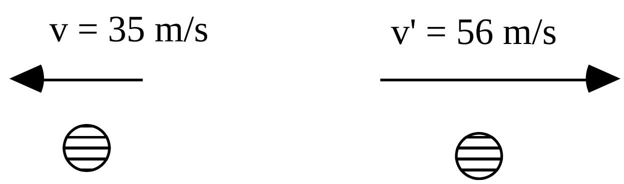
220A Solutions

Assignment 11

9-22. The speeds are shown; the initial momentum is -**i**mv and the final



momentum is **i**mv'. Thus, the change in momentum is

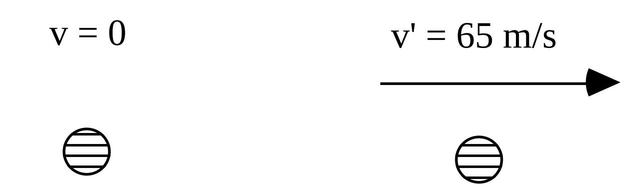
$$\Delta\mathbf{p} = \mathbf{i}mv' - (-\,\mathbf{i}mv) = \mathbf{i}m(v' + v)$$

This is equal to the impulse, which for a constant force is $\mathbf{F}\Delta t$.

$$\mathbf{F}\Delta t = \mathbf{i}m(v' + v)$$

$$\mathbf{F} = \mathbf{i}m(v' + v)/\Delta t = 0.145\text{ kg}(35\text{ m/s} + 56\text{ m/s})/5 \times 10^{-3}\text{ s} = \mathbf{i}\, 2.64 \times 10^{3}\text{ N.}$$

9-23. The initial momentum is zero and the final **i**mv'



Thus, the change in momentum is

$$\Delta\mathbf{p} = \mathbf{i}mv' - 0$$

This is equal to the impulse, which for a constant force is $\mathbf{F}\Delta t$.

$$\mathbf{F}\Delta t = \mathbf{i}mv'$$

$$\mathbf{F} = \mathbf{i}mv'/\Delta t = 0.06\text{ kg}\cdot 65\text{ m/s}/0.03\text{ s} = \mathbf{i}\, 130\text{ N.}$$

To lift a 60-kg person a force of mg = 60 kg·9.8 m/s^2 = 588 N. The force on the tennis ball is not sufficient to lift a 60-kg person.

9-24. The speeds are shown. The initial momentum

$$\mathbf{p} = \mathbf{i}mv\cos 45 + \mathbf{j}mv\sin 45$$

and the final momentum

$$\mathbf{p'} = - \mathbf{i}mv\cos 45 + \mathbf{j}mv\sin 45.$$

Subtracting,

$$\Delta\mathbf{p} = - 2\, \mathbf{i}mv\cos 45.$$

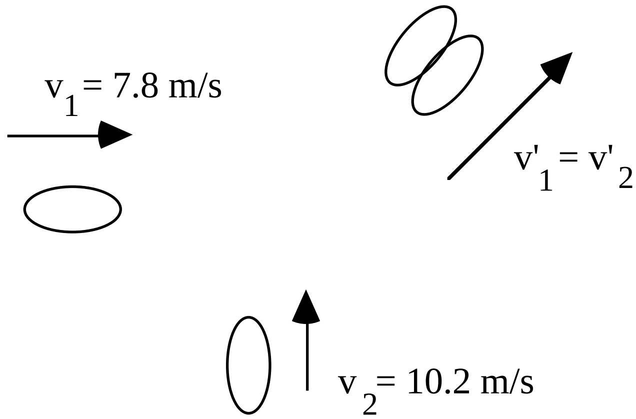
But this is equal to the imulse on the ball. The impulse on the wall is opposite this equal to 2 **i**mvcos 45 = 2**i**0.06 kg·28 m/s cos45 = **i**2.38 kg m/s. The impulse on the wall is to the right and on the ball, to the left.

