GRAVITATION

1. Halley's comet has a period of 76, had distance of closest approach to the sun equal to 8.9×10^{10}m. the comet's farthest distance from the sun if the mass of sun is 2×10^{30} kg and $G = 6.67 \times 10^{11}$ in MKS units is
   a) 2×10^{12}m b) 2.7×10^{13}m c) 5.3×10^{12}m d) 5.3×10^{13}m
2. Average density of the earth
   a) does not depend on g b) is a complex function of g
   c) is directly proportional to g d) is inversely proportional g
3. Let g be the acceleration due to gravity at earth's surface and K be the rotational kinetic energy of the earth. Suppose the earth's radius decreases by 2% keeping all other quantities same, then
   a) g decreases by 2% and K decreases by 4% b) g decreases by 4% and K increases by 2%
   c) g increases by 4% and K increases by 4% d) g decreases by 4% and K increases by 4%
4. A body is taken to a height of nR from the surface of the earth. The ratio of the acceleration due to gravity on the surface to that at the altitude is
   a) $(n+1)^2$ b) $(n+1)^{-2}$ c) $(n+1)^{-1}$ d) $(n+1)$
5. Infinite number of masses, each 1 kg, are placed along the x-axis at $x = \pm 1\text{m}, \pm 2\text{m}, \pm 4\text{m}, \pm 8\text{m}, \pm 16\text{m}$ ..... The magnitude of the resultant gravitational potential in terms of gravitational constant G at the origin $(x = 0)$ is
   a) $G/2$ b) G c) $2G$ d) $4G$
6. In the above problem, the ratio of the time duration of his jump on the moon to that of his jump on the earth is
   a) 1 : 6 b) 6 : 1 c) $\sqrt{6} : 1$ d) $1 : \sqrt{6}$
7. The escape velocity from the earth is 11 kms^{-1}. The escape velocity from a planet having twice the radius and same mean density as that of earth is
   a) 5.5 kms^{-1} b) 11 kms^{-1} c) 22 kms^{-1} d) None of these
8. The escape velocity of a planet having mass 6 times and radius 2 times as that of earth is
   a) $\sqrt{3}\, V_e$ b) $3\, V_e$ c) $\sqrt{2}\, V_e$ d) $2\, V_e$
9. Kepler discovered
   a) Laws of motion b) Laws of rotational motion
   c) Laws of planetary motion d) Laws of curvilinear motion
10. In the solar system, which is conserved
    a) Total Energy b) K.E. c) Angular Velocity d) Linear Momentum
11. A small satellite is revolving near earth's surface. Its orbital velocity will be nearly
    a) 8 km/sec b) 11.2 km/sec c) 4 km/sec d) 6 km/sec
12. The ratio of the radius of the earth to that of the moon is 10. The ratio of acceleration due to gravity on the earth and on the moon is 6. The ratio of the escape velocity from the earth's surface to that from the moon is
    a) 10 b) 6 c) Nearly 8 d) 1.66
13. A mass m is placed at a point B in the gravitational field of mass M. When the mass m is brought from B to near point A, its gravitational potential energy will
    a) Remain unchanged b) Increase c) Decrease d) Become zero

14. The centripetal force acting on a satellite orbiting round the earth and the gravitational force of earth acting on the satellite both equal F. The net force on the satellite is

a) Zero b) F c) $F\sqrt{2}$ d) $2F$

15. The largest and the shortest distance of the earth from the sun are r_1 and r_2, its distance from the sun when it is at the perpendicular to the major axis of the orbit drawn from the sun

a) $\frac{r_1+r_2}{4}$ b) $\frac{r_1 r_2}{r_1+r_2}$ c) $\frac{2r_1 r_2}{r_1+r_2}$ d) $\frac{r_1+r_2}{3}$

16. The escape velocity for a body of mass 1 kg from the earth's surface is $11.2\ \text{kms}^{-1}$. The escape velocity for a body of mass 100 kg would be

a) $11.2 \times 10^2 \text{kms}^{-1}$ b) $112\ \text{kms}^{-1}$ c) $11.2\ \text{kms}^{-1}$ d) $11.2 \times 10^{-2} \text{kms}^{-1}$

17. The relay satellite transmits the T.V. 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

18. A man weighs 80 kg on earth surface. The height above ground where he will weigh 40kg, is (radius of earth is 6400 km)

a) 0.31 times r b) 0.41 times r c) 0.51 times r d) 0.61 times r

19. At what temperature, the hydrogen molecule will escape from earth's surface?

a) 10^1 K b) 10^2 K c) 10^3 K d) 10^4 K

20. An earth satellite of mass m revolves in a circular orbit of a height h from the surface of the earth. R is the radius of the earth and g is acceleration due to gravity at the surface of the earth. The velocity of the satellite in the orbit is given by

a) $\frac{gR^2}{R+h}$ b) gR c) $\frac{gR}{R+h}$ d) $\sqrt{\frac{gR^2}{R+h}}$

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

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

22. 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

23. The ratio of the radii of planets A and B is k_1 and ratio of acceleration due to gravity on them is k_2. The ratio of escape velocities from them will be

a) $k_1 k_2$ b) $\sqrt{k_1 k_2}$ c) $\sqrt{\frac{k_1}{k_2}}$ d) $\sqrt{\frac{k_2}{k_1}}$

24. Two identical satellites are at R and $7R$ away from earth surface, the wrong statement is (R =Radius of earth)

a) Ratio of total energy will be y

b) Ratio of kinetic energies will be y

c) Ratio of potential energies will be y

d) Ratio of total energy will be y but ratio of potential and kinetic energy will be z

25. 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

26. A satellite moves in elliptical orbit about a planet. The maximum and minimum velocities of satellites are $3 \times 10^4 \text{ms}^{-1}$ and $1 \times 10^3 \text{ms}^{-1}$ respectively. What is the minimum distance of satellite from planet, if maximum distance is 4×10^4 km?

a) 4×10^3 km b) 3×10^3 km c) $4/3 \times 10^3$ km d) 1×10^3 km

27. Two small and heavy spheres, each of mass M, are placed a distance r apart on a horizontal surface. The gravitational potential at the mid-point on the line joining the centre of the spheres is

a) Zero b) $-\frac{GM}{r}$ c) $-\frac{2GM}{r}$ d) $-\frac{4GM}{r}$

28. 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

29. A satellite is launched into a circular orbit of radius $'R'$ around earth while a second satellite is launched into an orbit of radius 1.02 R. The percentage difference in the time periods of the two satellites is

a) 0.7 b) 1.0 c) 1.5 d) 3

30. Gravitational mass is proportional to gravitational

a) Field b) Force c) Intensity d) All of these

31. A satellite moves round the earth in a circular orbit of radius R making 1 rev/day. A second satellite moving in a circular orbit, moves round the earth ones in 8 days. The radius of the orbit of the second satellite is

a) 8 R b) 4 R c) 2 R d) R

32. The diameters of two planets are in the ratio 4:1 and their mean densities in the ratio 1:2. The acceleration due to gravity on the planets will be in ratio

a) 1 : 2 b) 2 : 3 c) 2 : 1 d) 4 : 1

33. If M is the mass of the earth and R its radius, the ratio of the gravitational acceleration and the gravitational constant is

a) $\frac{R^2}{M}$ b) $\frac{M}{R^2}$ c) MR^2 d) $\frac{M}{R}$

34. Venus looks brighter than other planets because

a) It is heavier than other planets b) It has higher density than other planets

c) It is closer to the earth than other planets d) It has no atmosphere

35. There are two bodies of masses 100,000 kg and 1000 kg separated by a distance of 1 m. At what distance (in metre) from the smaller body, the intensity of gravitational field will be zero?

a) 1/9 b) 1/10 c) 1/11 d) 10/11

36. Force of gravity is least of

a) The equator b) The poles

c) A point in between equator and any pole d) None of these

37. The period of a planet around sun is 27 times that of earth. The ratio of radius of planet's orbit to the radius of earth's orbit is

a) 4 b) 9 c) 64 d) 27

38. An object weighs 72 N on earth. Its weight at a height of $R/2$ from earth is

a) 32 N b) 56 N c) 72 N d) Zero

39. The acceleration due to gravity becomes $\left(\frac{g}{2}\right)$

($g =$ acceleration due to gravity on the surface of the earth) at a height equal to

a) $4R$ b) $\frac{R}{4}$ c) $2R$ d) $\frac{R}{2}$

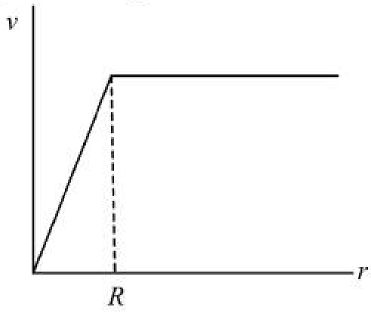
40. Imagine a light plant revolving around a very massive star in circular orbit of radius r with a period of revolution T. If the gravitational force of attraction between the planet and the star is proportional to $r^{-5/2}$. Then the correct relation is

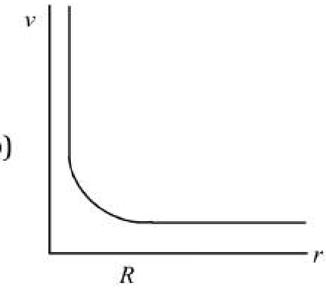
a) $T^2 \propto r^{5/2}$ b) $T^2 \propto r^{7/2}$ c) $T \propto r^{5/2}$ d) $T^2 \propto r^{7/2}$

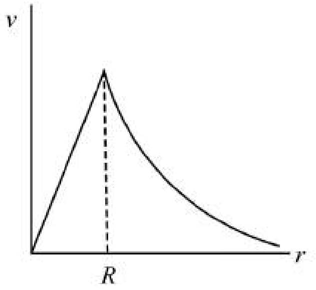
41. A spherically symmetric gravitational system of particles has a mass density

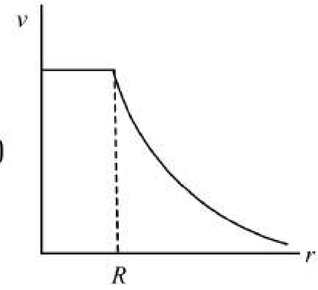
$\rho = \begin{cases} \rho_0 \text{ for } r \leq R \\ 0 \text{ for } r > R \end{cases}$

where ρ_0 is a constant. A test mass can undergo circular motion under the influence of the gravitational field of particles. Its speed v as a function of distance $r (0 < r < \infty)$ from the centre of the system is represented by

a) 

b) 

c) 

d) 

42. A spherical planet for out in space has a mass M_0 and diameter D_0. A particle of mass m falling freely new the surface of this planet will experience an acceleration due to gravity which is equal to
a) GM_0/D_0^2 b) $4mGM_0/D_0^2$ c) $4GM_0/D_0^2$ d) GmM_0/D_0^2

43. Two bodies of masses 2kg and 8kg are separated by a distance of 9 m. the point where the resultant gravitational field intensity is zero is at a distance of
a) 4.5 m from each mass b) 6 m from 2 kg c) 6 m from 8 kg d) 2.5 m from 2 kg

44. Suppose the law of gravitational attraction suddenly changes and becomes an inverse cube law i.e. $F \propto 1/r^3$, but still remaining a central force. Then
a) Keplers law of areas still holds
b) Keplers law of period still holds
c) Keplers law of areas and period still hold
d) Neither the law of areas, nor the law of period still holds

45. There are two planets. The ratio of radius of the two planets is K but ratio of acceleration due to gravity of both planets is g. What will be the ratio of their escape velocity
a) $(Kg)^{1/2}$ b) $(Kg)^{-1/2}$ c) $(Kg)^2$ d) $(Kg)^{-2}$

46. The period of revolution of planet A around the sun is 8 times that B. The distance of a from the sun is how many times greater than that of B from the sun?
a) 2 b) 3 c) 4 d) 5

47. What would be the velocity of earth due to rotation about its own axis so that the weight at equator become 3/5 of initial value. Radius of earth on equator is 6400 km
a) $7.4 \times 10^{-4} rad/sec$ b) $6.7 \times 10^{-4} rad/sec$ c) $7.8 \times 10^{-4} rad/sec$ d) $8.7 \times 10^{-4} rad/sec$

48. The period of a satellite in a circular orbit of radius R is T, the period of another satellite in a circular orbit of radius $4R$ is
a) $4T$ b) $T/4$ c) $8T$ d) $T/8$

49. The escape velocity for a body projected vertically upwards from the surface of the earth is 11.2 kms^{-1}. If the body is projected in a direction making an angle of 45° with the vertical, the escape velocity will be
a) 11.2 kms^{-1} b) $11.2 \times \sqrt{2}$ kms^{-1} c) 11.2×2 kms^{-1} d) $11.2/\sqrt{2}$ kms^{-1}

50. A body is at rest on the surface of the earth. Which of the following statement is correct?
a) No force is acting on the body

b) Only weight of the body acts on it

c) Net downward force is equal to the net upward force

d) None of the above statement is correct

51. If orbital velocity of planet is given by $v = G^a M^b R^c$, then

a) $a = 1/3, b = 1/3, c = -1/3$ b) $a = 1/2, b = 1/2, c = -1/2$

c) $a = 1/2, b = -1/2, c = 1/2$ d) $a = 1/2, b = -1/2, c = -1/2$

52. The escape velocity of a body on the earth's surface is v_e. A body is thrown up with a speed $\sqrt{5}\, v_e$. Assuming that the sun and planets do not influence the motion of the body, velocity of the body at infinite distance is

a) Zero b) v_e c) $\sqrt{2}v_e$ d) $2v_e$

53. A point mass is placed inside a thin spherical shell of radius R and mass M at a distance $R/2$ from the centre of the shell. The gravitational force exerted by the shell on the point mass is

a) $\frac{GM}{2R^2}$ b) $-\frac{GM}{2R^2}$ c) Zero d) $\frac{GM}{4R^2}$

54. A solid sphere is of density ρ and radius R. The gravitational field at a distance r from the centre of the sphere, where $r < R$, is

a) $\frac{\rho\pi G R^3}{r}$ b) $\frac{4\pi G\rho r^2}{3}$ c) $\frac{4\pi G\rho R^3}{3r^2}$ d) $\frac{4\pi G\rho r}{3}$

55. Three or two planets. The ratio of radius of the two planets is K but ratio of acceleration due to gravity of both planets is g. What will be the ratio of their escape velocity?

a) $(Kg)^{1/2}$ b) $(Kg)^{-1/2}$ c) $(Kg)^2$ d) $(Kg)^{-2}$

56. Out of the following, the only correct statement about satellites is

a) A satellite cannot move in a stable orbit in a plane passing through the earth's centre

b) Geostationary satellites are launched in the equatorial plane

c) We can use just one geostationary satellite for global communication around the globe

d) The speed of satellite increases with an increase in the radius of its orbit

57. If a planet consists of a satellite whose mass and radius were both half that of the earth, the acceleration due to gravity at its surface would be (g on earth $= 9.8\, m/\sec^2$)

a) $4.9 m/\sec^2$ b) $8.9 m/\sec^2$ c) $19.6 m/\sec^2$ d) $29.4 m/\sec^2$

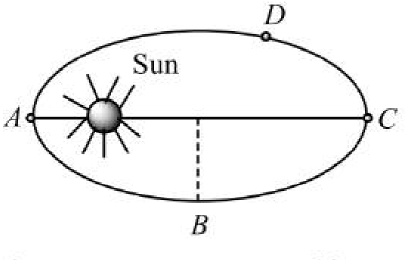
58. The escape velocity of a particle of mass m varias as

a) m^2 b) m c) m^0 d) m^{-1}

59. The mass of diameter of a planet are twice those of earth. The period of oscillation of pendulum on this planet will be (if it is a second's pendulum on earth)

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

60. A planet revolves around the sun in an elliptical orbit. The linear speed of the planet will be maximum at



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

61. 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) $T^2 = \frac{4\pi^2 G R^3}{M_m}$ c) $T^2 = \frac{2\pi R^3 G}{M_m}$ d) $T^2 = 4\pi M_m G R^3$

62. The mean radius of the earth is R, its angular speed on its own axis is ω and the acceleration due to gravity at earth's surface is g. The cube of the radius of the orbit of a geostationary satellite will be

a) $R^2 g/\omega$ b) $R^2\omega^2/g$ c) Rg/ω^2 d) $R^2 g/\omega^2$

63. The escape velocity from the earth is 11 kms^{-1}. The escape velocity from a planet having twice the radius and the same mean density as the earth would be

a) 5.5 kms^{-1} b) 11 kms^{-1} c) 15.5 kms^{-1} d) 22 kms^{-1}

64. If the Earth losses its gravity, then for a body

a) Weight becomes zero, but not the mass
b) Mass becomes zero, but not the weight
c) Both mass and weight become zero
d) Neither mass nor weight become zero

65. A body of mass 500 g is thrown upward with a velocity 20ms^{-1} and reaches back to the surface of a planet after 20 s. Then the weight of the body on that planet is

a) 2 N b) 4 N c) 5 N d) 1 N

66. Hubble's law states that the velocity with which milky ways is moving away from the earth is proportional to

a) Square of the distance of the milky way from the earth
b) Distance of milky way from the earth
c) Mass of the milky way
d) Product of the mass of the milky way and its distance from the earth

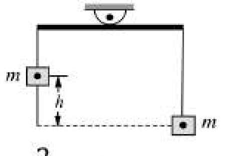
67. Which of the following statements is correct in respect of a geostationary satellite

a) It moves in a plane containing the Greenwich meridian
b) It moves in a plane perpendicular to the celestial equatorial plane
c) Its height above the earth's surface is about the same as the radius of the earth
d) Its height above the earth's surface is about six times the radius of the earth

68. A planet moves around the sun. At a given point P, it is closest from the sun at a distance d_1 and has a speed v_1. At another point Q, when it is farthest from the sun at a distance d_2, its speed will be

a) $\frac{d_1^2 v_1}{d_2^2}$ b) $\frac{d_2 v_1}{d_1}$ c) $\frac{d_1 v_1}{d_2}$ d) $\frac{d_2^2 v_1}{d_1^2}$

69. Two equal mass m and m are hung from balance whose scale pans differ in vertical height by h. Calculate the error in weighing. If any, in terms of density of earth ρ.



a) $\frac{2}{3}\pi\rho R^3 Gm$ b) $\frac{8}{3}\pi\rho Gmh$ c) $\frac{8}{3}\pi\rho R^3 Gm$ d) $\frac{4}{3}\pi\rho Gm^2 h$

70. To an astronaut in a spaceship, the sky appears

a) Black b) White c) Green d) Blue

71. If ρ is the density of the planet, the time period of nearby satellite is given by

a) $\sqrt{\frac{4\pi}{3G\rho}}$ b) $\sqrt{\frac{4\pi}{G\rho}}$ c) $\sqrt{\frac{3\pi}{G\rho}}$ d) $\sqrt{\frac{\pi}{G\rho}}$

72. Two planets of radii in the ratio 2:3 are made from the material of density in the ratio 3:2. Then, the ratio of acceleration due to gravity $\frac{g_1}{g_2}$ at the surface of the two planets will be

a) 1 b) 2.25 c) 4/9 d) 0.12

73. A planet has twice the radius but the mean density is $\frac{1}{4}$th as comparsed to earth.What is the ratio of escape velocity from earth to that from the planet?

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

74. The ratio $\frac{g}{g_h}$, where g and g_h are the accelerations due to gravity at the surface of the earth and at a height h above the earth's surface respectively, is

a) $\left(1+\frac{h}{R}\right)^2$ b) $\left(1+\frac{R}{h}\right)^2$ c) $\left(\frac{R}{h}\right)^2$ d) $\left(\frac{h}{R}\right)^2$

75. Orbital velocity of an artificial does not depend upon

a) Mass of the earth
b) Mass of the satellite
c) Radius of the earth
d) Acceleration due to gravity

76. Which is constant for a satellite in orbit

a) Velocity
b) Angular momentum
c) Potential energy
d) Acceleration

77. An object weighs 10N at the north-pole of the earth. In a geostationary satellite distance $7R$ from the centre of earth (of radius R) what will be its true weight?

a) 3 N
b) 5 N
c) 2 N
d) 0.2 N

78. Escape velocity on the earth

a) Is less than that on the moon
b) Depends upon the mass of the body
c) Depends upon the direction of projection
d) Depends upon the height from which it is projected

79. The acceleration of a body due to the attraction of the earth (radius R) at a distance $2R$ from the surface of the earth is (g = acceleration due to gravity at the surface of the earth)

a) $\frac{g}{9}$
b) $\frac{g}{3}$
c) $\frac{g}{4}$
d) g

80. The mass of the moon is 1/8 of the earth but the gravitational pull is 1/6 of the earth. It is due to the fact that

a) Moon is the satellite of the earth
b) The radius of the earth is 8.6 the moon
c) The radius of the earth is $\sqrt{8/6}$ of the moon
d) The radius of the moon is 6/8 of the earth

81. The angular velocity of rotation of star (of mass M and radius R) at which the matter start to escape from its equator will be

a) $\sqrt{\frac{2GM^2}{R}}$
b) $\sqrt{\frac{2GM}{g}}$
c) $\sqrt{\frac{2GM}{R^3}}$
d) $\sqrt{\frac{2GR}{M}}$

82. A synchronous satellite goes around the earth once in every 24 h. What is the radius of orbit of the synchronous satellite in terms of the earth's radius (Given mass of the earth, $m_e = 5.98 \times 10^{24} kg$. radius of earth, $r_e = 6.37 \times 10^6 m$, Universal constant of gravitation, $G = 6.67 \times 10^{-11} Nm^2/kg^2$)

a) $2.4r_e$
b) $3.6r_e$
c) $4.8r_e$
d) $6.6r_e$

83. 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

84. The gravitational force F_g between two objects does not depends on

a) Sum of the masses
b) Product of the masses
c) Gravitational constant
d) Distance between the masses

85. What is the intensity of gravitational field at the centre of a spherical shell

a) Gm/r^2
b) g
c) Zero
d) None of these

86. The gravitational attraction between the two bodies increases when their masses are

a) Reduced and distance is reduced
b) Increased and distance is reduced
c) Reduced and distance is increased
d) Increased and distance is increased

87. Two satellites of mass m and $9m$ are orbiting a planet in orbit of radius R. Their periods of revolution will be in the ratio of

a) 1:3
b) 1:1
c) 3:1
d) 9:1

88. A projectile is projected with velocity kv_e in vertically upward direction from the ground into the space. (v_e is escape velocity and $k < 1$). If resistance is considered to be negligible then the maximum height from the centre of earth to which it can go, will be : (R = radius of earth)

a) $\frac{R}{k^2+1}$
b) $\frac{R}{k^2-1}$
c) $\frac{R}{1-k^2}$
d) $\frac{R}{k+1}$

89. Two spherical bodies of mass M and $5M$ and radii R and $2R$ respectively are released in free space with initial separation between their centres equal to $12R$. If they attract each other due to gravitational force only, then the distance covered by the smaller body just before collision is

a) 2.5 R b) 4.5 R c) 7.5 R d) 1.5 R

90. A satellite is moving with a constant speed v in a circular orbit about the earth. An object of mass m is ejected from the satellite such that it just escapes from the gravitational pull of the earth. At the time of its ejection, the kinetic energy of the object is

a) $\frac{1}{2}mv^2$ b) mv^2 c) $\frac{3}{2}mv^2$ d) $2mv^2$

91. Acceleration due to gravity is g on the surface of the earth. Then the value of the acceleration due to gravity at a height of 32 km above earth's surface is (Assume radius of earth to be 6400 km)

a) 0.99 g b) 0.8 g c) 1.01 g d) 0.9 g

92. If acceleration due to gravity on the surface of a planet is two times that on surface of earth and its radius is double that of earth. Then escape velocity from the surface of that planet in comparison to earth will be

a) 2 v_e b) 3 v_e c) 4 v_e d) None of these

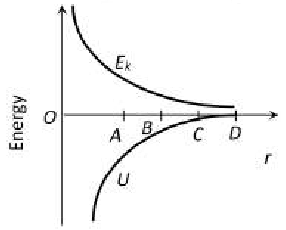
93. A body of mass m kg. starts falling from a point $2R$ above the Earth's surface. Its kinetic energy when it has fallen to a point $'R'$ above the Earth's surface [R-Radius of Earth, M-Mass of Earth, G-Gravitational Constant]

a) $\frac{1}{2}\frac{GMm}{R}$ b) $\frac{1}{6}\frac{GMm}{R}$ c) $\frac{2}{3}\frac{GMm}{R}$ d) $\frac{1}{3}\frac{GMm}{R}$

94. The gravitational force between a point like mass M and an infinitely long, thing rod of linear mass density perpendicular to distance L from M is

a) $\frac{MG\lambda}{L}$ b) $\frac{1}{2}\frac{MG\lambda}{L}$ c) $\frac{2MG\lambda}{L^2}$ d) Infinite

95. The curves for potential energy (U) and kinetic energy (E_k) of a two particle system are shown in figure. At what points the system will be bound



a) Only at point D b) Only at point A c) At point D and A d) At points A, B and C

96. A satellite whose mass is M, is revolving in circular orbit of radius r around the earth. Time of revolution of satellite is

a) $T \propto \frac{r^5}{GM}$ b) $T \propto \sqrt{\frac{r^3}{GM}}$ c) $T \propto \sqrt{\frac{r}{GM^2/3}}$ d) $T \propto \sqrt{\frac{r^3}{GM^1/4}}$

97. The ratio of the radius of a planet $'A'$ to that of planet $'B'$ is $'r'$. The ratio of acceleration due to gravity on the planets is $'x'$. The ratio of the escape velocities from the two planets is

a) xr b) $\sqrt{\frac{r}{x}}$ c) $\sqrt{rx}$ d) $\sqrt{\frac{x}{r}}$

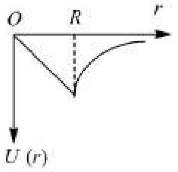
98. The depth d at which the value of acceleration due to gravity becomes $1/n$ times the value of the surface, is [R = radius of the earth]

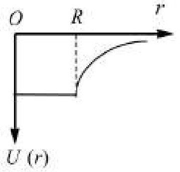
a) $\frac{R}{n}$ b) $R\left(\frac{n-1}{n}\right)$ c) $\frac{R}{n^2}$ d) $R\left(\frac{n}{n+1}\right)$

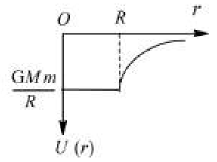
99. If g is the acceleration due to gravity at the earth's surface and r is the radius of the earth, the escape velocity for the body to escape out of earth's gravitational field is

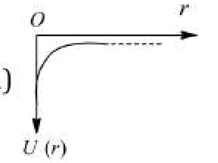
a) gr b) $\sqrt{2\,gr}$ c) g/r d) r/g

100. A shell of mass M and radius R has a point mass m placed at a distance r from its centre.

a) 

b) 

c) 

d) 

101. If three particles each of mass M are placed at the three corners of an equilateral triangle of side a, the forces exerted by this system on another particle of mass M placed (i) at the mid point of a side and (ii) at the centre of the triangle are respectively

a) 0, 0
b) $\frac{4GM^2}{3a^2}, 0$
c) $0, \frac{4GM^2}{3a^2}$
d) $\frac{3GM^2}{a^2}, \frac{GM^2}{a^2}$

102. In the above Question find apparent weight of the object?

a) 3 N
b) Zero
c) 2 N
d) 0.2 N

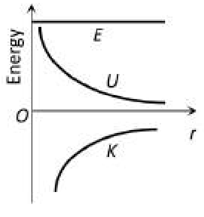
103. Two identical satellite A and B are circulating round the earth at the height of R and $2R$ respectively. (where R is radius of the earth). The ratio of kinetic energy of A to that of B is

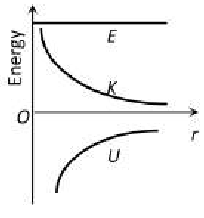
a) $\frac{1}{2}$
b) $\frac{2}{3}$
c) 2
d) $\frac{3}{2}$

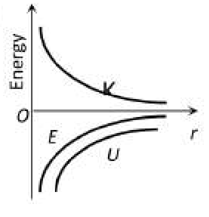
104. Sun is about 330 times heavier and 100 times bigger in radius than earth. The ratio of mean density of the sun to that of earth is

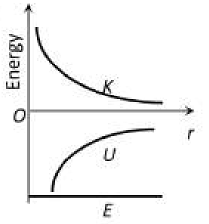
a) 3.3×10^{-6}
b) 3.3×10^{-4}
c) 3.3×10^{-2}
d) 1.3

105. The correct graph representing the variation of total energy (E) kinetic energy (K) and potential energy (U) of a satellite with its distance from the centre of earth is

a) 

b) 

c) 

d) 

106. At what height above the earth's surface does the force of gravity decrease by 10%? The radius of the earth is 6400 km?

a) 345.60 km
b) 687.20 km
c) 1031.8 km
d) 12836.80 km

107. A body is projected upwards with a velocity of 4×11.2 kms^{-1} from the surface of earth. What will be the velocity of the body when it escapes from the gravitational pull of earth?

a) 11.2 kms^{-1}
b) 2×11.2 kms^{-1}
c) 3×11.2 kms^{-1}
d) $\sqrt{15} \times 11.2$ kms^{-1}

108. The mean radius of the earth's orbit round the sun is 1.5×10^{11}. The mean radius of the orbit of mercury round the sun is $6 \times 10^{10} m$. The mercury will rotate around the sun in

a) A year
b) Nearly 4 years
c) Nearly $\frac{1}{4}$ year
d) 2.5 years

109. The mass of the moon is 1/81 of earth's mass and its radius 1/4th that of the earth. If the escape velocity from the earth's surface is 11.2 kms^{-1}, its value for the moon will be

a) 0.15 kms^{-1}
b) 5 kms^{-1}
c) 2.5 kms^{-1}
d) 0.5 kms^{-1}

110. g_e and g_p denote the acceleration due to gravity on the surface of the earth and another planet whose mass and radius are twice to that of the earth, then

a) $g_p = \frac{g_e}{2}$
b) $g_p = g_e$
c) $g_p = 2g_e$
d) $g_p = \frac{g_e}{\sqrt{2}}$

111. 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 :

I. Mass of the planet
II. Mass of the particle escaping
III. Temperature of the planet
IV. Radius of the planet

Select the correct answer from the codes given below :

a) I and II b) II and IV c) I and IV d) I, III and IV

112. A space ship moves from earth to moon and back. The greatest energy required for the space ship is to overcome the difficulty in
a) Entering the earth's gravitational field
b) Take off from earths field
c) Take off from lunar surface
d) Entering the moon's lunar surface

113. A body has weight 90 kg on the earth's surface, the mass of the moon is 1/9 that of the earth's mass and its radius is 1/2 that of the earth's radius. On the moon the weight of the body is
a) 45 kg b) 202.5 kg c) 90 kg d) 40 kg

114. A body revolved around the sun 27 times faster than the earth. What is the ratio of their radii
a) 1/3 b) 1/9 c) 1/27 d) 1/4

115. The orbital angular momentum of a satellite revolving at a distance r from the centre is L. If the distance is increased to $16r$, then the new angular momentum will be
a) $16\,L$ b) $64\,L$ c) $\frac{L}{4}$ d) $4\,L$

116. A man can jump to a height of 1.5 m on a planet A. What is the height he may be able to jump on another planet whose density and radius are, respectively, one-quarter and one-third that of planet A
a) 1.5 m b) 15 m c) 18 m d) 28 m

117. If satellite is shifted towards the earth. Then time period of satellite will be
a) Increase b) Decrease c) Unchanged d) Nothing can be said

118. If the force inside the earth surface varies as x^n, where r is the distance of body from the centre of earth, then the value of n will be
a) -1 b) -2 c) 1 d) 2

119. If the value of g acceleration due to gravity at earth surface is 10 ms^{-2}. Its value in ms^{-2} at the centre of the earth, which is assumed to be a sphere of radius R metre and uniform mass density is
a) 5 b) $10/R$ c) $10/2R$ d) Zero

120. A body of mass m rises to a height $h = R/5$ from the surface of earth, where R is the radius of earth. If g is the acceleration due to gravity at the surface of earth, the increase in potential energy is
a) $(4/5)mgh$ b) $(5/6)mgh$ c) $(6/7)mgh$ d) mgh

121. Two satellite A and B go round a planet orbits having radii $4R$ and R, respectivly. If the speed of satellite A is $3v$, then speed of satellite B is
a) $\frac{3v}{2}$ b) $\frac{4v}{2}$ c) $6v$ d) $12v$

122. Rockets are launched in Eastward direction to take advantage of
a) The clear sky on Eastesn side
b) The thinner atmosphere on this side
c) Earth's rotation
d) Earth's tilt

123. If the moon is to escape from the gravitational field of the earth forever, it will require a velocity
a) 11.2 kms^{-1}
b) Less than 11.2 kms^{-1}
c) Slightly more than 111.2 kms^{-1}
d) 22.4 kms^{-1}

124. A uniform ring of mass M and radius r is placed directly above a uniform sphere of mass $8M$ and of same radius R. The centre of the ring is at a distance of $d = \sqrt{3}R$ from the centre of the sphere. The gravitational attraction beween the sphere and the ring is
a) $\frac{GM^2}{R^2}$ b) $\frac{3GM^2}{2R^2}$ c) $\frac{2GM^2}{\sqrt{2}R^2}$ d) $\frac{\sqrt{3}GM^2}{R^2}$

125. The time period of a satellite of earth is 5h. 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 h b) 18 h c) 40 h d) 20 h

126. 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 center of mass is

a) $\sqrt{\frac{Gm}{R}}$ b) $\sqrt{\frac{Gm}{4R}}$ c) $\sqrt{\frac{Gm}{3R}}$ d) $\sqrt{\frac{Gm}{2R}}$

127. A pendulum clock is set to give correct time at the sea level. This clock is moved to hill station at an altitude of 2500 m above the sea level. In order to keep correct time of the hill station, the length of the pendulum

a) Has to be reduced
b) Has to be increased
c) Needs no adjustment
d) Needs no adjustment but its mass has to be increased

128. A particle falls towards earth from infinity. It's velocity on reaching the earth would be

a) Infinity b) $\sqrt{2gR}$ c) $2\sqrt{gR}$ d) Zero

129. The acceleration due to gravity on a planet is 1.96 ms^{-2}. If it is safe to jump from a height of 3 m on the earth, the corresponding height on the planet will be

a) 3 m b) 6 m c) 9 m d) 15 m

130. Weight of $1kg$ becomes 1/6 on moon. If radius of moon is 1.768×10^6 m, then the mass of moon will be

a) $1.99 \times 10^{30} kg$ b) $7.56 \times 10^{22} kg$ c) $5.98 \times 10^{24} kg$ d) $7.65 \times 10^{22} kg$

131. A satellite in launched in a circular orbit of radius R around the earth. A second satellite is launch in to an orbit of radius $1.01R$. The period of second satellite is longer than the first one (approximately) by

a) 1.5 % b) 0.5% c) 3% d) 1%

132. At a distance 320 km above the surface of earth, the value of acceleration due to gravity will be lower than its value on the surface of the earth by nearly (radius of earth = 6400 km)

a) 2% b) 6% c) 10% d) 14%

133. Escape velocity on the surface of earth is 11.2 km/s. Escape velocity from a planet whose mass is the same as that of earth and radius 1/4 that of earth is

a) 2.8 km/s b) 15.6 km/s c) 22.4 km/s d) 44.8 km/s

134. The period of moon's rotation around the earth is nearly 29 $days$. If moon's mass were 2 fold, its present value and all other things remained unchanged, the period of moon's rotation would be nearly

a) $29\sqrt{2}$ $days$ b) $29\sqrt{2}$ $days$ c) 29×2 $days$ d) 29 $days$

135. 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 depending upon its initial velocity

136. If a planet of given density were made larger its force of attraction for an object on its surface would increase because of planet's greater mass but would decease because of the greater distance from the object to the centre of the planet. Which effect predominate?

a) Increases in mass
b) Increase in radius
c) Both affect attraction equally
d) None of the above

137. A body is orbiting around earth at a mean radius which is two times as greater as parking orbit of a satellite, the period of body is

a) 4 days b) 16 days c) $2\sqrt{2}$ days d) 64 days

138. 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 tangentially to the original orbit with the same velocity
c) Become stationary in its orbit
d) Move towards the earth

139. A geostationary satellite is revolving around the earth. To make it escape from gravitational field of earth, its velocity must be increased

a) 100% b) 41.4% c) 50% d) 59.6%

140. A satellite is orbiting around the earth with orbital radius R and time period T. The quantity which remain constant is

a) T/R b) T^2/R c) T^2/R^2 d) T^2/R^3

141. Two spherical planets A and B have same mass but densities in the ratio 8:1. For these planets, the ratio of acceleration due to gravity at the surface of A to its value at the surface of B is

a) 1 : 4 b) 1 : 2 c) 4 : 1 d) 8 : 1

142. An earth satellite is moved from one stable circular orbit to farther stable circular orbit. Which one of the following quantities increase?

a) Linear orbit speed b) Gravitational force
c) Centripetal acceleration d) Gravitational potential energy

143. A man starts walking from a point on the surface of earth (assumed smooth) and reaches diagonally opposite point. What is the work done by him?

a) Zero b) Positive c) Negative d) Nothing can be said

144. The acceleration to gravity at a height 1/20th of the radius of the earth above the earth surface is 9ms^{-2}. Its value at a point at an equal distance below the surface of the earth in ms^{-2} is about below the surface of the earth in ms^{-2} is about

a) 8.5 b) 9.5 c) 9.8 d) 11.5

145. Gravitational potential on the surface of earth is (M =mass of the earth, R = radius of earth)

a) $-GM/2R$ b) $-gR$ c) gR d) GM/R

146. The escape velocity of an object from the earth depends upon the mass of the earth (M), its mean density, (ρ), its radius (R) and the gravitational constant (G). Thus the formula for escape velocity is

a) $v = R\sqrt{\frac{8\pi}{3}G\rho}$ b) $v = M\sqrt{\frac{8\pi}{3}GR}$ c) $v = \sqrt{2GMR}$ d) $v = \sqrt{\frac{2GM}{R^2}}$

147. Earth binds the atmosphere because of

a) Gravity b) oxygen between earth and atmosphere
c) Both (a) and (b) d) None of the above

148. The acceleration due to gravity about the earth's surface would be half of its value on the surface of the earth at an altitude of ($R = 4000\ mile$)

a) 1200 *mile* b) 2000 *mile* c) 1600 *mile* d) 4000 *mile*

149. The acceleration due to gravity on the planet A is 9 times the acceleration due to gravity on planet B. A man jumps to height of 2 m on the surface of A. What is the height of jump by the same person on the planet B?

a) 6 m b) $\frac{3}{2}$ m c) 2/9 m d) 18 m

150. The time period of a geostationary satellite is

a) 12 hours b) 24 hours c) 6 hours d) 48 hours

151. A satellite is revolving around the planet. The gravitational force between them varies with $R^{-5/2}$, where R is the radius of the satellite. The square of the time period T will be directly proportional to

a) R^3 b) $R^{7/2}$ c) $R^{3/2}$ d) $R^{5/7}$

152. The mass of a planet is six times that of the earth. The radius of the planet is twice that of the earth. If the escape velocity from the earth is v, then the escape velocity from the planet is

a) $\sqrt{3}v$ b) $\sqrt{2}v$ c) v d) $\sqrt{5}v$

153. Choose the correct statement from the following. The radius of the orbit of a geostationary satellite depends upon

a) Mass of the satellite, its time period and the gravitational constant
b) Mass of the satellite, mass of the earth and the gravitational constant
c) Mass of the earth, mass of the satellite, time period of the satellite and the gravitational constant
d) Mass of the earth, time period of the satellite and the gravitational constant

154. If the radius of earth decreases by 1% and its mass remains same, then the acceleration due to gravity

a) increases by 1% b) decreases by 1% c) increases by 2% d) decreases by 2%

155. Acceleration due to gravity is maximum at (R is the radius of earth)

a) A height $\frac{R}{2}$ from the earth's surface b) The centre of the earth

c) The surface of the earth d) A depth $\frac{R}{2}$ from the earth's surface

156. If satellite is revolving around a planet of mass M in an elliptical orbit of semi-major axis a, find the orbital speed of the satellite when it is at a distance r from the focus

a) $v^2 = GM\left[\frac{2}{r} - \frac{1}{a}\right]$ b) $v^2 = GM\left[\frac{2}{r^2} - \frac{1}{a}\right]$ c) $v^2 = GM\left[\frac{2}{r^2} - \frac{1}{a^2}\right]$ d) $v^2 = G\left[\frac{2}{r} - \frac{1}{a}\right]$

157. Three equal masses of $1kg$ each are placed at the vertices of an equilateral triangle PQR and a mass of $2kg$ is placed at the centroid O 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 $2kg$ is

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

158. LANDSAT series of satellites move in near polar orbits at an altitude of

a) 3600 km b) 3000 km c) 918 km d) 512 km

159. A particle of mass 10 g is kept on the surface of a uniform sphere of mass 100 kg and radius 10 cm. Find the work to be done against the gravitational force between them, to take the particle far away from the sphere.

