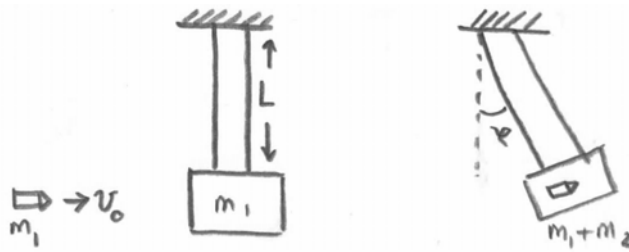


Problem 4: (Ballistic Pendulum)

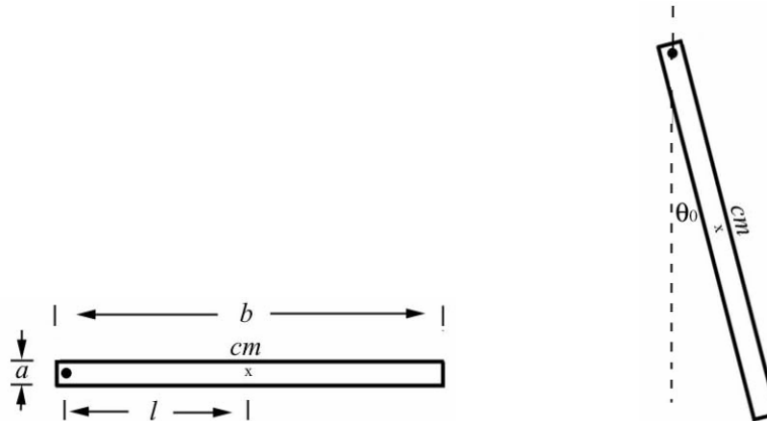
A simple way to measure the speed of a bullet is with a ballistic pendulum. This consists of a wooden block of mass m_1 into which a bullet of mass m_2 is shot. The block is suspended from two cables, each of length L . The impact of the bullet causes the block and embedded bullet to swing through a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



Problem 5: Experiment 8 Physical Pendulum Pre-experiment Question

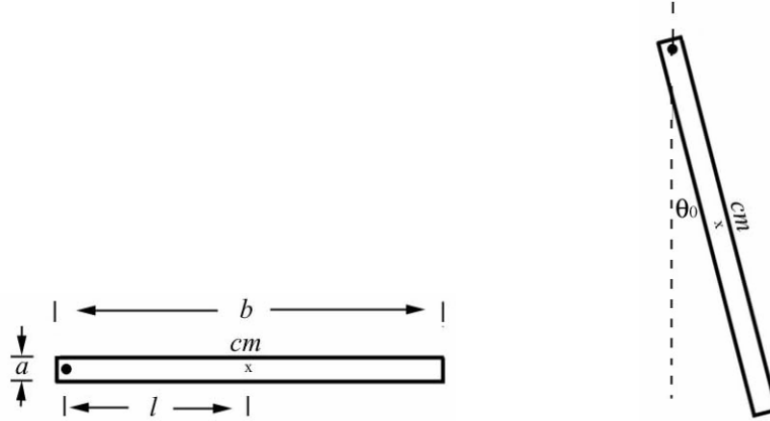
Consider a uniform ruler shown in the figures below. The ruler has mass m_1 , width a and length b . The ruler is pivoted about a point at one end and allowed to oscillate. The pivot point is a distance l from the center of mass.



- 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?

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- The equation of motion for the angle θ is:

$$I \frac{d^2\theta}{dt^2} = -m_1 l g \sin(\theta)$$

where I is the momentum of inertia of the ruler around the suspension point and the right hand side is the torque of the gravitational force around it.

For small θ the equation reduces to:

$$I \frac{d^2\theta}{dt^2} = -m_1 l g \theta$$

which is exactly of the form required for harmonic motion with $\omega = \sqrt{\frac{m_1 l g}{I}}$.

- If the initial displacement is not small the absolute value of the torque $|m_1 l g \sin(\theta)| < |m_1 l g \theta|$ so that the period will increase.