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CHANDIGARH REGION

CLASS-XI

SUBJECT-PHYSICS

Chapter -8

Gravitation

INDEX

1. GIST OF TOPICS

Every object in the universe attracts every other object with a force which is called the force of **gravitation.**

Gravitation is one of the four types of interactions found in nature.These are

(i) the gravitational force
(ii) the electromagnetic force
(iii) the strong nuclear force
(iv) the weak nuclear forces.

Newton's Law of Gravitation

Gravitational force is an attractive force between two masses m_1 and m_2 separated by a distance r.

The gravitational force acting between two point objects is proportional to the product of their masses and inversely proportional to the square of the distance between them.

Gravitational force:

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

where G is universal gravitational constant.

The value of G is 6.67 X 10^{-11} Nm^2 kg^{-2} and is same throughout the universe.

The value of G is independent of the nature and size of the bodies well as the nature of the medium between them.

Dimensional formula of G is $[M^{-1}L^{3}T^{-2}]$.

Important Points about Gravitation

(i) Gravitational force is a central as well as conservative force.
(ii) It is the weakest force in nature.
(iii) It is 10^{36} times smaller than electrostatic force and 10^{l8}times smaller than nuclear force.
(iv) The law of gravitational is applicable for all bodies, irrespective of their size, shape and position.
(v) Gravitational force acting between sun and planet provide it centripetal force for orbital motion.
(vi) Gravitational pull of the earth is called gravity.
(vii) Newton's third law of motion holds good for the force of gravitation. It means the gravitation forces between two bodies are action-reaction pairs.

Properties of Gravitation forces

(i) Unlike the electrostatic force, it is independent of the medium between the particles.
(ii) It is conservative in nature.
(iii) It expresses the force between two point masses (of negligible volume). However, for external points of spherical bodies the whole mass can be assumed to be concentrated at its centre of mass.

Acceleration Due to Gravity

The uniform acceleration produced in a freely falling object due to the gravitational pull of the earth is known as acceleration due to gravity.

It is denoted by g and its unit is m/s^2. It is a vector quantity and its direction is towards the centre of the earth.The value of g is independent of the mass of the object which is falling freely under gravity.

Relation between g and G

$g = Gm / R^2$

where M = mass of the earth = $6.0 * 10^{24}$ kg and

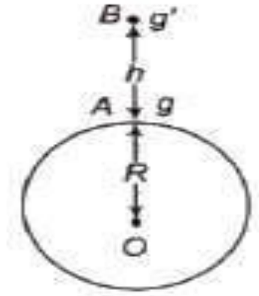
R = radius of the earth = $6.38 * 10^{6}$ m

Factors Affecting Acceleration Due to Gravity

(i) Effect of Altitude

The value of g at height h from earth'ssurface

$g' = g / (1 + h / R)^2$

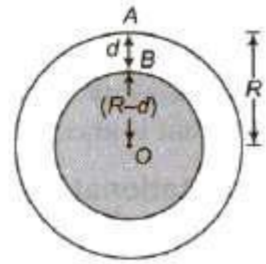


Therefore g decreases with altitude.

(ii) Effect of Depth

The value of gat depth h A from earth's surface

$g' = g * (1 - h / R)$

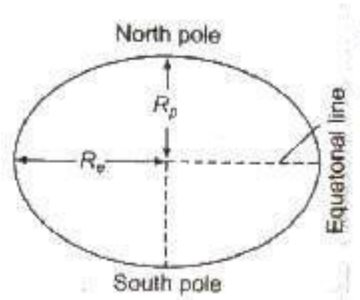


Therefore g decreases with depth from earth's surface.

The value of g becomes zero at earth's centre.

(iii) Effect of shape of Earth

Earth is elliptical in shape. Itsdiameter at poles is approximately 42 km less than its diameter at equator.

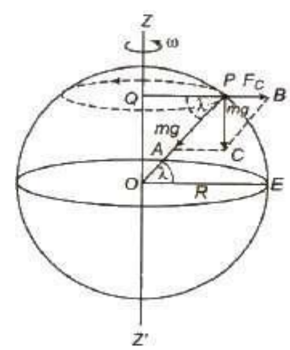


Therefore, g is minimum at equator and maximum at poles.

(iv) Effect of rotation of Earth about Its Own Axis

If ω is the angularvelocity of rotation of earthabout its own axis, then acceleration due to gravity at a place having latitude λ is given by

$g' = g - R\omega^2 \cos^2 \lambda$



At poles $\lambda = 90°$ and $g' = g$

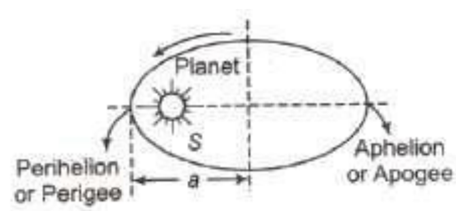
Therefore, there is no effect of rotation of earth about its own axis at poles.
At equator $\lambda = 0°$ and $g' = g - R\omega^2$

The value of g is minimum at equator.

If earth stapes its rotation about its own axis, then g will remain unchanged at poles but increases by $R\omega^2$at equator.

Kepler's Laws of Planetary Motion

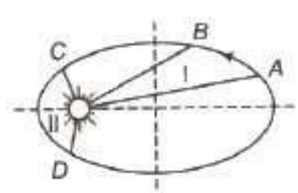
(i) **Law of orbit:**Every planet revolve around the sun in elliptical orbit and sun is at its onefocus.



(ii) **Law of area:**The radius vector drawn from the sun to a planet sweeps out equal areas inequal intervals of time, i.e., the areal velocity of the planet around the sun is constant.