(You may take $G = 6.67 \times 10^{-11} \text{Nm}^2\text{kg}^2$)

a) 13.34×10^{-10}J b) 3.33×10^{-10}J c) 6.67×10^{-9}J d) 6.67×10^{-10}J

160. Choose the correct statement from the following :

Weightlessness of an astronaut moving in a satellite is a situation of

a) Zero g b) No gravity c) Zero mass d) Free fall

161. The binding energy of a satellite of mass m in a orbit of radius r is (R = radius of earth, g = acceleration due to gravity)

a) $\frac{mgR^2}{r}$ b) $\frac{mgR^2}{2r}$ c) $-\frac{mgR^2}{r}$ d) $-\frac{mgR^2}{2r}$

162. Who among the following gave first the experimental value of G

a) Cavendish b) Copernicus c) Brook Teylor d) None of these

163. An asteroid of mass m is approaching earth, initially at a distance of 10 R_e with speed v_i. It hits the earth with a speed v_f (R_e and M_e are radius and mass of earth), then

a) $v_f^2 = v_i^2 + \frac{2Gm}{M_e R}\left(1 - \frac{1}{10}\right)$ b) $v_f^2 = v_i^2 + \frac{2GM_e}{R_e}\left(1 + \frac{1}{10}\right)$

c) $v_f^2 = v_i^2 + \frac{2GM_e}{R_e}\left(1 - \frac{1}{10}\right)$ d) $v_f^2 = v_i^2 + \frac{2Gm}{R_e}\left(1 - \frac{1}{10}\right)$

164. According to Kepler's law T^2 is proportional to

a) R^3 b) R^2 c) R d) R^{-1}

165. The gravitational field due to a mass distribution is $1 = \frac{C}{x^2}$ in x direction. Hence C is constant. Taking the gravitational potential to be zero at infinity, potential at x is

a) $\frac{2C}{x}$ b) $\frac{C}{x}$ c) $\frac{2C}{x^2}$ d) $\frac{C}{2x^2}$

166. A body falls freely under gravity. Its speed is v when it has lost an amount U of the gravitational energy. Then its mass is

a) $\frac{Ug}{v^2}$ b) $\frac{U^2}{g}$ c) $\frac{2U}{v^2}$ d) $2Ugv^2$

167. For the moon to cease to remain the earth's satellite, its orbital velocity has to increase by a factor of

a) 2 b) $\sqrt{2}$ c) $1/\sqrt{2}$ d) $\sqrt{3}$

168. If the radius of a planet is R and its density is ρ, the escape velocity from its surface will be

a) $v_e \propto \rho R$ b) $v_e \propto \sqrt{\rho R}$ c) $v_e \propto \frac{\sqrt{\rho}}{R}$ d) $v_e \propto \frac{1}{\sqrt{\rho R}}$

169. The distance of neptune and saturn from sun are nearly 10^{13} and $10^{12} m$ respectively. Assuming that they move in circular orbits, their periodic times will be in the ratio

a) $\sqrt{10}$ b) 100 c) $10\sqrt{10}$ d) $1/\sqrt{10}$

170. Planetary system in the solar system describes

a) Conservation of energy b) Conservation of linear momentum
c) Conservation of angular momentum d) None of these

171. A mass M is split into two parts m and $(M-m)$, which are then separated by a certain distance. The ratio m/M which maximizes the gravitational force between the parts is

a) 1 : 4 b) 1 : 2 c) 4 : 1 d) 2 : 1

172. If the mass of moon is $\frac{1}{90}$ of earth^' s mass, its radius is $\frac{1}{3}$ of earth^' sradius and if g is acceleration due to gravity on earth, then the acceleration due to gravity on moon is..

a) $\frac{g}{3}$ b) $\frac{g}{90}$ c) $\frac{g}{10}$ d) $\frac{g}{9}$

173. If the angular speed of the earth is doubled, the value of acceleration due to gravity (g) at the north pole

a) Doubles b) Becomes half c) Remains same d) Becomes zero

174. The change in potential energy when a body of mass m is raised to a height nR from the centre of earth (R= radius of earth)

a) $mgR\frac{(n-1)}{n}$ b) $nmgR$ c) $mgR\frac{n^2}{n^2+1}$ d) $mgR\frac{n}{n+1}$

175. A mass of 6×10^{24}kg is to be compressed in a sphere in such a way that the escape velocity from the sphere is 3×10^8 m/s. What should be the radius of the sphere?
$(G = 6.67 \times 10^{-11}$ N- m^2/kg$^2)$

a) 9 km b) 9 m c) 9 mc d) 9 mm

176. For a body to escape from earth, angle at which it should be fired is?

a) 45° b) > 45° c) < 45° d) any angle

177. The radius of the earth is R. The 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) 8 R b) 9 R c) 10 R d) 20 R

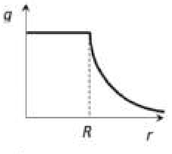
178. The density of earth in terms of acceleration due to gravity (g), radius of earth (R) and universal gravitational constant (G) is

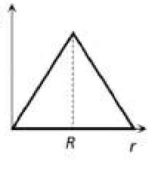
a) $\frac{4\pi RG}{3g}$ b) $\frac{3\pi RG}{4g}$ c) $\frac{4g}{3\pi RG}$ d) $\frac{3g}{4\pi RG}$

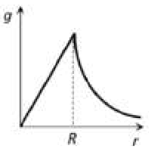
179. Escape velocity of a body of 1 kg mass on a planet is 100 m/sec. Gravitational Potential energy of the body at the Planet is

a) $-5000\,J$ b) $-1000\,J$ c) $-2400\,J$ d) $5000\,J$

180. Assuming the earth to have a constant density, point out which of the following curves show the variation of acceleration due to gravity from the centre of earth to the points far away from the surface of earth

a) 

b) 

c) 

d) None of these

181. 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

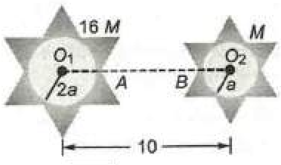
182. A body weighs 700 $g\ wt$ on the surface of the earth. How much will it weigh on the surface of a planet whose mass is $\frac{1}{7}$ and radius is half that of the earth

a) 200 $g\ wt$
b) 400 $g\ wt$
c) 50 $g\ wt$
d) 300 $g\ wt$

183. A satellite in a circular orbit of radius R has a period of 4 h. Another satellite with orbital radius $3R$ around the same planet will have a period (in hour)

a) 16
b) 4
c) $4\sqrt{27}$
d) $4\sqrt{8}$

184. Distance between the centres of two stars is 10 a. The masses of these stars are M and 16 M and their radii a and $2a$ respectively. A body of mass m is fired straight from the surface of the larger star towards the smaller star. The minimum initial speed for the body to reach the surface of smaller star is



a) $\frac{2}{3}\sqrt{\frac{GM}{a}}$
b) $\frac{3}{2}\sqrt{\frac{5GM}{a}}$
c) $\frac{2}{3}\sqrt{\frac{5GM}{a}}$
d) $\frac{3}{2}\sqrt{\frac{GM}{a}}$

185. Three particles each of mass m are kept at verities of an equilateral triangle of side L. The gravitational field at centre due to these particle is

a) Zero
b) $\frac{3GM}{L^2}$
c) $\frac{9GM}{L^2}$
d) $\frac{12}{\sqrt{3}}\frac{GM}{L^2}$

186. The escape velocity of projectile on the earth's surface is 11.2 kms^{-1}. A body is projected out with thrice this speed. The speed of the body for away from the earth will be

a) 22.4 kms^{-1}
b) 31.7 kms^{-1}
c) 33.6 kms^{-1}
d) None of these

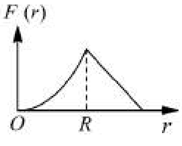
187. The distance of a geo-stationary satellite from the centre the earth (Radius $R = 6400\ km$) is nearest to

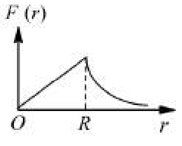
a) 5 R
b) 7 R
c) 10 R
d) 18 R

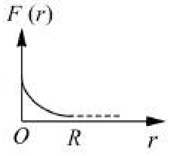
188. Kepler's second law regarding constancy of aerial velocity of a planet is consequence of the law of conservation of

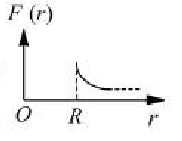
a) Energy
b) Angular momentum
c) Linear momentum
d) None of these

189. In the above problem, if the shell is replaced by a sphere of same mass and radius then the graph of $F(r)$ *versus* r will be

a) 

b) 

c) 

d) 

190. The weight of a body on surface of earth is 12.6 N. When it is raised to a height half the radius of earth its weight will be

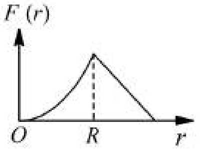
a) 2.8 N
b) 5.6 N
c) 12.5 N
d) 25. 2N

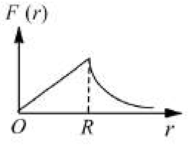
191. A man inside an artificial satellite feels weightlessness because the force of attraction due to earth is

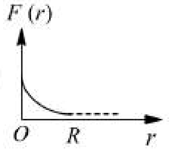
a) Zero at that place
b) Is balanced by the force of attraction due to moon
c) Equal to the centripetal force

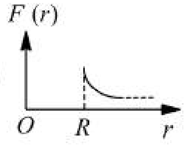
d) Non-effective due to particular design of the satellite

192. A particle of mass m is located at a distance r from the centre of a shell of mass M and radius R. The force between the shell and mass is $F(r)$. The plot of $F(r)$ *versus* r is

a) 

b) 

c) 

d) 

193. Two particles each of mass m are moving around a circle of radius R due to their mutual gravitational force of attraction, velocity of each particle is

a) $v = \sqrt{\frac{Gm}{2R}}$ b) $v = \sqrt{\frac{Gm}{R}}$ c) $v = \sqrt{\frac{Gm}{4R}}$ d) None of these

194. A particle is fired vertically upwards from the surface of earth and reaches a height 6400 km. The initial velocity of the particle is ($R = 6400$ km, $g = 10\text{ms}^{-2}$)

a) 11.2 ms^{-1} b) 8 kms^{-1} c) 3.2 kms^{-1} d) None of these

195. What will be the effect on the weight of a body placed on the surface of earth, if earth suddenly starts rotating with half of its angular velocity of rotation?

a) No effect
b) Weight will increase
c) Weight will decrease
d) Weight will become zero

196. Imagine a light planet revolving around a very massive star in a circular orbit of radius r with a period of revolution T. If the gravitational force of attraction between the planet and the star is proportional to $R^{-3/2}$, then T^2 is proportional to

a) R^3 b) $R^{5/2}$ c) $R^{3/2}$ d) $R^{7/2}$

197. In planetary motion the areal velocity of position vector of a planet depends on angular velocity (ω) and the distance of the planet from sun (r). If so the correct relation for areal velocity is

a) $\frac{dA}{dt} \propto \omega r$ b) $\frac{dA}{dt} \propto \omega^2 r$ c) $\frac{dA}{dt} \propto \omega r^2$ d) $\frac{dA}{dt} \propto \sqrt{\omega r}$

198. Energy required to move a body of mass m from an orbit of radius $2\ R$to $3R$ is

a) $GMm/12R^2$ b) $GMm/3R^2$ c) $GMm/8R$ d) $GMm/6R$

199. An artificial satellite is revolving round the earth in a circular orbit. Its velocity is half the escape velocity. Its height from earth's surface is

a) 6400 *km* b) 12800 *km* c) 3200 *km* d) 1600 *km*

200. Two astronauts have deserted their space ships in a region of space far from the gravitational attraction of any other body. Each has a mass of 100 kg and they are 100 m apart. They are initially at rest relative to one another. How long will it be before the gravitational attraction brings them 1 cm closer together?

a) 2.52 days b) 1.41 days c) 0.70 days d) 0.41 days

201. The earth revolves round the sun in one year. If the distance between them becomes double, the new period of revolution will be

a) 1/2 *year* b) $2\sqrt{2}$ *years* c) 4 *years* d) 8 *years*

202. Where will it be profitable to purchase 1 kilogram sugar

a) At poles b) At equator c) At 45° latitude d) At 40° latitude

203. If the density of the earth is doubled keeping radius constant, find the new acceleration due to gravity? ($g = 9.8\text{ m/s}^2$)

a) 9.8 m/s^2 b) 19.6 m/s^2 c) 4.9 m/s^2 d) 39.2 m/s^2

204. In the previous question, the angular speed of S_2 as actually observed by an astronaut is S_1

a) $\frac{\pi}{2}\text{radh}^{-1}$ b) $\pi\text{ radh}^{-1}$ c) $\frac{2\pi}{3}\text{ radh}^{-1}$ d) $\frac{\pi}{3}\text{ radh}^{-1}$

205. If V, R and g denote respectively the escape velocity from the surface of the earth radius of the earth, and acceleration due to gravity, then the correct equation is

a) $V = \sqrt{gR}$ b) $V = \sqrt{\frac{4}{3}gR^3}$ c) $V = R\sqrt{g}$ d) $V = \sqrt{2gR}$

206. The force of gravitation is

a) Repulsive b) Electrostatic c) Conservative d) Non-conservative

207. A satellite moves in a circle around the earth. The radius of this circle is equal to one-half of the radius of the moon's orbit. The satellite completes one revolution in

a) $\frac{1}{2}$ lunar month b) $\frac{2}{3}$ lunar month c) $2^{-3/2}$ lunar month d) $2^{3/2}$ lunar month

208. The height at which the acceleration due to gravity decreases by 36% of its value on the surface of the earth. (The radius of the earth is R)

a) $\frac{R}{6}$ b) $\frac{R}{4}$ c) $\frac{R}{2}$ d) $\frac{2}{3}R$

209. Four particles each of mass M, are located at the vertices of a square with side L. The gravitational potential due to this at the centre of the square is

a) $-\sqrt{32}\frac{GM}{L}$ b) $-\sqrt{64}\frac{GM}{L^2}$ c) Zero d) $\sqrt{32}\frac{GM}{L}$

210. A body weighs w newton at the surface of the earth. Its weight at a height equals to half the radius of the earth, will be

a) $\frac{w}{2}$ b) $\frac{2w}{3}$ c) $\frac{4w}{9}$ d) $\frac{8w}{27}$

211. 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 11kms^{-1}, the escape velocity from the surface of the planet would be

a) 1.1 kms^{-1} b) 11 kms^{-1} c) 110 kms^{-1} d) 0.11 kms^{-1}

212. Radius of earth is around 6000 km. The weight of body of height of 6000 km from earth surface becomes

a) Half b) One-fourth c) One third d) No change

213. The gravitational field due to a mass distribution is $I = k/x^3$ in the x-direction (k is a constant). Taking the gravitational potential to be zero at infinity, its value at a distance $x/\sqrt{2}$ is

a) k/x b) $k/2x$ c) k/x^2 d) $k/2x^2$

214. The weight of an astronaut, in an artificial satellite revolving around the earth, is

a) Zero b) Equal to that on the earth

c) More than that on the earth d) Less than that on the earth

215. Two satellites S_1 and S_2 revolve around a planet in coplanar circular orbits in the same sense. Their periods of revolution are 1 h and 8 h respectively. The radius of orbit of S_1 is 10^4 km. When S_2 is closest to S_1, the speed of S_2 relative to S_1 is

a) $\pi \times 10^4 \text{ kmh}^{-1}$ b) $2\pi \times 10^4 \text{ kmh}^{-1}$ c) $3\pi \times 10^4 \text{ kmh}^{-1}$ d) $4\pi \times 10^4 \text{ kmh}^{-1}$

216. The earth (mass $= 6 \times 10^{24}$kg) revolves around the sun with angular velocity $2 \times 10^{-7} \text{ rads}^{-1}$ in a circular orbit of radius 1.5×10^8km. The force exerted by the sun on the earth in newton is

a) Zero b) 18×10^{25} c) 27×10^{39} d) 36×10^{21}

217. The required kinetic energy of an object of mass m, so that it may escape, will be

a) $\frac{1}{4}mgR$ b) $\frac{1}{2}mgR$ c) mgR d) $2mgR$

218. The gravitational potential energy of a body of mass m at a distance r from the centre of the earth is U. What is the weight of the body at this distance?

a) U b) Ur c) $\frac{U}{r}$ d) $\frac{U}{2r}$

219. The radius of orbit of a planet is two times that of the earth. The time period of planet is

a) 4.2 *years* b) 2.8 *years* c) 5.6 *years* d) 8.4 *yeasrs*

220. If the radius of the earth were to shrink by two percent, its mass remaining the same, the acceleration due to gravity on the earth's surface would

a) Decrease by 2% b) Increase by 2% c) Increase by 4% d) Decrease by 4%

221. Two planets of mean distance d_1 and d_2 from the sun and their frequencies are n_1 and n_2 respectively then

a) $n_1^2 d_1^2 = n_2 d_2^2$ b) $n_2^2 d_2^3 = n_1^2 d_1^3$ c) $n_1 d_1^2 = n_2 d_2^2$ d) $n_1^2 d_1 = n_2^2 d_2$

222. The escape velocity for the earth is v_e. The escape velocity for a planet whose radius is four times and density is nine times that of the earth, is

a) $36v_e$ b) $12v_e$ c) $6v_e$ d) $20v_e$

223. The escape velocity on earth is

a) 1.12 kms^{-1} b) 11.2 ms^{-1} c) 11.2 kmh^{-1} d) 11.2 kms^{-1}

224. The total energy of satellite moving with an orbital velocity v around the earth is

a) $\frac{1}{2}mv^2$ b) $-\frac{1}{2}mv^2$ c) mv^2 d) $\frac{3}{2}mv^2$

225. Which one of the following statements regarding artificial satellite of the earth is incorrect

a) The orbital velocity depends on the mass of the satellite

b) A minimum velocity of 8 km/sec is required by a satellite to orbit quite close to the earth

c) The period of revolution is large if the radius of its orbit is large

d) The height of a geostationary satellite is about 36000 km from earth

226. The time period of geostationary satellite at a height 36000 km is 24 h. A spy satellite orbits earth at a height 6400km. What will be the time period of sky satellite?

(Radius of earth = 6400 km)

a) 5 h b) 4 h c) 3 h d) 12 h

227. Two stars of mass m_1 and m_2 are parts of a binary system. The radii of their orbits are r_1 and r_2 respectively, measured from the C.M. of the system. The magnitude of gravitational force m_1 exerts on m_2 is

a) $\frac{m_1 m_2 G}{(r_1+r_2)^2}$ b) $\frac{m_1 G}{(r_1+r_2)^2}$ c) $\frac{m_2 G}{(r_1+r_2)^2}$ d) $\frac{(m_1+m_2)}{(r_1+r_2)^2}$

228. If the density of a small planet is the same as that of earth, while the radius of the planet is 0.2 times that of the earth, the gravitational acceleration of the surface of that planet is

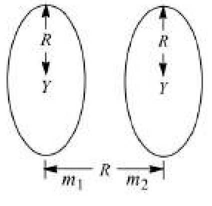
a) 0.2 g b) 0.4 g c) 2 g d) 4 g

229. In an elliptical orbit under gravitational force, in general

a) Tangential velocity is constant b) Angular velocity is constant

c) Radial velocity is constant d) Areal velocity is constant

230. Two identical thin rings each of radius R are coaxially placed at a distance R. If the rings have a uniform mass distribution and each has mass m_1 and m_2 respectively, then the work done in moving a mass m from centre of one ring to that of the other is



a) $\frac{Gmm_1(\sqrt{2}+1)}{m_2 R}$

b) $\frac{Gm(m_1-m_2)(\sqrt{2}+1)}{\sqrt{2}R}$

c) $\frac{Gm\sqrt{2}(m_1+m_2)}{R}$

d) Zero

231. The ratio of acceleration due to gravity at a height $3R$ above earth's surface to the acceleration due to gravity on the surface of the earth is ($R=$ radius of earth)

a) $\frac{1}{9}$ b) $\frac{1}{4}$ c) $\frac{1}{16}$ d) $\frac{1}{3}$

232. A geostationary satellite is orbiting the earth at a height of $6R$ above the surface of the earth; R being the radius of the earth. What will be the time period of another satellite at a height 2.5 R from the surface of the earth?

a) $6\sqrt{2}$ h b) $6\sqrt{2.5}$ h c) $6\sqrt{3}$ h d) 12 h

233. A satellite of mass m revolves around the earth of radius R at a height x from its surface. If g is the acceleration due to gravity on the surface of the earth, the orbital speed the satellite is

a) gx b) $\frac{gR}{R-x}$ c) $\frac{gR^2}{R+x}$ d) $\left(\frac{gR^2}{R+x}\right)^{1/2}$

234. A spring balance is graduated on sea level. If a body is weighed with this balance at consecutively increasing heights from earth's surface, the weight indicated by the balance

a) Will go on increasing continuously b) Will go on decreasing continuously
c) Will remain same d) Will first increase and then decrease

235. A particle of mass m is placed at the centre of a uniform spherical shell of mass 3 m and radius R. The gravitational potential on the surface of the shell is

a) $-\frac{Gm}{R}$ b) $-\frac{3Gm}{R}$ c) $-\frac{4Gm}{R}$ d) $-\frac{2Gm}{R}$

236. In the following four periods

(i) Time of revolution of a satellite just above the earth's surface (T_{st})
(ii) Period of oscillation of mass inside the tunnel bored along the diameter of the earth (T_{ma})
(iii) Period of simple pendulum having a length equal to the earth's radius in a uniform field of $9.8N/kg(T_{sp})$
(iv) Period of an infinite length simple pendulum in the earth's real gravitational filed (T_{is})

a) $T_{st} > T_{ma}$ b) $T_{ma} > T_{st}$
c) $T_{sp} > T_{is}$ d) $T_{st} = T_{ma} = T_{sp} = T_{is}$

237. The change in the gravitational potential energy when a body mass m is raised to a height nR above the surface of the earth is (here R is the radius of the earth)

a) $\left(\frac{n}{n+1}\right)mgR$ b) $\left(\frac{n}{n-1}\right)mgR$ c) $nmgR$ d) $\frac{mgR}{n}$

238. A planet of mass m moves around the sun of mass M in an elliptical orbit. The maximum and minimum distance of the planet from the sun are r^1 and r^2, respectively. The time period of the planet is proportional to

a) (r_1+r_2) b) $(r_1+r_2)^{1/2}$ c) $(r_1-r_2)^{3/2}$ d) $(r_1+r_2)^{3/2}$

239. The masses and radii of the earth and moon are M_1, R_1 and M_2, R_2 respectively. Their centres are distance d apart. The minimum velocity with which a particle of mass m shoule be projected from a point midway between their centres so that it escapes to infinity is

a) $2\sqrt{\frac{G}{d}(M_1+M_2)}$ b) $2\sqrt{\frac{2G}{d}(M_1+M_2)}$ c) $2\sqrt{\frac{Gm}{d}(M_1+M_2)}$ d) $2\sqrt{\frac{Gm(M_1+M_2)}{d(R_1+R_2)}}$

240. One goes from the centre of the earth to a distance two third the radius of the earth, where will the acceleration due to gravity be the greatest?

a) At the centre of the earth
b) At a height half the radius of the earth
c) At a height one-third the radius of the earth
d) At a height two-third the radius of the earth

241. The value of g decreases inside the surface of earth because

a) A force of upward attraction is applied by the shell of earth above

b) The shell of earth above exerts no net force
c) The distance from the centre of the earth decreases
d) The density of the material at the centre of the earth is very small

242. Two balls, each of radius R, equal mass and density are placed in contact, then the force of gravitation between them is proportional to

a) $F \propto \frac{1}{R^2}$ b) $F \propto R$ c) $F \propto R^4$ d) $F \propto \frac{1}{R}$

243. The orbital speed of an artificial satellite very close to the surface of the earth is V_o. Then the orbital speed of another artificial satellite at a height equal to three times the radius of the earth is

a) 1 V_o b) 2 V_o c) 0.5 V_o d) 4 V_o

244. The ratio of the distances of two planets from the sun is 1.38. The ratio of their period of revolution around the sun is

a) 1.38 b) $1.38^{3/2}$ c) $1.38^{1/2}$ d) 1.38^3

245. The escape velocity of a body on the surface of the earth is 11.2 km/s. If the earth's mass increases to twice its present value and the radius of the earth becomes half, the escape velocity would become

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

246. The maximum vertical distance through which a full dressed astronaut can jump on the earth is 0.5 m. Estimate the maximum vertical distance through which he can jump on the moon, which has a mean density 2/3rd that of earth and radius one quarter that of the earth

a) 1.5 m b) 3 m c) 6 m d) 7.5 m

247. Distance of geostationary satellite from the surface of earth $radius(R_e = 6400\ km)$ in terms of R_e is

a) 13.76 R_e b) 10.76 R_e c) 6.56 R_e d) 2.56 R_e

248. A particle of mass m is placed inside a spherical shell, away from its centre. The mass of the shell is M

a) The particle will move towards the centre if $m < M$, and away from the centre if $m > M$
b) The particle will move towards the centre
c) The particle will oscillate about the centre of shell
d) The particle will remain stationary

249. A straight rod of length L extends from $x = a$ to $x = L + a$. Find the gravitational force it, exerts on a point mass m at $x = 0$ if the linear density of rod $\mu = A + Bx^2$

a) $Gm\left[\frac{A}{a} + BL\right]$
b) $Gm\left[A\left(\frac{1}{a} - \frac{1}{a+L}\right) + BL\right]$
c) $Gm\left[BL + \frac{A}{a+L}\right]$
d) $Gm\left[BL - \frac{A}{a}\right]$

250. The escape velocity of a body from the earth is v_e. If the radius of earth contracts to 1/4th of its value, keeping the mass of the earth constant, the escape velocity will be

a) Doubled b) Halved c) Tripled d) Unaltered

251. In a satellite, if the time of revolution is T, then KE is proportional to

a) $\frac{1}{T}$ b) $\frac{1}{T^2}$ c) $\frac{1}{T^3}$ d) $T^{-2/3}$

252. A satellite is launched into a circular orbit of radius R around the earth. A second satellite is launched into an orbit of radius $4R$. The ratio of their respective periods is

a) 4:1 b) 1:8 c) 8:1 d) 1:4

253. A satellite which is geostationary in a particular orbit is taken to another orbit. Its distance from the centre of earth in new orbit is 2 times that of the earlier orbit. The time period in the second orbit is

a) 4.8 *hours* b) $48\sqrt{2}$ *hours* c) 24 *hours* d) $24\sqrt{2}$ *hours*

254. A clock S is based on oscillation of a spring and a clock P is based on pendulum motion. Both clocks run at the same rate on earth. On a planet having the same density as earth but twice the radius

a) S will run faster than P
b) P will run faster than S
c) They will both run at the same rate as on the earth
d) None of these

255. If mass of a satellite is doubled and time period remain constant the ratio of orbit in the two cases will be

a) 1 : 2 b) 1 : 1 c) 1 : 3 d) None of these

256. If a man weighs 90 kg on the surface of earth, the height above the surface of the earth of radius R, where the weight is 30 kg is

a) 0.73 R b) $R/\sqrt{3}$ c) $R/3$ d) $\sqrt{3}R$

257. A particle is projected vertically upwards from the surface of earth (radius R_e) with a kinetic energy equal to half of the minimum value needed for it to escape. The height to which it rises above the surface of earth is

a) R_e b) $2R_e$ c) $3R_e$ d) $4R_e$

258. If the escape velocity of a planet is 3 times that of the earth and its radius is 4 times that of the earth, then the mass of the planet is (Mass of the earth $= 6 \times 10^{24} kg$)

a) $1.62 \times 10^{22} kg$ b) $0.72 \times 10^{22} kg$ c) $2.16 \times 10^{26} kg$ d) $1.22 \times 10^{22} kg$

259. What will be the acceleration due to gravity at height h if $h >> R$. Where R is radius of earth and g is acceleration due to gravity on the surface of earth

a) $\frac{g}{\left(1+\frac{h}{R}\right)^2}$ b) $g\left(1-\frac{2h}{R}\right)$ c) $\frac{g}{\left(1-\frac{h}{R}\right)^2}$ d) $g\left(1-\frac{h}{R}\right)$

260. A body of mass m is moved to a height h equal to the radius of the earth. The increase in potential energy is

a) $2\ mgR$ b) mgR c) $mgR/2$ d) $mgR/4$

261. Assume that the acceleration due to gravity on the surface of the moon is 0.2 times the acceleration due to gravity on the surface of the earth. If R_e is the maximum range of a projectile on the earth's surface, what is the maximum range on the surface of the moon for the same velocity of projection

a) 0.2 R_e b) 2 R_e c) 0.5 R_e d) 5 R_e

262. A particle of mass M is situated at the centre of a spherical shell of same mass and radius a. The magnitude of the gravitational potential at a point situated at $a/2$ distance from the centre, will be

a) $\frac{4GM}{a}$ b) $\frac{GM}{a}$ c) $\frac{2GM}{a}$ d) $\frac{3GM}{a}$

263. The distance of a planet from the sun is 5 times, the distance between the earth and the sun. the time period of the planet is

a) $6^{3/2}T$ yr b) $5^{3/2}T$ yr c) $5^{3/1}T$ yr d) $5^{1/2}T$ yr

264. A satellite of mass m is orbiting close to the surface of the earth (Radius R = 6400 km) has a kinetic energy k. The corresponding kinetic energy of the satellite to escape from the earth's gravitational field is

a) K b) $2K$ c) mgR d) mK

265. Two equal masses m and m are hung from a balance whose scale pans differ in height by h. If ρ is the mean density of earth, then the error in weighing is

a) Zero b) $4\pi G\rho mh/3$ c) $8\pi G\rho mh/3$ d) $2\pi G\rho mh/3$

266. A body is projected with velocity of 2×11.2 km/s from the form the surface of earth. The velocity of the body when it escapes the gravitational pull of earth is

a) $\sqrt{3} \times 11.2$ km/s b) 11.2 km/s c) $\sqrt{2} \times 11.2$ km/s d) 0.5×11.2 km/s

267. If the earth 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

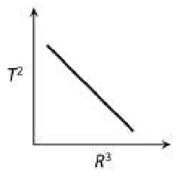
c) Remain unchanged at the equator but decrease at the poles

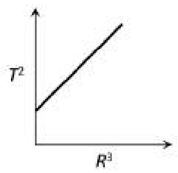
d) Remain unchanged at the equator but increase at the poles

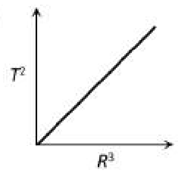
268. The escape velocity from earth is v_{es}. A body is projected with velocity $2v_{es}$ with what constant velocity will it move in the inter planetary space

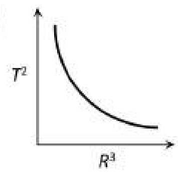
a) v_{es} b) $3v_{es}$ c) $\sqrt{3}v_{es}$ d) $\sqrt{5}v_{es}$

269. Which of the following graphs represents the motion of a planet moving about the sun

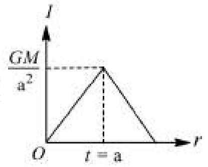
a) 

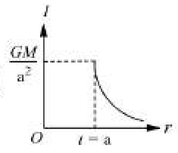
b) 

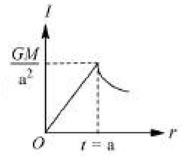
c) 

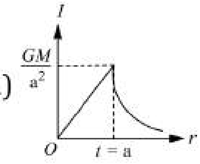
d) 

270. Which of the following graphs represents correctly the variation of the intensity of gravitational field (I) with the distance (r) from the centre of a spherical shell of mass M and radius a?

a) 

b) 

c) 

d) 

271. Astronaut is in a stable orbit around the earth when he weighs a body of mass 5 kg. What is reading of spring balance?
a) Spring will not be extended
b) Spring will be extended according to Hook's law
c) Less than 5 kg-wt
d) More than 5 kg-wt

272. The gravitational field in a region is given by $\vec{\mathbf{I}} = (4\hat{\mathbf{i}} + \hat{\mathbf{j}})\text{Nkg}^{-1}$. Work done by this field is zero when a particle is moved along the line
a) $x + y = 6$ b) $x + 4y = 6$ c) $y + 4x = 6$ d) $x - y = 6$

273. Satellite A and B are revolving around the orbit of earth. The mass of A is 10 times of mass of B. The ratio of time period $\left(\frac{T_A}{T_B}\right)$ is
a) 10 b) 1 c) $\frac{1}{5}$ d) $\frac{1}{10}$

274. Mass of moon is 7.34×10^{22} kg. If the acceleration due to gravity on the moon is 1.4 ms^{-2}, the radius of the moon is ($G = 6.667 \times 10^{11} \text{Nm}^2\text{kg}^{-2}$)
a) 0.56×10^4m b) 1.87×10^6m c) 1.92×10^6m d) 1.01×10^8m

275. The angular velocity of the earth with which it has to rotate so that acceleration due to gravity on 60° latitude becomes zero is (Radius of earth = 6400 km. At the poles $g = 10\ ms^{-2}$)
a) $2.5 \times 10^{-3} rad/s$ b) $5.0 \times 10^{-1} rad/s$ c) $1 \times 10^1 rad/s$ d) $7.8 \times 10^{-2} rad/s$

276. If the diameter of mars is 6760 km and mass one-tenth that of earth. The diameter of earth is 12742 km. If acceleration due to gravity on earth is 9.8 ms^{-2}, the acceleration due to gravity on mass is
a) 34.8 ms^{-2} b) 2.84 ms^{-2} c) 3.48 ms^{-2} d) 28.4 ms^{-2}

277. If mass of earth is M, radius is R and gravitational constant is G, then work done to take 1 kg mass from earth surface to infinity will be
a) $\sqrt{\frac{GM}{2R}}$ b) $\frac{GM}{R}$ c) $\sqrt{\frac{2GM}{R}}$ d) $\frac{GM}{2R}$

278. Gravitational field is
a) Conservative b) Non-conservative c) Electromagnetic d) Magnetic

279. An artificial satellite moving in circle 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 $-3E_0$ c) $2E_0$ and $-E_0$ d) $-2E_0$ and $-E_0$

280. If the change in the value of $'g'$ at a height h above the surface of the earth is the same as at a depth x below it, then (both x and h being much smaller than the radius of the earth)
a) $x = h$ b) $x = 2h$ c) $x = \frac{h}{2}$ d) $x = h^2$

281. Acceleration due to gravity on moon is 1/6 of the acceleration due to gravity on earth. If the ratio of densities of earth (ρ_e) and moon (ρ_m) is $\left(\frac{\rho_e}{\rho_m}\right) = \frac{5}{3}$ then radius of moon (R_m) in terms of R_e will be

a) $\frac{5}{18} R_e$ b) $\frac{1}{6} R_e$ c) $\frac{3}{18} R_e$ d) $\frac{1}{2\sqrt{3}} R_e$

282. At what depth below the surface of the earth, the value of g is the same as that at a height of 5 km?

a) 1.25 km b) 2.5 km c) 5 km d) 10 km

283. A man is standing on an international space station, which is orbiting earth at an altitude 520 km with a constant speed 7.6 km/s. If the man's weight is 50 kg, his acceleration is

a) $7.6 km/s^2$ b) $7.6 m/s^2$ c) $8.4 m/s^2$ d) $10 m/s^2$

284. Time speed of revolution of a nearest satellite around a planet of radius R is T. Period of revolution around another planet, whose radius is 3R but having same density is

a) T b) $3T$ c) $9T$ d) $3\sqrt{3}T$

285. 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

286. If g_e, g_h and g_d be the accelerations due to gravity at earth's surface, a height h and at depth d respectively. Then

a) $g_e > g_h > g_d$ b) $g_e > g_h < g_d$ c) $g_e < g_h < g_d$ d) $g_e < g_h > g_d$

287. If a planet of given density were made larger (keeping its density unchanged) its force of attraction for an object on its surface would increase because of increased mass of the planet but would decrease because of larger separation between the centre of the planet and its surface. Which effect would dominate?

a) Increase in mass b) Increase in radius

c) Both affect the attraction equally d) None of the above

288. Two planets have the same average density but their radii are R_1 and R_2. If acceleration due to gravity on these planets be g_1 and g_2 respectively, then

a) $\frac{g_1}{g_2} = \frac{R_1}{R_2}$ b) $\frac{g_1}{g_2} = \frac{R_2}{R_1}$ c) $\frac{g_1}{g_2} = \frac{R_1^2}{R_2^2}$ d) $\frac{g_1}{g_2} = \frac{R_1^3}{R_2^3}$

289. Two satellite A and B, ratio of masses 3 : 1 are in circular orbits of radii r and $4r$. Then ratio of total mechanical energy of A to B is

a) 1 : 3 b) 3 : 1 c) 3 : 4 d) 12 : 1

290. What is the escape velocity for a body on the surface of a planet on which the acceleration due to gravity is $(3.1)^2 ms^{-2}$ and whose radius is 8100 km

a) 2790 $km.s^{-1}$ b) 27.9 $km.s^{-1}$ c) $\frac{27.9}{\sqrt{5}} km.s^{-1}$ d) $27.9\sqrt{5} km.s^{-1}$

291. An astronaut on a strange planet finds that acceleration due to gravity is twice as that on the surface of earth. Which of the following could explain this

a) Both the mass and radius of the planet are half as that of earth

b) Radius of the planet is half as that of earth, but the mass is the same as that of earth

c) Both the mass and radius of the planet are twice as that of earth

d) Mass of the planet is half as that of earth, but radius is same as that of earth

292. The height from the earth surface at which the value of acceleration due to gravity reduces to $1/4^{th}$ of its value at earth's surface (assume earth to be sphere of radius 6400 km)

a) 6400 km b) 2649 km c) 2946 km d) 1600 km

293. Gravitational acceleration on the surface of a planet is $\frac{\sqrt{6}}{11} g$, where g is the gravitational acceleration on the surface of earth. The average mass density of the planet is $\frac{2}{3}$ times that of the earth. If the escape speed on the surface of the earth is taken on be 11 kms^{-1}, the escape speed on the surface of the planet in kms^{-1} will be

a) 5 b) 7 c) 3 d) 11

294. Two identical trains P and Q move with equal speeds on parallel tracks along the equator. P moves from east to west and Q from west to east

a) Data is sufficient to arrive at a conclusion

b) Both exert equal force on track

c) Train Q exerts force on track

d) Train P exerts greater force on track

295. What is the height the weight of body will be the same as at the same depth from the surface of the earth? Radius of earth is R

a) $\frac{R}{2}$ b) $\sqrt{5}R - R$ c) $\frac{\sqrt{5}R - R}{2}$ d) $\frac{\sqrt{3}R - R}{2}$

296. The additional kinetic energy to be provided to a satellite of mass m revolving around a planet of mass M, to transfer it from a circular orbit of radius R_1 to another of radius $R_2 (R_2 > R_1)$ is

a) $GmM\left(\frac{1}{R_1^2} - \frac{1}{R_2^2}\right)$ b) $GmM\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ c) $2GmM\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ d) $\frac{1}{2}GmM\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

297. A body is projected vertically upwards from the surface of a planet of radius R with a velocity equal to half the escape velocity for that planet. The maximum height attained by the body is

a) $R/3$ b) $R/2$ c) $R/4$ d) $R/5$

298. Given radius of Earth $'R'$ and length of a day $'T'$ the height of a geostationary satellite is [G-Gravitational Constant, M-Mass of Earth]

a) $\left(\frac{4\pi^2 GM}{T^2}\right)^{1/3}$ b) $\left(\frac{4\pi GM}{R^2}\right)^{1/3} - R$ c) $\left(\frac{GMT^2}{4\pi^2}\right)^{1/3} - R$ d) $\left(\frac{GMT^2}{4\pi^2}\right)^{1/3} + R$

299. The gravitational potential energy of a body of mass $'m'$ at the earth's surface is $-mgR_e$. Its gravitational potential energy at a height R_e from the earth's surface will be (Here R_e is the radius of the earth)

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

300. 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 BCD

c) The time taken in travelling $CDAD$ is less than that for ABC

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

301. If an object of mass m is taken from the surface of earth (radius R) to a height $2R$, then the work done is

a) $2mgR$ b) mgR c) $\frac{2}{3}mgR$ d) $\frac{3}{2}mgR$

302. A comet of mass m moves in a highly elliptical orbit around the sun of mass M. The maximum and minimum distances of the comet from the centre of the sun are r_1 and r_2 respectively. The magnitude of angular momentum of the comet with respect to the centre of sun is

a) $\left[\frac{GMr_1}{(r_1 + r_2)}\right]^{1/2}$ b) $\left[\frac{GMmr_1}{(r_1 + r_2)}\right]^{1/2}$ c) $\left(\frac{2Gm^2 r_1 r_2}{r_1 + r_2}\right)^{1/2}$ d) $\left(\frac{2GMm^2 r_1 r_2}{r_1 + r_2}\right)^{1/2}$

303. If density of earth increased 4 times and its radius become half of what it is, our weight will

a) Be four times its present value b) Be doubled

c) Remain same d) Be halved

304. Suppose the gravitational force varies inversely as the nth power of distance. Then the time period of a planet in circular orbit of radius R around the sun will be proportional to

a) $R^{\left(\frac{n+1}{2}\right)}$ b) $R^{\left(\frac{n-1}{2}\right)}$ c) R^n d) $R^{\left(\frac{n-2}{2}\right)}$

