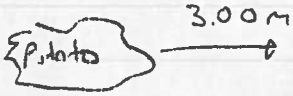
Worksheet - 4.1 Work

① Work = Force × distance

$W = 20.0N \cdot 1.5m = 30. N \cdot m = 30. J$

② $W = F \cdot d = 6.00N \cdot 3.00m =$

$= \boxed{18.0J}$



③

no distance = no work - $\boxed{0J}$

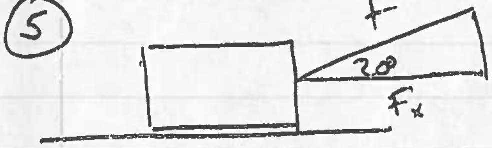
④ Find distance

$$a = \frac{v}{t} = \frac{11.0m/s}{5s} = 2.2m/s^2$$

$$d = \frac{v^2}{2a} = \frac{(11.0)^2}{2(2.2)} = 27.5m$$

$W = F \cdot d = m \cdot a \cdot d = (10.0kg) \cdot (2.2m/s^2) \cdot (27.5m) = \boxed{605J}$

⑤



$F_x = 75N \cdot \cos(20°) \approx 70.5N$

$W = F_x \cdot d = 70.5N \cdot 10.0m = \boxed{705J}$

⑥ $W = F \cdot d = m \cdot g \cdot d = (60.0kg) \cdot (9.8m/s^2)(3.2m)$

$= \boxed{1900J}$

⑦ No F $W = F \cdot d = (0N)(90m) = \boxed{0J}$

⑧ $W = F \cdot d = m \cdot g \cdot d_y = (80.0kg) \cdot (9.8m/s^2)(7.0m)$

$= \boxed{5500J}$

⑨ $\boxed{\text{Find } F_{app}}$

$$a = \frac{2d}{t^2} = \frac{2 \cdot (6.0)}{(4.0)^2} = 0.75m/s$$

$F_{net} = F_{app} - F_{ff}$

$F_{net} + F_f = F_{app} = m \cdot a - f_f = (25.0kg) \cdot 0.75m/s^2 + 3.8N$

$= 22.55N$

$W = F \cdot d = 22.55N \cdot 6.0m = \boxed{140J}$

$55\,km/hr = 15.27m/s$

⑩ $\boxed{\text{Find acceleration}}$

$v^2 = \cancel{v_0^2} + 2ad$

$\frac{v^2}{2d} = a = \frac{(15.27m/s)^2}{2(38m)} = -3.07m/s^2$ ← Slowing down

$W = F \cdot d = m \cdot a \cdot d = (1165kg) \cdot (-3.07m/s^2) \cdot (38m)$
$= \boxed{-1.4 \times 10^5 J}$

Worksheet 4.1 E_p and E_k

① $E_p = m \cdot g \cdot h = 25.0N \cdot 2.10N = \boxed{52.5J}$

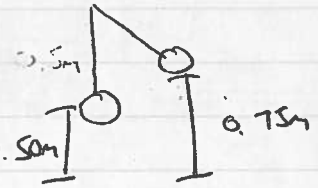
② $\Delta x = 20.0cm - 13.5cm = 6.5cm = 0.065m$

$W = F \cdot \Delta x = (65N)(0.065m) = 4.225J = \boxed{4.2J}$

③ $E_p = m \cdot g \cdot h = (2.75kg)(9.8m/s^2)(7.00m) = \boxed{189J}$

④ $\Delta h = 0.75m - 0.50m = 0.25m$

$E_p = m \cdot g \Delta h = 2.0kg \cdot 9.8m/s^2 \cdot 0.25m$
$= \boxed{4.9J}$



⑤ $E_p = m \cdot gh = (2.00 \times 10^3 kg)(9.8m/s^2)(6.0m) = \boxed{1.2 \times 10^5 J}$