9-28. (a) The impulse is the area under the curve in Figure 9-37. Each square is 0.01 s·50 N = 0.5 N·s. Count the squares. I got about 9.5 - 10 squares which would give 4.8 - 5.0 N·s. Use 4.9 ± 0.1 N·s.

(b) The change in momentum is mv since the initial momentum is zero. This is equal to the impulse, so

$$mv = 4.9 \text{ N·s}$$
$$v = 4.9 \text{ N·s}/0.06 \text{ kg} = 82 \text{ m/s}.$$

9-51. There is no external force on the two eagles, so the momentum is constant.



$$\mathbf{p}_1 + \mathbf{p}_2 = \mathbf{p}'_1 + \mathbf{p}'_2$$

The momentum of the first eagle before the collision

$$\mathbf{p}_1 = \mathbf{i}m_1v_1 = \mathbf{i}3.3\ \text{kg}\cdot 7.8\ \text{m/s} = \mathbf{i}25.7\ \text{kg}\cdot\text{m/s}$$

and of the second,

$$\mathbf{p}_2 = \mathbf{j}m_1v_1 = \mathbf{j}4.6\ \text{kg}\cdot 10.2\ \text{m/s} = \mathbf{j}46.9\ \text{kg}\cdot\text{m/s}.$$

After the collision, they have same velocity, so

$$\mathbf{p}'_1 + \mathbf{p}'_2 = \mathbf{v}'(m_1 + m_2).$$

Thus,

$$\mathbf{i}25.7\ \text{kg}\cdot\text{m/s} + \mathbf{j}46.9\ \text{kg}\cdot\text{m/s} = \mathbf{v}'(3.3\ \text{kg} + 4.6\ \text{kg})$$

Dividing by 3.3 kg + 4.6 kg = 7.9 kg

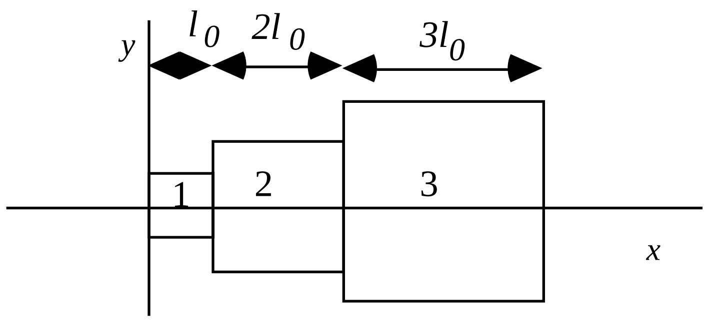
$$\mathbf{v}' = \mathbf{i}3.3\ \text{m/s} + \mathbf{j}\ 5.9\ \text{m/s}.$$

We are asked for the speed and the direction. The speed is

$$\sqrt{(3.3\ \text{m/s})^2 + (5.9\ \text{m/s})^2} = 6.8\ \text{m/s}$$

The direction: $\tan\theta = 5.9/3.3 = 1.8$, so $\theta = 61\,°$.

9-62. The cm of the 3 blocks are located at $l_0/2$, $4l_0/2$, and $9l_0/2$, respectively.



Now, we need the mass of each block. They are of the same density ρ. The densty is the mass per unit volume, so

$$m_1 = \rho V_1 = \rho l_0^3,$$
$$m_2 = \rho V_2 = \rho(2l_0)^3,$$
$$m_3 = \rho V_3 = \rho(3l_0)^3.$$

