PHY 2130 Homework solutions
Assignment 5

5.1 If the weights are to move at constant velocity, the net force on them must be zero. Thus, the force exerted on the weights is upward, parallel to the displacement, with magnitude 350 N. The work done by this force is

$$W = (F\cos\theta)s = [(350\ \text{N})\cos 0°](2.00\ \text{m}) = \boxed{700\ \text{J}}.$$

5.4 The applied force makes an angle of 25° with the displacement of the cart. Thus, the work done on the cart is

$$W = (F\cos\theta)s = [(35\ \text{N})\cos 25°](50\ \text{m}) = 1.6\times 10^3\ \text{J} = \boxed{1.6\ \text{kJ}}.$$

5.17 $W_{net} = (F_{road}\cos\theta_1)s + (F_{resist}\cos\theta_2)s = [(1000\ \text{N})\cos 0°]s + [(950\ \text{N})\cos 180°]s$

$$W_{net} = (1000\ \text{N-}950\ \text{N})(20\ \text{m}) = 1.0\times 10^3\ \text{J}$$

Also, $W_{net} = KE_f - KE_i = \frac{1}{2}mv^2 - 0$, so

$$v = \sqrt{\frac{2W_{net}}{m}} = \sqrt{\frac{2(1.0\times 10^3\ \text{J})}{2000\ \text{kg}}} = \boxed{1.0\ \text{m/s}}$$

5.27 Since no non-conservative forces do work, we use conservation of mechanical energy, with the zero of potential energy selected at the level of the base of the hill. Then, $\frac{1}{2}mv_f^2 + mgy_f = \frac{1}{2}mv_i^2 + mgy_i$ with $y_f = 0$ yields

$$y_i = \frac{v_f^2 - v_i^2}{2g} = \frac{(3.00\ \text{m/s})^2 - 0}{2(9.80\ \text{m/s}^2)} = \boxed{0.459\ \text{m}}.$$

5.31 (a) We choose the zero of potential energy at the level of the bottom of the arc. The initial height of Tarzan above this level is

$$y_i = (30.0 \text{ m})(1 - \cos 37.0°) = 6.04 \text{ m} .$$

Then, using conservation of mechanical energy, we find

$$\frac{1}{2}mv_f^2 + 0 = \frac{1}{2}mv_i^2 + mgy_i \text{, or}$$

$$v_f = \sqrt{v_i^2 + 2gy_i} = \sqrt{0 + 2(9.80 \text{ m/s}^2)(6.04 \text{ m})} = \boxed{10.9 \text{ m/s}}.$$

(b) In this case, conservation of mechanical energy yields

$$v_f = \sqrt{v_i^2 + 2gy_i} = \sqrt{(4.00 \text{ m/s})^2 + 2(9.80 \text{ m/s}^2)(6.04 \text{ m})} = \boxed{11.6 \text{ m/s}}.$$

5.46 The normal force exerted on the sled by the track is $n = mg\cos\theta$ and the friction force is $f_k = \mu_k n = \mu_k mg\cos\theta$.

If s is the distance measured along the incline that the sled travels, applying $W_{nc} = (KE + PE_g)_f - (KE + PE_g)_i$ to the entire trip gives

$$\left[(\mu_k mg\cos\theta)\cos 180°\right]s = \left[0 + mgs(\sin\theta)\right] - \left[\frac{1}{2}mv_i^2 + 0\right],$$

or $$s = \frac{v_i^2}{2g(\sin\theta + \mu_k\cos\theta)} = \frac{(4.0 \text{ m/s})^2}{2(9.80 \text{ m/s}^2)(\sin 20° + 0.20\cos 20°)} = \boxed{1.5 \text{ m}}.$$

5.50 Let ΔN be the number of steps taken in time Δt. We determine the number of steps per unit time by

$$\text{Power} = \frac{\text{work done}}{\Delta t} = \frac{(\text{work per step per unit mass})(\text{mass})(\#\text{ steps})}{\Delta t},$$

or $$70 \text{ W} = \left(0.60\ \frac{\text{J/step}}{\text{kg}}\right)(60 \text{ kg})\left(\frac{\Delta N}{\Delta t}\right), \text{ giving } \frac{\Delta N}{\Delta t} = 1.9 \text{ steps/s} .$$

The running speed is then

$$\bar{v} = \frac{\Delta x}{\Delta t} = \left(\frac{\Delta N}{\Delta t}\right)(\text{distance traveled per step}) = \left(1.9\ \frac{\text{step}}{\text{s}}\right)\left(1.5\ \frac{\text{m}}{\text{step}}\right) = \boxed{2.9 \text{ m/s}}$$