GRAVITATION

FACT/DEFINITION TYPE QUESTIONS

1. Newton's universal law of gravitation applies to
   (a) small bodies only
   (b) planets only
   (c) both small and big bodies
   (d) only valid for solar system
2. For a particle inside a uniform spherical shell, the gravitational force on the particle is
   (a) infinite (b) zero
   (c) $\frac{-Gm_1m_2}{r^2}$ (d) $\frac{Gm_1m_2}{r^2}$
3. The value of G varies with
   (a) height above the earth's surface
   (b) depth below the ground
   (c) radius of the planet
   (d) None of these
4. Force of gravitational attraction is least
   (a) at the equator
   (b) at the poles
   (c) at a point in between equator and any pole
   (d) None of these
5. The ratio of the inertial mass to gravitational mass is equal to
   (a) 0.5 (b) 1
   (c) 2 (d) no fixed number
6. Who among the following gave first the experimental value of G
   (a) Cavendish (b) Copernicus
   (c) Brok Taylor (d) None of these
7. Mass of the Earth has been determined through
   (a) use of Kepler's $\frac{T^2}{R^3}$ constancy law and Moon's period
   (b) sampling the density of Earth's crust and using Earth's radius
   (c) Cavendish's determination of G and using Earth radius and g at its surface
   (d) use of periods of satellites at different heights above Earth's surface and known radius of Earth
8. 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) 3 F (b) F
   (c) $\frac{F}{3}$ (d) $\frac{F}{9}$
9. Consider Earth to be a homogeneous sphere. Scientist A goes deep down in a mine and scientist B goes high up in a balloon. The gravitational field measured by
   (a) A goes on decreasing and that by B goes on increasing
   (b) B goes on decreasing and that by A goes on increasing
   (c) each decreases at the same rate
   (d) each decreases at different rates
10. In some region, the gravitational field is zero. The gravitational potential in this region.
    (a) must be variable (b) must be constant
    (c) cannot be zero (d) must be zero
11. Where will it be profitable to purchase one kilogram sugar?
    (a) At poles (b) At equator
    (c) At 45° latitude (d) At 40° latitude
12. At sea level, a body will have minimum weight at
    (a) pole (b) equator
    (c) 42° south latitude (d) 37° north latitude
13. Earth is flattened at poles, bulged at the equator. This is due to
    (a) the angular velocity of spinning about its axis is less at equator
    (b) the angular velocity of spinning about its axis is more at equator
    (c) the centrifugal force is more at the equator than at the poles
    (d) earth revolves round the sun in an elliptical orbit
14. In a gravitational field, at a point where the gravitational potential is zero
    (a) the gravitational field is necessarily zero
    (b) the gravitational field is not necesarily zero
    (c) any value between one and infinite
    (d) None of these

15. There are _______ gravitational lines of force inside a spherically symmetric shell.
(a) infinitely many
(b) zero
(c) varying number depending upon surface area
(d) varying number depending upon volume

16. Intensity of the gravitational field inside the solid sphere is
(a) variable (proportional to distance from centre)
(b) constant
(c) variable (does not depend on distance from the centre)
(d) zero

17. Intensity of the gravitational field inside the hollow spherical shell is
(a) variable (b) minimum
(c) maximum (d) zero

18. The value of acceleration due to gravity on moving from equator to poles will
(a) decrease (b) increase
(c) remain same (d) become half

19. The weight of a body at the centre of the earth is
(a) zero
(b) infinite
(c) same as on the surface of earth
(d) None of these

20. In motion of an object under the influence of gravitational force of another object, which of the following quantity is not conserved?
(a) Linear momentum
(b) Angular momentum
(c) Total mechanical energy
(d) None of these

21. As we go down below the earth's surface, the acceleration due to gravity decreases by a factor (d $\to$ distance, R $\to$ radius of earth)
(a) $1+\frac{d}{R}$ (b) $1-\frac{R}{d}$
(c) $1-\frac{d}{R}$ (d) remains constant

22. There is no atmosphere on moon, because of
(a) smaller value of G (b) smaller value of g
(c) smaller value of R (d) smaller value of m

23. If measured by a spring balance, then 1 kg of salt will weigh more at
(a) equator (b) poles
(c) centre of earth (d) same at all places

24. The gravitational potential energy associated with two particles separated by a distance r, when $r \to \infty$, is given by
(a) $\frac{Gm_1 m_2}{r}$ (b) $\frac{-Gm_1 m_2}{r}$
(c) zero (d) infinity

25. For elliptical orbits, in the equation $T^2 = \left(\frac{4\pi^2}{GM_s}\right)R^3$
R refers to
(a) radius of orbit (b) major axis
(c) semi-minor axis (d) semi-major axis

26. If the distance of earth is halved from the sun, then the no. of days in a year will be
(a) 365 (b) 182.5
(c) 730 (d) 129

27. In planetary motion
(a) the angular speed remains constant
(b) the total angular momentum remains constant
(c) the linear speed remains constant
(d) neither the angular momentum nor angular speed remains constant

28. Kepler's second law regarding constancy of areal velocity of a planet is a consequence of the law of conservation of
(a) energy (b) angular momentum
(c) linear momentum (d) None of these

29. In planetary motion, the angular momentum conservation leads to the law of
(a) orbits
(b) areas
(c) periods
(d) conservation of kinetic energy

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

31. If the earth is at one-fourth of its present distance from the sun, the duration of the year will be
(a) half the present year
(b) one-eighth the present year
(c) one-sixth the present year
(d) one-tenth the present year

32. Time period of a simple pendulum inside a satellite orbiting earth is
(a) zero (b) ∞
(c) T (d) 2T

33. Which of the following is always positive?
(a) Potential energy of an object
(b) Total energy of a satellite
(c) Kinetic energy (d) None of these

34. The distance of neptune and saturn from the sun is nearly 10^{13} and 10^{12} meter respectively. Assuming that they move in circular orbits, their periodic times will be in the ratio
(a) 10 (b) 100
(c) $10\sqrt{10}$ (d) 1000

35. A person sitting in a chair in a satellite feels weightless because
(a) the earth does not attract the objects in a satellite
(b) the normal force bythe chair on the person balances the earth's attraction
(c) the normal force is zero
(d) the person in satellite is not accelerated.

36. The relay satellite transmits the TV programme continuously from one part of the world to another because its
(a) period is greater than the period of rotation of the earth
(b) period is less than the period of rotation of the earth about its axis
(c) period has no relation with the period of the earth about its axis
(d) period is equal to the period of rotation of the earth about its axis

37. To an astronaut in a spaceship the sky appears black due to
(a) absence of atmosphere in his neighbourhood
(b) light from the sky is absorbed by the medium surrounding him
(c) the fact at that height, sky radiations are only in the infra-red and the ultraviolet region
(d) None of these

38. To have an earth synchronous satellite it should be launched at the proper height moving from
(a) north to south in a polar plane
(b) east to west in an equatorial plane
(c) south to north in a polar plane
(d) west to east in an equatorial plane

39. A missile is launched with a velocity less than escape velocity. The sum of its kinetic and potential energies is
(a) zero
(b) negative
(c) positive
(d) may be positive, negative or zero.