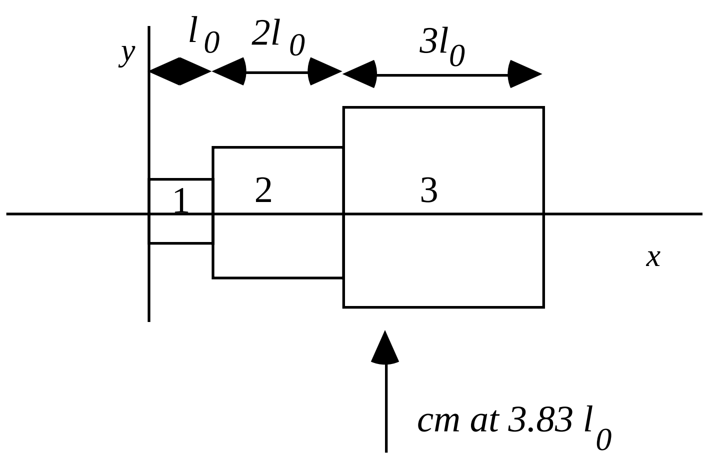
The definition of the center of mass

$$x_{cm} = \Sigma x_i m_i / \Sigma m_i$$

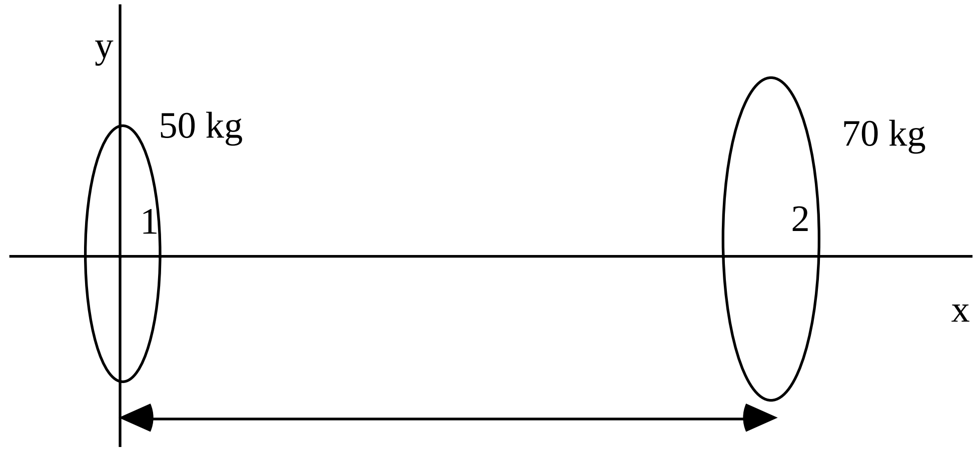
$$= [l_0/2 \cdot \rho l_0^3 + 4l_0/2 \cdot \rho(2l_0)^3 + 9l_0/2 \cdot \rho(3l_0)^3]/[\rho l_0^3 + \rho(2l_0)^3 + \rho(3l_0)^3]$$

$$= [l_0/2 + 32l_0/2 + 243l_0]/2/[1+ 8+ 27]$$

$$= [138l_0\,]/[36] = 3.83\ l_0$$



9-71. Place the origin at the woman.



