(2) The motion of the moon and artificial satellites around the Earth.
(3) The motion of the planets , asteroids , comets ,etc ., around the sun
(4) The tides of the sea due to the moon and the sun.

6) A body weight more at poles and less at equator.

Ans):1) The weight of an object is defined as the force with which the earth attracts the object.It is given as, W=F=mg.
2) The weight of an object depends on the mass and the value of acceleration due to gravity.
3) The value of g on pole is 9.832 m/s2 and on equator is 9.78 m/s2.
4) Hence,a body weighs more at the poles and less at equator.

7) Space travellers as well as objects in the spacecraft appear to be floating

Ans): (1) In space, space craft is only under the influence of gravitational force of the earth alone. so, the spacecraft is in a state of free fall.
2) The velocity in free fall is not depend on properties of an object.
3) Thus, velocity is the same for the spacecraft, space travelers and the objects in the spacecraft
4) Weightlessness of space travelers as well as object in the spacecraft is due to free fall.
5) Due to weightlessness, space travelers as well as object in the spacecraft appear to be.

Q.3 Answer the following.

1) What is difference between mass and weight of an object? Will the mass and weight of an object
On the earth be the same as their values on Mars? Why?

Ans):1) The mass of an object is the amount of matter present in it.
2) Mass is same everywhere in the universe and it is never be zero. Mass is scalar quantity.
3) The weight of an object is the force with which the earth attracts planets and it is directed towards the center of earth.
4) The weight of an object is different at places on the earth. It is zero at the center of the earth. 5) Mass Will be same on Earth and Mars But weight will not be same. As value of g changes from place to place.

1. GRAVITATION

Q.1(A)Define the terms.

1)Force: The physical quantity which changes or tends to change the state of rest or **state of uniform motion in a straight line is called force.**

2) Uniform circular motion: When an object moves in a circular path with uniform speed, its motion is called uniform circular motion.

3) Centripetal force: The force that acts on any object moving along a circular path and directed towards the center of the circle is called centripetal force.

4) Gravitational potential energy: The energy stored in a body due to the gravitational force between the body and the earth is called the gravitational potential energy.

5) Universal constant of gravitation (G): The force of attraction between two unit masses placed at
unit distance apart from each other is called as universal constant of gravitation.

6) Acceleration due to gravity: The acceleration produced in a body due to the gravitational force of the earth is called the acceleration due to gravity.

7) Mass (m): The amount of matter present in the body is called mass.

8) Weight (W): The weight of a body is defined as the force with which the earth attracts the object.

9) Escape velocity: When a body is thrown vertically upward from the surface of the earth, the minimum initial velocity of the body for which the body is able to overcome the downward pull by the earth and can escape the earth forever is called the escape velocity.

10) Free fall : When a body falls towards the earth under the influence of the earth's gravity alone, its motion is called a `free fall'. OR
When an object moves under the influence of the gravity alone, it is said to be falling freely.

Q.1(B) State the laws:

(1) Kepler's first law : The orbit of a planet is an ellipse with the sun at one of the foci.

(2) Kepler's second law: The line joining the planet and sun sweeps equal areas in equal intervals of time.

(3) Kepler's thirdlaw: The square of its period of revolution around the sun is directly proportional to the cube of the mean distance of a planet from the sun.

(4) Newton's universal law of gravitation: Every object in the universe attracts every other object with a definite force. This force is directly proportional to the product of the masses of the two object and inversely proportional to the square of the distance between them.

Q. 2 Give scientific reasons:

(1) Any object on earth falls vertically downwards and not at an angle to the vertical ; nor fly off in a horizontal direction.

Ans:

1)The earth attracts any object directed towards the center of the earth.

2) At any given position of a falling object, the direction from the falling object towards the

3) Hence, any object on earth will fall vertically downward and not at an angle to the vertical;

4) Nor will the object fly off in a horizontal direction.

(2) Explain why the value of g is zero at the center of the earth.

Ans:

1) The value of g depends on the mass (M) of the earth and the radius (R) of the earth.