Areal velocity of a planet

$dA / dt = L / 2m =$ constant



where L = angular momentum and m = mass of the planet

(iii) Law of period: The square of the time period of revolution of planet around the sun isdirectly proportional to the cube semi-major axis of its elliptical orbit.

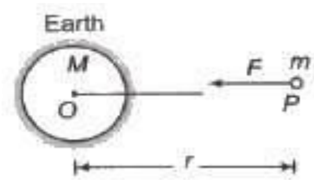
$(T_1 / T_2)^2 = (a_1 / a_2)^3$

where, a = semi-major axis of the elliptical orbit.

Gravitational Field

The space in the surrounding of any body in which its gravitational pull can be experienced by other bodies is called **gravitational field**.

Intensity of Gravitational Field



The gravitational force acting per unit mass at Earth any point in gravitational field is called intensity of gravitational field at that point.

It is denoted by E_g or I.

E_g or I = F / m

Intensity of gravitational field at a distance r from a body of mass M is given by

E_g or I = GM / r^2

It is a vector quantity and its direction is towards the centre of gravity of the body.

Its S1 unit is N/m and its dimensional formula is $[LT^{-2}]$.

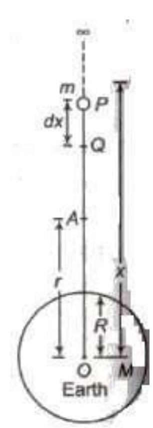
Gravitational Potential

Gravitational potential at any point in gravitational field is equal the work done per unit mass in bringing a very light body from infinity to that point.

It is denoted by V_g.

Gravitational potential, $V_g = W / m = - GM / r$

Its SI unit is J / kg and it is a scalar quantity. Its dimensional formula is $[L^3r^{-2}]$.



Since work W is obtained, that is, it is negative, the gravitational potential is always negative.

Gravitational Potential Energy

Gravitational potential energy of any object at any point in gravitational field is equal to the work done in bringing it from infinity to that point. It is denoted by U.

Gravitational potential energy $U = - GMm / r$

The negative sign shows that the gravitational potential energy decreases with increase in distance.

Gravitational potential energy at height h from surface of earth

$U_h = – GMm / R + h = mgR / 1 + h/R$

Satellite

A heavenly object which revolves around a planet is called a satellite. Natural satellites are those heavenly objects which are not man made and revolve around the earth. Artificial satellites are those heavenlyobjects which are man made and launched for some purposes revolve around the earth.

Time period of satellite

$T = 2\pi \sqrt{r^3 / GM}$

$T= 2\pi \sqrt{(R + h)^3 / g}$ [$g = GM / R^2$]

Near the earth surface, time period of the satellite

$T = 2\pi \sqrt{R^3 / GM} = \sqrt{3\pi / Gp}$

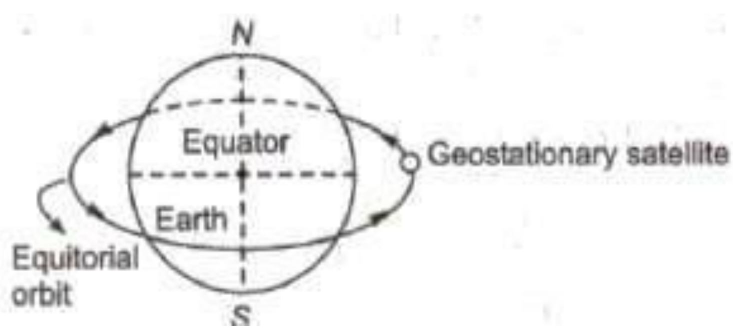
$T = 2\pi \sqrt{R / g} = 5.08 * 10^3$ s = 84 min.

where p is the average density of earth.

Artificial satellites are of two types:

1. **Geostationary or Parking Satellites**

A satellite which appears to be at a fixed position at a definite height to an observer on earth is called geostationary or parking satellite.



Height from earth's surface = 36000 km

Radius of orbit = 42400 km

Time period = 24 h

Orbital velocity = 3.1 km/s

Angular velocity = $2\pi / 24 = \pi / 12$ rad / h

There satellites revolve around the earth in equatorial orbits.

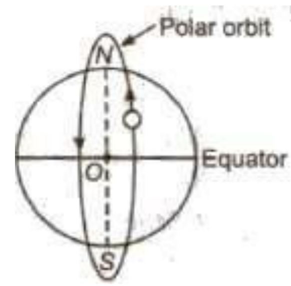
The angular velocity of the satellite is same in magnitude and direction as that of angular velocity of the earth about its own axis.

These satellites are used in communication purpose.

INSAT 2B and INSAT 2C are geostationary satellites of India.

2. **Polar Satellites**

These are those satellites which revolve in polar orbits around earth. A polar orbit is that orbit whose angle of inclination with equatorial plane of earth is 90°.



height from earth's surface = 880 km

Time period = 84 min

Orbital velocity = 8 km / s

Angular velocity = $2\pi / 84 = \pi / 42$ rad / min.

There satellites revolve around the earth in polar orbits.

These satellites are used in forecasting weather, studying the upper region of the atmosphere, in mapping, etc.

PSLV series satellites are polar satellites of India.

Orbital Velocity

Orbital velocity of a satellite is the minimum velocity required to the satellite into a given orbit around earth.

Orbital velocity of a satellite is given by

$v_o = \sqrt{GM} / r = R \sqrt{g} / R + h$

where, M = mass of the planet, R = radius of the planet and h = height of the satellite from planet's surface.