40. The orbital speed of Jupiter is
(a) greater than the orbital speed of earth
(b) less than the orbital speed of earth
(c) equal to the orbital speed of earth
(d) zero

41. The total energy of a circularly orbiting satellite is
(a) twice the kinetic energy of the satellite
(b) half the kinetic energy of the satellite
(c) twice the potential energy of the satellite
(d) half the potential energy of the satellite

42. Geo-stationary satellite is one which
(a) remains stationary at a fixed height from the earth's surface
(b) revolves like other satellites but in the opposite direction of earth's rotation
(c) revolves round the earth at a suitable height with same angular velocity and in the same direction as earth does about its own axis
(d) None of these

43. An artificial satellite orbiting the earth does not fall down because the earth's attraction
(a) is balanced by the attraction of the moon
(b) vanishes at such distances
(c) is balanced by the viscous drag produced by the atmosphere
(d) produces the necessary acceleration of its motion in a curved path

44. The period of a satellite in a circular orbit near 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 of the above

45. If a satellite is orbiting the earth very close to its surface, then the orbital velocity mainly depends on
(a) the mass of the satellite
(b) the radius of earth
(c) the orbital radius
(d) the mass of earth

46. Two satellites of masses m_1 and m_2 $(m_1 > m_2)$ are revolving round the earth in circular orbits of radii r_1 and r_2 $(r_1 > r_2)$ respectively. Which of the following statements is true regarding their velocities v_1 and v_2?
(a) $v_1 = v_2$ (b) $v_1 < v_2$
(c) $v_1 > v_2$ (d) $(v_1 / r_2) = (v_2 / r_2)$

47. The escape velocity of a body depends upon mass as
(a) m^0 (b) m^1
(c) m^2 (d) m^3.

48. The minimum velocity of projection to go out from the earth's gravitational pull is called
(a) terminal velocity (b) escape velocity
(c) angular velocity (d) orbital velocity

49. 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 lesser than their root mean square velocity

50. The escape velocity of a projectile from the earth is approximately
(a) 7 km/sec (b) 112 km/sec
(c) 11.2 km/sec (d) 1.1 km/sec

51. The escape velocity of an object projected from the surface of a given planet is independent of
(a) radius of the planet
(b) the direction of projection
(c) the mass of the planet
(d) None of these

52. Escape speed on the moon is _______ than escape speed on the earth.
(a) five times smaller (b) five times greater
(c) six times greater (d) six times smaller

53. The orbit traced by planet around a star is in general
(a) a circle (b) an ellipse
(c) a parabola (d) a straight line

54. If V_e is escape speed from the earth and V_p is that from a planet of half the radius of earth, then

(a) $V_e = V_p$ (b) $V_e = \frac{V_p}{2}$

(c) $V_e = 2V_p$ (d) $V_e = \frac{V_p}{4}$

55. In which of the following cases, a person feels weightless?

(a) A person standing on the moon

(b) A person sitting in an artificial satellite of earth

(c) Both (a) & (b)

(d) None of these

56. When does the object in a satellite escapes to infinity?

(a) When the total energy is positive

(b) When total energy is zero

(c) Both (a) & (b)

(d) None of these

57. In case of a circular orbiting satellite which option is correct for its energies?

(a) Kinetic energy is negative

(b) Potential energy is positive

(c) Total energy is positive

(d) None of these

58. What is the distance of a geostationary satellite from the earth's centre?

(a) 4.22×10^4 km (b) 4.22×10^4 m

(c) 4.22×10^6 km (d) 4.22×10^6 m

59. Persons sitting in artificial satellite of the earth have

(a) zero mass (b) zero weight

(c) certain definite weight (d) infinite weight

STATEMENT TYPE QUESTIONS

60. Consider the following statements and select the correct statement(s).

I. Gravitational force may be attractive or repulsive

II. Gravitational force between two particles is independent of presence of other particles

III. Gravitational force is a short-range force

(a) I only (b) II only

(c) II and III (d) I, II and III

61. For a body taken to the moon which of the following statements is/are true?

I. Weight of the body will become 1\6 of that on earth

II. Inertial mass remains the same

III. Gravitational mass remains the same

(a) I only (b) II only

(c) I and II (d) I, II and III

62. Which of the given statements is/are true?

I. Motion of a particle under a central force is always confined to a plane

II. Under the influence of central force, position vector sweeps out equal areas in equal intervals of time

(a) I only (d) II only

(c) Both (I) and (II) (d) None of these

63. Let V and E be the gravitational potential and gravitational field at a distance r from the centre of a uniform spherical shell. Consider the following two statements and select the correct statement(s).

I. The plot of V against r is discontinuous

II. The plot of E against r is discontinuous.

(a) Both I and II (b) I only

(c) II only (d) None of these

64. Select the incorrect statements from the following.

I. The orbital velocity of a satellite increases with the radius of the orbit

II. Escape velocity of a particle from the surface of the earth depends on the speed with which it is fired

III. The time period of a satellite does not depend onthe radius of the orbit

IV. The orbital velocity is inversely proportional to the sequare root of the radius of the orbit.

(a) I and II (b) I and IV

(c) I, II and IV (d) I, II and III

65. Which of the following is/are not a relevant statement(s) to Kepler's laws of planetary motion?

I. Kepler's second law is based on law of conservation of angular momentum.

II. Every planet revolves around the sun in circular orbits with sun at the centre of the orbit.

III. Planets situated at larger distances from the sun take longer time to complete one rotation

(a) I only (b) II only

(c) II and III (d) I, II and III

66. Consider the following statements and select the incorrect statement(s) from the following.

I. When height of a satellite is increased, its potential energy increases & kinetic energy decrease

II. When speed of satellite increases, the total energy increases & it starts orbiting in a circular path

III. For a satellite orbiting in circular orbit, the kinetic energy is always greater than potential energy

(a) I and II (b) II and III

(c) III only (d) I, II and III

MATCHING TYPE QUESTIONS

67. Match the columns I and II.

	Column I		Column II
(A)	Force between any two bodies	(1)	Maximum at the earth's surface
(B)	Acceleration due to gravity	(2)	Always attractive
(C)	Escape velocity	(3)	$\sqrt{gR}$
(D)	Orbital velocity	(4)	$\sqrt{2}.\sqrt{gR}$

(a) (A)→(2); (B)→(1); (C)→(3); (D)→(4)

(b) (A)→(2); (B)→(2); (C)→(4); (D)→(3)

(c) (A)→(4); (B)→(3); (C)→(2); (D)→(1)

(d) (A)→(2); (B)→(1); (C)→(4); (D)→(3)

68.

	Column I		Column II
(A)	Gravitational force F_g	(1)	$g\left(1-\frac{2h}{R}\right)$
(B)	$g_{\text{surface of earth}}$	(2)	$G\frac{Mm}{R^2}$
(C)	Escape velocity	(3)	$\sqrt{2gR}$
(D)	g_{height}	(4)	GM/R^2

(a) (A)$\to$(2); (B)$\to$(1); (C)$\to$(3); (D)$\to$(4)
(b) (A)$\to$(2); (B)$\to$(2); (C)$\to$(4); (D)$\to$(3)
(c) (A)$\to$(4); (B)$\to$(3); (C)$\to$(2); (D)$\to$(1)
(d) (A)$\to$(2); (B)$\to$(4); (C)$\to$(3); (D)$\to$(1)

69.

	Column I		Column II
(A)	Gravitational constant	(1)	Law of periods
(B)	g_h	(2)	24 Hrs
(C)	$T^2 \propto R^3$	(3)	6.67×10^{-11} Nm^2kg^{-2}
(D)	Time period of a geostationary satellite	(4)	$g_0\left(1-\frac{2h}{R}\right)$

(a) (A)$\to$(2); (B)$\to$(1); (C)$\to$(3); (D)$\to$(4)
(b) (A)$\to$(3); (B)$\to$(4); (C)$\to$(1); (D)$\to$(2)
(c) (A)$\to$(4); (B)$\to$(3); (C)$\to$(2); (D)$\to$(1)
(d) (A)$\to$(3); (B)$\to$(4); (C)$\to$(2); (D)$\to$(1)

70.

