Homework 5 solutions

(C5.) REMEMBER THAT WORK DUE TO GRAVITY IS ΔPE. THEREFORE, ASSUMING NO NON-CONSERVATIVE FORCES, THERE IS NO DIFFERENCE BETWEEN A STEEP SLOPE OR A SHALLOW SLOPE WITH SWITCHBACKS. IF YOU INCLUDE N.C. FORCES, IT DOES TAKE MORE WORK (DUE TO ROLLING FRICTION) TO DRIVE A LONGER ROAD. HOWEVER, THE REASON FOR SWITCHBACKS RELATES TO POWER. BECAUSE $\overline{P} = \frac{W}{\Delta t}$, A LONGER ROAD TAKES LESS POWER

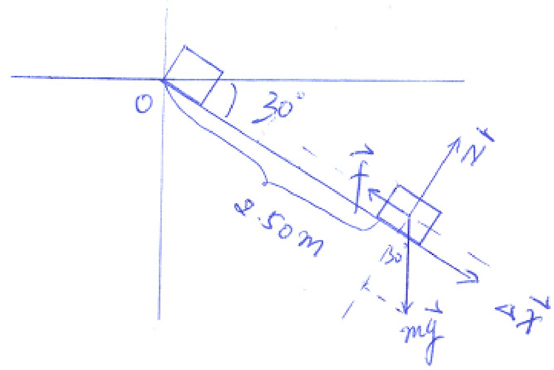
(C6.) $KE = \frac{1}{2} m v^2$ $\quad v \to 2v, \quad KE \to 4KE$

$W_{NET} = \Delta KE$ $\quad$ IF $\Delta KE = 0$, $\Delta V = 0$.

5.2 To lift the bucket at constant speed, the woman exerts an upward force whose magnitude is $F = mg = (20.0\text{ kg})(9.80\text{ m/s}^2) = 196\text{ N}$. The work done is $W = (F\cos\theta)s$, so the displacement is

$$s = \frac{W}{F\cos\theta} = \frac{6.00\times10^3\text{ J}}{(196\text{ N})\cos 0^\circ} = \boxed{30.6\text{ m}}.$$

5 This problem wants us to clarify that the work done by a constant force $\vec{F}$ is due to the product of the component of the force in the direction of displacement and the magnitude of the displacement: $W \equiv (F\cos\theta)\Delta x$.



(a) The force $\vec{F}$ is $m\vec{g}$, its angle from the displacement $\theta = \frac{\pi}{2} - 30° = 60°$, and the magnitude of displacement $\Delta x = 2.50\,m$.

$W_g = mg \cdot \cos 60° \cdot \Delta x = 5.00\,kg \cdot 9.8\,m/s^2 \cdot \cos 60° \cdot 2.5\,m$

$= \boxed{61.3\,J}$

(b) $\vec{F} = \vec{f}$, its angle from the displacement θ is π.

Since $f = N\mu_k$ where $N = mg\cos 30°$,

$W_f = f\cos\pi \cdot \Delta x = mg\cos 30° \cdot \mu_k \cdot \cos\pi \cdot \Delta x$

$= 5.00\,kg \cdot 9.8\,m/s^2 \cdot \cos 30° \cdot 0.436 \cdot \cos\pi \cdot 2.5\,m$

$= \boxed{-46.3\,J}$

(c) $\vec{F} = \vec{N}$, its angle from the displacement θ is $\frac{\pi}{2}$.

Since $\cos\theta = \cos\frac{\pi}{2} = 0$, then

$W_N = N\cos\frac{\pi}{2} \cdot \Delta x = \boxed{0}$.

5.9 (a) The work-energy theorem, $W_{net} = KE_f - KE_i$, gives

$$5000\text{ J} = \frac{1}{2}\left(2.50\times10^3\text{ kg}\right)v^2 - 0\text{, or}\qquad v = \boxed{2.00\text{ m/s}}.$$

(b) $W = (F\cos\theta)s = (F\cos 0°)(25.0\text{ m}) = 5000\text{ J}$, so $F = \boxed{200\text{ N}}$.

$\boxed{11}$ The work-energy theorem gives

$$W_{net} = KE_f - KE_i = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

where $v_i = 0$.

$$\because W_{net} = (\vec{F} + m\vec{g})\,\Delta\vec{x}$$

where $F = 2\,(355\text{ N}) = 710\text{ N}$

$$\therefore v_f = \sqrt{2m^{-1}W_{net} + v_i^2}$$

$$= \sqrt{2m^{-1}(F - mg)\cdot\Delta x + v_i^2} = \sqrt{2\,\frac{g}{W}(F - W)\,\Delta x + v_i^2}$$

$$= \sqrt{2\,\frac{9.8\text{ m/s}^2}{700\text{ N}}(710\text{ N} - 700\text{ N})\cdot(25\text{ cm}) + 0}$$

$$= \boxed{0.265\text{ m/s}}$$

13 (a) Since the base runner slides on a level surface, the change in gravitational potential energy is

$$\Delta PE_g = mgy_f - mgy_i = mg(\Delta y) = 0$$

The change in mechanical energy is therefore

$$W_{nc} = \frac{1}{2}m(v_f^2 - v_i^2) = \frac{1}{2}(70\,kg)[0 - (4.0\,m/s)^2]$$
$$= \boxed{-5.6 \times 10^2\,J}$$

6

(b) The friction force is directed opposite to the displacement ($\theta = 180°$) and has magnitude $f_k = \mu_k n$ where $n = mg$. All other forces acting on the base runner are perpendicular to the displacement, so do no work. The total work done by non-conservative force is then $W_{nc} = (f_k \cos 180°)\,\Delta x$, so

$$\Delta x = \frac{W_{nc}}{f_k \cos 180°} = \frac{W_{nc}}{-\mu_k mg} = \frac{-5.6 \times 10^2\,J}{-(0.70)(70\,kg)(9.8\,m/s^2)} = \boxed{1.2\,m}$$

19 Since there is no non-conservative force acting on the ball, the kinetic energy changes due to the gravity. Choose up the positive y direction.