⑥ $E_k = \frac{1}{2}mv^2 = \frac{1}{2}(7.5m/s)^2(3.0kg) = \boxed{84J.}$

⑦ $E_k = \frac{1}{2}mv^2$

$v = \sqrt{\frac{2E_k}{m}} = \sqrt{\frac{2 \cdot 5.00 \times 10^2 J}{(20.0N/9.8m/s^2)}} \equiv 22.1\,m/s^2$

⑧ $E_K = F_{net}\cdot d = m\cdot a\cdot d = \frac{F_g}{g}\cdot a\cdot d = \left(\frac{10.0N}{9.8m/s^2}\right)(2.5m/s^2)\cdot(15.0m)$

$= \boxed{38J}$

⑨ $d = \cancel{V_0 t} + \frac{1}{2}at^2$

$d = \frac{1}{2}(9.8m/s^2)(4.5s)^2 = 99.2m$

$E_K = F_{net}\cdot d = (1200.0N)\cdot(99.2m) = 1.2\times10^5 J$

⑩ $E_k = E_p = mg\cdot h = (8.0kg)(9.8m/s^2)(7.0m)$

$= 550J$

⑪ $E_p = E_k = (9.00kg)(1.2m)(9.8m/s^2) = 105.84J$

$E_K = \frac{1}{2}mV^2$

$V = \sqrt{\frac{2E_K}{m}} = \sqrt{\frac{2\cdot 105.84J}{9.00kg}} = \boxed{4.85m/s}$

⑫ $V_0 = 0$

$a = 9.8m/s^2$

$d = 1.2m$

$V_f = ?$

$V_f = \sqrt{\cancel{V_0^2} + 2ad}$

$= \sqrt{2(1.2)(9.8)} = 4.85m/s$

<u>Worksheet</u> - 4.1 Law of conservation of Energy

① $E_{pi} = E_{kf}$

$\cancel{m}g\cdot h = \frac{1}{2}\cancel{m}v^2$

$h = \frac{\frac{1}{2}v^2}{g} = \frac{(0.5)(3.2m/s)^2}{9.8m/s^2} = 0.52m$

② $E_{p_i} = E_{k_f}$

$$\cancel{m}g \cdot h = \frac{1}{2}\cancel{m}v^2$$

$$\sqrt{2gh} = v = \sqrt{2 \cdot (9.8) \cdot (8.0)} = \boxed{13 m}$$

③ $E_{p_i} = E_{k_f}$

$$\cancel{m}gh = \frac{1}{2}\cancel{m}v^2$$

$$h = \frac{0.5v^2}{g} = \frac{(0.5) \cdot (37.0 m/s)^2}{(9.8 m/s^2)} = \boxed{69.8 m}$$

④ $E_{p_i} + E_{k_i} = \overset{0}{\cancel{E}_{p_f}} + E_{k_f}$

$$\cancel{m}gh + \frac{1}{2}\cancel{m}v_i^2 = \frac{1}{2}\cancel{m}v_f^2$$

$$v_f = \sqrt{2gh + v_i^2}$$

$$= \sqrt{2(9.8 m/s^2)(1.3 \times 10^2 m) + (11.0 m/s)^2}$$

$$= \boxed{52 m/s}$$

⑤ $E_{p_i} + \cancel{E}_{k_i} = \cancel{E}_{p_f} + E_{k_f}$

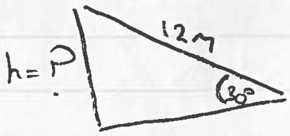
see next page for 6!

$$\cancel{m}gh = \frac{1}{2}\cancel{m}v_f^2$$

$$v = \sqrt{2 \cdot g \cdot h} = \sqrt{2 \cdot (9.8 m/s^2)(4.0 m)}$$

$$= \boxed{8.9 m/s}$$

⑦ $E_{p_i} + \overset{0}{\cancel{E}_{k_i}} = \overset{0}{\cancel{E}_{p_f}} + E_{k_f}$



$$\cancel{m}gh = \frac{1}{2}\cancel{m}v_f^2$$

$h = 12 \cdot \sin(30°) = 6.00 m$

$$v = \sqrt{2 \cdot g \cdot h}$$

$$= \sqrt{2 \cdot (9.8 m/s^2) \cdot (6.00 m)}$$

$$= \boxed{10.8 m/s}$$

⑥ all potential energy has been converted to kinetic energy

$$E_{p_i} + \cancelto{0}{E_{k_i}} = \cancelto{0}{E_{p_f}} + E_{k_f}$$

$$\cancel{m} g \cdot h = \frac{1}{2} \cancel{m} v_f^2$$

$$v_f = \sqrt{2 \cdot g \cdot h} = \sqrt{2 \cdot (9.8)(0.25)} = \boxed{2.2\,m/s}$$

