I. Multiple Choice:

1. (b) \[ P = F \cdot v = F \cdot v \cos 20^\circ = (10)(3)(.94) = 28.2 \text{ W} \]

2. (a) \[ \Sigma F_r = m \cdot a_r = \frac{mv^2}{r} \quad \text{and} \quad \Sigma F_y = O = T \cos \theta - mg \]
   \[ T = \frac{mg}{\cos \theta} \quad \Rightarrow \quad \frac{mv^2}{r} = mg \tan \theta \]
   \[ \Rightarrow \quad v^2 = \left( \frac{r \sin \theta}{g} \right) g \tan \theta \]
   \[ \therefore \quad v = f(\theta, L, g) \]

3. (c) \[ E_i = E_f \quad \text{and} \quad \text{KE}_i + U_i = \text{KE}_f + U_f \]
   \[ 0 + mg(1 - \cos \theta) = \frac{1}{2} mv^2 + 0 \]
   \[ v^2 = 2gL(1 - \cos \theta) \]

4. (e) \[ F_x = \frac{du}{dx} \quad \text{at} (e) \text{ the slope is the most positive, so there is} \]
   \[ \text{the largest force in the negative} \ x \text{ direction} \]

5. (a) To raise the block a distance \( h \), you must do work \( Mgh \) against gravity. The block and tackle system shown allows you to pull with a force \( \frac{Mg}{4} \), but you pull the rope a distance \( 4h \), so \( F \cdot d = Mgh \)

Problems:

II. (a) \[ E_i = E_f \quad \text{and} \quad E_i = U_i = Mgh \quad \text{and} \quad U_f = 0 \]
   \[ \text{KE}_i = 0 \quad \text{and} \quad \text{KE}_f = \frac{1}{2} mv^2 \]
   \[ \Rightarrow \quad Mgh = \frac{1}{2} mv^2 \quad \text{and} \quad v = \sqrt{2gh} \]

(b) At the bottom of the circle, the normal force provides the centripetal force.
   \[ \Sigma F_r = m \cdot a_r = \frac{mv^2}{R} = N - Mg \]
   \[ N = Mg + \frac{mv^2}{R} = Mg \left( 1 + \frac{2h}{R} \right) \]
   using the result from (a).

(c) At the lip of the ramp, \[ \frac{1}{2} mv^2 + Mg \frac{R^2}{2} = Mgh \]
   \[ v^2 = 2gh - gR \]
   \[ v = \sqrt{2g(2h-R)} \]
(d). Set $U_f = 0$ at bottom, $U_i$ at top of first ramp $= 2Mgh$, $KE_i = 0$.
Now, after the work of the snow, $KE_f = 0$. 

$$\Delta KE = W_{\text{grav}} + W_{\text{snow}} = 0$$ for the full motion.

$$W_{\text{snow}} = -W_{\text{grav}} = \Delta U = U_f - U_i = -2Mgh$$ (The snow takes all of the energy out of the skier)

Or, you can show this through a calculation of $\Delta KE$:
At the top of the snow pile, we can find $KE_f$ from:

$$U_i = 2Mgh, \quad U_f = Mg \cdot \quad KE_i = 0. \quad \Rightarrow KE_f + Mg = 2Mgh,$$

$$KE_f = 2Mgh - Mg \text{ at the top of the pile}.$$

falling to the bottom of the pile, we have $W_{\text{grav}} = (\Delta KE_{\text{grav}}) = Mg$ and $W_{\text{snow}}$, which we need.