If satellite is revolving near the earth's surface, then r = (R + h) =- R

Now orbital velocity,

$v_o = \sqrt{gR}$

= 7.92km / h

if v is the speed of a satellite in its orbit and v_o is the required orbital velocity to move in the orbit, then

(i) If $v < v_o$, then satellite will move on a parabolic path and satellite falls back to earth.
(ii) If $v = v_o$ then satellite revolves in circular path/orbit around earth.
(iii) If $v_o < V < v_e$ then satellite shall revolve around earth in elliptical orbit.

Energy of a Satellite in Orbit

Total energy of a satellite

E = KE + PE

$= GMm / 2r + (- GMm / r)$
$= - GMm / 2r$

Binding Energy

The energy required to remove a satellite from its orbit around the earth (planet) to infinity is called binding energy of the satellite.

Binding energy of the satellite of mass m is given by

$BE = + GMm / 2r$

Escape Velocity

Escape velocity on earth is the minimum velocity with which a body has to be projected vertically upwards from the earth's surface so that it just crosses the earth's gravitational field and never returns.

Escape velocity of any object

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

$= \sqrt{2gR} = \sqrt{8\pi p \, GR^2 / 3}$

Escape velocity does not depend upon the mass or shape or size of the body as well as the direction of projection of the body.

Escape velocity at earth is 11.2 km / s.

Weightlessness

It is a situation, in which the effective weight of the body becomes zero,

Weightlessness is achieved

(i) during freely falling under gravity
(ii) inside a space craft or satellite
(iii) at the centre of the earth

FORMULA AND FLOW CHART

BRAIN MAP

CLASS XI

GRAVITATION

Newton's Law of Gravitation

Gravitational force (F) between two bodies is directly proportional to product of masses and inversely proportional to square of the distance between them.

$$\vec{F} = -\frac{Gm_1m_2}{r^2}\cdot\hat{r}$$

Kepler's Laws of Planetary Motion

Law of orbits : Every planet revolves around the sun in an elliptical orbit and the sun is situated at one of its foci.

Law of areas : The areal velocity of the planet around the sun is constant i.e., $\frac{dA}{dt}$ = a constant

Law of periods : The square of the time period of revolution of a planet is directly proportional to the cube of semi major axis of the elliptical orbit.

$$T^2 \propto a^3$$

Acceleration due to gravity

- For a body falling freely under gravity, the acceleration in the body is called acceleration due to gravity.
- Relationship between g and G

$$g = \frac{GM_e}{R_e^2} = \frac{4}{3}\pi G R_e \rho$$

where G = gravitational constant

ρ = density of earth

M_e and R_e be the mass and radius of earth

Characteristics of gravitational force

- It is always attractive.
- It is independent of the medium.
- It is a conservative and central force.
- It holds good over a wide range of distance.

Gravitational Potential Energy

Work done in bringing the given body from infinity to a point in the gravitational field.

$$U = -GMm/r$$

Gravitational potential

Work done in bringing a unit mass from infinity to a point in the gravitational field.

$$V = \frac{-GM}{r}$$

Escape speed

The minimum speed of projection of a body from surface of earth so that it just crosses the gravitational field of earth.

$$v_e = \sqrt{\frac{2GM}{R}}$$

Variation of acceleration due to gravity (g)

Due to altitude (h)

$$g_h = g\left(1 - \frac{2h}{R_e}\right)$$

The value of g goes on decreasing with height.

Due to depth (d)

$$g_d = g\left(1 - \frac{d}{R_e}\right)$$

The value of g decreases with depth.

Due to rotation of earth

$g_\lambda = g - R_e\omega^2\cos^2\lambda$

At equator, $\lambda = 0°$

$g_{\lambda\,\min} = g - R_e\omega^2$

At poles, $\lambda = 90°$

$g_{\lambda\,\max} = g_p = g$

Earth's Satellite

Types of Satellite

Polar satellilte

- Time period : 100 min
- Revolves in polar orbit around the earth.
- Height : 500-800 km.
- Uses : Weather forecasting, military spying

Geostationary satellite

- Time period : 24 hours
- Same angular speed in same direction with earth.
- Height : 36000 km.
- Uses : GPS, satellite communication (TV)

Orbital speed of satellite

The minimum speed required to put the satellite into a given orbit.

$$v_0 = R_e\sqrt{\frac{g}{R_e + h}}$$

For satellite orbiting close to the earth's surface

$$v_0 = \sqrt{gR_e}$$

Time period of satellite

$$T = \frac{2\pi}{R_e}\sqrt{\frac{(R_e + h)^3}{g}}$$

For satellite orbiting close to the earth's surface

$$T = 2\pi\sqrt{\frac{R_e}{g}} = 84.6 \text{ min}$$

Energy of satellite

- Kinetic energy $K = \frac{GM_e m}{2(R_e + h)}$
- Potential energy $U = \frac{-GM_e m}{R_e + h}$
- Total energy

$$E = K + U = -\frac{GM_e m}{2(R_e + h)}$$

3. MULTIPLE CHOICE QUESTIONS

Q.1 Which of the following is the evidence to show that there must be a force acting on earth and directed towards the sun

(a) Deviation of the falling bodies towards east
(b) Revolution of the earth round the sun
(c) Phenomenon of day and night
(d) Apparent motion of sun round the earth

Q.2. Newton's law of gravitation is valid

(a) in laboratory (b) only on the earth
(c) only in our solar system (d) everywhere

Q.3. Which of the following statements is true?

(a) g is same at all places on the surface of earth.
(b) g has its maximum value at the equator.
(c) g is less at the earth's surface than at a heightabove it or a depth below it.
(d) g is greater at the poles than at the equator.

