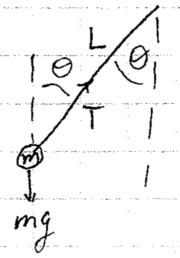
Physics 10310 Exam 2 Solutions Spring 2008

I. Multiple Choice:

1. (b) $P = \vec{F}\cdot\vec{v} = Fv\cos 20° = (10)(3)(.94) = 28.2\ \text{W}$

2. (a)



$$\Sigma F_r = ma_r = \frac{mv^2}{r} = \frac{mv^2}{L\sin\theta} = T\sin\theta$$

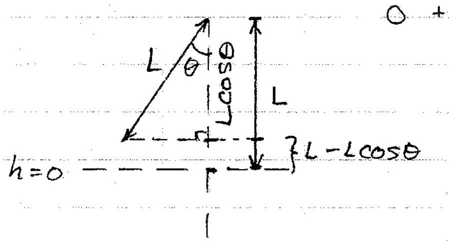
$$\Sigma F_y = 0 = T\cos\theta - mg, \quad T = \frac{mg}{\cos\theta} \rightarrow \frac{\cancel{m}v^2}{L\sin\theta} = \cancel{m}g\tan\theta$$

$$\Rightarrow v^2 = (L\sin\theta)g\tan\theta$$

$$\therefore v = f(\theta, L, g)$$

3. (c) $E_i = E_f$, $KE_i + U_i = KE_f + U_f$

$$0 + mgL(1-\cos\theta) = \tfrac{1}{2}mv^2 + 0$$



$$v^2 = 2gL(1-\cos\theta)$$

4. (e) $F_x = -\dfrac{dU}{dx}$, at (e) the slope is the most positive, so there is the largest force in the negative x direction

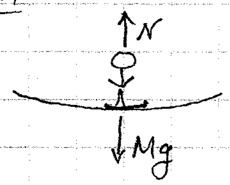
5. (a) To raise the block a distance h, you must do work Mgh against gravity. The block and tackle system shown allows you to pull with a force $Mg/4$, but you pull the rope a distance 4h, so $F\cdot d = Mgh$.

Problems:

II. (a) $E_i = E_f$, $E_i = U_i = Mgh$, $U_f = 0$, $KE_i = 0$, $KE_f = \frac{1}{2}Mv^2$

$$\Rightarrow Mgh = \tfrac{1}{2}Mv^2, \quad \underline{v = \sqrt{2gh}}$$

(b) At the bottom of the circle, the normal force provides the centripetal force.



$$\Sigma F_r = Ma_r = \frac{Mv^2}{R} = N - Mg$$

$$N = Mg + \frac{Mv^2}{R} = Mg\left(1 + \frac{2h}{R}\right)$$

using the result from (a).

(c) At the lip of the ramp, $\frac{1}{2}Mv^2 + Mg\frac{R}{2} = Mgh$, $v^2 = 2gh - gR$

$$\underline{v = \sqrt{g(2h-R)}}$$

Problem II, (cont.)

(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, $KE_f = 0.$

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

$W_{snow} = -W_{grav} = \Delta U = U_f - U_i = \underline{-2Mgh}$

(The snow takes all of the energy out of the skier)

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

$U_i = 2Mgh, \quad U_f = Mgp, \quad KE_i = 0, \quad \Rightarrow KE_f + Mgp = 2Mgh,$

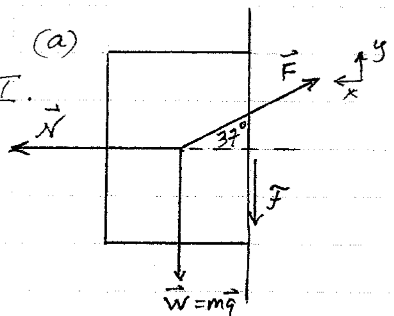
$KE_f = 2Mgh - Mgp.$ at the top of the pile.

