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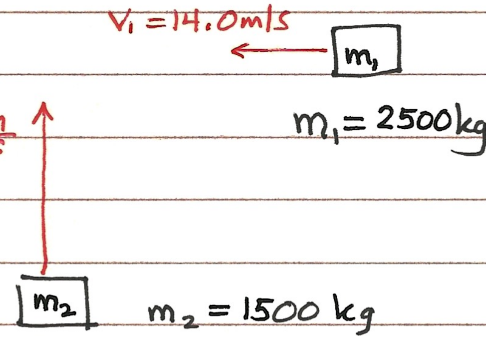
Chapter 8

Ex. 4 Two vehicles are approaching an intersection.

a). $p_x = ?$ $p_y = ?$



$p_x = m_1 V_1 = (2500\,kg)(-14\,m/s)$

$p_x = -35{,}000\ kg \cdot m/s$

$p_y = m_2 V_2 = (1500\,kg)(23.0\,m/s)$

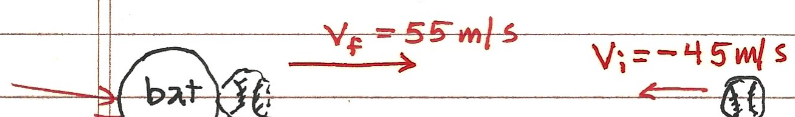
$p_y = +34{,}500\ kg \cdot m/s$

b.) Magnitude and Direction

$|\vec{p}| = \sqrt{(-35{,}000)^2 + (34{,}500)^2} = \boxed{4.91 \times 10^4\ kg \cdot m/s}$

$\theta = Tan^{-1}\left(\frac{p_y}{p_x}\right) = Tan^{-1}\left(\frac{34{,}500}{-35{,}000}\right) = -44.6^\circ + 180^\circ = \boxed{135.4^\circ}$

Ex. 8 A baseball has a mass of 0.145 kg.



a.) $\Delta p = ?$ $\Delta p = mV_f - mV_i = m\,(55 - (-45))\,m/s$ (m = 0.145 kg)

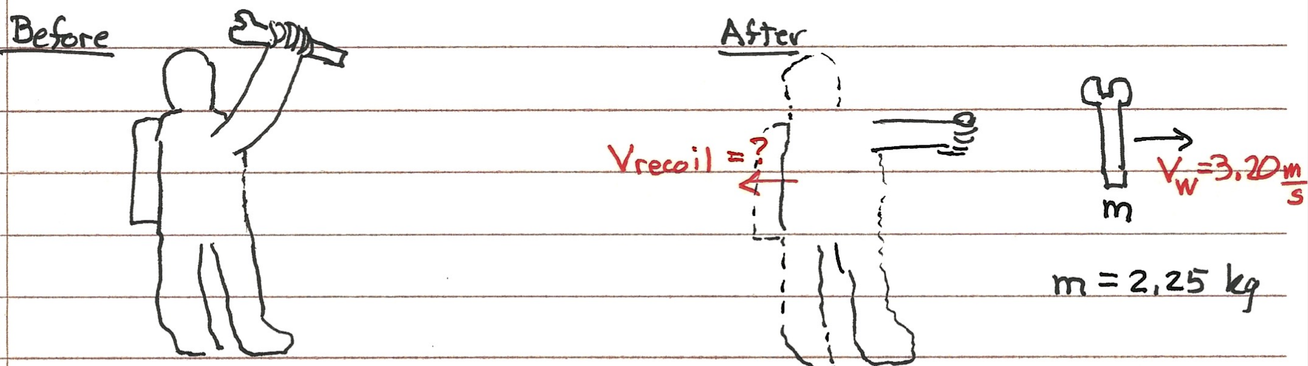
$\Delta p = 14.5\ kg \cdot m/s$

b.) $F_{Av} = ?$ $F_{Av}\,\Delta t = \Delta p$ $F_{Av} = \frac{\Delta p}{\Delta t} = \frac{14.5\ kg \cdot m/s}{2.00 \times 10^{-3}\ s}$

$\boxed{F_{Av} = 7250\ N}$

Chapter 8

Ex. 16 A 68.5 kg astronaut is doing a repair in space . . . .