Q.4. What happens to the acceleration due to gravity with the increase in altitude from the surface of the earth?

(a) Increases (b) Decreases
(c) First decreases and then increases (d) Remains same.

Q.5 There is no atmosphere on the moon because

(a) it is closer to the earth (b) it revolves round the earth
(c) it gets light from the sun
(d) the escape velocity of gas molecules is less than their root mean square velocity here.

Q.6**.** The tidal waves in the sea are primarily due to

(a) The gravitational effect of the moon on the earth
(b) The gravitational effect of the sun on the earth
(c) The gravitational effect of Venus on the earth
(d) The atmospheric effect of the earth itself.

Q.7 If the distance between two masses is doubled, the gravitational attraction between them

(a) Is doubled (b) Becomes four times
(c) Is reduced to half (d) Is reduced to a quarter.

Q.8 The value of 'g'

a. Increases as we go above the earth's surface
b. Decreases as we go to the Centre of the earth
c. Remains constant
d. Is more at equator and less at poles.

Q.9 The distance between two bodies becomes 6 times more than the usual distance. The the F becomes

a. 36 times
b. 6 times
c. 12 times
d. 1/36 times.

Q.10When an object is thrown upward, the force of gravity is
(a) opposite to the direction of motion
(b) in the same direction as the direction of motion
(c) becomes zero at the highest point
(d) increases as it rises up.

Q.11 Where will it be profitable to purchase one kilogram sugar?
(a) At poles (b) At equator
(c) At 45c latitude (d) at 40c latitude.

12 Acceleration due to gravity is maximum at (R is theradius of earth)
(a) a height R from the earth's surface (b) the Centre of the earth
(c) the surface of the earth (d) a depth R from earth's surface.

13. The value of acceleration due to gravity is high if
(a) mass and radius both are small (b) mass is small and radius is large
(c) mass is large and radius is small (d) mass and radius both are large.

Q.14. An apple falls towards the earth because the earth attracts it. The apple also attracts the earth by the same force. Why do we not see the earth rising towards the apple?
(a) Acceleration of the earth is very large when compared to that of apple.
(b) Acceleration of the earth is equal to that of apple.
(c) Acceleration of the earth is neither high nor too low.
(d) Acceleration of the earth is very small when compared to that of apple.

Q.15 The value of g is zero
(a) at the top of the atmosphere
(b) at 20 km below the surface of the earth
(c) at 20 km above the surface of the earth
(d) at the Centre of the earth.

16. A coin and a feather are dropped together in a vacuum. Then
(a) the coin will reach the ground first
(b) the feather will reach the ground first
(c) both will reach the ground at the same time
(d) the feather will not fall down.

Q.17Conventionally, the magnitude of gravitational potential energy for an object at infinity from the earth is _____ (M = Mass of the earth; m = Mass of the object at infinity; R = Radius of the earth).
a) $-(GM)/R^2$ b) $-(GM)/R$
c) $-(GMm)/R$ d) Zero

Q.18The gravitational potential energy of the Moon with respect to Earth is
(a) always positive (b) always negative
(c) can be positive or negative (d) always zero

Q.19. The masses of two planets are in the ratio 1 : 2. Their radii are in the ratio 1 : 2. The acceleration due to gravity on the planets are in the ratio.

(a) 1 : 2 (b) 2 : 1

(c) 3 : 5 (d) 5 : 3

Q.20. . When a body is thrown up, the force of gravity is

(a) in the upward direction (b) in the downward direction

(c) zero (d) in the horizontal direction.

Q.21A artificial satellite moving in a circular orbit around the earth has a total (kinetic + potential) energy E_0. Its potential energy is

(a) $2E_0$ (b) E_0

(c) 1.5 E_0 (d) $-E_0$

Q.22 A missile is launched with a velocity less than the escape velocity. The sum of its kinetic and potential energy is

(a) Positive (b) Negative

(c) Zero (d) may be positive or negative

Q.23 The escape velocity of projection from the earth is approximately (R = 6400 km)

(a) 7 km/sec (b) 11.2 km/sec

(c) 122 km/sec (d) 1.1 km/sec

Q.24 The mass of a body is measured to be 12 kg on theearth. If it is taken to the moon, its mass will be

(a) 12 kg (b) 6 kg

(c) 2 kg (d) 72 kg

Q.25. The weight of a body is 120 N on the earth. If it is taken to the moon, its weight will be about

(a) 120 N (b) 60 N

(c) 20 N (d) 720 N

Q.26. The mass of a body is increased 4 fold and mass of other body is increased 16 fold. How should the distance between them be changed to keep the same gravitational force between them?

(a) 4 times (b) 16 times

(c) 8 times (d) 81 times

Q.27. When you put an object on a spring balance, what do you measure?

(a) Weight (b) Force

(c) Mass (d) Acceleration.

Q.28. . In spaceship moving in space, person experience weightlessness as the value of

(a) mass is zero (b) acceleration due to gravity is zero

(c) gravitational force is zero (d) none of these.

Q.29. Orbital velocity of earth satellite does not depend on

(a) mass of the earth (b) mass of the satellite

(c) radius of the earth (d) acceleration due to gravity

Q.30. Which of the following is correct?

(a) Weight is a scalar quantity.

(b) Weight is not a fundamental quantity.

(c) Weight does not depend on acceleration due togravity.