	Column I		Column II
(A)	Weight	(1)	Minimum
(B)	g_{equator}	(2)	Zero
(C)	g_{poles}	(3)	Vector
(D)	g_{centre}	(4)	Maximum

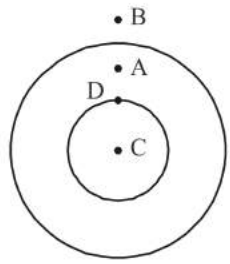
(a) (A)$\to$(2); (B)$\to$(1); (C)$\to$(3); (D)$\to$(4)
(b) (A)$\to$(2); (B)$\to$(2); (C)$\to$(4); (D)$\to$(3)
(c) (A)$\to$(3); (B)$\to$(1); (C)$\to$(4); (D)$\to$(2)
(d) (A)$\to$(4); (B)$\to$(3); (C)$\to$(1); (D)$\to$(2)

71. On the surface of earth acceleration due to gravity is g and gravitational potential is V. Match the following:

	Column I		Column -II
(A)	At height $h = R$, value of g	(1)	decreases by a factor 1/4
(B)	At depth $h = R/2$, value of g	(2)	decreases by a factor 1/2
(C)	At height $h = R/2$, value of g	(3)	decreases by a factor 3/4
(D)	At depth $h = R/4$, value of g	(4)	decreases by a factor 2/3

(a) (A)$\to$(2); (B)$\to$(1); (C)$\to$(3); (D)$\to$(4)
(b) (A)$\to$(2); (B)$\to$(2); (C)$\to$(4); (D)$\to$(3)
(c) (A)$\to$(4); (B)$\to$(3); (C)$\to$(2); (D)$\to$(1)
(d) (A)$\to$(4); (B)$\to$(3); (C)$\to$(1); (D)$\to$(2)

72. Two concentric spherical shells are as shown in figure. Match the following:



	Column I		Column II
(A)	Potential at A	(1)	greater than B
(B)	Gravitational field at A	(2)	less than B
(C)	As one moves from C to D	(3)	potential remains constant
(D)	As one moves from D to A	(4)	gravitational field decreases
		(5)	None

(a) (A)$\to$(2); (B)$\to$(5); (C)$\to$(3); (D)$\to$(4)
(b) (A)$\to$(3); (B)$\to$(2); (C)$\to$(1); (D)$\to$(4)
(c) (A)$\to$(4); (B)$\to$(3); (C)$\to$(2); (D)$\to$(1)
(d) (A)$\to$(5); (B)$\to$(3); (C)$\to$(1); (D)$\to$(2)

73.

	Column I		Column II
(A)	Acceleration due to gravity	(1)	$\sqrt{2gR_E}$
(B)	Escape speed	(2)	$\frac{-Gm_1m_2}{r}$
(C)	Total energy of a satellite	(3)	Gm/R^2
(D)	Gravitational potential energy.	(4)	$\frac{-Gm_1m_2}{2(R+h)}$

(a) (A)$\to$(4); (B)$\to$(2); C$\to$(1); (D)$\to$(3)
(b) (A)$\to$(3); (B)$\to$(1); C$\to$(4); (D)$\to$(2)
(c) (A)$\to$(3); (B)$\to$(2); C$\to$(4); (D)$\to$(1)
(d) (A)$\to$(2); (B)$\to$(4); C$\to$(1); (D)$\to$(3)

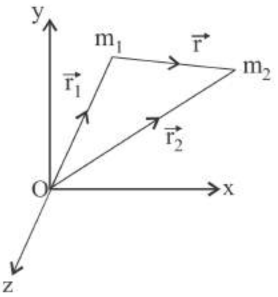
74.

	Column I		Column II
(A)	Potential energy of satellite	(1)	Positive
(B)	Total energy of satellite	(2)	Negative
(C)	kinetic energy of satellite	(3)	Zero
(D)	Gravitational potential energy of satellite at infinity	(4)	Infinite

(a) (A)$\to$(4); (B)$\to$(2); C$\to$(1); (D)$\to$(3)
(b) (A)$\to$(3); (B)$\to$(1); C$\to$(4); (D)$\to$(2)
(c) (A)$\to$(2); (B)$\to$(2); C$\to$(1); (D)$\to$(3)
(d) (A)$\to$(2); (B)$\to$(4); C$\to$(1); (D)$\to$(3)

DIAGRAM TYPE QUESTIONS

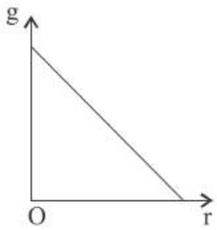
75. In the figure, the direction of gravitational force on m_1 due to m_2 is along

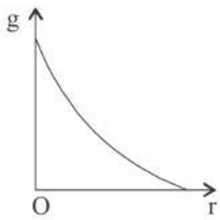


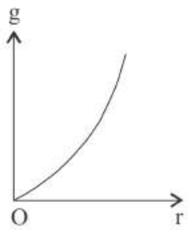
(a) $\vec{r}_1$ (b) $\vec{r}_2$

(c) $\vec{r}$ (d) $-\vec{r}$

76. Which of the following graphs shows the correct variation of acceleration due to gravity with the height above the earth's surface?

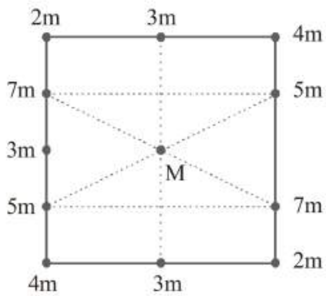
(a) 

(b) 

(c) 

(d) None of these

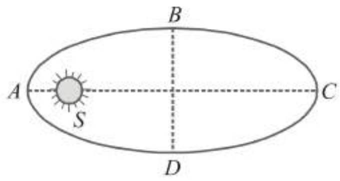
77. A central particle M is surrounded by a square array of other particles, separated by either distance d or distance $d/2$ along the perimeter of the square. The magnitude of the gravitational force on the central particle due to the other particles is



(a) $\dfrac{9\,GMm}{d^2}$ (b) $\dfrac{5\,GMm}{d^2}$

(c) $\dfrac{3\,GMm}{d^2}$ (d) $\dfrac{GMm}{d^2}$

78. A planet is revolving around the sun as shown in elliptical path



The correct option is

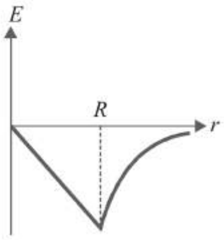
(a) the time taken in travelling DAB is less than that for BCD

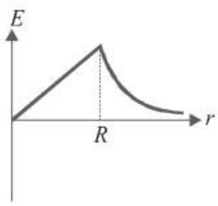
(b) the time taken in travelling DAB is greater than that for ABC

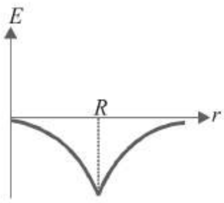
(c) the time taken in travelling CDA is less than that for ABC

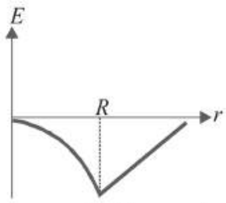
(d) the time taken in travelling CDA is greater than that for ABC

79. The gravitational field strength due to a solid sphere (mass M, radius R) varies with distance r from centre as

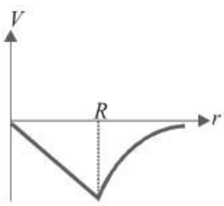
(a) 

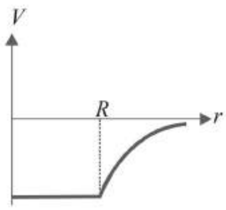
(b) 

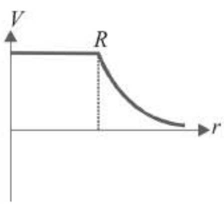
(c) 

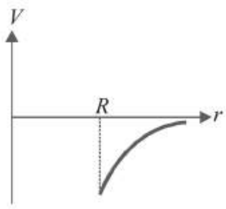
(d) 

80. The gravitational potential due to a hollow sphere (mass M, radius R) varies with distance r from centre as

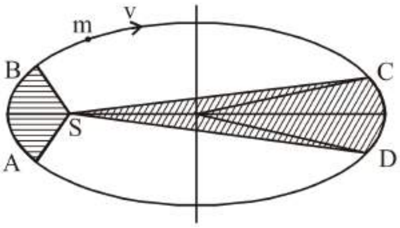
(a) 

(b) 

(c) 

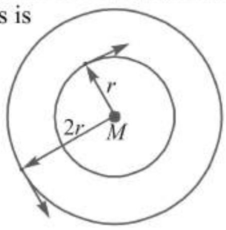
(d) 

81. The figure shows elliptical orbit of a planet m about the sun S. The shaded area SCD is twice the shaded area SAB. If t_1 is the time for the planet to move from C to D and t_2 is the time to move from A to B then



(a) $t_1 = 4t_2$ (b) $t_1 = 2t_2$
(c) $t_1 = t_2$ (d) $t_1 > t_2$

82. Two satellites of masses m and $2m$ are revolving around a planet of mass M with different speeds in orbits of radii r and $2r$ respectively. The ratio of minimum and maximum forces on the planet due to satellites is



(a) $\frac{1}{2}$

(b) $\frac{1}{4}$

(c) $\frac{1}{3}$

(d) None of these

ASSERTION- REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

83. **Assertion :** Gravitational force between two particles is negligibly small compared to the electrical force.
Reason : The electrical force is experienced by charged particles only.