⑧ A → C $\Delta h = 8.0\,m$

$$E_{p_i} + \cancelto{0}{E_{k_i}} = E_{p_f} + E_{k_f}$$

$$\cancel{m} \cdot g \cdot h_a = \cancel{m} \cdot g h_c + \frac{1}{2} \cancel{m} v_f^2$$

$$V = \sqrt{2 \cdot g \cdot \Delta h}$$

$$V = \sqrt{2 \cdot (9.8\,m/s) \cdot (8.0\,m)} = 13\,m/s$$

⑨ $E_{p_i} = E_{k_f}$

$$\cancel{m} g h = \frac{1}{2} \cancel{m} v_f^2$$

$$V = \sqrt{2 \cdot g \cdot h} = \sqrt{2 (9.8)(10.0)} = 14\,m/s$$

⑩ $\cancelto{0}{E_{p_i}} + E_{k_i} = E_{p_f} + \cancelto{0}{E_{k_f}}$

$$\frac{1}{2} \cancel{m} v_i^2 = \cancel{m} g h$$

$$h = \frac{0.5 v_i^2}{g} = \frac{0.5 \cdot (3.5)^2}{9.8 (m/s^2)} = 0.625\,m$$

$$= \boxed{0.63\,m}$$

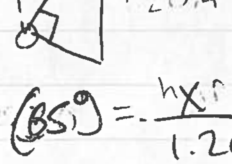
⑪ $E_{p_i} + \cancelto{0}{E_{k_i}} = \cancelto{0}{E_{p_f}} + E_{k_f}$

$$\cancel{m} \cdot g \cdot h = \frac{1}{2} \cancel{m} v_f^2$$

$$V = \sqrt{2 \cdot g \cdot h}$$

$$= \sqrt{2 \cdot 9.8 \cdot 0.11}$$

$$= \boxed{1.5\,m/s}$$



$$\sin(65°) = \frac{hx}{1.20m} \; ; \; x = 1.09\,m$$

$$h = 1.20m - 1.09m = 0.11m$$

Worksheet 4.2 - Power and Efficancy

① $P = \frac{W}{\Delta t}$

$$\Delta t = \frac{W}{P} = \frac{m \cdot g \cdot d}{P} = \frac{45.0\,kg \cdot 9.8\,m/s^2 \cdot 6.0\,m}{1.50 \times 10^3\,W} = \boxed{1.8\,s}$$

② $$P = \frac{W}{\Delta t} = \frac{F_g \cdot d}{\Delta t} = \frac{20.0\,kg \cdot 9.8\,m/s^2 \cdot 2.50\,m}{2.0\,s} = \boxed{245\,W}$$

③ $$P = \frac{W}{\Delta t} = \frac{\Delta E}{\Delta t} = \frac{\frac{1}{2}mv^2}{\Delta t} = \frac{\frac{1}{2} \cdot 2.00\,kg \cdot (3.00\,m/s)^2}{1.5\,m}$$

$$= 9.0\,W$$

$$d = \left(\frac{v_f + v_i}{2}\right)t$$

$$t = \frac{2d}{v_f} = \frac{2(1.5\,m)}{(3.0\,m/s)} = 1.0\,s$$

④ $$P_{out} = \frac{W}{\Delta t} = F\left(\frac{d}{t}\right) = F \cdot v = mg \cdot v = (8.50 \times 10^2\,kg)(9.8\,m/s^2)(1.00\,m/s)$$
$$= \boxed{8.3 \times 10^3\,W}$$

$$P_{in} = 10{,}000\,W \qquad Eff = \frac{P_{out}}{P_{in}} = \frac{8.3 \times 10^3\,W}{1.0 \times 10^4\,W} \times 100\% = 83\%$$

