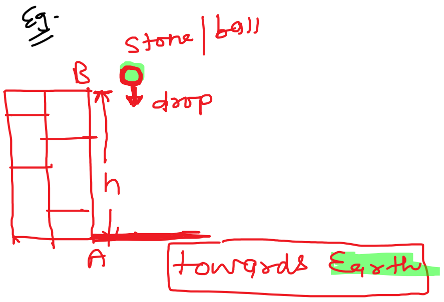
Eg.



* A force must be acting on this stone / ball as it moves downwards.

* This force is Called Force of attraction b/w Earth and Stone

Force

push or pull of a body

→ Necessary to produce motion in a body

Geo

* Gravitational force of Earth (Gravity)

The force of attraction exerted by the Earth towards an object, is called gravity.

Application → ① An apple falls down

② Rain falls down from the sky to the Earth due to Gravity

③ Water flow down the rivers.

④ Moon revolves around the Earth

Newton

* Every objects in the universe attracts every other object

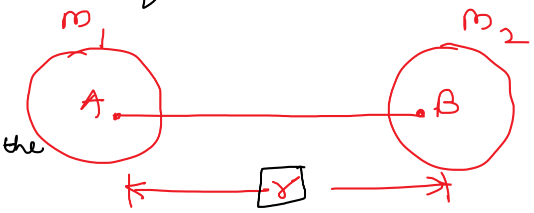
↓

Universal Law of Gravitation

Attraction Force

① $\boxed{F} \propto \boxed{m_1 \times m_2}$ ——— (I)

✓Force is directly proportional to the product of their masses.



② Force is Inversely proportional to square of the distance between b/w them

$F \propto \frac{1}{r^2}$ ——— (II)

Combine (I) & (II)

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

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

G is called proportionality Constant

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

$\boxed{G}$ is Called proportionality Constant

<u>Universal</u> <u>Gravitational</u> <u>Constant</u> (G)

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

$G \leftarrow$ universal Gravit-ational Constant

kg $\leftarrow m_1 \leftarrow$ mass of object 1

kg $\leftarrow m_2 \leftarrow$ mass of object 2

m $\leftarrow r \leftarrow$ Distance b/w these 2 objects

N $\leftarrow F \leftarrow$ Gravity

unit of $\boxed{G}$ $\quad \dfrac{F r^2}{m_1 \times m_2} = G$

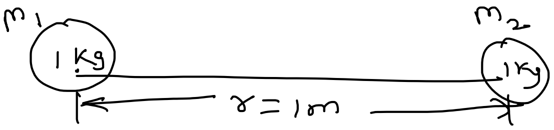
$\because \dfrac{1}{x^2} = x^{-2}$

$\dfrac{N m^2}{kg\ kg} = G$

$\because \dfrac{1}{kg^2} = kg^{-2}$

$\boxed{N m^2 kg^{-2}}$ unit of $\boxed{G}$

#



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

$$F = G\frac{\overset{1kg}{m_1}\overset{1kg}{m_2}}{\underset{1m}{r^2}}$$

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

$\boxed{G = 6.67 \times 10^{-11}\ N m^2 kg^{-2}} \leftarrow$ Everywhere in the universe

Henry Cavendish

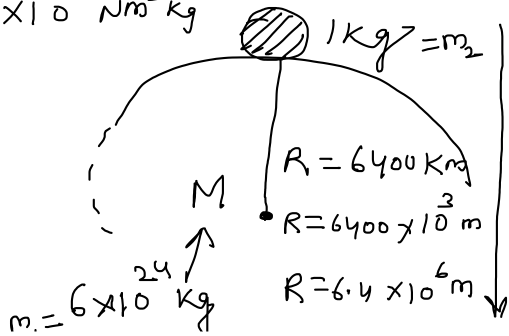
Q. ① Calculate the $\boxed{\text{force}}$ of gravitation due to earth on a ball of 1 kg mass lying on the ground

