called Pressure.

* it is SI unit is ~~Nm^{-2} / Pa~~ (Pa = Pascal)
N/m^2 or Pascal

"In a gentle way, you can shake the world." —Mahatma Gandhi

Buoyancy :- The upward force exerted by the water on the object is known as upthrust or buoyant force.

density :- The density of a substance is defined as the mass per unit volume.

* $\text{Density} = \frac{\text{mass}}{\text{volume}}$

V. Imp. * objects of density less than that of a liquid float on the liquid.

Archimedes principal :- 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.

applications of Archeimeds principals :-

* it is used in designing ships and Submarines. Lactometer, which are used to determine the purity of a sample of milk and hydrometers used for determining density of liquids are based on this principal.

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Relative density :— The relative density of a substances is the ratio of ~~its~~ density ~~to that~~ of water.

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

NCERT textbook Page no: 141

Q.1 why is it difficult to hold a school bag having a strap made of a thin and strong string?

Ans because the shoulders is quite large. This is because the pressure is inversely proportional to the surface Area on which the force acts. The smaller is the surface are, the larger will be the pressure on the surface. In the case of a thin strap, the Contact surface area is very small. Hence, the shoulders is very large.

Q.2 what do you mean by buoyancy?

Ans The upward force exerted by the water on the object is known as buoyancy.

Q.3 why does an object float or sink when placed on the surface of water?

"In a gentle way, you can shake the world." —Mahatma Gandhi

Ans The density of the object and water decides the floating or sinking of the object in water. The density of water is 1 gm/cm³

- if the density of an object is less than the density of water then the object will float.
- if the density of an object is more than the density of water then the object will sink.

NCERT Textbook Page no. 142

Q.1 You find your mass to be 42 kg on a weighing machine. Is your mass more or less than 42 kg?

Ans The weighing machine actually measures the mass of the body. Hence, the mass reading of 42 kg given by a weighing machine is same as the actual mass of the body. As mass is the quantity of inertia. it remains the same.

Q.2 You have a bag of cotton and an iron bar, each indicating a mass of 100 kg when measured on a weighing machine. In reality, one is heavier than other. Can you say which one is heavier and why?

Ans The heaviness of the bag can be given by density

$$\text{Density} = \frac{\text{mass}}{\text{Volume}}$$

mass of both Cotton bag and iron bag is same. But the volume of Cotton bag is more than the iron bag.
Hence, density is inversely proportional to volume. The bag of iron will be heavier.

NCERT Exercise

Q.1 How does the force of gravitation between two objects change when the distance between them is reduced to half?

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

if d is reduced to $\frac{1}{2}$

$$F \propto \frac{1}{\left(\frac{1}{2}\right)^2}$$

$$F \propto \frac{1}{\frac{1}{4}} \quad \therefore \quad F \propto \frac{4}{1}$$

The force of gravitation becomes 4 times more.

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Q.2 Gravitational force acts on all objects in proportion to their masses. Why then, a heavy object does not fall faster than a light object?

Ans The heavy object when falls, the acceleration due to gravity 'g' is acting on it, which is independent of the mass of the body.

$$g = \frac{GMm}{R^2}$$

Therefore, a heavy object does not fall faster than a light object.

Q.3 What is the magnitude of the gravitational force between the earth and a 1 kg object on its surface? (mass of the earth is 6×10^{24} kg and radius of the earth is 6.4×10^6 m)

Ans $M_E = 6 \times 10^{24}$ kg

$m = 1$ kg

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

$R = 6.4 \times 10^6$ m

$$F = G\frac{Mm}{R^2} = \frac{6.67 \times 10^{-11} \times 6 \times 10^{24} \times 1}{6.4 \times 10^6 \times 6.4 \times 10^6}$$

$$= \frac{0.98}{40.02 \times 10^{13}} \cancel{40.96 \times 10^{12}}$$

$$= 0.98 \times 10 = 9.8 \text{ N}$$ Ans

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Q.4 The earth and the moon are attracted to each other by gravitational force. Does the earth attract the moon with a force that is greater or smaller or the same as the force with which the moon attracts the earth? Why?

Ans According to the universal law of gravitation ~~ed~~, two object attract each other with equal force, but in opposite direction. The earth attracts the moon with an equal force with which the moon attracts the earth.

Q.5 if the moon attracts the earth, why does the earth not move towards the moon?

Ans The earth and the moon experience equal gravitational force from each other, However, the mass of the earth is much larger than the mass of the moon. Hence, it accelerated rate lesser than the acceleration rate of moon towards the earth. for this reason, the earth does not move towards the moon.

Q.6 what happens to the force between two objects. if.

i) the mass of one object is doubled?

"In a gentle way, you can shake the world." –Mahatma Gandhi

Ans if the mass of one object is doubled, the force between two objects will be doubled.

ii) The distance between the objects is doubled and tripled?

Ans if the distance between the objects is doubled the force between two objects will be one-fourth and if the distance will be tripled, the force will be one-ninth (1/9).

iii) The masses of both objects are doubled?

