



CHAPTER-Gravitation

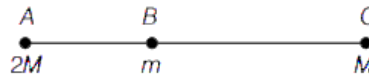
Objective Questions

Multiple Choice Questions

- The force of gravitation is
 (a) repulsive (b) electrostatic (c) conservative (d) non-conservative
- Newton's law of gravitation is universal because
 (a) it acts on all bodies in the universe
 (b) it acts on all the masses at all distances and not affected by the medium
 (c) it is a attractive force
 (d) it acts only when bodies are in contact
- Both the earth and the moon are subject to the gravitational force of the sun. As observed from the sun, the orbit of the moon
 (a) will be elliptical
 (b) will not be strictly elliptical because the total gravitational force on it is not central
 (c) is not elliptical but will necessarily be a closed curve
 (d) deviates considerably from being elliptical due to influence of planets other than the earth
- Two sphere 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. The gravitational force will now be
 (a) F (b) $\frac{F}{3}$ (c) $\frac{F}{9}$ (d) $3 F$
- A mass of $1g$ is separated from another mass of $1g$ by a distance of 1 cm . How many force (in $g\text{-wt}$) exists between them?
 (a) $7 \times 10^{-11} g - wt$ (b) $7 \times 10^{11} g - wt$
 (c) $9 \times 10^{-11} g - wt$ (d) $9 \times 10^{11} g - wt$
- If the distance between the sun and the earth is increased by three times, then attraction between two will
 (a) remain constant (b) decrease by 63%
 (c) increase by 63% (d) decrease by 89%
- If the gravitation force on body 1 due to 2 is given by F_{12} and on body 2 due to 1 is given as F_{21} , then
 (a) $F_{12} = F_{21}$ (b) $F_{12} = -F_{21}$ (c) $F_{12} = \frac{F_{21}}{4}$ (d) None of the above
- Two equal point masses are separated by a distance d_1 . The force of gravitation acting between them is F_1 . If the separation is decreased to d_2 , then the new force of gravitation F_2 is given by
 (a) $F_2 = F_1$ (b) $F_2 = F_1 \left(\frac{d_1}{d_2}\right)^2$ (c) $F_2 = F_1 \left(\frac{d_2}{d_1}\right)^2$ (d) $F_2 = F_1 \left(\frac{d_1}{d_2}\right)$

9. Particles of masses $2M$, m and M are respectively at points A , B and C with $AB = \frac{1}{2}(BC)$, m is much smaller than M and at time $t = 0$, they are all at rest as given in figure. At subsequent times before any collision takes place.

- (a) m will remain at rest
 (b) m will move towards
 (c) m will move towards $2M$
 (d) m will have oscillatory motion

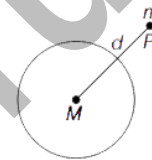


10. Two particles of equal masses go round a circle of radius R under the action of their mutual gravitational attraction. The speed v of each particle is

- (a) $\sqrt{\left(\frac{GM}{2R}\right)}$ (b) $\frac{1}{2R}\sqrt{\left(\frac{GM}{2R}\right)}$ (c) $\frac{1}{2}\sqrt{\left(\frac{GM}{R}\right)}$ (d) $\sqrt{\left(\frac{4GM}{R}\right)}$

11. A point mass m is placed outside a hollow spherical shell of mass M and uniform density at a distance d from centre of the sphere as shown in figure. Gravitational force on point mass m at P is

- (a) $\frac{GmM}{d^2}$ (b) zero
 (c) $\frac{2GmM}{d^2}$ (d) Data insufficient



12. Three equal masses of 2 kg each are placed at the vertices of an equilateral triangle and a mass of 4 kg is placed at the centroid of the triangle which is at a distance of $\sqrt{2}$ m from each of the vertices of the triangle. The force (in newton) acting on the mass of 4 kg is

- (a) 2 (b) $\sqrt{2}$ (c) 1 (d) zero

13. During the free fall of an object,

- (a) acceleration due to gravity is zero (b) force on object is zero
 (c) force on object decreases with height (d) acceleration due to gravity is 9.8 m/s^2

