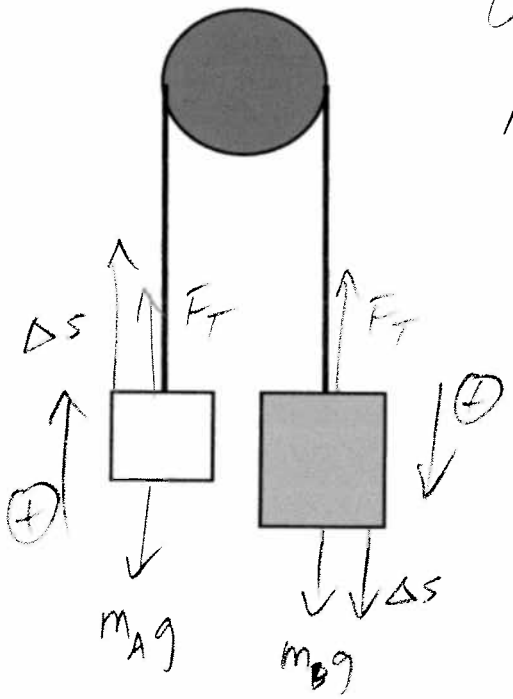
Physics 10154 - Summer 2013 - Exam #2A

Instructions: Be sure to SHOW ALL WORK and clearly indicate your answers. I will not give full credit if I cannot logically follow how you got your answer, even if the answer is correct. Partial credit will be given provided you are solving parts of the problem correctly. Clearly indicate your final answer, including correct units and significant figures.

1. (30 pts) Two masses (A = 5.0 kg, B = 8.0 kg) are connected by a massless, frictionless pulley as shown below. The system is released from rest, and mass B is allowed to fall a distance of 45 cm. What is the velocity of mass B at this point?



Using forces:

$A: \Sigma F_y = F_T - m_A g = m_A a$

$B: \Sigma F_y = m_B g - F_T = m_B a$

$m_B g - (m_A g + m_A a) = m_B a$

$m_B g - m_A g = (m_A + m_B) a$

$a = \frac{78.4 - 49.0}{13} = 2.26\ m/s^2$

$v_0 = 0$ $\quad v^2 = v_0^2 + 2a\Delta y$

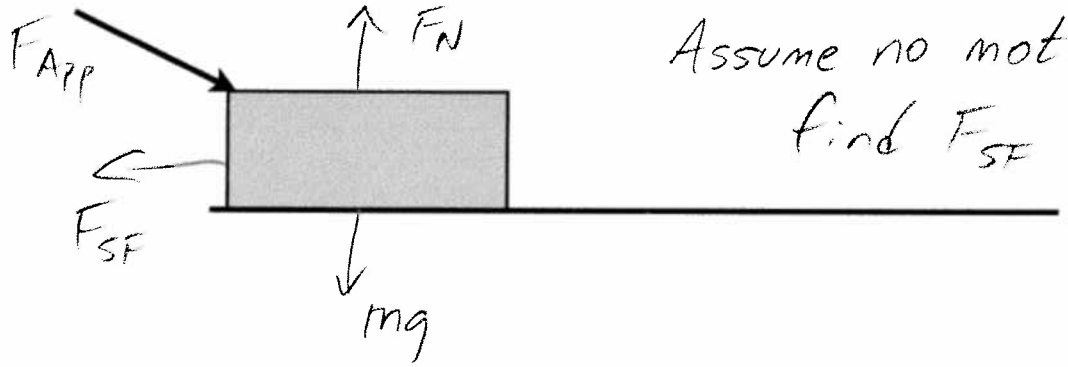
$\Delta y = .45m$ $\quad v = \sqrt{2a\Delta y} = 1.4\ m/s$

Using work: $\Sigma W_F = W_{grav,A} + W_{T,A} + W_{T,B} + W_{grav,B} = \frac{1}{2}(m_A + m_B)v^2$

