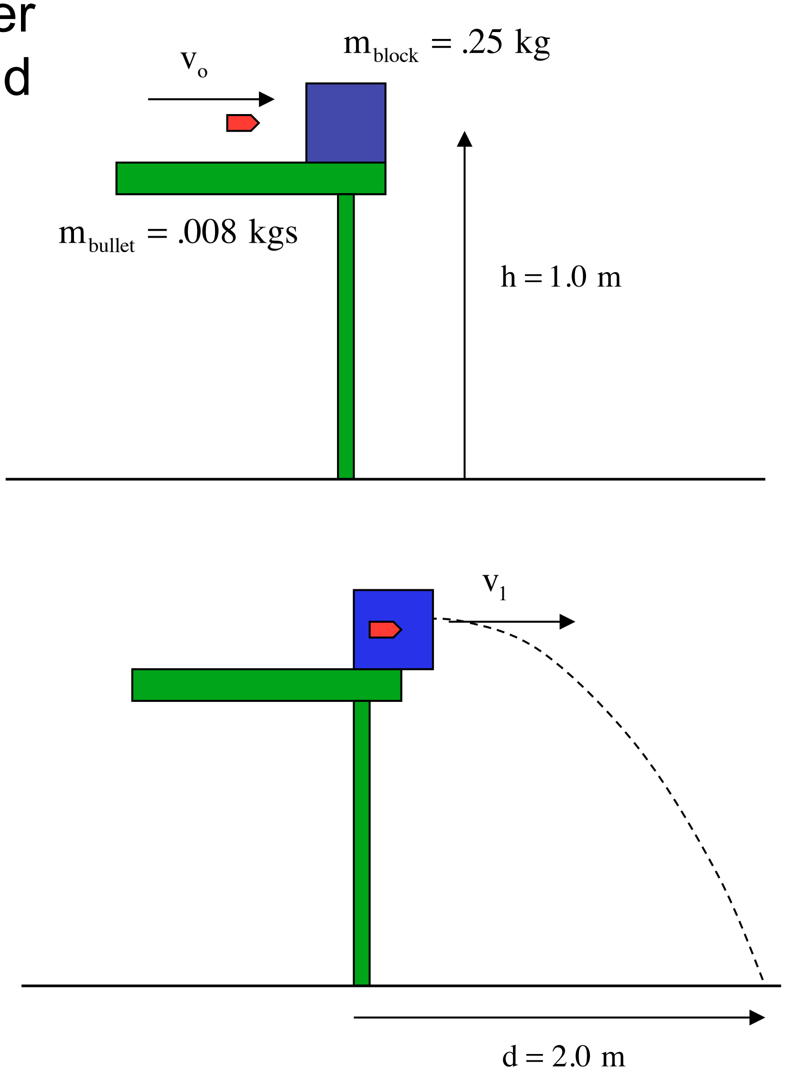
Problem 6.40

An 8 gram bullet fired into a 250 gram block initially at rest at edge of 1.0 meter high table. If bullet remains in block and lands 2 meters from table after impact:



a.) Where is energy conserved?

b.) Where is energy not conserved?

c.) Where is momentum conserved?

d.) What kind of collision is this?

e.) What must the initial velocity be?

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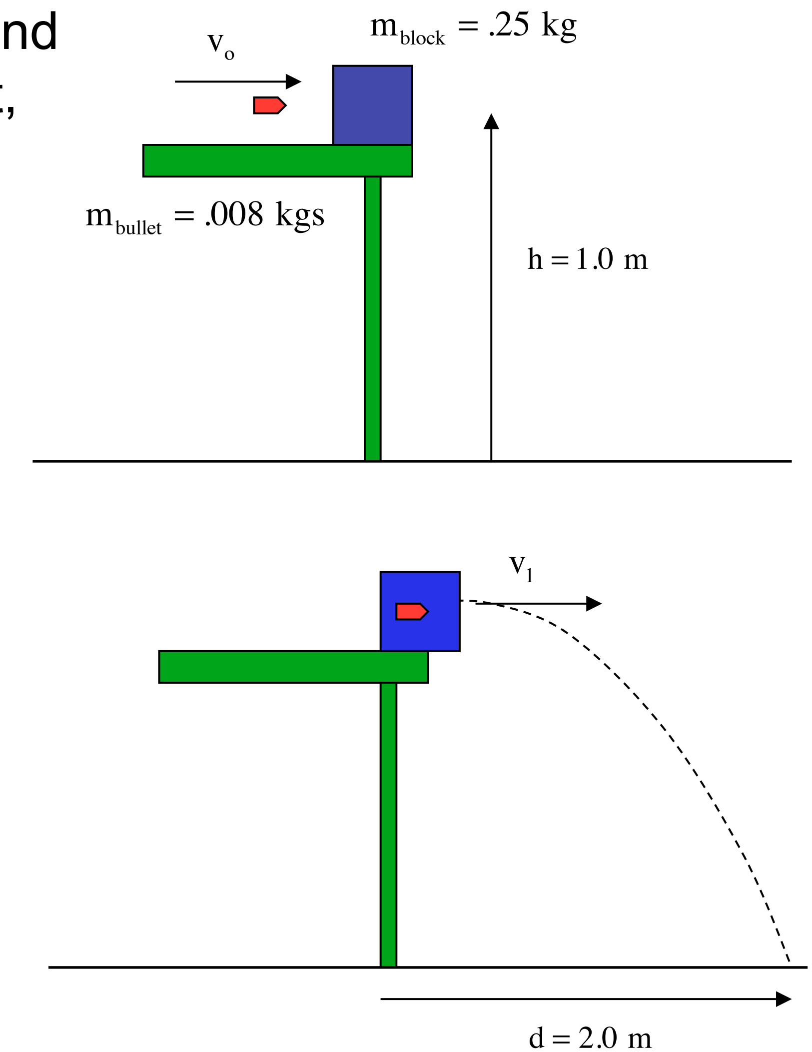