14. What will happen to the weight of the body at the south-pole, if the earth stops rotating about its polar axis?

- (a) No change (b) Increases
 (c) Decreases but not become zero (d) Reduces to zero

15. If G is universal gravitational constant and g is acceleration due to gravity, then the unit of the quantity $\frac{G}{g}$ is

- (a) $kg - m^2$ (b) kgm^{-1} (c) kgm^{-2} (d) $m^2 kg^{-1}$

16. The earth is an approximate sphere. If the interior contained matter which is not of the same density everywhere, then on the surface of the earth, the acceleration due to gravity

- (a) will be directed towards the centre but not the same everywhere
 (b) will have the same value everywhere but not directed towards the centre
 (c) will be same everywhere in magnitude directed towards the centre
 (d) cannot be zero at any point

17. The height at which the weight of a body becomes 1/16th of its weight, on the surface of the earth (radius R), is

- (a) $5R$ (b) $15R$ (c) $3R$ (d) $4R$

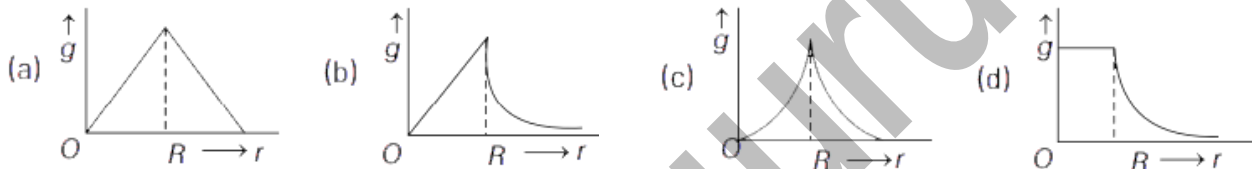
18. The radius of earth is R . Height of a point vertically above the earth's surface at which acceleration due to gravity becomes 1% of its value at the surface is

- (a) $8R$ (b) $9R$ (c) $10R$ (d) $20R$

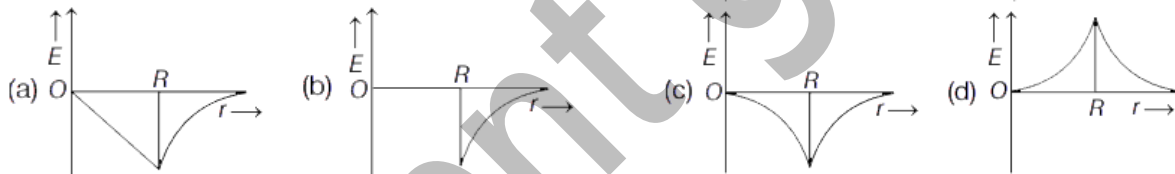
19. What will be the value of g at the bottom of sea 7 km deep? Diameter of the earth is 12800 km and g on the surface of the earth is 9.8 ms^{-2} .

- (a) $9789. \text{ m/s}^2$ (b) $9259. \text{ m/s}^2$
 (c) $9789. \text{ m/s}^2$ (d) $0987. \text{ m/s}^2$

20. Starting from the centre of the earth having radius R , the variation of g (acceleration due to gravity) is shown by which of the following option?



21. Dependence of intensity of gravitational field (E) of earth with distance (r) from centre of earth is correctly represented by



22. A thin rod of length L is bent to form a semicircle. The mass of rod is M . What will be the gravitational potential at the centre of the circle?

