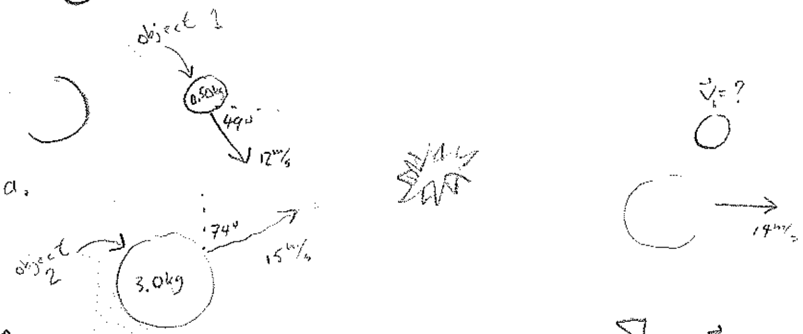
# Physics 12: Collisions in 2D

a.




$\hat{x}$:

$$\sum \vec{p}_0 = \sum \vec{p}$$

$$m_1 \vec{v}_{10x} + m_2 \vec{v}_{02x} = m_1 \vec{v}_{1x} + m_2 \vec{v}_{2x}$$

$$0.50\,kg(12\,m/s \cos 49°) + 3.0\,kg(15\,m/s \sin 74°) = 0.50\,kg\,\vec{v}_{1x} + 3.0\,kg(14\,m/s)$$

$$\vec{v}_{1x} = 10.38626098\,m/s$$

$\hat{y}$:

$$\sum \vec{p}_0 = \sum \vec{p}$$

$$m_1 \vec{v}_{10y} + m_2 \vec{v}_{20y} = m_1 \vec{v}_{1y} + \cancel{m_2 \vec{v}_{2y}}$$

$$0.50\,kg(-12\,m/s \sin 49°) + 3.0\,kg(15\,m/s \cos 74°) = 0.5\,kg\,\vec{v}_{1y}$$

$$\vec{v}_{1y} = 15.75084706$$

$$\vec{v}_1 = \vec{v}_{1x} + \vec{v}_{1y} \Rightarrow$$


$$v_1 = 18.86699765\,m/s$$

$$\theta = 56.59875539°$$

$$\boxed{\vec{v}_1 = 19\,m/s \text{ @ } 57° \text{ above } +x}$$

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b. $\Delta \vec{p}_1 = \vec{p}_1 - \vec{p}_{01}$

$\hat{x}$: $\Delta \vec{p}_{1x} = \vec{p}_{1x} - \vec{p}_{01x} = 0.50\,kg(18.8\ldots\,m/s \cos(56.5\ldots)°) - 0.50\,kg(12\,m/s \cos 49°)$

$\Delta \vec{p}_{1x} = 1.256776316\,kg\,m/s$

$\hat{y}$: $\Delta \vec{p}_{1y} = \vec{p}_{1y} - \vec{p}_{01y} = 0.50\,kg(18.8\ldots\,m/s \sin(56.5\ldots)) - 0.50\,kg(-12 \sin 49°)$

$\Delta \vec{p}_{1y} = 12.40368101\,kg\,m/s$

$$\vec{J}_1 = \Delta \vec{p}_1 = 12.467\,kg\,m/s \text{ @ } 84.214\ldots°$$

$$\boxed{\vec{J}_1 = 12\,N{\cdot}s \text{ @ } 84° \text{ above } +x}$$

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c. $\Delta \vec{p}_2 = \vec{p}_2 - \vec{p}_{02}$

$\hat{x}$: $\Delta \vec{p}_{2x} = \vec{p}_{2x} - \vec{p}_{2x0} = 3.0\,kg(14\,m/s) - 3.0\,kg(15\,m/s \sin 74°)$

$\Delta \vec{p}_{2x} = -1.256776316\,kg\,m/s$ (compare to $\Delta \vec{p}_{1x}$)

$\hat{y}$: $\Delta \vec{p}_{2y} = \vec{p}_{2y}^{\,0} - \vec{p}_{2y0} = -3.0\,kg(15\,m/s \cos 74°)$

$\Delta \vec{p}_{2y} = -12.40368101\,kg\,m/s$ (compare to $\Delta \vec{p}_{1y}$)

