CHAPTER 8

Gravitation

TRY YOURSELF ANSWERS

1. Given, $m_P = 2.4 \times 10^{25}$ kg, $m_S = 3.2 \times 10^{28}$ kg and the distance, $r = 6.4 \times 10^{12}$ m.
Then according to universal law of gravitation,

$$F_g = \frac{Gm_s m_p}{r^2} = \frac{6.67\times10^{-11}\times3.2\times10^{28}\times2.4\times10^{25}}{(6.4\times10^{12})^2}$$

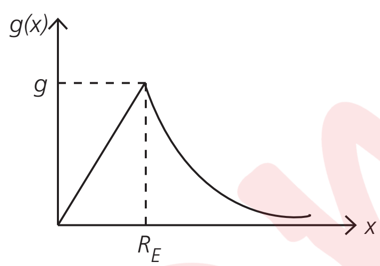
$= 1.25 \times 10^{18}$ N

2. Newton's law of gravitation is called as a universal law as it holds good for any pair of bodies anywhere in the universe even if the bodies are microscopically small or astronomically big.

3. Kepler's laws are applicable whenever inverse square law is involved.

4. No, it is not possible to shield a body from gravitational effects because gravitational interaction does not depend upon the nature of the intervening medium.

5. The plot between acceleration due to gravity $g(x)$ and distance x from the centre of earth is as shown below.



6. In the regions near equator, due to the rotation of earth, the value of acceleration due to gravity is slightly less than that at the poles *i.e.*, $g_p > g_e$. Thus an object weighs more at poles than at the equator.

7. Given, $R_1 = R$ and $R_2 = 4R$.
Similarly, $\rho_1 = \rho$ and $\rho_2 = \rho/2$.

Since $g = \frac{GM}{R^2} = G\frac{4}{3}\frac{\pi R^3\rho}{R^2} = \frac{4}{3}G\pi\rho R$

$\therefore \frac{g_1}{g_2} = \frac{\rho_1 R_1}{\rho_2 R_2} = \frac{\rho R}{\frac{\rho}{2}\times 4R} = \frac{1}{2}$

$\therefore g_1 : g_2 = 1 : 2$

8. Given, $g(d) = 2\%$ of $g = 2g/100$

Since $g(d) = g\left(1-\frac{d}{R}\right)$

$\Rightarrow \frac{2g}{100} = g\left(1-\frac{d}{R}\right)$ or $\frac{1}{50} = 1-\frac{d}{R}$

$\Rightarrow \frac{1}{50} = 1-\frac{d}{6400}$

or $d = 6400\left(1-\frac{1}{50}\right) = 6400\times\frac{49}{50} = 6272\,\text{km}$

9. The gravitational field intensity of a point is equal to the negative of the potential gradient at that point *i.e.*, $\vec{I} = -\frac{dV}{dr}$

10. The unit of intensity of gravitational field is N kg^{-1}.

11. Given $F = 200$ N, $m = 5$ kg

$\therefore$ Intensity of gravitational field, $\vec{I} = \frac{\vec{F}}{m} = \frac{200}{5} = 40\,\text{N kg}^{-1}$

12. Gravitational field intensity, $I = \frac{GM}{R^2}$

Gravitational potential, $V = -\frac{GM}{R}$

$\therefore \frac{V}{I} = -R$

or $V = -I \times R = -4.2 \times 20{,}000 \times 10^3 = -8.4 \times 10^7$ J kg^{-1}

13. The gravitational potential energy at a distance d from the centre of earth, $|U| = \frac{GMm}{d}$

where M is the mass of earth and m is the mass of the body.

$\therefore |U| = \frac{GMm}{d} = \left(\frac{GM}{d^2}\right)dm = gdm$

$\therefore$ Weight of body, $W = mg = \frac{|U|}{d}$

14. Gravitational potential energy of a body at a point is defined as the amount of work done in bringing the given body from infinity to that point against the gravitational force.

15. Gravitational potential energy arises due to the attractive force of gravitation and thus it is negative.

16. Escape speed is the minimum speed with which a body must be projected vertically upwards in order that it may just escape gravitational field of earth.

17. As $v_e = \sqrt{\frac{2GM}{R}}$, therefore escape velocities have different values on different planets which are of different masses and different sizes.

18. The escape velocity does not depend on the angle of projection, therefore the escape velocity of a satellite launched at an angle of 60° with vertical is 11.2 km s^{-1}.

19. Orbital speed, $v_0 \propto \frac{1}{\sqrt{R_E + h}}$; so the satellite at smaller height would possess greater velocity.

20. Angle of inclination of polar orbit with the earth's equatorial plane is 90°.

21. The energy required by a satellite to leave its orbit around the earth and escape to infinity is called its binding energy.

22. Satellites are always at finite distance from the earth and hence their energy cannot be positive or zero.

23. The height of a polar satellite is 500 km-800 km above earth's surface.

24. A body is said to be in state of weightlessness when the reaction of supporting surfaces is zero or its apparent weight is zero.

25. Weightlessness in a satellite is due to zero gravitational acceleration.

$$W = mg$$

When $g = 0$, $W = 0$