a.) Where is energy conserved?

Energy is conserved after the collision.

b.) Where is energy not conserved?

Energy is not conserved through the collision (it takes energy to deform the block making the hole).

c.) Where is momentum conserved?

There are no external forces acting through the collision, so momentum is conserved through the collision.

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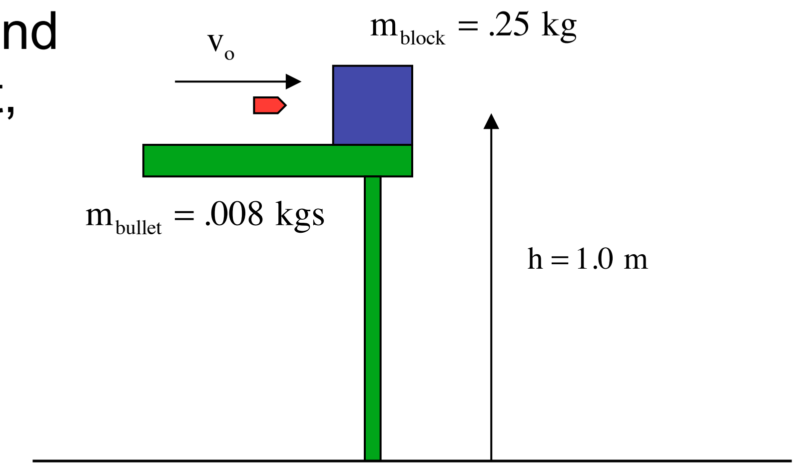
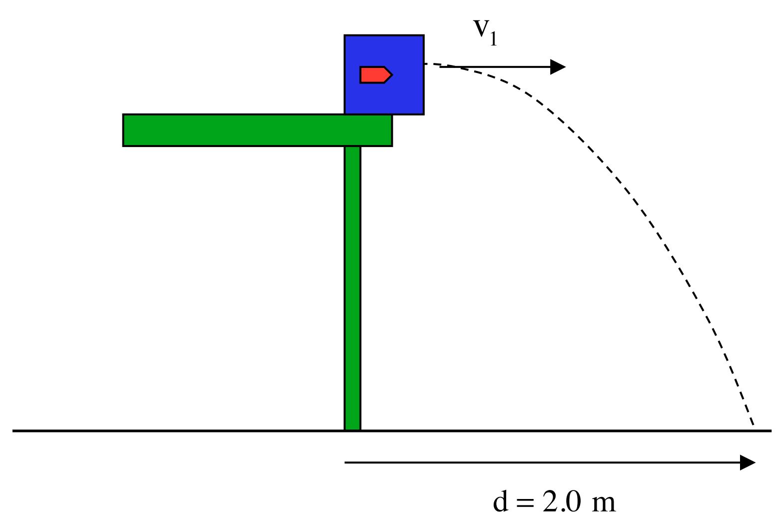


d.) What kind of collision is this?

This is what is called an *inelastic* collision.

e.) What must the initial velocity be?



To do this, we need to use conservation of momentum when it is acceptable and conservation of energy when it is acceptable.