2) As we go inside the earth, our distance from the center of the earth decreases and radius (R) of the earth also decreases.

3) Along with the distance, the gravitational force felt also decreases and decreasing the value of mass (M).

4) Due to combined result of change in radius and mass, value of g becomes zero at the center of the earth.

(3) One can jump higher on the surface of the moon than on the earth.

Ans):1) Acceleration due to gravity (g) on the surface of a planet or moon is given by the *formula* $g=GM/R^2$

2) The earth and the moon have different massed and radii due to which the value of g is different on their surfaces.

3) The value of g on moon is $1/6^{th}$ of that on the surfaceof earth.

4) Hence, one can jump higher on the surface of the moon than on the earth.

4) If the value of g suddenly becomes twice its value, it will become tetra times more difficult to pull a heavy object along the floor. Why?

Ans): 1) The weight of an object is the force with which the earth attracts the object . It is given as, W=F=mg

2) The weight of an object depends on the mass of the object and the value of acceleration due to gravity.

(3) If the value of g doubles, the force with which the earth attracts the object also becomes twice.

4) Thus, the object becomes twice as heavier, making it harder to be pulled along the floor.

(3) Along with the distance, the part of earth which contributes towards the gravitational force Felt by the object (M) also decreases.

(4) Thus, due to the combined effect of changing value of r and M, the value of g decreases.

(5) At the Centre of the earth, the value of g becomes zero.

(5) State the importance of Newton's universal law of gravitation.

(Ans): This law explains (1) The force that binds the objects on the earth to the earth.

(1) Weight of all the objects on the earth will become double
(2) Human body weight will become twice the original weight.
(3) The atmospheric air pressure would increase leading to various climatic changes.
(4) Various structures like houses, bridges, dams etc. would collapse due to the increase in weight .
(5) The earth's orbit around the sun will be affected which will result in catastrophic climatic Changes.

(3) Why does the apple fall towards the earth , but the earth does not move towards the apple?

(Ans) :(1) The apple attracts the earth with the same force with which the earth attracts the apple.
(2) According to Newton's third law, these two forces are equal and opposite in direction.
(3) For same magnitude of force , the acceleration produced in a body is inversely proportional toits mass.
(4) As the mass of the earth is very large compared to that of the apple ,the acceleration of theearth is too small as compared to the acceleration of the apple that is cannot be noticed.Hence , the apple falls towards the earth while the earth does not move towards the apple.

(4) Write a short note on escape velocity.

(Ans):(1) Goes on decreasing and after some time the body falls back to the ground.
(2) If its initial velocity is increased, the maximum height attained by it is more , but it does fall back to the ground.
(3) If the initial velocity is increased continuously, for a particular initial velocity, the body can Overcome the earth's
gravitational force and move to infinity and come to rest there.
This velocity is called the escape velocity.

(2) Write the three laws given by Kepler. How did they help Newton to arrive at inverse square law of gravity?

(Ans): **(1) Kepler's first law** : The orbit of a planet is an ellipse with the sun at one of the foci.
(2) **Kepler's second law** : The line joining the planet and the sun sweeps equal areas in equal Intervals of time.
(3) **Kepler's third law**: The square of its period of revolution around the sun is directly Proportional to the cube of the mean distance of planet from the sun.

NEWTON'S INVERSE SQUARE LAW OF GRAVITATION:

(1) Consider a planet revolves around the sun in a circular orbit, then the centripetal force Exerted on planet by the sun is $F=mv^2/r$
Where, m-mass of the planet
v-velocity of the planet
r-radius of the orbit
(2)Distance travelled in one revolution by the planet=Circumference=$2\pi r$
Time period of revolution = T
Speed =distance / time

$$v = 2\pi r/T \ldots\ldots(1)$$

$$F=m(2\pi r)^2/T/r$$

$$F=m4\pi^2r^2/T^2/r$$

$$F=4m\pi^2 r/T^2$$

Multiplying and dividing by r^2

From kepler's third law

$$F = 4m\pi^2 r/T^2 \times r^2/r^2$$

$$F = 4m\pi^2/r^2 \times r^3/T^2 \times 1/r^2 \ldots\ldots\ldots\left[\frac{T^2}{r^3} = kor\ \frac{r^3}{T^2} = \frac{1}{k}\right]\ldots\ldots\ldots(2)$$

$$F = 4m\pi^2/k \times 1/r^2 \left[but\ \frac{4m\pi^2}{k} isconstant\right]$$

$$F\ \alpha\ 1/r^2$$

This is how newton proved gravity.

