PROBLEMS FOR PRACTICE *(GRAVITATION)

1. Masses of 0.02 kg and 0.08 kg are placed 0.12 m apart. Find the gravitational field and potential at a point distance 0.04 m from the smaller mass and collinear with them. Also compute the force required to shift a unit mass from this point to another point a distant 0.04 m from the larger mass along the same line.

[**Ans: E = 0, V = -1.0×10^{-10} Jkg^{-1} , -0.5×10^{-10} Jkg^{-1}**]

2.(a) A spaceship is launched into a circular orbit whose height form the earth's surface is one quarter times radius of the earth. What additional velocity now to be imparted to the spaceship in the orbit to overcome the gravitational pull

[**Ans:4.12 kms^{-1}**]

(b) Imagine a planet having a mass and radius half of the corresponding quantity for earth. The surface temperature of this planet reached up to 527^0 C. Estimate whether there is a possibility of the presence of oxygen molecules in the planet's atmosphere. (Boltzmann's constant k = 1.38×10^{-23} J K^{-1}, mass of a molecule of oxygen = 5.3×10^{-26} kg

3. (a) If the earth has mass 9 times and radius twice that of the planet Mars, calculate the minimum velocity required by a rocket to pull out of the gravitational force of Mars. Escape velocity on the surface of the earth is 11.2 km/s. [**Ans:5.28 kms^{-1}**]

(b) Jupiter has a mass 318 times that of the mass of the earth and its radius is 11.2 times that of earth's radius. Estimate the escape velocity of a body from Jupiter's surface, given that escape velocity on earth's surface is 11.2 kms^{-1}

[**Ans: 59.7 kms^{-1}**]

4. Two neutron stars are separated by a distance of 10^{10} m.They each have a mass of 10^{30} kg and a radius of 10^5 m .They are initially at rest with respect to one another. How fast are they moving when their separation has decreased to one half of its initial value? [**Ans: 81.6 kms^{-1}**] .

5. What would be the acceleration due to gravity on the surface of the moon if its radius is $\frac{1}{4}th$ the radius of the earth and its mass $\frac{1}{80}th$ the mass of the earth?. What will be the escape velocity on the surface of the moon if it is 11.2 kms^{-1} on the surface of the earth?. [**Ans: 1.96 ms^{-2}, 2.5 kms^{-1}**]

6. A geostationary satellite is taken to another orbit. Its new orbit is two times that in the earlier orbit. Estimate the time period in the new orbit and the height above the earth's surface. [**Ans: $48\sqrt{2}$ hours, 7.828×10^7 m**]

7. A binary star system consisting of two stars each of mass 4.0×10^{30} kg separated by 2.0×10^{11} kg .The stars rotate about the centre of mass of the system.
(a) Determine the gravitational potential at a point where the gravitational field

strength is zero . [**Ans: -5.36×10^{9}Jkg^{-1}**

(b) Calculate the linear speed of each star in the system**.** [**Ans: 2.59×10^{4} ms^{-1}**]

(c) Determine the period of rotation. [**Ans: 2.43×10^{7}s**]

8. Taking the earth to be uniform sphere of radius 6400 km, and the value of g at the surface to be 10 ms^{-2}, calculate the total energy needed to raise a satellite of mass 2000 kg to a height of 800 km above the ground and to set it into circular orbit at that altitude. Explain briefly how the satellite is set into orbit once the intended altitude has been reached, and also what would happen if this procedure failed to come into action.

[Ans:7.1×10^{10} J]

9. (a) A man can jump 2.0 m high on the earth. Calculate the approximate height he might be able to jump on a planet whose density is one quarter that of the earth where the radius is one third of the earth's radius. [**Ans: 24.0 m high**]

(b**)** If a body is projected vertically upwards from earth's surface so as to reach a height equal to ten times the radius of the earth, with what velocity the body should be projected. [**Ans: 10.34 kms^{-1}**]

10. A rocket is fired vertically from the surface of mars with a speed of 2.0 kms^{-1}. If 20 % of its initial energy is lost due to Martian atmospheric resistances, how far will the rocket go from the surface of mars before returning to it?.

Mass of mars = 6.4×10^{23} kg, radius of mars = 3395 km, G = 6.67×10^{-11} N m^2 kg^{-2}

[**Ans: 1651 km**]

11. (a) A satellite of mass 900 kg orbits the earth at a height 400 km above the surface. How much energy must be expanded to rocket the satellite out of the earth's gravitational influence?.

Take mean radius of the earth = 6400 km, mass of the earth = 6.0×10^{24} kg.

[Ans:2.67×10^{10} J]

(b) A sky laboratory of mass 4×10^{3} kg has to be lifted from one circular orbit of radius 3R into another circular orbit of radius 5R. Calculate the minimum energy required if the radius of earth R = 6370 km and g = 9.8 ms^{-2} **[Ans:1.65×10^{10} J]**

12 Estimate the ratio between the energy required to take the satellite to a height 9600 km above the earth's surface and extra energy to put it in circular orbit at hat altitude. Radius of the earth = 6400 km. **(Ans: 3)**

13. Calculate the distance from the earth to the point where the gravitational field due to the earth and moon cancel out. Given that the earth- moon distance is 3.8×10^{8} m and the mass of earth is 81 times that of the moon. **[Ans:3.42×10^{8} m]**

14. Find the percentage decrease in weight of a body, when taken 16km below the surface of the earth take radius of the earth as 6400km**.** **[Ans:0.25%]**

15. Find the gravitational attraction between the two atoms of a hydrogen molecule. Given that G = 6.67 X 10^{-11}m$^2kg^{-2}$, mass of hydrogen atom = 1.67 x 10^{-27} and the distance between the two atoms = 1Å.