84. **Assertion :** A body becomes massless at the centre of earth.
Reason : This follows from $g' = g\left(1 - \frac{d}{R}\right)$

85. **Assertion :** If earth suddenly stops rotating about its axis, then the value of acceleration due to gravity will become same at all the places.
Reason : The value of acceleration due to gravity depends upon the rotation of the earth.

86. **Assertion :** Space rockets are usually launched in the equatorial line from west to east.
Reason : The acceleration due to gravity is minimum at the equator.

87. **Assertion:** The value of acceleration due to gravity i.e. 'g' is different at different places on the surface of earth.
Reason: Earth is flattened at poles and bulging out at the equator. Therefore radius is smaller at poles and larger at equator and $g \propto \frac{1}{R^2}$, so, g is smaller at equator than at poles.

88. **Assertion:** A body loses weight when it is at the centre of the earth.
Reason: At the centre of earth, $g = 0$
$\therefore$ weight = mg = 0.

89. **Assertion:** The gain in potential energy of an object of mass m raised to height equal to the radius of earth is $\frac{1}{2}$ mg R
Reason: Kinetic energy at surface = P.E at the top $\frac{1}{2}mv^2$ and at the top $v = \sqrt{gR}$. $\therefore$ PE = $\frac{1}{2}$mgR.

90. **Assertion :** The tidal waves in sea are primarily due to the gravitational effect of earth.
Reason : The intensity of gravitational field of earth is maximum at the surface of earth.

91. **Assertion :** Smaller the orbit of the planet around the sun, shorter is the time it takes to complete one revolution.
Reason : According to Kepler's third law of planetary motion, square of time period is proportional to cube of mean distance from sun.

92. **Assertion :** Moon travellers tie heavy weight at their back before landing on the moon.
Reason : The acceleration due to gravity on moon is smaller than that of earth.

93. **Assertion :** Generally, the path of a projectile from the earth is parabolic but it is elliptical for projectiles going to a very large height.
Reason : The path of a projectile is independent of the gravitational force of earth.

94. **Assertion :** Gravitational potential is maximum at infinity.
Reason : Gravitational potential is the amount of work done to shift a unit mass from infinity to a given point in gravitational attraction force field.

95. **Assertion :** Gravitational potential of earth at every place on it is negative.
Reason : Every body on earth is bound by the attraction of earth.

96. **Assertion :** For the planets orbiting around the sun, angular speed, linear speed and K.E. changes with time, but angular momentum remains constant.
Reason : No torque is acting on the rotating planet. So its angular momentum is constant.

97. **Assertion:** Planets appear to move slower when they are farther from the sun than when they are nearer.
Reason: All planets move in elliptical orbits with sun at one of the foci of the ellipse.

98. **Assertion:** The escape velocity on the moon is much higher than that on the earth.

Reason: $V_e = \sqrt{2g / R}$

Thus for lower R, V_e on moon is higher.

99. **Assertion :** The escape speed does not depend on the direction in which the projectile is fired.

Reason : Attaining the escape speed is easier if a projectile is fired in the direction the launch site is moving as the earth rotates about its axis.

100. **Assertion :** If an object is projected from earth surface with escape velocity path of object will be parabola.

Reason : When object is projected with velocity less than escape velocity from horizontal surface and greater than orbital velocity path of object will be ellipse.

101. **Assertion :** The atmosphere of Jupiter contains light gases, where as earth's atmosphere has little amount of hydrogen gas.

Reason : The escape velocity from the Jupiter is smaller than the escape velocity from the earth.

102. **Assertion :** An astronaut in an orbiting space station above the earth experiences weightlessness.

Reason : An object moving around earth under the influence of earth's gravitational force is in a state of free fall.

103. **Assertion :** Space rocket are usually launched in the equatorial line from west to east

Reason : The acceleration due to gravity is minimum at the equator.

104. **Assertion :** 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.

105. **Assertion :** Escape velocity is independent of the angle of projection.

Reason : Escape velocity from the surface of earth is $\sqrt{2gR}$ where R is radius of earth.

106. **Assertion :** If the total energy of a satellite moving around earth is E, its potential energy is 2 E.

Reason : Total energy $E = \text{KE} + \text{PE}$.

107. **Assertion :** The speed of satellite always remains constant in an orbit.

Reason : The speed of a satellite depends on its path.

108. **Assertion :** A person sitting in an artificial satellite revolving around earth feels weightless.

Reason : There is no gravitational force on the satellite.

CRITICALTHINKING TYPE QUESTIONS

109. If three equal masses m are placed at the three vertices of an equilateral triangle of side $1/m$ then what force acts on a particle of mass 2m placed at the centroid?
(a) Gm^2 (b) $2Gm^2$
(c) Zero (d) $-Gm^2$

110. Both earth and 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 earth.

111. Two identical spheres of gold are in contact with each other. The gravitational attraction between them is
(a) directly proportional to the square of the radius
(b) directly proportional to the cube of the radius
(c) directly proportional to the fourth power of the radius
(d) inversely proportional to the square of the radius

112. Two air bubbles in water
(a) attract each other
(b) repel each other
(c) neither attract nor repel
(d) None of these

113. If suddenly the gravitational force of attraction between earth and a satellite revolving around it becomes zero, then the satellite will
(a) continue to move in its orbit with same velocity
(b) move tangentialy to the original orbit in the same velocity
(c) become stationary in its orbit
(d) move towards the earth

114. Two particles of equal mass 'm' go around a circle of radius R under the action of their mutual gravitational attraction. The speed of each particle with respect to their centre of mass is
(a) $\sqrt{\frac{Gm}{4R}}$ (b) $\sqrt{\frac{Gm}{3R}}$
(c) $\sqrt{\frac{Gm}{2R}}$ (d) $\sqrt{\frac{Gm}{R}}$

115. The change in the value of 'g' at a height 'h' above the surface of the earth is the same as at a depth 'd' below the surface of earth. When both 'd' and 'h' are much smaller than the radius of earth, then which one of the following is correct ?
(a) $d = \frac{3h}{2}$ (b) $d = \frac{h}{2}$
(c) $d = h$ (d) $d = 2h$

116. The height at which the acceleration due to gravity becomes $\frac{g}{9}$ (where g = the acceleration due to gravity on the surface of the earth) in terms of R, the radius of the earth, is
(a) $\frac{R}{\sqrt{2}}$ (b) $R/2$
(c) $\sqrt{2}R$ (d) 2R

117. The density of a newly discovered planet is twice that of earth. The acceleration due to gravity at the surface of the planet is equal to that at the surface of the earth. If the radius of the earth is R, the radius of the planet would be
(a) ½ R (b) 2 R
(c) 4 R (d) 1/4 R

118. Imagine a new planet having the same density as that of earth but it is 3 times bigger than the earth in size. If the acceleration due to gravity on the surface of earth is g and that on the surface of the new planet is g′, then
(a) $g' = g/9$ (b) $g' = 27g$
(c) $g' = 9g$ (d) $g' = 3g$

119. Average density of the earth
(a) is a complex function of g
(b) does not depend on g
(c) is inversely proportional to g
(d) is directly proportional to g

120. A uniform spherical shell gradually shrinks maintaining its shape. The gravitational potential at the centre
(a) increases (b) decreases
(c) remains constant (d) cannot say

121. If the earth were to rotates faster than its present speed, the weight of an object will
(a) increase at the equator but remain unchanged at the poles
(b) decrease at the equator but remain unchanged at the poles
(c) remain unchanged at the equator but decrease at the poles
(d) remain unchanged at the equator but increase at the poles

122. At what height from the ground will the value of g be the same as that in 10 km deep mine below the surface of earth?
(a) 20 km (b) 10 km
(c) 15 km (d) 5 km

123. 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 and directed towards the centre.
(d) Cannot be zero at any point.