(d) None of these

Q.31 The value of acceleration due to gravity at the MountEverest is

(a) g (b) > g

(c) < g (d) zero

Q.32 The mass of the body on moon is 40kg, what is the weight on the earth.

a. 240kg b. 392N

c. 240N d. 400kg

Q.33 The mean radius of the earth is R, its angular speed on its own axis is w and the acceleration due to gravity at earth's surface is g. The cube of the radius of the orbit of a geo-stationary satellite will be

(a) R^2g / w (b) R^2w^2/ g

(c) RG w^2 (d) R^2g / w^2

Q.34 The escape velocity for a body projected vertically upwards from the surface of the earth is 11 km/s. If the body is projected at an angle of 450 with the vertical, the escape velocity will be

(a) $11/\sqrt{2}$ km/s (b) $11\sqrt{2}$ km/s

(c) 2 km/s (d) 11 km/s

Q.35. If the distance between the Earth and Sun were to be doubled from its present value, the number of days in a year would be

(a) 64.5 (b) 1032

(c) 182.5 (d) 730

Q.36. A planet moving along an elliptical orbit is closest to the Sun at distance r_1 and farthest away at a distance of r_2. If v_1 and v_2 are linear speeds at these points respectively. Then the ratio V_1/V_2 is

a) $\left(\frac{r_2}{r_1}\right)$ b) $\left(\frac{r_2}{r_1}\right)^2$

c) $\left(\frac{r_1}{r_2}\right)$ d) $\left(\frac{r_1}{r_2}\right)^2$

Q.37The time period of a satellite orbiting Earth in a cirular orbit is independent of

(a) Radius of the orbit (b) The mass of the satellite

(c) Both the mass and radius of the orbit

(d) Neither the mass nor the radius of its orbit

Q.38. A body weighs 500 N on the surface of the earth. How much would it weight half way below the surface of the earth?

(a) 1000 N (b) 500 N
(c) 250 N (d) 125 N

Q.39 The time – period of a satellite of earth is 5 hours. If the separation between the earth and the satellite is increased to 4 times the previous value, the new time – period will become

(a) 10 hours (b) 20 hours
(c) 40 hours (d) 80 hours

Q.40. What would be the duration of the year if the distance between the earth and the sun gets doubled?

(a) 1032 days (b) 129 days
(c) 365 days (d) 730 days

Q.41 If a body of mass m is taken out from a point below the surface of earth equal to half the radius of earth, R, to a height R above the earths surface, then work done on it will be

(a) (5/6) mgR (b) (6/7) mgR
(c) (7/8) mgR (d) (8/9) mgR

Q.42 A body is projected vertically from the surface of the earth of radius R with velocity equal to half of the escape velocity. The maximum height reached by the body is

(a) R (b) R/2
(c) R/3 (d) R/4

Q.43 The value of g at a particular point is 9.8 m/sec^2 suppose the earth suddenly shrink uniformly to half its present size without losing any mass. The value of g at the same point (assuming that the distance of the point from the Centre of the earth does not shrink) will become

(a) 9.8 m/sec^2 (b) 4.9 m/sec^2
(c) 19.6 m/sec^2 (d) 2.45 m/sec^2

Q.44 If the radius of the earth were to be raise by 1% its mass remaining the same, the acceleration due to gravity on the surface of the earth will

(a) increase by 1% (b) decrease by 2%
(c) decrease by 1% (d) increase by 2%

Q.45 If the distance between the earth and the sun were half its present value, the number of day in a year would have been

(a) 64.5 (b) 129
(c) 182.5 (d) 730

Q.46 A satellite of the earth is revolving in a circular orbit with a uniform speed ***v***. If the gravitational force suddenly disappears, the satellite will

(a) Continue to move with velocity *v* along the original orbit
(b) Move with a velocity *v*, tangentially to the original orbit
(c) Fall down with increasing velocity
(d) Ultimately come to rest somewhere on the original orbit.

Q.47. A body of mass 1kg is attracted by the earth with a force which is equal to

a. 9.8N b. $6.67x\ 10^{11}$

c. 1 N d. 9.8m/s

Q.48. What is the gravitational force between two objects?
a. attractive at large distances only
b. attractive at small distances only
c. attractive at all distances
d. attractive at large distances but repulsive at small distances

Q.49 From Kepler's law of orbit, we can infer that the sun is located _____ of the planet's orbit.
a) at the centre b) at one of the foci
c) at both foci d) anywhere along the semi-minor axis

Q.50.What does Kepler's law of period relate?
a) Time period and semi-minor axis b) Time period and eccentricity
c) Time period and semi-major axis d) Time period and area swept by the planet

4.Assertion and reasoning questions.

Instructions for Questions 1-20.

These questions consist of two statements, each printed as Assertion and Reason. While answering these questions, you are required to choose any one of the following four responses.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

(c) If the Assertion is correct but Reason is incorrect.

(d) If both the Assertion and Reason are incorrect.

Q.1Assertion : When distance between two bodies is doubled and also mass of each body is doubled, gravitational force between them remains the same.
Reason : According to Newton’s law of gravitation, force is directly proportional to product of the mass of bodies and inversely proportional to the square of the distance between them.
(a) A. (b) B. (c) C. (d) D.

Q.2Assertion: The value of acceleration due to gravity does not depends upon mass of the body on which force is applied.
Reason: Acceleration due to gravity is a constant quantity.
(a) A. (b) B. (c) C. (d) D.

Q.3Assertion : The acceleration due to gravity on the moon is one-sixth that on the earth.
Reason : The law of gravitation is the same on both the moon and the earth.
(a) A. (b) B. (c) C. (d) D.

Q.4 Assertion: The acceleration due to gravity increases with height above the earth's surface
Reason: Gravitational force increases with height
(a) A. (b) B. (c) C. (d) D.

Q.5 Assertion: Objects appear 'weightless' inside an orbiting spacecraft.
Reason: Objects in circular motion experience centripetal force
(a) A. (b) B. (c) C. (d) D.

