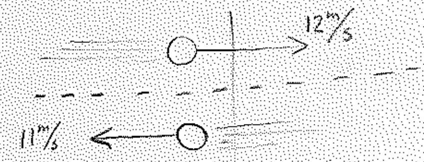
# Impulse & Momentum: With a Hint of Cocoa butter




a. $\Delta\vec{p} = \vec{p} - \vec{p}_0 = m\vec{v} - m\vec{v}_0 = 0.165\,kg(-11\,m/s) - 0.165\,kg(12\,m/s)$

$\boxed{\Delta\vec{p} = 3.80\,kg\,m/s \text{ in the dir'n of final velocity}}$

b. $\vec{J} = \Delta\vec{p} = \boxed{3.80\,Ns \text{ in the dir'n of final velocity}}$

c. $\vec{J} = \vec{F}t \Rightarrow \vec{F} = \frac{\vec{J}}{t} = \boxed{22.9\,N \text{ in the dir'n of final velocity}}$

2. $\vec{v}_x = \vec{v}_{0x} = 1.4\,m/s \cos 34°$ right $\Rightarrow \Delta\vec{v}_x = 0 \Rightarrow \Delta\vec{p}_x = 0! \Rightarrow \Delta\vec{p} = \Delta\vec{p}_y$

$\left.\begin{array}{l}\vec{v}_{0y} = 1.4\sin 34° \\ \vec{v}_y = -1.4\sin 34°\end{array}\right\}$ $\Delta\vec{p}_y = m(\vec{v}_y - \vec{v}_{0y}) = 0.325\,kg(-1.4\,m/s\sin 34° - 1.4\,m/s\sin 34°) = -0.51\,kg\,m/s$

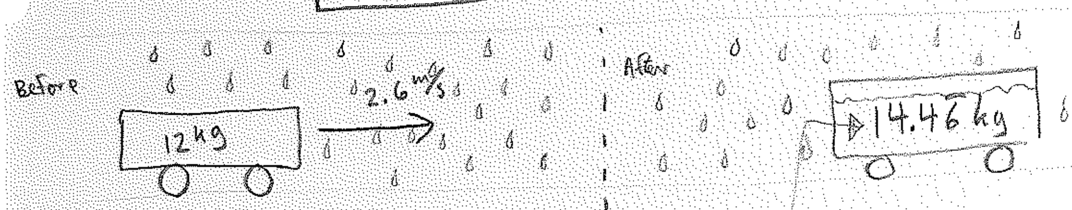
a. $\boxed{\Delta\vec{p} = 0.51\,kg\,m/s \text{ down}}$

b. $\boxed{\vec{J} = \Delta\vec{p} = 0.51\,kg\,m/s \text{ down}}$

c. $F_N$ (normal force)

d. $\vec{J} = \vec{F}t \Rightarrow \boxed{\vec{F} = \frac{\vec{J}}{t} = 36\,N \text{ down}}$

3




$\frac{74.0\,kg}{60\,min} \times 2.0\,min = 2.4\bar{6}\,kg$

$\Sigma p_0 = \Sigma \vec{p}$

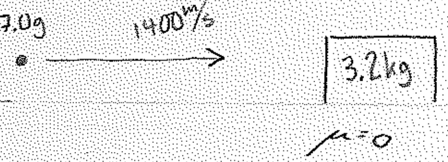
$m_0\vec{v}_0 = m\vec{v}$

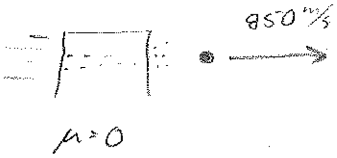
$12\,kg(2.6\,m/s) = 14.4\bar{6}\,kg(\vec{v})$

$\boxed{2.2\,m/s = \vec{v}}$

4. $\boxed{\text{Equal To}}$ b. $\boxed{\text{Equal To}}$ c. $\boxed{\text{Equal To}}$ d. $\boxed{\text{Greater Than}}$ e. $\boxed{\text{Greater Than}}$

5.