$P_{TOTAL} = 0$ (before)

M = 68.5 kg

$P_{TOTAL} = 0$ (after)

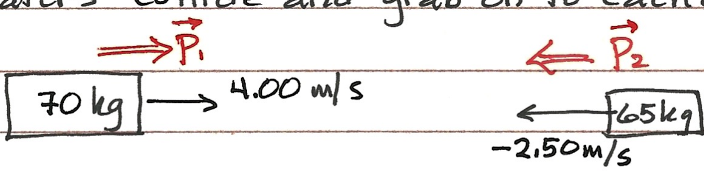
$$P_{TOTAL}^{before} = P_{TOTAL}^{after}$$

$$0 = M V_{recoil} + m_W V_W \qquad V_{recoil} = -\frac{m_W V_W}{M}$$

$$V_{recoil} = -\frac{(2.25\ kg)(3.20\ m/s)}{68.5\ kg}$$

$$\boxed{V_{recoil} = -0.105\ m/s}$$

Ex. 32 Two skaters collide and grab on to each other on frictionless ice.

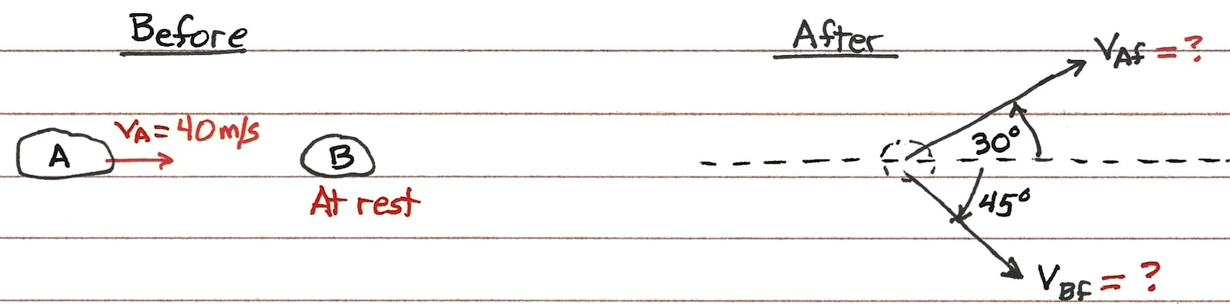


$$P_{TOTAL} = P_1 + P_2 = (70\,kg)(4.00\ m/s) + (65\,kg)(-2.50\ m/s)$$

$$P_{TOTAL} = 117.5\ kg \cdot m/s \quad \text{(to the right)}$$

Chapter 8

Ex. 30 Asteroid Collision: Two asteroids of equal mass in the ....



Cons. of momentum)$_x$

$$M V_A + M(0\,m/s) = M V_{Af} \cos 30° + M V_{Bf} \cos 45°$$

① $$\boxed{V_A = V_{Af} \cos 30° + V_{Bf} \cos 45°}$$

Cons. of momentum)$_y$

$$0 + 0 = M V_{Af} \sin 30° - M V_{Bf} \sin 45°$$

② $$\boxed{V_{Af} \sin 30° = V_{Bf} \sin 45°} \Rightarrow V_{Bf} = V_{Af} \frac{\sin 30°}{\sin 45°}$$ } Substitute this into Eq. 1

① $$V_A = V_{Af} \cos 30° + \left(V_{Af} \frac{\sin 30°}{\sin 45°}\right) \cos 45°$$

$$V_A = V_{Af} \left[\cos 30° + \frac{\sin 30°}{(\tan 45°)}\right] \quad (\tan 45° = 1)$$