- (a) $-\frac{GM}{L}$ (b) $-\frac{GM}{L}$ (c) $-\frac{\pi GM}{2L}$ (d) $-\frac{\pi GM}{L}$

23. A particle is kept on the surface of a uniform sphere of mass 100 kg and radius 10 cm. Find the work to be done per unit mass against the gravitational force between them, to take the particle far away from the sphere (you may take $h = 6.67 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$)

- (a) $13.34 \times 10^{-10} \text{ J}$ (b) $3.33 \times 10^{-10} \text{ J}$
 (c) $6.67 \times 10^{-9} \text{ J}$ (d) $6.67 \times 10^{-8} \text{ J}$

24. The gravitational potential energy of a system consisting of two particles separated by a distance r is

- (a) directly proportional to product of the masses of particles
 (b) inversely proportional to the separation between them
 (c) independent of distance r
 (d) Both (a) and (b)

25. The mass of the earth is $6.00 \times 10^{24} \text{ kg}$ and that of the moon is $7.40 \times 10^{22} \text{ kg}$. The constant of gravitation $G = 6.67 \times 10^{-11} \text{ N-m}^2 \text{ kg}^{-2}$. The potential energy of the system is $-7.79 \times 10^{28} \text{ J}$. The mean distance between the earth and the moon is

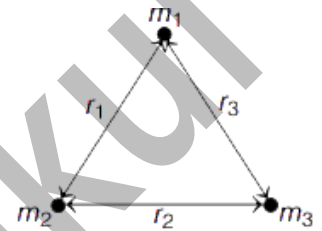
- (a) 3.80×10^8 m (b) 3.37×10^6 m (c) 7.60×10^4 m (d) 1.90×10^2 m

26. Two-point masses m_1 and m_2 are separated by a distance r . The gravitational potential energy of the system is G_1 . When the separation between the particles is doubled, the gravitational potential energy is G_2 . Then, the ratio of $\frac{G_1}{G_2}$ is

- (a) 1 (b) 2 (c) 3 (d) 4

27. Gravitational potential energy of a system of particles as shown in the figure is

- (a) $\frac{Gm_1m_2}{r_1} + \frac{Gm_2m_3}{r_2} + \frac{Gm_1m_3}{r_3}$
 (b) $\left(\frac{-Gm_1m_2}{r_1}\right) + \left(\frac{-Gm_2m_3}{r_2}\right) + \left(\frac{-Gm_1m_3}{r_3}\right)$
 (c) $\frac{-Gm_1m_2}{r_1} - \frac{-Gm_2m_3}{r_2} - \frac{-Gm_1m_3}{r_3}$
 (d) $\frac{-Gm_1m_2}{r_1} + \frac{Gm_2m_3}{r_2} - \frac{Gm_1m_3}{r_3}$



28. Escape velocity of a body on the surface of earth is independent of

- (a) mass (b) radius of earth
 (c) direction of projection of body (d) Both (a) and (c)

29. An object is thrown from the surface of the moon. The escape speed for the object is

- (a) $\sqrt{2gR_m}$, where g' = acceleration due to gravity on the moon and R_m = radius of the moon
 (b) $\sqrt{2gR_e}$, where g' = acceleration due to gravity on the moon and R_e = radius of the earth
 (c) $\sqrt{2gR_m}$, where g' = acceleration due to gravity on the earth and R_m = radius of the moon
 (d) None of the above

30. A body is projected vertically upwards from the surface of a planet of radius R with a velocity equal to $1/3$ rd of the escape velocity for the planet. The maximum height attained by the body is

- (a) $R/2$ (b) $R/3$ (c) $R/5$ (d) $R/9$

31. Two planets A and B have the same material density. If the radius of A is twice that of B , then the ratio of escape velocity $\frac{v_A}{v_B}$ is

- (a) 2 (b) $\sqrt{2}$ (c) $\frac{1}{\sqrt{2}}$ (d) $\frac{1}{2}$

32. Escape velocity on earth is 11.2 kms^{-1} , what would be the escape velocity on a planet whose mass is 1000 times and radius is 10 times that of earth?

