Physics 151 Class Exercise: Multi-Step Problems 2

1. A 1.34 kg block of wood is sitting on a wooden table and the coefficient of kinetic friction between the two surfaces is 0.24. Malcolm throws his giant 48 g wad of bubble gum which hits the block traveling horizontally with a velocity of 14.2 m/s and sticks to it. After the impact, how far does the block slide across the table?

First we need to apply conservation of momentum to determine the velocity of the block-gum combination after the impact.

$$p_{xi} = p_{xf}$$

$$m_{gum}v_{gum} = \left(m_{block} + m_{gum}\right)v_f$$

$$v_f = \frac{m_{gum}v_{gum}}{\left(m_{block} + m_{gum}\right)} = \frac{\left(0.048kg\right)\left(14.2\frac{m}{s}\right)}{\left(1.34kg + 0.048kg\right)} = 0.49\frac{m}{s}$$

Now apply conservation of energy with work done by a nonconservative force. Note that the normal force is just the weight of the block-gum combination.

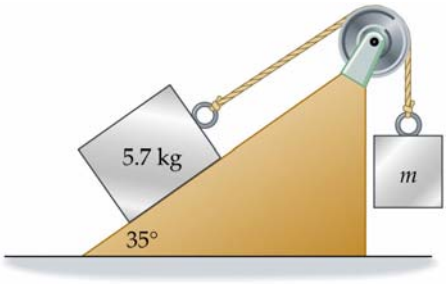
$$W_{NC} = KE_f + PE_f - KE_i - PE_i$$

$$W_{NC} = -KE$$

$$-\mu m_{combined} gd = -\frac{1}{2}m_{combined}v_f^2$$

$$d = \frac{v_f^2}{2\mu g} = \frac{\left(0.491\frac{m}{s}\right)^2}{2\left(0.24\right)\left(9.81\frac{m}{s^2}\right)} = 0.051m = 5.1cm$$

2. (a) Use dynamics and kinematics to determine the speed of the blocks after little m has fallen 0.25 m. Block m has a mass of 6 kg and the incline is frictionless.



Remember that we need to make the coordinate systems for each mass consistent so that a positive acceleration for both occurs when the pulley turns clockwise.

$$\Sigma F_{x-M} = T - Mg\sin\theta = Ma$$
$$\Sigma F_{y-m} = mg - T = ma$$
$$mg - Mg\sin\theta = (m+M)a$$
$$a = \frac{mg - Mg\sin\theta}{(m+M)} = \frac{\left(9.81\frac{m}{s^2}\right)\left[(6kg) - (5.7kg)\sin 35°\right]}{(6kg + 5.7kg)} = 2.29\frac{m}{s^2}$$

Now apply kinematics. The speed for the two objects must be the same. We know a, v_0, and x and want to solve for v, thus t is the variable not involved.

$$v^2 = v_0^2 + 2ax$$
$$v = \sqrt{2ax} = \sqrt{2\left(2.29\frac{m}{s^2}\right)(0.25m)} = 1.07\frac{m}{s}$$

(b) Use conservation of energy to verify your result to part (a).

It is useful to think carefully about what is happening. The heavy block looses GPE while the lighter block gains it. The net loss in GPE is what is converted into KE for both blocks. Note that when block m falls through a distance 0.25 m, block M rises through a distance of 0.25sin35º.

$$-\Delta PE_m - \Delta PE_M = KE_{fm} + KE_{fM}$$
$$-mg\Delta h - Mg\Delta h = \frac{1}{2}(m+M)v_f^2$$
$$v_f = \sqrt{\frac{2g(-m\Delta h_m - M\Delta h_m)}{(m+M)}} = \sqrt{\frac{2\left(9.81\frac{m}{s^2}\right)\left[-(6kg)(-0.25m) - (5.7kg)(0.25m\sin 35°)\right]}{(6.0kg + 5.7kg)}} = 1.07\frac{m}{s}$$