Chapter 9 Problem 23 [†]

Given

$m_b = 150\ g = 0.15\ kg$
$v_b = 60\ km/h = 16.67\ m/s$ let's say it is in the $+x$ direction
$m_1 = 38\ g = 0.038\ kg$
$v_1 = 85\ km/h = 23.61\ m/s$ in the $+x$ direction

Solution

Find how much energy the pieces gain in the explosion.

First we must find the mass and velocity of the second piece. The mass will be the difference between the original ball and the first peice.

$$m_2 = m_b - m_1 = 0.15\ kg - 0.038\ kg = 0.112\ kg$$

Using conservation of momentum we can find the velocity of the second piece.

$$\vec{p}_{before} = \vec{p}_{after}$$

$$\vec{p}_b = \vec{p}_1 + \vec{p}_2$$
$$m_b\vec{v}_b = m_1\vec{v}_1 + m_2\vec{v}_2$$
$$m_2\vec{v}_2 = m_b\vec{v}_b - m_1\vec{v}_1$$
$$\vec{v}_2 = \frac{m_b\vec{v}_b - m_1\vec{v}_1}{m_2}$$
$$\vec{v}_2 = \frac{(0.150\ kg)(16.67\hat{i}\ m/s) - (0.038\ kg)(23.61\hat{i}\ m/s)}{0.112\ kg}$$
$$\vec{v}_2 = 14.32\hat{i}\ m/s$$

Kinetic energy before the explosion is

$$K_{before} = \tfrac{1}{2}m_b v_b^2 = \tfrac{1}{2}(0.15\ kg)(16.67\ m/s)^2 = 20.84\ J$$

Kinetic energy after the explosion is

$$K_{after} = K_1 + K_2 = \tfrac{1}{2}m_1 v_1^2 + \tfrac{1}{2}m_2 v_2^2$$
$$K_{after} = \tfrac{1}{2}(0.038\ kg)(23.61\ m/s)^2 + \tfrac{1}{2}(0.112\ kg)(14.32\ m/s)^2$$
$$K_{after} = 22.07\ J$$

The difference in the energies is

$$K_{after} - K_{before} = 22.07\ J - 20.84\ J = 1.23\ J$$

[†]Problem from Essential University Physics, Wolfson