Our $KE_f$ from above is now $KE_i$ for this last piece:

$$\Delta KE = W_{\text{grav}} + W_{\text{snow}} \Rightarrow KE_f = 0 - (2Mgh - Mg) = Mg + W_{\text{snow}}$$

$$W_{\text{snow}} = -2Mgh.$$

(b). $\Sigma F_x = -F \cos 37^\circ + N = 0, \quad N = F \cos 37^\circ = 8N$

(c). $\Sigma F_y = ma_y = F \sin 37^\circ - mg - F_k, \quad F_k = \mu_k N$

$$l = (10)(0.6) - (0.5)(9.8) - \mu_k (8)$$

$$\mu_k = \frac{1.1}{8} = 0.1375 = 0.14$$

(d). $W = (\Sigma F)dy = mg \cdot \Delta y = (0.5)(2)(3) = 3J$

$$m, \quad \text{find } \Delta y \text{ from } v_f^2 - v_i^2 = 2a \Delta y = 12 \text{ m/s}^2$$

$$W = \Delta KE = \frac{1}{2}m(v_f^2 - v_i^2) = \frac{(1)}{(2)}(12) = 3J$$
Problem IV

(a.) \[ U_i = U_{grav} + U_{spring} = 0 + \frac{1}{2} kx_i^2 = \frac{1}{2} (1000)(1)^2 = 500 \text{ J} \]

(b.) \[ U_f = U_{grav} + U_{spring} = mg y_f + 0 = (2)(9.8)(\frac{3}{2}) = 9.8 \text{ J} \]

(c.) \[ \text{So, } KE_f + U_f = KE_i + U_i, \quad \frac{1}{2} mv_f^2 + mg y_f = 0 + \frac{1}{2} kx_i^2 \]

\[ v_f^2 = (490.2), \quad |v_f| = 22.14 \text{ m/s, } @ 30^\circ \text{ above horizontal} \]

\[ v_x = 19.2 \text{ m/s, } v_y = 11.1 \text{ m/s} \]

(d.) Several ways: (1) use conservation of Energy.

\[ \frac{1}{2} kx_i^2 = \frac{1}{2} mv_f^2 + mg y_f \]

\[ 500 = 368.6 + 2(9.8) y_f \]

\[ h_{max} = \frac{16.7}{m} \]

\[ \text{Kinematics: find max height above top of ramp:} \]

\[ v_{fy}^2 = 0 = v_{fy}^2 - 2gy_f \]

\[ (\frac{11.1}{m})^2 = 2(9.8)y_f, \quad y_f = \frac{6.8}{m}, \]

\[ y_{max} = 6.3 + 0.5 = 6.8 \text{ m} \]

3) Cons. of Energy from top of ramp:

\[ \frac{1}{2} mv_x^2 + \frac{1}{2} mv_y^2 + mg y = \frac{1}{2} mv_x^2 + mg y_f \]

\[ v_x = 2g (y_e - y_i), \quad y_e = \frac{16.8}{m} \]

\[ (11.1)^2 \]

\[ \text{Problem V} \]

(a.) \[ R = 10 + 5 \sin \theta \]

(b.) \[ \Sigma F_y = 0 = T \cos \theta - mg, \quad \Sigma F_x = T \sin \theta = \frac{mv^2}{R}, \quad \text{or} \]

\[ \Sigma F = ma = \vec{F} + \vec{W} = \frac{mv^2}{R}, \quad \Rightarrow T \cos \theta - mg \dot{y} + T \sin \theta \dot{x} = \frac{mv^2}{R} \]

\[ T \cos \theta = mg, \quad T = mg / \cos \theta \]

\[ \text{(or, } T = \frac{mv^2}{(10 + 5 \sin \theta) \sin \theta} \text{)} \]

(d.) \[ \cos \theta = \frac{mg}{\frac{mv^2}{(10 + 5 \sin \theta) \sin \theta}} = \frac{(2000)(9.8)}{60,000 \text{ N}}, \quad \cos \theta = 0.324, \quad \theta = 70.9^\circ \]

\[ \frac{mv^2}{(10 + 5 \sin \theta)} = T \sin \theta, \quad (2000)\frac{V^2}{(14.7)} = 56.696, \quad V^2 = 416.7, \quad V = 20.4 \text{ m/s} \]