(3) A stone thrown vertically upwards with initial velocity u reaches a height `h' before coming down. Show that the time taken to go up is same as the time taken to come down.

(Ans): The time taken to go up = the time taken to come down. ,

During going up:

$V = u + at$ $(v = 0, = -g, t = t1)$

$0 = u - gt1$

$gt1 = u$

$t1 = u / g$ .....(1)

During go down

$S = ut + \frac{1}{2} at^2$ (but $u = o$, $a = g$, $t = t2$)

$S = 0 + \frac{1}{2} gt2^2$

$S = gt2^2 / 2$ .....(2)

We know, the formula of max height attained

$S = u^2 / 2g$ .....(3)

From equation (2) and (3)

$u^2 / 2g \div gt2^2 / 2 = u^2 / 2g \times 2 / gt2^2 = u^2 / g^2 = t2^2$

$t2 = u / g$ .....(4)

Form equation (1) and (4)

$t1 = t2$

(4) Let the period of revolution of a planet at a distance R from a star be T. Prove that if it was at a Distance of 2R from the star, its period of revolution will be $\sqrt{8}$ T.

(Ans): According to Kepler's third law, the square of orbital period of revolution T of planet around a Star is directly proportional to the cube of the mean distance R of the planet from the star. $T^2 \propto R^3$

$T^2 = k \times R^3$ ..... (1) (Where k is constant)

When planet is at a distance of 2R from the star, then its period of revolution T will be

$T^2 \propto (2R)^3$

$T^2 = k \times (2R)^3$ .....(2)

Dividing equation (1) and (2) we get

$T^2 / T^2 = R^3 / (2R)^3$

$T^2 / T^2 = R^3 / 8 \times R^3 = 1 / 8$

$T^2 \times 8 = 1 \times T^2$

$T^2 = 8 \times T^2$

$T = \sqrt{8T}$

Thus, for a planet at a distance of 2R from the star, its period of revolution will be $\sqrt{8T}$.

Q . 4 Answer the following.

(1) Explain the factors affecting the value of g.

(Ans) : The following factors affect on value of `g' :

(a) Shape of the earth:

(1) The shape of the earth is not perfectly spherical. It is slightly flattened at the poles and bulgedat the equator.

(2) As a result, the radius of the earth at the poles is less than that at the equator.

(3) Hence, the value of `g' is highest at the poles (9.83m/s^2) and decreases slowly with decreasing latitude . It is the lowest at the equator. (9.78 m/s^2)

(b) Height :

(1) As the height of an object from the surface of the earth increases , the distance between the Object and the center of the earth (r) increases .

(2) As a result, the value of `g' decreases with increases in height.

Place	**Height(km)**	**G(m/ s^2)**
Surface of Earth	0	9.8
Mount Everest	8.8	9.8
Height of weather satellite	400	8.7
Height of communication satellite	35700	0225

(c) Depth:

(1) The value of g is maximum on the surface of the earth.

(2) As depth of an object increases, the distance between the object and the center of the earth decreases.

in a free fall. As the velocity of free fall does Not depend on the properties of an object, the velocity of free fall is the same for the spacecraft, The travelers and the objects in the craft. Thus, if a Traveler releases an object from her hand, It will remain stationary with respect to her and will appear to be weightless.

(1) Is the value of g zero in the space station?

(Ans) : No, the value of g is only 11% less than its value on the surface of earth.

(2) Why is weightlessness caused in a spacecraft?

(Ans): The weight is caused due to free fall.