Sol

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

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

$$F = \frac{6.67 \times 10^{-11} \times 6 \times 10^{24} \times 1}{6.4 \times 10^6 \times 6.4 \times 10^6} N$$



mm
cm
dm
$\boxed{m}$
Dm
hm
$\boxed{Km}$

$$\frac{}{6.4\times10^{6}\times6.4\times10^{6}}\ N$$

$m_1 = 6\times10^{24}$ Kg $R = 6.4\times10^{6}$ m ↓ $\boxed{Km}$

$$F = \frac{\boxed{6.67\times6}}{\boxed{6.4\times6.4}}\times10^{-11+24-12}\ N$$

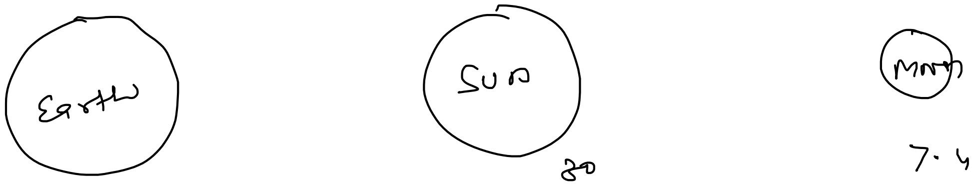
$= 10^{-23+24} = 10^{1}$

$$F = \frac{6.67\times6}{6.4\times6.4}\times10$$

1kg —— 1kg → Negligible force

$$F = \frac{667\times\cancel{60}^{15}}{64\times\cancel{64}_{16}} = \frac{667\times15}{64\times16} = \boxed{9.8\ N}$$ Ans.

⇐ large force



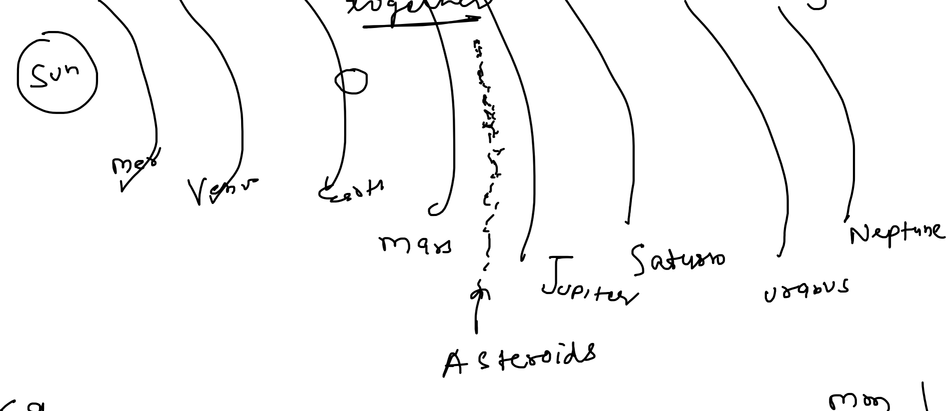
Mass = 6×10^{24} kg 2×10^{30} Kg 7.4×10^{22} Kg } Extremely large

5) Gravitational force holds the $\boxed{\text{solar system}}$ together

$F \propto m_1 m_2$

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

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



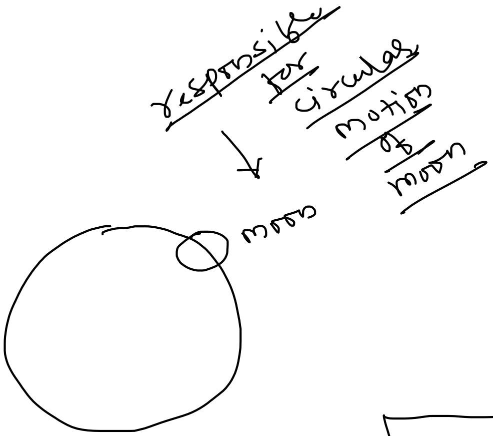
Q.2 $M_E = 6\times10^{24}$ Kg

$M_m = 7.4\times10^{22}$ kg F = ?

$r = 3.84\times10^{5}$ Km $= 3.84\times10^{8}$ m

mm
cm
dm
(m)
Dm
Hm
$\boxed{Km}$
↓

Sol ⇒ $$F = G\frac{M_E M_m}{r^2} = \frac{6.67\times10^{-11}\times6\times10^{24}\times7.4\times10^{22}\ Kg}{3.84\times3.84\times10^{16}}$$

