21. A 4.08×10^5 kg Space station is in a circular earth orbit that has a radius of 4.10×10^5 m. A net external force must act on the Space station to make it change to a circular orbit that has a radius of 8.50×10^4 m. What work must be the net external force do?

Solution

relevant equations:

Work done - $W = \Delta E$

$$\sum \vec{F}_g = \frac{GM}{r^2} \times m$$

$$\sum \vec{F}_r = \frac{m_s v^2}{r}$$

Work done:

$$W = \Delta E$$
$$= E_f - E_i$$
$$= \frac{1}{2} m_s (v_f^2 - v_i^2)$$

The velocity can be calculated from the net radial force acting on the location on the space station.

$$\sum \vec{F}_r = \sum \vec{F}_g$$

$$\frac{\cancel{m_s} v^2}{\cancel{r}} = \frac{G\cancel{m_s}}{\cancel{r^2}} \times m_E$$

$$v^2 = \frac{G \times m_E}{r}$$

plug this into work done equation

$$W = \frac{1}{2} m_s \left(\frac{G m_E}{r_f} - \frac{G m_E}{r_i} \right)$$

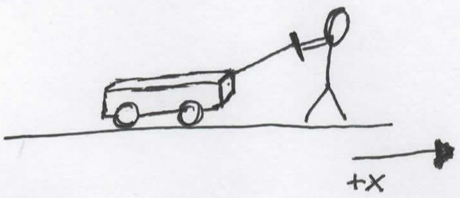
$$W = \frac{1}{2} G m_E m_s \left(\frac{1}{r_f} - \frac{1}{r_i} \right)$$

$$W = \frac{1}{2} \times (9.8 \tfrac{m}{s^2})(6.972 \times 10^{24}\, kg)(4.08 \times 10^5\, kg)\left(\frac{1}{8.50 \times 10^4\, m} - \frac{1}{4.10 \times 10^5\, m} \right)$$

$$\boxed{W = 1.11 \times 10^{26}\, J}$$

19. A wagon is being pulled across a horizontal path. Friction is negligible. The pulling force points in the same direction as the wagon's displacement, which is along the +x axis. As a result, the kinetic energy of the wagon increases by 47.5 percent. By what percentage would the sled's kinetic energy have increased if this force had pointed 72.4-degrees above the +x axis?

Solution



$$W = KE_f - KE_i = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = \Delta KE$$

$$W = (F\cos\theta)s$$

$$W_1 = F(\cos 0^\circ)s = \Delta KE_1$$

$$W_2 = F(\cos 72.4^\circ)s = \Delta KE_2$$

$$\frac{\Delta KE_1}{KE_0} = \frac{F(\cos 0^\circ)s}{KE_0} = 0.475 \rightarrow Fs = (0.475)KE_0 \quad eq1$$

$$\frac{\Delta KE_2}{KE_0} = \frac{F(\cos 72.4^\circ)s}{KE_0} \rightarrow \frac{Fs}{KE_0} \times (\cos 72.4^\circ) \quad eq2$$

Combine equations

$$\frac{\Delta KE_2}{KE_0} = \frac{Fs}{KE_0}(\cos 72.4^\circ) = \frac{(0.475)\cancel{KE_0}}{\cancel{KE_0}} \times (\cos 72.4^\circ)$$

$$\frac{\Delta KE_2}{KE_0} = 0.475 \times (\cos 72.4^\circ)$$

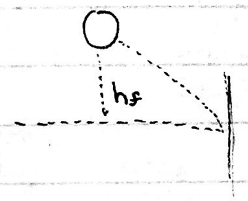
$$\boxed{\frac{\Delta KE_2}{KE_0} = 0.144}$$

The wagons kinetic energy would increase by <u>14.4%</u>

Chapter 6

52. You are practicing Volleyball when you throw a 0.280 Kg ball at 20.0 m/s towards your friend. In hitting the ball, your friend does $W_{nc} = 70.0$ J of work on the ball. Ignoring air resistance, determine the speed after the ball leaves your friend's outstretched arms 5.0 m above the point of impact.

Diagram



Known	UK
$m_b = 0.28$ Kg.	
$V_i = 20$ m/s.	V_f @ 5.0m
$h_f = 5.0$ m.	

Energy Analysis

Initial KE of ball: $\frac{1}{2}mV^2 = \frac{1}{2}(0.28)(20)^2 = 56$J.

Add the Wnc energy to the ball $= 70+56 = 126$J.

The ball increases in potential energy.

$\hookrightarrow mg(h_i - h_f) = (0.28\,kg)(-9.81\,m/s^2)(0-5)$

$= 13.734$

Because the ball increases in potential energy, it must lose that amount from its current total.

Thus $126 - 13.734 = 112.266$ J @ height of 5 m.

Use KE equation to find V_f with new energy.

$\frac{1}{2}(0.28)(V_f)^2 = 112.266$

$V_f = \sqrt{801.9}$

$V_f = 28.3$ m/s