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

$$m_1\vec{v}_{1o} + \cancel{m_2\vec{v}_{2o}}^{\,0} = m_1\vec{v}_1 + m_2\vec{v}_2$$

$$0.007\,kg(1400\,m/s) = (0.007\,kg)(850\,m/s) + 3.2\,kg\,\vec{v}_2$$

$$\boxed{\vec{v}_2 = 1.2\,m/s}$$

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6a. $\hat{x}: \Sigma \vec{p}_0 = \Sigma \vec{p}$

$$m_1\vec{v}_{1x_0} + m_2\vec{v}_{2x_0} = m_1\vec{v}_{1x} + m_2\vec{v}_{2x}$$

$$0.50\,kg\,(12\cos 49°) + 3(15\sin 74) = 0.5\,V_{1x} + 3(14)$$

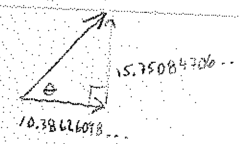
$$v_{1x} = 10.38626098\,m/s$$

$\hat{y}: \Sigma \vec{p}_o = \Sigma \vec{p}$

$$m_1\vec{v}_{1y_0} + m_2\vec{v}_{2y_0} = m_1\vec{v}_{1y} + \cancel{m_2\vec{v}_{2y}}^{\,0}$$

$$0.5(-12\sin 49) + 3(15\cos 74) = m_1\vec{v}_{1y} + 0$$

$$V_{1y} = 15.75084706\,m/s$$




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

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b. $\vec{J} = \Delta\vec{p} = m\Delta\vec{v}$

$\hat{x}: \Delta\vec{v}_x = \vec{v}_x - \vec{v}_{0x}$

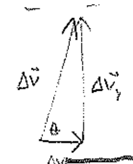
$$\Delta\vec{v}_x = 10.386260098\,m/s - 12\,m/s(\cos 49°)$$

$$\Delta\vec{v}_x = 2.513552632\,m/s$$

$\hat{y}: \Delta\vec{v}_y = \vec{v}_y - \vec{v}_{oy}$

$$\Delta\vec{v}_y = 15.750847706\,m/s - (-12\sin 49°)$$

$$\Delta\vec{v}_y = 24.80736202\,m/s$$




$\Delta\vec{v}_1 = 24.934...\,m/s\ [84°\ \text{above}\ +x]$

$$\boxed{\vec{J} = m\Delta\vec{v} = 12\,Ns\ [84°\ \text{above}\ +x]}$$

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c. $\vec{J} = \Delta\vec{p} = m\Delta\vec{v}$

$\hat{x}: \Delta\vec{v}_x = \vec{v}_x - \vec{v}_{x0}$

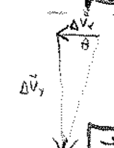
$$\Delta\vec{v}_x = 14\,m/s - 15\,m/s\sin 74°$$

$$\Delta\vec{v}_x = -0.4189254391\,m/s$$

$$\Delta\vec{v}_y = \vec{v}_y - \vec{v}_{oy}$$

$$\Delta\vec{v}_y = 0 - 15\,m/s\cos 74°$$

$$\Delta\vec{v}_y = -4.134560337\,m/s$$




$\Delta\vec{v} = 4.15572...\,m/s\ [84°\ \text{below}\ -x]$

$$\boxed{\vec{J} = 12\,N{\cdot}s\ [84°\ \text{below}\ -x]}$$

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7a. NO  b. NO  c. YES  d. YES

8. It depends upon their directions.
If direction is the same, then YES
If direction is different, then NO

9. Part 1, Collison:

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

$$M_1\vec{v}_1 + M_2\vec{v}_2 = M_1\vec{v}_{10} + \cancel{M_2\vec{v}_{20}}^{\,0}$$

$$(M_1 + M_2)V = M_1 V_{10}$$

$$V = \frac{2.2\,kg\,(3.0\,m/s)}{(2.2\,kg + 1.2\,kg)} = 1.941176471$$

Part 2, Projectile

$\hat{y}: \vec{v}_{oy} = 0$
$\vec{a}_y = 9.80\,m/s^2$
$\vec{d}_y = 1.6\,m$
$t = ?$

$$\vec{d} = \cancel{\vec{v}_o t}^{\,0} + \tfrac{1}{2}\vec{a}t^2$$

$$t = \sqrt{\frac{2\vec{d}}{\vec{a}}} = 0.5714\ldots s$$

$\hat{x}: \vec{d}_x = \vec{v}_x t$

$$d_x = 1.941176471\,m/s\,(0.5714\ldots s)$$

$$\boxed{\vec{d}_x = 1.1\,m}$$

10. 3 PARTS! Hooray!