305. Acceleration due to gravity g for a body of mass m on earth's surface is proportional to (Radius of earth = R, mass of earth = M)

a) M/R^2 b) m^0 c) mM d) $1/R^{3/2}$

306. 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

307. If $g \propto \frac{1}{R^3}$ (instead of $\frac{1}{R^2}$), then the relation between time period of a satellite near earth's surface and radius R will be

a) $T^2 \propto R^3$ b) $T \propto R^2$ c) $T^2 \propto R$ d) $T \propto T$

308. The potential energy of gravitational interaction of a point mass m and a thin uniform rod of mass M and length l, if they are located along a straight line at distance a from each other is

a) $U = \frac{GMm}{a}\log_e\left(\frac{a+l}{a}\right)$ b) $U = GMm\left(\frac{1}{a} - \frac{1}{a+l}\right)$

c) $U = -\frac{GMm}{l}\log_e\left(\frac{a+l}{a}\right)$ d) $U = -\frac{GMm}{a}$

309. The earth revolves about the sun in an elliptical orbit with mean radius $9.3 \times 10^7 m$ in a period of 1 year. Assuming that there are no outside influences

a) The earth's kinetic energy remains constant b) The earth's angular momentum remains constant

c) The earth's potential energy remains constant d) All are correct

310. Which force in nature exits every where

a) Nuclear force b) Electromagnetic force

c) Weak force d) Gravitation

311. The distance between the earth and the moon is 3.85×10^8m. At what distance from the earth's centre, the intensity of gravitational field will be zero? The masses of earth and moon are 5.98×10^{24} kg and 7.35×10^{22} kg respectively

a) 3.47×10^8m b) 0.39×10^8m c) 1.82×10^8m d) None of these

312. At what height in km over the earth's pole the free fall acceleration decreases by one percent? (Assume the radius of the earth to be 6400 km)

a) 32 b) 64 c) 80 d) 1.253

313. If r denotes the distance between the sun and the earth, then the angular momentum of the earth around the sun is proportional to

a) $r^{3/2}$ b) r c) $\sqrt{r}$ d) r^2

314. At what distance from the centre of the earth, the value of acceleration due to gravity g will be half that on the surface (R = radius of earth)

a) 2 R b) R c) 1.414 R d) 0.414 R

315. The depth from the surface of the earth of radius R at which the acceleration due to gravity will be 75% of the value on the surface of the earth is

a) $R/4$ b) $R/2$ c) $3R/4$ d) $R/8$

316. The escape velocity for a body projected vertically upwards from the surface of earth is 11 kms^{-1}. If the body is projected at an angle of 45° with the vertical, the escape velocity will be

a) $11\sqrt{2}\text{kms}^{-1}$ b) 22 kms^{-1} c) 11 kms^{-1} d) $11/\sqrt{2}\ \text{ms}^{-1}$

317. Reason of weightlessness in a satellite is

a) Zero gravity b) Centre of mass

c) Zero reaction force by satellite surface d) None

318. The mass and radius of the sun are $1.99 \times 10^{30} kg$ and $R = 6.96 \times 10^8$ m. The escape velocity of a rocket from the Sun is

a) 11.2 km/s b) 2.38 km/s c) 59/5 km/s d) 618 km/s

319. When earth moves around the sun, the quantity which remains constant is

a) Angular velocity b) Kinetic energy c) Potential energy d) Areal velocity

320. If g is the acceleration due to gravity on the surface of the earth, the gain in potential energy of an object of mass m raised from the earth's surface to a height equal to the radius R of the earth is

a) $\frac{mgR}{4}$ b) $\frac{mgR}{2}$ c) mgR d) $2mgR$

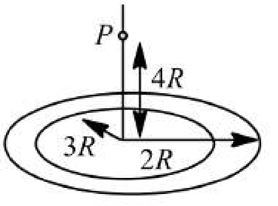
321. If the radius of the earth were to shrink by 1% its mass remaining same, the acceleration due to gravity on the earth's surface would

a) Decrease by 2% b) Remain unchanged c) Increase by 2% d) Become zero

322. If the diameter of mass is 6760 km and mass one-tenth that of earth. The diameter of earth is 12742 km. If acceleration due to gravity on earth is 9.8 ms^{-2}, the acceleration due to gravity on mass is

a) 34.8 ms^{-2} b) 2.48 ms^{-2} c) 3.48 ms^{-2} d) 28.4 ms^{-2}

323. A thin uniform annular disc (see figure) of mass M has outer radius $4R$ and inner radius $3R$. The work required to take a unit mass from point P on its axis to infinity is



a) $\frac{2GM}{7R}(4\sqrt{2}-5)$ b) $-\frac{2GM}{7R}(4\sqrt{2}-5)$ c) $\frac{GM}{4R}$ d) $\frac{2GM}{5R}(\sqrt{2}-1)$

324. A spaceship is launched into a circular orbit close to earth's surface. The additional velocity that should be imparted to the spaceship in the orbit to overcome the gravitational pull is (Radius of earth = 6400 km and g = 9.8 ms^{-2})

a) 11.2 kms^{-1} b) 8 kms^{-1} c) 3.2 kms^{-1} d) 1.5 kms^{-1}

325. The escape velocity of a projectile from the earth is approximately

a) 11.2 m/sec b) 112 km/sec c) 11.2 km/sec d) 11200 km/sec

326. Two satellites of earth, S_1 and S_2, are moving in the same orbit. The mass of S_1 is four times the mass of S_2. Which one of the following statements is true?

a) The time period of S_1 is four times that of S_2

b) The potential energies of earth and satellite in the two cases are equal

c) S_1 and S_2 are moving with the same speed

d) The kinetic energies of the two satellites are equal

327. The acceleration due to gravity is g at a point distant r from the centre of earth of radius R. If $r < R$, then

a) $g \propto r$ b) $g \propto r^2$ c) $g \propto r^{-1}$ d) $g \propto r^{-2}$

328. The value of g on the surface of earth is smallest at the equator because

a) The centripetal force is maximum at equator

b) The centripetal force is least at equator

c) The angular speed of earth is maximum at equator

d) The angular speed of earth is least at equator

329. The ratio of acceleration due to gravity at a height h above the surface of the earth and at a depth h below the surface of the earth for $h <<$ radius of earth

a) Is constant

b) Increases linearly with h

c) Decreases linearly with h

d) Decreases parabolically with h

330. The mass of the moon is about 1.2% of the mass of the earth. Compared to the gravitational force the earth exerts on the moon, the gravitational force the moon exerts on earth

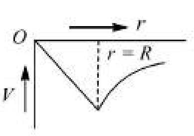
a) Is the same b) Is smaller c) Is greater d) Varies with its phase

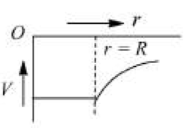
331. If the earth were to spin faster, acceleration due to gravity at the poles

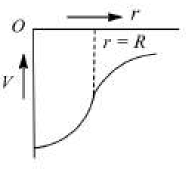
a) increase b) decreases

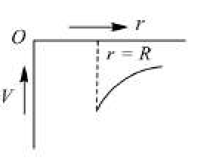
c) remain the same d) depends on how fast it spins

332. P is point at a distance r from the centre of a solid sphere of radius r. The variation of gravitational potential at P (ie, V) and distance r from the centre of sphere is represented by the curve.

a) 

b) 

c) 

d) 

333. A solid sphere of mass M and radius R has a spherical gravity of radius $\frac{R}{2}$ such that the centre of cavity is at distance $R/2$ from the centre of the sphere. A point mass m is placed inside the cavity at a distance $R/4$ from the centre of sphere. The gravitational pull between the sphere and the point mass m is

a) $\frac{11GMm}{R^2}$ b) $\frac{14GMm}{R^2}$ c) $\frac{GMm}{2R^2}$ d) $\frac{GMm}{R^2}$

334. Assuming that the earth is a sphere of radius R_E with uniform density, the distance from its centre at which the acceleration due to gravity is equal to $\frac{g}{3}$ (g is the acceleration due to gravity on the surface of earth) is

a) $\frac{R_E}{3}$ b) $\frac{2R_E}{3}$ c) $\frac{R_E}{2}$ d) $\frac{R_E}{4}$

335. If v_e and v_o represent escape velocity and orbital velocity of a satellite corresponding to a circular orbit of radius R, then

a) $v_e = v_o$
b) $\sqrt{2}v_o = v_e$
c) $v_e = v_o/\sqrt{2}$
d) v_e and v_o are not related

336. The acceleration due to gravity near the surface of a planet of radius R and density d is proportional to

a) $\frac{d}{R^2}$ b) dR^2 c) dR d) $\frac{d}{R}$

337. A body of weight 500 N on the surface of the earth. How much would it weigh half-way below the surface of the earth?

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

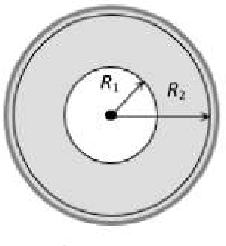
338. Three identical bodies of mass M are located at the vertices of an equilateral triangle of side L. They revolve under the effect of mutual gravitational force in a circular orbit, circumscribing the triangle while preserving the equilateral triangle. Their orbital velocity is

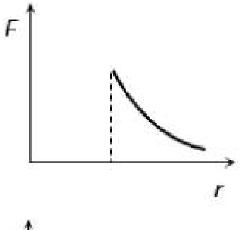
a) $\sqrt{\frac{GM}{L}}$ b) $\sqrt{\frac{3GM}{2L}}$ c) $\sqrt{\frac{3GM}{L}}$ d) $\sqrt{\frac{2GM}{3L}}$

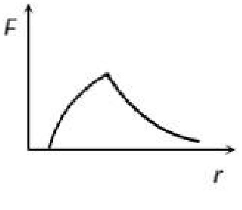
339. A satellite A of mass m is at a distance of r from the centre of the earth. Another satellite B of mass $2m$ is at a distance of $2r$ from the earth's centre. Their time periods are in the ratio of

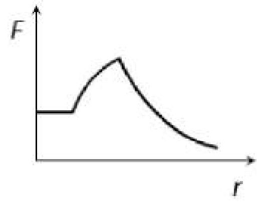
a) $1:2$ b) $1:16$ c) $1:32$ d) $1:2\sqrt{2}$

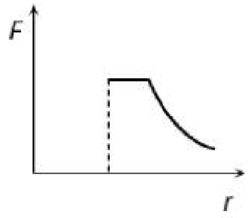
340. A sphere of mass M and radius R_2 has a concentric cavity of radius R_1 as shown in figure. The force F exerted by the sphere on a particle of mass m located at a distance r from the centre of sphere varies as ($0 \le r \le \infty$)



a) 

b) 

c) 

d) 

341. 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) $\sqrt{2gR^2}$ b) $\sqrt{\frac{2GM}{R^2}}$ c) $\sqrt{\frac{2GM}{R}}$ d) $\sqrt{\frac{2gM}{R^2}}$

342. The gravitational force between two point masses m_1 and m_2 at separation r is given by $F = k\frac{m_1 m_2}{r^2}$
The constant k

a) Depends on system of units only
b) Depends on medium between masses only
c) Depends on both (a) and (b)
d) Is independent of both (a) and (b)

343. At what height h above earth, the value of g becomes $g/2$? ($R =$ radius of earth)

a) $3R$ b) $\sqrt{2}\,R$ c) $(\sqrt{2}-1)R$ d) $\frac{1}{\sqrt{2}}R$

344. If a body describes a circular motion under inverse square field, the time taken to complete one revolution T is related to the radius of the of the circular orbit is

a) $T \propto r$ b) $T \propto r^2$ c) $T^2 \propto r^3$ d) $T \propto r^4$

345. The value of g on the earth's surface is 980 cms^{-2}. Its value at a height of 64 km from the earth's surface is

a) 960.40 cms^{-2} b) 984.90 cms^{-2} c) 982.45 cms^{-2} d) 977.55 cms^{-2}

346. The atmosphere is held to the earth by

a) Winds b) Gravity c) Clouds d) None of the above

347. The value of escape velocity on a certain planet is 2 km s^{-1}. Then, the value of orbital speed for a satellite orbiting close to its surface is

a) 112 kms^{-1} b) 1 kms^{-1} c) $\sqrt{2}$ Kms^{-1} d) $2\sqrt{2}$ kms^{-1}

348. A satellite with kinetic energy E_k is revolving round the earth in a circular orbit. How much more kinetic energy should be given to it so that it may just escape into outer space

a) E_k b) $2\,E_k$ c) $\frac{1}{2}E_k$ d) $3\,E_k$

349. Select the correct statement from the following

a) The orbital velocity of a satellite increases with the radius of the orbit
b) Escape velocity of a particle from the surface of the earth depends on the speed with which it is fired
c) The time period of satellite does not depend on the radius of the orbit
d) The orbital velocity is inversely proportional to the square root of the radius of the orbit

350. Correct form of gravitational law is

a) $F = -\frac{Gm_1m_2}{r^2}$ b) $\vec{F} = -\frac{Gm_1m_2}{r^2}$ c) $\vec{F} = -\frac{Gm_1m_2}{r^3}\hat{r}$ d) $\vec{F} = -\frac{Gm_1m_2\vec{r}}{r^3}$

351. If the earth suddenly shrinks (without changing mass) to half of its present radius, the acceleration due to gravity will be

a) $g/2$ b) $4g$ c) $g/4$ d) $2g$

352. Two bodies of masses 100 kg and 1000 kg are separated by distance of 1 m. What is the intensity of gravitational field at the mid point of the line joining them?
a) $6.6 \times 10^{-11} Nm^2kg^{-2}$ b) $2.4 \times 10^{-8} Mkg^{-1}$ c) $2.4 \times 10^{-7} Nkg^{-1}$ d) $2.4 \times 10^{-6} Nkg^{-1}$

353. If r represents the radius of the orbit of a satellite of mass m moving around a planet of mass M, the velocity of the satellite is given by
a) $v^2 = g\frac{M}{r}$ b) $v^2 = \frac{GMm}{r}$ c) $v = \frac{GM}{r}$ d) $v^2 = \frac{GM}{r}$

354. When a satellite going round the earth in a circular orbit of radius r and speed v loses some of its energy, then r and v change as
a) r and v both will increase
b) r and v both will decrease
c) r will decrease and v will increase
d) r will decrease and v will decrease

355. A person sitting on a chair in a satellite feels weightless because
a) The earth dose not attract the object in a satellite
b) The normal force by the chair on the person balances the earth's attraction
c) The normal force is zero
d) The person in satellite is not accelerated

356. Assuming earth to be a sphere of radius R, if $g_{30°}$ is value of acceleration due to gravity at latitude of 30° and g at the equator, the value of $g - g_{30°}$is
a) $\frac{1}{4}\omega^2 R$ b) $\frac{3}{4}\omega^2 R$ c) $\omega^2 R$ d) $\frac{1}{2}\omega^2 R$

357. How high a man be able to jump on surface of a planet of radius 320 km, but having density same as that of the earth if he jumps 5 m on the surface of the earth (Radius of earth = 6400 km)
a) 60 m b) 80 m c) 100 m d) 120 m

358. The escape velocity of a sphere of mass m from earth having mass M and radius R is given by
a) $\sqrt{\frac{2GM}{R}}$ b) $2\sqrt{\frac{GM}{R}}$ c) $\sqrt{\frac{2GMm}{R}}$ d) $\sqrt{\frac{GM}{R}}$

359. 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
a) 6.4×10^{11} $Joules$ b) 6.4×10^{8} $Joules$ c) 6.4×10^{9} $Joules$ d) 6.4×10^{10} $Joules$

360. Mass M is divided into two parts xM and $(1-x)M$. For a given separation, the value of x for which the gravitational attraction between the two pieces becomes maximum is
a) $\frac{1}{2}$ b) $\frac{3}{5}$ c) 1 d) 2

361. The changes in potential energy when a body of mass m is raised to a height nR from earth's surface is (R = radius of the earth)
a) $mgR\frac{n}{(n-1)}$ b) mgR c) $mgR\frac{n}{(n+1)}$ d) $mgR\frac{n^2}{(n^2+1)}$

362. If the earth stops rotating, the value of g at the equator
a) increases b) decreases c) no effect d) None of these

363. The escape velocity from the earth is 11.2 kms^{-1}. The escape velocity from a planet having twice the radius and the same mean density is (in kms^{-1})
a) 11.2 b) 5.6 c) 15 d) 22.4

364. What is the binding energy of earth-sun system neglecting the effect of other planets and satellites? (Mass of earth $M_e = 6 \times 10^{24}$kg, mass of the sun $M_x = 2 \times 10^{30} kg^{-2}$)
a) 8.8×10^{10} J b) 8.8×10^{3} J c) 5.2×10^{33} J d) 2.6×10^{33} J

365. If g is the acceleration due to gravity on earth's surface, the gain of the potential energy of an object of mass m raised from the surface of the earth to a height equal to the radius R of the earth is
a) $2mgR$ b) mgR c) $\frac{1}{2}mgR$ d) $\frac{1}{4}mgR$

366. An artificial satellite is moving in a circular orbit around the Earth. The height of the satellite above the surface of Earth is R. Suppose the satellite is stopped suddenly in its orbit and allowed to fall freely. On reaching Earth, its speed will be

a) $\sqrt{gR}$ b) $2\sqrt{gR}$ c) $3\sqrt{gR}$ d) $5\sqrt{gR}$

367. Two spheres of mass 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) F b) $\frac{F}{3}$ c) $\frac{F}{9}$ d) $3F$

368. If the radius of earth's orbit is made $1/4^{th}$, then duration of an year will become

a) 8 times b) 4 times c) 1/8 times d) 1/4 times

369. The rotation period of an earth satellite close to the surface of the earth is 83 min. the satellite in a orbit at a distance of three times earth radii from its surface will be

a) 83 min b) $83 \times \sqrt{8}$ min c) 664 min d) 249 min

370. Three weights w, $2w$ and $3w$ are connected to identical spring suspended from a rigid horizontal rod. The assembly of the rod and weights fall freely. The positions of the weight from the rod are such that

a) $3w$ will be farthest b) w will be farthest
c) All will be at the same distance d) $2w$ will be farthest

371. A planet moving along an elliptical orbit is closest to the sun at a distance r_1 and farthest away at a distance of r_2. If v_1 and v_2 are the linear velocities at these points respectively. Then the ratio $\frac{v_1}{v_2}$ is

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

372. An astronaut orbiting the earth in a circular orbit 120 km above the surface of earth, gently drops a spoon out of space-ship. The spoon will

a) Fall vertically down to the earth b) Move towards the moon
c) Will move along with space-ship d) Will move in an irregular way then fall down to earth

373. At some point the gravitational potential and also the gravitational field due to earth is zero. The speed is

a) On earth's surface b) Below earth's surface
c) At a height R_e from earth's surface (R_e = radius of the earth) d) At infinity

374. A satellite is to revolve round the earth in a circle of radius 8000 km. The speed at which this satellite be projected into an orbit, will be

a) 3 km/s b) 16 km/s c) 7.15 km/s d) 8 km/s

375. Two planets have radii r_1 and r_2 and densities d_1 and d_2 respectively. Then the ratio of acceleration due to gravity on them will be

a) $r_1d_1:r_2d_2$ b) $r_1d_2:r_2d_1$ c) $r_1^2d_1:r_2^2d_2$ d) $r_1:r_2$

376. The maximum and minimum distances of a comet from the sun are $8 \times 10^{12} m$ and $1.6 \times 10^{12} m$. If its velocity when nearest to the sun is 60 m/s, what will be its velocity in m/s when it is farthest

a) 12 b) 60 c) 112 d) 6

377. Radius of orbit of satellite of earth is R. Its kinetic energy is proportional to

a) $\frac{1}{R}$ b) $\frac{1}{\sqrt{R}}$ c) R d) $\frac{1}{R^{3/2}}$

378. R is the radius of the earth and ω is its angular velocity and g_p is the value of g at the poles. The effective value of g at the latitude $\lambda = 60°$ will be equal to

a) $g_p - \frac{1}{4}R\omega^2$ b) $g_p - \frac{3}{4}R\omega^2$ c) $g_p - R\omega^2$ d) $g_p + \frac{1}{4}R\omega^2$

379. The ratio of the radii of the planets P_1 and P_2 is a. The ratio of their acceleration due to gravity is b. The ratio of the escape velocities from them will be

a) ab b) $\sqrt{ab}$ c) $\sqrt{a/b}$ d) $\sqrt{b/a}$

380. An artificial satellite of the earth moves at an altitude to $h = 670$ km along a circular orbit. The velocity of the satellite is

a) 7.5 kms^{-1} b) 8.5 kms^{-1} c) 11.2 kms^{-1} d) 4.5 kms^{-1}

381. Read the following statements

S_1 : An object shall weigh more at pole than at equator when weighed by using a physical balance

S_2 : It shall weigh the same at pole and equator when weighed by using a physical balance

S_3 : It shall weigh the same at pole and equator when weighed by using a spring balance

S_4 : It shall weigh more at the pole than at equator when weighed using a spring balance

Which of the above statements is/are correct

a) S_1 and S_2 b) S_1 and S_4 c) S_2 and S_3 d) S_3 and S_4

382. If gravitational force on a body of mass 1.5 kg at point is 45N, then the intensity of the gravitational field at that point is

a) 67.5 N kg^{-1} b) 45 N kg^{-1} c) 30 N kg^{-1} d) 15 N kg^{-1}

383. A spherical hollow is made in a lead sphere of radius R such that its surface touches the outside surface of the lead sphere and passes through the centre. The mass of the lead sphere before hollowing was M. The force of attraction that this sphere would exert on a particle of mass m which lies at a distance $d(> R)$ from the centre of the lead sphere on the straight line joining the centres of the sphere and the hollow is

a) $\frac{GM\,m}{d^2}$ b) $\frac{GM\,m}{8d^2}$

c) $\frac{GM\,m}{d^2}\left[1 + \frac{1}{8\left(1 + \frac{R}{2d}\right)}\right]$ d) $\frac{GM\,m}{d^2}\left[1 - \frac{1}{8\left(1 - \frac{R}{2d}\right)^2}\right]$

384. A geostationary satellite is orbiting the earth at the height of 6 R above the surface of earth, R being radius of earth. The time period of another satellite at a height of 2.5 R from the surface of earth, is

a) 10 h b) $\frac{6}{\sqrt{2}}$ h c) 6 h d) $6\sqrt{2}$ h

385. The kinetic energy needed to project a body of mass m from the earth surface (radius R) to infinity is

a) $mgR/2$ b) $2\,mgR$ c) mgR d) $mgR/4$

386. The effect of rotation of the earth on the value of acceleration due to gravity is

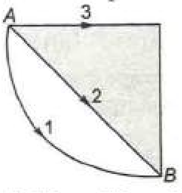
a) g is maximum at the equator and maximum at the poles

b) g is minimum at the equator and maximum at the poles

c) g is maximum at the both poles

d) g is minimum at the both poles

387. If W_1, W_2 and W_3 represent the work done in moving a particle from A to B along three different paths 1,2 and 3 respectively (as shown) in a gravitational field of point mass m, then



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

388. A satellite revolves around the earth in an elliptical orbit. Its speed

a) Is the same at all points in the orbit

b) Is greatest when it is closest to the earth

c) Is greatest when it is farthest from the earth

d) Goes on increasing or decreasing continuously depending upon the mass of the satellite

389. 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) $2R$ b) $\frac{R}{\sqrt{3}}$ c) $\frac{R}{2}$ d) $\sqrt{2}R$

390. A geostationary satellite
a) Revolves about the polar axis
b) Has a time period less than that of the near earth satellite
c) Moves faster than a near earth satellite
d) Is stationary in the space

391. In a certain region of space gravitational field is given by $I(Kr)$. Taking the reference point to be at $r = V_0$, find the potential.
a) $K \log \frac{r}{r_0} + V_0$ b) $K \log \frac{r_0}{r} + V_0$ c) $K \log \frac{r}{r_0} - V_0$ d) $\log \frac{r}{r_0} - V_0 r$

392. If mass of a body is M on the earth surface, then the mass of the same body on the moon surface is
a) $M/6$ b) Zero c) M d) None of these

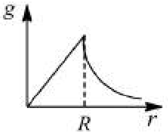
393. The time period of a simple pendulum on a freely moving artificial satellite is
a) Zero b) 2 sec c) 3 sec d) Infinite

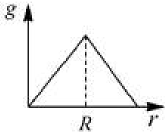
394. The Earth is assumed to be a sphere of radius R. A platform is arranged at a height R from the surface of the Earth. The escape velocity of a body from this platform is fv, where v is its escape velocity from the surface of the Earth. The value of f is
a) $\frac{1}{3}$ b) $\frac{1}{2}$ c) $\sqrt{2}$ d) $\frac{1}{\sqrt{2}}$

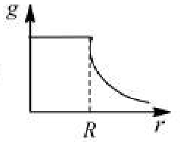
395. The mass of the moon is 7.34×10^{22} kg and the radius is 1.74×10^{6}m. the value of gravitational field intensity will be
a) 1.45 Nkg^{-1} b) 1.55 Nkg^{-1} c) 1.7 Nkg^{-1} d) 1.62 Nkg^{-1}

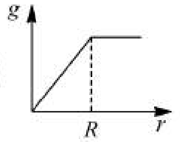
396. At the surface of a certain planet, acceleration due to gravity is one-quarter of that on earth. If a brass ball is transported to this planet, then which one of the following statements is not correct
a) The mass of the brass ball on this planet is a quarter of its mass as measured on earth
b) The weight of the brass ball on this planet is a quarter of the weight as measured on earth
c) The brass ball has the same mass on the other planet as on earth
d) The brass ball has the same volume on the other planet as on earth

397. Assuming earth to be a sphere of a uniform density, what is the value of gravitational acceleration in a min 100 km below the earth' surface (Given $R = 6400\ km$)
a) 9.66 m/s^2 b) 7.64 m/s^2 c) 5.06 m/s^2 d) 3.10 m/s^2

398. When of the following graphs correctly represents the variation of g on earth?
a) 

b) 

c) 

d) 

399. 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 necessarily zero
c) Nothing can be said definitely about the gravitational field
d) None of these

400. The radius of a planet is 1/4 of earth's radius and its acceleration due to gravity is double that of earth's acceleration due to gravity. How many times will the escape velocity at the planet's surface be as compared to its value on earth's surface
a) $\frac{1}{\sqrt{2}}$ b) $\sqrt{2}$ c) $2\sqrt{2}$ d) 2

401. If distance between earth and sun become four times, then time period becomes
a) 4 times b) 8 times c) 1/4 times d) 1/8 times

402. If suppose moon is suddenly stopped and then released (given radius of moon is one-fourth the radius of earth)and the acceleration of moon with respect to earth is 0.0027 ms^{-2}), then the acceleration of the moon just before striking the earth's surface is (Take $g = 10\ \text{ms}^{-2}$)

a) 0.0027 ms^{-2} b) 5.0 ms^{-2} c) 6.4 ms^{-2} d) 10 ms^{-2}

403. A satellite is moving around the earth with speed v in a circular orbit of radius r. If the orbit radius is decreased by 1%, its speed will

a) Increase by 1% b) Increase by 0.5% c) Decrease by 1% d) Decrease by 0.5%

404. The orbit of geostationary satellite is circular, the time period of satellite depends on

(i) mass of the satellite
(ii) mass of the earth
(iii) radius of the orbit
(iv) height of the satellite from the surface of earth

Which of the following correct?

a) (i) only b) (i) and (ii) c) (i), (ii) and (iii) d) (ii), (iii) and (iv)

405. The condition for a uniform spherical mass m of radius r to be a black hole is [G = gravitational constant and g = acceleration due to gravity]

a) $(2Gm/r)^{1/2} \le c$ b) $(2Gm/r)^{1/2} = c$ c) $(2Gm/r)^{1/2} \ge c$ d) $(gm/r)^{1/2} \ge c$

406. Two point masses A and B having masses in the ratio 4:3 are separated by a distance of 1 m. When another point mass C of mass M is placed in between A and B, the force between A and C is $\frac{1}{3}$rd of the force between B and C. Then the distance of C from A is

a) $\frac{2}{3}$ m b) $\frac{1}{3}$ m c) $\frac{1}{4}$ m d) $\frac{2}{7}$ m

407. The distance between centre of the earth and moon is 384000 km. If the mass of the earth is 6×10^{24} kg and $G = 6.66 \times 10^{-11} Nm^2/kg^2$. The speed of the moon is nearly

a) 1 km/sec b) 4 km/sec c) 8 km/sec d) 11.2 km/sec

408. A rocket is sent vertically up with a velocity v less than the escape velocity from the earth. Taking M and r as the mass and radius of earth, the maximum height h attained by the rocket is given by the following expression

a) $v^2R^2/(2GR - Mv)$ b) $v^2R^2/(2GR + v^2R)$

c) $v^2R^2/(2GR - v^2R)$ d) $v^2R^2/(2GRv + RM)$

409. The ratio of radii of earth to another planet is $\frac{2}{3}$ and the ratio of their mean densities is $\frac{4}{5}$. If an astronaut can jump to a maximum height of 1.5 m on the earth, with the same effort, the maximum height he can jump on the planet is

a) 1 m b) 0.8 m c) 0.5 m d) 1.25 m

410. A body is acted upon by a force towards a point. The magnitude of the force is inversely proportional to the square of the distance. The path of body will be

a) Ellipse b) Hyperbola c) Circle d) Parabola

411. 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) $d = \frac{h}{2}$ b) $d = \frac{3h}{2}$ c) $d = 2h$ d) $d = h$

412. A satellite of mass m is placed at a distance r from the centre of earth (mass M). The mechanical energy of the satellite is

a) $-\frac{GMm}{r}$ b) $\frac{GMm}{r}$ c) $\frac{GMm}{2r}$ d) $-\frac{GMm}{2r}$

413. The time period of an earth satellite in circular orbit is independent of

a) The mass of the satellite
b) Radius of its orbit
c) Both the mass and radius of the orbit
d) Neither the mass of the satellite nor the radius of its orbit

414. An artificial satellite is moving in a circular orbit around the earth with a speed equal to half the magnitude of escape velocity from the earth. The height of the satellite above the earth's surface will be

a) 6000 km b) 5800 km c) 7500 km d) 6400 km

415. Spot the *wrong* statement:
The acceleration due to gravity $'g'$ decreases if
a) We go down from the surface of the earth towards its centre
b) We go up from the surface of the earth
c) We go from the equator towards the poles on the surface of the earth
d) The rotational velocity of the earth is increased

416. A satellite is revolving around the earth with a kinetic energy E. The minimum addition of kinetic energy needed to make it escape from its orbit is
a) $2E$ b) $\sqrt{E}$ c) $E/2$ d) E

417. How much energy will be necessary for making a body of 500 kg escape from the earth [$g = 9.8 \text{ ms}^{-2}$, radius of earth $= 6.4 \times 10^6$m]
a) About 9.8×10^6J b) About 6.4×10^8J c) About 3.1×10^{10}J d) About 27.4×10^{12}J

418. The gravitational potential difference between the surface of a planet and a point 20 m above it is 14 Jkg^{-1}. The work done in moving a 2.0 kg mass by 8.0 m on a slop of 60° from the horizontal is equal to
a) 7 J b) 9.6 J c) 16 J d) 32 J

419. The radius of the earth is about 6400 km and that of the mars is 3200 km. The mass of the earth is about 10 times the mass of the mars. An object weighs 200 N on the surface of earth, its weight on the surface of mars will be
a) 8 N b) 20 N c) 40 N d) 80 N

420. In a certain region of space, the gravitational field is given by $-k/r$, where r is the distance and k is a constant. If the gravitational potential at $r = r_0$ be V_0, then what is the expression for the gravitational potential V?
a) $k \log(r/r_0)$ b) $k \log(r_0/r)$ c) $V_0 + k \log(r/r_0)$ d) $V_0 + k \log(r_0/r)$

421. A satellite of mass m is circulation around the earth with constant angular velocity. If radius of the orbit is R_0 and mass of the earth M, the angular momentum about the centre of the earth is
a) $m\sqrt{GMR_0}$ b) $M\sqrt{GMR_0}$ c) $m\sqrt{\frac{GM}{R_0}}$ d) $M\sqrt{\frac{GM}{R_0}}$

422. An iron ball and a wooden ball of the same radius are released from a height $'h'$ in vacuum. The time taken by both of them to reach the ground is
a) Unequal b) Exactly equal c) Roughly equal d) Zero

423. If then radius of earth R, then the height h at which the value of g becomes one-fourth, will be
a) $\frac{R}{8}$ b) $\frac{3R}{8}$ c) $\frac{3R}{4}$ d) $\frac{R}{2}$

424. Which of the following astronomer first proposed that sun is static and earth rounds sun
a) Copernicus b) Kepler c) Galileo d) None

425. The acceleration due to gravity increase by 0.5 % when we go from the equator to the poles. What will be the time period of the pendulum at the equator which beats seconds at the poles?
a) 1.950 s b) 1.995 s c) 2.050 s d) 2.005 s

426. If the height of a satellite from the earth is negligible in comparison to the radius of the earth R, the orbital velocity of the satellite is
a) gR b) $gR/2$ c) $\sqrt{g/R}$ d) $\sqrt{gR}$

427. If the earth were to suddenly contract to $\frac{1}{n}$ th of its present radius without any change in its mass, the duration of the new day will be nearly
a) $\frac{24}{n}$h b) $24n$ h c) $\frac{24}{n^2}$h d) $24n^2$h

428. A person will get more quantity of matter in kg-wt at
a) Poles b) at latitude of 60° c) Equator d) Satellite

429. As we go from the equator to the poles, the value of g

a) Remains the same
b) Decreases
c) Increases
d) Decreases upto a latitude of 45°

430. The mass of the moon is $\frac{1}{81}$ of the earth but the gravitational pull is $\frac{1}{6}$ of the earth. It is due to the fact that
a) The radius of the moon is $\frac{81}{6}$ of the earth
b) The radius of the earth is $\frac{9}{\sqrt{6}}$ of the moon
c) Moon is the satellite of the earth
d) None of the above

431. A spherical planet has a mass M_P and diameter D_P. A particle of mass m falling freely near the surface of this planet will experience an acceleration due to gravity, equal to
a) $4GM_P/D_P^2$
b) GM_Pm/D_P^2
c) GM_P/D_P^2
d) $4GM_Pm/D_P^2$

432. A 20 cm long capillary tube is dipped in water. The water rises upto 8 cm. if entire arrangement is put in a freely falling elevator lengths of water column in the capillary tube will be
a) 4 cm
b) 8 cm
c) 10 cm
d) 20 cm

433. 320 km above the surface of earth, the value of acceleration due to gravity is nearly 90% of its value on the surface of the earth. Its value will be 95% of the value on the earth's surface
a) Nearly 160 km below the earth's surface
b) Nearly 80 km below the earth's surface
c) Nearly 640 km below the earth's surface
d) Nearly 320 km below the earth's surface

434. Two identical solid copper spheres of radius R are placed in contact with each other. The gravitational attraction between them is proportional to
a) R^2
b) R^{-2}
c) R^4
d) R^{-4}

435. The moon's radius is 1/4 that of the earth and its mass is 1/80 times that of the earth. If g represents the acceleration due to gravity on the surface of the earth, that on the surface of the moon is
a) $g/4$
b) $g/5$
c) $g/6$
d) $g/8$

436. Which of the following statement about the gravitational constant is true?
a) It is a force
b) It has no unit
c) It has same value in all system of units
d) It does not depend on the nature of the medium in which the bodies are kept

437. At a given place where, acceleration due to gravity is g ms^{-2}, a sphere of lead of density d kgm^{-2} is gently released in a column of liquid of density ρ kgm^{-3}. If $d > \rho$, the sphere will
a) Fall vertically with an acceleration of g ms^{-2}
b) Fall vertically with no acceleration
c) Fall vertically with an acceleration $g\left(\frac{d-\rho}{d}\right)$
d) Fall vertically with an acceleration ρ/d

438. Two metallic spheres each of mass M are suspended by two strings each of length L. The distance between the upper ends of strings is L. The angle which the strings will make with the vertical due to mutual attraction of the spheres is
a) $\tan^{-1}\left[\frac{GM}{gL}\right]$
b) $\tan^{-1}\left[\frac{GM}{2gL}\right]$
c) $\tan^{-1}\left[\frac{GM}{gL^2}\right]$
d) $\tan^{-1}\left[\frac{2GM}{gL^2}\right]$

439. The bodies situated on the surface of earth at its equator, becomes weightless, when the earth has KE about it axis
a) mgR
b) $2\ mgR/5$
c) $MgR/5$
d) $5MgR/2$

440. 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) $g' = 2g$
b) $g' = 3g$
c) $g' = 4g$
d) $g' = 5g$

441. A geostationary satellite is orbiting the earth at a height of $5R$ above the 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) $\frac{6}{\sqrt{2}}$

442. According to Kepler, the period of revolution of a planet (T) and its mean distance from the sun (r) are related by the equation

a) $T^3r^3 =$ constant b) $T^2r^{-3}=$ constant c) $Tr^3 =$ constant d) $T^2r =$ constant

443. The mass of the earth is 6.00×10^{22} kg. The constant of gravitation $g = 6.67 \times 10^{-11}\text{Nm}^2\text{kg}^{-2}$. The potential energy of the system is -7.73×10^{28} J. The mean distance between earth and moon is

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

444. A satellite S is moving in an elliptical orbit around earth. The mass of the satellite is very small compared to the mass of the earth?