124. If a person goes to height equal to the radius of the earth, from its surface, then his weight (w′) relative to the weight on earth (w) will be
(a) $W' = \frac{W}{4}$ (b) $W' = 2W$
(c) $W' = \frac{W}{2}$ (d) $W' = W$

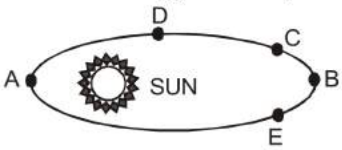
125. The gravitational potential at the centre of a square of side 'a' and four equal masses (m each) placed at the corners of a square is
(a) Zero (b) $4\sqrt{2}\,\frac{Gm}{a}$
(c) $-4\sqrt{2}\,\frac{Gm}{a}$ (d) $-4\sqrt{2}\,\frac{Gm^2}{a}$

126. If value of acceleration due to gravity is 'g' at a height 50 km above the surface of earth, then at what depth inside the earth will the acceleration due to gravity be same as 'g'?
(a) 100 km (b) 50 km
(c) 25 km (d) 75 km

127. The tail of the comet Halley is directed away from the sun due to the fact that
(a) the comet rotates around the sun the lighter mass of the comet is pushed away due to centrifugal force only
(b) the comet rotates the lighter mass of the comet is attracted by some star situated in the direction of the tail
(c) the radiation emitted by the sun exerts a radiation pressure of the comet throwing its tail away from the sun
(d) the tail of the comet always exists in the same orientation

128. The time period T of the moon of planet Mars (mass M_m) is related to its orbital radius R (G = Gravitational constant) as
(a) $T^2 = \frac{4\pi^2 R^3}{GM_m}$ (b) $T^2 = \frac{4\pi^2 GR^3}{M_m}$
(c) $T^2 = \frac{2\pi R^3 G}{M_m}$ (d) $T^2 = 4\pi M_m GR^3$

129. The planet mercury is revolving in an elliptical orbit around the sun as shown in fig. The kinetic energy of mercury will be greatest at
(a) A
(b) B
(c) C
(d) D



130. A geostationary satellite is orbiting the earth at a height of $5R$ above that surface of the earth, R being the radius of the earth. The time period of another satellite in hours at a height of $2R$ from the surface of the earth is
(a) 5 (b) 10
(c) $6\sqrt{2}$ (d) $\frac{6}{\sqrt{2}}$

131. A particle of mass M is situated at the centre of a spherical shell of same mass and radius a. The gravitational potential at a point situated at $\frac{a}{2}$ distance from the centre, will be
(a) $-\frac{3GM}{a}$ (b) $-\frac{2GM}{a}$
(c) $-\frac{GM}{a}$ (d) $-\frac{4GM}{a}$

132. The mass of a spaceship is 1000 kg. It is to be launched from the earth's surface out into free space. The value of g and R (radius of earth) are 10 m/s^2 and 6400 km respectively. The required energy for this work will be

(a) 6.4×10^{11} J (b) 6.4×10^{8} J
(c) 6.4×10^{9} J (d) 6.4×10^{10} J

133. A particle of mass m is thrown upwards from the surface of the earth, with a velocity u. The mass and the radius of the earth are, respectively, M and R. G is gravitational constant and g is acceleration due to gravity on the surface of the earth. The minimum value of u so that the particle does not return back to earth, is

(a) $\sqrt{\frac{2GM}{R}}$ (b) $\sqrt{\frac{2GM}{R^2}}$
(c) $\sqrt{2gR^2}$ (d) $\sqrt{\frac{2GM}{R^2}}$

134. A planet in a distant solar system is 10 times more massive than the earth and its radius is 10 times smaller. Given that the escape velocity from the earth is 11 km s^{-1}, the escape velocity from the surface of the planet would be

(a) 1.1 km s^{-1} (b) 11 km s^{-1}
(c) 110 km s^{-1} (d) 0.11 km s^{-1}

135. For a satellite moving in an orbit around the earth, the ratio of kinetic energy to potential energy is

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

136. The radii of circular orbits of two satellites A and B of the earth, are 4R and R, respectively. If the speed of satellite A is 3 V, then the speed of satellite B will be

(a) 3 V/4 (b) 6 V
(c) 12 V (d) 3 V/2

137. What is the minimum energy required to launch a satellite of mass m from the surface of a planet of mass M and radius R in a circular orbit at an altitude of 2R?

(a) $\frac{5GmM}{6R}$ (b) $\frac{2GmM}{3R}$
(c) $\frac{GmM}{2R}$ (d) $\frac{GmM}{2R}$

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. (c) It is applicable to both small & big bodies.
2. (b) Various regions of spherical shell attract the point mass inside it in various directions. These forces cancel each other completely. Therefore the gravitational force on the particle is zero.
3. (d) G is a universal gravitational constant as the value of G is same for all pairs of bodies situated anywhere in the universe.
4. (a) The gravitational force of attraction on a body of mass m is given by

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

Therefore, $F \propto \frac{1}{R^2}$

The radius of earth is maximum at equator, therefore, gravitational force of attraction is least at equator.
5. (c) The inertial mass & gravitational mass are equivalent & ratio of inertial mass to gravitational mass = 1 to a high degree of accuracy (experimental finding).
6. (a) 7. (c)
8. (b) It will remain the same as the gravitational force is independent of the medium separating the masses.
9. (d) Both decreases but variation are different.
10. (b) $I = \frac{-dV}{dr}$. If $I = 0$ then V = constant
11. (a)
12. (b) At poles, the effect of rotation is zero and also the distance from the centre of earth is least.
13. (c) Because of the centrifugal force, earth stretches out and so bulges at the equator.
14. (a) $I = \frac{-dV}{dx}$
15. (b) There is no gravitational field in the shell.
16. (a) The gravitational field intensity inside the solid sphere is given by $E_g = -\frac{GMr}{R^3}$. ie, $E_g \propto r$
17. (d) At a point inside a spherical shell, the value of gravitational intensity, $I = 0$.
If $V = 0$ then gravitational field is necessarily zero.
18. (b) Acceleration due to gravity (g) is given by

$$g = \frac{GM}{R^2} \Rightarrow g \propto \frac{1}{R^2}$$

As one moves from the equator to the poles, the radius of the earth decreases, hence g increases.
19. (a) The weight (= mg) of the body at the centre of the earth is zero, because the value of g at centre is zero.
20. (a) In the motion of an object under gravitational influence of another object, angular momentum and total mechanical energy is conserved but linear momentum is not conserved.
21. (c) Acceleration due to gravity g varies with dpth as

$$g' = g\left(1 - \frac{d}{R_E}\right)$$

22. (b) Because of smaller value of acceleration due to gravity on moon, the value of escape velocity is small there. The molecules of atmospheric gases have thermal speeds much greater than the escape velocity. So all the molecules have escaped and there is no atmosphere.
23. (b) Value of g is larger at poles than the equator so, if salt is weighed by a spring balance 1 kg will weigh more at poles.
24. (c) Gravitational potential energy associated with two particles of masses m_1 & m_2 separated by distance r is given by

$$V = -\frac{G m_1 m_2}{r} \qquad \therefore \text{if } r \to \infty, \ \therefore \ \frac{1}{\infty} = 0.$$

