Q- A bullet with a mass of 45 g is fired upward through a hole in a table into a block of wood with a mass of 5.2 kg. The bullet lodges in the block and the two rise to a height of 3.1 m above the table.

1. Calculate the potential energy of the block above the table.
2. Calculate kinetic energy and velocity of the block as it left the table.
3. Calculate the velocity of the bullet as it struck the block.
4. Calculate the kinetic energy of the bullet immediately before it struck the block.

Solutions:

1. Considering the tabletop as the reference level the potential energy of the block with bullet lodged will be

$$PE = m*g*h = (5.2 + 0.045)*9.8*3.1 = 159.343 \text{ J}$$

2. Calculate kinetic energy and velocity of the block as it left the table.

This potential energy is gained due to work done against gravity which is done by the body by losing its kinetic energy. Hence gain in potential energy at the highest point is equal to the kinetic energy at the table top. Gives

KE at the table = potential energy at highest point = 159.343 J

If the velocity just before leaving the table is v then

$$KE = \tfrac{1}{2} Mv^2$$

Or $\tfrac{1}{2} (5.2 + 0.045)*v^2 = 159.343$

Gives $v^2 = 60.76$

Or $v = 7.795$ m/s

3. Calculate the velocity of the bullet as it struck the block.

As the bullet is lodged to the block the loss of energy in form of heat will be there and hence we can't conserve energy in the process. But as the collision is instantaneous i.e. the time taken is very short we can conserve momentum just before and after the impact and hence momentum of the bullet just before the impact will be equal to the momentum of the combined body just after the impact and hence if initial velocity of bullet is v_o then

$$0.045*v_o = (5.2 + 0.045)*7.795$$

Gives $v_o = 908.55$ m/s

4. Calculate the kinetic energy of the bullet immediately before it struck the block.

The kinetic energy of bullet just before the impact will be

$$KE_B = \tfrac{1}{2} *0.045*908.55^2 = 18572.92 \text{ J}$$

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