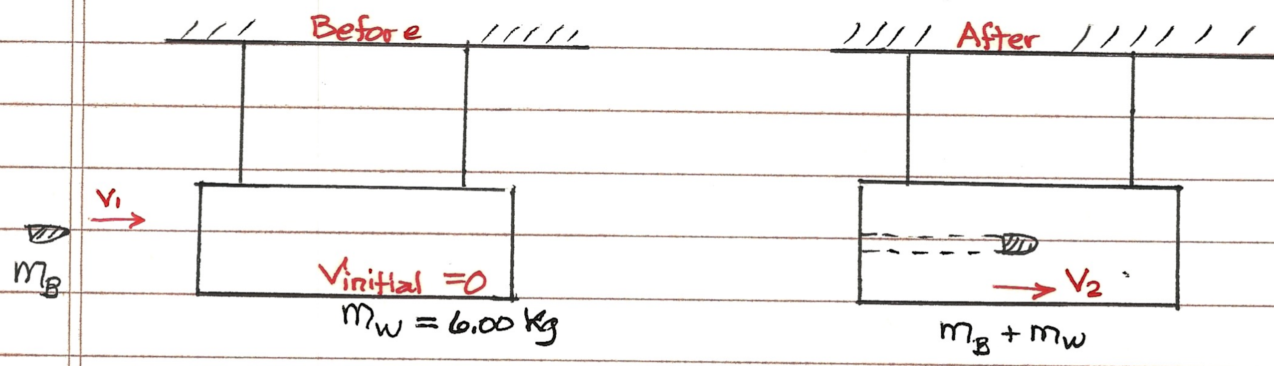
$$V_{Af} = \frac{V_A = 40\,m/s}{\cos 30° + \sin 30°}$$

$$V_{Af} = 29.28\,m/s$$

② $$V_{Bf} = V_{Af} \frac{\sin 30°}{\sin 45°} = (29.28\,m/s) \frac{\sin 30°}{\sin 45°}$$ $$\boxed{V_{Bf} = 20.71\,\frac{m}{s}}$$

Chapter 8

Ex. 43 **A Ballistic Pendulum** A 12.0-g (m_B) rifle bullet is fired with a speed of 380 m/s (v_1) into a ballistic pendulum.



$$P^{Total}_{initial} = P^{Total}_{final} \qquad m_B V_1 = (m_B + m_W) V_2$$

$$V_2 = \frac{m_B V_1}{m_B + m_W} = \left(\frac{0.012\ kg}{6.012\ kg}\right) 380\ m/s = \boxed{0.7585\ m/s} \quad V_2$$

a). The vetical height the block moves $h = ?$

$$W_{TOTAL} = \Delta K \qquad W_{gr} = \overset{K=0}{K_f} - K_i \Rightarrow -\underset{}{\overset{m_B+m_W}{m}} g h = -\frac{1}{2} \underset{m_B+m_W}{m} \overset{V_i = V_2}{v_i^2}$$

$$h = \frac{V_2^2}{2g} = \frac{(0.7585\ m/s)^2}{2(9.8\ m/s^2)} \qquad \boxed{h = 2.935 \times 10^{-2}\ m}$$

b.) The initial KE of the bullet = ? $\quad K_B = \frac{1}{2} m_B V_1^2$

$$K_B = \frac{1}{2}(0.012\ kg)(380\ m/s)^2$$

$$\boxed{K_B = 866\ J}$$

c.) The kinetic energy of the $(m_B + m_W)$ immediately after the bullet becomes embedded.

$$K = \frac{1}{2}(m_B + m_W) V_2^2 = \frac{1}{2}(6.012\ kg)(0.7585\ m/s)^2$$

$$\boxed{K = 1.73\ J}$$

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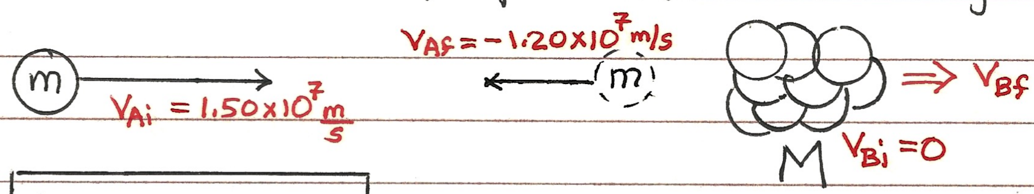
Chapter 8

Ex. 50 You are at the controls of a particle accelerator, sending a beam of 1.50×10^7 m/s protons (mass m) at a gas target...