① Collision. $\Sigma \vec{p} = \Sigma \vec{p}_0$

$(m_1 + m_2)\vec{v} = m_1 \vec{v}_{01} + \cancel{m_2 \vec{v}_{02}}^{\,0}$

$\vec{v} = 1.941176471 \, m/s$

② Slide to edge, could use Work/Energy or Kinematics:

$\vec{v}_0 = 1.941176471$

$\vec{a} = \frac{\Sigma \vec{F}}{m} = \frac{-\mu m g}{m} = -\mu g$

$\vec{d} = 0.78 m$

$\vec{v}^2 = \vec{v}_0^2 + 2\vec{a}\vec{d}$

$\vec{v} = 1.496451165 \, m/s$

③ Projectile:

$\hat{y}: \vec{v}_{0y} = 0$

$\vec{a}_y = 9.8 m/s^2$

$\vec{d}_y = 1.6 m$

$\vec{d} = \cancel{\vec{v}_0 t}^{\,0} + \frac{1}{2}\vec{a}t^2$

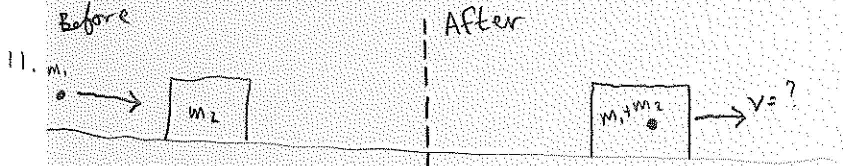
$t = \sqrt{\frac{2\vec{d}}{\vec{a}}} = 0.5714285714 s$

$\hat{x}: \vec{d}_x = \vec{v}_x t$

$\vec{d}_x = (1.496\ldots m/s)(0.571\ldots s)$

$\boxed{\vec{d}_x = 0.86 m}$

11.

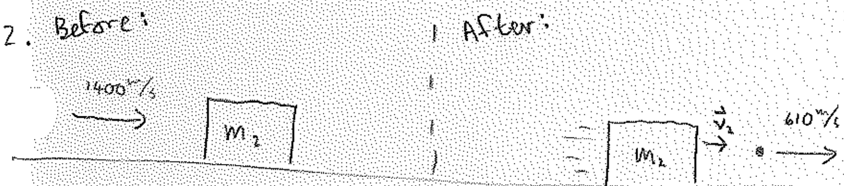



$\Sigma \vec{p}_0 = \Sigma \vec{p}$

$m_1 \vec{v}_{10} + \cancel{m_2 \vec{v}_{20}}^{\,0} = (m_1 + m_2)\vec{v}$

$\frac{0.0070 kg (1400 m/s)}{3.207 kg} = \boxed{v = 3.1 m/s}$

12.

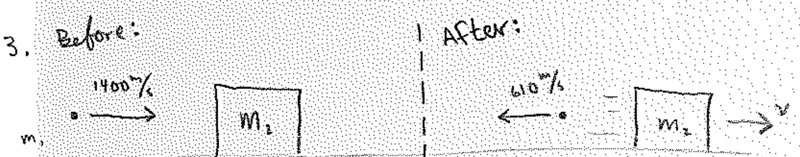



$\Sigma \vec{p}_0 = \Sigma \vec{p}$

$m_1 \vec{v}_{10} + \cancel{m_2 \vec{v}_{20}}^{\,0} = m_1 \vec{v}_1 + m_2 \vec{v}_2$

$\frac{0.0070 kg (1400 m/s) - 0.0070 kg (610 m/s)}{3.2 kg} = \boxed{v_2 = 1.7 m/s}$

13.




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

$m_1 \vec{v}_{10} + \cancel{m_2 \vec{v}_{20}}^{\,0} = m_1 \vec{v}_1 + m_2 \vec{v}_2$

$\frac{0.0070 kg (1400 m/s) - 0.0070 kg (-610 m/s)}{3.2 kg} = \boxed{v_2 = 4.4 m/s}$

14. $\vec{F}t = m\Delta\vec{v}$

$$t = \frac{m\Delta\vec{v}}{\vec{F}} = \frac{4.0\,kg\,(14\,m/s - (-16\,m/s))}{25\,N} = \boxed{4.8\,s}$$

