The bullet, the block and the spring

An 8 gram bullet fired at a 30 degree angle into a 250 gram block initially at rest on a frictional table, where the coefficient of friction of .2. Attached to the block is a spring whose spring constant is k=40 nt/m.

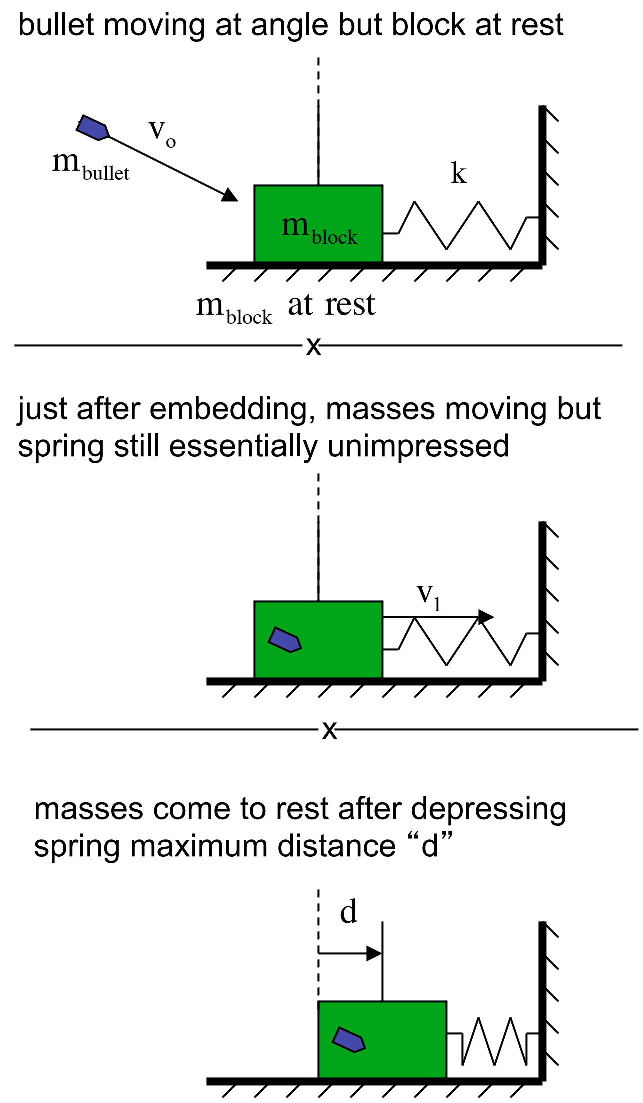
a.) Where is energy conserved?

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?



a.) Where is energy conserved?

Energy is not conserved THROUGH the collision. Also, due to friction, energy is not conserved after the collision, though you can use the modified conservation of energy relationship because you know enough to determine the amount of extraneous work friction does.

c.) Where is momentum conserved?

Momentum is conserved in the "x" direction through the collision but only through the collision (see note on next page). It is not conserved in the "y" direction as the normal force provides an enormous external impulse in that direction.

d.) What kind of collision is this?

It is an perfectly inelastic collision.

e.) What must the initial velocity be?

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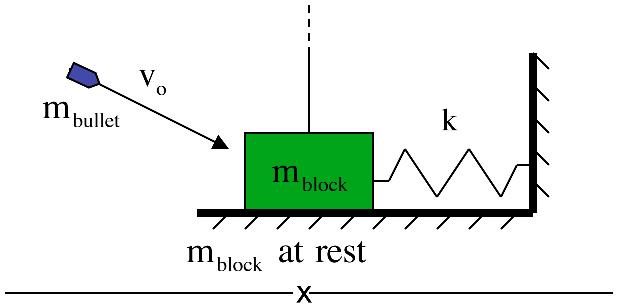
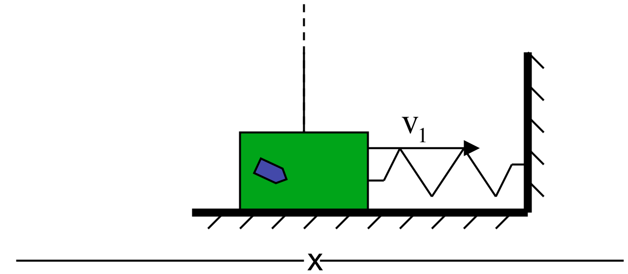
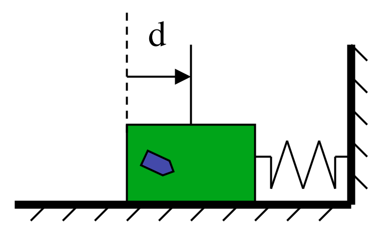
bullet moving at angle but block at rest



just after embedding, masses moving but spring still essentially unimpressed



masses come to rest after depressing spring maximum distance "d"

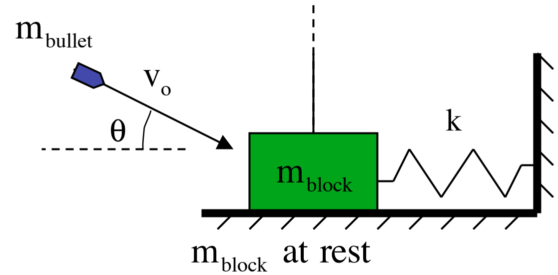


An 8 gram bullet fired at a 30 degree angle into a 250 gram block initially at rest on a frictional table, where the coefficient of friction of .2. Attached to the block is a spring whose spring constant is k=40 nt/m.

a.) What must the initial velocity be?