Elastic Collision

a.) $M = ?$ $V_{Af} = \left(\frac{m - M}{m + M}\right) V_{Ai} + 0$

$$\frac{m-M}{m+M} = \frac{V_{Af}}{V_{Ai}} = \frac{-1.20}{1.50} = \frac{-4}{5} \qquad m - M = -\frac{4}{5}(m+M)$$

$$m + \frac{4}{5}m = M - \frac{4}{5}M \Rightarrow \frac{9}{5}m = \frac{1}{5}M \Rightarrow \boxed{M = 9m}$$

b.) $V_{Bf} = ?$

$$V_{Bf} = \left(\frac{2m}{m+9m}\right) V_{Ai} + 0 = \frac{1}{5} V_{Ai} = \frac{1}{5}\left(1.50\times10^7 \frac{m}{s}\right)$$

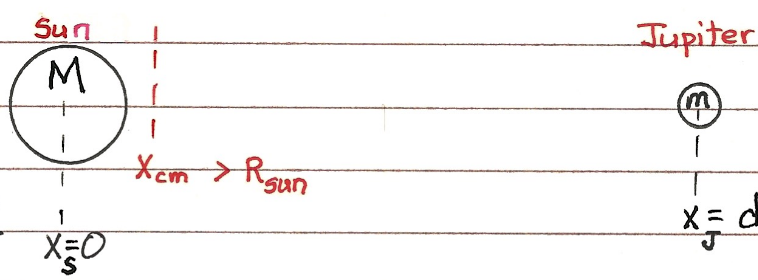
$$\boxed{V_{Bf} = 3.00 \times 10^6 \text{ m/s}}$$

Ex. 52 Find the position of the center of mass of the system of the sun and Jupiter.

$$X_{cm} = \frac{M X_s + m X_J}{M + m} \quad (X_s = 0)$$

$$X_{cm} = \frac{0 + (1.90\times10^{27})(7.78\times10^{11}\text{m})}{1992\times10^{27}\text{ kg}}$$

$$\boxed{X_{cm} = 7.42\times10^8 \text{ m}}$$



$R_{sun} = 6.96 \times 10^8$ m

Chapter 8

Ex. 61

A 70.0 kg (m) astronaut floating in space in a 110-kg (M) MMU (manned maneuvering unit) experiences an acceleration ....

$a = 0.029\ m/s^2$ $\qquad$ $\text{Thrust} = (M+m)a = 180\ kg\,(0.029\ m/s^2)$

$= \underline{5.22\ N}$ (b.)

$$\text{Thrust} = V_{ex}\frac{dm}{dt}$$

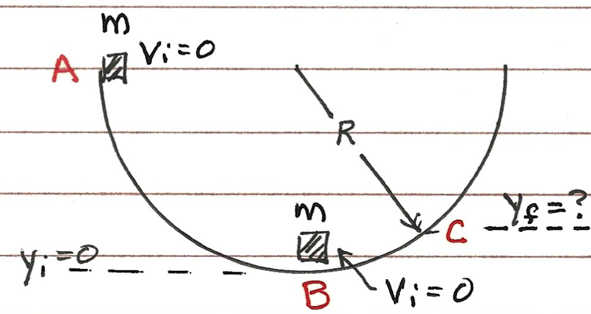
a.) $$\frac{\Delta m}{\Delta t} = \frac{\text{Thrust}}{V_{ex}} = \frac{5.22\ N}{490\ m/s} = 10.65\ \frac{grams}{sec}$$

$$\Delta m = \left(\frac{\Delta m}{\Delta t}\right)\Delta t = 10.65\ \frac{grams}{sec}\,(5.0\,s)$$

$$\boxed{\Delta m = 53.3\ grams}$$

Ex. 82

Two identical masses are released from rest in a smooth hemispherical bowl...