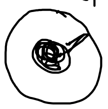


$$= \frac{6.67\times6\times7.4}{3.84\times3.84}\times10^{-11+24+22-16}$$

$$= \frac{6.67\times6\times7.4}{3.84\times3.84}\times10^{46-27}$$

$$\approx 20.01 \times 10^{19}$$

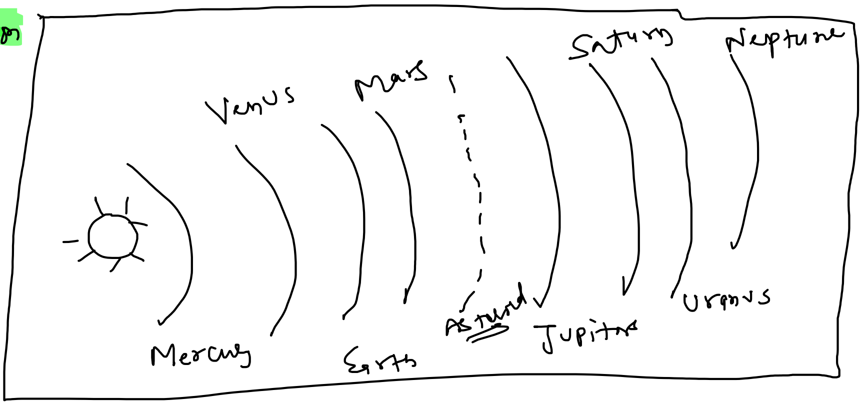
$$\boxed{F \approx 2.01\times10^{20}\ N}$$ ← Extremely large



$F_g = F_c = \frac{mv^2}{r}$

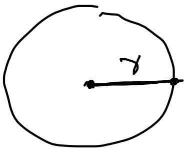
⑥ The tides in the sea formed by rising and falling of water level is because of gravitation

Kepler's Law of Planentary motion



① The planet move in elliptical orbits around the sun, with the sun at one of the focus

② Each planet revolves around the sun in such a way that the line joining the planet to the sun sweeps over equal areas in equal intervals of time.

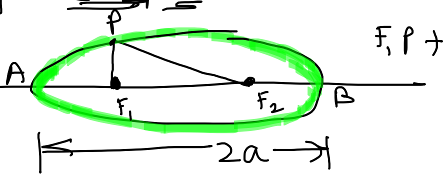


→ $A = \pi r^2$

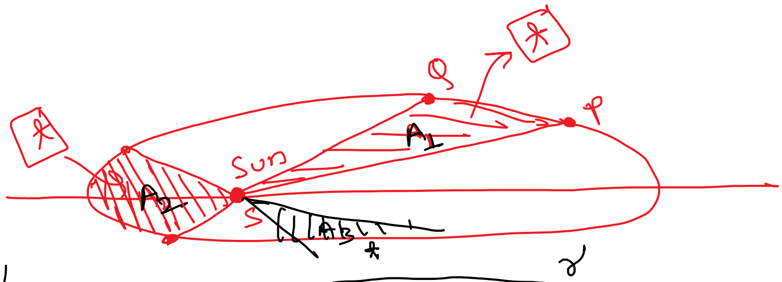
$C = 2\pi r$

$d = 2r$

Ellipse



$F_1P + F_2P = AB$



$A_1 = A_2 = A_3$

③ The cube of the mean distance (r) of a planet from the Sun is

③ The cube of the $\boxed{\overset{r}{\text{mean distance}}}$ of a planet from the Sun is directly proportional to the square of $\boxed{\underset{T}{\text{time}}}$ it takes to move around the sun.

$$\boxed{r^3 \propto T^2}$$

$$r^3 = K T^2$$

2 objects

$$\frac{r_1^3}{r_2^3} = \frac{K T_1^2}{K T_2^2} \Rightarrow \boxed{\frac{r_1^3}{r_2^3} = \frac{T_1^2}{T_2^2}}$$

Note

Centripetal force

$$\boxed{F_c = \frac{mv^2}{r}}$$

$r_1 = 2m$

$r_2 = 3m$

$T_1 = 4yr$

$T_2 = ?$

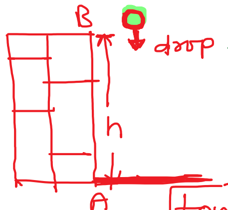
$$\rightarrow \frac{2^3}{3^3} = \frac{4^2}{T_2^2}$$

$$T_2^2 = \frac{\overset{2}{\cancel{16}} \times 9}{\cancel{8}}$$

$$T_2 = \sqrt{18}\,yr = 3\sqrt{2}yr$$

Free-Fall → The falling of a body from a height towards the earth under only the gravitational force of the Earth is called free fall.

Eg. stone | ball } ← Freely falling body



Free Fall

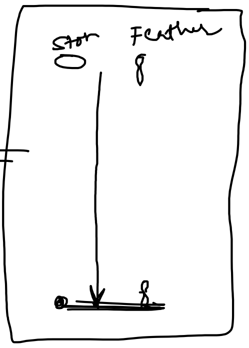
towards Earth

Eg. Bungee Jumping

Eg. sky diving

Note :-

The acceleration of an object falling freely towards the earth does not depend on the mass of the object ⇐



Acceleration due to Gravity (g)

Acceleration due to Gravity (g)

→ Acceleration produced in a freely falling body due to gravity.