- (a) 112 kms^{-1} (b) 11.2 kms^{-1} (c) 1.12 kms^{-1} (d) 3.7 kms^{-1}

33. The time period of a satellite in a circular orbit around a planet is independent of

- (a) the mass of the planet (b) the radius of the planet
 (c) the mass of the satellite (d) All the three parameters (a), (b) and (c)

34. Satellites orbiting the earth have finite life and sometimes debris of satellites fall to the earth. This is because

- (a) the solar cells and batteries in satellites run out

- (b) the laws of gravitation predict a trajectory spiraling inwards
(c) of viscous forces causing the speed of satellite and hence height to gradually decrease
(d) of collisions with other satellites.

35. An artificial satellite is revolving around the earth, close to its surface. Find the orbital velocity of artificial satellite? (Take, radius of earth = 6400 km)

- (a) 7.2 km/s (b) 7.9 km/s (c) 11.2 km/s (d) 9.5 km/s

36. Two satellites A and B go around a planet P in circular orbits having radius $4R$ and R , respectively. If the speed of satellite A is $3v$, then the speed of satellite B will be

- (a) $6v$ (b) $9v$ (c) $3v$ (d) None of the above

37. An artificial satellite moving in a circular orbit around the earth has a total (kinetic + potential) energy E_0 . Its potential energy and kinetic energy respectively are

- (a) $2E_0$ and $-2E_0$ (b) $-2E_0$ and E_0 (c) $2E_0$ and $-E_0$ (d) $-2E_0$ and $-E_0$

38. The kinetic energy of the satellite in a circular orbit with speed v is given as

- (a) $KE = \frac{-GmM_e}{2(R_2 + h)}$ (b) $KE = \frac{GmM_e}{(R_e + h)}$ (c) $KE = \frac{GmM_e}{2(R_2 + h)}$ (d) $KE = \frac{1}{2}mv^2$

39. The time period of geo-stationary satellite is

- (a) 6 h (b) 12 h (c) 24 h (d) 48 h

40. Geo-stationary satellites are placed in equatorial orbits at the height approximately

- (a) 1000 km (b) 15000 km (c) 25000 km (d) 36000 km

41. An astronaut experiences weightlessness in a space satellite. It is because

- (a) the gravitational force is small at that location in space.
(b) the gravitational force is large at that location in space.
(c) the astronaut experiences no gravity
(d) the gravitational force is infinitely large at that location in space.

42. A pendulum beats sounds on the earth. Its time period on a stationary satellite of the earth will be

- (a) zero (b) 1s (c) 2s (d) infinity

43. is defined to be numerically equal to the force of attraction between two bodies each of mass 1 kg and separated by a distance of 1 m.

- (a) Universal gravitational constant (G) (b) Gravity (g)
(c) Force (F) (d) Magnetic field (B)

44. Weight of a body is maximum at

- (a) poles (b) equator (c) centre of earth (d) at latitude 45°

45. The ratio of the magnitude of potential energy and kinetic energy of a satellite is

- (a) 1 : 2 (b) 2 : 1 (c) 3 : 1 (d) 1 : 3

46. Weightlessness experienced while orbiting the earth in spaceship, is the result of
 (a) inertia (b) acceleration (c) zero gravity (d) centre of gravity

47. Which of the following statement is incorrect?
 (a) Acceleration due to gravity decreases with increasing altitude.
 (b) Acceleration due to gravity increases with increasing depth (assume the earth to be a sphere of uniform density).
 (c) Acceleration due to gravity increases with increasing altitude.
 (d) None of the above

48. If the gravitational attraction of earth suddenly disappears, then which of the following statement is correct?
 (a) Both masses as well as the weight will be zero.
 (b) Weight of the body will become zero but the mass will remain unchanged.
 (c) Weight of the body will remain unchanged but the mass will become zero.
 (d) Neither mass nor weight will be zero.