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

where $v_i = 0$, So $W_g = \frac{1}{2}mv_f^2$

And $W_g = -(PE_f - PE_i) = -mg(y_f - y_i) = -mgy_f$

where $y_i = 0$. Thus,

$$-mgy_f = \frac{1}{2}mv_f^2 \Rightarrow y_f = -\frac{v_f^2}{2g} = -\frac{(9.0\,m/s)^2}{2(9.8\,m/s^2)} = -4.1\,m$$

Thus, the height should be $\boxed{4.1\,m}$.

9

20 Suppose a real flea's mass is m, when it jumps, its maximum force exerted by a musle $F \propto S$ which is its cross-sectional area, and the length of contraction is l.

Thus, $W = Fl = mgh$ where $h = 0.5\,m$.

If we magnified a flea by 1000, then

$m' = 1000^3 m$; $S' = 1000^2 S \Rightarrow F' = 1000^2 F$;

$l' = 1000\, l \Rightarrow$

$$W' = F'l' = 1000^2 F \cdot 1000\, l = 1000^3 Fl = m'gh'$$

$$= 1000^3 mgh' \Rightarrow$$

$$h' = \frac{Fl}{mg} = h = \boxed{0.5\ m}$$

23.) From the work energy theorem,

$$\Delta PE = \Delta KE$$

$$\Delta KE = \cancel{\tfrac{1}{2}} \cancel{m} (35^2 - 33^2) = \cancel{\tfrac{1}{2}} \cancel{m} g h$$

$$\frac{35^2 - 33^2}{g} = h = 13.6\,m.$$

25.)

$F = 800N$

$\Delta x = 7.5\,cm = .075\,m$

You have two arms, so

$$W = 2 \cdot 800N \cdot .075m = 120\ N \cdot m$$

To do a chin up (Ignoring NC forces)

$W = mg\Delta h$ $\Delta h = .4\,m$

$$W = 75\,kg \cdot 9.8\,m/s^2 \cdot .4m = 294\ N \cdot m.$$

The biceps are not the only muscle involved.

5.39 We shall take $PE_g = 0$ at the lowest level reached by the diver under the water. The diver falls a total of 15 m, but the non-conservative force due to water resistance acts only during the last 5.0 m of fall. The work-kinetic energy theorem then gives

$$W_{nc} = \left(KE + PE_g\right)_f - \left(KE + PE_g\right)_i,$$

or $$\left(\bar{F}\cos 180^\circ\right)(5.0\text{ m}) = (0+0) - \left[0 + (70\text{ kg})\left(9.80\text{ m/s}^2\right)(15\text{ m})\right].$$

This gives the average resistance force as $\bar{F} = 2.1\times 10^3\text{ N} = \boxed{2.1\text{ kN}}$.

$\boxed{46}$ Choose the bottom as the original point, and up along the incline as positive direction.

$W_{nc} = (KE_f + PE_f) - (KE_i + PE_i)$

$-f_k \cdot \Delta x = (0 + mgh_f) - (\frac{1}{2}mv_i^2 + 0)$

where $v_i = 4.0\,m/s$, $h_f = \Delta x \sin 20^\circ$

$f_k = mg\cos 20^\circ \cdot \mu_k \Rightarrow$

$\frac{1}{2}mv_i^2 - mg\,\Delta x \cdot \sin 20^\circ = mg\cos 20^\circ \mu_k \cdot \Delta x$

$mg(\sin 20^\circ + \cos 20^\circ \mu_k)\Delta x = \frac{1}{2} m v_i^2 \Rightarrow$

$$\Delta x = \frac{\frac{1}{2}v_i^2}{(\sin 20^\circ + \cos 20^\circ \mu_k)g} = \frac{\frac{1}{2}(4.0\,m/s)^2}{(\sin 20^\circ + 0.2\cdot\cos 20^\circ)(9.8\,m/s^2)}$$

$= \boxed{1.54\ m}$

4a.) WORST QUESTION INVOLVING DAVE BARRY EVER.

$\Delta y = 5.49\,m$

$V = 1.89 \times 10^6 L \Rightarrow \dfrac{1.89 \times 10^6 L}{} \left| \dfrac{10^{-3} m^3}{L} \right| = 1.89 \times 10^3 m^3.$

$MASS = 1.89 \times 10^3 m^3 \cdot 1050 \frac{Kg}{m^3} = 1.98 \times 10^6 Kg$

a.)

$P = \dfrac{W}{\Delta t}$ $\Delta t = 60 \cdot 60 \cdot 24 = 86400$ SECONDS

BECAUSE THE SEWAGE ENTERS THROUGH EQUAL SIZE TUBES AND AT 1 ATM, $W = \Delta PE$.

$P = \dfrac{\Delta PE}{\Delta t} = \dfrac{mgh}{\Delta t} = \dfrac{1.98 \times 10^6 Kg \cdot 9.8 m/s^2 \cdot 5.49 m}{86400 \, s}$

$= 1.24 \, KW.$

b) EFFICIENCY IS $\dfrac{\text{OUTPUT}_{\text{MEASURED}}}{\text{OUTPUT}_{\text{TOTAL}}} \times 100$

$E = \dfrac{1.24 KW}{5.9 KW} = 21\%$