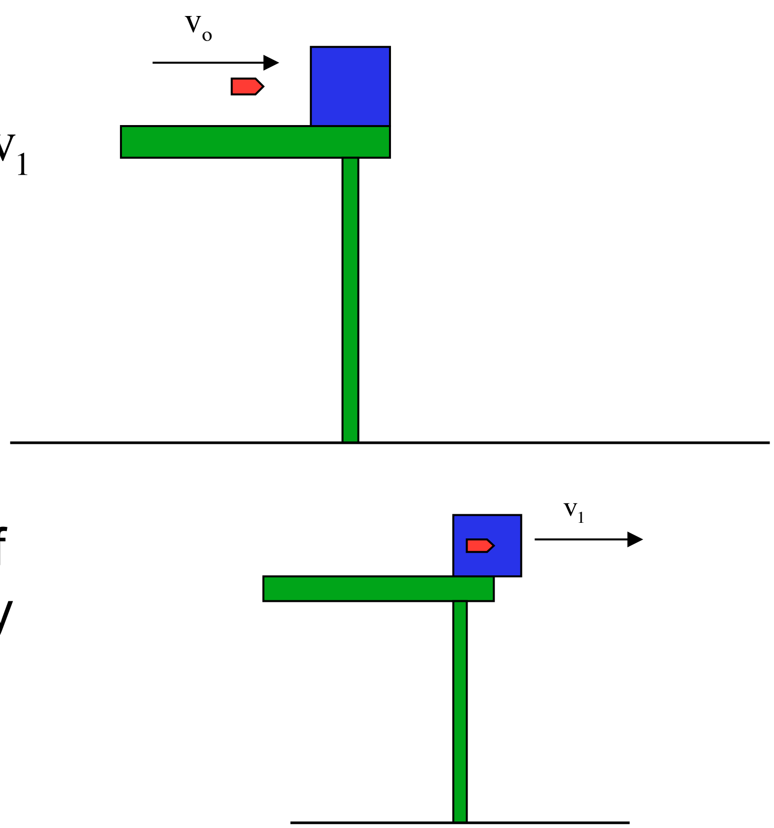
Through the collision, momentum is conserved:

$$\sum p_{initial,x} + \sum F_{ext}\Delta t = \sum p_{final,x}$$

$$m_{bullet}v_o + 0 = \left(m_{bullet} + m_{block}\right)v_1$$

$$\Rightarrow (.008)v_o = \left(.008 + .25\right)v_1$$

$$\Rightarrow v_o = 32.25v_1$$



If we can figure out v_1, we have it. It may be tempting to try conservation of energy, but we don't know the velocity when the block reaches the floor so kinematics is out best bet.

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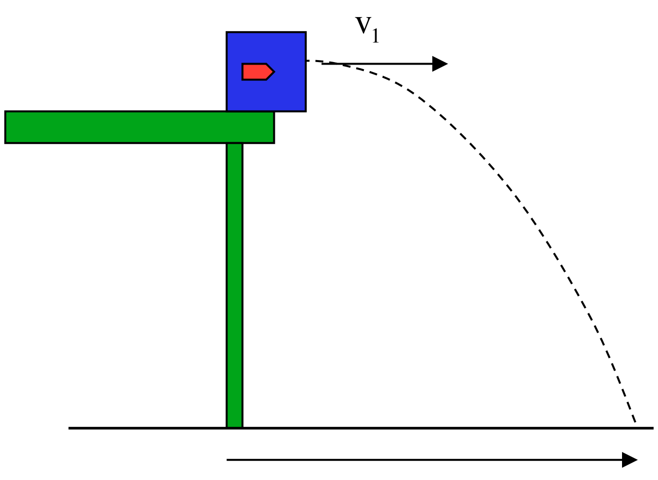
With no acceleration in the "x" direction and an initial "x" velocity of "v_1," kinematics yields:



$$\Delta x = v_1 t$$

$$\Rightarrow \quad 2 = v_1 t$$

$$\Rightarrow \quad v_1 = \frac{2}{t}$$

With acceleration of gravity in the "y" direction and no initial "y" velocity, kinematics yields:

$$(y_2 - y_1) = \cancelto{0}{v_{o,y}}\, t + \frac{1}{2}(-g)t^2$$

$$\Rightarrow \quad (0 - 1) = -4.9t^2$$

$$\Rightarrow \quad t = \left(\frac{1}{4.9}\right)^{1/2} = .45 \text{ seconds} \quad \text{so that} \quad v_1 = \frac{2}{t} = \frac{2}{.45} = 4.44 \text{ m/s}$$

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This means that:

$$v_o = 32.25 v_1$$
$$= (32.25)(4.44 \text{ m/s})$$
$$= 143.2 \text{ m/s}$$