GRAVITATION NUMERICALS FOR PRACTICE

1. A sphere of mass 40 kg is attracted by another spherical mass of 15 kg by a force of 9.8×10^{-7} N when the distance between their centres is 0.2 m. Find G. **(6.53×10^{-11} Nm²/kg²)**

2. Two masses m_1 and m_2 kept a distance r apart are such that $m_1 = 2\ m_2$. When the distance between them is reduced by 20 cm, the force between the masses increases from 6.4×10^{-9} N to 14.4×10^{-9}. What are the values of m_1 and m_2? Given $G = 6.67 \times 10^{-11}$ S.I. units. **(0.6 m; 4.156 kg; 8.312 kg)**

3. Taking $G = 6.67 \times 10^{-11}$ N m²/kg², radius of earth as 6400km and mean density of earth as 5500 kg/m³, calculate g at the surface of the earth. **(9.83 m/s²)**

4. The radius of a planet is half that of earth. The acceleration due to gravity on the planet's surface is half that on earth's surface. Find the mass of planet in terms of mass M of earth. **(M/8)**

5. At what height will the acceleration due to gravity of the earth fall off to one half that at the surface? At what height will the acceleration due to gravity be 8 m/s²? Take radius of earth = 6400 km. **(2624 km; 684.8 km)**

6. At what height will the acceleration due to gravity be 1% less than that at the surface of the earth? Radius of earth = 6400 km. **(32 km)**

7. How far from the centre of the earth does the acceleration due to gravity reduce by 5 per cent of its value at the surface of the earth? Take radius of earth as 6.4×10^6 m. **(6567 km)**

8. At what height will the acceleration due to gravity will fall to 25% that at the earth's surface? **(R)**

9. A body weighs 4.5 kg on the surface of earth. How much will it weigh on the surface of a planet whose mass is $\frac{1}{9}$ that of earth and whose radius is half that of earth? **(2 kg)**

10. The mass of mars is $\frac{1}{9}$th that of earth and its radius is half that of earth's radius. If a body weighs 900 kg on the earth, what is its weight on mars? **(3920 N)**

11. Taking the ratio of Jupiter's orbit to earth's orbit around the sun to be 5, find the period of revolution of Jupiter around the sun. **(11.18 years)**

12. For a body weighing 63 N on the earth's surface, what is the weight at a height equal to half of earth's radius? Take g on the earth's surface = 10 m/s². **(28 N)**

13. Find the depth at which the acceleration due to gravity reduces to one per cent of its value at the surface of the earth. Take the radius of the earth as 6400 km. **(6336 km)**

14. How much will a body of mars 1000 kg weigh on the (1) equator of the earth (2) pole and (3) at latitude 60° ? Take the radius of the earth as 6.4×10^6 m. 9792

((1) 9766 N; (2) 9800 N; (3) 9783 N)

15. Find the escape velocity for a 2000 kg body from the earth's surface and the KE the body must have to overcome the earth's gravitational field. Take $G = 6.67 \times 10^{-11}$ S.I. units $R = 6.4 \times 10^6$ m and $M = 6 \times 10^{24}$ kg. **(11.18 km/s; 6.25×10^{10} J)**

16. At what height will the acceleration due to gravity be the same as at a depth of 240 km below the earth's surface? **(120 km)**

17. At what distance from the centre of the earth will a 1 kg object have a weight of 1 N? R = 6400 km. **(667 km)**

18. What should be the angular velocity of the earth about its axis of rotation if bodies on the equator are to be weightless? How long would a day be then? **(1.25×10^{-3} rad/s; 1.4 hr.)**

19. Assuming that the earth is spherical in shape (R = 6400 km) rotating about its axis with a period of 24 hours, find how much the acceleration due to gravity would differ at the pole and the equator. **(3.41×10^{-2} m/s^2)**

20. Find the mass of the Sun given that the radius of earth's orbit is 1.5×10^8 km. $G = 6.67 \times 10^{-11}$ S. I. units and the period of earth's revolution around the Sun is 365 days. **(2.006×10^{30} kg)**

21. An artificial satellite is circling the earth at an altitude of R/2 where $R = 6.38 \times 10^6$ m is the radius of the earth. Find the period of its revolution. $g = 9.8$ m/s^2. **(9309 s)**

22. A satellite takes 90 minutes for a circular revolution around the earth. What is its height? Radius of earth = 6370 km and g at the orbit of the satellite = 9.8 m/s^2. **(278 km)**