$\Rightarrow V = 0.$
25. (d) Kepler's third law states that the square of time period of revolution of a planet around the sun is directly proportional to the cube of semi-major axis of its elliptical orbit.
26. (d) From Kepler's law of periods,

$$T_2 = T_1\left(\frac{R_2}{R_1}\right)^{3/2} = 365\left(\frac{R/2}{R}\right)^{3/2}$$

$$= 365 \times \frac{1}{2\sqrt{2}} = 129 \text{ days.}$$

27. (b) In planetary motion, there is no external torque. Hence from the equation $\frac{d\vec{L}}{dt} = \vec{\tau}_{ext.}$, if $\vec{\tau}_{ext.} = 0 \Rightarrow L = $ constant
28. (b) Since areal velocity $\vec{A}$ & angular momentum $\vec{L}$ of a planet are related by equation $\vec{A} = \frac{\vec{L}}{2M}$, where M is the mass of planet. Since in planetary motion $\vec{L}$ is constant ($\vec{\tau}_{ext.} = 0$), hence $\vec{A}$ is also constant.
29. (b) In planetary motion, the angular momentum conservation leads to the law of areas. Which means it sweeps out equal area in equal internals of tine or areal velocity is constant.

30. (c) Weightlessness means that there is no reaction on a body from the floor. Since both the artificial satellite & the astronaut have same centripetal acceleration (as in a lift; which is falling freely, we does not feel any weight, because both lift & we fall with same acceleration). so the astronaut does not feel any weight inside the space craft.

31. (b) $\frac{T_1^2}{T_2^2} = \frac{r_1^3}{r_2^3} = (4)^3$

$\therefore \quad T_2 = T_1/8.$

32. (b) Since $T = 2\pi\sqrt{\frac{l}{g}}$

but inside the satellite $g = 0$

So $T = \infty$

33. (c) Kinetic energy $= \frac{1}{2}mv^2$ is always positive but potential energy and total energy are negative for a satellite.

34. (c) $T^2 \propto R^3$ (According to Kepler's law)

$T_1^2 \propto (10^{13})^3$ and $T_2^2 \propto (10^{12})^3$

$\therefore \frac{T_1^2}{T_2^2} = (10)^3$ or $\frac{T_1}{T_2} = 10\sqrt{10}$.

35. (c)

36. (d) Because, the period of satellite is equal to period of rotation of earth about its own axis & it seems to be at one point about the equator and so is able to transmit the signals from one part to other.

37. (a)

38. (d) The sense of synchronous satellite must be same as the sense of rotation of earth i.e., from west to east.

39. (b)

40. (b) orbital speed $v \propto \frac{1}{\sqrt{r}}$; As Jupiter is farther than earth from sun, so its orbital speed is less than orbital speed of earth.

41. (d) Total energy of satellite is half the potential energy i.e.,

$E = \frac{U}{2}$

42. (c) Geo-stationary satellites are also called synchronous satellite. They always remain about the same path on equater, i.e., it has a period of exactly one day (86400 sec)

So orbit radius $\left(T = 2\pi\sqrt{\frac{r^3}{GM}}\right)$ comes out to be 42400 km, which is nearly equal to the circumference of earth. So height of Geostationary satellite from the earth surface is $42,400 - 6400 = 36,000$ km.

43. (d)

44. (c) The orbital velocity of satellite moving in circular orbit near a planet is $v_0 = \sqrt{\frac{GM}{R}}$

so period $T = \frac{2\pi R}{v_0} = 2\pi R\sqrt{\frac{R}{GM}} = 2\pi\sqrt{\frac{R^3}{GM}}$

Where R & M are the radius & mass of that planet. Since satellite moves very near to planet, hence the radius of its circular orbit is approximately equal to radius of the planet.

45. (b) When satellite is orbiting close to the surface of earth, orbital velocity, $v_o = \sqrt{\frac{GM}{R}}$ where M and R are the mass and radius of earth.

46. (b) Since v_0(orbital velocity) $= \sqrt{\frac{GM}{r}}$

So $\frac{v_{01}}{v_{02}} = \sqrt{\frac{r_2}{r_1}} \Rightarrow v_{01} < v_{02} \because r_1 > r_2$

47. (a) $v_{esc} = \sqrt{2gR}$, where R is radius of the planet. Hence escape velocity is independent of m.

48. (b) It is called escape velocity $(v_e = \sqrt{2gR_e})$

49. (d) There is no atmosphere at moon, because escape velocity is less than the root mean square velocity of the molecules at moon. Hence all molecules escape.

50. (c) The escape velocity of projectile from earth is

$v_e = \sqrt{2gR_e}$, where R_e is radius of earth

since $g = 9.8 m/sec^2$, $R_e = 6.4 \times 10^6$ metre

$\Rightarrow v_e = 11.2$ km/sec

51. (b) The escape velocty of an object from any planet is

$v_{escape} = \sqrt{2gR} = \sqrt{2GM/R}$

where R & M are the radius & mass of the planet.

52. (a) Since 'g' on moon is smaller than earth and radius of moon is also smaller, therefore escape velocity on moon is just 2.3 km/s, which is approximately five times smaller than earth 11.2 km/s.

53. (b) According to Kepler's law of planetary motion all the planets revolve around the sun in elliptical orbit. Therefore, the orbit traced by planet around a star is an ellipse.

54. (c) Escape speed, $V_e = R\sqrt{\frac{8}{3}\pi G s}$

$\therefore V_e \propto R.$

55. (b) When a person is sitting in an artificial satellite of earth, the gravitational pull on the person due to earth is counterbalanced by the centrifugal force acting on the person. Thus the net force acting on the person in the satellite is zero & the person feels weightless but on the moon his weight is due to the gravitational pull of the moon.

56. (c) Since total energy of a body is positive or zero, when it is at infinity from the earth therefore, the satellite will escape to infinity if its total energy becomes zero or positive.

57. (d) For a satellite in circular orbit the kinetic energy is positive, potential energy and total energy is negative. Hence none of the given options is correct.

58. (a) A geostationary satellite moves in a circular orbit in the equatorial plane at an approx. distance of 4.22×10^4 km from zero the earth's centre.

59. (b) The reaction force of the artificial satellite acting on the person sitting in satellite is zero. Therefore, the weight of the person is zero in artificial satellite is zero.

STATEMENT TYPE QUESTIONS

60. (b) Gravitational force is always attractive and a long range force. It is independent of the presence of other bodies.

61. (d) All the three statements are true.

62. (c) 63. (c)

64. (d) Orbital velocity $v_0 = \sqrt{\frac{GM}{r}}$

65. (b) Every planet revolves around the sun in elliptical orbit and not in circular orbit.

66. (c) For a satellite orbiting in circular orbit the potential energy is always greater than the kinetic energy.

MATCHING TYPE QUESTIONS

67. (d) $(A) \to (2)$; $(B) \to (1)$; $(C) \to (4)$; $(D) \to (3)$

68. (d) $(A) \to (2)$; $(B) \to (4)$; $(C) \to (3)$; $(D) \to (1)$

69. (b) $(A) \to (3)$; $(B) \to (4)$; $(C) \to (1)$; $(D) \to (2)$

70. (c) $(A) \to (3)$; $(B) \to (1)$; $(C) \to (4)$; $(D) \to (2)$

71. (b) $(A) \to (2)$; $(B) \to (2)$; $(C) \to (4)$; $(D) \to (3)$

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

At height $h = R$: $g' = \frac{g}{1+\frac{h}{R}} = \frac{g}{2}$

i.e., g' decreases by a factor $\frac{1}{2}$.

Similarly, at height h = R/2, $g' = \frac{2}{3}g$.

