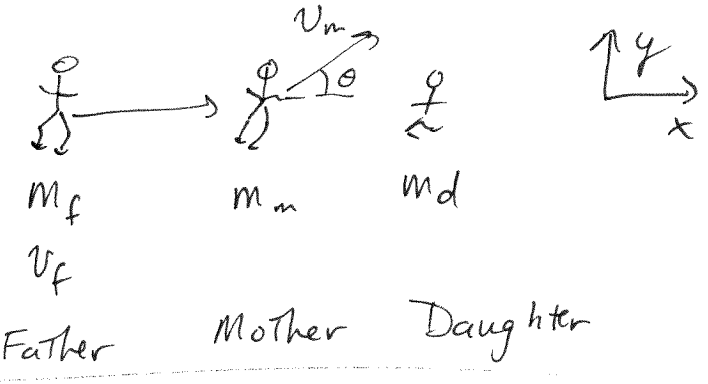
Chapter 9 Problem 60

$m_f = 75\,kg$ $\vec{v}_f = 8.2\ m/s$

$m_m = 50\,kg$ $\vec{v}_m = 3.3\ m/s \angle 45^\circ$

$m_d = 30\,kg$ $\vec{v}_d = 0$



Let the Father's velocity be in the +x-direction Then

$$\vec{v}_f = (8.2\,\hat{i})\ m/s$$

Let the Mothers velocity be in the 1st Quadrant, Then

$$\vec{v}_m = 3.3\cos 45^\circ \hat{i} + 3.3\sin 45^\circ \hat{j} = (2.33\,\hat{i} + 2.33\,\hat{j})\ m/s$$

The daughter is stationary.

$$\vec{v}_d = 0$$

Assuming no loss due to friction, the sequential collisions can be treated as happening simultaneously for ease of calculation

Using Conservation of Momentum

$$\vec{p}_o = \vec{p}_f$$

$$m_f\vec{v}_f + m_m\vec{v}_m + m_d\vec{v}_d = (m_f + m_m + m_d)\vec{v}_{final}$$

← all are moving as one object.

Solve for $\vec{v}_f$

$$\vec{v}_{final} = \frac{m_f\vec{v}_f + m_m\vec{v}_m + m_d\vec{v}_d}{m_f + m_m + m_d}$$

$$= \frac{(75\,kg)(8.2\,\hat{i}\ m/s) + (50\,kg)(2.33\,\hat{i}_{\frac{m}{s}} + 2.33\,\hat{j}_{m/s}) + (30\,kg)(0\ m/s)}{75\,kg + 50\,kg + 30\,kg}$$

$$= \frac{(615\,\hat{i} + 116.5\,\hat{i} + 116.5\,\hat{j} + 0)\ kg\cdot m/s}{155\ kg}$$

$$= \frac{731.5\,\hat{i} + 116.5\,\hat{j}}{155}\ m/s = (4.7\,\hat{i} + 0.75\,\hat{j})\ m/s$$

Magnitude of the velocity is

$$v_{final} = \sqrt{(4.7)^2 + (0.75)^2} = \boxed{4.8\ m/s}$$

at an angle of

$$\theta = \tan^{-1}\left(\frac{0.75}{4.7}\right) = \boxed{9.1^\circ}$$