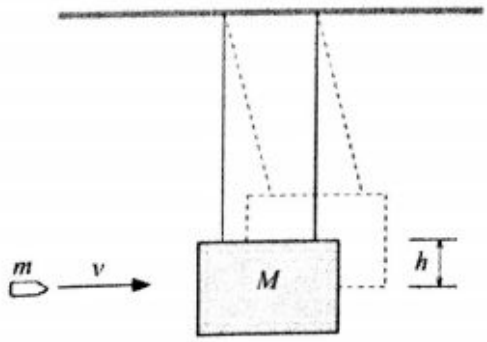
BALLISTIC PENDULUM

(*College Physics* 10th ed. pages 182–183/11th ed. pages 172–173)

A ballistic pendulum is a device used to measure the velocities of small projectiles such as bullets. The simplest model of a ballistic pendulum consists of a block of wood hanging by vertical cords. When a bullet is fired and embeds itself in the wood block, it transfers momentum and energy to the block, causing it to swing through an arc. By measuring the mass of the block, M, and the mass of the bullet, m, and by measuring the vertical elevation, h, of the block, the initial velocity of the bullet can be determined.

The momentum (mv) of the flying bullet becomes the momentum of the combined mass ($M + m$). That mass has some kinetic energy that is converted to gravitational potential energy ($M + m)gh$ as the block rises.



SAMPLE PROBLEM 9

Consider the above diagram. A 10 g bullet is fired into the stationary 3990 g block of a ballistic pendulum. The bullet is captured in the block, elevating it vertically by 0.03 m.

(a) What is the velocity, V, of the block-bullet system just after impact?

(b) What is the velocity, v, of the bullet prior to impact with the block?

SOLUTION TO PROBLEM 9

(a) Mechanical energy is conserved from the time the bullet impacts the block through its 0.03 m rise. Writing the law of conservation of mechanical energy:

$E_0 = E$ and at the moment just after impact

$\frac{1}{2}(m + M)V^2 = (m + M)gh$. Solving for V:

$$V = \sqrt{2gh} = \sqrt{2\left(9.8\ \frac{m}{s^2}\right)(0.03\ m)} = 0.77\ \frac{m}{s}$$

(b) On impact, $\Sigma p_0 = \Sigma p$ and $mv = (m + M)V$. Solving for the initial velocity of the bullet, v:

$$v = \frac{(m + M)V}{m} = \frac{(4.0\ kg)\left(0.77\ \frac{m}{s}\right)}{0.01\ kg} = 308\ \frac{m}{s}$$