Calculation

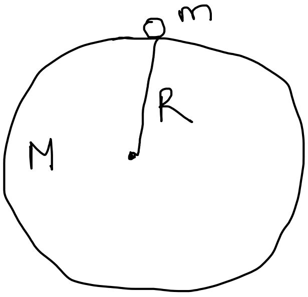
as per universal law of gravitation

$$F = \frac{GMm}{R^2} \quad \text{———} \; ①$$

as per II law of motion

$$F = ma \quad \text{———} \; ⑪$$

from ① & ⑪



$$\frac{GM\cancel{m}}{R^2} = \cancel{m}a$$

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

Q.

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

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

$R = 6.4 \times 10^{6}\ m$

$$g = \frac{6.67 \times 10^{-11} \times 6 \times 10^{24}}{6.4 \times 6.4 \times 10^{12}}$$

$$g = \frac{6.67 \times \overset{3}{\cancel{6}}}{\underset{3.2}{\cancel{6.4}} \times 6.4} \times 10$$

$$\begin{array}{r} 32 \times 64 \\ \hline 128 \\ 192 \\ \hline 2048 \end{array}$$

$$g = \frac{667 \times 30}{32 \times 64} = \frac{20010}{2048}$$

$$\begin{array}{r} 2048 \overline{)\,20010\,}(9. \\ 18432 \\ \hline \times 1578 0 \end{array}$$

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

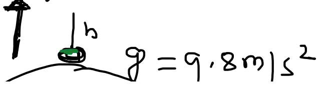
$$\boxed{g = 10\ m/s^2}$$ Approx

Note about g

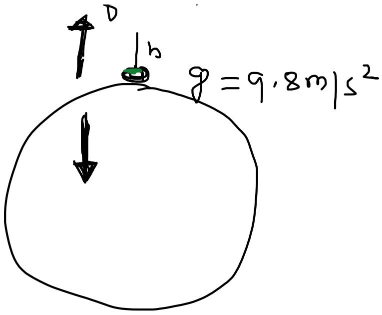
① Value of 'g' does not depend on the mass of a body

(ii) It's not constant at all the places on the surface of Earth

(iii) Decreases as we go up or down



(iii) Decreases as we go up or down from the centre of the Earth



UP

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

$$\frac{7}{3} < \frac{7}{2}$$

$$\boxed{g_h = \frac{GM}{(R+h)^2}}$$

$d = \frac{M}{V}$

$M = dV$

$g_h < g_{surface}$

$$\frac{7}{3} < \frac{11}{3}$$

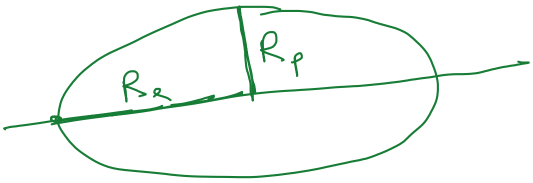
down | depth

$$g_s = \frac{GM}{R^2} = \frac{GdV}{R^2} = \frac{4\pi d}{3}\boxed{R}$$

$$g_d = \frac{4\pi d}{3}\boxed{(R-h)}$$

$g_d < g_s$

(iv)



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

$g_e < g_p$

(v) $g_{at\ centre} = 0\ m/s^2$

$$g = \frac{GM}{R^2} = \boxed{\frac{4\pi d}{3}} R$$

$g = 0\ m/s^2$

Q.

Q. Calculate g_{moon} if Mass of moon $= 7.4 \times 10^{22}$ kg $= \frac{1}{80} M_E$

[illegible] = $\boxed{1740}$ km = [illegible]

(moon of of kg $= \frac{1}{80} M_E$

Radius — = $\boxed{1740}$ km $= \frac{1}{4} R_E$

$R_E = 6400$ km

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

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

Soln

$$g_E = \frac{G M_E}{R_E^2} \quad \text{—①}$$

$$g_m = \frac{G M_m}{R_m^2} \quad \text{—⑪}$$

$$g_m = \frac{G\, M_E \cancel{\times 16}}{\cancel{80}\,5 \times R_E}$$

$$\boxed{g_m = \frac{g_E}{5}}$$

for exact

$$\boxed{g_m = \frac{1}{6} g_E}$$

$$g_m = \frac{9.8}{6} = 1.63 \text{m/s}^2$$

$$g_m = \frac{6.67 \times 10^{-11} \times 7.4 \times 10^{22}}{1740 \times 1740 \times 10^6 \text{m}} = 1.63 \text{m/s}^2$$

Q.