Ans if the masses of both objects are doubled the force will be 4 times.

As $F \propto \frac{Mm}{d^2}$

Q.7 what is the importance of universal law of gravitation?

Ans i) the force that binds us to the earth.
ii) The motion of the moon around the earth.
iii) the motion of planets around the Sun.
iv) The tides due to the moon and the Sun.

Q.8 what is the acceleration of free fall?

Ans A body falling towards the centre of the earth under the influence of gravitational Pull alone is called free fall. Acceleration of free fall is $9.8\ m/s^2$.

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Q.9 What do we Call the gravitational force between the earth and an object?

Ans Gravitational force between the earth and an object is Called weight of the object.

Q.10 Amit buys ---------- equator].

Ans weight of body on the earth is given by:-

$$w = mg$$

m = mass of the body

g = Acceleration due to gravity

The value of g is greater at poles than at the equator. Therefore, gold at the equator weighs less than at the polse. Hence, Amit's friend will not agree with the weight of gold bought.

Q.11 ~~when a sheet of paper is crumpled into a ball, then its density increase~~

Q.11 Why will a sheet of paper fall slower than one with that is Crumpled into a ball?

Ans when a sheet of paper is Crumpled into a ball then its density increase. Hence, resistance to its motion through the air decreases and it falls faster than the sheet of paper.

Q.12 Gravitational force on the surface of the moon is only $\frac{1}{6}$ as strong as gravitational

on the earth. what is the weight in newtons of a 10kg object on the moon and on the earth?

Ans
$M = 10\ kg$
$g = 9.8\ m/s^2$
$W = ?$
$W = m \times g$
$W = 10 \times 9.8$
$W_E = 98\ N$ Ans

weight of object on moon $= \frac{1}{6} \times$ weight of earth

$= \frac{1}{6} \times 98$

$W_m = 16.3\ N$ Ans

Q.13 A ball is thrown vertically upwards with a velocity of 49 m/s. Calculate

i) The maximum height to which it rises,

Ans
$v = 0\ m/s$ $u = 49\ m/s$
$g = 9.8\ m/s^2$ $s = ?$

using IIIrd equation of gravitation

$v^2 = u^2 + 2gs$
$(0)^2 = (49)^2 + 2 \times 9.8 \times s$
$0 = 2401 + 19.6 \times s$
$s = \frac{2401}{19.6} = 122.5\ m$ Ans

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ii) the total time it takes to return to the surface of the earth.

Ans $T = ?$

using IST equation of gravitation

$$V = u + gt$$
$$0 = 49 + 9.8 \times t$$
$$t = \frac{49}{9.8}$$
$$t = 5 \text{ sec.}$$

Time of ascent = Time of descent

$\therefore$ Total time $= 5 + 5$

$= 10$ sec. Ans

Q.14 A stone is released from the top of a tower of height 19.6 m calculate its final velocity just before touching the ground.

Ans $u = 0 \text{ m/s}$

$S = 19.6 \text{ m}$

$V = ?$

$g = 9.8 \text{ m/s}^2$

using IIIrd equation of gravitation

$$v^2 = u^2 + 2gs$$
$$v^2 = (0)^2 + 2 \times 9.8 \times 19.6$$
$$v^2 = 0 + 384.16$$
$$v = \sqrt{384.16}$$
$$\boxed{v = 19.6 \text{ m/s}}$$ Ans

Q.15 A stone is thrown vertically upward with an initial velocity of 40 m/s. Taking $g = 10 m/s^2$. find the maximum height reached by the stone. what is the net displacement and the total distance covered by the stone?

Ans $u = 40 m/s$ $g = 10 m/s^2$

$v = 0 m/s$ $S = ?$

using III rd equation of gravitation

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

$$(0)^2 = (40)^2 + 2 \times 10 \times s$$

$$0 = 1600 + 20s$$

$$s = \frac{1600}{20}$$

$$\boxed{s = 80 m}$$ Ans

Total displacement = 0 Ans

Total distance = Covered by stone during its upward and downward journey

$= 80 + 80 = 160 m$ Ans

Q.16 Calculate the force of gravitation between the earth and the Sun. given that the mass of the earth $= 6 \times 10^{24}$ kg and of the Sun $= 2 \times 10^{30}$ kg. The average distance between the two is $1.5 \times 10^{11} m$.

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Ans $M = 6 \times 10^{24}$ kg $\quad m = 2 \times 10^{30}$ kg

$R = 1.5 \times 10^{11}$ m $\quad G = 6.67 \times 10^{-11}$ Nm²/kg²

$F = ?$

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

$$F = \frac{6.67 \times 10^{-11} \times 6 \times 10^{24} \times 2 \times 10^{30}}{(1.5 \times 10^{11})^2}$$

$$F = \frac{35.6}{\cancel{80.04}} \times \frac{10^{43}}{\cancel{2.25} \times 10^{22}}$$

$F = 35.6 \times 10^{21}$ or 3.56×10^{22} Ans

Q.17 A stone is allowed to fall from the top of a tower 100 m high and at the same time another stone is projected vertically upwards from the ground with a velocity of 25 M/s. Calculate when and where the two stones will meet.