There is friction in the "x" direction, so there will be an external impulse in that direction as the block moves to the right. Still, if all you are looking at is the time interval through the collision, things will happen so fast that friction will not have the time to affect the overall "x"-directed momentum of the system to any great degree. In other words, for that tiny time interval you can use the modified conservation of momentum relationship and assume the external impulse factor is essentially zero for the interval. As for the "y" direction, the normal force produces an enormous impulse that makes conservation of momentum unusable even through the collision.

bullet moving at angle but block at rest



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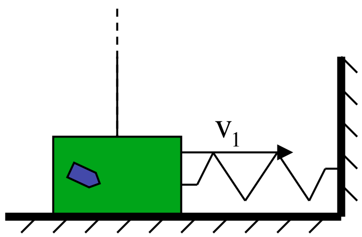

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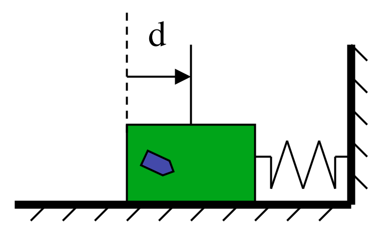


THROUGH THE COLLISION in the "x" direction:

$$\sum p_{1,x} + \sum F_{ext,x}\Delta t = \sum p_{2,x}$$

$$m_{bullet}(v_o)(\cos\theta) + 0 = (m_{bullet} + m_{block})v_1$$

$$(.008\text{kg})(v_o)(\cos 30^\circ) = (.008\text{kg} + .25\text{kg})v_1$$

$$\Rightarrow v_o = 37.24 v_1$$

Figure out v_1 and you've got it.

An 8 gram bullet is fired at a 30 degree angle into a 250 gram block initially at rest on a frictional table, where the coefficient of friction of .2. Attached to the block is a spring whose spring constant is k=40 nt/m. If the spring deflects a maximum of .4 meters:

To get the after-collision velocity v_1, we need to deal with energy consideration as they exist after the collision (that is, just after the bullet embeds until both the bullet and block come to rest under the influence of the spring). Noting that JUST after the collision the spring will have deflected only a tiny, tiny bit (ignorable, in other words), we can write":

$$\sum KE_1 + \sum U_1 + \sum W_{ext} = \sum KE_2 + \sum U_2$$

$$(1/2)(m_{bullet} + m_{block})v_1^{\,2} + 0 + (-f_k d) = 0 + (1/2)kd^2$$

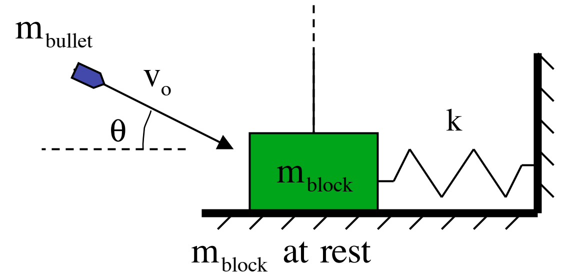
$$\Rightarrow \quad (1/2)(m_{bullet} + m_{block})v_1^{\,2} - \left[\mu_k (m_{bullet} + m_{block})gd\right] = (1/2)kd^2$$

$$\Rightarrow \quad (1/2)(.008+.25)v_1^{\,2} - \left[(.2)(.008+.25)(9.8)(.4)\right] = (1/2)(40)(.4)^2$$

$$\Rightarrow v_1 = 5.14 \text{ m/s}$$

$$\Rightarrow v_o = 37.24 v_1 = (37.24)(5.14) = 191 \text{ m/s}$$

bullet moving at angle but block at rest



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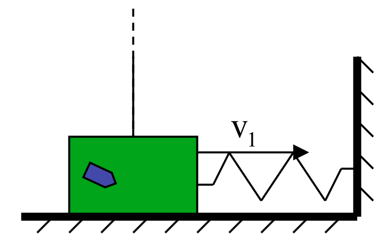

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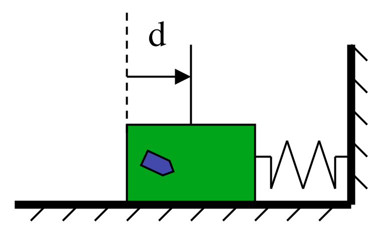

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