At depth $h = \frac{R}{2}$: $g' = g\left(1-\frac{h}{R}\right) = \left(1-\frac{1}{2}\right) = \frac{g}{2}$

Similarly at h = R/4, $g' = \frac{3}{4}g$

72. (a) $(A) \to (2)$; $(B) \to (5)$; $(C) \to (3)$; $(D) \to (4)$

Inside a shell $V = -\frac{GM}{R}$ = constant and $E = 0$

Outside the shell, $V = -\frac{GM}{r}$ and $E = \frac{GM}{r^2}$

As r increases, V increases and E decreases.

73. (b) (A)→(3); (B)→(1); C→(4); (D)→(2)

Acceleration due to gravity, $g = Gm/R^2$

Escape velocity, $V_E = \sqrt{2gR_E}$

Total energy of a satellite at a height, h above the earth surface $= \frac{-G m_1 m_2}{2(R+h)}$

Gravitational potential energy $= \frac{-G m_1 m_2}{r}$

74. (c) (A)→(2); (B)→(2); C→(1); (D)→(3)

Potential energy of a satellite = Negative

Total energy of a satellite = Negative

Kinetic energy of a satellite = Positive

Grav P.E of a satellite at infinity = zero.

DIAGRAM TYPE QUESTIONS

75. (c) As m_2 attracts m_1 towards itself, ∴ force is along r^3.

76. (b) Acceleration due to gravity with height h varies as $g \propto \frac{1}{r^2}$

(when r = R + h). Thus variation of g and r is a parabolic curve.

77. (c) $F = \frac{GM(3m)}{d^2} = \frac{3GMm}{d^2}$.

78. (a) The speed of the planet is faster in region DAB in comparision to the region BCD.

79. (a) $\vec{g}' = -\frac{g\vec{r}}{R}$ for $r \le R$ and $g' = \frac{g}{(1+r/R)^2}$ for $r \ge R$

so option (a) is correct.

80. (b) $v_g = -\frac{GM}{R}$ for $r \le R$ and $v_g = -\frac{GM}{r}$, for $r > R$, and so option (b) is correct.

81. (b) According to Kepler's law, the areal velocity of a planet around the sun always remains constant.

SCD : $A_1 - t_1$ (areal velocity constant)

SAB : $A_2 - t_2$

$$\frac{A_1}{t_1} = \frac{A_2}{t_2},$$

$$t_1 = t_2 \cdot \frac{A_1}{A_2}, \qquad \text{(given } A_1 = 2A_2\text{)}$$

$$= t_2 \cdot \frac{2A_2}{A_2} \qquad \therefore \quad t_1 = 2t_2$$

82. (c)

$$F_{min} = \frac{GMm}{r^2} - \frac{GM(2m)}{(2r)^2} = \frac{GMm}{2r^2}$$

and

$$F_{max} = \frac{GMm}{r^2} + \frac{GM(2m)}{(2r)^2} = \frac{3}{2}\frac{GMm}{r^2}.$$

$$\therefore \frac{F_{min}}{F_{max}} = \frac{1}{3}.$$

ASSERTION- REASON TYPE QUESTIONS

83. (b) For two electron $\frac{F_g}{F_e} = 10^{-43}$ i.e., gravitational force is negligible in comparison to electrostatic force of attraction.

84. (d) At the centre of the earth, weight is zero but mass cannot be and never zero.

85. (c) **86. (c)** **87. (a)** **88. (a)**

89. (c) Work done in raising the body

$$= \int_R^{2R} \frac{GMm}{x^2}dx$$

$$= \int_R^{2R} \frac{gR^2}{x^2} m dx = mgR^2 . \left[\frac{-1}{x}\right]_R^{2R}$$

$$= mgR^2\left[\frac{-1}{2R} + \frac{1}{R}\right]$$

$$= mgR^2\left[\frac{-1+2}{2R}\right] = \frac{1}{2}mgR$$

90. (d) The tidal effect is due to the gravitation effect of moon and earth both. $g' = \frac{g}{\left(1+\frac{h}{R}\right)^2}$, for $h = 0, g' = g$.

91. (a) According to Kepler's third law $T^2 \propto r^3$ if r is small then T will also be small.

92. (a) To counter balance the effect of gravity.

93. (c) **94. (b)**

95. (a) Because gravitational force is always attractive in nature and every body is bound by this gravitational force of attraction of earth.

96. (a)

97. (b) Both assertion and reason are true, but reason is not correct explanation of the assertion.
From Kepler's laws of period $T^2 \alpha r^3$
$\therefore$ For more r, T is more.

98. (d) Escape velocity on the moon is five times smaller than on the earth 11.2 km/s.

99. (c) **100. (c)**

101. (c) Escape velocity for Jupiter is greater than escape velocity for earth.

102. (a) Freely faling body experiences weightlessness.

103. (b) Space rocket are usually launched from west to east to take the advantage of rotation of earth.
Also $g' = g - \omega^2 R\cos^2\lambda$, at equator $\lambda = 0$, and so $\cos\lambda = 1$, and g' is least.

104. (d) **105. (a)**

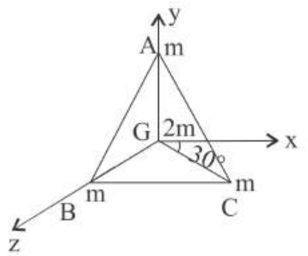
106. (a) $K = -E = -\frac{U}{2}$.

107. (d) If the orbital path of a satellite is circular, then its speed is constant and if the orbital path of a satellite is elliptical, then its speed in its orbit is not constant. In that case its areal velocity is constant.

108. (c) Gravitational force on the person in satellite is not zero, but normal reaction of the satellite on the person is zero.

CRITICALTHINKING TYPE QUESTIONS

109. (c)



$$F_{GA} = \frac{Gm(2m)}{1}\hat{j}$$

$$F_{GB} = \frac{Gm(2m)}{1}(-\hat{i}\cos 30° - \hat{j}\sin 30°)$$

$$F_{GC} = \frac{Gm(2m)}{1}(\hat{i}\cos 30° - \hat{j}\sin 30°)$$

$\therefore$ Resultant force on (2m) is $F_R = F_{GA} + F_{GB} + F_{GC}$

$$= 2Gm^2\hat{j} + 2Gm^2\hat{i}(-\cos 30° + \cos 30°)$$
$$+ 2Gm^2\hat{j}(-\sin 30° - \sin 30°)$$

$$= 2Gm^2\hat{j}.2Gm^2\hat{j}\left(-2 \times \frac{1}{2}\right)$$

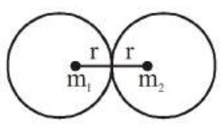
$$= 2Gm^2\hat{j} - 2Gm^2\hat{j} = 0.$$

110. (b)

111. (c) The gravitational force of attraction between two identical spheres of radius r is

$$F = \frac{Gm_1m_2}{r^2} = \frac{G\frac{4}{3}\pi r^3\rho \times \frac{4}{3}\pi r^3\rho}{(2r)^2}$$

$$= \frac{4}{9}\pi^2 p^2 r^4$$



ie. $F \propto r^4$

112. (a) The two air bubbles in water attract each other. The mass of air bubble in water (denser medium in comparision to air) behave like a negative mass as far as gravitational attraction is concerned. The absolute value of mass of bubble in water is equal to the mass of an equal volume of water. So by Newton' Law of gravitation

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

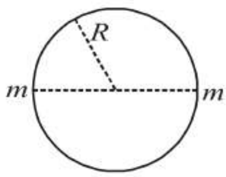
but in water $\vec{F} = \frac{G(-m_1)(-m_2)}{r^2}\hat{r} = \frac{Gm_1m_2}{r^2}\hat{r}$

It means that force has attractive nature between two air bubble in water.

113. (b) When gravitational force becomes zero, centripetal force on satellite becomes zero so satellite will move tangentially to the original orbit with same velocity.