Ans $h = 100$ M $\quad t = ?$

$g = 10$ m/s² $\quad u = 0$ m/s

Height covered by the falling stone = S_1

$$S_1 = ut + \frac{1}{2}gt^2$$

$$S_1 = 0 \times t + \frac{1}{2} \times 10^5 \times t^2$$

$$S_1 = 5t^2$$

The distance covered by the stone train upward = S_2

$u = 25\ m/s$

$g = -10\ m/s$

$S_2 = ut + \frac{1}{2}gt^2$

$S_2 = 25 \times t + \frac{1}{2} \times -10 \times t^2$

$S_2 = 25t - 5t^2$

Total height given = 100 m

$S_1 + S_2 = 100$

$5t^2 + 25t - 5t^2 = 100$

$25t = 100$

$t = \frac{100}{25}\ s$

$t = 4$ sec. Ans

Putting the value of S_1

$S_1 = 5t^2$

$= 5 \times (4)^2$

$= 5 \times 16 = 80\ m$ Ans

4 sec. 80 m from the meet two stones.

Q. 18 A ball thrown up vertically returns to the thrower after 6 sec. find.

a) the velocity with which it was thrown up.

Ans Upward and downward time = 6 sec.

upward time = $\frac{6}{2} = 3$ sec.

$V = 0\ m/s$

$g = 9.8\ m/s^2$

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using I^st equation of gravitation

$v = u + gt$

$0 = u + 9.8 \times 3$

$0 = u + 29.4$

$u = 29.4$ m/s Ans

(ii) The maximum height it reaches, Ans

$u = 29.4$ m/s $\quad v = 0$ m/s

$g = 9.8$ m/s^2 $\quad s = ?$

using II^nd equation of gravitation

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

$(0)^2 = (29.4)^2 + 2 \times 9.8 \times s$

$0 = 864.36 + 19.6\,s$

$s = \frac{-864.36}{19.6}$

$s = -44.1$ m Ans

(iii) its position after 4 sec. Ans

$u = 29.4$ m/s $\quad g = -9.8$ m/s^2

$t = 4$ sec. $\quad s = ?$

using II^nd equation of gravitation

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

$s = 29.4 \times 4 + \frac{1}{2} \times -9.8 \times (4)^2$

$s = 117.6 + \frac{1}{2} \times -9.8 \times 16$

$s = 117.6 + (-78.4)$

$s = 39.2$ m Ans

"In a gentle way, you can shake the world." –Mahatma Gandhi

Q.19 In what direction does the buoyant force on an object immersed in a liquid act?

Ans An object immersed in a liquid experiences buoyant force in the upward direction.

Q.20 Why does a block of plastic released under water come up to the surface of water?

Ans The floating or sinking of a body in the water is decided by the density of both the body and water's buoyant force acting on the body.
The density of plastic is less than the water and the buoyant force exerted by water on the plastic block is greater than the force exerted by plastic on the water.

Q.21 The volume of 50g of a substance is 20 cm^3. if the density of water is 1 g/cm^3, will the substance float or sink?

Ans M = 50g.
Volume = 20cm^3

$$\text{Density} = \frac{\text{mass}}{\text{Volume}} = \frac{50}{20} = 2.5\ g/cm^3$$

Density of water = 1 g/cm^3

As the density of a given substance is more

then the density of water the substance will sink in water.

Q.22 The volume of a 500 g sealed packet is 350 cm^3. will the packet float or sink in water if the density of water is 1 g/cm^3? what will be the mass of the water displaced by this packed?

Ans $M = 500g$

$V = 350 cm^3$

$$\text{Density} = \frac{m}{V} = \frac{500}{350} = 1.4289 g/cm^3$$

Density of water = $1 g/cm^3$

The packet will sink in water as the ~~packet~~ density of packet is greater than the density of water.

mass of the water displaced by this packed = Volume of the packed × Density of water

$= 350 \times 1$

$= 350 g$ Ans

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Revision

Q.1 weight of a girl is 294 N. find her mass.

Ans $g = 9.8\ m/s^2$ $W = 294\ N$ $m = ?$

$W = mg$

$294 = m \times 9.8$

$\frac{294 \times 10}{98} = m$

$m = 30\ kg$ Ans

V.Imp

Q.2 what is the force of gravitation between two point masses of 1 kg and 2 kg depth 1 m apart.

Ans $M = 1\ kg$ $m = 2\ kg$ $d = 1\ m$

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

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

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

$$F = \frac{13.34 \times 10^{-11}}{1}$$

$F = 13.34 \times 10^{-11}\ N$ Ans

"Failure comes only when we forget our ideals and objectives and principles." – Jawaharlal Nehru