1.) Conservation of momentum: A → B

At B $\qquad mv_i = 2mV_f$

$v_i = \sqrt{2gR}$ from cons. of energy

both masses → $$V_f = \frac{V_i}{2} = \sqrt{\frac{gR}{2}}$$

[m|m] → $V_B = \sqrt{\dfrac{gR}{2}}$

At point B

2.) Use the Work-Energy Theorem to determine the motion between B → C.

$W_{TOT} = K_f - K_i$ ($K_f = 0$) $\qquad W_{gr} = -K_i \qquad -2mg(y_f - y_i) = -\frac{1}{2}(2m)V_B^2$ ($y_i = 0$)

$$2mgy_f = mV_B^2 \qquad y_f = \frac{V_B^2}{2g} = \frac{gR/2}{2g}$$

$$\boxed{y_f = \frac{R}{4}}$$

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Chapter 8

Ex. 96 A 20.0-kg projectile is fired at an angle of 60° above the horizontal with a speed of 80.0 m/s.

a.) At the highest point of the trajectory

$m = 20$ kg

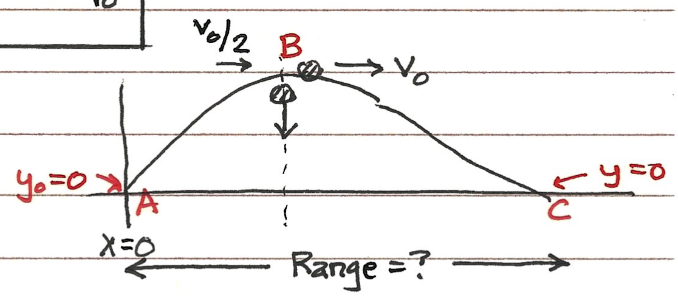
$m/2 = 10$ kg

$$P_x^{before} = P_x^{after}$$

$$m V_{ox} = \frac{m}{2} V_x + \frac{m}{2}(0)$$

$$V_x = 2 V_{ox} = 2 V_o \underbrace{\cos 60°}_{= 1/2}$$

V_x = velocity of mass $m/2$ $= V_o$



Time of flight = ?

$y = 0$

$a_y = -g$

$V_{oy} = V_o \sin 60° = 69.3$ m/s

$t = ?$

Eq. 3 $\quad y = V_{oy}t - \frac{1}{2}gt^2 \qquad 0 = V_{oy}t - \frac{1}{2}gt^2$

$$V_{oy}t = \frac{1}{2}gt^2 \qquad t = \frac{2V_{oy}}{g} = \frac{2(69.3 \text{ m/s})}{9.8 \text{ m/s}^2} = 14.14 \text{ sec}$$

$$\text{Range} = V_{ox} t_{1/2} + V_o t_{1/2} = t_{1/2}(V_{ox} + V_o)$$

$$\text{Range} = t_{1/2}\left(\frac{1}{2}V_o + V_o\right) = t_{1/2}\left(\frac{3}{2}V_o\right) = 7.07 \text{ sec}\,(1.5\,(80 \text{ m/s}))$$

Range = 848 m

b.) $$W_{explosion} = \frac{1}{2}\frac{m}{2}V_f^2 - \frac{1}{2}mV_{ox}^2 = \frac{m}{4}V_o^2 - \frac{1}{2}m\left(\frac{V_o}{2}\right)^2 = \frac{1}{8}mV_o^2$$

$$W_{explosion} = \frac{1}{8}(20 \text{ kg})(80 \text{ m/s})^2 = \boxed{1.60 \times 10^4 \text{ J}}$$