49. Study the following statements and choose the incorrect option.
 I. G is not equal to $6.67 \times 10^{-11} \text{ Nm}^{-2} \text{ kg}^{-2}$ on the surface of earth.
 II. The escape velocity on the surface of earth is lesser than the escape velocity from moon's surface.
 III. The angular momentum of a satellite going around the earth remains conserved.
 IV. The relation, $g = \frac{GM}{r^2}$ holds good for all the celestial bodies.
 (a) Only I (b) Only III (c) Both I and II (d) Both II and IV

50. Which of the following statement is correct?
 (a) A polar satellite goes around the earth's pole in north-south direction.
 (b) A geo-stationary satellite goes around the earth in east-west direction.
 (c) A geo-stationary satellite goes around the earth in north-south direction.
 (d) A polar satellite goes around the earth in east-west direction.

51. Match the Column I (quantities) with Column II (approximate values) and select the correct answer from the codes given below.

Codes

A	B	C	A	B	C
(a) p	q	r	(b) r	q	p
(c) q	p	r	(d) r	p	q

Column I	Column II
A. Escape velocity of earth	p. 1.6 m/s^2
B. Gravitational acceleration at moon's surface	q. 6400 km
C. Radius of earth	r. 11.2 km/s

52. A satellite of mass m revolving with a velocity v around the earth. With reference to the above situation, match the Column I (types of energy) with Column II (expression) and select the correct answer from the codes given below.

Codes

A	B	C
(a) p	q	r
(b) q	r	p

Column I	Column II
A. Kinetic energy of the satellite	p. $-\frac{1}{2}mv^2$
B. Potential energy of the satellite	q. $\frac{1}{2}mv^2$
C. Total energy of the satellite	r. $-mv^2$

(c) r q p

(d) r p q

Assertion-Reasoning MCQs

For question numbers 53 to 66, two statements are given-one labeled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) are as given below

- (a) Both A and R are true and R is the correct explanation of A.
- (b) Both A and R are true but R is not the correct explanation of A.
- (c) A is true but R is false.
- (d) A is false and R is also false.

53. Assertion Newton's law of universal gravitation states that a particle attracts every other particle in the universe using a force of attraction that is directly proportional to the product of their masses and inversely proportional to the square of distance between them.

Reason Law of gravitation is analogous to magnetic force between the moving charges.

54. Assertion The value of acceleration due to gravity does not depend upon mass of the body on which force is applied.

Reason Acceleration due to gravity is a variable quantity.

55. Assertion As we go up the surface of the earth, we feel light weighed than on the surface of the earth.

Reason The acceleration due to gravity decreases on going up above the surface of the earth.

56. Assertion Work done by or against gravitational force in moving a body from one point to another is independent of the actual path followed between the two points.

Reason This is because gravitational forces are conservative in nature.

57. Assertion If gravitational potential at some point is positive, then the gravitational field strength at that point will also be zero.

Reason Except at infinity gravitational potential due to a system of point masses at some finite distance cannot be negative.

58. Assertion The force of attraction between a hollow spherical shell of uniform density and a point mass situated inside it, is zero.

Reason The value of G does not depend on the nature and size of the masses.

59. Assertion Moon has no atmosphere.

Reason The escape speed for the moon is much smaller.

60. Assertion The escape velocity for a planet is $v_e = \sqrt{2gR}$. If the radius of the planet is four times, the escape velocity becomes half (i.e. $v_e = \frac{v_e}{2}$).

Reason In the relation for escape velocity, $v_e = \sqrt{2gR}$, the acceleration due to gravity g is inversely proportional to radius of the planet. Thus, $v_e \propto \frac{1}{\sqrt{R}}$

61. Assertion The velocity of the satellite increases as its height above earth's surface increases and is minimum near the surface of the earth.

Reason The velocity of the satellite is directly proportional to square root of its height above earth's surface.

62. Assertion A satellite moves around the earth in a circular orbit under the action of gravity. A person in the satellite experience zero gravity field in the satellite.

Reason The contact force by the surface on the person is not zero.

63. Assertion The total energy of the satellite is always negative irrespective of the nature of its orbit, i.e. elliptical or circular and it cannot be positive or zero.

Reason If the total energy is negative the satellite would leave its orbit.

