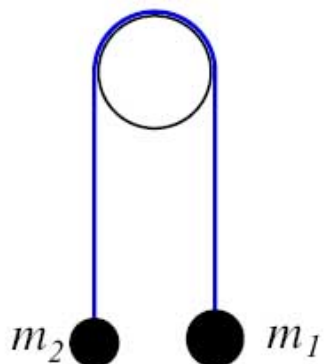


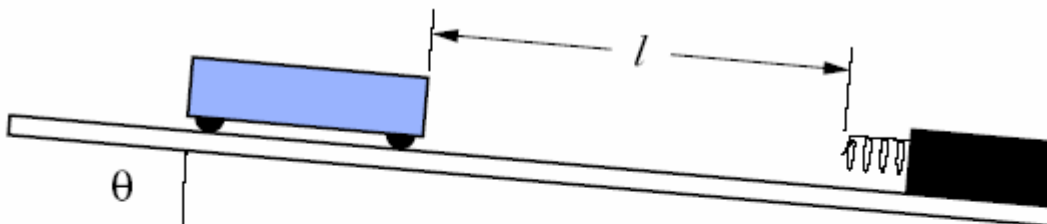
### Problem 1: Experiment Five b) Analysis

Two unequal masses ( $m_1 > m_2$ ) are suspended by a string over a rod. The coefficient of static friction between the string and the rod is  $\mu_s$ , and the coefficient of sliding friction is  $\mu_k < \mu_s$ . Recall that the tension in the string is not constant (see Problem Set 5: Problem 3 part b).

- What is the largest ratio  $m_1/m_2$  before the string starts to slide?
- What is the magnitude of the acceleration of the masses after sliding has begun.



### ~~Problem 2: Experiment 6 Pre-Lab Question~~



A cart of mass  $M$  rolls down a track inclined at an angle  $\theta$ . The cart starts from rest a distance  $l$  up the track from a spring, and rolls down to collide with the spring.

- Assuming no non-conservative work is done, what is the speed of the cart when it first contacts the spring? (Express your answer in terms of the given variables and the gravitational acceleration  $g$ .)
- Suppose the spring has a force constant  $k$ . What is the peak force compressing the spring during the collision?

**Problem 1. Experiment 5 b) Analysis.**

a) We know that when the string is about to slide, the tension varies as  $T(\theta) = T_0 e^{-\mu_s \theta}$ . It means that  $T_2 = T_1 e^{-\mu_s \pi}$ . On the other hand, analyzing the free-body diagrams for the masses, we conclude that  $T_1 = m_1 g$  and  $T_2 = m_2 g$ . Thus the maximum ratio of the masses before the string starts to slide is

$$\frac{m_1}{m_2} = e^{\mu_s \pi}$$

b) If we assume that the string is massless, the derivation of the tension of the string, which is given in the description of Experiment 5 b) is unchanged, except that the friction force is now  $\mu_k N$ . Thus the tension varies as  $T(\theta) = T_0 e^{-\mu_k \theta}$ . Since both masses move with the same acceleration,  $T_1 - m_1 g = -m_1 a$  and  $T_2 - m_2 g = m_2 a$ . Thus

$$m_2(g + a) = m_1(g - a)e^{-\mu_k \pi}.$$

The solution of this equation is

$$a = g \frac{m_1 e^{-\mu_k \pi} - m_2}{m_2 + m_1 e^{-\mu_k \pi}}$$

~~**Problem 2. Experiment 6 Pre-Lab Question.**~~

~~a) The work done on the cart by the force of gravity before it comes in contact with the spring is~~

~~$$W = (mg \sin \theta)l$$~~

~~and is equal to the change in the kinetic energy of the cart  $W = K_f - K_i = mv_f^2/2$ . Thus the velocity of the cart when it first contacts the spring is~~

~~$$v_c = \sqrt{2gl \sin \theta}.$$~~

~~b) The peak force is achieved when the spring compression is at maximum, i.e. just before the spring is about to bounce back. Assuming this point~~