114. (a) Here, centripetal force will be given by the gravitational force between the two particles.

$$\frac{Gm^2}{(2R)^2} = m\omega^2 R$$



$$\Rightarrow \frac{Gm}{4R^3} = \omega^2$$

$$\Rightarrow \omega = \sqrt{\frac{Gm}{4R^3}}$$

If the velocity of the two particles with respect to the centre of gravity is v then $v = \omega R$

$$v = \sqrt{\frac{Gm}{4R^3}} \times R = \sqrt{\frac{Gm}{4R}}$$

115. (d) Variation of g with altitude is,

$$g_h = g\left[1 - \frac{2h}{R}\right];$$

variation of g with depth is,

$$g_d = g\left[1 - \frac{d}{R}\right]$$

Equating g_h and g_d, we get $d = 2h$

116. (d) We know that $\frac{g'}{g} = \frac{R^2}{(R+h)^2}$

$$\therefore \frac{g/9}{g} = \left[\frac{R}{R+h}\right]^2$$

$$\therefore \frac{R}{R+h} = \frac{1}{3}$$

$$\therefore h = 2R$$

117. (a) $g = \frac{GM}{R^2}$ also $M = d \times \frac{4}{3}\pi R^3$

$\therefore g = \frac{4}{3}d\pi R$ at the surface of planet

$$g_p = \frac{4}{3}(2d)\pi R', \; g_e = \frac{4}{3}(d)\pi R$$

$$g_e = g_p \Rightarrow dR = 2d\,R'$$

$$\Rightarrow R' = R/2$$

118. (d) We know that

$$g = \frac{GM}{R^2} = \frac{G\left(\frac{4}{3}\pi R^3\right)\rho}{R^2} = \frac{4}{3}\pi G R \rho$$

$$\frac{g'}{g} = \frac{R'}{R} = \frac{3R}{R} = 3 \quad \therefore g' = 3g$$

119. (d) $g = \frac{GM}{R^2} = \frac{G\rho \times V}{R^2} \Rightarrow g = \frac{G \times \rho \times \frac{4}{3}\pi R^3}{R^2}$

$g = \frac{4}{3}\rho\pi G.R$ where $\rho \to$ average density

$$\rho = \left(\frac{3g}{4\pi GR}\right)$$

$\Rightarrow \rho$ is directly proportional to g.

120. (a) The gravitational potential at the centre of uniform spherical shell is equal to the gravitational potential at the surface of shell i.e.,

$V = \frac{-GM}{a}$, where a is radius of spherical shell

Now, if the shell shrinks then its radius decrease then density increases, but mass is constant. so from above expression if a decreases, then V increases.

121. (b) At the equator, $g' = g - R\omega^2$

As ω increases, g' decreases and hence weight decreases.

At the pole, $g' = g$.

So weight remain unchanged.

122. (d) $g'\left(1 - \frac{d}{R}\right) = g'\left(1 - \frac{2h}{R}\right)$

$\Rightarrow \quad d = 2h \Rightarrow 10 = 2h$

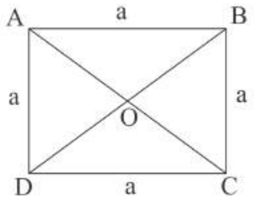
$\Rightarrow \quad h = 5$ km

123. (d)

124. (a) $W_r = mg = GMm/R^2$; at a height h, $W_h = \frac{GMm}{(R+R)^2}$

$$= \frac{GMm}{(2R)^2} = \frac{1}{4}W_E. \qquad \therefore w_h^1 = \frac{w}{4}$$

125. (c)



$OA = OB = OC = OD = \frac{a\sqrt{2}}{2} = \frac{a}{\sqrt{2}}$

Total gravitational potential at the centre of the square

$= \frac{-Gm \times 4}{OA} = \frac{-4Gm}{a/\sqrt{2}} = \frac{-4\sqrt{2}Gm}{a}$

126. (a) As we know, $g' = g\left(1 - \frac{2h}{R}\right) = g\left(1 - \frac{d}{R}\right)$

$\therefore \frac{2h}{R} = \frac{d}{R}$ $\quad \therefore h = \frac{d}{2}$ or $d = 2h$.

$\therefore d = 2 \times 50 = 100$ km.

127. (c) A comet consists of solid mass of rocks surrounded by large volume of combustible gases. The gravitational force acting between the sun and comet attracts the comet's mass, due to which head of comet points towards the sun. The radiations emitted by the sun exerts a radiation pressure on the comet throwing its tail away from the sun.

128. (a) Time period of satellite is given by :

$= \frac{\text{circumference of an orbit}}{\text{Velocity in orbit}} = \frac{2\pi R}{v_0}$

$= \frac{2\pi R}{\sqrt{\frac{GM_m}{R}}} = \frac{2\pi R^{3/2}}{\sqrt{GM_m}}$

Squaring both sides, we get

$T^2 = \frac{4\pi^2 R^3}{GM_m}$

129. (a) Angular momentum is conserved. At A, the moment of inertia is least and hence angular speed is maximum. Thus the K.E. at A is maximum.

130. (c) According to Kepler's law of period $T^2 \propto R^3$

$\frac{T_1^2}{T_2^2} = \frac{R_1^3}{R_2^3} = \frac{(6R)^3}{(3R)^3} = 8$

$\frac{24 \times 24}{T_2^2} = 8$

$T_2^2 = \frac{24 \times 24}{8} = 72 = 36 \times 2$

$T_2 = 6\sqrt{2}$

131. (a) Potential at the given point = Potential at the point due to the shell + Potential due to the particle

$= -\frac{GM}{a} - \frac{2GM}{a} = -\frac{3GM}{a}$

132. (d) Potential energy on earth surface is – mgR while in free space it is zero. So, to free the spaceship, minimum required energy is

$K = mgR = 10^3 \times 10 \times 6400 \times 10^3$ J

$= 6.4 \times 10^{10}$ J

133. (a) The velocity u should be equal to the escape velocity.

That is, $u = \sqrt{2gR}$

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

$\therefore u = \sqrt{2 \cdot \frac{GM}{R^2} \cdot R} \Rightarrow \sqrt{\frac{2GM}{R}}$

134. (c) $\frac{(v_e)_p}{(v_e)_e} = \frac{\sqrt{\frac{2GM_p}{R_p}}}{\sqrt{\frac{2GM_e}{R_e}}} = \sqrt{\frac{M_p}{M_e} \times \frac{R_e}{R_p}}$

$= \sqrt{\frac{10M_e}{M_e} \times \frac{R_e}{R_e/10}} = 10$

$\therefore (v_e)_p = 10 \times (v_e)_e = 10 \times 11 = 110$ km/s

135. (a) K.E. of satellite moving in an orbit around the earth is

$K = \frac{1}{2}mv^2 = \frac{1}{2}m\left(\sqrt{\frac{GM}{r}}\right)^2 = \frac{GMm}{2r}$

P.E. of satellite and earth system is

$U = \frac{GMm}{r} \Rightarrow \frac{K}{U} = \frac{\frac{GMm}{2r}}{\frac{GMm}{r}} = \frac{1}{2}$

136. (b) Orbital velocity of a satellite in a circular orbit of radius a is given by

$v = \sqrt{\frac{GM}{a}} \Rightarrow v \propto \sqrt{\frac{1}{a}} \Rightarrow \frac{v_2}{v_1} = \sqrt{\frac{a_1}{a_2}}$

$\therefore \quad v_2 = v_1\sqrt{\frac{4R}{R}} = 2v_1 = 6V$

137. (a) As we know,

Gravitational potential energy $= \frac{-GMm}{r}$

and orbital velocity, $v_0 = \sqrt{GM/R+h}$

$E_f = \frac{1}{2}mv_0^2 - \frac{GMm}{3R} = \frac{1}{2}m\frac{GM}{3R} - \frac{GMm}{3R}$

$= \frac{GMm}{3R}\left(\frac{1}{2} - 1\right) = \frac{-GMm}{6R}$

$E_i = \frac{-GMm}{R} + K$

$E_i = E_f$

Therefore minimum required energy, $K = \frac{5GMm}{6R}$