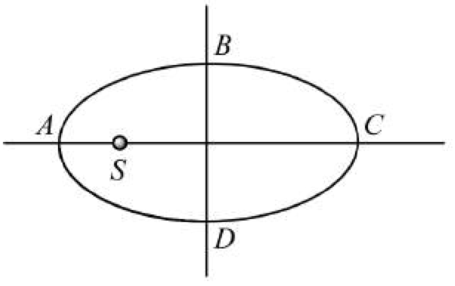
a) The acceleration of S is always directed towards the centre of the earth

b) The angular momentum of S about the centre of the earth changes in direction but its magnitude remains constant

c) The total mechanical energy of S varies periodically with time

d) The linear momentum of S remains constant in magnitude

445. The orbital velocity of the planet will be maximum at



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

446. Two spheres of radius r and $2r$ are touching each other. The fore of attraction between them is proportional to

a) r^6 b) r^4 c) r^2 d) r^{-2}

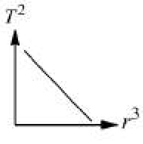
447. The satellite of mass m revolving in a circular orbit of radius r around the earth has kinetic energy E. Then its angular momentum will be

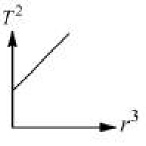
a) $\sqrt{\frac{E}{mr^2}}$ b) $\frac{E}{2mr^2}$ c) $\sqrt{2\,Emr^2}$ d) $\sqrt{2\,Emr}$

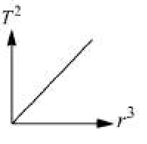
448. A rocket is launched with velocity 10 km/s. If radius of earth is R, then maximum height attained by it will be

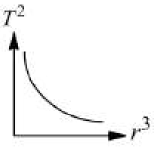
a) $2R$ b) $3R$ c) $4R$ d) $5R$

449. Which of the following graphs between the square of the time period and cube of the distance of the planet from the sun is correct?

a) 

b) 

c) 

d) 

450. The speed of earth's rotation about its axis is ω. Its speed is increased to x times to make the effective acceleration due to gravity equal to zero at the equator, then x is around ($g = 10\text{ms}^{-2}, R = 6400$ km)

a) 1 b) 8.5 c) 17 d) 34

451. For a body lying on the equator to appear weightless, what should be the angular speed of the earth?(Take $g = 10\text{ms}^{-2}$; radius of earth = 6400 km)

a) 0.125 rads^{-1} b) 1.25 rads^{-1} c) 1.25×10^{-3}rads^{-1} d) 1.25×10^{-2}rads^{-1}

452. A thief stole a box full of valuable articles of weight w and while carrying it on his head jumped down from a wall of height h from the ground. Before he reaches the ground, he experienced a load

a) Zero b) $w/2$ c) w d) $2\,w$

453. Where can a geostationary satellite be installed

a) Over any city on the equator
b) Over the north or south pole
c) At height R above earth
d) At the surface of earth

454. If g is the acceleration due to gravity on the surface of earth, its value at a height equal to double the radius of earth is

a) g
b) $\frac{g}{2}$
c) $\frac{g}{3}$
d) $\frac{g}{9}$

455. If both the masses and radius o the earth, each decreases by 50%, the acceleration due to gravity would

a) Remain same
b) Decrease by 50%
c) Decrease by 100%
d) Increase by 100%

456. The acceleration due to gravity on a planet is same as that on earth and its radius is four times that of earth. What will be the value of escape velocity on that planet if it is v_e on earth

a) v_e
b) $2v_e$
c) $4v_e$
d) $\frac{v_e}{2}$

457. The velocity with which is projectile must be fired so that it escapes earth's gravitation does not depend on

a) Mass of the earth
b) Mass of the projectile
c) Radius of the projectile's orbit
d) Gravitational constant

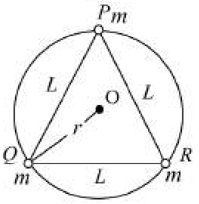
458. A satellite is revolving round the earth in an orbit of radius r with time period T. If the satellite is revolving round the earth in an orbit of radius $r + \Delta r(\Delta r \ll r)$ with time period $T + \Delta T(\Delta T \ll T)$ then

a) $\frac{\Delta T}{T} = \frac{3}{2}\frac{\Delta r}{r}$
b) $\frac{\Delta T}{T} = \frac{2}{3}\frac{\Delta r}{r}$
c) $\frac{\Delta T}{T} = \frac{\Delta r}{r}$
d) $\frac{\Delta T}{T} = -\frac{\Delta r}{r}$

459. If different planets have the same density but different radii, then the acceleration due to gravity on the surface of the planet is related to the radius (R) of the planet as

a) $g \propto R^2$
b) $g \propto R$
c) $g \propto \frac{1}{R^2}$
d) $g \propto \frac{1}{R}$

460. Three particles each of mass m rotate in a circle of radius r with uniform angular speed ω under their mutual gravitational attraction. If at any instant the points are on the vertex of an equilateral of side L, then angular velocity ω is



a) $\sqrt{\frac{2Gm}{L^3}}$
b) $\sqrt{\frac{3Gm}{L^3}}$
c) $\sqrt{\frac{5Gm}{L^3}}$
d) $\sqrt{\frac{Gm}{L^3}}$

461. Pick out the most correct statement with reference to earth satellites

a) Geostationary satellites are used for remote sensing
b) Polar satellites are used for telecommunications
c) INSAT group of satellites belong to geostationary satellites
d) Polar satellites are at a height of about 36,000 km

462. The value of $'g'$ at a particular point is 9.8 m/s^2. Suppose the earth suddenly shrinks 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 earth does not shrink) will now be

a) 4.9 m/sec^2
b) 3.1 m/sec^2
c) 9.8 m/sec^2
d) 19.6 m/sec^2

463. The potential energy of 4-particalse each of mass 1 kg placed at the four vertices of a square of side length 1 m is

a) +4.0 G
b) −7.5 G
c) −5.4 G
d) +6.3 G

464. Three identical bodies of mass M are located at the vertices of an equilateral triangle of side L. They revolve under the effect of mutual gravitational force in a circular orbit, circumscribing the triangle while preserving the equilateral triangle. Their orbital velocity is

a) $\sqrt{\frac{GM}{L}}$ b) $\sqrt{\frac{3GM}{2L}}$ c) $\sqrt{\frac{3GM}{L}}$ d) $\sqrt{\frac{2GM}{3L}}$

465. Two bodies of masses m_1 and m_2 are initially at rest at infinite distance apart. They are then allowed to move towards each other under mutual gravitational attraction. Their relative velocity of approach at a separation distance r between them is

a) $\left[2G\frac{(m_1-m_2)}{r}\right]^{1/2}$ b) $\left[\frac{2G}{r}(m_1+m_2)\right]^{1/2}$ c) $\left[\frac{r}{2G(m_1m_2)}\right]^{1/2}$ d) $\left[\frac{2G}{r}m_1m_2\right]^{1/2}$

466. The escape velocity of an object on a planet whose g value is 9 times on earth and whose radius is 4 times that of earth in km/s is

a) 67.2 b) 33.6 c) 16.8 d) 25.2

467. A satellite is placed in a circular orbit around earth at such a height that it always remains stationary with respect to earth surface. In such case, its height from the earth surface is

a) 32000 km b) 36000 km c) 6400 km d) 4800 km

468. Periodic time of a satellite revolving above Earth's surface at a height equal to R, radius of Earth, is [g is acceleration due to gravity at Earth's surface]

a) $2\pi\sqrt{\frac{2R}{g}}$ b) $4\sqrt{2\pi}\sqrt{\frac{R}{g}}$ c) $2\pi\sqrt{\frac{R}{g}}$ d) $8\pi\sqrt{\frac{R}{g}}$

469. According to Kelper's law of planetary motion if T represent time period and r is orbital radius, then for two planets these are related as

a) $\left(\frac{T_1}{T_2}\right)^3=\left(\frac{r_1}{r_2}\right)^3$ b) $\left(\frac{T_1}{T_2}\right)^{\frac{3}{2}}=\frac{r_1}{r_2}$ c) $\left(\frac{T_1}{T_2}\right)^4=\left(\frac{r_1}{r_2}\right)^3$ d) $\left(\frac{T_1}{T_2}\right)^2=\left(\frac{r_1}{r_2}\right)^3$

470. If a new planet is discovered rotating around the sum with the orbital radius double that of earth, then what will be its time period (in earth's days)?

a) 1032 b) 1023 c) 1024 d) 1043

471. If a planet was suddenly stopped in its orbit, k suppose to be circular, find how much time will it take in falling onto the sun?

a) $\sqrt{2}/8$ times the period of the planet's revolution

b) $4\sqrt{2}$ times the period of the planet's revolution

c) $3\sqrt{2}$ times the period of the planet's revolution

d) 9 times the period of the planet's revolution

472. If Gravitational constant is decreasing with time, what will remain unchanged in case of a satellite orbiting around earth

a) Time period b) Orbiting radius c) Tangential velocity d) Angular velocity

473. A research satellite of mass 200 kg circles the earth in an orbit of average radius $3R/2$ where R is the radius of the earth. Assuming the gravitational pull on a mass of 1 kg on the earth's surface to be 10 N, the pull on the satellite will be

a) 880 N b) 889 N c) 890 N d) 892 N

474. A point $P(R\sqrt{3},0,0)$ lies on the axis of a ring of mass M and radius R. The ring is located in $y-z$ plane with its centre at origin O. A small particle of mass m starts from P and reaches O under gravitational attraction only. Its speed at O will be

a) $\sqrt{\frac{GM}{R}}$ b) $\sqrt{\frac{Gm}{R}}$ c) $\sqrt{\frac{GM}{2R}}$ d) $\sqrt{\frac{Gm}{2R}}$

475. Weight of a body of mass m decreases by 1% when it is raised to height h above the earth's surface. If the body is taken on a depth h in a mine, change in its weight is

a) 0.5% decrease b) 2% decrease c) 0.5% increase d) 1% increase

476. 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

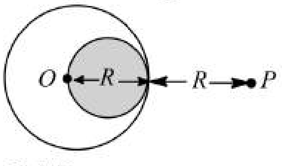
477. A body is released from a point distance r from the centre of earth. If R is the earth and $r > R$, then the velocity of the body at the time of striking the earth will be

a) $\sqrt{gR}$ b) $\sqrt{2gR}$ c) $\sqrt{\frac{2gR}{r-R}}$ d) $\sqrt{\frac{2gR(r-R)}{r}}$

478. A clock S is based on oscillation of a spring and clock P is based on pendulum motion. Both clock run at the same rate on earth. On a planet having the same density as earth but twice the radius,

a) S will run faster than P
b) P will run faster than S
c) Both will run at the same rate as on the earth
d) Both will run at the same rate which will be different from that on the earth

479. A solid sphere of uniform density and radius r applies a gravitational force of attraction equal to F_1 on a particle placed at P, distance $2R$ from the centre O of the sphere. A spherical cavity of radius $R/2$ is now made in the sphere as shown in figure. The sphere with cavity now applied an gravitational force F_2 on same particle placed at P. The ratio F_2/F_1 will be

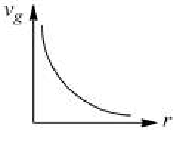


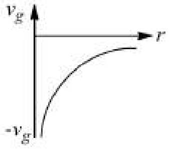
a) 1/2 b) 7/9 c) 3 d) 7

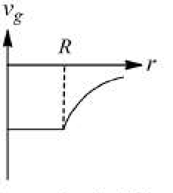
480. The escape velocity of a body from earth's surface is v_e. The escape velocity of the same body from a height equal to $7R$ from earth's surface will be

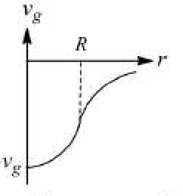
a) $\frac{v_e}{\sqrt{2}}$ b) $\frac{v_e}{2}$ c) $\frac{v_e}{2\sqrt{2}}$ d) $\frac{v_e}{4}$

481. Select the proper graph between the gravitational potential (v_g) due to hollow sphere and distance (r) from its centre

a) 

b) 

c) 

d) 

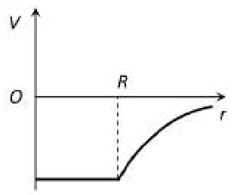
482. What should be the angular speed of earth in rad^{-1} so that a body 5kg weighs zero at the equator? (Take g $= 10$ ms^{-2} and radius of earth $= 6400$ km)

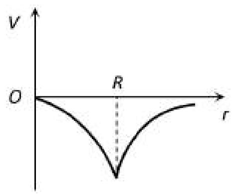
a) 1/1600 b) 1/800 c) 1/400 d) 1/80

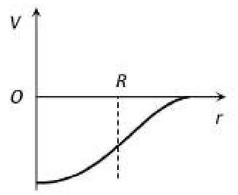
483. The work that must be done in lifting a body of weight P from the surface of the earth to a height h is

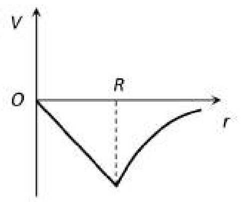
a) $\frac{PRh}{R-h}$ b) $\frac{R+h}{PRh}$ c) $\frac{PRh}{R+h}$ d) $\frac{R-h}{PRh}$

484. The diagram showing the variation of gravitational potential of earth with distance from the centre of earth is

a) 

b) 

c) 

d) 

485. An artificial of mass $'m'$ revolves around the earth near to its surface then its binding energy is [R_e, g are radius and acceleration due to gravity respectively of the earth]

a) $\frac{1}{2}mg\ R_e$ b) $-\frac{1}{2}mg\ R_e$ c) $mg\ R_e$ d) $-mg\ R_e$

486. If the radius of the earth shrinks by 1%, its mass remaining same, the acceleration due to gravity on the surface of earth will

a) Decrease by 2% b) Decrease by 0.5% c) Increase by 2% d) Increase by 0.5%

487. Weight of a body is maximum at

a) Moon b) Poles of earth c) Equator of earth d) Centre of earth

488. Kepler's second law states that the straight line joining the planet to the sun sweeps out equal times. This statement is equivalent to saying that

a) Total acceleration is zero
b) Tangential acceleration is zero
c) Longitudinal acceleration is zero
d) Radial acceleration is zero

489. What does not change in the field of central force

a) Potential energy b) Kinetic energy c) Linear momentum d) Angular momentum

490. There is a mine of depth about 2.0 km. In this mine the conditions as compared to those at the surface are

a) Lower air pressure, higher acceleration due to gravity
b) Higher air pressure, lower acceleration due to gravity
c) Higher air pressure, higher acceleration due to gravity
d) Lower air pressure, lower acceleration due to gravity

491. The periodic time of a communication satellite is

a) 6 *hours* b) 12 *hours* c) 18 *hours* d) 24 *hours*

492. A satellite is orbiting around the earth. By what percentage should we increase its velocity, so as to enable it escape away from the earth?

a) 41.4% b) 50% c) 82.8% d) 100%

493. The 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) $W_1 = W_2 = W_3$ c) $W_1 < W_2 < W_3$ d) $W_1 > W_2 > W_3$

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

a) $\frac{3}{2}V$ b) $\sqrt{\frac{3}{2}}V$ c) $\sqrt{\frac{2}{3}}V$ d) $\frac{2}{3}V$

495. Potential energy of a satellite having mass $'m'$ and rotating at a height of $6.4 \times 10^6 m$ from the earth surface is

a) $-0.5\ mgR_e$ b) $-mgR_e$ c) $-2\ mgR_e$ d) $4\ mgR_e$

496. Two equal masses m and m are hung from a balance whose scale pan differs in vertical height by $h/2$. The error in weighing in terms of density of the earth ρ is

a) $\frac{1}{3}\pi G\rho mh$ b) $\pi G\rho mh$ c) $\frac{4}{3}\pi G\rho mh$ d) $\frac{8}{3}G\rho mh$

497. The height at which the weight of a body becomes $1/16^{\text{th}}$, its weight on the surface of earth (radius R), is

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

498. The mass of a planet that has a moon whose time period and orbital radius are T and R respectively can be written as

a) $4\pi^2R^3G^{-1}T^{-2}$ b) $8\pi^2R^3G^{-1}T^{-2}$ c) $12\pi^2R^3G^{-1}T^{-2}$ d) $16\pi^2R^3G^{-1}T^{-2}$

499. If the mass of earth is 80 times of that of a planet and diameter is double that of planet and $'g'$ on earth is $9.8 m/s^2$, then the value of $'g'$ on that planet is

a) $4.9\ m/s^2$ b) $0.98\ m/s^2$ c) $0.49\ m/s^2$ d) $49\ m/s^2$

500. Escape velocity on a planet is v_e. If radius of the planet remains same and mass becomes 4 times, the escape velocity becomes

a) $4v_e$ b) $2v_e$ c) v_e d) $\frac{1}{2}v_e$

501. A point mass m is placed inside a spherical shell of radius R and mass M. at a distance $R/2$ from the centre of the shell. The gravitational force exerted by the shell on the point mass is

a) $\frac{GMm}{R^2}$ b) $-\frac{GMm}{R^2}$ c) Zero d) $4\frac{GMm}{R^2}$

502. Orbital velocity of earth's satellite near the surface is $7\ km/s$. When the radius of the orbit is 4 times than that of earth's radius, then orbital velocity in that orbit is

a) $3.5\ km/s$ b) $7\ km/s$ c) $72\ km/s$ d) $14\ km/s$

503. A body is orbiting very close to the earth's surface with kinetic energy KE. The energy required to completely escape from it is

a) KE b) 2 KE c) $\frac{\text{KE}}{2}$ d) $\frac{3\text{KE}}{2}$

504. At what depth below the surface of the earth, acceleration due to gravity g will be half its value 1600 km above the surface of the earth

a) $4.2 \times 10^6 m$ b) $3.19 \times 10^6 m$ c) $1.59 \times 10^6 m$ d) None of these

505. Two bodies of masses m and $4m$ are placed at a distance r. The gravitational potential at a point on the line joining them where the gravitational field is zero is

a) $-\frac{4Gm}{r}$ b) $-\frac{6Gm}{r}$ c) $-\frac{9Gm}{r}$ d) zero

506. Geostationary satellite

a) Falls with g towards the earth b) Has period of 24 hrs

c) Has equatorial orbit d) Above all correct

507. One can easily "weight the earth" by calculating the mass of earth using the formula (in usual notation)

a) $\frac{G}{g}R_E^2$ b) $\frac{g}{G}R_E^2$ c) $\frac{g}{G}R_E$ d) $\frac{G}{g}R_E^3$

GRAVITATION

: ANSWER KEY :

1)	c	2)	b	3)	c	4)	a	157)	d	158)	c	159)	d	160)	d
5)	c	6)	b	7)	c	8)	a	161)	b	162)	a	163)	c	164)	a
9)	c	10)	a	11)	a	12)	c	165)	b	166)	c	167)	b	168)	b
13)	c	14)	b	15)	c	16)	c	169)	c	170)	c	171)	b	172)	c
17)	d	18)	b	19)	d	20)	d	173)	c	174)	a	175)	d	176)	d
21)	b	22)	b	23)	b	24)	d	177)	b	178)	d	179)	a	180)	c
25)	a	26)	c	27)	d	28)	b	181)	d	182)	b	183)	c	184)	b
29)	d	30)	d	31)	b	32)	c	185)	a	186)	b	187)	b	188)	b
33)	b	34)	c	35)	c	36)	a	189)	b	190)	b	191)	c	192)	d
37)	b	38)	a	39)	b	40)	b	193)	c	194)	b	195)	b	196)	b
41)	c	42)	c	43)	c	44)	d	197)	c	198)	d	199)	a	200)	b
45)	a	46)	b	47)	c	48)	c	201)	b	202)	b	203)	b	204)	d
49)	a	50)	c	51)	b	52)	d	205)	d	206)	c	207)	c	208)	b
53)	c	54)	d	55)	a	56)	b	209)	a	210)	c	211)	c	212)	b
57)	c	58)	c	59)	b	60)	c	213)	c	214)	a	215)	a	216)	d
61)	a	62)	d	63)	d	64)	a	217)	c	218)	c	219)	b	220)	c
65)	d	66)	b	67)	d	68)	c	221)	b	222)	b	223)	d	224)	b
69)	b	70)	a	71)	c	72)	a	225)	a	226)	b	227)	a	228)	a
73)	c	74)	a	75)	b	76)	b	229)	d	230)	b	231)	c	232)	a
77)	d	78)	d	79)	a	80)	c	233)	d	234)	b	235)	c	236)	c
81)	c	82)	d	83)	d	84)	a	237)	a	238)	d	239)	a	240)	d
85)	c	86)	b	87)	b	88)	c	241)	b	242)	c	243)	c	244)	b
89)	c	90)	b	91)	a	92)	a	245)	c	246)	b	247)	c	248)	d
93)	b	94)	c	95)	d	96)	b	249)	b	250)	a	251)	d	252)	b
97)	c	98)	b	99)	b	100)	b	253)	b	254)	b	255)	b	256)	a
101)	b	102)	b	103)	d	104)	b	257)	a	258)	c	259)	a	260)	c
105)	c	106)	a	107)	d	108)	c	261)	d	262)	d	263)	b	264)	b
109)	c	110)	a	111)	c	112)	b	265)	c	266)	a	267)	b	268)	c
113)	d	114)	b	115)	d	116)	c	269)	c	270)	b	271)	a	272)	c
117)	b	118)	c	119)	d	120)	b	273)	b	274)	b	275)	a	276)	c
121)	c	122)	c	123)	a	124)	d	277)	b	278)	a	279)	c	280)	b
125)	c	126)	b	127)	a	128)	b	281)	a	282)	d	283)	c	284)	a
129)	d	130)	d	131)	a	132)	c	285)	b	286)	b	287)	b	288)	a
133)	c	134)	d	135)	b	136)	a	289)	d	290)	b	291)	a	292)	a
137)	c	138)	c	139)	b	140)	d	293)	c	294)	d	295)	c	296)	d
141)	c	142)	d	143)	a	144)	b	297)	a	298)	c	299)	d	300)	b
145)	b	146)	a	147)	a	148)	c	301)	c	302)	d	303)	b	304)	a
149)	d	150)	b	151)	b	152)	a	305)	a	306)	d	307)	b	308)	c
153)	d	154)	c	155)	c	156)	a	309)	b	310)	d	311)	a	312)	a

313)	c	314)	c	315)	a	316)	c	413)	a	414)	d	415)	c	416)	d
317)	c	318)	d	319)	d	320)	b	417)	c	418)	b	419)	d	420)	c
321)	c	322)	c	323)	a	324)	c	421)	a	422)	b	423)	b	424)	a
325)	c	326)	c	327)	a	328)	c	425)	d	426)	d	427)	c	428)	c
329)	c	330)	a	331)	c	332)	c	429)	c	430)	b	431)	a	432)	d
333)	b	334)	a	335)	b	336)	c	433)	d	434)	c	435)	b	436)	d
337)	b	338)	a	339)	d	340)	b	437)	c	438)	c	439)	c	440)	b
341)	c	342)	a	343)	c	344)	c	441)	c	442)	b	443)	a	444)	a
345)	a	346)	b	347)	c	348)	a	445)	c	446)	d	447)	c	448)	c
349)	d	350)	d	351)	b	352)	c	449)	c	450)	c	451)	c	452)	a
353)	d	354)	c	355)	c	356)	b	453)	a	454)	d	455)	d	456)	b
357)	c	358)	a	359)	d	360)	a	457)	b	458)	a	459)	b	460)	b
361)	c	362)	a	363)	d	364)	d	461)	c	462)	c	463)	c	464)	a
365)	c	366)	a	367)	a	368)	c	465)	b	466)	a	467)	b	468)	b
369)	c	370)	c	371)	c	372)	c	469)	d	470)	a	471)	a	472)	c
373)	d	374)	c	375)	a	376)	a	473)	b	474)	a	475)	a	476)	b
377)	a	378)	a	379)	b	380)	a	477)	d	478)	b	479)	b	480)	c
381)	d	382)	c	383)	d	384)	d	481)	c	482)	b	483)	c	484)	c
385)	c	386)	a	387)	a	388)	b	485)	a	486)	c	487)	b	488)	b
389)	a	390)	a	391)	a	392)	c	489)	d	490)	b	491)	d	492)	a
393)	d	394)	d	395)	d	396)	a	493)	a	494)	c	495)	a	496)	c
397)	a	398)	a	399)	a	400)	a	497)	c	498)	a	499)	c	500)	b
401)	b	402)	c	403)	b	404)	d	501)	c	502)	a	503)	a	504)	a
405)	c	406)	a	407)	a	408)	c	505)	c	506)	d	507)	b		
409)	c	410)	a	411)	c	412)	d								

GRAVITATION

: HINTS AND SOLUTIONS :

1 **(c)**

It is self-evident that the orbit of the comet is elliptic with sun begin at one of the focus. Now, as for elliptic orbits, according to kepler's third law,

$$T^2 = \frac{4\pi^2 a^3}{GM} \Rightarrow a = \left(\frac{T^2 GM}{4\pi^2}\right)^{1/3}$$

$$a = \left[\frac{(76 \times 3.14 \times 10^7) \times 6.67 \times 10^{-11} \times 2 \times 10^{10}}{4\pi^2}\right]^{1/3}$$

But in case of ellipse,

$2a = r_{\min} + r_{\max}$

$\therefore r_{\max} = 2a - r_{\min} = 2 \times 2.7 \times 10^{12} - 8.9 \times 10^{10}$

$\cong 5.3 \times 10^{12}$m

2 **(b)**

Acceleration due to gravity $g = \frac{GM}{R^2}$, $M = \left(\frac{4}{3}\pi R^3\right)\rho$

$$\therefore \quad g = \frac{4G}{3}\frac{\pi R^3}{R^2}\rho$$

$$\Rightarrow \quad g = \left(\frac{4G\pi R}{3}\right)\rho$$ (ρ = average density)

$\Rightarrow g \propto \rho$ or $\rho \propto g$

3 **(c)**

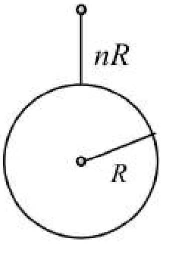
$g = \frac{GM}{R^2}$ and $K = \frac{L^2}{2I}$

If mass of the earth and its angular momentum remains constant then $g \propto \frac{1}{R^2}$ and $K \propto \frac{1}{R^2}$

i.e., if radius of earth decreases by 2% then g and K both increases by 4%

4 **(a)**

Acceleration due to gravity at a height above the earth surface



$$g' = g\left(\frac{R}{R+h}\right)^2$$

$$\frac{g}{g'} = \left(\frac{R+h}{R}\right)^2$$

$$\frac{g}{g'} = \left(\frac{R+nR}{R}\right)^2$$

$$\frac{g}{g'} = (1+n)^2$$

5 **(c)**

Gravitational potential

$$V = GM\left(\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} + \cdots\right)$$

$$= G \times 1\left(\frac{1}{1} + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \cdots.\right)$$

$$= G\left(\frac{1}{1-1/2}\right) \quad \left(\because \text{sum of GP} = \frac{a}{1-r}\right)$$

$$= 2G$$

6 **(b)**

$\frac{g_e}{g_m} = \frac{R_e \rho_e}{R_m \rho_m} = \frac{2}{3} \times \frac{4}{1} = 6$ or $g_m = \frac{g_e}{6}$

For motion on earth, using the relation,

$s = ut + \frac{1}{2}at^2$

We have, $\frac{1}{2} = 0 + \frac{1}{2} \times 9.8r^2$ or $t = 1/\sqrt{9.8}s$

For motion on moon, $3 = 0 + \frac{1}{2}(9.8/6)t_1^2$

or $t_1 = 6\sqrt{9.8}s \therefore \frac{t_1}{t} = 6$ or $t_1 = 6t$

7 **(c)**

Escape velocity,

$$v_{\text{ascape}} = \sqrt{\frac{2\,GM}{R}}$$

$$= R\sqrt{\frac{8}{3}\pi G\rho}$$

$\therefore v_e \propto R$ if $\rho =$ constant.

Since the planet is having double radius in comparision to earth, therefore escape velocity becomes twice *ie*, 22 kms^{-1} .

8 **(a)**

$$\frac{v_p}{v_e} = \sqrt{\frac{M_p}{M_e} \times \frac{R_e}{R_p}} = \sqrt{6 \times \frac{1}{2}} = \sqrt{3} \therefore v_p = \sqrt{3} v_e$$

12 **(c)**

$$\frac{v_e}{v_m} = \sqrt{\frac{g_e}{g_m}\frac{R_e}{R_m}} = \sqrt{6 \times 10} = \sqrt{60} = 8 \text{ (nearly)}$$

13 **(c)**

Gravitational potential energy of a body in the gravitational field, $E = \frac{-GM\,m}{r}$. When r decreases negative value of E increase *ie*, E decreases

14 **(b)**

Actually gravitational force provides the centripetal force

15 **(c)**

The earth moves around the sun is elliptical path, so by using the properties of ellipse

$r_1 = (1+e)a$ and $r_2 = (1-e)a$

$\Rightarrow a = \frac{r_1+r_2}{2}$ and $r_1 r_2 = (1-e^2)a^2$

Where $a =$ semi major axis

$b =$ semi minor axis

$e =$ eccentricity

Now required distance = semi latusrectum $= \frac{b^2}{a}$

$$= \frac{a^2(1-e^2)}{a} = \frac{(r_1 r_2)}{(r_1+r_2)/2} = \frac{2r_1 r_2}{r_1+r_2}$$

16 **(c)**

At a certain velocity of projection of the body will go out of the gravitational field of earth and never to return to earth. The initial velocity is called escape velocity

$$v_e = \sqrt{2gR}$$

Where g is acceleration due to gravity and R the radius. As is clear from above formula, that escape velocity dose not depends upon mass of body hence, it will be same for a body of 100kg as for 1kg body.

17 **(d)**

Telecommunication satellites are geostationary satellite

18 **(b)**

Weight of body at height above the earth's surface is

$$w' = \frac{w}{\left(1+\frac{h}{r}\right)^2}$$

$$\Rightarrow \quad 40 = \frac{80}{\left(1+\frac{h}{r}\right)^2}$$

$$\Rightarrow \quad h = 0.41r$$

19 **(d)**

As we know gas molecules cannot escape from earth's atmosphere because their root mean square velocity is less than escape velocity at earth's surface. If we fill this requirement, then gas molecules can escape from earth's atmosphere.

ie, $\quad v_{\text{rms}} = v_{\text{es}}$

or $\quad \sqrt{\frac{3RT}{M}} = \sqrt{2gR_e}$

or $\quad T = \frac{2MgR_e}{3R} \quad$ ....(i)

Given, $M = 2 \times 10^{-3}$kg, $\quad g = 9.8\ ms^{-2}$

$R_e = 6.4 \times 10^6$ m, $R = 8.31$ Jmol^{-1}– K^{-1}

Substituting in Eq. (i), we have

$$T = \frac{2 \times 2 \times 10^{-3} \times 9.8 \times 6.4 \times 10^6}{3 \times 8.31}$$

$$= 10^4 \text{ K}$$

20 **(d)**

$$v_0 = \sqrt{\frac{GM}{r}} = \sqrt{\frac{gR^2}{R+h}}$$

21 **(b)**

For a moving satellite kinetic energy $= \frac{GMm}{2r}$

Potential energy $= \frac{-GMm}{r} \Rightarrow \therefore \frac{\text{Kinetic energy}}{\text{Potential energy}} = \frac{1}{2}$

22 **(b)**

$I = \frac{-dV}{dr}$. If $I = 0$ then $V =$ constant

23 **(b)**

$$v = \sqrt{2gR} \Rightarrow \frac{v_A}{v_B} = \sqrt{\frac{g_A}{g_B} \times \frac{R_A}{R_B}} = \sqrt{k_1 \times k_2}$$

$$= \sqrt{k_1 k_2}$$

24 **(d)**

Orbital radius of satellites $r_1 = R + R = 2R$

$r_2 = R + 7R = 8R$

$U_1 = -\frac{GMm}{r_1}$ and $U_2 = -\frac{GMr}{r_2}$

$K_1 = \frac{GMm}{2r_1}$ and $K_2 = \frac{GMm}{2r_2}$

$E_1 = \frac{GMm}{2r_1}$ and $E_2 = \frac{GMm}{2r_2}$

$\therefore \frac{U_1}{U_2} = \frac{K_1}{K_2} = \frac{E_1}{E_2} = 4$

26 **(c)**

If no external torque acts on a system, then angular momentum of the system does not change.

ie, If $\tau = 0$

$\Rightarrow \frac{dL}{dt} = 0$

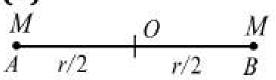
$\therefore L = \text{constant}$

Hence, $mv_{\max}r_{\min} = mv_{\min}r_{\max}$

$\Rightarrow r_{\min} = \frac{v_{\min} \times r_{\max}}{v_{\max}}$

$= \frac{1 \times 10^3 \times 4 \times 10^4}{3 \times 10^4} = \frac{4}{3} \times 10^3 \text{km}$

27 **(d)**



Gravitational potential of A at $O = -\frac{GM}{r/2} = -\frac{2GM}{r}$

For B, potential at $O = -\frac{GM}{r/2} = -\frac{2GM}{r}$

$\therefore$ Total potential $= -\frac{4GM}{r}$

28 **(b)**

Orbital radius of Jupiter > Orbital radius of Earth

$\frac{v_J}{v_e} = \frac{r_e}{r_J}$. As $r_J > r_e$ therefore $v_J < v_e$

29 **(d)**

% change in $T = \frac{3}{2}$(% change in R) $= \frac{3}{2} \times (2)\% = 3\%$

31 **(b)**

From Kepler's third law of planetary motion

$T^2 \propto R^3$

Given, $T_1 = 1, T_2 = 8, R_1 = R$

$\therefore \frac{T_1^2}{T_2^2} = \frac{R_1^3}{R_2^3}$

$R_2^3 = R_1^3 \frac{T_2^2}{T_1^2}$

$R_2^3 = R_1^3 \times (8)^2$

$R_2^3 = R^3 \times (2^3)^2$

$\Rightarrow R_2 = R \times 4 = 4R$

32 **(c)**

$g = \frac{4}{3} G\pi R\rho \Rightarrow \frac{g_1}{g_2} = \frac{\rho_1 R_1}{\rho_2 R_2} = \frac{1}{2} \times \frac{4}{1} = \frac{2}{1}$

33 **(b)**

Gravitational acceleration is given by

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

where G= gravitational constant

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

35 **(c)**

Let x be the distance of point from the smaller body where gravitational intensity is zero.

$\therefore \frac{Gm_1}{(1-x)^2} = \frac{Gm_2}{x^2}$

or $\frac{x}{1-x} = \sqrt{\frac{m_2}{m_1}} = \sqrt{\frac{1000}{100,000}} = \frac{1}{10}$

or $10x = -x$

or $x = (1/11)\text{m}$

37 **(b)**

From kepler's third law of planetary motion:

$T^2 \propto R^3$

Given, $T_p = 27T_{e'}$

$\frac{T_e^2}{T_p^2} = \frac{R_e^3}{R_p^3}$

$\frac{T_e^2}{(27T_e)^2} = \frac{R_e^3}{R_p^3}$

$\frac{R_p}{R_e} = (27)^{1/2}$

$\frac{R_p}{R_e} = 3^2$

$R_p = 9R_e$

38 **(a)**

$g' = g\left(\frac{R}{R+h}\right)^2 = g\left(\frac{R}{R+\frac{R}{2}}\right)^2 = \frac{4}{9}g$

$\therefore W' = \frac{4}{9} \times W = \frac{4}{9} \times 72 = 32N$

39 **(b)**

The acceleration due to gravity

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

At a height h above the earth's surface, the acceleration due to gravity is

$g' = \frac{GM}{(R+h)^2}$

$\therefore \frac{g}{g'} = \left(1+\frac{h}{R}\right)^{-2} = \left(1+\frac{h}{R}\right)^2$

$\frac{g'}{g} = \left(1+\frac{h}{R}\right)^{-2} = \left(1-\frac{2h}{R}\right)$

but $g' = \frac{g}{2}$ (given)

$\therefore \frac{g/2}{g} = 1 - \frac{2h}{R}$

$\frac{2h}{R} = \frac{1}{2}$

$h = \frac{R}{4}$

40 **(b)**

Since, gravitation provides centripetal force

$\frac{mv^2}{r} = \frac{k}{r^{5/2}}$ $ie, v^2 = \frac{k}{mr^{3/2}}$

So that $T = \frac{2\pi r}{v} = \sqrt{\frac{mr^{3/2}}{k}}$ $ie, T^2 = \frac{4\pi^2 m}{k} r^{7/2}$

$\therefore T^2 \propto r^{7/2}$

41 **(c)**

For $r \le R$:

$$\frac{mv^2}{r} = \frac{Gmm'}{r^2}$$

Here, $m' = \left(\frac{4}{3}\pi r^3\right)\rho_0$

Substituting in Eq. (i) we get

$$v \propto r$$

ie, $v-r$ graph is a straight line passing through orgine.

For $r > R$:

$$\frac{mv^2}{r} = \frac{G\,m\left(\frac{4}{3}\pi R^3\right)\rho_0}{r^2}$$

or $v \propto \frac{1}{\sqrt{r}}$

The corresponding $v-r$ graph will be as shown in option (c).

42 **(c)**

$g = \frac{GM}{R^2} = \frac{GM_0}{(D_0/2)^2} = \frac{4GM_0}{D_0^2}$

43 **(c)**

If x is the distance of point on the line joining the two masses from mass m_2' where gravitational field intensity is zero, then

$\frac{Gm}{(r-x)^2} = \frac{Gm_2}{x^2}$ or $\frac{2}{(9-x)^2} = \frac{8}{x^2}$

or $\frac{1}{9-x} = \frac{2}{x}$

On solving, $x = 6$m

45 **(a)**

$v = \sqrt{2gR}$ $\therefore \frac{v_1}{v_2} = \sqrt{\frac{g_1}{g_2} \times \frac{R_1}{R_2}} = \sqrt{g \times K} = (Kg)^{1/2}$

46 **(b)**

As $T^2 \propto r^3$,

so, $\frac{T_A^2}{T_B^2} = \frac{r_A^3}{r_B^3}$

or $\frac{r_A}{r_B} = \left(\frac{T_A}{T_B}\right)^{2/3} = (8)^{2/3} = 4$

or $r_A = 4r_B$;

so $r_A - r_B = 4r_B - r_B = 3r_B$

47 **(c)**

Weight of the body at equator $= \frac{3}{5}$ of initial weight

$\therefore g' = \frac{3}{5} g$ (because mass remains constant)

$g' = g - \omega^2 R \cos^2 \lambda \Rightarrow \frac{3}{5} g = g - \omega^2 R \cos^2(0°)$

$\Rightarrow \omega^2 = \frac{2g}{5R} \Rightarrow \omega = \sqrt{\frac{2g}{5R}} = \sqrt{\frac{2 \times 10}{5 \times 6400 \times 10^3}}$

$= 7.8 \times 10^{-4} \frac{rad}{sec}$

48 **(c)**

$\frac{T_1}{T_2} = \left(\frac{R_1}{R_2}\right)^{3/2} = \left(\frac{R}{4R}\right)^{3/2} \Rightarrow T_2 = 8T_1$

49 **(a)**

Escape velocity of a body from the surface of earth is 11.2 kms^{-1} which is independent of the angle of project

51 **(b)**

$v = \sqrt{\frac{GM}{R}} = G^{1/2} M^{1/2} R^{-1/2}$

52 **(d)**

Since, velocity of projection (v)is greater than the escape velocity (v_e),therefore at infinite distance the body moves with a velocity

$$v' = \sqrt{v^2 - v_e^2}$$

$\therefore$ $v' = \sqrt{(\sqrt{5}v_e)^2 - v_e^2} = 2v_e$

53 **(c)**

Gravitational field inside hollow sphere will be zero

54 **(d)**

When $r < R$, Gravitational field intensity,

$I = \frac{GM}{R^3} r = \frac{Gr}{R^3}\left(\frac{4}{3}\pi R^3 \rho\right) = \frac{4\pi G\rho r}{3}$

55 **(a)**

Escape velocity $v = \sqrt{2gR}$

$\therefore$ $\frac{v_1}{v_2} = \sqrt{\frac{g_1}{g_2} \times \frac{R_1}{R_2}}$

$= \sqrt{g \times K} = (Kg)^{1/2}$

56 **(b)**

Orbital speed, $v_0 = \sqrt{\frac{GM}{r}}$; so speed of satellite decreases with the increase in the radius of its orbit. We need more than one satellite for global communication. For stable orbit it must pass through the centre of earth. So, only (b) is correct

57 **(c)**

$g = \frac{GM}{R^2} \therefore g \propto \frac{M}{R^2}$

According to problem $M_p = \frac{M_e}{2}$ and $R_p = \frac{R_e}{2}$

$\therefore \frac{g_p}{g_e} = \left(\frac{M_p}{M_e}\right)\left(\frac{R_e}{R_p}\right)^2 = \left(\frac{1}{2}\right) \times (2)^2 = 2$

$\Rightarrow g_p = 2g_e = 2 \times 9.8 = 19.6\ m/s^2$

58 **(c)**

The escape velocity of a particle

$$v_e = \sqrt{2gR}$$

Hence, the escape velocity is independent of mass of the particle.

59 **(b)**

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

$\therefore \frac{g_{earth}}{g_{planet}} = \frac{M_e}{M_p} \times \frac{R_p^2}{R_e^2}$

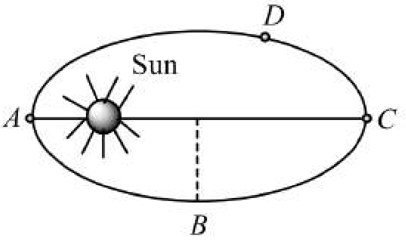
$\Rightarrow \frac{g_e}{g_p} = \frac{2}{1}$

Also, $T \propto \frac{1}{\sqrt{g}} \Rightarrow \frac{T_e}{T_p} = \sqrt{\frac{g_p}{g_e}}$

$\Rightarrow \frac{2}{T_p} = \sqrt{\frac{1}{2}} \Rightarrow T_p = 2\sqrt{2}s$

60 **(c)**

From Kepler's second law of planetary motion, the linear speed of a planet is maximum, when its distance from the sun is least, *ie*, at point *A*.



61 **(a)**

Time period, $T = \frac{2\pi R}{\sqrt{\frac{GM_m}{R}}} = \frac{2\pi R^{3/2}}{\sqrt{GM_m}}$

Where the symbols have their meaning as given in the question

Squaring both sides, we get

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

62 **(d)**

Orbital velocity $v_0 = \sqrt{\frac{GM}{r}} = \sqrt{\frac{gR^2}{r}}$ and $v_0 = r\omega$

This gives $r^3 = \frac{R^2 g}{\omega^2}$

63 **(d)**

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

$v_e = \sqrt{\frac{2G\ \frac{4}{3}\pi R^3 \times d}{R}}$

$\sqrt{2G\ \frac{4}{3}\pi R^3 \times d} = R\sqrt{\frac{8}{3}\pi G d}$

where d = mean density of earth

$\because\ v_e \propto R\sqrt{d}$

$\therefore\ \frac{v_e}{v_p} = \frac{R_e}{R_p}\sqrt{\frac{d_e}{d_p}}$

$= \frac{R_e}{2R_e}\sqrt{\frac{d_e}{d_e}}$

$= v_p = 2v_e$

$= 2 \times 11 = 22\text{kms}^{-1}$

65 **(d)**

Here, $u = 20\ \text{ms}^{-1}, m = 500\text{g} = 0.5\text{kg}, t = 20$ s

Using Newton's equation of motion

$$s = ut + \frac{1}{2}gt^2$$

$$0 = 20 \times 20 + \frac{1}{2}(-g)(20)^2$$

or $\quad g = 2\ \text{ms}^{-2}$

$\therefore$ Weight of body on planet $= mg$

$= 0.5 \times 2 = 1$ N

68 **(c)**

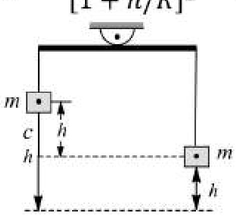
Angular momentum remains constant

$mv_1d_1 = mv_2d_2 \Rightarrow v_2 = \frac{v_1 d_1}{d_2}$

69 **(b)**

As with height g varies as

$g'' = \frac{g}{[1 + h/R]^2} = g\left[1 - \frac{2h}{R}\right]$



and in according with figure $h_1 > h_2$, so W_1 will be lesser than W_2 and

$W_2 - W_1 = mg_2 - mg_1 = 2mg\left[\frac{h_1}{R} - \frac{h_2}{R}\right]$

or $\ W_2 - W_1 = 2m\frac{GM}{R^2}\frac{h}{R}$

$\left[\text{as } g = \frac{GM}{R^2} \text{ and } (h_1 - h_2) = h\right]$

or $\ W_2 - W_1 = \frac{2mhG}{R^3}\left(\frac{4}{3}\pi R^3 \rho\right)$

$= \frac{8}{3}\pi\rho G m h\ \left[as\ M = \frac{4}{3}\pi R^3 \rho\right]$

71 **(c)**

Time period of nearby satellite

$$T = 2n\sqrt{\frac{r^3}{GM}}$$

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

$$= \frac{2\pi(R^3)^{1/2}}{\left[G\,\frac{4}{3}\pi R^3\rho\right]^{1/2}} = \sqrt{\frac{3\pi}{G\rho}}$$

72 **(a)**

The acceleration due to gravity (g) is given by

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

where M is mass, G the gravitational constant and R the radius.

Since, planets have a spherical shape

$$V = \frac{4}{3}\pi r^3$$

Also, mass (M) = volume(V) × density(ρ)

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

$$\Rightarrow \quad g = \frac{4G\pi\rho R}{3}$$

Given, $R_1 : R_2 = 2 : 3$

$$\rho_1 : \rho_2 = \frac{3}{2}$$

$$\therefore \quad \frac{g_1}{g_2} = \frac{\rho_1 R_1}{\rho_2 R_2} = \frac{3}{2} \times \frac{2}{3} = 1$$

73 **(c)**

The maximum velocity with which a body must be projected in the atmosphere, so as to enable it to just overcome the gravitational pull, is known as escape velocity.