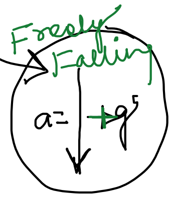
$\boxed{5 \text{kg}}$ $\boxed{a = 5 \text{m/s}^2}$ ✓ 9.8m/s^2

$\boxed{3 \text{kg}}$ $\boxed{a = 5 \text{m/s}^2}$ ✓ 9.8 m/s^2

Equation of motion for freely falling body

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

$\approx \boxed{10\text{m/s}^2}$

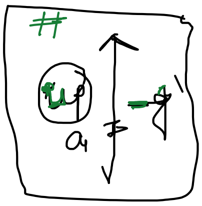


I → $v = u + at \Rightarrow \boxed{v = u + gt}$

II

#

$\equiv \boxed{10 m/s^2}$

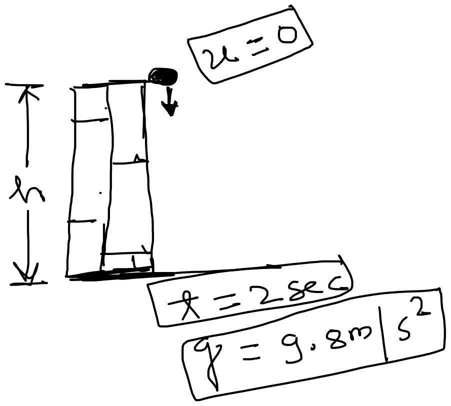


$\boxed{II} \rightarrow s = ut + \frac{1}{2} a t^2$

$\rightarrow \boxed{h = ut + \frac{1}{2} g t^2}$

$\boxed{III} \quad v^2 - u^2 = 2as \Rightarrow \boxed{v^2 - u^2 = 2gh}$

Q.①



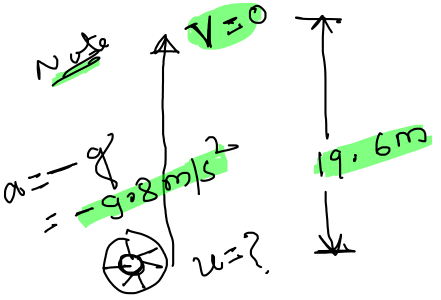
(II) Eqⁿ of Motion

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

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

$\boxed{h = 19.6 m}$

Q.②



using III Eqⁿ of motion

$v^2 - u^2 = 2gh$

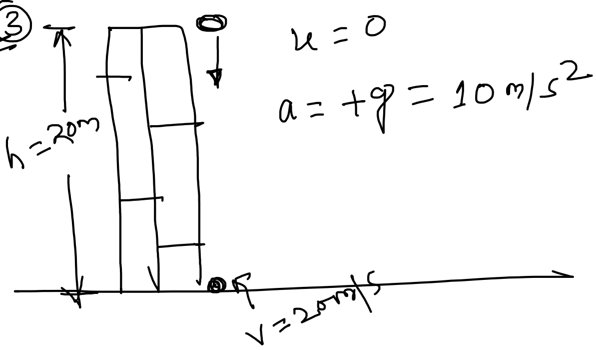
$0 - u^2 = 2 \times (-9.8) \times 19.6$

$u^2 = 19.6 \times 19.6$

$u = \sqrt{19.6 \times 19.6}$

$\boxed{u = 19.6 m/s}$

Q.③



$u = 0$

$a = +g = 10 m/s^2$

(a) $V = ?$

III Eqⁿ of motion

$v^2 - u^2 = 2gh$

$v^2 = 2 \times 10 \times 20$

$v = \sqrt{400} = \sqrt{20^2} = \boxed{20 m/s}$

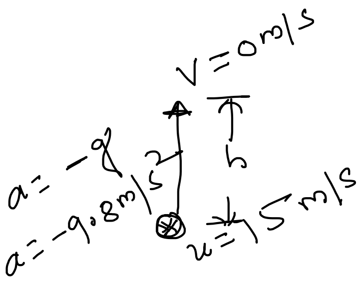
(b) $t = ?$

$\boxed{\text{I Eq}^n \text{ of motion}} \quad V = u + g t$

$20 = 10 \times t$

$\boxed{t = 2 \text{ Second}}$

Q.4



using III eq^n of motion

$v^2 - u^2 = 2as$

$v^2 - u^2 = 2(-g)h$

$0 - 15^2 = 2(-9.8)h$

$\frac{-225}{-19.6} = h$

$\boxed{11.4m = h}$

Mass	Weight
① Definition → The mass of a body is quantity of matter contained in it.	① The weight of a body is the force with which it is attracted towards the centre of the Earth.
② SI unit → Kilogram (kg)	② SI unit → Newton (N)
③ Measured by → Equal arm/beam balances → chemical balance (Science lab:)	③ The force earth's gravity on the object. Force = Mass × acceleration $F = m \times a$ $F = mg$ $\boxed{W = mg}$
④ The mass of a body/object is constant and does not change from place to place.	④ → $W \propto m$ ← weight increases as the mass ↑ on any surface → $W \propto g$ ← If g change

Note Mass is the measure

Note Mass is the measure

5) of Inertia of a body.

6) Mass of a body cannot be zero.

7) Scalar quantity

→ $w \propto g$ ← If g change then also weight get changed

⑤ Weight is '0' at centre of the Earth

$\boxed{W = mg = m \times 0 = 0N}$

weightlessness

⑥ Vector quantity

⑦ Measured using spring balance.

* On moon surface weight is $\left(\frac{1}{6}\right)^{th}$ of that of Earth's surface

Q. Find weight of 1Kg mass?

Sol. $m = 1kg$

$g = 9.8\ m/s^2$

$W = mg$

$$\boxed{W = 1 \times 9.8\ kg\,m/s^2 = 9.8\ N}$$

Q. Find weight of 5kg mass.

Sol. $W = mg$

$W = 5 \times 9.8$

$= 49\ N$

1.The weight of a body on the surface of the earth is 392 N. what will be the weight of this body on a planet whose mass is double that of the earth and radius is four times that of the earth?

