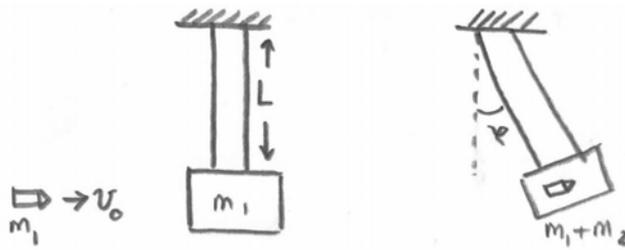


**Problem 4: (Ballistic Pendulum)**

A simple way to measure the speed of a bullet is with a ballistic pendulum. This consists of a wooden block of mass  $m_1$  into which a bullet of mass  $m_2$  is shot. The block is suspended from two cables, each of length  $L$ . The impact of the bullet causes the block and embedded bullet to swing through a maximum angle  $\varphi$ . The initial speed of the bullet is  $v_0$ .

- How fast is the block and embedded bullet moving immediately after the bullet comes to rest in the block? Assume that the time the bullet takes to come to rest is negligibly small. Express your answer in terms of the quantities  $m_1$ ,  $m_2$ ,  $L$ ,  $g$ ,  $v_0$ , and  $\varphi$ . You may not need all these quantities.
- Find a relation for the initial speed of the bullet as a function of  $m_1$ ,  $m_2$ ,  $L$ ,  $g$ , and  $\varphi$ .



~~**Problem 5: Experiment 8 Physical Pendulum Pre-experiment Question**~~

~~Consider a uniform ruler shown in the figures below. The ruler has mass  $m_1$ , width  $a$  and length  $b$ . The ruler is pivoted about a point at one end and allowed to oscillate. The pivot point is a distance  $l$  from the center of mass.~~

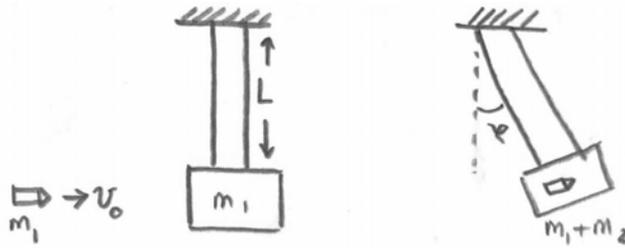


- ~~If the ruler is given a small initial displacement by an angle of 5 degrees to one side, explain why it will undergo simple harmonic motion.~~
- ~~If the initial displacement is increased by an additional twenty degrees will the period increase, decrease, or stay the same?~~

**Problem 4: (Ballistic Pendulum)**

A simple way to measure the speed of a bullet is with a ballistic pendulum. This consists of a wooden block of mass  $m_1$  into which a bullet of mass  $m_2$  is shot. The block is suspended from two cables, each of length  $L$ . The impact of the bullet causes the block and embedded bullet to swing through a maximum angle  $\varphi$ . The initial speed of the bullet is  $v_0$ .

- How fast is the block and embedded bullet moving immediately after the bullet comes to rest in the block? Assume that the time the bullet takes to come to rest is negligibly small. Express your answer in terms of the quantities  $m_1$ ,  $m_2$ ,  $L$ ,  $g$ ,  $v_0$ , and  $\varphi$ . You may not need all these quantities.
- Find a relation for the initial speed of the bullet as a function of  $m_1$ ,  $m_2$ ,  $L$ ,  $g$ , and  $\varphi$ .



- Using conservation of momentum we have for the speed of the system just after the collision  $v$ :

$$v = m_2 \frac{v_0}{m_1 + m_2}$$

- Using conservation of energy we have

$$(m_1 + m_2)gL(1 - \cos(\theta)) = 2(m_1 + m_2)gL \sin^2\left(\frac{\theta}{2}\right) = \frac{1}{2}(m_1 + m_2)v^2$$

from which:

$$v_0 = (m_1 + m_2) \frac{v}{m_2} = 2 \sin\left(\frac{\theta}{2}\right) \sqrt{gL} \frac{m_1 + m_2}{m_2}$$