Q.6 Assertion: The earth revolves around the sun in an elliptical orbit.
Reason: The sun always attracts the earth with the same force.
(a) A. (b) B. (c) C. (d) D.

Q.7 Assertion: Any two objects in the universe attract each other by a force called gravitation force.
Reason: The force of gravitation exerted by the earth is called gravity.
(a) A. (b) B. (c) C. (d) D.

Q.8 Assertion: It is necessary to use satellites for long distance T.V transmission
Reason : The television signals are low frequency signals
(a) A. (b) B. (c) C. (d) D.

Q.9Assertion : Gravitational potential of earth at every place body are equal to one.
 Reason: Everybody on earth is bound by the attraction of earth.
(a) A. (b) B. (c) C. (d) D.

Q.10Assertion : Gravitational potential and gravitational potential energy, both are related to the work done by gravitational force in the gravitational field
Reason : Gravitational field strength is related to the gravitational force in gravitational field.
(a) A. (b) B. (c) C. (d) D.

Q.11 Assertion
Gravitational potential is maximum at infinite
Reason
Gravitational potential is the amount of work done to shifting a unit mass from infinity to a given point in Gravitational attraction force field.
(a) A. (b) B. (c) C. (d) D.

Q.12 The escape velocity from the surface of Jupiter is found to be less than that from the earth's surface.
Reason: The radius of Jupiter is smaller than that of earth.
(a) A. (b) B. (c) C. (d) D.

Q.13Assertion : Moon has no atmosphere.
Reason : The escape velocity for moon is less than that for earth.
(a) A. (b) B. (c) C. (d) D.

Q.14 Assertion-Escape velocity is independent of the angle of projection.
ReasonEscape velocity from the surface of earth is 2gR where R is radius of earth.
(a) A. (b) B. (c) C. (d) D.

Q.15 Assertion: Orbit of a satellite is within the gravitational field of earth whereas escaping is beyond the gravitational field of earth.
Reason : Orbital velocity of a satellite is greater than its escape velocity.
(a) A. (b) B. (c) C. (d) D.

Q.16 Assertion: A planet moves faster, when it is closer to the sun in its orbit and vice versa
Reason: Orbital velocity for an orbiting planet is constant.
(a) A. (b) B. (c) C. (d) D.

Q.17Assertion: The difference in the value of acceleration due to gravity at pole and equator is due to difference in the latitude of the place.
Reason: The value of acceleration due to gravity is minimum at the equator and maximum at the poles.
(a) A. (b) B. (c) C. (d) D.

Q.18Assertion- Orbital velocity of a satellite is greater than its escape velocity.
Reason-Orbit of a satellite is within the gravitational field of earth whereas escaping is beyond the gravitational field of earth,
(a) A. (b) B. (c) C. (d) D.

Q.19Assertion: The magnitude of the gravitational potential at the surface of a solid sphere is less than that of the center of the sphere.
Reason: Due to the solid sphere, the gravitational potential is the same within the sphere.
(a) A. (b) B. (c) C. (d) D.

Q.20Assertion- Gravitational potential of earth at every place on it is negative.
Reason- Every body on earth is bound by the attraction of earth.
(a) A. (b) B. (c) C. (d) D.

5. CASE STUDY TYPE QUERSTIONS

QUESTION:-1 Geostationary or geosynchronous orbit

Geostationary or geosynchronous orbit is the best spot for communications satellites to use, however. This is a zone above Earth's equator at an altitude of 35,786 km (22,236 mi). At this altitude, the rate of "fall" around the Earth is about the same as Earth's rotation, which allows the satellite to stay above the same spot on Earth almost constantly. The satellite thus keeps a perpetual connection with a fixed antenna on the ground, allowing for reliablecommunications.

When geostationary satellites reach the end of their life, protocol dictates they're moved out of the way for a new satellite to take their place. That's because there is only so much room, or so many "slots" in that orbit, to allow the satellites to operate without interference.
While some satellites are best used around the equator, others are better suited to more polar orbits — those that circle the Earth from pole to pole so that their coverage zones include the north and south poles. Examples of polar-orbiting satellites include weather satellites and reconnaissance satellites.

Q:1 Most waves used for communication purposes rely on geostationary satellites because _____

a) they cannot transmit data at long distances due to curvature of the earth

b) they are reflected by the atmosphere

c) they are very cheap

d) it does not occupy space on the earth's surface

Q:2 A geostationary satellite seems to be fixed in the sky because it does not orbit the earth.

a) True b) False

Q:3 The height of the geostationary satellites above the earth's surface is approximately

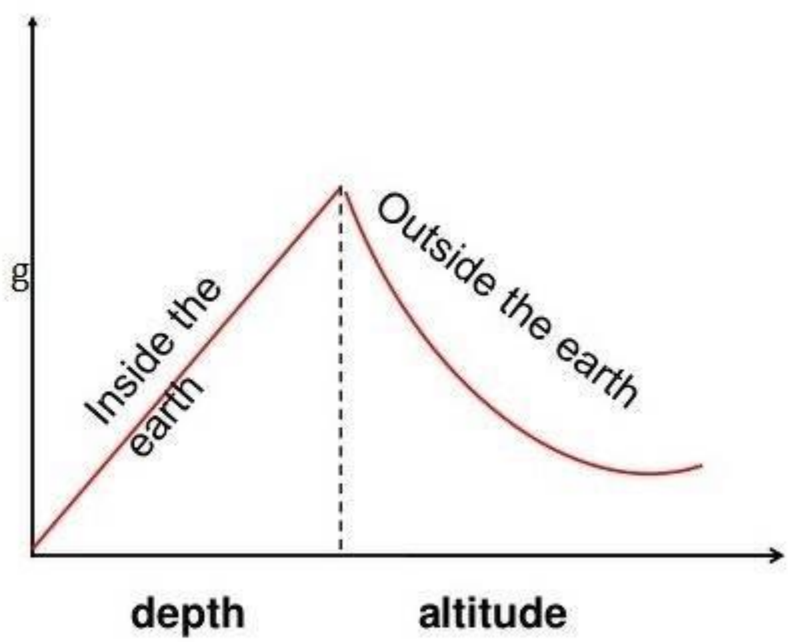
a) 36,000 km b) 72,000 km c) 15,000 km d) 30,000 km