Falling to the bottom of the pile, we have $W_{grav} = (\Delta KE_{grav}) = Mgp$ and W_{snow}, which we need.
Our KE_f from above is now KE_i for this last piece:

$$\Delta KE = W_{grav} + W_{snow} \Rightarrow 0 - \overbrace{(2Mgh - Mgp)}^{KE_f} = Mgp + W_{snow}$$

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

III. (a)



(b). $\sum F_x = -F\cos 37° + N = 0, \quad N = F\cos 37° = 8\,N = 8\,N\,\hat{i}$

(c.) $\sum F_y = ma_y = F\sin 37° - mg - \mathcal{F}_k \,, \quad \mathcal{F}_k = \mu_k N$

$1 = (10)(0.6) - (0.5)(9.8) - \mu_k(8)$

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

(d.) $W = (\sum F)\Delta y = ma_y \Delta y = (0.5)(2)(3) = \underline{3\,J}$

or, find $\Delta V^2 : V_f^2 - V_i^2 = 2a\Delta y = 12\ m^2/s^2$

$W = \Delta KE = \frac{1}{2}m(v_f^2 - v_i^2) = (\frac{1}{4})(12) = \underline{3J}$

Problem IV

(a) $U_i = U_{grav_i} + U_{spring_i} = 0 + \frac{1}{2}kx_i^2 = \frac{1}{2}(1000)(1)^2 = 500\ J$

(b.) $U_f = U_{grav_f} + U_{spring_f} = mgy_f + 0 = (2)(9.8)(\frac{1}{2}) = 9.8\ J$

(c.) So, $KE_f + U_f = KE_i + U_i$, $\quad \frac{1}{2}mv^2 + mgy_f = 0 + \frac{1}{2}kx_i^2$

$v_f^2 = (490.2)$, $\underline{|\vec{v}_f| = 22.14\ m/s.}$ $\underline{@\ 30° \text{ above horizontal}}$

$\underline{v_x = 19.2\ m/s}$, $\underline{v_y = 11.1\ m/s}$

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

$\frac{1}{2}kx_i^2 = \frac{1}{2}mv_f^2 + mgh_{max} = \frac{1}{2}mv_{x_0}^2 + mgh_{max}$ $\quad (v_{y_f} = 0)$

$\to$ still moving horizontally!

$500 = 368.6 + 2(9.8)h_{max}$,

$\underline{h_{max} = 6.7\ m} = \underline{\quad\ m}$

② Kinematics: find max height above top of ramp:

$v_{fy}^2 = 0 = v_{oy}^2 - 2gy$, $\quad (\cancel{\ }\ 11.1)^2 = 2(9.8)y$, $y = \cancel{\ }\ 6.3\ m$,

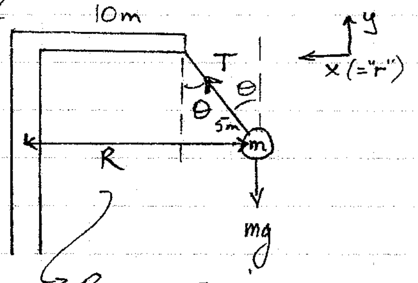
$y_{max} = 6.3 + 0.5 = \underline{6.8\ m}$

③ Cons. of Energy from top of ramp: $\frac{1}{2}\cancel{m}v_{ox}^2 + \frac{1}{2}mv_{oy}^2 + mgy_i = \frac{1}{2}\cancel{m}v_{ox}^2 + mgy_f$

$\underbrace{v_{oy}^2}_{(11.1)^2} = 2g(y_f - \underbrace{y_i}_{0.5})$, $y_f = \cancel{\ }\ 6.8\ m$

Problem V

(a.)



$\underline{R = 10 + 5\sin\theta}$

(b.) $\Sigma F_y = 0 = T\cos\theta - mg$, $\Sigma F_r = T\sin\theta = \frac{mv^2}{R}$

or

$\Sigma\vec{F} = m\vec{a} = \vec{T} + \vec{W} = \frac{mv^2}{R}\hat{i}$

$\Rightarrow T\cos\theta\,\hat{j} - mg\,\hat{j} + T\sin\theta\,\hat{i} = \frac{mv^2}{R}\hat{i}$

(c.) $T\cos\theta = mg$, $\quad T = mg/\cos\theta$ $\quad \left(\text{or, } T = \frac{mv^2}{(10 + 5\sin\theta)\sin\theta}\right)$

(d.) $\cos\theta = \frac{mg}{T_{max}} = \frac{(2000)9.8}{60{,}000\ N}$, $\cos\theta = 0.326$, $\underline{\theta = 70.9°}$

$\frac{mv^2}{(10 + 5\sin\theta)} = T\sin\theta$, $\quad \frac{(2000)v^2}{(14.7)} = 56{,}696$, $\quad v^2 = 416.7$, $\quad \underline{V = 20.4\ m/s}$