The definition of the center of mass

$$x_{cm} = \Sigma x_i m_i / \Sigma m_i$$

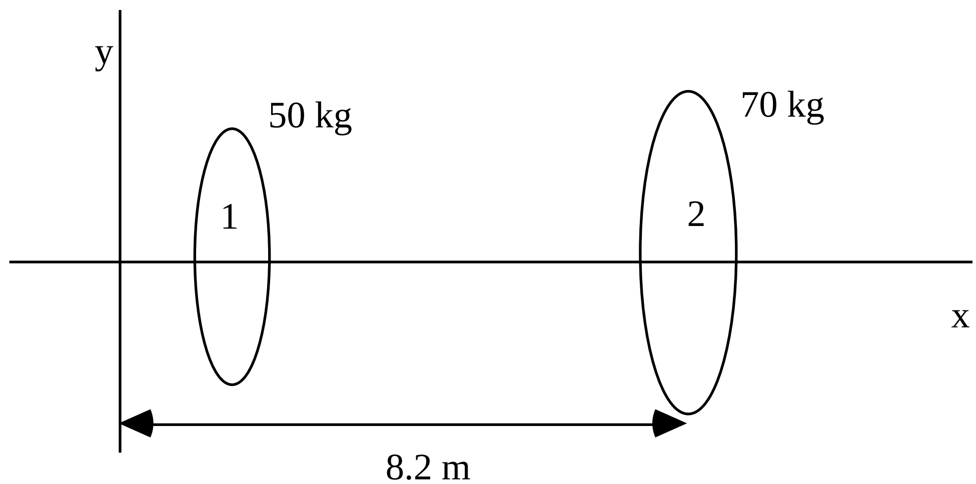
$$= (m_1 x_1 + m_2 x_2)/(m_1 + m_2)$$

$$= (50\text{ kg} \cdot 0 + 70\text{ kg} \cdot 11\text{ m})/(50\text{ kg} + 70\text{ kg})$$

$$= (50\text{ kg} \cdot 0 + 70\text{ kg} \cdot 11\text{ m})/(50\text{ kg} + 70\text{ kg}) = 6.4\text{ m}.$$

This is the distance to the woman, so the distance to the man is 4.6 m.

(b) The center of mass remains fixed since there is no external force of the two of them.



$$x_{cm} = \Sigma x_i m_i / \Sigma m_i$$

$$6.4\text{ m} = (m_1 x_1 + m_2 x_2)/(m_1 + m_2)$$

$$= (50\ \text{kg} \cdot x_1 + 70\ \text{kg} \cdot 8.2\ \text{m})/(50\ \text{kg} + 70\ \text{kg}),$$

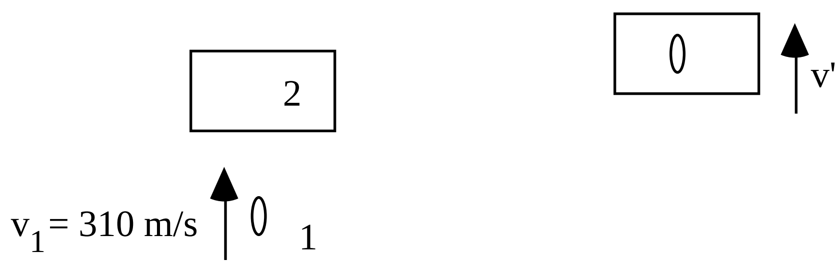
so

$$6.4\ \text{m} = (0.417 \cdot x_1 + 4.78\ \text{m})$$
$$0.417 \cdot x_1 = 6.4\ \text{m} - 4.78\ \text{m}$$
$$x_1 = 3.9\ \text{m}.$$

This is the position of the woman, so they will be 8.2 m - 3.9 m = 4.3 m apart.

(c) They meet at the cm so the man will have moved 4.6 m.

9-86. The block is at rest, so the initial momentum is



$$\mathbf{p} = \mathbf{j} m_1 v_1$$

After the collision, they move together at velocity **v**'. Immediately after the collision, there is not external force on the system, so

$$\mathbf{j} m_1 v_1 = \mathbf{v}'(m_1 + m_2), \text{ so}$$

$$\mathbf{v}' = \mathbf{j} m_1 v_1/(m_1 + m_2)$$

$$= \mathbf{j} 21 \times 10^{-3}\ \text{kg} \cdot 310\ \text{m/s}/(21 \times 10^{-3}\ \text{kg} + 1.4\ \text{kg}) = \mathbf{j}\ 4.58\ \text{m/s}.$$

Keep in mind that this is only the initial velocity of the block + bullet; as soon as the clock leaves the table, there is an external force due to gravity and the momentum is no longer constant. The rest of the problem asks how high the block goes. We know how to do this, because we know the initial velocity and $v^2 = v_0^2 + 2a_y(y - y_0)$ holds since the acceleration is constant at $a_y = -9.9\ \text{m/s}^2$.

$$0^2 = (4.58 \text{ m/s})^2 + 2(-9.8 \text{ m/s}^2)(y - y_0)$$

$$(y - y_0) = -(4.58 \text{ m/s})^2/2(-9.8 \text{ m/s}^2) = 1.07 \text{ m}.$$