64. Assertion The geo-stationary satellite goes around the earth in west-east direction.

Reason Geo-stationary satellites orbits around the earth in the equatorial plane with $T = 24 h$ same as that of the rotation of the earth around its axis.

65. Assertion In the satellite, everything inside it is in a state of free fall.

Reason Every part and parcel of the satellite has zero acceleration.

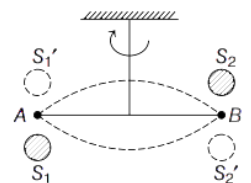
66. Assertion An object is weightless when it is in free fall and this phenomenon is called weightlessness.

Reason In free fall, there is upward force acting on the object.

Case Based MCQs

Direction Answer the questions from 67-71 on the following case.

Cavendish's Experiment: The figure shows the schematic drawing of Cavendish's experiment to determine the value of the gravitational constant. The bar AB has two small lead spheres attached at its ends. The bar is suspended from a rigid support by a fine wire. Two large lead spheres are brought close to the small ones but on opposite sides as shown. The value of G from this experiment came to be $6.67 \times 10^{-11} N - m^2 / kg^2$.



67. The big spheres attract the nearby small ones by a force which is

- (a) equal and opposite (b) equal but in same direction
(c) unequal and opposite (d) None of the above

68. The net force on the bar is

- (a) non-zero (b) zero (c) Data insufficient (d) None of these

69. The net torque on the bar is

- (a) zero
(b) non-zero
(c) F times the length of the bar, where F is the force of attraction between a big sphere and its neighboring
(d) Both (b) and (c)

70. The torque produces twist in the suspended wire. The twisting stops when

- (a) restoring torque of the wire equals the gravitational torque
- (b) restoring torque of the wire exceeds the gravitational torque
- (c) the gravitational torque exceeds the restoring torque of the wire
- (d) None of the above

71. After Cavendish's experiment, there have been given suggestions that the value of the gravitational constant G becomes smaller when considered over very large time period (in billions of years) in the future. If that happens, for our earth,

- (a) nothing will change
- (b) we will become hotter after billions of years
- (c) we will be going around but not strictly in closed orbits
- (d) None of the above

Direction Answer the questions from 72-76 on the following case.

Acceleration due to gravity:

The acceleration for any object moving under the sole influence of gravity is known as acceleration due to gravity. So, for an object of mass m , the acceleration experienced by it is usually denoted by the symbol g which is related to F by Newton's second law by relation $F = mg$.

$$Thus, g = \frac{F}{m} = \frac{GM_e}{R_e^2}$$

Acceleration g is readily measurable as R_e is a known quantity. The measurement of G by Cavendish's experiment (or otherwise), combined with knowledge of g and R_e enables one to estimate M_e from the above equation. This is the reason why there is a popular statement regarding Cavendish "Cavendish weighed the earth". The value of g decrease as we go upwards from the earth's surface or downwards, but it is maximum at its surface.

72. If g is the acceleration due to gravity at the surface of the earth, the force acting on the particle of mass m placed at the surface is

- (a) mg
- (b) $\frac{GmM_e}{R_e^2}$
- (c) Data insufficient
- (d) Both (a) and (b)

73. The weight of a body at the centre of earth is

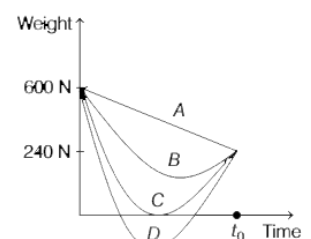
- (a) same as on the surface of earth
- (b) same as on the poles
- (c) same as on the equator
- (d) None of the above

74. If the mass of the sun is ten times smaller and gravitational constant G is ten times larger in magnitude, then for earth,

- (a) walking on ground would become more easy
- (b) acceleration due to gravity on the earth will not change
- (c) raindrops will fall much slower
- (d) airplanes will have to travel much faster

75. Suppose, the acceleration due to gravity at the earth's surface is 10 ms^{-2} and at the surface of mars, it is 4.0 ms^{-2} . A 60 kg passenger goes from the earth to the mars in a spaceship moving with a constant velocity. Neglect all other objects in the sky.