(3) Why doesn't the spacecraft does not fall towards earth

(Ans): The spacecraft does not fall towards earth because of its velocity along the orbit.

(4) If a traveler releases an object from her hand in the spacecraft what will happen?

(Ans): The object will remain stationary with respect to her hand , because , the velocity of free fall Is the same for the spacecraft , traveler and objects in the craft.

Q. 6 Distinguish between.

(1) Universal gravitational constant and Gravitational acceleration of the earth .

Universal gravitational constant	Gravitational acceleration of the earth
(1) The universal gravitational constant numerically equals the force of attraction two unit masses separated by a unit distance.	(1) The gravitational acceleration of the earth is the acceleration produced in a body due to the gravitational force of
(2) Its value remains constant throughout the Universe.	(2) Its value changes from place to place.
(3) It has magnitude but not direction	(3) It has both magnitude and direction.
(4) Its SI unit is $N.m^2/kg^2$.	(4) Its SI unit is m/s^2.

(2) Mass and Weight

Mass	Weight
(1) The mass of a body is the amount of matter Present in it.	(1) The weight of a body is the force with which The earth attracts it.
(2) It has only magnitude.	(2) It has both magnitude and direction.
(3) It does not change from place to place.	(3) It changes from place to place.
(4) It can never be zero.	(4) IT is zero at the centre of the earth.

(5) What would happen if there were no gravity?

(Ans): If gravitational force ceased to exist on earth , then

(1) All the objects will no longer be drawn towards each other and the earth objects not beingattracted to the earth along with humans would float off into space away from the surface
of the earth.

(2) The important constituents of the earth including the atmosphere and the water from the Ocean , seas etc would also float into space.

(3) The moon would stop orbiting the earth and would drift in space.

(6) What would happen if the value of G was twice as large

(Ans): If the value of G were to be doubled, then :

(1) Weight of all the objects on the earth will become double

(2) Human body weight will become twice the original weight.

(3) The atmospheric air pressure would increase leading to various climatic changes.

(4) Various structures like houses, bridges, dams etc would collapse due to the increase in weight .

(5) The earth's orbit around the sun will be affected which will result in catastrophic climatic Changes.

(7) State Newton's universal law of gravitation. Express it in mathematical form.

(Ans): Newton's universal law of gravitation: Every object in the universe attracts every other object with a definite force. This force is directly proportional to the product of the masses of the two and inversely proportional to the square of the distance between them.

Let m1 = masses of first object
m2 = masses of second object
d = the distance between their centers

The gravitational attraction between the two will be given by,

$F \alpha m1\ m2$ .....(1)

$F \alpha 1/d^2$ .....(2)

From equation (1) and (2)

$F \alpha m1\ m2/d$

$F=Gm1m2/d^2$ (G is constant)

(8) What is acceleration due to gravity? Derive an expression for acceleration due to gravity on the earth's surface.

(Ans): Acceleration due to gravity: The acceleration produced in a body due to gravitational force of the Earth is called as acceleration due to gravity. It is denoted by `g'.

Expression for acceleration due to gravity:

(1) suppose an object of mass `m' is situated at a distance `R' from the center of the earth.

(2) Let `M' be the mass of the earth, then the gravitational force of attraction F between the Object and the earth is given by :

$F = G\,Mm\,/R^2$ ……..(1)

(3) But acceleration is given by acceleration due to gravity.

Force =mass × acceleration due to gravity

$F = m \times g$ …….. (2)

(4) From equation (1) and (2) we get

$m \times g = GMm/ R^2$

(5) From the above relation, acceleration due to gravity on earth's surface depends upon the mass of the earth (M) and distance (R) of the object from the centre of the earth i.e., the radius of the earth.

(9) Using the law of conservation of energy, derive an expression for the escape velocity of an object From the surface of the earth.

(Ans): Consider an object of mass m moving with initial velocity equal to escape velocity (Vesc)

Energy of object on the surface of the earth.

