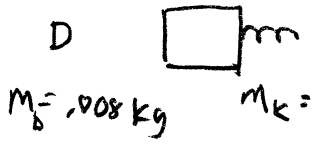
Group Problem

You are working as an intern for the CIA analyzing the effectiveness of rifles used by various para-military groups throughout the world. The apparatus used for measuring the velocity of the bullets shot from the rifles consists of a Kevlar block attached to a horizontal spring. To use this apparatus, you shoot a bullet at the Kevlar block that sits on a nearly frictionless horizontal surface. The bullet embeds itself in the block, then the block and bullet compress the spring some distance and comes to rest. In one trial, an 8.00 gram bullet strikes a 0.992 kg block that rests on the frictionless surface. After the collision, the bullet and block compress the spring 15.0 cm. From a previous calibration, you know that a force of 0.750 N compresses the spring 0.250 cm. With this information, you are able to report the initial velocity of the bullet to your supervisor.

FOCUS the PROBLEM

Draw a Picture Using ALL Given Information



For .750N
Compresses spring
$\Delta x' = .00250\,m$

Questions(s) what is the initial speed of the bullet

Approach

Use conservation of momentum during the collision and conservation of energy after collision, changing kinetic energy to elastic potential energy. To find spring constant use Hooke's law

DESCRIBE the PHYSICS

Diagram(s) and Define Quantities

Momentum

<Before>	<Transfer>	<After>
$V_{b1} = ?$	None	$m = 1.00\,kg$
$V_{k1} = 0$		$V_2 = ?$
$m_b = .008\,kg$		
$m_k = .992\,kg$		

Energy

<Before>	<Transfer>	<After>
$m = 1.00\,kg$	None	$V_3 = 0$
$V_2 = ?$		$\Delta x_3 = .15\,m$
$\Delta x_2 = 0$		

$F' = .750N \quad \Delta x' = .00250m$

Target Quantity(ies)

V_{b1}

Quantitative Relationships

$W_{ext} = \Delta K + \Delta U + \Delta E_{int}$

$\vec{I} = \Delta \vec{p}$

$F = -k\Delta x$

$K = \frac{1}{2}mv^2$

$U = \frac{1}{2}k|\Delta x|^2$

PLAN the SOLUTION

Construct Specific Equations (Same Number as Unknowns)

Use momentum to solve for V_1

$\vec{I} = \Delta\vec{p} = 0$

$\vec{p}_1 = \vec{p}_2$

UNKNOWNS

V_{1b} V_2

$m_{1b}V_{1b} = mV_2$ ①

Use Energy to solve for V_2

$W_{nc}^{\nearrow 0} = \Delta K + \Delta U + \Delta E_{mt}^{\nearrow 0}$

$K_2 + U_{E2}^{\nearrow 0} = K_3^{\nearrow 0} + U_{E3}$

$\frac{1}{2}mV_2^2 = \frac{1}{2}k\Delta x_3^2$ ② k

Use Hookes Law to solve for k

$F' = k\Delta x'$

$k = \frac{F'}{\Delta x'}$ ③

Plug ③ into ②

$V_2^2 = \frac{k}{m}\Delta x_3^2 = \frac{F'}{\Delta x'}\cdot\frac{\Delta x_3^2}{m}$ ④

Plug ④ into ①

$V_{1b} = \frac{mV_2}{m_{1b}} = \sqrt{\frac{F'm}{\Delta x'}}\ \frac{\Delta x_3}{m_{1b}}$

Check Units

$\left\{\frac{[m][L][m]}{[T]^2[L]}\right\}^{1/2}\ \frac{[L]}{[m]} = \frac{[L]}{[T]}$ ok

EXECUTE the PLAN

Calculate Target Quantity(ies)

$V_{1b} = \left\{\frac{.750N\ 1.00kg}{.00250m}\right\}^{1/2}\ \frac{.15m}{.008kg}$

$= 325\ m/s$

EVALUATE the ANSWER

Is Answer Properly Stated?

Yes, in m/s

Is Answer Unreasonable?

No, bullets can go faster than the speed of sound

Is Answer Complete?

Yes

(extra space if needed)