Which curve best represents the weight (net gravitational force) of the passenger as a function of time?



- (a) A (b) B (c) C (d) D

76. If the mass of the earth is doubled and its radius halved, then new acceleration due to the gravity g' is

- (a) $g' = 4g$ (b) $g' = 8g$ (c) $g' = g$ (d) $g' = 16g$

Direction Answer the questions from 77-81 on the following case.

Earth's Satellite:

Earth satellites are objects which revolve around the earth. Their motion is very similar to the motion of planets around the Sun. In particular, their orbits around the earth are circular or elliptic. Moon is the only natural satellite of the earth with a near circular orbit with a time period of approximately 27.3 days which is also roughly equal to the rotational period of the moon about its own axis. Also, the speed that a satellite needs to be travelling to break free of a planet or moon's gravity well and leave it without further propulsion is known as escape velocity. For example, a spacecraft leaving the surface of earth needs to be going 7 miles per second or nearly 25000 miles per hour to leave without falling back to the surface or falling into orbit.

77. Gas escapes from the surface of a planet because it acquires an escape velocity. The escape velocity will depend on which of the following factors?

- (a) Mass of the planet (b) Mass of the particle escaping
(c) Temperature of the planet (d) None of the above

78. The escape velocity of a satellite from the earth is v_e . If the radius of earth contracts to $(1/4)$ th of its value, keeping the mass of the earth constant, escape velocity will be

- (a) doubled (b) halved (c) tripled (d) unaltered

79. The ratio of escape velocity at earth (v_e) to the escape velocity at a planet (v_p), whose radius and mean density are twice as that of earth is

- (a) $1:2\sqrt{2}$ (b) $1:4$ (c) $1:\sqrt{2}$ (d) $1:2$

80. A satellite S is moving in an elliptical orbit around the earth. The mass of the satellite is very small as compared to the mass of the earth, then

- (a) the angular momentum of S about the centre of the earth changes in direction, but its magnitude remains constant
(b) the total mechanical energy of S varies periodically with time
(c) the linear momentum of S remains constant in magnitude
(d) the acceleration of S is always directed towards the centre of the earth

81. The orbital velocity of an artificial satellite in a circular orbit just above the earth's surface is v_0 . The orbital velocity of a satellite orbiting at an altitude of half of the radius, is

- (a) $\frac{3}{2}V_0$ (b) $\frac{2}{3}V_0$ (c) $\sqrt{\frac{3}{2}}V_0$ (d) $\sqrt{\frac{2}{3}}V_0$

ANSWERS

Multiple Choice Questions

1. (c) 2. (b) 3. (b) 4. (a) 5. (a) 6. (d) 7. (b) 8. (b) 9. (c) 10. (c) 11. (a) 12. (d) 13. (d)
14. (a) 15. (d) 16. (d) 17. (c) 18. (b) 19. (a) 20. (b) 21. (a) 22. (d) 23. (d) 24. (d) 25. (a) 26. (b)
27. (b) 28. (d) 29. (a) 30. (d) 31. (a) 32. (a) 33. (c) 34. (c) 35. (b) 36. (a) 37. (c) 38. (c) 39. (c)
40. (d) 41. (c) 42. (d) 43. (a) 44. (a) 45. (b) 46. (c) 47. (b) 48. (b) 49. (c) 50. (a) 51. (d) 52. (b)

Assertion-Reasoning MCQs

53. (c) 54. (a) 55. (a) 56. (a) 57. (d) 58. (b) 59. (a) 60. (a) 61. (d) 62. (c) 63. (c) 64. (a) 65. (c)
66. (c)

Case Based MCQs

67. (a) 68. (b) 69. (d) 70. (a) 71. (c) 72. (d) 73. (d) 74. (d) 75. (c) 76. (b) 77. (a) 78. (a) 79. (a)
80. (d) 81. (d)

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