Escape velocity from earth's surface is

$$v_{es} = \sqrt{\frac{2GM_e}{R_e}}$$

$$= \sqrt{\frac{2G\cdot\frac{4}{3}\pi R_e^3 d_e}{R_e}} \quad \left(\therefore M = \frac{4}{3}\pi R_e^3 d_e\right)$$

or $\quad v_{es} \propto \sqrt{d_e} \times R_e \quad \ldots.(i)$

similarly, for a planet

$$v'_{es} \propto \sqrt{d_p} \times R_p \quad \ldots(ii)$$

So, $$\frac{v_{es}}{v'_{es}} = \left(\frac{d_e}{d_p}\right)^{1/2} \times \frac{R_e}{R_p}$$

Given, $\quad d_p = \frac{1}{4}d_e, R_p = 2R_e$

$$\frac{v_{es}}{v_{es}} = \left(\frac{d_e}{\frac{d_e}{4}}\right)^{\frac{1}{21}} \times \frac{R_e}{2R_e}$$

$$= (4)^{1/2} \times \frac{1}{2}$$

$$= 2 \times \frac{1}{2} = 1$$

So, $\quad \frac{v_{es}}{v'_{es}} = 1:1$

74 **(a)**

The value of acceleration due to gravity g at height h above the surface of earth is

$$g_h = \frac{g}{\left(1+\frac{h}{R}\right)^2}$$

Where R is radius of earth.

$$\therefore \quad \frac{g}{g_h} = \left(1+\frac{h}{R}\right)^2$$

75 **(b)**

$$v = \sqrt{\frac{GM}{r}}$$

76 **(b)**

Angular momentum is conserved in central field

77 **(d)**

The true weight of a body is given by mg and with height g decrease

So, $\frac{W_s}{W_E} = \frac{mg'}{mg} = \frac{1}{[1+(h/R)]^2}\left[\text{as } g' = \frac{g}{[1+(h/R)]^2}\right]$

But here, $h = 7R - R = 6R$, $ie, h/R = 6$

So, $W_S = \frac{W_E}{(1+6)^2} = \frac{10}{49} = 0.2\text{N}$

78 **(d)**

$$v_e = \sqrt{\frac{2GM}{(R+h)}}$$

79 **(a)**

$$g' = g\left(\frac{R}{R+h}\right)^2 = g\left(\frac{R}{R+2R}\right)^2 = \frac{g}{9}$$

80 **(c)**

$$\frac{g_m}{g_e} = \frac{G(M/8)}{GM/R_e^2} = \frac{R_e^2}{8R_m^2}; \ \ldots(i)$$

Given, $\frac{mg_m}{mg_e} = \frac{1}{6}$

or $\frac{g_m}{g_e} = \frac{1}{6}$ ...(ii)

From Eqs. (i) and (ii); $\frac{R_e^2}{8R_m^2} = \frac{1}{6}$

or $R_e = \sqrt{8/6}R_m$

81 **(c)**

Escape velocity $v = \sqrt{\frac{2GM}{R}}$

If star rotates with angular velocity ω

Then $\omega = \frac{v}{R} = \frac{1}{R}\sqrt{\frac{2GM}{R}} = \sqrt{\frac{2GM}{R^3}}$

82 **(d)**

Time period (T) of a synchronous satellite around the earth is given by

$$T^2 = \frac{4\pi^2 r^3}{Gm_e} \Rightarrow r = \left(\frac{T^2 Gm_e}{4\pi^2}\right)^{1/3}$$

Substituting the given values, we get

$$r = \left[\frac{(24\times 60\times 60)^2 + 6.67\times 10^{-11}\times 5.98\times 10^{24}}{4\times\frac{22}{7}\times\frac{22}{7}}\right.$$

$r = 42.08\times 10^6 m$

$\therefore \frac{r}{r_e} = \frac{42.08\times 10^6 m}{6.37\times 10^6 m} = 6.6 \Rightarrow r = 6.6 r_e$

83 **(d)**

Kinetic energy of the satellite is $K = \frac{GMm}{2r}$ ...(i)

Potential energy of the satellite is $U = -\frac{GMm}{r}$ ...(ii)

Total energy of the satellite is $E = -\frac{GMm}{2r}$ ...(iii)

Divide (iii) by (i), we get $\frac{E}{K} = -1$ or $E = -K$

Divide (iii) by (ii), we get $\frac{E}{U} = \frac{1}{2}$ or $E = \frac{U}{2}$

86 **(b)**

$F = Gm_1m_2/r^2$, thus on increasing masses and reducing distance r, force of gravitational attraction F will increase

87 **(b)**

Time period is independent of mass. Therefore their periods of revolution will be same.

88 **(c)**

Kinetic energy = Potential energy

$$\frac{1}{2}m(kv_e)^2 = \frac{mgh}{1+\frac{h}{R}} \Rightarrow \frac{1}{2}mk^2 2gR = \frac{mgh}{1+\frac{h}{R}} \Rightarrow h = \frac{Rk^2}{1-k^2}$$

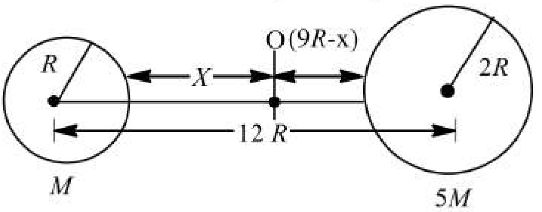
Height of Projectile from the earth's surface $= h$

Height from the centre $r = R + h = R + \frac{Rk^2}{1-k^2}$

By solving $r = \frac{R}{1-k^2}$

89 **(c)**

Let at O there will be a collision. If smaller sphere moves x distance to reach at O, then bigger sphere will move a distance of $(9R - x)$



$$a_{small} = \frac{F}{M} = \frac{G\times 5M}{(12R-x)^2}$$

$$a_{big} = \frac{F}{5M} = \frac{GM}{(12R-x)^2}$$

$$x = \frac{1}{2}a_{small}t^2 = \frac{1}{2}\frac{G\times 5M}{(12R-x)^2} \quad \text{... (i)}$$

$$(9R-x) = \frac{1}{2}a_{big}t^2 = \frac{1}{2}\frac{GM}{(12R-x)^2}t^2 \quad \text{... (ii)}$$

Thus, dividing Eq. (i) by Eq. (ii), we get

$\therefore \quad \frac{x}{9R-x} = 5$

$\Rightarrow \quad x = 45R - 5x$

$\Rightarrow \quad 6x = 45R$

$\Rightarrow \quad x = 7.5\ R$

90 **(b)**

In circular orbit of a satellite of potential energy

$$= -2\times(\text{kinetic energy})$$
$$= -2\times\frac{1}{2}m^v = -mv^2$$

Just to escape from the gravitational pull, its total mechanical energy should be zero. Therefore , its kinetic energy should be $+mv^2$

91 **(a)**

Acceleration due to gravity at height h is

$$g' = \frac{g}{\left(1+\frac{h}{R_e}\right)^2} = \frac{g}{\left(1+\frac{32}{6400}\right)^2} = 0.99\ g$$

92 **(a)**

$v = \sqrt{2gR}$. If acceleration due to gravity and radius of the planet, both are double that of earth then escape velocity will be two times, $i.e.\ v_p = 2v_e$

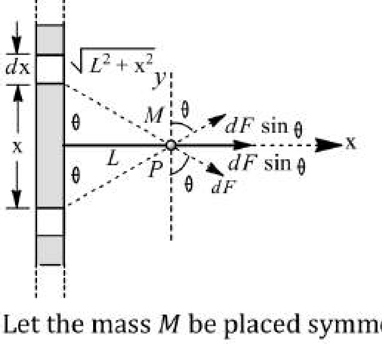
93 **(b)**

Potential energy $U = \frac{-GMm}{r} = -\frac{GMm}{R+h}$

$U_{initial} = -\frac{GMm}{3R}$ and $U_{final} = -\frac{GMm}{2R}$

Loss in PE = gain in KE $= \frac{GMm}{2R} - \frac{GMm}{3R} = \frac{GMm}{6R}$

94 **(c)**



Let the mass M be placed symmetrically

$$\Rightarrow F_{\text{net}} = \int_{-\infty}^{\infty} dF \sin\theta = \int_{-\infty}^{\infty} \frac{GM(\lambda dx)}{X^2+L^2}\frac{L}{\sqrt{X^2+L^2}}$$

$$\Rightarrow F_{\text{net}} = GM\lambda L \int_{-\infty}^{\infty} \frac{dx}{(X^2+L^2)^{3/2}}$$

$$\Rightarrow F_{\text{net}} = \frac{GM\lambda L}{L^2}(2)$$

$$\Rightarrow F_{\text{net}} = \frac{2GM\lambda}{L^2}$$

95 **(d)**

The system will be bound at points where total energy is negative. In the given curve at point A, B and C the P.E. is more than K.E.

97 **(c)**

$$v_e = \sqrt{2gR} \Rightarrow \frac{v_A}{v_B} = \sqrt{\frac{g_A}{g_B}\times\frac{R_A}{R_B}} = \sqrt{x\times r} \therefore \frac{v_A}{v_B} = \sqrt{rx}$$

98 **(b)**

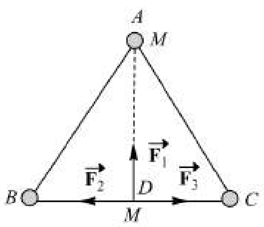
$$g' = g\left(1-\frac{d}{R}\right) \Rightarrow \frac{g}{n} = g\left(1-\frac{d}{R}\right) \Rightarrow d = \left(\frac{n-1}{n}\right)R$$

100 **(b)**

$$U_{(r)} = \begin{cases} -\frac{GMm}{r}, r \geq R \\ -\frac{GMm}{R}, r < R \end{cases}$$

101 **(b)**

(i)Gravitational force on the particle placed at mid point D of side BC of length a is



$\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3$

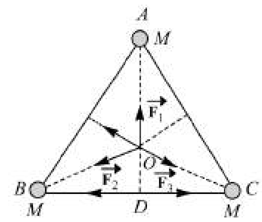
Here, $\vec{F}_2 = -\vec{F}_3$

$\therefore \vec{F} = \vec{F}_1 + 0 = \vec{F}_1$

or $F = F_1 = \frac{GMM}{[AD]^2} = \frac{GM^2}{(3a^2/4)} = \frac{4GM^2}{3a^2}$

(ii)gravitational force on the particle placed at the point O, *ie* the intersection of three medians is

$\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 = \vec{0}$ or $F = 0$



Since, the resultant of $\vec{F}_2$ and $\vec{F}_3$ is equal and opposite to $\vec{F}_1$

102 **(b)**

If g is the acceleration due to gravity of earth at the position of satellite, the apparent weight of a body in the satellite will be

$W_{\text{app}} = m(g' - a)$

But as satellite is a freely falling body, *ie*, $g' = a$

So, $W_{\text{app}} = 0$

103 **(d)**

$$\frac{K_A}{K_B} = \frac{r_B}{r_A} = \left(\frac{R+h_B}{R+h_A}\right) = \left(\frac{R+2R}{R+R}\right) = \frac{3}{2}$$

104 **(b)**

As mass, $M = \frac{4}{3}\pi R^2 \rho$

or $\rho = \frac{3M}{4\pi R^3}$

$$\therefore \frac{\rho_s}{\rho_s} = \frac{M_s}{M_e}\times\frac{R_e^3}{R_s^3} = 330\times\left(\frac{1}{100}\right)^3 = 3.3\times10^{-4}$$

105 **(c)**

$U = \frac{-GMm}{r}, K = \frac{GMm}{2r}$ and $E = \frac{-GMm}{2r}$

For a satellite U, K and E varies with r and also U and E remains negative whereas K remain always positive

106 **(a)**

$$g' = g - \frac{10g}{100} - \frac{90}{100}g$$

$$g' = g\frac{R^2}{(R+h)^2} \text{ or } \frac{9}{10} = \frac{R^2}{(R+h)^2}$$

or $\frac{3}{\sqrt{10}} = \frac{R}{R+h}$

or $h = (\sqrt{10}-3)R/3$

$$\frac{(\sqrt{10}-3)\times 6400}{3} = 345.60 \text{ km}$$

107 **(d)**

The minimum velocity of projection to achieve escape velocity can be calculated as

$$\text{Intial KE} = \frac{1}{2}mv^2$$

$$= \frac{1}{2}\times m(4\times11.2)^2 = 16\times\frac{1}{2}mv_e^2$$

As $\frac{1}{2}mv_e^2$ energy is used up in coming out from the gravitational pull of the earth, so final KE should be $15 \times \frac{1}{2}mv_e^2$

Hence, $\frac{1}{2}mv_e'^2 = 15 \times \frac{1}{2}mv_e^2$

$\therefore \quad v'^2 = 15v_e^2$

or $\quad v' = \sqrt{15}v_e$

$= \sqrt{15} \times 11.2\text{kms}^{-1}$

108 **(c)**

$$\frac{T_{\text{mercury}}}{T_{\text{earth}}} = \left(\frac{r_{\text{mercury}}}{r_{\text{earth}}}\right)^{3/2} = \left(\frac{6 \times 10^{10}}{1.5 \times 10^{11}}\right)^{3/2} = \frac{1}{4}$$

(approx.)

$\therefore T_{\text{mercury}} = \frac{1}{4}\text{year}$

109 **(c)**

$$\frac{g_m}{g_e} = \frac{M_m}{M_e} \times \left(\frac{R_e}{R_m}\right) = \frac{1}{81} \times (4)^2 = \frac{16}{81}$$

$$g_m = \frac{16}{81}g_e$$

$\therefore v_e = \sqrt{2g_eR_e} = \sqrt{2 \times 9.8 \times (6400 \times 1000)}$

$\approx 11.2 \text{ kms}^{-1}$

$$v_m = \sqrt{2g_mR_m} = \sqrt{2 \times \frac{16}{81}g_e \times \frac{1}{4}R_e}$$

$$= \frac{2}{9}\sqrt{2g_eR_e} = \frac{2}{9} \times 11 \approx 2.5 \text{ kms}^{-1}$$

110 **(a)**

Acceleration due to gravity is given by

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

where G is gravitational constant.

For earth: $g_e = \frac{GM_e}{R_e^2}$

For planet: $g_p = \frac{GM_p}{R_p^2}$

Therefore, $\frac{g_e}{g_p} = \frac{GM_e/R_e^2}{GM_p/R_p^2}$

or $\quad \frac{g_e}{g_p} = \frac{M_e}{M_p} \times \frac{R_p^2}{R_e^2} \quad$ ... (i)

Given, $\quad M_p = 2M_e, \quad R_p = 2R_e$

Putting the values in the Eq. (i), we obtain

$$\frac{g_e}{g_p} = \frac{M_e}{2M_e} \times \frac{(2R_e)^2}{R_e^2} = \frac{1}{2} \times \frac{4}{1} = 2$$

$\therefore \quad g_p = \frac{g_e}{2}$

111 **(c)**

$v_e = \sqrt{\frac{2GM}{R}}$ *i.e.* escape velocity depends upon the mass and radius of the planet

112 **(b)**

When the spaceship is to take off, gravitational pull of earth requires more energy to be spent to overcome it

113 **(d)**

Acceleration due to gravity on earth is given by

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

$\left(\text{Here}, M_m = \frac{M_e}{9}, R_m = \frac{R_e}{2}\right)$

Hence, $\quad \frac{g_e}{g_m} = \frac{M_e}{M_m} \times \frac{R_m^2}{R_e^2} = \frac{9M_e}{M_e} \times \left(\frac{R_e}{2R_e}\right)^2$

or $\quad \frac{g_e}{g_m} = \frac{9}{4}$

So, $\quad \frac{g_m}{g_e} = \frac{4}{9}$

$\because$ Weight of body on moon

= weight of body on earth $\times g_m/g_e$

$= 90 \times \frac{4}{9} = 90 \times \frac{4}{9} = 40\text{kg}$

114 **(b)**

$\omega_{\text{body}} = 27\omega_{\text{earth}}$

$T^2 \propto r^3 \Rightarrow \omega^2 \propto \frac{1}{r^3} \Rightarrow \omega \propto \frac{1}{r^{3/2}} \therefore r \propto \frac{1}{\omega^{2/3}}$

$\Rightarrow \frac{r_{\text{body}}}{r_{\text{earth}}} = \left(\frac{\omega_{\text{earth}}}{\omega_{\text{body}}}\right)^{2/3} = \left(\frac{1}{27}\right)^{2/3} = \frac{1}{9}$

115 **(d)**

$$L = mvr = m\left(\sqrt{\frac{GM}{r}}\right)r = m\sqrt{GMr} \therefore L \propto \sqrt{r}$$

116 **(c)**

$H = \frac{u^2}{2g} \Rightarrow H \propto \frac{1}{g} \Rightarrow \frac{H_B}{H_A} = \frac{g_A}{g_B}$

Now $g_B = \frac{g_A}{12}$ as $g \propto \rho R$

$\therefore \frac{H_B}{H_A} = \frac{g_A}{g_B} = 12$

$\Rightarrow H_B = 12 \times H_A = 12 \times 1.5 = 18m$

117 **(b)**

$T^2 \propto r^3$

118 **(c)**

Force acting on a body of mass M at a point at depth d. Inside the earth is

$F = mg' = mg\left(1 - \frac{d}{R}\right)$

$= \frac{mGM}{R^2}\left(\frac{R-d}{R}\right) = \frac{GM\,m}{R^3}r \quad (\because R - d = r)$

So, $F \propto r$; Given $F \propto r^n$

$n = 1$

119 **(d)**

Let the gravitational force on a body mass m at O due to moon of mass M and earth of mass $8/M$ be zero, where $EO = x$ and $MO = (r - x)$. Then,

$$\frac{G81M \times m}{x^2} = \frac{GM\,m}{(r-x)^2}$$

or $\frac{81}{x^2} = \frac{1}{(r-x)^2}$

or $\frac{9}{x} = \frac{1}{(r-x)}$

On solving; $x = 9r/10$

120 **(b)**

Gravitational force on a body at a distance x from the centre of earth $F = \frac{GMm}{x^2}$

Work done,

$$W = \int_R^{R+h} F\,dx = \int_R^{R+h} \frac{GM\,m}{x^2} dx$$

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

This work done appears as increase in potential energy

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

$$= mg(5h)^2\left[\frac{1}{5h} - \frac{1}{6h}\right] = \frac{5}{6}mgh$$

121 **(c)**

According to Kepler's third law, we have

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

Hence, $\frac{T_A^2}{T_B^2} = \left(\frac{4R}{R}\right)^3 = \frac{64}{1}$

or $\frac{T_A}{T_B} = \frac{8}{1}$

or $\frac{2\pi\omega_B}{2\pi\omega_A} = \frac{8}{1}$

or $\frac{v_B \times 4R}{R \times v_A} = \frac{8}{1}$

or $\frac{v_B}{3v} = 2$

or $v_B = 6v$

122 **(c)**

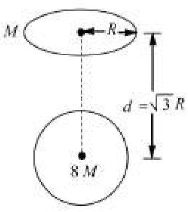
Launching the rocket in the direction of earth's rotation allows it to exploit the earth's rotational velocity *ie*, launching it from West to East. (It gains speed from velocity addition with the earth's rotational velocity.)

123 **(a)**

The escape velocity at the surface of earth is 11.2 kms^{-1}

124 **(d)**

From the figure the gravitational intensity due to the ring at a distance $d = \sqrt{3}R$ on its axis is



$$I = \frac{GM}{(d^2 + R^2)^{3/2}} = \frac{GM \times \sqrt{3}R}{(3R^2 + R^2)^{3/2}} = \frac{\sqrt{3}GM}{8R^2}$$

Force on sphere = $(8M)I = (8M) \times \frac{\sqrt{3}GM}{8R^2}$

$$= \frac{\sqrt{3}GM^2}{R^2}$$

125 **(c)**

According to Kepler's law

$$T^2 \propto r^3$$

or $5^2 \propto r^3$ ... (i)

and $(T')^2 \propto (4r)^3$ ... (ii)

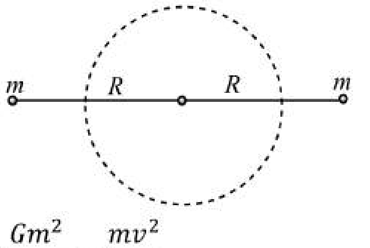
From Eqs.(i) and (ii), we have

$$\frac{25}{(T')^2} = \frac{r^3}{64r^3}$$

$$T = \sqrt{1600} = 40\text{h}$$

126 **(b)**

Gravitational force provides necessary centripetal force



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

$$\Rightarrow v = \sqrt{\frac{Gm}{4R}}$$

127 **(a)**

$T = 2\pi\sqrt{\frac{l}{g}}$. At the hill g will decrease so to keep the time period same the length of pendulum has to be reduced

128 **(b)**

This should be equal to escape velocity *i.e.*, $\sqrt{2gR}$

129 **(d)**

A person is safe, if his velocity while reaching the surface of moon from a height h' is equal to its velocity while falling from height h on earth. So

$$\sqrt{2g'h'} = \sqrt{2gh}$$

or $h' = gh/g' = 9.8 \times 3/1.96 = 15\text{m}$

130 **(d)**

$g_m = \frac{GM_m}{R_m^2}$ and $g_m = \frac{g_e}{6} = \frac{9.8}{6} m/s^2 = 1.63\ m/s^2$

Substituting $R_m = 1.768 \times 10^6 m, g_m = 1.63\ m/s^2$

and $G = 6.67 \times 10^{-11} N\text{-}m^2/kg^2$ We get

$M_m = 7.65 \times 10^{22} kg$

131 **(a)**

From Kepler's law, $T^2 \propto R^3$

or $\left(\frac{T_2}{T_1}\right)^2 = \left(\frac{R_2}{R_1}\right)^3 = \left(\frac{1.01\ R}{R}\right)^3 = (1+0.01)^3$

or $\frac{T_2}{T_1} = (1+0.01)^{3/2} = 1 + \left(\frac{3}{2} \times 0.01\right)$

or $\frac{T_2 - T_1}{T_1} = \frac{1.5}{100} = 1.5\%$

132 **(c)**

$\frac{g'}{g} = 1 - \frac{2h}{R} = 1 - \frac{2 \times 320}{6400} = 1 - \frac{1}{10} = \frac{9}{10}$

$\therefore$ % decrease in g $= \left(\frac{g-g'}{g}\right) \times 100$

$= \frac{1}{100} \times 100 = 10\%$

133 **(c)**

$v_e \propto \frac{1}{\sqrt{R}}$. If R becomes $\frac{1}{4}$ then v_e will be 2 times

134 **(d)**

Time period does not depends upon the mass of satellite

135 **(b)**

If missile is launched with escape velocity, then it will escape from the gravitational field and at infinity its total energy becomes zero

But if the velocity of projection is less than escape velocity then sum of energies will be negative.

This shows that attractive force is working on the missile

136 **(a)**

Let R be the original radius of a planet. Then attraction on a body of mass m placed on its surface will be

$F = \frac{GM\,m}{R^2}$

If size of the planet is made double *ie*, $R' = 2R$, then mass of the planet becomes

$M' = \frac{4}{3}\pi(2R)^3\rho = 8 \times \frac{3}{4}\pi R^2 \rho = 8M$

New force $F' = -\frac{GM'm}{R'^2} = -\frac{G8M \times m}{(2R)^2} = 2F$

ie, force of attraction increases due to the increase in mass of the planet

137 **(c)**

From Kepler 's third law of planetary motion,

$T^2 \propto a^3$

Given, $T_1 = 1\text{day}$ (geostationary)

$a_1 = a, a_2 = 2a$

$\therefore \quad \frac{T_1^2}{T_2^2} = \frac{a_1^3}{a_2^3}$

$\Rightarrow \quad T_2^2 = \frac{a_2^3}{a_1^3} T_1^2 = \frac{(2a)^3}{a^3} \times 1 = 8$

$\Rightarrow \quad T_2 = 2\sqrt{2}$ days

138 **(c)**

When gravitational force becomes zero, then centripetal force on satellite becomes zero and therefore, the satellite will become stationary in its orbit.

139 **(b)**

The period of revolution of geostationary satellite is the same as that of the earth.

Orbital velocity $v_o = \sqrt{gR_e}$

Escape velocity $v_e = \sqrt{2gR_e}$

where R_e is radius of earth.

% increase $= \frac{v_e - v_o}{v_o} \times 100$

% increase $= \frac{\sqrt{2gR_e} - \sqrt{gR_e}}{\sqrt{gR_e}} \times 100$

$= (\sqrt{2} - 1) \times 100$

$= (1.141 - 1) \times 100 =$

41.4%

140 **(d)**

From Kepler's third law of planetary motion,

$T^2 \propto R^3$

$\Rightarrow \quad \frac{T^2}{R^3} = \text{constant}$

141 **(c)**

Mass of two planets is same, so

$\frac{4}{3}\pi R_1^3 \rho_1 = \frac{4}{3}\pi R_2^3 \rho_2$

or $\frac{R_1}{R_2} = \left(\frac{\rho_2}{\rho_1}\right)^{1/3} = \left(\frac{1}{8}\right)^{1/3} = \frac{1}{2}$

$\frac{g_1}{g_2} = \frac{GM/R_1^2}{GM/R_2^2} = \left(\frac{R_2}{R_1}\right)^2 = (2)^2 = 4$

142 **(d)**

Gravitational potential energy is given as

$U = -\frac{GMm}{r}$

$U_1 = -\frac{GMm}{r_1}, U_2 = -\frac{GMm}{r_2}$

As $r_2 > r_1$, hence,

$U_1 - U_2 = GMm\left[\frac{r_2 - r_1}{r_1 r_2}\right]$ is positie

ie, $U_1 > U_2$

or $U_2 < U_1$

ie, gravitational potential energy increases.

143 **(a)**

The earth behaves for all external points as if its mass M were concentrated at its centre. When man of mass m walks from a point on earth's surface and reaches diagonally opposite point, then gravitational potential energy given by

$$U = -\frac{GMm}{R}$$

Will remain same.

Hence, no work is done by the man against gravity.

144 **(b)**

Given, $g_h = 9 = \frac{gR^2}{(R+R/20)^2} = \frac{20\times20}{21\times21}g$

or $g = \frac{9\times21\times21}{20\times20}$

Now, $g_d = g\left(1 - \frac{d}{R}\right)$

$$= \frac{9\times21\times21}{20\times20}\left[1 - \frac{R/20}{R}\right] = 9.5\text{ms}^{-2}$$

145 **(b)**

Gravitational potential at a point on the surface of earth

$$V = \frac{-GM}{R} = \frac{-gR^2}{R} = -gR$$

147 **(a)**

Earth is surrounded by an atmosphere of gases (air). The reason is that in earth's atmosphere the average thermal velocity of even the highest molecules at the maximum possible temperature is small compared to escape velocity which in turn depends upon gravity ($v_e = \sqrt{gR_e}$).

Therefore, the molecules of gases cannot escape from the earth. Hence, an atmosphere exists around the earth.

148 **(c)**

$$\frac{g'}{g} = \left(\frac{R}{R+h}\right)^2 \Rightarrow \frac{1}{2} = \left(\frac{R}{R+h}\right)^2 \Rightarrow \frac{1}{2} = \left(\frac{4000}{4000+h}\right)^2$$

By solving we get $h = 1656.85\ mile \approx 1600\ mile$

149 **(d)**

It is given that, acceleration due to gravity on planet A is 9 times the acceleration due to gravity on planet B *ie*,

$$g_A = 9g_B \quad \text{...(i)}$$

From third equation of motion

$$v^2 = 2gh$$

At planet A, $h_A = \frac{v^2}{2g_A}$ ...(ii)

At planet B, $h_B = \frac{v^2}{2g_B}$ ...(iii)

Dividing Eq. (ii) by Eq. (iii), we have

$$\frac{h_A}{h_B} = \frac{g_B}{g_A}$$

From Eq. (i), $g_A = 9g_B$

$$\therefore \quad \frac{h_A}{h_B} = \frac{g_B}{9g_B} = \frac{1}{9}$$

or $h_B = 9h_A = 9 \times 2 = 18$ m $\quad (\because h_A = 2\text{m})$

151 **(b)**

Gravitational force provides the required centripetal force *ie*,

$$m\omega^2 R = \frac{GMm}{R^{\frac{5}{2}}}$$

$$\Rightarrow \quad \frac{m4\pi^2}{T^2} = \frac{GMm}{R^{\frac{7}{2}}}$$

$$\Rightarrow \quad T^2 \propto R^{7/2}$$

152 **(a)**

Escape velocity, $v_e = \sqrt{\frac{2GM_e}{R_e}}$

Given, $M_p = 6M_e, R_p = 2R_e$

$$\therefore \quad v_p = \sqrt{\frac{2G\cdot 6M_e}{(2R_e)}} = \sqrt{3}\,v_e$$

153 **(d)**

$$T = 2\pi\sqrt{\frac{r^3}{GM}} \Rightarrow r^3 = \frac{GMT^2}{4\pi^2} \Rightarrow r = \left[\frac{GMT^2}{4\pi^2}\right]^{1/3}$$

154 **(c)**

If M be mass of earth and R its radius, the acceleration due to gravity is given by

$$g = \frac{GM}{R^2} \quad \text{....(i)}$$

Where, G is gravitational constant.

Given, $R = 0.99R$

$$\therefore \quad g' = \frac{GM}{(0.99R)^2} \quad \text{...(ii)}$$

$$= 1.02\left(\frac{GM}{R^2}\right)$$

From Eq. (i), we get

$$g' = 1.02g$$

Hence, acceleration due to gravity increases by

$$g' - g = 1.02 - 1 = 0.02g$$

Hence, percentage increases =2%.

155 **(c)**

Acceleration due to gravity at a height h above the earth's surface is $g_h = \frac{g}{\left(1+\frac{h}{R}\right)^2}$

Where g is the acceleration due to gravity on the earth's surface

At $h = \frac{R}{2}, g_h = \frac{g}{\left(1+\frac{R}{2R}\right)^2} = \frac{4g}{9}$

At $h = R, g_h = \frac{g}{\left(1+\frac{R}{R}\right)^2} = \frac{g}{4}$

Acceleration due to gravity at a depth d below the earth's surface is $g_d = g\left(1 - \frac{d}{R}\right)$

At $d = \frac{R}{2}, g_d = g\left(1 - \frac{2}{2R}\right) = \frac{g}{2}$

At the centre of earth, $d = R$

$$g_d = g\left(1 - \frac{R}{R}\right) = 0$$

Thus, the acceleration due to gravity is maximum on the earth's surface

156 **(a)**

As in case of elliptic orbit of a satellite mechanical energy

$E = -(GMm/2a)$ remains constant, at any position of satellite in the orbit,

$\text{KE} + \text{PE} = -\frac{GMm}{2a}$ ...(i)

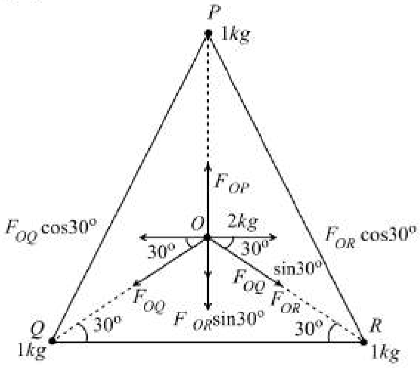
Now, if at position r, v is the orbital speed of satellite

$\text{KE} = \frac{1}{2}mv^2$ and $\text{PE} = -\frac{GMm}{r}$ ...(ii)

So, from Eqs. (i) and (ii), we have

$$\frac{1}{2}mv^2 - \frac{GMm}{r} = -\frac{GMm}{2a}, ie, v^2 = GM\left[\frac{2}{r} - \frac{1}{a}\right]$$

157 **(d)**



Here, $OP = OQ = OR = \sqrt{2}\,m$

The gravitational force on mass 2 kg at O due to mass

1 kg at P is $F_{OP} = \frac{G\times2\times1}{(\sqrt{2})^2} = G$ along OP

The gravitational force on mass 2 kg at O due to mass

1 kg at Q is $F_{OQ} = \frac{G\times2\times1}{(\sqrt{2})^2} = G$ along OQ

The gravitational force on mass 2 kg at O due to mass

1 kg at R is $F_{OR} = \frac{G\times2\times1}{(\sqrt{2})^2} = G$ along OR

Resolve forces F_{OQ} and F_{OR} into two rectangular components

$F_{OQ}\cos 30°$ and $F_{OR}\cos 30°$ are equal in magnitude of equal and opposite direction

$= F_{OP} - (F_{OQ}\sin 30° + F_{OR}\sin 30°)$

$$= G - \left(G \times \frac{1}{2} + G \times \frac{1}{2}\right) = G - G = \text{Zero } N$$

158 **(c)**

Landsats 1 through 3 operated in a near polar orbit at an altitude of 920 km with an 18 day repeat coverage cycle. These satellites circled the earth every 103 min completing 14 orbits a day.

159 **(d)**

$$U_i = -\frac{GMm}{r}$$

$$U_i = \frac{6.67\times10^{-11}\times100\times10^{-2}}{0.1}$$

$$U_i = -\frac{6.67\times10^{-11}}{0.1}$$

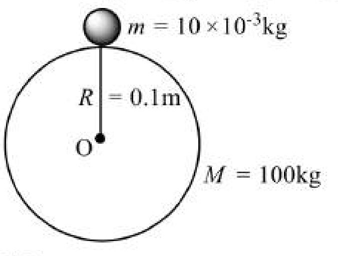
$$= -6.67\times10^{-10}\text{J}$$

We know

$\therefore \quad W = \Delta U$

$= U_f - U_i \quad (\because U_f = 0)$

$\therefore \quad W = U_i = 6.67\times10^{-10}\text{J}$



161 **(b)**

The energy required to remove the satellite from its orbit around the earth to infinity is called binding energy of the satellite. It is equal to negative of total mechanical energy of satellite in its orbit.

Thus, binding energy $= -E = \frac{GMm}{2r}$

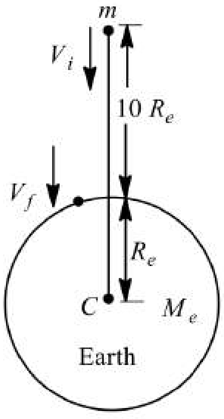
but, $\quad g = \frac{GM}{R^2}$

$\Rightarrow \quad GM = gR^2$

$\therefore \quad \text{BE} = \frac{gmR^2}{2r}$

163 **(c)**

Applying law of conservation of energy for asteroid at a distance 10 R_e and at earth's surface.



$$K_i + U_i = K_f + U_f \quad \text{.... (i)}$$

Now, $K_f = \frac{1}{2}mv_i^2$ and $U_i = -\frac{GM_e m}{10R_e}$

$K_f = \frac{1}{2}mv_f^2$ and $U_f = -\frac{GM_e m}{R_e}$

Substituting these values in Eq. (i), we get

$$\frac{1}{2}mv_i^2 - \frac{GM_e m}{10R_e} = \frac{1}{2}mv_f^2 - \frac{GM_e m}{R_e}$$

$$\Rightarrow \frac{1}{2}mv_f^2 = \frac{1}{2}mv_f^2 + \frac{GM_e m}{R_e} - \frac{GM_e m}{10R_e}$$

$$\Rightarrow v_f^2 = v_i^2 + \frac{2GM_e}{R_e} - \frac{2GM_e}{10R_e}$$

$$\therefore \quad v_f^2 = v_i^2 + \frac{GM_e m}{R_e}\left(1 - \frac{1}{10}\right)$$

165 **(b)**

$$V = -\int_{\infty}^{x} I\,dx = -\int_{\infty}^{x} \frac{C}{x^2}\,dx = \frac{C}{x}$$

166 **(c)**

U = Loss in gravitational energy = gain in K.E.

So, $U = \frac{1}{2}mv^2 \Rightarrow m = \frac{2U}{v^2}$

167 **(b)**

$v_e = \sqrt{2}\, v_o, i.e.$ if the orbital velocity of moon is increased by factor of $\sqrt{2}$ then it will escape out from the gravitational field of earth

168 **(b)**

$$v_e = R\sqrt{\frac{8}{3}G\pi\rho} \quad \therefore v_e \propto R\sqrt{\rho}$$

169 **(c)**

$$\frac{T_1}{T_2} = \left(\frac{R_1}{R_2}\right)^{3/2} = \left(\frac{10^{13}}{10^{12}}\right)^{3/2} = (1000)^{1/2} = 10\sqrt{10}$$

171 **(b)**

$F = \frac{Gm(M-m)}{x^2}$; For maxima,

$$\frac{dF}{dm} = \frac{G}{x^2}(M - 2m) = 0$$

or $\frac{m}{M} = \frac{1}{2}$

172 **(c)**

Acceleration due to gravity on moon g_m

$$= \frac{G \times M/90}{(R/3)^2} = \frac{1}{10}g$$

173 **(c)**

Acceleration due to gravity at poles is independent of the angular speed of earth

174 **(a)**

The change in potential energy in gravitational field is given by $\Delta E = GMm\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$

In this problem; $r_1 = R$ and $r_2 = nR$

$$\Delta E = GMm\left(\frac{1}{R} - \frac{1}{nR}\right)$$

$$= \frac{GMm}{R}\left(\frac{n-1}{n}\right)$$

$$= mgR\left(\frac{n-1}{n}\right) \quad \left(\because g = \frac{Gm}{R^2}\right)$$

175 **(d)**

Let escape velocity be v_e, then kinetic energy is

$$= \frac{1}{2}mv_e^2 \quad \text{.... (i)}$$

and escape energy $= +\frac{GM_e m}{R_e}$ ... (ii)

Equating Eqs. (i) and (ii), we get

$$\frac{1}{2}m_e^2 = \frac{GM_e m}{R_e}$$

$$\Rightarrow \quad v_e = \sqrt{\frac{2GM_e}{R_e}}$$

$$\Rightarrow \quad R = \frac{2GM_e}{v_e^2}$$

Given, $G = 6.67 \times 10^{-11}\text{N-m}^2/\text{kg}$,

$M_e = 6 \times 10^{24}\text{kg}, v_e = 3 \times 10^8 \text{ m/s}^2$

$$R = \frac{2 \times 6.67 \times 10^{-11} \times 6 \times 10^{24}}{(3 \times 10^8)^2}$$

$$R = 8.89 \times 10^{-3}$$

$$R \approx 9 \times 10^{-3}\text{m} = 9\text{mm}$$

176 **(d)**

The body can be fired at any angle because the energy is sufficient to take the body out of the gravitational field of earth

177 **(b)**

Acceleration due to gravity at a height h from earth's surface

$$g' = \frac{GM}{(R+h)^2}$$

Since, $g' = \frac{g}{100}$

or $\frac{g}{100} = \frac{GM}{(R+h)^2}$

or $\frac{(R+h)^2}{100} = \frac{GM}{g}$

or $\frac{(R+h)^2}{100} = R^2$ $\left[\because g = \frac{GM}{R^2}\right]$

or $R + h = 10R$

$\Rightarrow$ $h = 9R$

178 **(d)**

Acceleration due to gravity

$$g = \frac{GM}{R^2} = \frac{G}{R^2} \times \frac{4}{3}\pi R^3 \rho$$

$\therefore$ $\rho = \frac{3g}{4\pi GR}$

179 **(a)**

$$v_e = \sqrt{\frac{2GM}{R}} = 100 \Rightarrow \frac{GM}{R} = 5000$$

Potential energy $U = -\frac{GMm}{R} = -5000\, J$

180 **(c)**

$g \propto r$ (if $r < R$) and $g \propto \frac{1}{r^2}$ (if $r > R$)

181 **(d)**

$F \propto \frac{1}{r^2}$. If r becomes double then F reduces to $\frac{F}{4}$

182 **(b)**

We know that $g = \frac{GM}{R^2}$

On the planet $g_p = \frac{GM/7}{R^2/4} = \frac{4}{7}g$

Hence weight on the planet $= 700 \times \frac{4}{7} =$ 400 $gm\ wt$

183 **(c)**

According to Kepler's third law

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

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

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

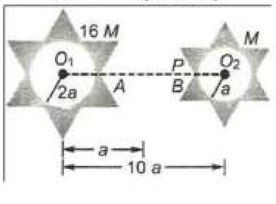
$\Rightarrow$ $\frac{T_2}{T_1} = \sqrt{27}$

$\therefore$ $T_2 = \sqrt{27}T_1 = \sqrt{27} \times 4 = 4\sqrt{27}$h

184 **(b)**

First we have to find a point where the resultant field due to both is zero. Let the point P be at a distance x from centre of bigger star.

$\Rightarrow \frac{G(16M)}{x^2} = \frac{GM}{(10a-x)^2} \Rightarrow x = 8a$ (from O_1)



ie, once the body reaches P, the gravitational pull of attraction due to M takes the lead to make m move towards it automatically as the gravitational pull of attraction due to 16 Mvanishes *ie*, a minimum KE or velocity has to be imparted to m from surface of 16M such that it is just able to overcome the gravitational pull of 16M. By law of conservation of energy.

(Total mechanical energy at A) = (Total mechanical energy at P)

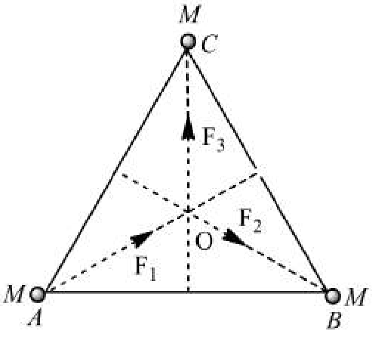
$$\Rightarrow \frac{1}{2}mv_{min}^2 + \left[\frac{G(16M)m}{2a} - \frac{GMm}{8a}\right]$$

$$= 0 + \left[\frac{GMm}{2a} - \frac{G(16M)m}{8a}\right]$$

$$\Rightarrow \frac{1}{2}mv_{\min}^2 = \frac{GMm}{8a}(45) \Rightarrow v_{\min} = \frac{3}{2}\sqrt{\frac{5GM}{a}}$$

185 **(a)**

The net force acting on a unit mass placed at O due to three equal masses M at verities A, B and C is the gravitational field intensity at point O. The gravitational force on the particle placed at the point of intersection of three medians.



