Gravitation

Worksheet -1

1. On which fundamental law of physics is Kepler's second law is based? 1

Ans. Law of conservation of angular momentum.

2. Which is greater the attraction of the earth for 1 kg of aluminum or aluminum or attraction of 1kg of aluminum for the earth? 1

Ans. same

3. Distance between two bodies is increased to three times its original value. What is the effect on the gravitational force between them? 1

Ans. $F = G\frac{m_1 m_2}{r^2}$

$r' = 3r$

$F' = G\frac{m_1 m_2}{(r')^2} = G\frac{m_1 m_2}{(3r)^2} = G\frac{m_1 m_2}{9r^2} = \frac{1}{9}G\frac{m_1 m_2}{r^2} = \frac{1}{9}F$

4. The distance of the planet Jupiter from the sun is 5.2 times that of the earth. Find the period of the Jupiter's revolution around the sun? 2

Ans. $\left(\frac{T_J}{T_E}\right)^2 = \left(\frac{R_J}{R_E}\right)^3$

$\left(\frac{T_J}{1}\right)^2 = \left(\frac{5.2R_E}{R_E}\right)^3$

$T_J = (5.2)^{\frac{3}{2}} = 11.86\ years$

5. Show that for a two particle system $\vec{F}_{12} = -\vec{F}_{21}$ 2

Ans. $\overrightarrow{F_{12}} = G\frac{m_1 m_2}{r^2}r_{21}$

$\overrightarrow{F_{12}} = G\frac{m_1 m_2}{r^3}\overrightarrow{r_{21}}$

Also, $\overrightarrow{F_{21}} = G\frac{m_1 m_2}{r^3}\overrightarrow{r_{12}}$

$\because \overrightarrow{r_{12}} = -\overrightarrow{r_{21}}$

$\therefore \overrightarrow{F_{21}} = -G\frac{m_1 m_2}{r^3}\overrightarrow{r_{21}}$

$\overrightarrow{F_{21}} = -\overrightarrow{F_{12}}$

6. State two essential requisites of geostationary satellite? 2

Ans. (1) The period of revolution of a satellite around the earth should be same as that of earth about its own axis (T=24hrs)
(2) The sense of rotation of satellite should be same as that of the earth about its own axis i.e. from west to east in anti-clockwise direction

7. Show that an artificial satellite circling round the earth in an orbit of radius obeys keeper's third low? 2

Ans. Orbital velocity of a satellite is $v = \sqrt{\frac{GM}{r}}$

Time period of a satellite is $T = \frac{2\pi r}{v}$

$$T = \frac{2\pi r}{\sqrt{\frac{GM}{r}}}$$

$$T^2 = \frac{4\pi^2 r^2}{\frac{GM}{r}}$$

$$T^2 = \frac{4\pi^2 r^3}{GM}$$

$$T^2 = kr^3$$

$$T^2 \alpha\, r^3$$

8 A 400kg satellite in a circular orbit of radius 2 Re about the earth calculate the kinetic energy, potential energy and total energy of the satellite? $R_E = 6.4\text{x}10^6$m, $M = 6\text{x}10^{24}$kg 3

Ans.

$$K = \frac{Gm_1m_2}{r} = \frac{6.67\times10^{-11}\times6\times10^{24}\times400}{2\times6.4\times10^6} = 6.25\times10^9\,J$$

$$P = \frac{-2Gm_1m_2}{r} = -\frac{2\times6.67\times10^{-11}\times6\times10^{24}\times400}{2\times6.4\times10^6} = -12.5\times10^9\,J$$

$$T = P + K = 6.25\times10^9 - 12.5\times10^9\,J = -6.25\times10^9\,J$$

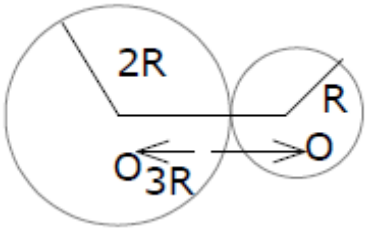
9. Two uniform solid spheres of radii R and 2R are at rest with their surfaces just touching. Find the force of gravitational attraction between them if density of spheres be P? 2

Ans.

$$m_1 = \frac{4}{3}\pi\rho(2R)^3$$

$$m_2 = \frac{4}{3}\pi\rho R^3$$

$$r = 2R + R = 3R$$



$$F = G\frac{m_1m_2}{r^2} = G\frac{\frac{4}{3}\pi\rho(2R)^3\times\frac{4}{3}\pi\rho R^3}{(3R)^2} = \frac{128}{81}\pi^2\rho^2R^4$$

10. Find expressions for (1) potential energy (2) kinetic energy (3) total energy for an artificial satellite. 3

Ans.