Q:4 Polar satellites are used for high-resolution imaging of the earth's surface because
a) they have better cameras
b) they are very high above the surface of the earth and travel slowly to gather more information
c) they are closer to the surface of the earth and can cover vast areas very quickly
d) they can be launched by most countries in the world

Q:5 A geostationary satellite is orbiting the earth at a height of 4R above the earth's surface. The time period of another satellite at a height of 2R is _____
a) $24 \times (3/5)^{1/2}$ hr b) $12 \times (3/5)^{1/2}$ hr
c) $6 \times (3/5)^{1/2}$ hr d) $72 \times (3/5)^{1/2}1$ hr

QUESTION:-2 VARIATION OF g

Depending on the location, an object at the surface of Earth falls with an acceleration between 9.76 and 9.83 m/s^2 (32.0 and 32.3 ft/s^2).Earth is not exactly spherical. It is similar to a "squashed" sphere, with the radius at the equator slightly larger than the radius at the poles. This has the effect of slightly increasing gravitational acceleration at the poles (since we are close to the centre of Earth and the gravitational force depends on distance) and slightly decreasing it at the equator. Also, because of centripetal acceleration, the acceleration due to gravity is slightly less at the equator than at the poles. Changes in the density of rock under the ground or the



presence of mountains nearby can affect gravitational acceleration slightly.

The acceleration of an object changes with altitude. The change in gravitational acceleration with distance from the centre of Earth follows an inverse-square law.]This means that gravitational acceleration is inversely proportional to the square of the distance from the centre of Earth. As the distance is doubled, the gravitational acceleration decreases by a factor of 4. As the distance is tripled, the gravitational acceleration decreases by a factor of 9, and so on.The extent of the variation of g with height differs from that of the variation of g with depth, but it's to note that the value of g falls both with increasing height & with increasing depth, with respect to the earth's surface. This also means the value of g is maximum on the surface of the earth itself.

Q:1The value of 'g' is inversely proportional to the square of the Earth's

a) diameter b) radius c) weight d) area

Q:2 If R is the radius of the earth, the height at which the weight of body becomes ¼ its weight on the surface of earth is

a) 2R b) R/2 c) R d) R/4

Q:3 A body weighs 200 N on the surface of earth. How much will it weigh half way down to the centre of earth?

a) 100 N b) 150 N c) 200 N d) 250 N

Q:4The weight of an object in the coal mine, sea level, at the top of the mountain are W_1 , W_2 and W_3 respectively then

a) $W_1 = W_2 > W_3$ b) W_1 , $W_3 < W_2$ c) $W_2 = W_3, W_1$ d)$W_1 < W_2 < W_3$

Q:5 Which of the following statements is true

(a) g is less at the earth's surface than at a height above it or a depth below it
(b) g is same at all places on the surface of the earth
(c) g has its maximum value at the equator
(d) g is greater at the poles than at the equator

QUESTION:-3 Escape Speed

Did you ever watch a group of children playing "Red Rover?" Arms linked up for strength, they chant, "Red Rover, Red Rover, let Sally come over," and Sally's challenge is to break through that chain of linked arms. If she does it, Sally wins.

If Sally breaks through the chain of arms, she's also demonstrated several key aspects to the space concept of escape velocity. Escape velocity (or a rousing game of Red Rover) requires an object to propel itself with enough speed and thrust to break through a barrier. Sally's reward is the cheers of her teammates. A spacecraft's reward is a journey into space or orbit.

Achieving escape velocity is one of the biggest challenges facing space travel. The vehicle requires an enormous amount of fuel to break through Earth's gravitational pull. All that fuel adds significant weight to the spacecraft, and when an object is heavier, it takes more thrust to lift it. To create more thrust, you need more fuel. It's a cycle that scientists are hoping to resolve by creating lighter vehicles, more efficient fuels and new methods of propulsion that don't require the same ingredients to attain great speeds.

The existence of escape velocity is a consequence of conservation of energy and an energy field of finite depth. For an object with a given total energy, which is moving subject to conservative forces (such as a static gravity field) it is only possible for the object to reach combinations of locations and speeds which have that total energy; and places which have a higher potential energy than this cannot be reached at all. By adding speed (kinetic energy) to the object it expands the possible locations that can be reached, until, with enough energy, they become infinite.

Q:1 For a planet having mass equal to mass of the earth but radius is one fourth of radius of the earth. The escape velocity of this planet will be

a) 11.2 km/s b) 22.4 km/s c) 5.6 km/s d) 44.8 km/s

Q:2 A black hole is an object whose gravitational field is so strong that even light cannot escape from it. To what approximate radius would earth (mass= 5.98×10^{24} kg) have to be compressed to be a black hole?

a) 10^{-9} m b) 10^{-6} m c) 10^{-2} m d) 100m

Q:3 The escape velocity of a body on the surface of the earth is 11.2 km/s. If a body is to be projected in a direction making an angle 45^0 to the vertical, then the escape velocity is

a) 11.2 X 2 km/s b) 11.2 km/s c) 11.2 X $\sqrt{2}$ km/s d) 11.2 X $2\sqrt{2}$ km/s

Q:4 With what velocity should particle be projected so that its height becomes equal to radius of earth?