Since, the resultant of $\mathbf{F}_1$ and $\mathbf{F}_2$ is equal and opposite to $\mathbf{F}_3$.

186 **(b)**

By the law of conservation of energy

$$(U+K)_{\text{surface}} = (U+K)_\infty$$

$$\Rightarrow -\frac{GMm}{R} + \frac{1}{2}m(3v_e)^2 = 0 + \frac{1}{2}mv^2$$

$$\Rightarrow -\frac{GM}{R} + \frac{9v_e^2}{2} = \frac{1}{2}v^2$$

Since, $v_e^2 = \frac{2GM}{R}$

$$\therefore -\frac{v_e^2}{2} + \frac{9v_e^2}{2} = \frac{1}{2}v^2 \Rightarrow v^2 = 8v_e^2$$

$$v = 2\sqrt{2}v_e$$

$$= 2\sqrt{2} \times 11.2$$

$$= 31.7\text{kms}^{-1}$$

187 **(b)**

$6R$ from the surface of earth and $7R$ from the centre

188 **(b)**

$\frac{dA}{dt} = \frac{L}{2m} = \text{constant}$

189 **(b)**

$F(r) = \left\{ \frac{\frac{GMm}{r^2}}{\frac{4\pi G\rho r m}{3}}, r < R \right.$(where ρ is density of sphere)

190 **(b)**

Weight of body on the surface of earth $mg = 12.6$ N

At height h, the value of g' is given by

$$g' = g\frac{R^2}{(R+h)^2}$$

Now, $h = \frac{R}{2}$

$$\therefore \quad g' = g\left(\frac{R}{R+(R/2)}\right)^2 = g\frac{4}{9}$$

Weight at height $h = mg\frac{4}{9}$

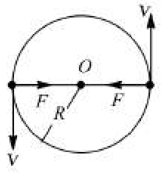
$$= 12.6 \times \frac{4}{9} = 5.6 \text{ N}$$

192 **(d)**

$F = \left\{\frac{GMm}{r^2}\right\}, r \geq R$

193 **(c)**

Here the force of attraction between them provides the necessary centripetal force



$\therefore \frac{mv^2}{R} = \frac{Gm^2}{(4R)^2}$

$\therefore v = \sqrt{\frac{Gm}{4R}}$

194 **(b)**

If a body is projected from the surface of earth with a velocity v and reaches a height h, applying conservation of energy (relative to surface of earth)

$\frac{1}{2}mv^2 = \frac{mgh}{[1+(h/R)]}$

$h = R = 6400$ km, $g = 10\text{ms}^{-2}$

So, $v^2 = gh$ $ie, v = \sqrt{10 \times 6400 \times 10^3} = 8 \text{ kms}^{-1}$

195 **(b)**

The value of g at latitude λ is ; $g' = g - R\omega'^2 \cos^2\lambda$. If earth stops rotating, $\omega = 0$; $g' = g$. It means the weight of body will increase

196 **(b)**

Gravitational force $\left(= \frac{GM\,m}{R^{3/2}}\right)$ provides the necessary centripetal force ($ie, m\,R\,\omega^2$)

So, $\frac{GM\,m}{R^{3/2}} = mR\omega^2 = mR\left(\frac{2\pi}{T}\right)^2 = \frac{4\pi^2 mR}{T^2}$

or $T^2 = \frac{4\pi^2 R^{5/4}}{GM} ie, T^2 \propto R^{5/2}$

197 **(c)**

$\frac{dA}{dt} = \frac{L}{2m} \Rightarrow \frac{dA}{dt} \propto vr \propto \omega r^2$

198 **(d)**

Gravitational potential energy of body will be

$$E = \frac{GM_e m}{r}$$

At $r = 2R$,

$$E_1 = -\frac{GM_e m}{(2R)}$$

At $r = 3R$

$$E_2 = -\frac{GM_e m}{(3R)}$$

Energy required to move a body of mass m from on orbit of radius $2R$ to $3R$ is

$$\Delta E = \frac{GM_e m}{R}\left[\frac{1}{2} - \frac{1}{3}\right] = \frac{GM_e m}{6R}$$

199 **(a)**

$$v = \sqrt{\frac{GM}{R+h}} = \frac{1}{2}\sqrt{\frac{2GM}{R}}$$

$\Rightarrow 4R = 2(R+h) \Rightarrow h = R = 6400\ km$

200 **(b)**

Here, $m_1 = m_2 = 100$ kg ; $r = 100$m

Acceleration of first astronaut,

$a_1 = \frac{Gm_1 m_2}{r^2} \times \frac{1}{m_1} = \frac{Gm_1}{r^2}$

Acceleration of second astronaut,

$a_2 = \frac{Gm_1 m_2}{r^2} \times \frac{1}{m_2} = \frac{Gm_2}{r^2}$

Net acceleration of approach

$a = a_1 + a_2 = \frac{Gm_2}{r^2} + \frac{Gm_1}{r^2} = \frac{2Gm_1}{r^2}$

$= \frac{2 \times (6.67 \times 10^{-11}) \times 100}{(100)^2}$

$= 2 \times 6.67 \times 10^{-13}\text{ms}^{-2}$

As $s = \frac{1}{2}at^2$

$\therefore t = \left(\frac{2s}{a}\right)^{1/2} = \left[\frac{2\times(1/100)}{2\times 6.67\times 10^{-13}}\right]^{1/2}$ second

On solving we get $t = 1.41$ days

201 **(b)**

$$\frac{T_2}{T_1}=\left(\frac{r_2}{r_1}\right)^{3/2}=(2)^{3/2}=2\sqrt{2}\Rightarrow T_2=2\sqrt{2}\ years$$

202 **(b)**

Weight is least at the equator

203 **(b)**

Acceleration due to gravity $g=\frac{4}{3}\pi\rho GR$

or $g\propto\rho$

$\therefore \quad \frac{g_1}{g_2}=\frac{\rho_1}{\rho_2}$

$\frac{g_1}{g_2}=\frac{\rho}{2\rho} \quad [\because \rho_2=2\rho]$

$g_2=g_1\times 2=9.8\times 2$

$g_2=19.6\ \text{m/s}^2$

204 **(d)**

$$\omega=\frac{|v|}{R_2-R_1}=\frac{\pi\times 10^4}{4\times 10^4-1\times 10^4}=\frac{\pi}{3}\ \text{radh}^{-1}$$

207 **(c)**

The period of revolution of a satellite at a height h from the surface of earth is given by

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

Given, $T_m=1$ lunar month,

$$\therefore \quad T_{sat}=2\pi\sqrt{\frac{\left(R+\frac{h}{2}\right)^2}{gR^2}}$$

$$\Longrightarrow \quad T_{sat}=\frac{1}{2^{3/2}}$$

$T_{moon}=2^{-3/2}$ lunar month

208 **(b)**

The value of acceleration due to gravity at a height h reduces to

$=100-36=64\%=\frac{64}{100}\mathrm{g}$

$\therefore \frac{64}{100}\mathrm{g}=\frac{\mathrm{g}R^2}{(R+h)^2}$

or $\frac{8}{10}=\frac{R}{R+h}$ or $h=\frac{R}{4}$

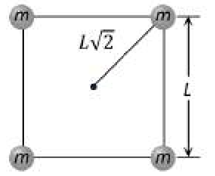
209 **(a)**

Potential at the centre due to single mass $=\frac{-GM}{L/\sqrt{2}}$

Potential at the centre due to all four masses

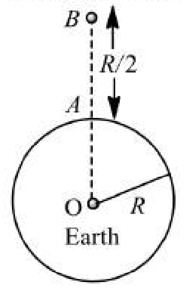
$=-4\frac{GM}{L/\sqrt{2}}=-4\sqrt{2}\frac{GM}{L}$

$=-\sqrt{32}\times\frac{GM}{L}$



210 **(c)**

The value of acceleration due to gravity at a height h above the earth's surface is given by



$$g'=\frac{g}{\left(1+\frac{h}{R}\right)^2}$$

where R is radius of earth.

When $h=\frac{R}{2}$

$$g'=\frac{g}{\left(1+\frac{h}{R}\right)^2}=\frac{4g}{9}$$

Hence, weight $w'=mg'=\frac{4}{9}mg=\frac{4}{9}w$.

211 **(c)**

Mass of planet, $M_p=10M_e$, where M_e is mass of earth. Radius of planet,

$R_p=\frac{R_e}{10}$, where R_e is radius of earth.

Escape speed is given by,

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

So, for planet $v_p=\sqrt{\frac{2\ G\times M_p}{R_p}}=\sqrt{\frac{100\times 2\ GM_e}{R_e}}$

$=10\times v_e$

$=10\times 11\text{kms}^{-1}=110\text{kms}^{-1}$

212 **(b)**

$g'=g\left(\frac{R}{R+h}\right)^2\Rightarrow$ when $h=R$ then $g'=\frac{g}{4}$

So the weight of the body at this height will become one-fourth

213 **(c)**

$dV=-Edx$

or $V=-\int_{\infty}^{x/\sqrt{2}}Edx=-\int_{\infty}^{x/\sqrt{2}}kx^{-3}dx=k/x^2$

215 **(a)**

$$\frac{mv^2}{R}=\frac{RMm}{R^2}\Rightarrow v^2=\frac{GM}{R}$$

$$v = \frac{2\pi R}{T} \Rightarrow v^2 = \frac{4\pi^2 R^2}{T^2} = \frac{GM}{R}$$

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

If T_1 and T_2 are the time periods for satellite S_1 and S_2 respectively

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

$T_1 = 1$ h, $T_2 = 8$ h $= 10^4$km

$$R_2 = \left(\frac{8}{1}\right)^{3/2} \times 10^4 \text{ km} = 4 \times 10^4 \text{ km}$$

$$v_1 = \frac{2\pi R_1}{T_1} = \frac{2\pi \times 10^4}{1} = 2\pi \times 10^4 \text{ kmh}^{-1}$$

$$v_2 = \frac{2\pi R_2}{T_2} = \frac{2\pi \times 4 \times 10^4}{8} = \pi \times 10^4 \text{ kmh}^{-1}$$

Relative velocity of S_2 with respect to S_1 is

$v = v_2 - v_1(\pi \times 10^4 - 2\pi \times 10^4)$ kmh^{-1}

$|v| = \pi \times 10^4$ kmh^{-1}

216 **(d)**

$F = mR\,\omega^2$

$= 6 \times 10^{24} \times (1.5 \times 10^{11})(2 \times 10^{-7})^2$

$= 36 \times 10^{21}$N

217 **(c)**

$$\text{kinetic energy} = \frac{1}{2} m v_e^2 = \frac{1}{2} m \times 2gR = mgR$$

218 **(c)**

Gravitational potential energy, $U = \frac{GMm}{r}$

or $U = \frac{GMm}{r^2} \times r$

or $U = g \times mr$

or $U = (mg)r$

or $mg = \frac{U}{r}$

219 **(b)**

$$T_2 = T_1 \left(\frac{R_2}{R_1}\right)^{3/2} = 1 \times (2)^{3/2} = 2.8 \textit{ year}$$

220 **(c)**

$g = \frac{GM}{R^2}$; If R decreases then g increases. Taking logarithm of both the sides;

$\log g = \log G + \log M = -2 \log R$

Differentiating it we get; $\frac{dg}{g} = 0 + 0 - \frac{2dR}{R}$

$$= -2\left(\frac{-2}{100}\right) = \frac{4}{100}$$

$\therefore$ % increase in g $= \frac{dg}{g} \times 100 = \frac{4}{100} \times 100 = 4\%$

221 **(b)**

$\frac{T^2}{R^3} = \frac{T^2}{d^3} = \frac{1}{n^2 d^3} =$ constant

$\therefore n_1^2 d_1^3 = n_2^2 d_2^3$ [where $n =$ frequency]

222 **(b)**

$$v \propto R\sqrt{\rho} \;\therefore \frac{v_p}{v_e} = \frac{R_p}{R_e} \times \sqrt{\frac{\rho_p}{\rho_e}} = 4 \times \sqrt{9} = 12$$

$\Rightarrow v_p = 12 v_e$

224 **(b)**

Let a satellite is revolving around earth with orbital velocity v. The gravitational potential energy of satellite is

$$U = -\frac{GM_e m}{R_e} \quad \text{... (i)}$$

The kinetic energy of satellite is

$$K = \frac{1}{2}\frac{GM_e m}{R_e} \quad \text{... (ii)}$$

$\therefore$ Total energy of satellite

$$E = U + K = -\frac{GM_e m}{R_e} + \frac{1}{2}\frac{GM_e m}{R_e} = -\frac{1}{2}\frac{GM_e m}{R_e} \quad \text{...(iii)}$$

But we know that necessary centripetal force to the satellite is provided by the gravitational force. *ie*,

$$\frac{mv^2}{R_e} = \frac{GM_e m}{R_e^2}$$

or $mv^2 = \frac{GM_e m}{R_e}$ ... (iv)

Hence, from Eqs. (iii) and (iv), we get

$$E = -\frac{1}{2} m v^2$$

226 **(b)**

From Kepler's third law of planetary motion

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

$$\therefore \frac{T_2^2}{T_1^2} = \frac{R_2^3}{R_1^3}$$

or $\frac{T_2^2}{(24)^2} = \left(\frac{6400 + 6400}{36000 + 6400}\right)^3$

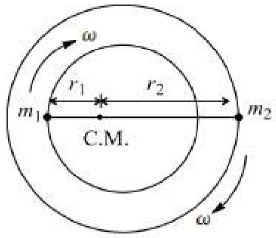
or $T_2^2 = (24)^2 \times \left(\frac{16}{53}\right)^3$

$\Rightarrow T_2 = 4$ h

227 **(a)**

Both the stars with same angular velocity ω around the centre of mass (CM) in their respective orbits as shown in figure

The magnitude of gravitational force m_1 exerts on m_2 is $|F| = \frac{Gm_1 m_2}{(r_1 + r_2)^2}$



228 **(a)**

Let R be the radius of earth and ρ its density, then since shape of earth is assumed spherical we have

Mass of earth = volume × density

$$M=\frac{4}{3}\pi R^3\times\rho \qquad \text{.... (i)}$$

The acceleration due to gravity which arises in the body due to gravitational force of attraction is given by

$$g=\frac{GM}{R^2} \qquad \text{.... (ii)}$$

Putting the value of M from Eq.(i), we get

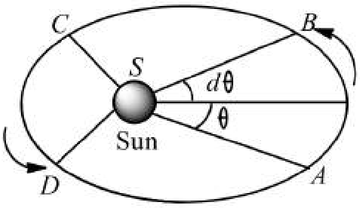
$$g=\frac{G\frac{4}{3}\pi R^3\rho}{R^2}=G\frac{4}{3}\pi R\rho \qquad \text{.... (iii)}$$

Given, $\rho_p=\rho, R_p=0.2R_e$

$\therefore\ g_p=G\frac{4}{3}\pi R_p\rho_p=G\times\frac{4}{3}\pi\times 0.2R\rho=0.2g$

229 **(d)**

From Kepler's second law of planetary motion, a line joining any planet to the sun sweeps out equal areas in equal times, that is, the aerial velocities of the planet remains constant $dA=$ area of the curved triangle SAB



$$\approx\frac{1}{2}(AB\times SA)$$
$$\approx\frac{1}{2}(rd\theta\times r)$$
$$\approx\frac{1}{2}r^2d\theta$$

Thus, the areal (instantaneous) velocity of the planet is

$$\frac{dA}{dt}=\frac{1}{2}r^2\frac{d\theta}{dt}=\frac{1}{2}r^2\omega=\text{constant}$$

where ω is angular speed of planet and r its radius.

230 **(b)**

V_A =(Potential at A due to A) + (Potential at A due to B)

$$\Rightarrow\ V_A=-\frac{Gm_1}{R}-\frac{Gm_2}{\sqrt{2}R}$$

Similarly,

V_B =(Potential at B due to A) + (Potential at B due to B)

$$\Rightarrow\ V_B=-\frac{Gm_2}{R}-\frac{Gm_1}{\sqrt{2}R}$$

Since, $W_{A\to B}=m(V_B-V_A)\Rightarrow W_{A\to B}$

$$=\frac{Gm(m_1-m_2)(\sqrt{2}-1)}{\sqrt{2}R}$$

231 **(c)**

The value of acceleration due to gravity changes with height (*ie*, altitude). If g' is the acceleration due to gravity at a point, at height h above the surface of earth, then

$$g'=\frac{GM}{(R+h)^2}$$

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

$$\therefore\ \frac{g'}{g}=\frac{GM}{(R+h)^2}\times\frac{R^2}{GM}=\frac{R^2}{(R+h)^2}$$

Here, $$g'=\frac{GM}{(R+h)^2}=\frac{GM}{(R+3R)^2}$$
$$=\frac{GM}{(4R)^2}=\frac{GM}{16R^2}=\frac{g_e}{16}$$

232 **(a)**

According to Kepler's law of periods

$$T^2\propto a^3[a=\text{semi-major axis}]$$

Here, in case I a is $7R$ as satellite is $6R$ above the earth and for a geostationary satellite $T=24$ h

$$\therefore\quad (24)^2\propto(7R)^3 \qquad \text{.... (i)}$$

Similarly for case II

$$T^2\propto(3.5R)^3 \qquad \text{.... (ii)}$$

Dividing Eq. (i) by Eq. (ii), we get

$$\frac{(24)^2}{T^2}=\frac{(7R)^3}{(3.5R)^3}$$

$$\Rightarrow\quad T^2=\frac{(24)^2}{8}$$

or $$T=6\sqrt{2}\text{ h}$$

233 **(d)**

The gravitational force exerted on satellite at a height x is

$$F_G=\frac{GM_em}{(R+x)^2}$$

where M_e = mass of earth.

Since, gravitational force provides the necessary centripetal force, so,

$$\frac{GM_em}{(R+x)^2}=\frac{mv_o^2}{(R+x)}$$

where v_o is orbital speed of satellite.

$$\Rightarrow \quad \frac{GM_e m}{(R+x)} = mv_o^2$$

$$\Rightarrow \quad \frac{gR^2 m}{(R+x)} = mv_o^2 \qquad \left(\therefore g = \frac{GM_e}{R^2}\right)$$

$$\Rightarrow \; v_o = \sqrt{\left[\frac{gR^2}{(R+x)}\right]} = \left[\frac{gR^2}{(R+x)}\right]^{1/2}$$

234 **(b)**

Because value of g decreases with increasing height

235 **(c)**

Gravitational potential on the surface of the shell is

$V =$ Gravitational potential due to particle (V_1)

+ Gravitational potential due to shell particle (V_2)

$$= -\frac{Gm}{R} + \left(-\frac{G3m}{R}\right) = -\frac{4Gm}{R}$$

236 **(c)**

(i) $T_{st} = 2\pi\sqrt{\frac{(R+h)^3}{GM}} = 2\pi\sqrt{\frac{R}{g}}$ [As $h << R$ and $GM = gR^2$]

(ii) $T_{ma} = 2\pi\sqrt{\frac{R}{g}}$

(iii) $T_{sp} = 2\pi\sqrt{\frac{1}{g\left(\frac{1}{l}+\frac{1}{R}\right)}} = 2\pi\sqrt{\frac{R}{2g}}$ [As $l = R$]

(iv) $T_{is} = 2\pi\sqrt{\frac{R}{g}}$ [As $l = \infty$]

237 **(a)**

Gravitational potential energy of mass m at any point at a distance r from the centre of earth is

$$U = -\frac{GMm}{r}$$

At the surface of earth $r = R$

$$\therefore U_s = -\frac{GMm}{R} = -mgR \quad \left(\because g = \frac{GM}{R^2}\right)$$

At the height $h = nR$ from the surface of earth

$$r = R + h = R + nR = R(1+n)$$

$$\therefore U_h = -\frac{GMm}{R(1+n)} = -\frac{mgR}{(1+n)}$$

Change in gravitational potential energy is

$$\Delta U = U_h - U_s = -\frac{mgR}{(1+n)} - (-mgR)$$

$$= -\frac{mgR}{1+n} + mgR = mgR\left(1 - \frac{1}{1+n}\right)$$

$$= mgR\left(\frac{n}{1+n}\right)$$

238 **(d)**

According to Kepler's third law, T^2 is proportional to cube of semi-major axis of the elliptical orbit.

Semi- major axis $= \frac{r_1 + r_2}{2}$

$$\therefore \qquad T^2 \propto \left[\frac{r_1 + r_2}{2}\right]^3$$

or $\qquad T \propto (r_1 + r_2)^{3/2}$

239 **(a)**

Gravitational potential at mid point

$$V = \frac{-GM_1}{d/2} + \frac{-GM_2}{d/2}$$

Now, $PE = m \times V = \frac{-2Gm}{d}(M_1 + M_2)$

(m = mass of particle)

So, for projecting particle from mid point to infinity

$KE = |PE|$

$$\Rightarrow \frac{1}{2}mv^2 = \frac{2\,Gm}{d}(M_1 + M_2) \Rightarrow v$$

$$= 2\sqrt{\frac{G(M_1 + M_2)}{d}}$$

240 **(d)**

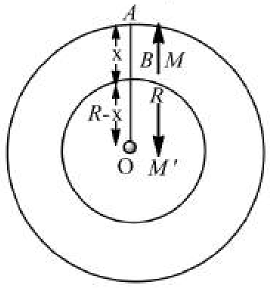
The acceleration due to gravity at a depth d inside the earth is

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

where, $R - d = r$ = distance of a place from the centre of earth, therefore, $g' \propto r$

241 **(b)**

Consider that the earth is sphere of radius R and mass M. Then, value of acceleration due



to gravity at the point A on the surface of earth is given by

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

If ρ is density of the material of earth, then

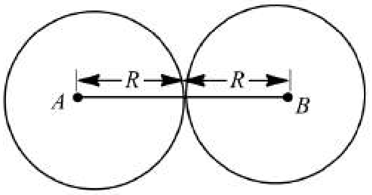
$$M = \frac{4}{3}\pi R^3 \rho$$

$$\therefore \qquad g = \frac{G \times \frac{4}{3}\pi R^3 \rho}{R^2}$$

or $\qquad g = \frac{4}{3}\pi G R \rho$

Let g' be acceleration due to gravity at the point B at a depth x below the surface of earth. A body at point B will experience force only due to the portion of the earth of radius $OB (= R - x)$. The outer spherical shell, whose thickness is x, will not exert any force on body at point B.

242 **(c)**



Let masses of two balls are $m_1 = m_2 = m$ (given) and the density be ρ.
Distance between their centres $= AB = 2R$
Thus, the magnitude of the gravitational force F that two balls separated by a distance $2R$ exert on each other is

$$F = G\frac{(m)(m)}{(2R)^2}$$

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

$\therefore \quad F \propto R^4$

243 **(c)**

$v \propto \frac{1}{\sqrt{r}}$, If $r = R$ then $v = V_0$

If $r = R + h = R + 3R = 4R$ then $v = \frac{V_0}{2} = 0.5V_0$

245 **(c)**

$$v_e = \sqrt{\frac{2GM}{R}} \therefore v_e \propto \sqrt{\frac{M}{R}}$$

If M becomes double and R becomes half then escape velocity becomes two times

246 **(b)**

Here to point 7 of problem Solving skills

$[\frac{h_1}{h_2} = \frac{g_2}{g_1} \text{or } h_2 = \frac{h_1 g_1}{g_2} = \frac{0.5 \times g}{g/6} = 3.0]$

Energy spent $= mg\, h_e = mg_m h_m$

or $\quad h_m = g_e h_e / g_m \quad$ ...(i)

$$= \left(\frac{G\frac{4}{3}\pi R_e^3\rho/R_e^2)h_e}{\left(G\frac{4}{3}\pi R_m^2\rho_m/R_m^2\right)}\right) = \left(\frac{G\frac{4}{3}\pi R_e^3\rho/R_e^2)h_e}{\left(G\frac{4}{3}\pi R_m^2\rho_m/R_m^2\right)}\right)$$

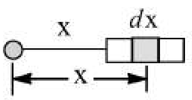
$$= \frac{R_e}{R_m} \times \frac{\rho_e}{\rho_m} \times h_e = \frac{3}{2} \times \frac{4}{1} \times 0.5 = 3\text{m}$$

248 **(d)**

The gravitational intensity at a point inside the spherical shell is zero

249 **(b)**

$$\therefore dF = \frac{Gm(\mu dx)}{x^2}$$



$$F = Gm\int_a^{a+L}(A + Bx)\frac{dx}{x^2}$$

$$F = Gm\left[A\left(\frac{1}{a} - \frac{1}{a+L}\right) + BL\right]$$

250 **(a)**

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

If $R' = \frac{R}{4}$

$$v'_e = 2\sqrt{\frac{2GM}{R}}$$

Since, G and M are constant hence,

$$v'_e = 2v_e$$

251 **(d)**

Velocity of satellite $v = \sqrt{\frac{GM}{r}}$

$$\text{KE} \propto v^2 \propto \frac{1}{r}$$

and $\quad T^2 \propto r^3$

$$\text{KE} \propto T^{-2/3}$$

252 **(b)**

We have

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

$$R_1 = r$$

and $\quad R_2 = 4r$

$\therefore \quad \frac{T_1^2}{T_2^2} = \frac{(r)^3}{(4r)^3}$

or $\quad \frac{T_1}{T_2} = \frac{1}{8}$

253 **(b)**

$T \propto r^{3/2}$. If r becomes double then time period will become $(2)^{3/2}$ times

So new time period will be $24 \times 2\sqrt{2}\ hr\ i.e. T = 48\sqrt{2}$

254 **(b)**

$g = \frac{4}{3}\pi\rho GR$. If density is same then $g \propto R$

According to problem $R_p = 2R_e \therefore g_p = 2g_e$

For clock P (based on pendulum motion) $T = 2\pi\sqrt{\frac{l}{g}}$

Time period decreases on planet so it will run faster because $g_p > g_e$

For clock S (based on oscillation of spring) $T = 2\pi\sqrt{\frac{m}{k}}$

So it does not change

255 **(b)**

Mass of satellite does not affect its orbital radius

256 **(a)**

Given, $\frac{mg'}{mg} = \frac{30}{90}$ or $\frac{g'}{g} = \frac{1}{3}$

Now, $g' = g\frac{R^2}{(R+h)^2}$ or $\frac{g'}{g} = \frac{R^2}{(R+h)^2} = \frac{1}{3}$

or $\frac{R}{R+h} = \frac{1}{\sqrt{3}}$ or $(R+h) = \sqrt{3}R$

or $h = (\sqrt{3}-1)R = 0.73R$

257 **(a)**

$$(\text{KE})_{\text{escape}} = \frac{1}{2}m\left(\sqrt{\frac{2GM}{R_e}}\right)^2 = \frac{GMm}{R_e}$$

$$(\text{KE})_{\substack{\text{body}\\ \text{initially}}} = \frac{1}{2}\frac{GMm}{R_e}$$

By law of conservation of energy

$$\begin{pmatrix}\text{Total}\\ \text{mechanical}\\ \text{energy}\end{pmatrix} = \begin{pmatrix}\text{Total final}\\ \text{mechanical}\\ \text{energy}\end{pmatrix}$$

$(\text{KE} + \text{PE})_{\text{surface}} = (\text{KE} + \text{PE})_{\text{at height } h}$

$$\Rightarrow \frac{1}{2}\frac{GMM}{R_e} - \frac{GMm}{R_e} = 0 - \frac{GMm}{R_e + h}$$

($\because$ velocity at maximum height is zero)

$\Rightarrow v = R_e$

258 **(c)**

Escape velocity of the planet is $v_p = \sqrt{\frac{2GM_p}{R_p}}$

Where M_p and R_p be the mass and radius of the planet respectively

Escape velocity of the earth is $v_e = \sqrt{\frac{2GM_e}{R_e}}$

Where M_e and R_e be the mass and radius of the earth respectively

According to given problem, $v_p = 3v_e$ and $R_p = 4R_e$

$$\therefore \sqrt{\frac{2GM_p}{4R_e}} = 3\sqrt{\frac{2GM_e}{R_e}} \Rightarrow \frac{M_p}{4R_e} = \frac{9M_e}{R_e}$$

$\Rightarrow M_p = 36M_e = 36 \times 6 \times 10^{24} kg$

$= 216 \times 10^{24} kg = 2.16 \times 10^{26} kg$

259 **(a)**

$$g' = g\left(\frac{R}{R+h}\right)^2 = \frac{g}{\left(1+\frac{h}{R}\right)^2}$$

260 **(c)**

Increase in potential energy,

$$\Delta U = \frac{GMm}{(R+R)} - \left(-\frac{GMm}{R}\right)$$

$$= \frac{1}{2}\frac{GMm}{R} = \frac{1}{2}\left(\frac{GM}{R^2}\right)mR = \frac{1}{2}mgR$$

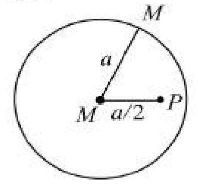
261 **(d)**

Range of projectile $R = \frac{u^2 \sin 2\theta}{g}$

If u and θ are constant then $R \propto \frac{1}{g}$

$$\frac{R_m}{R_e} = \frac{g_e}{g_m} \Rightarrow \frac{R_m}{R_e} = \frac{1}{0.2} \Rightarrow R_m = \frac{R_e}{0.2} \Rightarrow R_m = 5R_e$$

262 **(d)**



$V_p = V_{\text{sphere}} + V_{\text{partical}}$

$$= \frac{GM}{a} + \frac{GM}{a/2} = \frac{3GM}{a}$$

263 **(b)**

From Kepler's third law of planetary motion

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

Given, $R_1 = R$, $R_2 = 5R$

$$\therefore \quad \frac{T_1^2}{T_2^2} = \frac{R^3}{(5R)^3}$$

$$\Rightarrow \quad \frac{T_1}{T_2} = \frac{1}{(5)^{3/2}}$$

$$T_2 = 5^{3/2}T_1$$

$\therefore \quad T_2 = 5^{\frac{3}{2}}T \qquad [\because T_1 = T]$

264 **(b)**

$$K = \frac{GMm}{2R}$$

Escape velocity $V_e = \sqrt{\frac{2GM}{R}}$

Kinetic energy to escape $(K') = \frac{1}{2}m \times 2\frac{GM}{R}$

$K' = 2K$

265 **(c)**

Error in weighing

$= mg - mg' = mg - mg(1 - 2h/R)$

$= mg2h/R = \frac{m2hg}{R}$

$$= \frac{m2h}{R} \times \frac{G\frac{4}{3}\pi R^2 \rho}{R^2} = \frac{8\pi G\rho mh}{3}$$

266 **(a)**

$$\text{KE} = \frac{1}{2}mv^2 - \frac{1}{2}m(11.2)^2$$

$$= \frac{1}{2}m(2 \times 11.2)^2 - \frac{1}{2}m(11.2)^2$$

$$\frac{1}{2}mv^2 = 3 \times \frac{1}{2}m \times (11.2)^2$$

$$v = \sqrt{3} \times 11.2$$

267 **(b)**

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

Rotation of the earth results in the decreased weight apparently. This decrease in weight is not felt at the poles as the angle of latitude is 90°

268 **(c)**

Velocity of body in inter planetary space $v' = \sqrt{v^2 - v_{es}^2}$

Where v_{es}= escape velocity and

v = velocity of projection

$\therefore v' = \sqrt{(2v_{es})^2 - v_{es}^2} = \sqrt{3v_{es}^2} \Rightarrow v' = \sqrt{3}v_{es}$

269 **(c)**

Kepler's law $T^2 \propto R^3$

270 **(b)**

Intensity of gravitational field at a point inside the spherical shell is zero and outside the shell is $I \propto 1/r^2$

271 **(a)**

As there is no gravity in space so spring will not be extened.

272 **(c)**

Work done by the gravitational field is zero, when displacement is perpendicular to gravitational field. Here, gravitational field, $\vec{\mathbf{I}} = 4\hat{\mathbf{i}} + \hat{\mathbf{j}}$. if θ_1 is the angle which makes with positive x-axis, then $\tan\theta_1 = \frac{1}{4}$ or $\theta_1 = \tan^{-1}\left(\frac{1}{4}\right) = 14°6'$

If θ_2 is the angle which the line $y + 4x = 6$ makes with positive x-axis, then $\theta_2 = \tan^{-1}(-4) = 75°56'$ so $\theta_1 + \theta_2 = 90°$

ie, the line $y + 4x = 6$ is perpendicular to I

273 **(b)**

Time period of satellite

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

Where, R_e = Radius of earth,

h = Height from earth surface .

Time period not depend on mass. So, time period of both satellite will be equal.

274 **(b)**

$$g = \frac{GM}{R^2} \text{ or } R = \sqrt{\frac{GM}{g}}$$

$$= \sqrt{6.67 \times 10^{-11} \times 7.34 \times 10^{22}/1.4}$$

$$= 1.87 \times 10^6 \text{ m}$$

275 **(a)**

$g' = g - \omega^2 R\cos^2\lambda \Rightarrow 0 = g - \omega^2 R\cos^2 60°$

$$0 = g - \frac{\omega^2 R}{4} \Rightarrow \omega = 2\sqrt{\frac{g}{R}} = \frac{1}{400}\frac{rad}{sec}$$

$$= 2.5 \times 10^{-3}\frac{rad}{sec}$$

276 **(c)**

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

So, $\frac{g_M}{g_E} = \left(\frac{M_M}{M_E}\right) \times \left(\frac{R_E}{R_M}\right)^2 = \frac{1}{10} \times \left(\frac{12742}{6760}\right)^2$

$\therefore \frac{g_M}{g_E} = 0.35 \Rightarrow g_M = 9.8 \times 0.35 = 3.48 \text{ ms}^{-2}$

277 **(b)**

Potential energy of the 1 kg mass which is placed at the earth surface $= -\frac{GM}{R}$

Its potential energy at infinite = 0

$\therefore$ Work done = change in potential energy $= \frac{GM}{R}$

279 **(c)**

KE $= \frac{GMm}{2r} = -E_0$, and

$$\text{PE} = -\frac{GMm}{r} = 2E_0$$

$$\Rightarrow \text{TE} = \text{KE} + \text{PE} = -\frac{GMm}{2r} = E_0$$

280 **(b)**

The value of g at the height h from the surface of earth

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

The value of g at depth x below the surface of earth

$$g' = g\left(1 - \frac{x}{R}\right)$$

These two are given equal, hence $\left(1 - \frac{2h}{R}\right) = \left(1 - \frac{x}{R}\right)$

On solving, we get $x = 2h$

281 **(a)**

$$g = \frac{4}{3}\pi G\rho R \Rightarrow g \propto \rho R \Rightarrow \frac{g_e}{g_m} = \frac{\rho_e}{\rho_m} \times \frac{R_e}{R_m}$$

$$\Rightarrow \frac{6}{1} = \frac{5}{3} \times \frac{R_e}{R_m} \Rightarrow R_m = \frac{5}{18}R_e$$

282 **(d)**

Acceleration due to gravity at depth d below the surface earth

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

Acceleration due to gravity at height h from the surface of the earth

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

Given $g_h = g_d$

$\therefore$ $\frac{2h}{R} = \frac{d}{R}$

$d = 2h$

$d = 10$ km

283 **(c)**

Acceleration due to gravity at an altitude h is

$g_h = \frac{gR_e^2}{(R_e+h)^2}$; where R_e is the radius of the earth

$$g_h = \frac{9.8m/s^2 \times (6400 \times 10^3 m)^2}{(6400 \times 10^3 m + 520 \times 10^3 m)^2} = 8.4m/s^2$$

284 **(a)**

Time period of satellite which is very near to planet

$$T = 2\pi\sqrt{\frac{R^3}{GM}} = 2\pi\sqrt{\frac{R^3}{G\frac{4}{3}\pi R^3\rho}} \therefore T \propto \sqrt{\frac{1}{\rho}}$$

$i.e.$ time period of nearest satellite does not depends upon the radius of planet, it only depends upon the density of the planet.

In the problem, density is same so time period will be same

285 **(b)**

Acceleration due to gravity on earth is given by

$$g = \frac{GM_e}{R_e^2}$$

or $$g \propto \frac{M_e}{R_e^2}$$

Hence, $$\frac{g_{p_1}}{g_{p_2}} = \frac{M_{p_1}}{M_{p_2}} \times \left(\frac{R_{p_1}}{R_{p_2}}\right)^2 \quad \text{... (i)}$$

Given, $$\frac{M_{p_1}}{M_{p_2}} = \frac{1}{2} \text{ and } \frac{R_{p_1}}{R_{p_2}} = \frac{1}{2}$$

Substituting the given value in Eq. (i), we get

$$\frac{g_{p_1}}{g_{p_2}} = \frac{1}{2} \times \left(\frac{2}{1}\right)^2 = \frac{2}{1}$$

$\therefore$ $g_{p_1} : g_{p_2} = 2 : 1$

286 **(b)**

When going above at a height h or at a depth d below earth's surface, in any case acceleration due to gravity decrease. Therefore,

$$g_e > g_h \text{ and } g_e > g_d$$

Moreover $g_h < g_d$, if $h = d$.

287 **(b)**

The relation between mass and density of earth is given form Newton's law of gravitation, according to which

$$M_e = \frac{gR_e^2}{G}$$

where M_e is mass of earth, G the gravitational constant, R_e the radius of earth and g the acceleration due to gravity.

Also, mass = volume × density

$$g = \frac{G \times \text{volume} \times \text{density}}{R^2}$$

Assuming spherical shape of earth volume

$$= \frac{4}{3}\pi R^3$$

$$g = G \times \frac{4}{3}\frac{\pi R^3}{R^2}\rho$$

$$\Rightarrow \quad g = G \cdot \frac{4}{3}\pi R\rho$$

Hence, increases in radius would dominate.

288 **(a)**

$g = \frac{4}{3}\pi\rho GR$. If ρ = constant then $\frac{g_1}{g_2} = \frac{R_1}{R_2}$

289 **(d)**

Total mechanical energy of satellite

$$E = \frac{-GMm}{2r} \Rightarrow \frac{E_A}{E_B} = \frac{m_A}{m_B} \times \frac{r_B}{r_A} \Rightarrow \frac{3}{1} \times \frac{4r}{r} = \frac{12}{1}$$

290 **(b)**

$$v = \sqrt{\frac{2GM}{R}} = \sqrt{2gR}$$

$$= \sqrt{2 \times (3.1)^2 \times 8100 \times (10)^3}$$

$= 27.9\ km/sec^{-1}$

291 **(a)**

Acceleration due to gravity on the surface of the earth is

$$g_e = \frac{GM_e}{R_e^2}$$

Where M_e and R_e are the mass and the radius of the earth respectively

Acceleration due to gravity on the surface of the planet is $g_p = \frac{GM_p}{R_p^2}$

Where M_p and R_p be the mass and the radius of the planet respectively

If both mass and radius of the planet are half as that of the earth, then

$$g_p = \frac{G(M_e/2)}{(R_e/2)^2} = 2\frac{GM_e}{R_e^2} = 2g_e$$

292 **(a)**

$$g' = \frac{g}{\left(1 + \frac{h}{R}\right)^2}$$

$$\frac{g}{4} = \frac{g}{\left(1 + \frac{h}{R}\right)^2}$$

$$1 + \frac{h}{R} = 2 \Rightarrow \frac{h}{R} = 1$$

$\Rightarrow h = R$

$\therefore h = 6400km$

293 **(c)**

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

or $g \propto \rho R$

or $R \propto \frac{g}{\rho}$

Now escape velocity, $v_e = \sqrt{2gR}$

or $v_e \propto \sqrt{gR}$

or $v_e \propto \sqrt{g \times \frac{g}{\rho}} \propto \sqrt{\frac{g^2}{\rho}}$

$\therefore (v_e)_{\text{panet}} = (11 \text{ ms}^{-1}) \sqrt{\frac{6}{121} \times \frac{3}{2}}$

$= 3 \text{ km s}^{-1}$

294 **(d)**

Since, earth from west to east, so train Q has effectively more angular velocity in comparison to train P and hence, experiences a greater centrifugal force directed radially outwards. So, train Q will exert a lesser force on track Q in comparison to train P. Hence, P exerts greater force on track

295 **(c)**

$\frac{gR^2}{(R+h)^2} = g\left(1 - \frac{h}{R}\right)$

or $\left(1 - \frac{h}{R}\right)\left(1 + \frac{h^2}{R^2} + \frac{2h}{R}\right) = 1$

or $\frac{h^3}{R^3} + \frac{h^2}{R^2} - \frac{h}{R} = 0$

or $\frac{h}{R}\left(\frac{h^2}{R^2} + \frac{h}{R} - 1\right) = 0$

or $\frac{h}{R} = \frac{-1 \pm \sqrt{1+4}}{2} = \frac{\sqrt{5}-1}{2}$

or $h = \frac{\sqrt{5}R - R}{2}$

296 **(d)**

$-\frac{GMm}{2R_1} + KE = -\frac{GMm}{2R_2}$

$KE = \frac{GMm}{2}\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

297 **(a)**

If body is projected with velocity $v(v < v_e)$ then

Height up to which it will rise, $h = \frac{R}{\frac{v_e^2}{v^2} - 1}$

$v = \frac{v_e}{2}$ (Given) $\therefore h = \frac{R}{\left(\frac{(v_e)}{v_e/2}\right)^2 - 1} = \frac{R}{4-1} = \frac{R}{3}$

298 **(c)**

$T = 2\pi\sqrt{\frac{r^3}{GM}} \Rightarrow T^2 = \frac{4\pi^2}{GM}(R+h)^3$

$\Rightarrow R + h = \left[\frac{GMT^2}{4\pi^2}\right]^{1/3} \Rightarrow h = \left[\frac{GMT^2}{4\pi^2}\right]^{\frac{1}{3}} - R$

299 **(d)**

$\Delta U = U_2 - U_1 = \frac{mgh}{1 + \frac{h}{R_e}} = \frac{mgR_e}{1 + \frac{R_e}{R_e}} = \frac{mgR_e}{2}$

$\Rightarrow U_2 - (-mgR_4) = \frac{mgR_e}{2} \Rightarrow U_2 = -\frac{1}{2}mgR_e$

300 **(b)**

From Kepler's third law of planetary motion also known as law of periods

$T^2 = kr^3$

Where T is time period and r the mean distance from the sun. Hence, greater is the distance of planet from sun, greater is its period of revolution.

