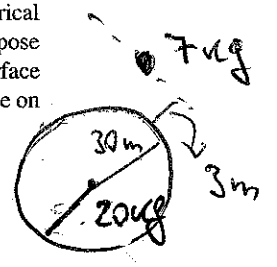
3E. One of the *Echo* satellites consisted of an inflated spherical aluminum balloon 30 m in diameter and of mass 20 kg. Suppose a meteor having a mass of 7.0 kg passes within 3.0 m of the surface of the satellite. What is the magnitude of the gravitational force on the meteor from the satellite at the closest approach? ssm




F=?

3. We use $F = Gm_s m_m/r^2$, where $m_s$ is the mass of the satellite, $m_m$ is the mass of the meteor, and $r$ is the distance between their centers. The distance between centers is $r = R + d = 15\,\text{m} + 3\,\text{m} = 18\,\text{m}$. Here $R$ is the radius of the satellite and $d$ is the distance from its surface to the center of the meteor. Thus,

$$F = \frac{(6.67 \times 10^{-11}\,\text{N}\cdot\text{m}^2/\text{kg}^2)(20\,\text{kg})(7.0\,\text{kg})}{(18\,\text{m})^2} = 2.9 \times 10^{-11}\,\text{N}\,.$$

What is $r$ if $F_g = 2.3 \times 10^{-12}$ N

5.2kg - - - - - - - 2.4kg

$r = ?$

1. The magnitude of the force of one particle on the other is given by $F = Gm_1m_2/r^2$, where $m_1$ and $m_2$ are the masses, $r$ is their separation, and $G$ is the universal gravitational constant. We solve for $r$:

$$r = \sqrt{\frac{Gm_1m_2}{F}} = \sqrt{\frac{(6.67 \times 10^{-11}\,\mathrm{N{\cdot}m^2/kg^2})(5.2\,\mathrm{kg})(2.4\,\mathrm{kg})}{2.3 \times 10^{-12}\,\mathrm{N}}} = 19\ \mathrm{m}\ .$$

$$F = \frac{Gm_1m_2}{r^2} \rightarrow r = \sqrt{\frac{G \cdot m_1 m_2}{F}}$$

An object is in equilibrium when positioned 150000 km from star X and 80000 km from star B. What is the ratio of masses ($M_x/M_Y$) of the two stars ?

$$F_x = G\, M_x M_{obj} / R_x^{\ 2} = F_y = G\, M_Y M_{obj} / R_Y^{\ 2}$$

$$\cancel{G}\, M_x \cancel{M_{obj}} / (150000.10^3\ m)^2 = \cancel{G}\, M_Y \cancel{M_{obj}} / (80000.10^3\ m)^2$$

$$(M_x/M_Y) = (80000.\ 10^3\ m/150000.10^3\ m)^2$$

$$(M_x/M_Y) = 0.284$$

**18.** **ORGANIZE AND PLAN** Use Newton's law of gravitation (Eq. 9.1) to calculate the attractive force due to gravity between the two balls.

*Known:* $m_1 = 25$ kg, $m_2 = 60$ kg, $r = 0.50$m.

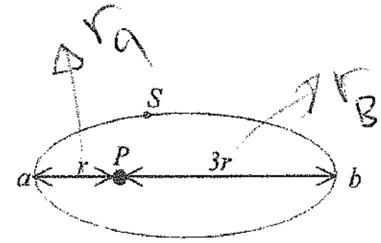
**SOLVE** Newton's law of gravitation gives [Eq. 1]

$$F = \frac{Gm_1m_2}{r^2} = \frac{(6.67\times10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2)(25\ \text{kg})(60\ \text{kg})}{(0.50\ \text{m})^2} = 4.00\times10^{-7}\ \text{N}$$

This is response (d).

**REFLECT** The problem does not state the radii of the two balls involved. Does this matter?

A satellite moves around a planet in an elliptical orbit. What is the ratio of the speed of the satellite at point $a$ to that at point $b$?




$\frac{r_B}{r_A} = 3$

**Answer:**

By the conservation of angular momentum, we have

$$I_a\omega_a = I_b\omega_b = L = \text{const} \quad ; \quad I = mr^2$$

where $I_a$ and $I_b$ are the moment of inertia of the system about $P$ at positions $a$ and $b$ respectively.

$V = \omega \cdot r \rightarrow \omega = \frac{V}{r}$

Now, we can write $\cancel{m}r_a^2(\frac{v_a}{r_a}) = \cancel{m}r_b^2(\frac{v_b}{r_b})$. $\rightarrow r_a V_a = r_B V_B$

which gives $\frac{v_a}{v_b} = \frac{r_b}{r_a} = \frac{3}{1}$. That is, $v_a : v_b = 3 : 1$.