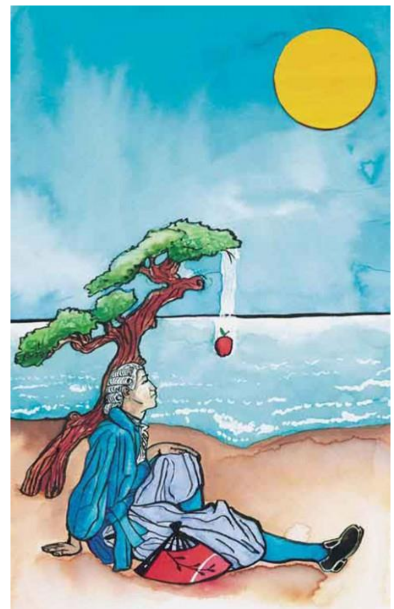
a) $\left(\frac{GM}{R}\right)^{1/2}$ b) $\left(\frac{8GM}{R}\right)^{1/2}$ c) $\left(\frac{4GM}{R}\right)^{1/2}$ d) $\left(\frac{2GM}{R}\right)^{1/2}$

Q:5 An elephant and an ant are to be projected out of the gravitational pull of the earth. What should be the velocities of the elephant and the ant?

a) elephant has more escape velocity b) ant has more escape velocity
c) different velocity d)same velocity

QUESTION:-4 Gravitation

What do aching feet, a falling apple, and the orbit of the Moon have in common? Each is caused by the gravitational force. Our feet are strained by supporting our weight—the force of Earth's gravity on us. An apple falls from a tree because of the same force acting a few meters above Earth's surface. And the Moon orbits Earth because gravity is able to supply the necessary centripetal force at a distance of hundreds of millions of meters. In fact, the same force causes planets to orbit the Sun, stars to orbit the center of the galaxy, and galaxies to cluster together. Gravity is another example of underlying simplicity in nature. It is the weakest of the four basic forces found in nature, and in some ways the least understood. It is a force that acts at a distance, without physical contact, and is expressed by a formula that is valid everywhere in the universe, for masses and distances that vary from the tiny to the immense.



Sir Isaac Newton was the first scientist to precisely define the gravitational force, and to show that it could explain both falling bodies and astronomical motions. See Figure 1. But Newton was not the first to suspect that the same force caused both our weight and the motion of planets. His forerunner Galileo Galilei had contended that falling bodies and planetary motions had the same cause. Some of Newton's contemporaries, such as Robert Hooke, Christopher Wren, and Edmund Halley, had also made some progress toward understanding gravitation. But Newton was the first to propose an exact mathematical form and to use that form to show that the motion of heavenly bodies should be conic sections—circles, ellipses, parabolas, and hyperbolas.

Q:1Two astronauts are floating in gravitational free space after having lost contact with their spaceship. The two will

a) move towards each other b) move away from each other

c)will become stationary d) keep floating at the same distance between them

Q:2 Two spheres of masses m and M are situated in air and the gravitational force between them is F. The space around the masses is now filled with a liquid of specific gravity 3. The gravitational force will now be

a) 3F b) F c) F/3 d) F/9

Q:3 Who among the following first gave the experimental velocity of G?
(a) Cavendish (b) Copernicus (c) Brook Taylor (d) none of these

Q:4 If the distance between the earth and the sun were half its present value, the number of day in a year would have been

(a) 64.5 (b) 129 (c) 182.5 (d) 730

Q:5A bail of weight W is thrown vertically upwards. The apparent w eight during the upward motion will be

(a) zero (b) more than W (c) less than W (d) W

6. Answers

ANSER KEY FOR MCQ

1	B	11	B	21	A	31	C	41	C
2	D	12	C	22	B	32	C	42	C
3	D	13	C	23	B	33	D	43	C
4	B	14	D	24	A	34	D	44	D
5	D	15	D	25	C	35	B	45	B
6	A	16	C	26	C	36	A	46	B
7	D	17	D	27	A	37	B	47	A
8	B	18	B	28	B	38	C	48	C
9	D	19	A	29	B	39	C	49	B
10	A	20	B	30	**B**	40	A	50	C

ANSER KEY FOR ASSERTION AND REASONING

1	A	6	C	11	B	16	C
2	C	7	B	12	D	17	B
3	B	8	C	13	A	18	D
4	D	9	A	14	A	19	C
5	B	10	B	15	C	20	A

CASE STUDY-1

Ans 1 a) they cannot transmit data at long distances due to curvature of the earth

Ans 2 b) False

Ans 3 a) 36,000 km

Ans 4 c) they are closer to the surface of the earth and can cover vast areas very quickly

Ans 5 a) $24 \times (3/5)^{1/2}$ hr

CASE STUDY-2

Ans1b) radius

Ans2 c) R

Ans3 a) 100 N

Ans4b) W_1 , $W_3 < W_2$

Ans 5(d) g is greater at the poles than at the equator

CASE STUDY-3

Ans1b) 22.4 km/s

Ans2c) 10^{-2} m

Ans3b) 11.2 km/s

Ans 4a) $\left(\frac{GM}{R}\right)^{1/2}$

Ans 5d)same velocity

CASE STUDY-4

Ans1a) move towards each other

Ans 2 b) F
Ans3 (a) Cavendish
Ans 4 (b) 129
Ans 5 (a) zero