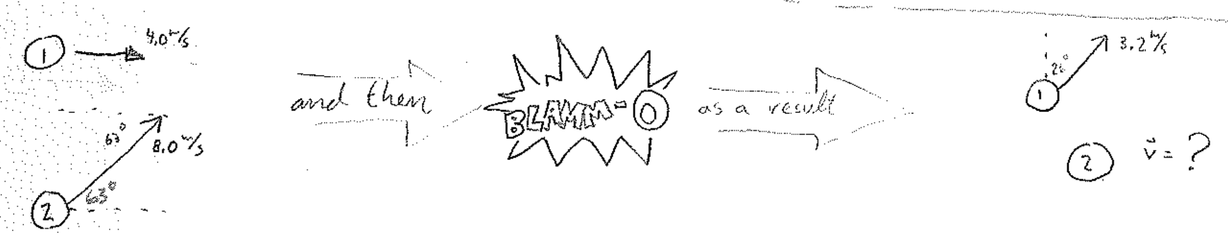
$$\vec{J}_2 = \Delta \vec{p}_2 = 12.467\ldots\,kg\,m/s \text{ @ } 84.214\ldots°$$

$$\boxed{\vec{J}_2 = 12\,Ns \text{ @ } 84° \text{ below } -x}$$

c. ALTERNATE SOLUTION!

$$\boxed{\vec{J}_2 = -\vec{J}_1 = 12\,\text{N·s} \text{ @ } 84^\circ \text{ below } -x}$$

2




$\hat{x}$: $\sum \vec{p}_{x0} = \sum \vec{p}_x$

$$m_1\vec{v}_{1x0} + m_2\vec{v}_{2x0} = m_1\vec{v}_{1x} + m_2\vec{v}_{2x}$$

$$1.0\text{kg}(4.0\,\text{m/s}) + 3.0\text{kg}(8.0\,\text{m/s}\cos 63^\circ) = 1.0\text{kg}(3.2\,\text{m/s}\sin 26^\circ) + 3.0\text{kg}\,\vec{v}_{2x}$$

$$\vec{v}_{2x} = 4.497661441\,\text{m/s}$$

$\hat{y}$: $\sum \vec{p}_{y0} = \sum \vec{p}_y$

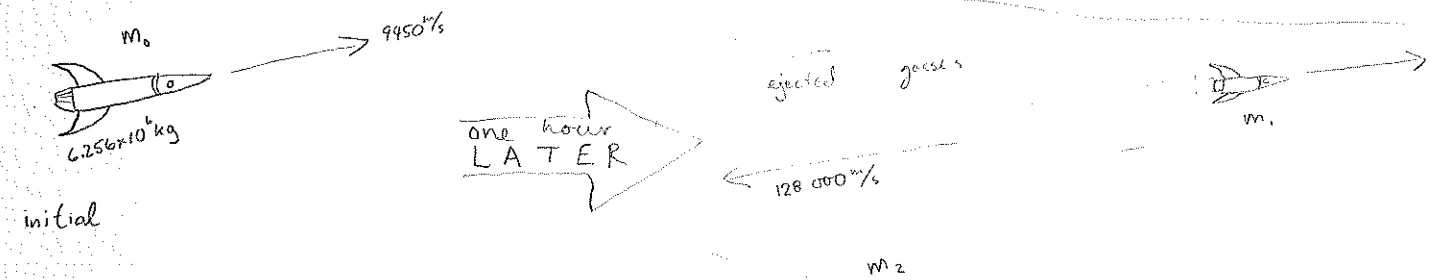
$$m_1\vec{v}_{1y0} + m_2\vec{v}_{2y0} = m_1\vec{v}_{1y} + m_2\vec{v}_{2y}$$

$$0 + 3.0\text{kg}(8.0\,\text{m/s}\sin 63^\circ) = 1.0\text{kg}(3.2\,\text{m/s}\cos 26^\circ) + 3.0\text{kg}\,\vec{v}_{2y}$$

$$\vec{v}_{2y} = 6.169338544\,\text{m/s}$$

$$\boxed{\vec{v}_2 = 7.6\,\text{m/s} \text{ @ } 54^\circ \text{ above } +x}$$

3




* We have to deal with a mass change here!

$m_0 = 6.256\times10^6$ kg → this is the total mass, and it remains CONSTANT. However after 1.000 hour of burning rocket fuel the mass is divided into $m_1$ = mass of rocket + contents AND $m_2$ = mass of ejected gasses.

$$m_2 = 250\frac{\text{kg}}{\text{min}} \times \frac{60\,\text{min}}{1\,\text{hour}} \times 1.000\,\text{h} = 15000\,\text{kg}.$$

$$m_1 = m_0 - m_2 = 6.241\times10^6\,\text{kg}$$

SO.....

$$\sum \vec{p}_0 = \sum \vec{p}$$

$$m_0\vec{v}_0 = m_1\vec{v}_1 + m_2\vec{v}_2$$

$$6.256\times10^6\text{kg}(9450\,\text{m/s}) = 6.241\times10^6\text{kg}\,\vec{v}_1 + 15000\text{kg}(-128\,000\,\text{m/s})$$

$$\boxed{\vec{v}_1 = 9780\,\text{m/s} \text{ same dir'n as before!}}$$