301 **(c)**

Work done

$W = \Delta U = \frac{mgh}{1 + \frac{-h}{R}}$

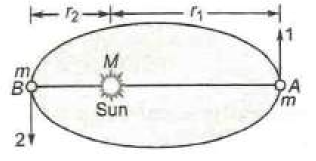
Substituting $R = \frac{h}{L}$ we get

$\Delta U = \frac{mg \times 2R}{1+2}$

$\Delta U = \frac{2mgR}{3}$

302 **(d)**

The gravitational force of sun on comet is radial, hence angular momentum is constant over the entire orbit. Using law of conservation of angular momentum, at locations A and B



$L = mv_1r_1 = mv_2r_2$ or $v_2 = \frac{v_1r_1}{r_2}$ ...(i)

Using the principle of conservation of total energy at A and B

$\frac{1}{2}mv_1^2 - \frac{GMm}{r_1} = \frac{1}{2}m\,v_2^2 - \frac{GMm}{r_2}$

or $v_2^2 - v_1^2 = 2GM\left(\frac{1}{r_2} - \frac{1}{r_1}\right)$ ...(ii)

Putting the values from Eq. (i) in Eq. (ii) and solving, we get

$v_1 = \left[\frac{2GMr_2}{r_1(r_1 + r_2)}\right]^{1/2}$

$\therefore L = mv_1r_1 = m\left[\frac{2GMr_1r_2}{(r_1 + r_2)}\right]^{1/2}$

303 **(b)**

$g \propto \rho R$

304 **(a)**

The necessary centripetal force required for a planet to move round the sun = gravitational force exerted on it ie, $\frac{mv^2}{R} = \frac{GM_e m}{R^n}$

$$v = \left(\frac{GM_e}{R^{n-1}}\right)^{1/2}$$

Now, $T = \frac{2\pi R}{v} = 2\pi R \times \left(\frac{R^{n-1}}{GM_e}\right)^{1/2}$

$$\Longrightarrow \quad = 2\pi\left(\frac{R^2 \times R^{n-1}}{GM_e}\right)^{1/2}$$

$$= 2\pi\left(\frac{R^{(n+1)/2}}{(GM_e)^{1/2}}\right)$$

$$\Longrightarrow \quad T \propto R^{(n+1)/2}$$

305 **(a)**

According of law of gravitation, the force of attraction acting on the body due to earth is given by

$$F = G\frac{Mm}{R^2} \quad \text{.... (i)}$$

The acceleration due to gravity g in the body arises due to the force F from Newton's second law of motion, we have

$$F = mg \quad \text{... (ii)}$$

From Eqs. (i) and (ii), we get

$$mg = G\frac{Mm}{R^2}$$

$$\Longrightarrow \quad g = \frac{GM}{R^2}$$

306 **(d)**

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

d = depth of mine

h = height from surface

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

$$\Rightarrow d = 2h$$

$$\Rightarrow 10 = 2h$$

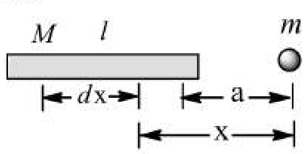
$$\Rightarrow h = 5km$$

307 **(b)**

Gravitational force provides the required centripetal force

$$m\omega^2 R = \frac{GMm}{R^3} \Rightarrow \frac{4\pi^2}{T^2} = \frac{GM}{R^4} \Rightarrow T \propto R^2$$

308 **(c)**



$$\Rightarrow dU = \frac{Gm\left(\frac{M}{l}dx\right)}{x}$$

$$\Rightarrow U\int dU = \frac{GmM}{l}\int_a^{a+l}\frac{dx}{x}$$

$$\Rightarrow U = -\frac{GmM}{l}\log_e\left(\frac{a+l}{a}\right)$$

309 **(b)**

Kinetic and potential energies varies with position of earth $w.r.t.$ sun. Angular momentum remains constant every where

311 **(a)**

$$\frac{GM_e}{x^2} = \frac{GM_m}{(r-x)^2}$$

or $\frac{r-x}{x} = \sqrt{\frac{M_m}{M_e}} = \sqrt{\frac{7.35\times10^{22}}{5.98\times10^{24}}}$

or $r = 0.11x + x = 1.11x$

$x = r/1.11 = 3.85 \times 10^8/1.11$

$= 3.47 \times 10^8$ m

312 **(a)**

At a height h, (Taking $h << R$) from the surface of earth

$g_h = g\left(1 - \frac{2h}{R}\right)$ or $\frac{g_h}{g} = 1 - \frac{2h}{R} = \frac{90}{100}$

or $\frac{2h}{R} = 1 - \frac{99}{100} = \frac{1}{100}$

or $g = \frac{R}{100} = \frac{6400}{200} = 32$ km

313 **(c)**

Angular momentum of the earth around the sun is

$L = M_E v_0 r$

$$\Rightarrow L = M_E\sqrt{\frac{GM_s}{r}}r \quad \left(\because v_0 = \sqrt{\frac{GM_s}{r}}\right)$$

$$\Rightarrow L = [M_E^2 GM_s r]^{1/2}$$

Where, M_E = Mass of the earth

M_s = Mass of the sun

r = Distance between the sun and the earth

$\therefore L \propto \sqrt{r}$

314 **(c)**

$$g' = g\left(\frac{R}{R+h}\right)^2 \Rightarrow \frac{1}{\sqrt{2}} = \frac{R}{R+h}$$

$$\Rightarrow R + h = \sqrt{2}R \Rightarrow h = (\sqrt{2} - 1)R = 0.414R$$

Hence, distance from centre $= R + 0.414\,R = 1.414\,R$

315 **(a)**

At depth d from the surface of the earth.

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

Given, $g' = \frac{75}{100}g = \frac{3}{4}g$

Then, $\frac{3g}{4} = g\left(1 - \frac{d}{R}\right)$

On solving, $d = R/4$

316 **(c)**

The escape velocity is independent of angle of projection, hence, it will remain same $ie.$ 11 kms^{-1}.

318 **(d)**

$$v_e=\sqrt{\frac{2GM}{R}}$$
$$=\sqrt{\frac{2\times6.67\times10^{-11}\times1.99\times10^{30}}{6.96\times10^8}}$$
$$=618\ km/sec$$

319 **(d)**

When earth moves round the sun then according to Kepler's second law, the radius vector drawn from the sun to earth, sweeps out equal areas in equal time, ie, its areal velocity (or the area swept out by it per unit time) is constant. While in such motion, angular velocity, kinetic energy and potential energy change.

320 **(b)**

$$\Delta U=\frac{mgh}{1+\frac{h}{R}}=\frac{mgh}{1+\frac{R}{R}}=\frac{mgR}{2}$$

321 **(c)**

$$g=\frac{GM}{R^2};g'=\frac{GM}{R'^2}=\frac{GM(100)^2}{(99)^2R^2}$$

% increase in $g=\frac{(g'-g)\times100}{g}$

$$=\left(\frac{g'}{g}-1\right)\times100=\left[\left(\frac{100}{99}\right)^2-1\right]\times100$$
$$\left[\left(1+\frac{1}{99}\right)^2-1\right]\times100\approx2\%$$

322 **(c)**

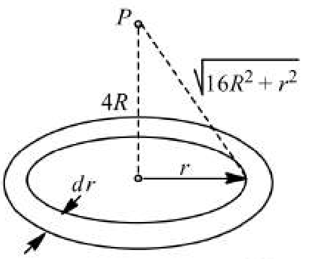
Acceleration due to gravity, $g=\frac{GM}{R^2}$

$$\frac{g_M}{g_E}=\left(\frac{M_M}{M_E}\right)\times\left(\frac{R_E}{R_M}\right)^2$$
$$=\frac{1}{10}\times\left(\frac{12742}{6760}\right)^2$$
$$\frac{g_M}{g_E}=0.35$$
$$g_M=9.8\times0.35=3.48\ ms^{-2}$$

323 **(a)**

$$W=\Delta U=U_f-U_i=U_\infty-U_P$$
$$=-U_P=-mV_P$$
$$=-V_P(\text{as } m=1)$$

Potential at point P will be obtained by integration as given below. Let dM be the mass of small rings as shown



$$dM=\frac{M}{\pi(4R)^2-\pi(3R)^2}(2\pi r)dr$$
$$=\frac{2Mr\,dr}{7R^2}$$
$$dV_P=-\frac{G.dM}{\sqrt{16R^2+r^2}}$$
$$=-\frac{2GM}{7R^2}\int_{3R}^{4R}\frac{r}{\sqrt{16R^2+r^2}}\cdot dr$$
$$=-\frac{2GM}{7R}(4\sqrt{2}-5)$$
$$\therefore\quad W=+\frac{2GM}{7R}(4\sqrt{2}-5)$$

324 **(c)**

For orbiting the earth close to its surface

$$=\frac{mv^2}{R}=\frac{GMm}{R^2}, ie, v_0=\sqrt{\frac{GM}{R}}=\sqrt{gR}$$
$$\therefore v_0=\sqrt{(9.8\times6.4\times10^6)}=8\ kms^{-1}$$

For escaping from close to the surface of earth,

$$\frac{GMm}{R}=\frac{1}{2}mv_t^2, v_e=\sqrt{\frac{2GM}{R}}=\sqrt{2gR}$$
$$v_e=\sqrt{2}\times v_0=1.41\times8kms^{-1}=11.2\ kms^{-1}$$

$\therefore$ the additional velocity to be imparted to the orbiting satellite for escaping is

11.2 −8 = 3.2 kms^{-1}

326 **(c)**

When two satellite of earth are moving in same orbit, then time period of both are equal. From Kepler's third law

$$T^2\propto r^3$$

Time period is independent of mass, hence their time periods will be equal.

The potential energy and kinetic energy are mass dependent, hence the PE and KE of satellites are not equal.

But, if they are orbiting in a same orbit, then they have equal orbital speed.

327 **(a)**

Inside the earth $g'=\frac{4}{3}\pi\rho Gr\ \therefore g'\propto r$

328 **(c)**

Due to rotation of earth the effective acceleration due to gravity $g'=g-R\omega^2\cos^2\lambda$.

For a given point on the surface of earth g decreases as ω increases. The angular speed of earth is maximum at equator hence, the value of g on the surface of the earth is smallest.

329 **(c)**

Acceleration due to gravity at height h,

$$g_1 = g\left(1-\frac{2h}{R}\right)$$

Acceleration due to gravity at depth h,

$$g_1 = g\left(1-\frac{h}{R}\right)$$

$$\therefore \frac{g_1}{g_2} = \frac{1-2h/R}{1-h/R} = \left(1-\frac{2h}{R}\right)\left(1-\frac{h}{R}\right)^{-1}$$

$$= \left(1-\frac{h}{R}\right)$$

$\therefore \frac{g_1}{g_2}$ decreases linearly with h

330 **(a)**

Force between earth and moon $F = \frac{Gm_m m_e}{r^2}$

This amount of force, both earth and moon will exert on each other $i.e.$ they exert same force on each other

331 **(c)**

The variation of g with angular velocity (ω) is given by

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

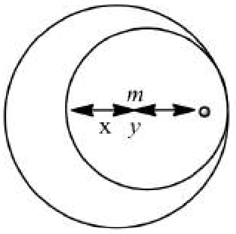
If earth were to spin faster, that is angular velocity increases, then except at poles, the weight of bodies will decrease at all places.

332 **(c)**

$V_P = -\frac{GM}{2R^3}(3R^2 - r^2)$ inside the sphere and $V_P = -\frac{GM}{r}$ outside the sphere

333 **(b)**

To calculate the force of attraction on the point mass m we should calculate the force due to the solid sphere and subtract from this the force which the mass of the hollow sphere would have exerted on m ie,



$$F = \frac{GmM}{x^2} - \frac{GmM'}{y^2}$$

$[x = R/4, x + y = R/2]$

$$M = \left(\frac{4}{3}\right)\pi R^3 \rho$$

and $M' = \frac{4}{3}\pi\left(\frac{R}{2}\right)^3 \rho = \frac{M}{8}$

$$F = \frac{GMm}{(R/4)^2} - \frac{Gm(M/8)}{(R/4)^2} = \frac{14GmM}{R^2}$$

335 **(b)**

$v_e = \sqrt{2gR}$ and $v_0 = \sqrt{gR}$ $\therefore$ $\sqrt{2}v_0 = v_e$

336 **(c)**

$g = \frac{4}{3}\pi\rho GR \Rightarrow g \propto dR$ $(\rho = d$ given in the problem)

337 **(b)**

Weight on surface of earth, $mg = 500\text{N}$ and weight below the surface of earth at

$$d = \frac{R}{2}$$

$$mg' = mg\left(1-\frac{d}{R}\right)$$

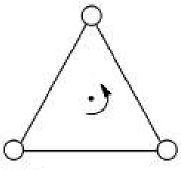
$$= mg\left(1-\frac{1}{2}\right)$$

$$= \frac{mg}{2} = 250\text{N}$$

338 **(a)**

$$\frac{GMM}{L^2} = \frac{MV^2}{L}$$

$$\Rightarrow V = \sqrt{\frac{GM}{L}}$$



339 **(d)**

Mass of the satellite does not affect the time period

$$\frac{T_A}{T_B} = \left(\frac{r_1}{r_2}\right)^{3/2} = \left(\frac{r}{2r}\right)^{3/2} = \left(\frac{1}{8}\right)^{1/2} = \frac{1}{2\sqrt{2}}$$

340 **(b)**

$F = 0$ when $0 \le r \le R_1$

Because intensity is zero inside the cavity

F increase when $R_1 \le r \le R_2$

$F \propto \frac{1}{r^2}$ when $r > R_2$

341 **(c)**

$GM = gR^2$

$$u = \sqrt{2gR} = \sqrt{2\frac{GM}{R^2}R} = \sqrt{\frac{2GM}{R}}$$

342 **(a)**

k represents gravitational constant which depends only on the system of units

343 **(c)**

The value of acceleration due to gravity at height h (when h is not negligible as compared to R)

$$g' = g\frac{R^2}{(R+h)^2}$$

Here, $g' = \frac{g}{2}$

$$\therefore \quad \frac{g}{2} = g\frac{R^2}{(R+h)^2}$$

or $\frac{1}{2} = \frac{R^2}{(R+h)^2}$

or $\sqrt{\frac{1}{2}} = \frac{R}{R+h}$

or $R + h = \sqrt{2}\,R$

$\therefore \quad h = (\sqrt{2}-1)R$

345 **(a)**

$$g' = \frac{gR^2}{(R+h)^2}$$

$$= 980 \times \left(\frac{6400}{6400+64}\right)^2 = 960\text{cms}^{-2}$$

347 **(c)**

The orbital velocity of satellite close to the earth is

$$v_0 = \sqrt{gR_e} \quad \text{....(i)}$$

where R_e is radius of the earth. The escape velocity for a body thrown from the earth's surface is

$$v_e = \sqrt{gR_e} \quad \text{....(ii)}$$

Thus, $\frac{v_o}{v_e} = \frac{\sqrt{gR_e}}{\sqrt{2gR_e}} = \frac{1}{\sqrt{2}}$

$\therefore \quad v_e = \sqrt{2}v_o$

or $v_o = \frac{v_e}{\sqrt{2}} = \frac{2}{\sqrt{2}} = \sqrt{2}\text{ kms}^{-1}$

348 **(a)**

Binding energy = − kinetic energy

And if this amount of energy (E_k) given to satellite then it will escape into outer space

349 **(d)**

$$v_0 = \sqrt{\frac{GM}{r}}$$

351 **(b)**

$g = \frac{GM}{R^2}$. If radius shrinks to half of its present value then g will becomes four times

352 **(c)**

Resultant gravitational intensity at a mid-point on the line joining the two bodies is

$$I = \frac{Gm_2}{(r/2)^2} - \frac{Gm_1}{(r/2)^2} = \frac{4G}{r^2}(m_2 - m_1)$$

$$= \frac{4 \times 6.6 \times 10^{-11}}{1^2}(1000 - 100)$$

$$= 2.4 \times 10^{-7}\text{Mkg}^{-1}$$

354 **(c)**

$B.E. = -\frac{GMm}{r}$. If $B.E.$ decreases then r also decreases and v increases as $v \propto \frac{1}{\sqrt{r}}$

355 **(c)**

A person feels weightlessness in satellite orbit because he is in free fall along with the satellite and experiences no force of support from the satellite. The perception of weight comes from the support force exerted on one by the floor, a chair etc. If that support is removed and one is in free fall, we feel no experience of weight.

356 **(b)**

The value of acceleration due to gravity at latitude λ is given by

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

$$\therefore \quad g - g_\lambda = R\omega^2\cos^2\lambda$$

At λ = 30°,

$$g - g_{30°} = R\omega^2\cos^2 30°$$

$$= R\omega^2\left(\frac{\sqrt{3}}{2}\right)^2$$

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

357 **(c)**

For earth, $g = \frac{GM}{R^2} = \frac{4}{3}\pi R\rho G$

For the planet, $g_1 = \frac{GM_1}{R_1^2} = \frac{4}{3}\pi R_1\rho G$

$$\frac{g}{g_1} = \frac{R}{R_1} = \frac{6400}{320} = 20$$

Let h and h_1 be the distance upto which the man can jump on surface of the earth and planet, then

$mgh = mg_1h_1$

$$\therefore h_1 = \frac{g}{g_1}h = 20 \times 5 = 100\text{ m}$$

358 **(a)**

Escape velocity does not depend on the mass of the projectiles

359 **(d)**

$$W = 0 - \left(-\frac{GMm}{R}\right) = \frac{GMm}{R}$$

$$= gR^2 \times \frac{m}{R} = mgR$$

$$= 1000 \times 10 \times 6400 \times 10^3$$

$$= 64 \times 10^9 J$$

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

360 **(a)**

$F \propto xm \times (1-x)m = xm^2(1-x)$

For maximum force $\frac{dF}{dx} = 0$

$\Rightarrow \frac{dF}{dx} = m^2 - 2xm^2 = 0$

$\Rightarrow x = 1/2$

361 **(c)**

Change in potential energy

$\Delta U = U_2 - U_1$

$\therefore \quad \Delta U = -\frac{GMm}{(R+nR)} + \frac{GMm}{R}$

or $\quad \Delta U = -\frac{GMm}{R(1+n)} + \frac{GMm}{R}$

or $\quad \Delta U = \frac{GMm}{R}\left[-\frac{1}{1+n} + 1\right]$

or $\quad \Delta U = \frac{(R^2g)m}{R} \times \frac{n}{(1+n)} \qquad \left[\therefore g = \frac{GM}{R^2}\right]$

or $\quad \Delta U = mgR\left(\frac{n}{n+1}\right)$

362 **(a)**

The earth possesses rotational motion about an axis through its poles. The value of acceleration due to gravity at a place (at given latitude) is affected due to its rotational motion. If earth ceases to rotate, the weight of body at equator will increase. However, there will be no effect on the weight at poles. The effect of rotation of the earth on acceleration due to gravity is to decrease its value. Therefore, if the earth stops rotating, the value of g will increase.

363 **(d)**

Escape velocity from the earth

$(v_e) = 11.2 \text{ kms}^{-1}$

Let the mass, radius and density of earth be M, R and ρ respectively and for given planet mass, radius and density are M', R' and ρ', respectively.

$\therefore$ Escape velocity from the earth

$$v_e = \sqrt{\frac{2G \times \left(\frac{4}{3}\pi R^3 \rho\right)}{R}}$$

$$v_e = \sqrt{\frac{8G\pi R^2 \rho}{3}} \qquad \text{....(i)}$$

Similarly, escape velocity from the given planet

$$v'_e = \sqrt{\frac{8G\pi R'^2 \rho}{3}} \qquad \text{....(ii)}$$

Dividing Eq. (i) by Eq. (ii) we get

$$\frac{v_e}{v'_e} = \sqrt{\frac{8G\pi R^2\rho}{3}} \times \sqrt{\frac{3}{8G\pi R'^2 \rho}} = \sqrt{\frac{R^2}{R'^2}}$$

or $\quad \frac{11.2}{v'_e} = \frac{R}{R'}$

or $\quad \frac{11.2}{v'_e} = \frac{R}{2R}$

$\therefore \quad v'_e = 22.4 \text{ kms}^{-1}$

364 **(d)**

Binding energy of the system $= \frac{GM_eM_s}{2r}$

$= \frac{6.6 \times 10^{-11} \times 6 \times 10^{24} \times 2 \times 10^{30}}{2 \times 1.5 \times 10^{11}}$

$= 2.6 \times 10^{33}$J

365 **(c)**

The potential energy of an object at the surface of the earth

$$U_1 = -\frac{GMm}{R} \qquad \text{....(i)}$$

The potential energy of the subject at a height $h = R$ from the surface of the earth

$$U_2 = -\frac{GMm}{R+h} = -\frac{GMm}{R+R} \qquad \text{...(ii)}$$

Hence, the gain in potential energy of the object

$\Delta U = U_2 - U_1$

$\Delta U = -\frac{GMm}{R+R} + \frac{GMm}{R}$

$\Delta U = -\frac{GMm}{2R} + \frac{GMm}{R}$

$\Delta U = \frac{1}{2}\frac{GMm}{R}$

But we know that $GM = gR^2$

Hence, $\quad \Delta U = \frac{1}{2}\frac{gR^2m}{R}$

or $\quad \Delta U = \frac{1}{2}mgR$

366 **(a)**

Using conservation of energy.

$\frac{1}{2}mv^2 - \frac{GMm}{R} = 0 - \frac{GMm}{2R}$

or $\quad \frac{1}{2}mv^2 = \frac{GMm}{R} - \frac{GMm}{2R}$

or $\quad v^2 = 2\frac{GM}{R}\left[1 - \frac{1}{2}\right]$

or $\quad v^2 = \frac{GM}{R}$

But $\quad gR^2 = GM$

$\therefore \quad v = \sqrt{\frac{gR^2}{R}}$

or $\quad v = \sqrt{gR}$

367 **(a)**

Gravitational force dsesnot depend on the medium.

368 **(c)**

$T_2 = T_1\left(\frac{r_2}{r_1}\right)^{3/2} = T_1\left(\frac{1}{4}\right)^{3/2} = \frac{1}{8}$ times

369 **(c)**

$$T_2 = T_1\left(\frac{r_2}{r_1}\right)^{2/3} = 83\left(\frac{R+3R}{R}\right)^{3/2}$$

$= 83 \times 8 = 664$ min

370 **(c)**

For $w2w, 3w$ apparent weight will be zero because the system is falling freely. So the distances of the weights from the rod will be same.

371 **(c)**

$v_1 r_1 = v_2 r_2$ [∵ angular momentum is constant]

372 **(c)**

The velocity of the spoon will be equal to the orbital velocity when dropped out of the space-ship

373 **(d)**

$V = \frac{-GM}{r}$ and $I = \frac{GM}{r^2}$

$V = 0$ and $I = 0$ at $r = \infty$

374 **(c)**

$$v_0 = \sqrt{\frac{GM}{r}} = \sqrt{\frac{gR^2}{r}} = \sqrt{\frac{10 \times (64 \times 10^5)^2}{8000 \times 10^3}}$$

$= 71.5 \times 10^2 m/s = 7.15\ km/s$

375 **(a)**

The relation between density (d) and acceleration due to gravity (g) is

$$d = \frac{3g}{4\pi R_e G}$$

$$\therefore \quad \frac{d_1}{d_2} = \frac{g_1}{r_1} \times \frac{r_2}{g_2}$$

$$\Rightarrow \quad \frac{g_1}{g_2} = \frac{d_1 r_1}{d_2 r_2}$$

376 **(a)**

By conservation of angular momentum $mvr =$ constant

$v_{\min} \times r_{\max} = v_{\max} \times r_{\min}$

$$\therefore v_{\min} = \frac{60 \times 1.6 \times 10^{12}}{8 \times 10^{12}} = \frac{60}{5} = 12\ m/s$$

377 **(a)**

$$K.E. = \frac{GMm}{2R}$$

378 **(a)**

$$g = g_p - R\omega^2 \cos^2\lambda$$
$$= g_p - \omega^2 R \cos^2 60° = g_p - \frac{1}{4}R\omega^2$$

379 **(b)**

$$\frac{(v_e)p_1}{(v_e)p_2} = \frac{\sqrt{2g_1R_1}}{\sqrt{2g_1R_2}} = \sqrt{\frac{g_1}{g_2} \times \frac{R_1}{R_2}} = \sqrt{ab}$$

380 **(a)**

For the satellite to move along closed orbit (a circle with a radius $R + h$) it should be acted upon by a force directed towards the centre. In this case, this is the force of earth's attraction.

According to Newton's Second law

$$\frac{mv^2}{R+h} = \frac{GMm}{(R+h)^2}$$

At the earth's surface, $\frac{GMm}{R^2} = mg$

Therefore, $v = \sqrt{\frac{gR^2}{R+h}} = 7.5\ kms^{-1}$

381 **(d)**

S_2 is correct because whatever be the g, the same force is acting on both the pans. Using a spring balance, the value of g is greater at the pole. Therefore mg at the pole is greater. S_4 is correct.

S_2 and S_4 are correct

382 **(c)**

$F = mI$

$$\therefore I = \frac{F}{m} = \frac{45}{1.5} = 30\text{N kg}^{-1}$$

383 **(d)**

Gravitational force between sphere of mass M and the particle of mass m at B is

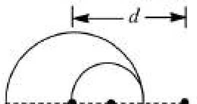
$$F_1 = \frac{GM\,m}{d^2}$$

If M_1 is the mass of the removed part of sphere, then

$$M_1 = \frac{4}{3}\pi(R/2)^3\rho = \frac{1}{8}\left(\frac{4}{3}\pi R^2\rho\right) = \frac{M}{8}$$

Gravitational force between the removed part and the particle of mass m at B is

$$F_2 = \frac{GM_1m}{(d-R/2)^2} = \frac{G(M/8)m}{(d-R/2)^2} = \frac{GM\,m}{8(d-R/2)^2}$$



∴ Required force,

$$F = F_1 - F_2 = \frac{GM\,m}{d^2} - \frac{GMm}{8[d-(R/2)]^2}$$

$$= \frac{GM\,m}{d^2}\left[1 - \frac{1}{8\left(1-\frac{R}{2d}\right)^2}\right]$$

384 **(d)**

By Kepler's law $T^2 \propto R^3$

$$\text{Hence,} \quad \left(\frac{T_2}{T_1}\right)^2 = \left(\frac{R_2}{R_1}\right)^3$$
$$= \left(\frac{2.5R + R}{6R + R}\right)^3$$

$$= \left(\frac{1}{2}\right)^3$$

$$T_2 = \frac{T_1}{(2)^{3/2}}$$

For a geostationary satellite

$$T_1 = 24\text{ h}$$

So, $T_2 = \frac{24}{2\sqrt{2}} = 6\sqrt{2}\text{ h}$

385 **(c)**

$$\frac{1}{2}mv_e^2 = \frac{1}{2}m\,2gR = mgR$$

386 **(a)**

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

The latitude at point on the surface of the earth is defined as the angle, which the line joining that point to the centre of earth makes with equatorial plane. It is denoted by λ. For the poles $\lambda = 90°$ and for equator $\lambda = 0°$.

(i) Substituting $\lambda = 90°$ in the above expression, we get

$$g_{\text{pole}} = g - \omega^2 R\cos^2 90°$$

$\therefore$ $g_{\text{pole}} = g$

ie, there is no effect of rotational motion of the earth on the value of g at the poles.

(ii) Substituting $\lambda = 0°$ in the above expression, we get

$$g_{\text{equator}} = g - \omega^2 R\cos^2 0°$$

$\therefore$ $g_{\text{equator}} = g - \omega^2 R$

ie, the effect of rotation of the earth on the value of g at the equator is maximum.

387 **(a)**

Since the gravitational field is conservative field, hence, the work done in taking a particle from one point to another in a gravitational field is path independent

389 **(a)**

$g' = \frac{GM}{(R+h)^2}$, acceleration due to gravity at height h

$\Rightarrow$ $\frac{g}{9} = \frac{GM}{R^2}\cdot\frac{R^2}{(R+h)^2}$

$$= g\left(\frac{R}{R+h}\right)^2$$

$\Rightarrow$ $\frac{1}{9} = \left(\frac{R}{R+h}\right)^2$

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

$\Rightarrow$ $3R = R + h$

$\Rightarrow$ $2R = h$

391 **(a)**

We know that intensity is negative gradient of potential,

ie, $m\,I = -(dV/dr)$ and as here $I = -(k/r)$, so

$$\frac{dV}{dr} = \frac{k}{r}, ie, \int_0^v dV = k\int_{r_0}^{r}\frac{dr}{r}$$

or $V - V_0 = k\log\frac{r}{r_0}$ so, $V = k\log\frac{r}{r_0} + V_0$

392 **(c)**

Mass does not vary from place to place

393 **(d)**

Time period of simple pendulum $T = 2\pi\sqrt{\frac{1}{g'}}$

In artificial satellite $g' = 0$ $\therefore T = $ infinite

394 **(d)**

Escape velocity of the body from the surface of earth is $v = \sqrt{2gR}$

Escape velocity of the body from the platform

Potential energy + Kinetic energy = 0

$$\Rightarrow -\frac{GMm}{2R} + \frac{1}{2}mv_p^2 = 0 \Rightarrow v_p = \sqrt{\frac{GM}{R^2}.R} = \sqrt{gR}$$

$$= \frac{1}{\sqrt{2}}\sqrt{2gR} = \frac{1}{\sqrt{2}};\ \therefore f = \frac{1}{\sqrt{2}}$$

395 **(d)**

Gravitational field intensity

$$I = \frac{GM}{R^2} = \frac{6.6\times10^{-11}\times7.34\times10^{22}}{(1.74\times10^6)^2}$$

$= 1.62\text{ Nkg}^{-1}$

396 **(a)**

Mass of the ball always remain constant. It does not depend upon the acceleration due to gravity

397 **(a)**

$$g' = g\left(1 - \frac{d}{R}\right) = 9.8\left(1 - \frac{100}{6400}\right) = 9.66 m/s^2$$

398 **(a)**

Below the surface of the earth $g \propto r$ and above the surface of earth $g \propto 1/r^2$. Therefore, the graph (a) is correct

399 **(a)**

$$I = \frac{-dV}{dx}$$

If $V = 0$ then gravitational field is necessarily zero

400 **(a)**

$$v = \sqrt{2gR} \Rightarrow \frac{v_p}{v_e} = \sqrt{\frac{g_p}{g_e}\times\frac{R_e}{R_p}} = \sqrt{2\times\frac{1}{4}} = \frac{1}{\sqrt{2}}$$

$$\therefore v_p = \frac{v_e}{\sqrt{2}}$$

401 **(b)**

According to Kelper's third law (law of periods), we have $T^2 \propto R^3$

where T is time taken by the planet to go once around the sun and R is semi-major axis (distance) of the elliptical orbit.

$\therefore \quad T^3 = k R^3 \quad$ ...(i)

Where k is constant of proportionality.

When R becomes 4 times let time period be T'.

$\therefore \quad T'^2 = k(4R)^3 \quad$ ... (ii)

$\therefore \quad \frac{T^2}{T'^2} = \frac{1}{64}$

or $\quad \frac{T}{T'} = \frac{1}{8}$

or $\quad T' = 8T$

So, time period becomes 8 times of previous value.

402 **(c)**

Just before striking, the distance between the centre of earth and moon is,

$r = R_e + \frac{R_e}{4} = \frac{5R_e}{4}$

So, acceleration of moon at this moment is

$a = \frac{GM_e}{(5R_e/4)^2} = \frac{16}{25} \times 10 = 6.4 \text{ ms}^{-2}$

403 **(b)**

$v \propto \frac{1}{\sqrt{r}}$

% increase in speed = 1/2 (% decrease in radius)

= 1/2(1%) = 0.5%

i.e. speed will increase by 0.5%

404 **(d)**

Time period of satellite

$T \propto \frac{1}{M^{1/2}}$, where M is mass of earth.

$\propto (R+h)^{3/2}$ where R is radius of the orbit, h is the height of satellite from the earth's surface.

405 **(c)**

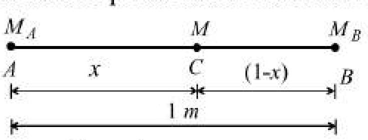
Escape velocity for that body $v_e = \sqrt{\frac{2Gm}{r}}$

v_e should be more than or equal to speed of light

i.e. $\sqrt{\frac{2Gm}{r}} \geq c$

406 **(a)**

Let a point mass C is placed at a distance of x m from the point mass A as shown in the figure



Here, $\frac{M_A}{M_B} = \frac{4}{3}$, Force between A and C is

$F_{AC} = \frac{GMM_A}{x^2} \quad$ ...(i)

Force between B and C is

$F_{BC} = \frac{GMM_B}{(1-x)^2} \quad$ ...(ii)

According to given problem $F_{AC} = \frac{1}{3}F_{BC}$

$\therefore \frac{GM_AM}{x^2} = \frac{1}{3}\left(\frac{GM_BM}{(1-x)^2}\right)$ [Using (i) and (ii)]

$\frac{M_A}{x^2} = \frac{M_B}{3(1-x)^2}$ or $\frac{M_A}{M_B} = \frac{x^2}{3(1-x)^2}$

$\Rightarrow \frac{4}{3} = \frac{x^2}{3(1-x)^2}$ or $4 = \frac{x^2}{(1-x)^2}$

Or $2 = \frac{x}{1-x}$ or $2 - 2x = x$

$3x = 2$ or $x = \frac{2}{3}m$

407 **(a)**

$$v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{6.67 \times 10^{-11} \times 6 \times 10^{24}}{384000 \times 10^3}} = 1\ km/s$$

408 **(c)**

If m is the mass of racket, M that of earth and R is the radius of earth, then gravitational potential energy of racket near the surface of earth

$$U_1 = \frac{GMm}{R}$$

Gravitational potential energy of racket at a height h from earth's surface

$$U_2 = -\frac{GMm}{(R+h)}$$

Increase in gravitational potential energy of racket

$$\Delta U = U_2 - U_1 = -\frac{GMm}{R+h} + \frac{GMm}{R}$$

or $\quad \Delta U = \frac{GMmh}{(R+h)R}$

If v is the escape velocity of racket, then

$$\Delta U = \frac{1}{2}mv^2$$

$\Rightarrow \quad \frac{1}{2}mv^2 = \frac{GMmh}{(R+h)R}$

$\Rightarrow \quad mv^2R^2 + mv^2Rh = 2GMm\,h$

$\Rightarrow \quad v^2R^2 = (2GM - v^2R)h$

$\therefore \quad h = \frac{v^2R^2}{2GM - v^2R}$

409 **(c)**

Given $\quad \frac{R_e}{R_p} = \frac{2}{3}$

$\frac{d_e}{d_p} = \frac{4}{5}$

As $\quad MG = gR_e^2$

and $\quad M = d_e \times \frac{4}{3}\pi R_e^3$

$d_e \times \frac{4}{3}\pi R_e^3 \times G = g_e R_e^2$

or $d_e \times \frac{4}{3}\pi R_e \times G = g_e$ ....(i)

Similarly for planet

$$d_p \times \frac{4}{3}\pi R_p G = g_p \quad ....(ii)$$

Dividing Eq. (i) by Eq. (ii), we get

$$\frac{g_e}{g_p} = \frac{R_e}{R_p} \times \frac{d_e}{d_p}$$

$$\frac{g_e}{g_p} = \frac{2}{3} \times \frac{4}{5} = \frac{8}{15} = 0.5$$

410 **(a)**

When a body is acted on by the force towards a point and the magnitude of force is inversely proportional to the square of distance. It means it obeys inverse square law and represents ellipse, for example path of the planet around the sun and the force acts between sun and planet proportional to $\frac{1}{r^2}$

411 **(c)**

Acceleration due to gravity at height h

$$g_h = g\left(1 - \frac{2h}{R}\right) \quad ....(i)$$

and depth d

$$g_d = g\left(1 - \frac{d}{R}\right) \quad ....(ii)$$

From Eq. (i) and (ii),

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

$\Rightarrow$ $2h = d$

413 **(a)**

Time period of satellite

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

where $R + h$ = orbital radius of satellite,

M_e = mass of earth.

Thus, time period does not depend on mass of satellite.

414 **(d)**

Given that, the orbital velocity of satellite

$$= \frac{\text{escape velocity}}{2}$$

$$\Rightarrow \quad v_o = \frac{v_e}{2} \quad ....(i)$$

But we know that,

$$v_o = \sqrt{\frac{gR^2}{R+h}} \text{ and } v_e = \sqrt{2gR}$$

On putting these values in Eq. (i)

$$\sqrt{\frac{gR^2}{R+h}} = \frac{\sqrt{2gR}}{2}$$

On squaring both sides, we obtain

$$\frac{gR^2}{R+h} = \frac{2gR}{4}$$

or $2gR^2 = gR(R+h)$

or $2R = R + h$ or $R = h$

or $h = R = 6400$ km

415 **(c)**

Value of g decreases when we go from poles to equator

416 **(d)**

Kinetic energy of satellite in its orbit

$$E = \frac{1}{2}mv_o^2$$

or $E = \frac{1}{2}m\left(\frac{GM}{r}\right) = \frac{GMm}{2r}$

kinetic energy at escape velocity

$$E' = \frac{1}{2}mv_e^2$$

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

$$= 2E$$

Therefore, additional kinetic energy required

$$= 2E - E = E$$

417 **(c)**

Potential energy of a body at the surface of the earth

$$PE = -\frac{GMm}{R} = -\frac{9R^2M}{R} = -mgR$$

$= 500 \times 9.8 \times 6.4 \times 10^6$

$= -3.6 \times 10^{10}$J

So, if we give this amount of energy in the form of kinetic energy then body escape from the earth

418 **(b)**

Gravitational intensity,

$I = \frac{dV}{dx} = \frac{14}{20} = 0.7$ Nkg^{-1}

Acceleration due to gravity,

g = $I = 0.7$ Nkg^{-1}

Work done under this field in displacing a body on a slope of 60° through a distance s

$= m(\text{g} \sin 60°)s$

$= 2 \times (0.7 \times \sqrt{3}/2) \times 8 = 9.6$ J

419 **(d)**

Weight on mars $= mg' = \frac{mG(m/10)}{(R/2)^2}$

$= m \times \frac{4}{10}mg = \frac{4}{10} \times 200 = 80$ N

420 **(c)**

Here, $I = \frac{dV}{dr} = -k/r$

or $dV = k\frac{dr}{r}$

Integrating it, we get

$$\int_{V_0}^{v} dV = \int_{r_0}^{r} k\frac{dr}{r}$$

or $V = V_0 + k\log r/r_0$

421 **(a)**

Angular momentum = Mass × Orbital velocity × Radius

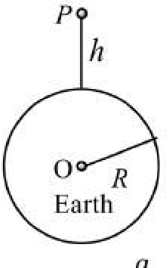
$$= m \times \left(\sqrt{\frac{GM}{R_0}}\right) \times R_0 = m\sqrt{GMR_0}$$

422 **(b)**

Time of decent $t = \sqrt{\frac{2h}{g}}$. In vacuum no other force works except gravity so time period will be exactly equal

423 **(b)**

The value of acceleration due to gravity at height h above the surface of the earth is given by



$$g' = \frac{g}{\left(1+\frac{h}{R}\right)^2}$$

$$g' = g\left(1+\frac{h}{R}\right)^{-2} = g\left(1-\frac{2h}{R}\right)$$

Given, $g' = \frac{g}{4}$

$$\frac{g}{4} = g\left(1-\frac{2h}{R}\right)$$

$$\Rightarrow \quad \frac{1}{4} = 1 - \frac{2h}{R}$$

$$\Rightarrow \quad \frac{2h}{R} = \frac{3}{4}$$

$$\Rightarrow \quad h = \frac{3R}{8}$$

425 **(d)**

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$\frac{\Delta T}{T} = \frac{\Delta g}{2g}$$

or $\Delta T = -\frac{\Delta g}{2g} \times T = -\frac{1}{2} \times \left(\frac{-0.5}{100}\right) \times 2 = +0.005$ s

∴ Time period at equator

$= 2 + 0.005 = 2.005$ s

427 **(c)**

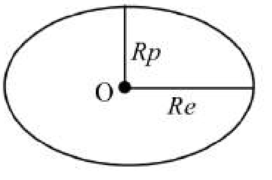
$I_1\omega_1 = I_2\omega_2$

$$\frac{2}{5}MR^2\left(\frac{2\pi}{T_1}\right) = \frac{2}{5}M\cdot\frac{R^2}{n^2}\left(\frac{2\pi}{T_2}\right)$$

$$T_2 = \frac{T_1}{n^2} = \frac{24}{n^2}$$

428 **(c)**

The earth is not a solid sphere but is somewhat flattened at the poles and bulged at equator, its equatorial radius is 21 km larger than its polar radius, since,



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

Hence, value of g is least at equator and maximum at poles. Also, $W = mg$, therefore a person will get more quantity of matter in kg-wt at equator.