23. Calculate the speed and period of revolution of a satellite orbiting at a height of 700 km above the earth's surface. Assume the orbit to be circular. Take radius of earth as 6400 km and g at the surface of earth to be 9.8 m/s^2. **(7.519 km/s; 5930 s)**

24. A satellite of the earth has a period of 10 hours. What is its height above the surface of the earth? R = 6400 km and $g = 9.8$ m/s^2. **(222.79 km)**

25. A satellite is revolving around a planet in a circular orbit with a velocity of 8 km/s at a height where the acceleration due to gravity is 8 m/s^2. How high is the satellite from the planet's surface? Radius of planet = 6000 km. **(2000 km)**

26. A satellite orbits the earth at a distance equal to the radius of the earth above its surface. Find its (a) speed (b) period. R = 6400 km; $M = 6 \times 10^{24}$ kg; $G = 6.67 \times 10^{-11}$ Nm^2/kg^2. **(5.59 km/s; 14380 s)**

27. A satellite is projected horizontally with a speed of 7 km/s from a height equal to the radius of the earth. What is the nature of its orbit? $G = 6.67 \times 10^{-11}$ S.I. units; R = 6400 km; $M = 6 \times 10^{24}$ kg.
[**Hint :** See solved problem No. 9] **(elliptical)**

28. What would be the speed of a satellite revolving in a circular orbit close to the earth's surface? Given $G = 6.67 \times 10^{-11}$ S.I. units; density of earth's matter = 5500 kg/m^3 and radius of earth = 6400 km. **(7931 m/s)**

[**Hint :** Orbital speed $v = \sqrt{\dfrac{GM}{R+h}}$. Close to the earth's surface,

$h = 0$. Hence $v = \sqrt{\dfrac{GM}{R}} = \sqrt{\dfrac{G\, 4\pi R^3 \rho}{3R}} = 2R\sqrt{\dfrac{\pi \rho G}{3}}$]

29. A satellite revolves around a planet of mean density 10^4 kg/m^3. If the radius of its orbit is only slightly greater than the radius of the planet, find the time of revolution of the satellite. $G = 6.67 \times 10^{-11}$ S.I. units. **(1.049 hours)**

[**Hint** : From the formula of the last problem, the period can be shown to be given by $T = \sqrt{\dfrac{3\pi}{G\rho}}$]

30. Show that for a satellite rotating about the earth close to its surface, the period of revolution is given by $2\pi\sqrt{\dfrac{R}{g}}$ where R is the radius of the earth.

31. Taking radius of earth as 6400 km and g at the earth's surface as 9.8 m/s^2, calculate the speed and period of revolution of a satellite orbiting close to the earth's surface. **(7.92 km/s; 5075 s)**

32. A satellite is revolving around a planet in a circular orbit with a critical velocity of 7 km/s. Find the radius of the orbit of the satellite and the period of its revolution.
$G = 6.67 \times 10^{-11}$ S.I. units and $M = 5.98 \times 10^{24}$ kg **(8140 km; 7300s)**

33. A satellite of mass 850 kg is in an orbit 820 km above the earth's surface. Assuming that the orbit is circular, find its speed and calculate the number of complete revolutions it makes around the earth in one day. $g = 9.8\ m/s^2$ and R = 6400 km. **(7.456 km/s; 14)**

34. Find the binding energy of a body of mass 15 kg at rest on the surface of a planet. Mass of planet = 4.5×10^{24} kg and its radius = 6150 km. **(7.32×10^8 J)**

35. A satellite weighing 1000 kg is raised from an orbit of radius 3R to an orbit of radius 5R. Find the work done. R is the radius of the earth. $R = 6.4 \times 10^6$ m; $G = 6.67 \times 10^{-11}$ S.I. units; $M = 6 \times 10^{24}$ kg. **(4.2×10^9 J)**

36. A 400 kg earth satellite is to be transferred from an orbit of radius 2R to an orbit of radius 4R. Find the energy required to achieve this. Also find the change in KE and the change in PE of the satellite in this transfer.
(3.13×10^9 J; change in KE = -3.13×10^9 J; change in PE = 6.25×10^9 J)

37 What is the binding energy of a satellite of mass 2000 kg moving in a circular orbit around the earth close to its surface and at a height of 600 km? $G = 6.67 \times 10^{-11}$ S. I. units; Radius of earth = 6400 km; Mass of earth = 6×10^{24} kg. **(6.25×10^{10} J; 5.72×10^{10} J)**