[Ans:1.86 x 10^{-44}N]

16. On a planet whose size is the same and mass three times as that of the earth, find the amount of work done to lift 5kg mass vertically upwards through 10m on the planet. The value of g on the surface of the earth is $9.8\text{m}s^{-2}$. [**Ans:1,470 J]**

17. An astronaut on the moon measures the acceleration due to gravity to be $1.7\text{m}s^{-2}$. He knows that the radius of the moon is about 0.27 times that of the earth. Find the mass of the earth to that of the moon, if the value of g on the earth's surface is $9.8\text{m}s^{-2}$. **[Ans:79.1]**

18.At what height above the surface of the earth, acceleration due to gravity will be 25% of its value on the surface of the earth. Given, radius of the earth = 6,400km. **[Ans:6400km]**

19.How far away from the surface of the earth does the acceleration due to gravity reduces to 64% of its value on the surface. Given, radius of the earth, R = 6.4 x 10^6m.

[4.27 x 10^6m].

20. Jupiter has a mass 318 times that of the earth and its radius is 11.2 times the earth's radius. Estimate the escape velocity of a body from Jupiter's surface, given the escape velocity from the earth's surface is $11.2\text{km}s^{-1}$. **[Ans:59.68km/s]**

21.The escape velocity of projectile on the earth's surface is 11.2km/s . A body is projected out with thrice this speed. What is the speed of the body, far away from the earth?

[Ans:31.68km/s]

22.List two ways of describing g as applied to gravitation. Give its appropriate units in each case.

23. At what height above the earth's surface, acceleration due to gravity will be 25% of its value on the surface of the earth. Given, radius of the earth $= 6{,}400km$. **[Ans:6,400km]**

24.How far from the surface of the earth does the acceleration due to gravity become 4% of its value on the surface of the earth? Radius of the earth$= 6{,}400km$. [$\boldsymbol{Ans: 25,600km}$]

25.At what height below the surface of the earth, value of g is the same as that at a height $64km$ above the surface of the earth? [**Ans:**$\boldsymbol{128km}$]

26.A man can jump $2m$ high on the earth. Calculate the approximate height he might be able to jump on a planet, where density is $\frac{1}{4}th$ and radius $\frac{1}{3}th$ that of the earth**.** **[Ans.24m]**

UP27.An unmanned Lander is sent to the surface of the planet Mars, which radius $R_m = 3.4 \times 10^6 m$ and mass $M_m = 6.42 \times 10^{23} kg$. The earth weight of the Mars Lander is $3920N$. Calculate its weight and acceleration due to the gravity Mars

(a) $6 \times 10^6 m$ above the surface of mars**.** **[F=** $\boldsymbol{194N,\ g = 0.48 m/s^2}$ **]**

(b) at the surface of Mars**.** **[F=** $\boldsymbol{1500N,\ g = 3.7\ m/s^2}$]

28. A particle of mass $10g$ is kept on the surface of a uniform sphere of mass $100kg$ and radius $10cm$. Find the work to be done against the gravitational force between them to take the particle far away from the sphere.
[$\boldsymbol{6.67 \times 10^{-10}}$ **J]**

29. Jupiter has a mass 318 times that of the earth and its radius is 11.2 times the earth's radius. Estimate the escape velocity of a body from Jupiter's surface, given that the escape velocity from the earth's surface is $11.2\ km/s$. [$\boldsymbol{59.68\ km/s}$]

30.Show that the square of the escape velocity is equal to the product of the diameter of the earth and the acceleration due to gravity.

31.Prove that the velocity of a body from the earth's surface is $\sqrt{2}$ times the velocity for a circular orbit just above the earth's surface.

32.Two spheres 0f masses 64kg and $298kg$ are placed a distance 10m apart. Find the position of a point on the line joining the two centres of the two spheres, where the gravitational field is zero.

$$[\mathbf{3.2m}\ (\boldsymbol{from\ the\ 64kg\ shere})]$$

33.The distance between earth and moon is $3.8 \times 10^5 m$ and the mass of the earth is 81 times the mass of the moon. Find the position of a point on the line joining the centres of earth and moon, where the gravitational field is zero. What would be the value of gravitational field there due to the earth and moon separately? Given, radius of the earth $= 6.4 \times 10^6 m$.

$$[\mathbf{3.42 \times 10^8 m}\ (\boldsymbol{from\ the\ earth}),\ \mathbf{3.43 \times 10^{-3}}\ \mathbf{N/kg}]$$

34.How much energy must be given to a $100kg$ rocket missile to carry it from the surface of earth into free space? Given, G$= 6.67 \times 10^{-11} Nm^2 kg^{-2}$, mass of the earth $= 6 \times 10^{24} kg$ and radius of the earth $= 6.4 \times 10^6 m$.
[$\mathbf{6.253 \times 10^9 J}$].

35.If earth has a mass of 9 times and radius twice that of the planet Mars. Calculate the minimum velocity required by a rocket to pull out of gravitational force of Mars, take the escape velocity on the surface of the earth to be $11.2\ km/s$. $[\mathbf{5.28\ km/s}]$

36.A body of mass $100kg$ falls on the earth from infinity. What will be its velocity and energy on reaching the earth? Given, radius of the earth$= 6400km$ and $g = 9.8 \mathrm{m} s^{-2}$.Air friction may be neglected.
[$\mathbf{11.2\ km/s, 6.272 \times 10^9 J}$].