8 - GRAVITATION

1) The escape velocity for a body at earth's surface is 11.2 km / s. If mass of Jupiter is 318 times that of Earth and its radius is 11.2 times that of Earth, then find the escape velocity of the same object on Jupiter. [March, 2003]
(Ans: 59.7 km / s , Note: the phrase ' the same object ' is unnecessary)

2) A satellite weighing 2000 kg is orbiting the earth at 1600 km height above the surface. Find (i) the binding energy of the satellite and (ii) its escape velocity.
Mass of earth = 6×10^{24} kg and its radius = 6400 km. [April, 2002]
(Ans: 5.0×10^{10} J, 7.07 km / s, Note: This escape velocity is in addition to its orbital velocity and is in a direction perpendicular to it .)

3) If the earth were entirely made of iron with a uniform density 7.86×10^{3} kg / m^3, what would be the value of acceleration due to gravity on its surface ? Radius of the earth = 6.37×10^{6} metre (Take G = 6.67×10^{-11} Nm^2/kg^2). [March, 2002]
(Ans: 13.98 m/s^2)

4) Find the value of 'G' so that the inertial mass (m_i) and gravitational mass (m_g) become equal on the surface of the earth. (Mass of earth = 5.98×10^{24} kg. Gravitational acceleration = 9.8 m/s^2. earth's radius = 6,400 km.) [October, 1997]
(Ans: 6.71 Nm^2 / kg^2)

5) A stone is projected with a velocity of 19.6 m / s and at 30 ° to the horizontal. Calculate (i) range, (ii) total time of motion and (iii) maximum height. [March, 1997]
(Ans: (i) 33.95 m, (ii) 2 s, (iii) 4.9 m)

6) Calculate the rate of change in gravitational acceleration (g) w. r. t. height from the surface of the earth.
(Radius of earth = 6400 km and g at the surface of earth = 980 cm/s^2)
(Ans: -3.06×10^{-6} $/s^2$ near the surface of earth) [October, 1996]

7) If G = 6.67×10^{-11} MKS unit and radius of the earth is 6370 km, the find average density of the earth. [March, 1996]
(Ans: 5.5×10^{3} kg / m^3)

8) A sphere of mass 40 kg is attracted by second sphere of mass 15 kg when their centres are 2 m apart with a force equal to 10^{-3} dyne. Calculate the constant of gravitation.
(Ans: 6.67×10^{-11} Nm^2 / kg^2)

9) The earth's mass is 90 times that of moon and their diameters are in the ratio 4 : 1. What is the value of g on moon ? g on earth = 9.8 m / s^2)
(Ans: 1.74 m/s^2)

10) How far from the earth does acceleration due to gravity become one percent of its value at the earth's surface ? Radius of earth = 6.38×10^{6} m.
(Ans: 57.4×10^{3} km)

11) What is the value of g at a height equal to the radius of the earth ? At what altitude above the earth's surface would the numerical value of g be half of that at the surface ? Radius of the earth = 6400 km.
(Ans: 2.45 m / s^2, 2650 km)

12) Moon revolves around earth 13 times in one year and the earth revolves around the sun once in a year. Compare the mass of sun and earth. The distance of earth from the sun is 390 times the distance of moon from the earth.
(Ans: 3.512×10^5)

13) Calculate the binding energy of the earth-sun system neglecting the effect of the presence of other planets and satellites. Mass of earth = 6×10^{24}, mass of sun = 3.3×10^5 times the mass of earth and the distance between earth and sun = 1.5×10^8 km.
(Ans: 5.28×10^{33} J)

14) The mass of the moon is 7.36×10^{22} kg and its radius is 1.74×10^6 m. What is the escape velocity from the surface of the moon ? G = 6.67×10^{-11} N m^2 / kg^2.
(Ans: 2.38 km / s)

