

Uniform Circular Motion – Concepts – Alternate Lab

DISCUSSION OF PRINCIPLES

Part 1: Experimental Determination of Mass

The principle behind this experiment is that the weight of the hanging mass provides a tension that will provide the centripetal force for the swinging mass. Thus, for a mass moving in a horizontal arc, the weight of the hanging mass, $m_h g$, is equal to the centripetal force on the stopper, $M_s \frac{v^2}{r}$.

The speed of the moving mass can be related to the period of rotation and the radius of the path. Since speed is distance over time for constant speed, the distance of a circular path (the circumference, $2\pi r$) divided by the time to travel the path (the period, T) gives the speed:

$$v = \frac{2\pi r}{T}. \quad (1)$$

So the centripetal acceleration is

$$a_c = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}. \quad (2)$$

In this case, the radius of the path will be L , the length of string between the end of the tube and the stopper.

Note that the centripetal force is being provided by the tension in the string necessary to support the weight of m_h . That is,

$$F_c = F_T = m_h g, \quad (3)$$

which yields

$$m_h g = M_s a_c. \quad (4)$$

This will be useful for calculating M_s from the slope of the trend line.

Part 2: An Alternate Method

In Part 1, an approximation is being made that the only force acting on the stopper is the tension in the string, and so the tension equals the centripetal force. In reality, gravity plays a role

in the process as well.

The string will actually be at an angle, as shown in Figure 1, rather than purely horizontal. In this case, the tension force (calculated with $m_h g$), is the hypotenuse of a right triangle, where the vertical side is the gravitational force on the stopper, $M_s g$, and the horizontal component is the centripetal force, $M_s \frac{v^2}{r}$.

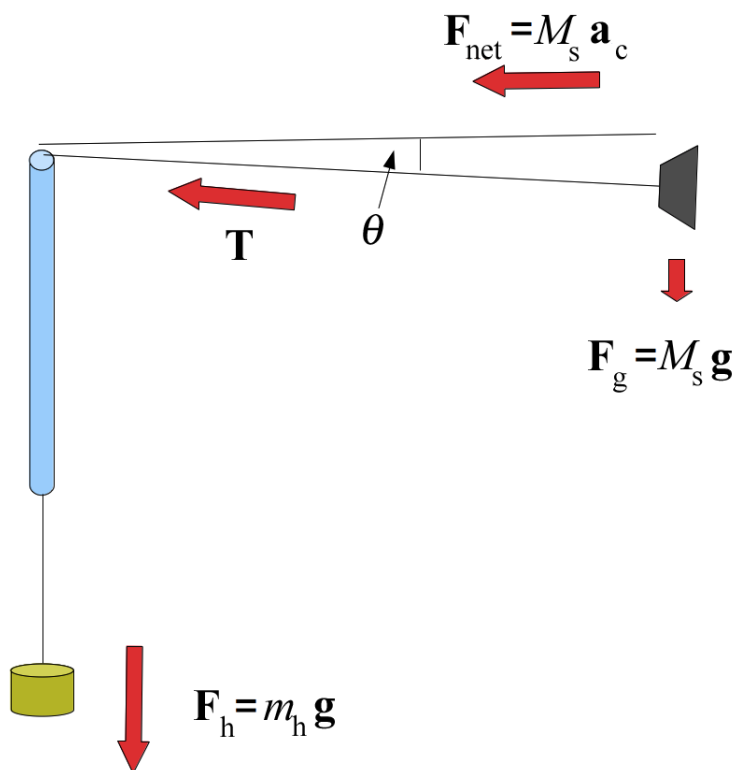


Figure 1: Including the force of gravity on the stopper

This means that when you include gravity, the centripetal force term, $M_s a_c$, is actually equal to only the horizontal component of the tension, $m_h g \cos(\theta)$.

$$M_s a_c = m_h g \cos(\theta) \quad (5)$$

The easiest way to determine the angle is to pause the video at a point where you can clearly see the angle θ and hold a small protractor up to the screen.