38. Binding energy of a satellite is 4×10^8 J. Calculate its KE and PE.
(KE = 4×10^8 J; PE = -8×10^8 J)

40. The radius of earth is 6400 km. Calculate the velocity with which a body should be projected so as to escape earth's gravitational influence. Does the escape velocity depend upon the direction in which the body is projected ? $g = 9.8\ m/s^2$. **(11.2 km/s; No)**

41. Calculate the escape velocity of a spaceshot from the following. Radius of the earth = 6400 km; Mass of earth = 6×10^{24} kg; $G = 6.67 \times 10^{-11}$ S. I. units. What is the energy imparted to the spaceshot if its mass is 100 kg ? **(11.2 km/s; 6.27×10^9 J)**

42. Calculate the minimum energy required to launch a 1000 kg satellite from the earth's surface in a circular orbit at a height 2R where R is the radius of the earth. Given R = 6400 km. $g = 9.8\ m/s^2$. **(5.2×10^{10} J)**

43. Show that the escape velocity of a body from the surface of the earth is $\sqrt{2}$ times the velocity of the body when orbiting close to earth's surface.

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44. The mass of the moon is 1/80th that of the earth and the diameter of the moon is 1/4th that of earth. Given that the escape velocity from the earth's surface is 11.2 km/s, find that from the moon's surface. **(2.5 km/s)**

45. A planet A has a mass and radius twice that of planet B. Find the ratio of the escape velocities from A and B. **(1 : 1)**

46. Find the radius of the circular orbit of a satellite moving with an angular speed equal to the angular speed of earth's rotation. $G = 6.67 \times 10^{-11}$ S.I. units, $M = 6 \times 10^{24}$ kg, $R = 6.4 \times 10^6$ m **(42300 km)**

47. The angular velocity of the earth's rotation about its axis is 7.3×10^{-5} rad/s. Taking the radius of the earth as 6400 km and $g = 9.8\ m/s^2$ at the earth's surface, find the height of a synchronous earth satellite from the earth's surface. **(35830 km)**

48. A geostationary satellite has an orbital radius of 4.23×10^7 m. Find g at its location. Find also its speed and acceleration. **($0.22\ m/s^2$; 3.05×10^3 m/s; $0.22\ m/s^2$)**

49. At what height above the surface of the earth should a satellite be parked so that it always stays at the same point above the earth? Mean radius of earth is 6400 km and $g = 9.8\ m/s^2$. **(36000 km)**

50. Given $G = 6.67 \times 10^{-11}$ S, I units, $R = 6.4 \times 10^6$ m and g at earth's surface to be $9.8 m/s^2$, find the density of earth's matter assuming it to be uniform. **($5483\ kg/m^3$)**

51. A body weigh 980 N on the surface of the earth. What is its mass and weight at an altitude of 36000 km? Take R = 6400 km and g at earth's surface = $9.8\ m/s^2$.

(100kg ; 147.92 N)

52. A satellite is revolving around the earth in a circular orbit in the equatorial plane at a height of 35850 km. Find its period of revolution. What is the possible use of such a satellite? In what direction is such a satellite projected and why must it be in the equatorial plane? Given $g = 9.81\ m/s^2$; Radius of earth 6.37×10^6 m. **(24 hrs.)**

53. At what height is the value of g the same as at a depth of 100 km from the surface of the earth? **(50 km)**

54. At what distance above the earth's surface and at what depth below the earth's surface is the acceleration due to gravity less by 10% of its value at the surface? R = 6400 Km

(13840 km; 640 km)

55. How much faster than its present speed should the earth rotate so that the bodies on the equator may just fly off into space?

R = 6370 km and g at the equator = $9.78\ m/s^2$ **(17 nearly)**

56. A body is raised to a height of 1600 km above the earth's surface and projected with a horizontal velocity of 6 km/s. Will it revolve around the earth as a satellite? ($G = 6.67 \times 10^{-11}$ SI unit, radius of earth R = 6400 km, mass of earth $M = 6 \times 10^{24}$ kg.)

(No; min. vel. 7.07 km/s)

57. A satellite is revolving around a planet in a circular orbit with a velocity of 6.8 km/s. Find the height of the satellite from the planet's surface and the period of its revolution. $g = 9.8\ m/s^2$; R = 6400 km. **(2281 km; 8017s)**