2. What happens to the magnitude of the force of gravitation between two objects if:

(i) distance between the objects is tripled?

(ii) mass of both object is doubled?

(iii) mass of both objects as well as distance between them is doubled?

3.If the distance between two masses be increased by a factor of 6, by what factor would the mass of one of them hence to be altered to maintain the same gravitational force?

4.A fire cracker is fired and it rises to a height of 1000 m. find the
(i) velocity by which it was released.
(ii) time taken by it to reach the highest point (take g=10 ms−2g=10 ms−2)
5.Obtain a relation between the weight of an object on the surface of earth and that on moon.
6.On the earth, a stone is thrown from a height in a direction parallel to the earth� surface while another stone is simultaneously dropped from the same height. Which stone would reach the ground first and why?
7.Prove that if a body is thrown vertically upward, the time of ascent is equal to the time of descent.
8.Find the gravitational force between the sun and the earth. The mass of the sun is 2.0× 10302.0×1030 kg, and the mass of the earth is 6.0×10246.0×1024 kg. the distance between the sun and the earth is 1.5 \times 1011 m. (G=6.67× 10−11 Nm2 kg−2G=6.67 × 10−11 Nm2 kg−2).
9.Why Newton� law of gravitation is called the universal law?
OR
Write four phenomena which were successfully explained using universal law of gravitation.
10. What happens to the gravitational force between two objects if:
(i)The mass of one object is doubled?
(ii)The distance between the objects is doubled?
(iii)The masses of both the objects are doubled?
(iv)The distance between them is halved?
(v)Mass of one of the objects is halved?
11.Explain the force responsible for the following:
(a) Moon revolves around the earth.
(b) Objects lying apart on earth attract each other, yet they do not cling to each other.
12.A flower pot drops from the edge of the roof of a multistoried building. Calculate the time taken by the pot to cross a particular distance AB of height 2.9 m, the upper point A being 19.6 m below the roof.
12. If a ball is thrown straight upwards at a speed of 11 m/sec from balcony, 4 m above the ground, how much time would it take to strike the ground at the base of the balcony?
13.(a) Find the value of acceleration due to gravity at a height of 12,800 km from the surface of the earth. Earth� radius = 6400 km.
(b) State Newton� law of gravitation and write the mathematical equation describing it.
14.The value of 'g' on earth� surface is 9.8 m/s29.8 m/s2. Suppose the earth suddenly shrinks to one �third of its present size without losing any mass. What is the value of g on the surface of shrinked earth?
15.A ball thrown vertically up returns to the thrower after 6 s. find:
(i) The velocity with which it was thrown up.
(ii) The maximum height it reaches.
(iii) Its position after 4 s.