HW07

Section 9.6 Motion of a System of Particles

41. A 2.00-kg particle has a velocity $(2.00\hat{\mathbf{i}} - 3.00\hat{\mathbf{j}})$ m/s, and a 3.00-kg particle has a velocity $(1.00\hat{\mathbf{i}} + 6.00\hat{\mathbf{j}})$ m/s. Find (a) the velocity of the center of mass and (b) the total momentum of the system.

$m_1 = 2\text{ kg}$ $\quad \vec{v}_1 = 2\hat{i} - 3\hat{j}$ m/s

$m_2 = 3\text{ kg}$ $\quad \vec{v}_2 = 1\hat{i} + 6\hat{j}$ m/s

b) $\vec{P}_{TOT} = m_1\vec{v}_1 + m_2\vec{v}_2$

$= 2(2\hat{i} - 3\hat{j}) + 3(1\hat{i} + 6\hat{j})$

$= 7\hat{i} + 12\hat{j}$ kg m/s

a) $M_{TOT}\bar{v}_{cm} = m_1\bar{v}_1 + m_2\bar{v}_2$

$5\,\bar{v}_{cm} = 7\hat{i} + 12\hat{j}$

$\bar{v}_{cm} = \frac{7}{5}\hat{i} + \frac{12}{5}\hat{j}$ m/s

44. A ball of mass 0.200 kg has a velocity of $1.50\hat{\mathbf{i}}$ m/s; a ball of mass 0.300 kg has a velocity of $-0.400\hat{\mathbf{i}}$ m/s. They meet in a head-on elastic collision. ~~(a) Find their velocities after the collision.~~ (b) Find the velocity of their center of mass before and after the collision.

$m_1 = 0.2$ kg $\quad \bar{v}_1 = 1.5\hat{i}$ m/s

$m_2 = 0.3$ kg $\quad \bar{v}_2 = -0.4\hat{i}$ m/s

b) Duh, the $\vec{v}_{cm}$ is the same before & after.

$M_{TOT}\bar{v}_{cm} = m_1\bar{v}_1 + m_2\bar{v}_2$

$0.5\,v_{cm} = 0.2(1.5\hat{i}) + 0.3(-0.4\hat{i})$

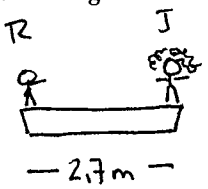
$= 0.3\hat{i} - 0.12\hat{i}$

$= 0.18\hat{i}$

$\vec{v}_{cm} = 0.36\hat{i}$ m/s

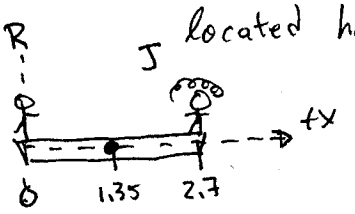
43. Romeo (77.0 kg) entertains Juliet (55.0 kg) by playing his guitar from the rear of their boat at rest in still water, 2.70 m away from Juliet, who is in the front of the boat. After the serenade, Juliet carefully moves to the rear of the boat (away from shore) to plant a kiss on Romeo's cheek. How far does the 80.0-kg boat move toward the shore it is facing?

$m_R = 77$ kg
$m_J = 55$ kg
$m_{Boat} = 88$ kg
} $M_{TOT} = 220$ kg



We can determine the center-of-mass of the Romeo-Juliet-boat system: x_{cm}
At the beginning of the problem, everything is stationary so that $V_{cm} = 0$ and therefore the center-of mass will not move.

Choose the origin at the left end of the picture above. The boat can be treated as a single 88 kg mass located half way along its length.

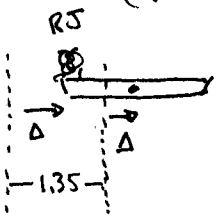


$$M_{TOT} x_{cm} = m_R x_R + m_J x_J + m_{boat} x_{boat}$$

$$220\ x_{cm} = 77(0) + 55(2.7) + 88(1.35)$$

$$x_{cm} = 1.215 \text{ m}$$

When Juliet walks to the rear, the boat will shift to the right (and so will Romeo). Let Δ be the distance the boat and Romeo shift.



$$M_{TOT} x_{cm} = m_R x_R + m_J x_J + m_{boat} x_{boat}$$

$$220(1.215) = 77\Delta + 55\Delta + 88(1.35 + \Delta)$$

$$267.3 = 118.8 + 220\Delta$$

$$\Delta = 0.675 \text{ m}$$