430 **(b)**

Gravitational pull depends upon the acceleration due to gravity on that planet

$$M_m = \frac{1}{81}M_e, g_m = \frac{1}{6}g_e$$

$$g = \frac{GM}{R^2} \Rightarrow \frac{R_e}{R_m} = \left(\frac{M_e}{M_m}\times\frac{g_m}{g_e}\right)^{1/2} = \left(81\times\frac{1}{6}\right)^{1/2}$$

$$\therefore R_e = \frac{9}{\sqrt{6}}R_m$$

431 **(a)**

Gravitational attraction force on particle B

$$F_g = \frac{GM_Pm}{(D_P/2)^2}$$

Acceleration of particle due to gravity $a = \frac{F_g}{m} = \frac{4GM_P}{D_P^2}$

432 **(d)**

Water fills the tube entirely in gravity less condition.

433 **(d)**

At height h', $\frac{g'}{g} = 1 - \frac{2h}{R} = \frac{90}{100}$

or $\frac{2h}{R} = 1 - \frac{90}{100} = \frac{10}{100} = \frac{1}{10}$

or $R = 20h = 20 \times 320 = 6400\ km$

At dept d, $\frac{g'}{g} = 1 - \frac{d}{R} = \frac{95}{100}$

or $\frac{d}{R} = 1 - \frac{95}{100} = \frac{5}{100} = \frac{1}{20}$

or $d = \frac{R}{20} = \frac{6400}{20} = 320$ km

434 **(c)**

$$F=\frac{G\times m\times m}{(2R)^2}=\frac{G\times\left(\frac{4}{3}\pi R^3\rho\right)^2}{4R^2}=\frac{4}{3}\pi^2\rho^2R^4$$

$\therefore F\propto R^4$

435 **(b)**

Using $g=\frac{GM}{R^2}$ we get $g_m=g/5$

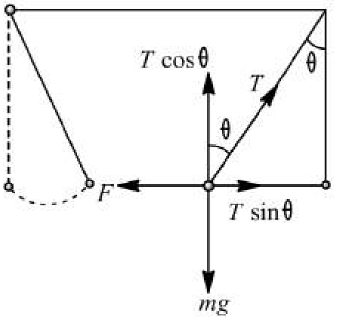
437 **(c)**

When a sphere of mass m is released in a liquid, it falls vertically down with acceleration $=\frac{mg-F_B}{m}$

$$\frac{\frac{4}{3}\pi r^3dg-\frac{4}{3}\pi r^3\rho g}{\frac{4}{3}\pi r^2d}=\frac{(d-\rho)g}{d}$$

438 **(c)**

The metallic spheres will be at positions as shown in the figure.



$$T\sin\theta=F=\frac{GM\times M}{L^2}$$

$$=\frac{GM^2}{L^2}$$

$$T\cos\theta=Mg$$

$$\therefore\quad \tan\theta=\frac{GM}{gL^2}$$

or $\quad\theta=\tan^{-1}\left(\frac{GM}{gL^2}\right)$

439 **(c)**

When there is a weightlessness in the body at the equator, then $g'=r-R\omega^2=0$

or $\omega=\sqrt{g/R}$ and linear velocity

$=\omega R=(\sqrt{g/R})R=\sqrt{gR}$

$\therefore$ KE of rotation of earth $=\frac{1}{2}I\omega^2$

$$=\frac{1}{2}\times\frac{2}{5}MR^2\times\omega^2$$

$$=\frac{2}{5}M(\omega R)^2=\frac{1}{5}MgR$$

440 **(b)**

The acceleration due to gravity on the new planet can be using the relation

$$g=\frac{GM}{R^2}\qquad\ldots(\text{i})$$

but $M=\frac{4}{3}\pi R^3\rho$, ρ being density.

Thus, Eq. (i) becomes

$$\therefore\quad g=\frac{G\times\frac{4}{3}\pi R^3\rho}{R^2}$$

$$=G\times\frac{4}{3}\pi R\rho$$

$$\Rightarrow\quad g\propto R$$

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

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

$$\Rightarrow\quad g'=3g$$

441 **(c)**

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

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

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

$$T_2^2=72$$

$$T_2^2=36\times 2$$

$$T_2=6\sqrt{2}$$

442 **(b)**

$\frac{T^2}{r^3}=\text{constant}\Rightarrow T^2r^{-3}=\text{constant}$

443 **(a)**

$U=\frac{-GMm}{r}$ or $r=\frac{-GMm}{U}$

$$r=\frac{-6.67\times 10^{-11}\times 6\times 10^{24}\times 7.4\times 10^{22}}{-7.79\times 10^{38}}$$

$=3.8\times 10^8$m

444 **(a)**

When a satellite is moving in on elliptical orbit, it's angular momentum $(=\vec{\mathbf{r}}\times\vec{\mathbf{p}})$ about the centre of earth dos not change its direction. The linear momentum $(=m\vec{\mathbf{v}})$ does not remain constant as velocity of satellite is not constant.

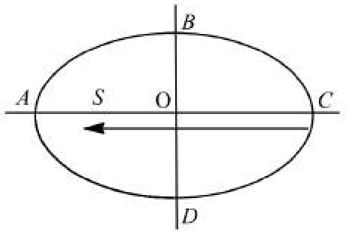
The total mechanical energy of S is constant at all locations.

The acceleration of S(=centripetal acceleration) is always directed towards the centre of earth

445 **(c)**

Let m be mass of planet and M that of sun, r the radius between the two. Let the planet be moving with velocity v_o, then

Gravitational force = centripetal force



$$\frac{GMm}{r^2} = \frac{mv_o^2}{r}$$

$$\Rightarrow \quad v_o = \sqrt{\frac{GM}{r}}$$

$$\Rightarrow \quad v_o \propto \frac{1}{\sqrt{r}}$$

Hence, larger the distance, smaller the orbital velocity. At point C distance from sun is maximum, hence orbital velocity is lowest. At point A distance from sun is minimum, hence orbital velocity is maximum.

446 **(d)**

$F = \frac{Gm_1m_2}{(r+2r)^2} = \frac{Gm_1m_2}{9r^2}$, $ie, F \propto r^{-2}$

Note that $F \propto r^4$ by taking $m = \frac{4}{3}\pi r^4 \rho$ and then

$F \propto \frac{r^3 r^3}{r^2}$, $ie, F \propto r^4$

is not correct because the gravitational law obeys inverse square law and is not related with densities

447 **(c)**

If m is the mass and v is the orbital velocity of the satellite, then kinetic energy.

$$E = \frac{1}{2}mv^2$$

or $\quad Em = \frac{1}{2}m^2v^2$

or $\quad m^2v^2 = 2Em$

or $\quad mv = \sqrt{2Em} \quad \ldots.(\mathrm{i})$

If r is the radius of the orbit of the satellite, then its angular momentum

$$L = mvr$$

Using Eq. (i),

$$L = (\sqrt{2Em})r = \sqrt{2Emr^2}$$

448 **(c)**

If the body is projected with velocity $v(v < v_e)$ then height up to where it rises,

$$h = \frac{R}{\frac{v_e^2}{v^2} - 1}$$

$$\Rightarrow h = \frac{R}{\left(\frac{11.2}{10}\right)^2 - 1} = 4R \text{ (approx.)}$$

449 **(c)**

According to kepler's third law $T^2 \propto r^3$; At $r = 0, T = 0$. It shows that the graph between T^2 and r^2 is a straight line passing through origin

450 **(c)**

At equator, $g' = g - R\omega^2$. When angular velocity be

$\omega'(= x\omega)$, then, $0 = g - R\omega'^2$ or $\omega' = \sqrt{g/R} = x\omega$

or $\quad x = (\sqrt{g/R})/\omega$

or $\quad x = \frac{\sqrt{10/(6.4\times10^6)}}{2\pi} \times 24 \times 60 \times 60 = 17$

451 **(c)**

At equator, $g' = g - R\omega^2 = 0$ or $\omega = \sqrt{g/R}$

or $\quad \omega = \sqrt{10/(6.4\times10^6)} = 1.25 \times 10^{-3}$ rads^{-1}

452 **(a)**

When the thief with box on his head jumped down from a wall, he along with box is falling down with acceleration due to gravity, so the apparent weight of box becomes zero, (because, $R = mg - mg = 0$), so he experiences no load till he reaches the ground

454 **(d)**

Acceleration due to gravity at a height h form the surface of the earth

$$g' = g\frac{1}{\left(1 + \frac{h}{R}\right)^2}$$

Given, $\quad h = 2R$

$$\therefore \quad g' = g\frac{1}{(1+2)^2}$$

or $\quad g' = \frac{g}{9}$

455 **(d)**

Here, $g = GM/R$ and $g' = \frac{G(M/2)}{(R/2)^2} = \frac{2GM}{R^2} = 2g$

$\therefore$ % increase in $g = \left(\frac{g'-g}{g}\right) \times 100$

$$= \left(\frac{2g - g}{g}\right) \times 100 = 100\%$$

456 **(b)**

$$v = \sqrt{2gR} \Rightarrow \frac{v_p}{v_e} = \sqrt{\frac{g_p}{g_e} \times \frac{R_p}{R_e}} = \sqrt{1 \times 4} = 2$$

$$\therefore v_p = 2v_e$$

458 **(a)**

Since, $T^2 = kr^3$

$$\Rightarrow \frac{2\Delta T}{T} = \frac{3\Delta r}{r} \Rightarrow \frac{\Delta T}{T} = \frac{3}{2}\frac{\Delta r}{r}$$

459 **(b)**

$$g = \frac{GM}{R^2} = \frac{G}{R^2}\frac{4}{3}\pi R^3 \rho = \frac{4}{3}\pi G\rho R \; ie, g = R$$

460 **(b)**

$$a\frac{Gm^2}{L^2}\cos 30° = m\omega^2 r = \frac{m\omega^2 L}{\sqrt{3}} \quad \therefore r = \frac{L}{\sqrt{3}} \therefore \omega$$

$$= \sqrt{\frac{3Gm}{L^3}}$$

462 **(c)**

$g = \frac{GM}{r^2}$. Since M and r are constant, so $g = 9.8 m/s^2$

463 **(c)**

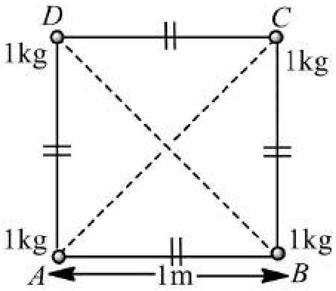
Here, $AB = BC = CD = DA = 1\text{m}$

$$BD = AC$$
$$= \sqrt{1^2 + 1^2}$$
$$= \sqrt{2}\text{m}$$

Total potential energy

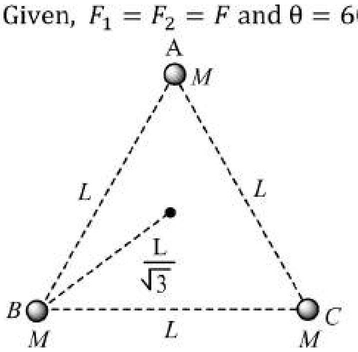
$$U = \left[\frac{-G \times 1 \times 1}{AB}\right] + \left[\frac{-G \times 1 \times 1}{BC}\right] + \left[\frac{-G \times 1 \times 1}{CD}\right] + \left[\frac{-G \times 1 \times 1}{DA}\right] + \left[\frac{-G \times 1 \times 1}{BD}\right] + \left[\frac{-G \times 1 \times 1}{AC}\right]$$

$$= 4 \times \left[\frac{-G \times 1 \times 1}{1}\right] + 2\left[\frac{-G \times 1 \times 1}{\sqrt{2}}\right] = -5.4G$$



464 **(a)**

Given, $F_1 = F_2 = F$ and $\theta = 60°$



Resultant force $= \sqrt{3}\,F$

$\therefore$ Force on mass at A due to mass at B and C

$$= \sqrt{3}\left(\frac{GM^2}{L^2}\right)$$

Centripetal force for circumscribing the triangle in a circular orbit is provided by mutual gravitational interaction.

ie, $$\frac{Mv^2}{(L/\sqrt{3})} = \sqrt{3}\left(\frac{GM^2}{L^2}\right)$$

or $$v = \sqrt{\frac{GM}{L}}$$

465 **(b)**

Let velocities of these masses at r distance from each other be v_1 and v_2 respectively

By conservation of momentum

$m_1 v_1 - m_2 v_2 = 0$

$\Rightarrow m_1 v_1 = m_2 v_2$ ...(i)

By conservation of energy

Change in $P.E.$ = change in $K.E.$

$$\frac{Gm_1 m_2}{r} = \frac{1}{2}m_1 v_1^2 + \frac{1}{2}m_2 v_2^2$$

$$\Rightarrow \frac{m_1^2 v_1^2}{m_1} + \frac{m_2^2 v_2^2}{m_2} = \frac{2Gm_1 m_2}{r} \quad ...(ii)$$

On solving equation (i) and (ii)

$$v_1 = \sqrt{\frac{2Gm_2^2}{r(m_1+m_2)}} \text{ and } v_2 = \sqrt{\frac{2Gm_1^2}{r(m_1+m_2)}}$$

$$\therefore v_{\text{app}} = |v_1| + |v_2| = \sqrt{\frac{2G}{r}(m_1 + m_2)}$$

466 **(a)**

$$\frac{v_p}{v_e} = \sqrt{\frac{g_p}{g_e} \times \frac{R_p}{R_e}} = \sqrt{9 \times 4} = 6 \quad \therefore v_p = 6 \times v_e$$

$$= 67.2 km/s$$

467 **(b)**

$$h = \left(\frac{T^2 R^2}{4\pi^2}\right)^{1/3} - R$$

$$= \left[\frac{(24 \times 60 \times 60)^2 \times (6.4 \times 10^6)^2 \times 9.8}{4 \times (22/7)^2}\right]^{1/3} - 6.4 \times 10^6$$

$= 3.6 \times 10^7\text{m} = 36000$ km

468 **(b)**

$$T = 2\pi\sqrt{\frac{(R+h)^3}{gR^2}} = 2\pi\sqrt{\frac{(2R)^3}{gR^2}} = 4\sqrt{2}\pi\sqrt{\frac{R}{g}}$$

469 **(d)**

According to Kepler's law $T^2 \propto r^3$

$$\Rightarrow \left(\frac{T_1}{T_2}\right)^2 = \left(\frac{r_1}{r_2}\right)^3$$

470 **(a)**

From Kepler's third law of planetary motion

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

Given, $R_p = 2R_e$

$$\therefore \frac{T_e^2}{T_p^2} = \frac{R_e^3}{R_p^3}$$

$$\Rightarrow \quad \frac{T_e^2}{T_p^2} = \frac{R_e^3}{(2R_e)^3}$$

$$\Rightarrow \quad \frac{T_e}{T_p} = \left(\frac{1}{2}\right)^{3/2}$$

$$\Rightarrow \quad T_p = 2\sqrt{2}\, T_e$$

Since, $T_e = 365$ days $= 1$ year, we have

$T_p = 2\sqrt{2} \times 365$ days

$T_p = 1032.37$

$T_p = 1032$ days.

471 **(a)**

If the mass of sun is M and radius of the planet's orbit is r,

then as $v_0 = \sqrt{GM/r}$

$T = \frac{2\pi r}{v_0} = 2\pi r\sqrt{\frac{r}{GM}}, ie, T^2 = \frac{4\pi^2 r^2}{GM}$ ...(i)

Now, if the planet (When stopped in the orbit) has velocity v when it is at a distance x from the sun, by conservation of mechanical energy,

$$\frac{1}{2}mv^2 + \left(-\frac{GMm}{x}\right) = 0 - \frac{GMm}{r}$$

or $\left(-\frac{dx}{dt}\right)^2 = \frac{2GM}{r}\left[\frac{r-x}{x}\right]$,

$$ie, -\frac{dx}{dt} = \sqrt{\frac{2GM}{r}}\sqrt{\frac{(r-x)}{x}}$$

or $\int_0^t dt = -\sqrt{\frac{r}{2GM}} \times \int_r^0 \left[\frac{x}{(r-x)}\right] dx$

Substituting $x\ r \sin^2\theta$ and solving the RHS,

$$T = \sqrt{\frac{r}{2GM}} \times \left(\frac{\pi r}{2}\right)$$

In the light of Eq. (i) reduces to

$$t = \frac{1}{\sqrt{4}\sqrt{2}}T, ie, t = \left(\frac{\sqrt{2}}{8}\right)T$$

472 **(c)**

$T^2 = \frac{4\pi^2}{GM}r^3$. If G is variable then time period, angular velocity and orbital radius also changes accordingly

473 **(b)**

$$g' = g\left(\frac{R}{R+h}\right)^2 = g\left(\frac{R}{3R/2)}\right)^2 = \frac{4}{9}g\ [g = 10 m/sec^2]$$

$$\therefore W' = \frac{4}{9} \times mg = \frac{4 \times 200 \times 10}{9} = 889\ N$$

474 **(a)**

$$\begin{pmatrix}\text{Total}\\ \text{mechanical}\\ \text{energy}\end{pmatrix}_P = \begin{pmatrix}\text{Total final}\\ \text{mechanical}\\ \text{energy}\end{pmatrix}_O$$

$$\Rightarrow \frac{1}{2}m(0)^2 - \frac{GMM}{\sqrt{(\sqrt{3}R)^2R^2}} = \frac{1}{2}mv^2 - \frac{GMm}{R}$$

$$\Rightarrow -\frac{GMm}{2R} - \frac{1}{2}mv^2 - \frac{GMm}{R}$$

$$\Rightarrow v = \sqrt{\frac{GM}{R}}$$

475 **(a)**

At an altitude h the acceleration due to gravity is

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

or $\quad mg' = mg\left(1 - \frac{2h}{R_e}\right)$

$ie,\quad w' = w\left(1 - \frac{2h}{R_e}\right)$

$$\frac{99}{100}w = w\left(1 - \frac{2h}{R_e}\right)$$

$ie,\quad h = 0.005R_e$

At point below the surface of earth at depth h. The weight of body given by

$$w' = w\left(1 - \frac{2h}{R_e}\right)$$

$$\frac{w'}{w} = 0.995$$

$$\%\Delta w = \frac{(1-0.995)w}{w} \times 100$$

$$\%\Delta w = 0.5\%(\text{decreases})$$

476 **(b)**

Due to inertia of direction

477 **(d)**

Using law of conservation of energy

$$-\frac{GMm}{r} = \frac{1}{2}mv^2 - \frac{GMm}{R}$$

$$\frac{v^2}{2} = \frac{GM}{R} - \frac{GM}{r}$$

$$= GM\left(\frac{r-R}{rR}\right) = gR\left(\frac{r-R}{r}\right)$$

$$v = \sqrt{2gR(r-R)/r}$$

478 **(b)**

$$g = \frac{GM}{R^2} = \frac{G \times \frac{4}{3}\pi R^3\rho}{R^2} = \frac{4}{3}\pi G\rho R \quad ie, g \propto R$$

For pendulum clock, g will increase on the planet, so time period will decrease. But for spring clock, it will not change. Hence, P will run faster than S

479 **(b)**

Gravitational force due to solid sphere, $F_1 = \frac{GM\,m}{(2R)^2}$, where M and m are mass of the solid sphere and particle respectively and R is the radius of the sphere. The gravitational force on particle due to sphere with cavity = force due to solid sphere creating cavity, assumed to be present above at that position

$ie, F_2 = \frac{GM\,m}{4R^2} - \frac{G(M/8)m}{(3R/2)^2} = \frac{7}{36}\frac{GM\,m}{R^2}$

So, $\frac{F_2}{F_1} = \frac{7GM\,m}{36R^2} / \left(\frac{GM\,m}{4R^2}\right) = \frac{7}{9}$

480 **(c)**

$v_e \propto \frac{1}{\sqrt{r}}$ where r is a position of body from the surface

$$\frac{v_1}{v_2} = \sqrt{\frac{r_1}{r_2}} = \sqrt{\frac{R+7R}{R}} \Rightarrow v_2 = \frac{v_1}{2\sqrt{2}}$$

481 **(c)**

Gravitational potential at a pint outside the sphere $V_g = \frac{-GM}{r}$. But V_s is same at a point inside the hollow sphere as on the surface of sphere. Hence, graph (c) is correct.

482 **(b)**

Hence, $g' = g - R\omega^2 = 0$;

$\omega = \sqrt{g/R} = \sqrt{10/(6400 \times 10^3)} = 1/800$

483 **(c)**

Force on the body $= \frac{GMm}{x^2}$

To move it by a small distance dx,

Work done $= F\,dx = \frac{GMm}{x^2}dx$

Total work done $= GMm \int_R^{R+h} \frac{dx}{x^2} = \left[\frac{-GMm}{x}\right]_R^{R+h}$

$= GMm\left[\frac{1}{R} - \frac{1}{R+h}\right]$

$= \left[\frac{(R+h)-R}{R(R+h)}\right] = \frac{GMmh}{R(R+h)}$

$\frac{GM}{R^3} \times \frac{mhR}{R+h} = \frac{gmhR}{R+h} = \frac{PRh}{R+h}$

484 **(c)**

$V_{in} = \frac{-GM}{2R}\left[3 - \left(\frac{r}{R}\right)^2\right], V_{surface} = \frac{-GM}{R}, V_{out} = \frac{-GM}{r}$

485 **(a)**

Binding energy $= |E|$

$= \frac{1}{2}\frac{GMm}{R_e} = \frac{1}{2}gmR_e$

486 **(c)**

$g = \frac{GM}{r^2}$

$\therefore \log g = \log G + \log M - 2\log r$

Differentiating both sides w.r.t. t

$\frac{1}{g} = \frac{dg}{dt} = 0 - 2 \times \frac{1}{r}\frac{dr}{dt}\left(\frac{dr}{dt} \times 100 = -1\right)$

$\Rightarrow \frac{1}{g}\left(\frac{dg}{dt} \times 100\right) = -2 \times \frac{1}{r}\left(\frac{dr}{dt} \times 100\right)$

$\Rightarrow \frac{dg}{dt} \times 100 = -2 \times (-1) = 2$

$\therefore$ g increasing by 2%

488 **(b)**

Earth and all other planets move around the sun under the effect of gravitational force. This force always acts along the line joining the centre of the planet and the sun and is directed towards the sun. In other words, a planet moves around the sun under the effect of a purely radial force. Therefore, areal velocity of the planet must always remain constant.

$\therefore \quad \frac{\Delta \mathbf{A}}{\Delta t} = \frac{\mathbf{L}}{2m}$ = a constant vector

Therefore, Kepler's 2nd law is the consequence of the principle of conservation of angular momentum (L)

$\tau = 0$

Now, $\quad \tau = I\alpha$

$\therefore \quad I\alpha = 0$ or $\alpha = 0$

or $\quad \alpha_T = r\alpha = 0$

ie, tangential acceleration is zero.

489 **(d)**

For central force, torque is zero

$\because \tau = \frac{dL}{dt} = 0 \Rightarrow L =$ constant

$i.e.$ Angular momentum is constant

490 **(b)**

Below the sea level the pressure is increasing with depth in mine due to presence of atmospheric air there. The acceleration due to gravity below the surface of the earth decreases with the distance from the surface of the earth as $g' = g\left(1 - \frac{d}{R}\right)$

492 **(a)**

The velocity with which satellite is orbiting around the earth is the orbital velocity (v_o) and that required to escape out of gravitational pull of earth is the escape velocity (v_e).

We know that

$$v_e = \sqrt{2gR} \text{ and } v_o = \sqrt{gR}$$

$\therefore$ Increase in velocity required

$$= \frac{v_e - v_o}{v_o} = \frac{\sqrt{2gR} - \sqrt{gR}}{\sqrt{gR}}$$

$$= \sqrt{2} - 1 = 0.414$$

Percent increase in velocity required

$= 0.414 \times 100 = 41.4\%$

493 **(a)**

Because value of g decreases when we move either in coal mine or at the top of mountain

494 **(c)**

$$v=\sqrt{\frac{GM}{R}}=V,$$

$$v'=\sqrt{\frac{GM}{(R+R/2)}}$$

$$=\sqrt{\frac{2}{3}\frac{GM}{R}}=\sqrt{\frac{2}{3}}V$$

495 **(a)**

Potential energy $=\frac{-GMm}{r}=\frac{GMm}{R_e+h}=\frac{-GMm}{2R_e}$

$$=-\frac{gR_e^2m}{2R_e}=-\frac{1}{2}mgR_e=-0.5mgR_e$$

496 **(c)**

Error in weight = difference in weight at two different heights

$$=mg\left[1-\frac{2h_1}{R}\right]-mg\left[1-\frac{2h_2}{R}\right]$$

$$=\frac{2mg}{R}(h_2-h_1)=\frac{2m}{R}\times\frac{GM}{R^2}\times\frac{h}{2}$$

[where, $h_2-h_1=h_2$]

$$=\frac{2m}{R^3}\times G\times\frac{4}{3}\pi R^2\rho\times\frac{h}{2}=\frac{4}{3}\pi Gm\rho h$$

497 **(c)**

$$g'=\frac{g}{\left(1+\frac{h}{R}\right)^2}$$

$$\frac{g}{16}=\frac{g}{\left(1+\frac{h}{R}\right)^2}$$

$$\left(1+\frac{h}{R}\right)^2=16$$

$$1+\frac{h}{R}=4$$

$$\frac{h}{R}=3$$

$$h=3R$$

498 **(a)**

$$m\omega^2R=\frac{GMm}{R^2}\Rightarrow\left(\frac{2\pi}{T}\right)^2R=\frac{GM}{R^2}\Rightarrow M=\frac{4\pi^2R^3}{GT^2}$$

499 **(c)**

$$g_p=g_e\left(\frac{M_p}{M_e}\right)\left(\frac{R_e}{R_p}\right)^2=9.8\left(\frac{1}{80}\right)(2)^2$$

$$=9.8/20=0.49m/s^2$$

500 **(b)**

$v_e=\sqrt{\frac{2GM}{R}}\Rightarrow v_e\propto\sqrt{M}$ if $R=$ constant

If the mass of the planet becomes four times then escape velocity will become 2 times

501 **(c)**

Gravitational field due to a spherical shell

At a point inside the shell, $i.e.,r<R$

$E_{\text{inside}}=0$

$\therefore$ The gravitational force acting on a point mass m at a distance $R/2$ is

$F=mE_{\text{inside}}=0$

502 **(a)**

$v\propto\frac{1}{\sqrt{r}}$. If orbital radius becomes 4 times then orbital velocity will becomes half, $i.e.\frac{7}{2}=$ $3.5\ km/s$

503 **(a)**

The energy given to the body so as to completely escape from its orbit is equal to its kinetic energy KE.

504 **(a)**

Radius of earth $R=6400\ km\ \therefore h=\frac{R}{4}$

Acceleration due to gravity at a height h

$$g_h=g\left(\frac{R}{R+h}\right)^2=g\left(\frac{R}{R+\frac{R}{4}}\right)^2=\frac{16}{25}g$$

At depth 'd' value of acceleration due to gravity

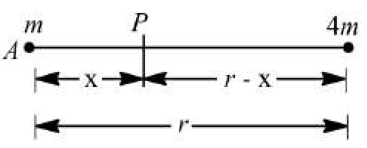
$g_d=\frac{1}{2}g_h$ (According to problem)

$$\Rightarrow g_d=\frac{1}{2}\left(\frac{16}{25}\right)g\Rightarrow g\left(1-\frac{d}{R}\right)=\frac{1}{2}\left(\frac{16}{25}\right)g$$

By solving we get $d=4.3\times10^6m$

505 **(c)**

Let gravitation field is zero at P as shown in figure.



$$\therefore\quad\frac{Gm}{x^2}=\frac{G(4m)}{(r-x)^2}$$

$$\Rightarrow\quad 4x^2=(r-x)^2$$

$$\Rightarrow\quad 2x=r-x$$

$$\Rightarrow\quad x=\frac{r}{3}$$

$$\therefore\quad V_p=\frac{Gm}{x}-\frac{G(4m)}{r-x}$$

$$=-\frac{3Gm}{r}-\frac{6Gm}{r}=-\frac{9Gm}{r}$$

507 **(b)**

$mg=\frac{GM_Em}{R_E^2}$; where M_E and R_E is the mass and radius of the earth respectively. $M_E=\frac{g}{G}R_E^2$

GRAVITATION

Assertion - Reasoning Type

This section contain(s) 0 questions numbered 1 to 0. Each question contains STATEMENT 1(Assertion) and STATEMENT 2(Reason). Each question has the 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

a) Statement 1 is True, Statement 2 is True; Statement 2 **is** correct explanation for Statement 1

b) Statement 1 is True, Statement 2 is True; Statement 2 **is not** correct explanation for Statement 1

c) Statement 1 is True, Statement 2 is False

d) Statement 1 is False, Statement 2 is True

1

Statement 1: A body becomes weightless at the centre of earth

Statement 2: As the distance from centre of earth decreases, acceleration due to gravity increases

2

Statement 1: The speed of revolution of an artificial satellite revolving very near the earth is 8 kms^{-1}

Statement 2: Orbital velocity of a satellite, become independent of height of satellite

3

Statement 1: We can not move even a finger without disturbing all the stars

Statement 2: Every body in this universe attracts every other body with a force which is inversely proportional to the square of distance between them

4

Statement 1: There is no effect of rotation of earth on acceleration due to gravity at poles

Statement 2: Rotation of earth is about polar axis

5

Statement 1: Space rockets are usually launched in the equatorial line from west to east

Statement 2: The acceleration due to gravity is minimum at the equator

6

Statement 1: Orbital velocity of a satellite is greater than its escape velocity

Statement 2: Orbit of a satellite is within the gravitational field of earth whereas escaping is beyouned the gravitational field of earth

7

Statement 1: The time period of geostationary satellite is 24 hours

Statement 2: Geostationary satellite must have the same time period as the time taken by the earth to complete one revolution about its axis

8

Statement 1: The principle of superposition is not valid for gravitational force

Statement 2: Gravitational force is a conservative force

9

Statement 1: A force act upon the earth revolving in a circular orbit about the sun. Hence work should be done on the earth

Statement 2: The necessary centripetal force for circular motion of earth comes from the gravitational force between earth and sun

10

Statement 1: Even when orbit of a satellite is elliptical, its plane of rotation passes through the centre of earth

Statement 2: According to law of conservation of angular momentum plane of rotation of satellite always remain same

11

Statement 1: A planet moves faster, when it is closer to the sun in its orbit and vice versa

Statement 2: Orbital velocity in the orbit of planet is constant

12

Statement 1: If earth suddenly stops rotating about its axis then the value of acceleration due to gravity will becomes same at all the places

Statement 2: The value of acceleration due to gravity is independent of rotation of earth

13

Statement 1: Earth has an atmosphere but the moon does not

Statement 2: Moon is very small in comparison to earth

14

Statement 1: If a pendulum is suspended in a lift and lift is falling freely, then its time period becomes infinite

Statement 2: Free falling body has acceleration equal to acceleration due to gravity

15

Statement 1: An astronaut in an orbiting space station above the earth experience weightlessness

Statement 2: An object moving around the earth under the influence of earth's gravitational force is in a state of free fall

16

Statement 1: Generally the path of a projectile from the earth is parabolic but it is elliptical for projectiles going to a very great height

Statement 2: Upto ordinary height the projectile moves under a uniform gravitational force, but for great heights, projectile moves under a variable force

17

Statement 1: The speed of satellite always remains constant in an orbit

Statement 2: The speed of a satellite depends on its path

18

Statement 1: The difference in the value of acceleration due to gravity at pole and equator is proportional to square of angular velocity of earth

Statement 2: The value of acceleration due to gravity is minimum at the equator and maximum at the pole

19

Statement 1: Two different planets have same escape velocity

Statement 2: Value of escape velocity is a universal constant

20

Statement 1: Two satellites are following one another in the same circular orbit. If one satellite tries to catch another (leading one) satellite, then it can be done by increasing its speed without changing the orbit

Statement 2: The energy of earth satellites system in circular orbit is given by $E = -\frac{GMm}{2r}$, where r is the radius of the circular orbit

21

Statement 1: When distance between two bodies is doubled and also mass of each body is also doubled. Gravitational force between them remains the same

Statement 2: According to Newton's law of gravitation, force is directly proportional to mass of bodies and inversely proportional to distance between them

22

Statement 1: For a mass M kept at the centre of a cube of side 'a', the flux of gravitational field passing through its sides is 4π GM

Statement 2: If the direction of a field due to a point source is radial and its dependence on the distance 'r' from the source is given as $\frac{1}{r^2}$, its flux through a closed surface depends only on the strength of the source enclosed by the surface and not on the size or shape of the surface

23

Statement 1: An astronaut in an orbiting space station above the Earth experiences weightlessness

Statement 2: An object moving around the Earth under the influence of Earth's gravitational force is in a state of 'free-fall'

24

Statement 1: Gravitational force between two particles is negligible small compared to the electrical force

Statement 2: The electrical force is experienced by charged particles only

25

Statement 1: The time period of revolution of a satellite close to surface of earth is smaller than that revolving away from surface of earth

Statement 2: The square of time period of revolution of a satellite is directly proportional to cube of its orbital radius

26

Statement 1: The binding energy of a satellite does not depend upon the mass of the satellite

Statement 2: Binding energy is the negative value of total energy of satellite

27

Statement 1: Gravitational potential of earth at every place on it is negative

Statement 2: Every body on earth is bound by the attraction of earth

GRAVITATION

: ANSWER KEY :

1)	c	2)	a	3)	a	4)	a	17)	d	18)	b	19)	d	20)	d
5)	b	6)	d	7)	b	8)	d	21)	a	22)	a	23)	a	24)	b
9)	d	10)	a	11)	c	12)	c	25)	a	26)	d	27)	a		
13)	b	14)	a	15)	a	16)	c								

GRAVITATION

: HINTS AND SOLUTIONS :

1 **(c)**
Variation of g with depth from surface of earth is given by

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

At the centre of earth, $d = R$

$$\therefore \; g' = g\left(1 - \frac{d}{R}\right) = 0$$

$\therefore$ Apparent weight of body $= mg' = 0$

Assertion is true but reason is false

2 **(a)**
$v_0 = R_e\sqrt{\frac{g}{R_e+h}}$ for a satellite revolving very near the earth surface $R_e + h = R_e$

$$v_0 = \sqrt{R_e g}$$

$$= \sqrt{64 \times 10^5 \times 10}$$

$$= 8 \times 10^3 \text{ms}^{-1} = 8\text{kms}^{-1}$$

Which is independent of height of satellite

Both Assertion and Reason are true and reason is the correct explanation of assertion

3 **(a)**
According to Newton's law of gravitation, every body in this universe attracts every other body with a force which is inversely proportional to the square of the distance between them. When we move our finger, the distance of the objects with respect to finger changes, hence the force of attraction changes, disturbing the entire universe, including stars

4 **(a)**
As a rotation of earth takes place about polar axis therefore, body places at poles will not feel any centrifugal force and its weight or acceleration due to gravity remains unaffected

5 **(b)**
We know that earth revolves from west to east about its polar axis. Therefore, all the particles on the earth have velocity from west to east

This velocity is maximum in the equatorial line, as $v = R\omega$, where R is the radius of earth and ω is the angular velocity of revolution of earth about its polar axis

When a rocket is launched from west to east in equatorial plane, the maximum linear velocity is added to the launching velocity of the rocket, due to which launching becomes easier

6 **(d)**
The orbital velocity, if a satellite close to earth is $v_0 = \sqrt{gR_e}$, while the escape velocity for a body thrown from the earths surface $v_e = \sqrt{2gR_e}$

Thus $\frac{v_0}{v_e} = \frac{\sqrt{gR_e}}{\sqrt{2gR_e}} = \frac{1}{\sqrt{2}}$ or $v_e = \sqrt{2}v$

Assertion is false but reason is true

7 **(b)**
As the geostationary satellite is established in an orbit in the plane of the equator at a particular place, so it move in the same sense as the earth and hence its time period of revolution is equal to 24 hours, which is equal to time period of revolution of earth about its axis

8 **(d)**
The total gravitational force on one particle due to number of particles is the resultant force of attraction (or gravitational force) exerted on the

given particle due to individual particles, *i.e.*, $\vec{F} = \vec{F_1} + \vec{F_2} + \vec{F_3} + \cdots$ It means the principle of superposition is valid

9 **(d)**

Earth revolves around the sun in circular path and required centripetal force is provided by gravitational force between earth and sun but the work done by this centripetal force is zero

10 **(a)**

As no torque is acting on the planet, its angular momentum must remain constant in magnitude as well as direction. Therefore, plane of rotation must pass through the centre of earth

11 **(c)**

According to Kepler's law of planetary motion, a planet revolves around the sun in such a way that its areal velocity is constant, *i.e.*, it move faster, when it is closer the sun and vice-versa

12 **(c)**

The value of g at any place is given by the relation,

$g' = g - \omega^2 R_e \cos^2 \lambda$. When λ is angle of latitude and ω is the angular velocity of earth

If $\omega = 0$, $\therefore g' = g$. If there is no rotation

Assertion is true but reason is false

13 **(b)**

If root mean square velocity of the gas molecules is less than escape velocity from that planet (or satellite) then atmosphere will remain attached with that planet and if $v_{rms} > u_{escape}$ then there will be no atmosphere on the planet. This is the reason for no atmosphere at moon

14 **(a)**

If a pendulum is suspended in a lift and lift is moving downward with some acceleration a, then time period of pendulum is given by, $T = 2\pi\sqrt{\frac{l}{g-a}}$

In the case of free fall, $a = g$ then $T = \infty$

i.e., the time period of pendulum becomes infinite

15 **(a)**

Force acting on astronant is utilised in providing necessary centripetal force, thus he feels weighlessness, as he in a state of free fall.

16 **(c)**

Upto ordinary heights the change in the distance of a projectile from the centre of the earth is negligible compared to the radius of the earth. Hence, projectile moves under a nearly uniform gravitation force and its path is parabolic. But for projectile going to great height, the gravitational force decreases in inverse proportion to the square of the distance of the projectile from the centre of the earth. Under such a variable force the path of projectile is elliptical.

Both Assertion and Reason are true and reason is the correct explanation of Assertion.

17 **(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

18 **(b)**

Acceleration due to gravity,

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

At equator, $\lambda = 0°$ *i.e.* $\cos 0° = 1 \therefore g_e = g - R\omega^2$

At poles, $\lambda = 90°$ *i.e.* $\cos 90° = 0 \therefore g_p = g$

Thus, $g_p = g_e = g - g + R\omega^2 = R\omega^2$

Also, the value of g is maximum at poles and minimum at equators

19 **(d)**

As, escape velocity $= \sqrt{\frac{2GM}{R}}$, so its value depends on mass of planet and radius of the planet. The two different planets have same escape velocity, when these quantities (mass and radius) are equal

21 **(a)**

According to Newton's law of gravitation, $F = \frac{Gm_1m_2}{r^2}$

When m_1, m_2 and r all are doubled,

$$F = \frac{v^2}{2} = \frac{GM}{R} \quad \frac{GM}{(R+h)} = \frac{gR}{R}$$

ie, remains the same.

Both assertion reason are true and reason is correct explanation of assertion

22 **(a)**

Gravitational Flux $(\phi_g) = \int \vec{E}.d\vec{s}$

For any closed surface $\phi_g = 4\pi\ GM$

and gravitational field $E \propto \frac{1}{r^2}$

24 **(b)**

If r is the distance between two electrons then according to Newtons law, the gravitational force between them is

$$F_G = G\frac{m^2}{r^2} = 6.67 \times 10^{-11} \times \frac{(9.1 \times 10^{-31})^2}{r^2}$$
$$\cong \frac{5 \times 10^{-71}}{r^2}$$

and according to Coulomb's law, the electrical force between electron is

$$F_e = \frac{1}{4\pi\varepsilon_0}\frac{q \times q}{r^2} = 9 \times 10^{-9} \times \frac{(1.6 \times 10^{-19})^2}{r^2}$$
$$\cong \frac{2 \times 10^{-28}}{r^2}$$

$$\therefore \frac{F_G}{F_e} \cong \frac{10^{-71}}{10^{-28}} \cong 10^{-43} \quad ie, F_G = 10^{-43}F_e$$

ie, gravitational force between two particles is negligible compared to the electrical force.

Both assertion and reason are true but reason is not the correct explanation of assertion

25 **(a)**

According to kepler's law $T^2 \propto r^3 \propto (R+h)^3$

i.e. if distance of satellite is more then its time period will be more

26 **(d)**

Binding energy is the minimum energy required to free a satellite from the gravitational attraction. It is the negative value of total energy of satellite. Let a satellite of mass m be revolving around earth of mass M_e and radius R_e total energy of satellite = PE + KE = $\frac{-GM_em}{R_e} + \frac{1}{2}mv^2$

$$= \frac{-GM_em}{R_e} + \frac{GM_em}{2R_e}$$

$$= -\frac{GMm}{2R_e}$$

$\therefore$ Binding energy of satellite = −(total energy of satellite)

which depend on mass of the satellite

Assertion is false but reason is true

27 **(a)**

Because gravitational force is always attractive in nature and every body is bound by this gravitational force of attraction of earth