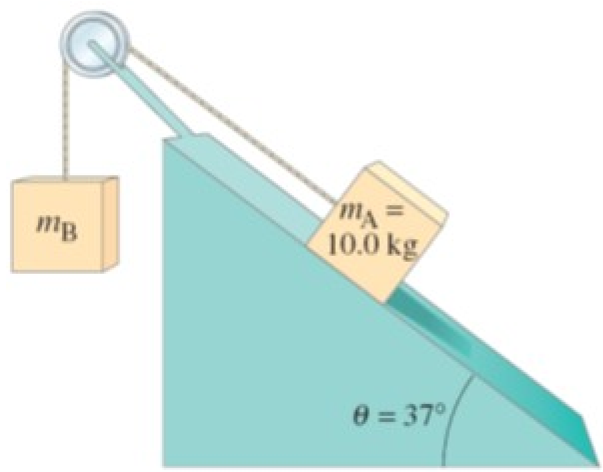
Phys101 Tutorial Worksheet 2

Name:______________________

Computing ID:______________________

A ramp, a pulley, and two boxes



The question (3 minutes)

Box A, of mass 10.0 kg, rests on a surface inclined at 37° to the horizontal. It is connected by a lightweight cord, which passes over a massless and frictionless pulley, to a second box B, which hangs freely as shown. (a) If the coefficient of static friction is 0.40, determine what range of values for mass B will keep the system at rest. (b) If the coefficient of kinetic friction is 0.30, and m_B = 10.0 kg, determine the acceleration of the system.

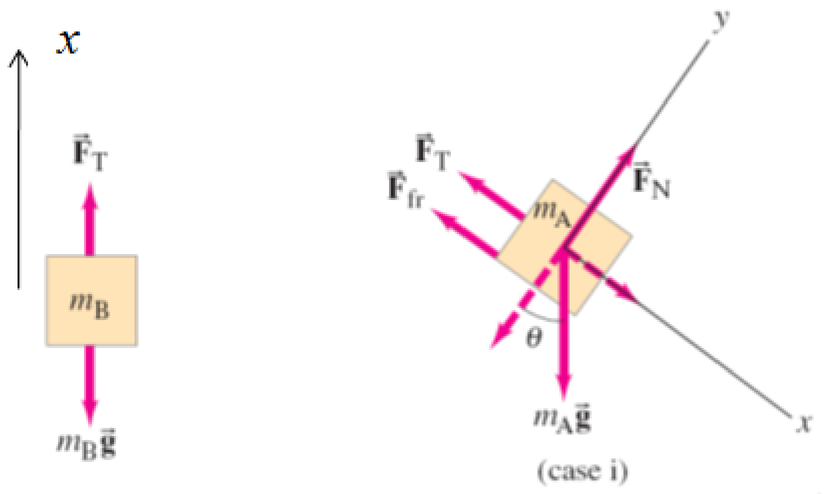
(a) We need to draw the free-body diagrams, of course. (5 minutes)

But we get stuck in deciding the direction of the frictional force between block A and the inclined plane. How should we approach? (discuss for 3 minutes)

Answer: Analyze 2 possible cases (almost like solving 2 problems).

case 1: Block A tends to slide down: Block B is small. (20 minutes)

Free-body diagrams (5 minutes for discussion, 5 minutes to show).



Write down Newton's law in the component form for both objects.

$$m_A g \sin\theta - F_T - F_{fr} = m_A a_x$$
$$F_N - m_A g \cos\theta = 0$$
$$F_T - m_B g = m_B a_x$$

Solve for m_B

$$\text{we want } a_x = 0,$$
$$\text{maximum static friction}: F_{fr} = \mu_S F_N$$
$$m_A g \sin\theta - F_T - \mu_S F_N = 0$$
$$F_N = m_A g \cos\theta$$
$$F_T = m_B g$$

$$m_A g \sin\theta - m_B g - \mu_S m_A g \cos\theta = 0$$

$$m_B = m_A \sin\theta - \mu_S m_A \cos\theta$$
$$m_B = 10 \sin 37° - (0.40)(10) \cos 37°$$
$$m_B = 2.8 kg$$

case 2: Block A tends to slide up: Block B is large (10 minutes).

$$m_A g\sin\theta - F_T + F_{fr} = 0$$

$$m_B = m_A \sin\theta + \mu_S m_A \cos\theta$$

$$m_B = 10\sin 37° + (0.40)(10)\cos 37°$$

$$m_B = 9.2kg$$

Conclusion:

$$2.8kg < m_B < 9.2kg$$

(b) Now $\mathrm{m_B} = 10kg > 9.2kg,$ **Block B is large:**

$$m_A g\sin\theta - F_T + F_{fr} = m_A a_x$$

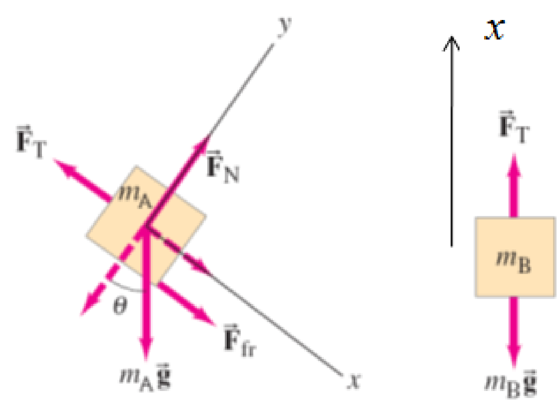
$$F_N - m_A g\cos\theta = 0$$

$$F_T - m_B g = m_B a_x$$

$$\text{Kinetic friction}: F_{fr} = \mu_k F_N$$

$$F_N = m_A g\cos\theta$$

$$F_T = m_B g + m_B a_x$$



(case ii)

$$\boldsymbol{m_A g\sin\theta - m_B g - m_B a_x + \mu_k m_A g\cos\theta = m_A a_x}$$

$$m_A g\sin\theta - m_B g + \mu_k m_A g\cos\theta = m_A a_x + m_B a_x$$

$$a_x = \frac{m_A g\sin\theta - m_B g + \mu_k m_A g\cos\theta}{m_A + m_B}$$

$$a_x = -0.78\,m/s^2$$