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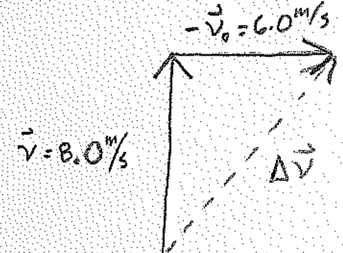
15. $\vec{F}t = m\Delta\vec{v}$

$$\vec{F} = \frac{m\Delta\vec{v}}{t} = \frac{m}{t}(\vec{v} - \vec{v}_0) = \frac{m}{t}\underbrace{(\vec{v} + (-\vec{v}_0))} = \frac{m}{t}(10.0\,m/s\ [53^\circ\ N\ of\ E])$$




$$\boxed{\vec{F} = 8.0\times10^2\,N\ [53^\circ\ N\ of\ E]}$$

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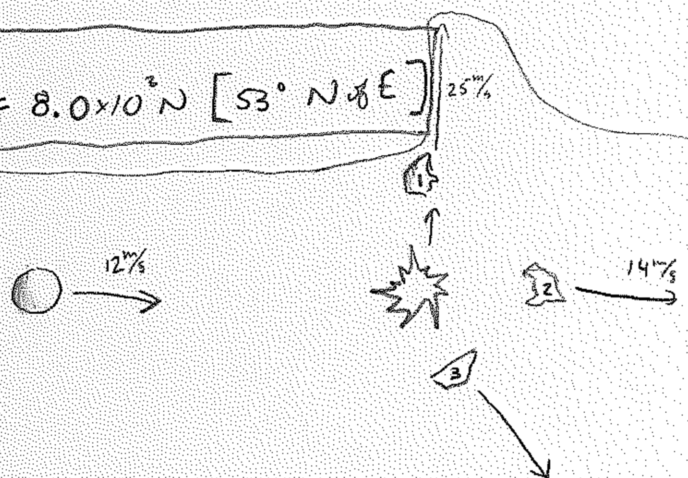
16.




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

$\hat{x}$: $m_T\vec{v}_{0x} = \cancel{m_1\vec{v}_{1x}}^{\,0} + m_2\vec{v}_{2x} + m_3\vec{v}_{3x}$

$260(12) = 125(14) + 60\,v_{3x}$

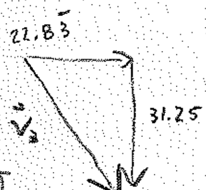
$v_{3x} = 22.8\overline{3}\,m/s$

$\hat{y}$: $\cancel{m_T v_{0y}}^{\,0} = m_1\vec{v}_{1y} + \cancel{m_2\vec{v}_{2y}}^{\,0} + m_3\vec{v}_{3y}$

$m_3 v_{3y} = m_1 v_{1y}$

$60\,v_{3y} = 75(25)$

$v_{3y} = 31.25\,m/s$




$$\boxed{\vec{v}_3 = 39\,m/s\ [54^\circ\ S\ of\ E]}$$

(17) $\vec{J} = \vec{F}t = m\vec{g}t = 1.8\text{kg}(-9.8\,\text{N/kg})(2.0\text{s}) = -35.28\,\text{Ns}$

$\boxed{\vec{J} = 35\,\text{Ns down}}$

(18) $\vec{J} = \vec{F}t = m\Delta\vec{v}$ → use kinematics to find either $t$ or $\vec{v}$

$\vec{v}_0 = 0\,\text{m/s}$

$\vec{a} = -9.80\,\text{m/s}^2$

$\vec{d} = -2.0\,\text{m}$

$\vec{v}^2 = \vec{v}_0^2 + 2\vec{a}\vec{d}$

$\vec{v} = -\sqrt{2(-9.80\,\text{m/s}^2)(-2.0\,\text{m})} = -6.260990337\,\text{m/s}$

$\vec{J} = 1.8\text{kg}\,(-6.260990337\,\text{m/s} - 0\,\text{m/s})$

$\vec{J} = -11.26978261\,\text{Ns}$

$\boxed{\vec{J} = 11\,\text{Ns down}}$

OR

$\vec{d} = \cancel{\vec{v}_0 t}^{\,0} + \frac{1}{2}\vec{a}t^2$

$t = \sqrt{\frac{2\vec{d}}{\vec{a}}} = 0.638876565\,\text{s}$

$\vec{J} = \vec{F}t = m\vec{g}t = 1.8\text{kg}(-9.8\,\text{N/kg})(0.638876565\,\text{s}) = -11.26978261\,\text{Ns}$

$\boxed{\vec{J} = 11\,\text{Ns down}}$