$-m_A g \Delta s + F_T \Delta s - F_T \Delta s + m_B g \Delta s = \frac{1}{2}(m_A + m_B)v^2$

$-22.05 + 35.28 = \frac{1}{2}(13)v^2 \Rightarrow v = 1.4\ m/s$

2. (40 pts) A crate with a mass of 71 kg is being pushed by an applied force of 450 Newtons directed 26° below the horizontal as shown. The coefficient of static friction between the crate and the floor is 0.52. The coefficient of kinetic friction is 0.33. First, determine whether the crate moves and justify your answer mathematically. Second, if the crate moves, find the magnitude and direction of its acceleration. If it doesn't move, find the magnitude and direction of the force of static friction acting on the crate.



Assume no motion, $a = 0$, find F_{SF}

$$\Sigma F_{\parallel} = F_{App}\cos 26^\circ - F_{SF} = 0$$

$$\Sigma F_{\perp} = -F_{App}\sin 26^\circ - mg + F_N = 0$$

$$F_{SF} = 450\cos 26^\circ = 404.46$$

$$F_{SF,MAX} = \mu_s F_N$$

$$F_N = F_{App}\sin 26^\circ + mg$$

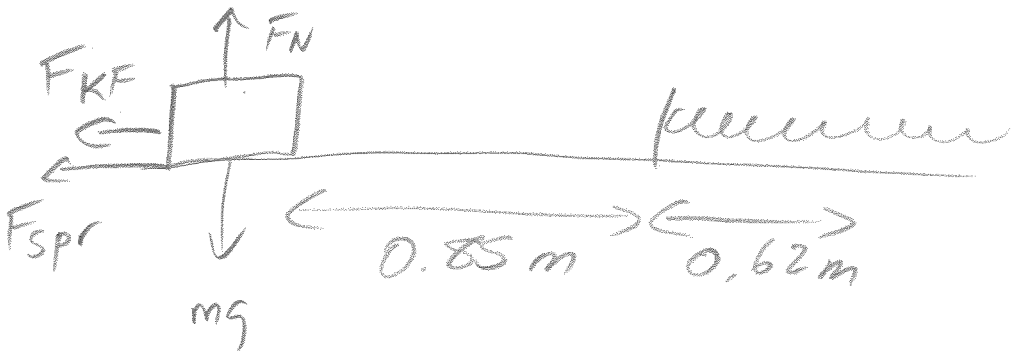
$$= 197.27 + 695.8 = 893.1$$

$$F_{SF,MAX} = (.52)(893.1) = 464.4$$

Since $F_{SF} < F_{SF,MAX}$, $a = 0$

$F_{SF} = 400\ N$, $-x$ dir

3. (30 pts) A 2.5 kg block has an initial velocity of 4.6 m/s across a rough, horizontal surface with a coefficient of kinetic friction of 0.33. The block travels 85 cm before encountering a horizontal spring, initially at equilibrium. The mass compresses the spring by a maximum amount of 62 cm while still on the rough surface. What is the spring constant, k, of the spring?



$$\Sigma W_F = W_N + W_{grav} + W_{spr} + W_{KF} = 0 - \frac{1}{2}mv_0^2$$

$W_N = 0$

$W_{grav} = 0$

$W_{spr} = -\frac{1}{2}kx^2$

$W_{KF} = -\mu_K F_N \Delta s = -\mu_K mg\Delta s$

$$-\frac{1}{2}kx^2 - \mu_K mg\Delta s = -\frac{1}{2}mv_0^2$$

$$\frac{1}{2}kx^2 + \mu_K mg\Delta s = \frac{1}{2}mv_0^2$$

$$\frac{1}{2}k(.62)^2 + (.33)(2.5)(9.8)(1.47) = \frac{1}{2}(2.5)(4.6)^2$$

$$.192k + 11.88 = 26.45$$

$$k = 76\ N/m$$