15) Two satellites of same mass, A and B, are orbiting the earth at altitudes R and 3R respectively, where R is the radius of the earth. Assuming the orbits to be circular, calculate the ratios of their potential and kinetic energies.
(Ans: 2 : 1, 2 : 1)

16) Prove that the escape velocity v_e for a body on a planet having density ρ and radius R is $v_e = 2R\sqrt{(2\pi G \rho / 3)}$

17) How much work would have to be done to lift a body of mass 10^4 kg from the earth's surface to an altitude equal to the radius of the earth ?
(Ans: 3.13×10^{11} joule)

18) A football player kicks a football in the direction making an angle of 45 ° with the horizontal. The initial velocity of the ball in that direction is 50 m / s . Find (a) the horizontal displacement, (b) the maximum height attained and (c) the time of flight.
(Ans: (a) 256 m, (b) 63.8 m, (c) 7. 2 s)

19) A bomber flying upwards at an angle of 60 ° with the vertical releases a bomb at an altitude of 800 m. The bomb strikes the ground 20 seconds after its release. Find (a) the velocity of the bomber at the time of release of the bomb, (b) the maximum height attained by the bomb and (c) the horizontal distance traveled by the bomb before it strikes the ground. g = 10 m / s^2.
(Ans: (a) 120 m / s, (b) 980 m, (c) 2078 m)

20) What should be the initial velocity of a football kicked at an angle of 45 ° with horizontal to pass just touching the top of a pole of 0.8 m height kept at 1 m distance from initial position ? g = 9.8 m / s^2.
(Ans: 7 m / s)

21) A ball is thrown horizontally with a velocity of 15 m / s from the top of a tower of 25 m height. Find the time of flight of the ball and the horizontal distance from the tower to the point where the ball falls on the ground.
(Ans: 2.26 s, 33.8 m)

22) A body travels half the total distance in the last second during free fall. Find its height from the ground and the total time of free fall.
(Ans: 57 m, 2.4 s)

23) A stone is projected from the ground in a direction making an angle of 22.5 ° with the horizontal. It falls on the ground at a distance of 10Ö2 m. Find the initial velocity of the stone, maximum height attained and the time of flight.
(Ans: 14 m/s, 1.4 m, 1.09 s)

24) Height of a tower is 39.2 m. A body is allowed to fall from the top of the tower. At the same time, another body is projected vertically upwards with velocity 19.6 m / s from its bottom. Where and when will they meet ? g = 9.8 m/s^2.
(Ans: at 19.6 m from the bottom of the tower, after 2 s)

25) A lift starts ascending from ground level with uniform acceleration of f m/s^2. A stone is dropped from it after t sec. Show that it reaches the ground after [Öf + Ö(f + g)] t Öf / g seconds.

26) A jungle native aims at a monkey, hanging on a tree, at a height of 300 m and 400 m horizontally away from him. If the shot is fired at the instant monkey lets go his hold on the tree, find the velocity of the shot when it leaves the gun, if the monkey is hit 123.6 m above the horizontal level of the gun.
(Ans: 83.3 m/s)

27) The distance between two bodies of mass M_1 and M_2 is d. Prove that the gravitational potential of the point between the two bodies at which the force of gravitational attraction is zero, is given by $f = -G/d\,[\,M_1 + M_2 + 2\sqrt{M_1 M_2}\,]$.

28) With what velocity should a body be projected in a vertically upward direction from the surface of the earth so that it can reach a height nR_e from the surface of the earth.
R_e = radius of the earth.
[Ans: $[\,2ngR_e / (n+1)\,]^{1/2}$]

29) A body is projected from the top of a 73.5 m high hill with a velocity of 19.6 m/s in the upward direction making an angle of 30 ° with the horizontal. Find the time of flight, range and its downward velocity when it strikes the ground.
(Ans: 5 s, 84.9 m, 39.2 m/s downwards)

30) Find the magnitude of displacement of a particle projected at 100 m/s making an angle of 60 ° with the horizontal in the fourth second of its motion.
(Ans: 72 m)