(1) kinetic energy = ½ mv^2esc

Total energy = E1 = K.E + P.E

= ½ mv^2esc - GM m / R …….(1)

$V^2esc = 2GM/R$

$Vesc = \sqrt{2GM/R}$

Also, we know, acceleration due to gravity is given as,

$g = GM / R^2$

$GM = gR^2$ ……..(4)

From equation (3) and (4)

$Vesc = \sqrt{2\frac{gR^2}{R}} = \sqrt{2gR}$

Q.5 Read the paragraph and answer the following question:

(1) You must be knowing about the high and low tides that occur regularly in the sea. The level of seawater at any given location along sea shore increases and decreases twice a day at regular intervals. High and low tides occur at different times at different places. The level of water in the sea changes

Because of the gravitational force exerted by the moon. Water directly under the moon gets pulled towards the moon and the level of water there goes up causing high tide at that place. Which cause low tide in another place.

(1) How many times does the sea level at the coast change?

(Ans): Sea level at the coast increases and decreases two times a day. Two high tides and two low tides.

(2) How does sea level get changed.

(Ans): The sea –level at the coastal region gets changed two times a day due to gravitational attraction of the Moon.

(3) Where is high tide and low tide caused?

(Ans): Due to gravitational attraction of the moon, the water mass swells towards the direction of the Moon causing high – tide. The water mass shrinks at 90'' from this place which cause low tide.

(2) Weightlessness in space:

Space travelers as well as objects in the spacecraft appear to be floating. Why does this happen? Thought the spacecraft is at a height from the surface of the earth, the value of g there is not zero. In the space station the value of g is only 11% less than its value on the surface of the earth. Thus, the height of a spacecraft is not the reason for their weightlessness. Their weightlessness is caused by their being in the state of free fall. though the spacecraft is not Falling on the earth because of its velocity along the orbit, the only force acting on it is the Gravitational force of the earth and therefore it is

Q.7.Choose the correct alternative .

1) As we go above the earth's surface , the value of g _____

a) increases b) becomes zero

c) dosen't change **d) decreases**

2) The formula for escape velocity is _____

a) $\sqrt{\frac{2M}{R}}$ **b)** $\sqrt{\frac{2GM}{R}}$ c) $\sqrt{\frac{GM}{R^2}}$ d) $\sqrt{\frac{GMm}{R^2}}$

3) The gravitational potential energy of body at height *h from the* earth's surface is _____

a) $\frac{GMm}{R+h}$ b) - $\frac{GMm}{(R+h)^2}$ c) $\frac{-GMm}{R+h}$ d) $\frac{GMm}{(R+h)^2}$

4) The gravitational force between two particles separated by distance *r* varies as _____

a) $\frac{1}{r}$ b) r c) r^2 **d)** $\frac{1}{r^2}$

5) In the usual notation, the acceleration due to gravity at a height *h* from the surface of the earth is ____

a) g = $\frac{GM}{(R+h)}$ b) g = $\frac{GM}{\sqrt{R+h}}$ **c)** $\frac{GM}{(R+h)^2}$ d) g = GM $(R+H)^2$

6) If an object weighs 720 N on the earth, what will be its weight on the moon?

a) 360 N b) 240 N **c) 120 N** d) 72 N

Q.8. True or False

1) If the separation between two particles is decreased by a factor of 2 the gravitational force between the particles becomes double the initial force. **(F)**

2) The SI unite of the universal constant of gravitation is the dyne-N-m^2/kg^2. **(T)**

3) At the center of the earth, the value of the acceleration due gravity becomes zero. **(T)**

4) The weight of a body is minimum at the poles. **(F)**

5) Mass is a vector quantity. **(F)**

6)Weight is vector quantity. **(T)**

7) g has maximum value at the equator. **(F)**

8) Outside the earth, g varies as $1/(R+h)^2$. **(T)**

9) The value of G changes from place to place. **(F)**

10) The escape velocity of a body does not depend on the mass of the body (**T**)

11) The value of g increases with altitude. **(F)**

12) The mass of a body is the amount of matter present in it. **(T)**