⑤ $$P = \frac{W}{\Delta t} = \frac{F_{app} \cdot d}{\Delta t} = \frac{(49\,N)(2.0\,m)}{0.67\,sec} = \boxed{1.5 \times 10^2\,W}$$

$$v_f^2 = \overset{0}{\cancel{v_0^2}} + 2ad \qquad d = \left(\frac{\overset{0}{\cancel{v_i}} + v_f}{2}\right)t$$

$$a = \frac{v_f^2}{2d} = \frac{(6.0)^2}{2 \cdot (2)} = 9.0\,m/s^2 \qquad \frac{2d}{v_f} = t = \frac{2 \cdot (2)}{6} = 0.67\,sec$$

$$F_{net} = F_{app} - F_f$$

$$F_{app} = (9.0\,m/s^2)(5.0\,kg) + 4.0\,N$$

$$= 49\,N$$

⑥ $P_{in} = 5.00 \times 10^2 \, W$

$$P_{out} = \frac{W}{\Delta t} = \frac{m \cdot g \cdot h}{\Delta t} = \frac{20.0kg \cdot 9.8m/s^2 \cdot 5.00m}{3.50s}$$

$$= 280W$$

$$Eff = \frac{P_{out}}{P_{in}} \times 100\% = \frac{280W}{5.00 \times 10^2 W} = 56\%$$

⑦

$$Eff = \frac{P_{out}}{P_{in}} \times 100\% = 82\%$$

$$P_{out} = \frac{82}{100} \times 1.00 \times 10^3 \, W = 820W$$

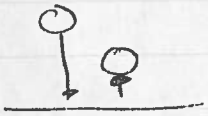
$$P = \frac{W}{\Delta t}$$

$$\Delta t = \frac{W}{P} = \frac{m \cdot g \cdot d}{P} = \frac{(50.0kg)(9.8m/s^2)(15.0m)}{8.20 \, W}$$

$$= 8.96 \, sec$$

43 - Momentum

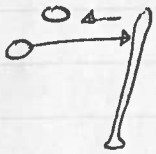
①



$\Delta p = m \cdot \Delta V = 1.0\,kg\,(1.6\,m/s - (-2.0\,m/s)) = \boxed{3.6\,kg \cdot m/s}$

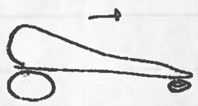
up = +

②



$\Delta p = m\,\Delta V = 0.144\,kg\,(-38\,m/s - 38\,m/s) = \boxed{-10.9\,kg \cdot m/s}$

③



$a = 12.5\,m/s^2$

$t = 3.25\,s$

$V_f = V_i + at = 10\,m/s + (12.5\,m/s^2 \cdot 3.25\,s)$

$= \boxed{50.625\,m/s}$

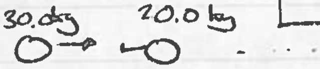
$V_i = 36\,km/hr\ E = 10\,m/s\ E$

$V_f = 50.625\,m/s$

$m = 800\,kg$

$\Delta p = m \cdot \Delta V = 800\,kg \cdot (50.625\,m/s - 10\,m/s)$

$= \boxed{32,500\,kg \cdot m/s}$

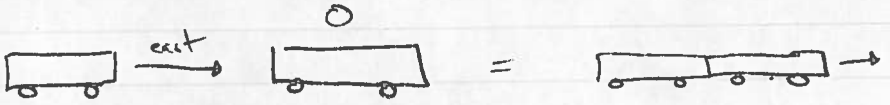


④ $m_{1i} V_{1i} + m_{2i} \cdot V_{2i} = m_{1f} V_{1f} + m_{2f} V_{2f}$

$(30.0)(1.00) + (20.0)(-5.00) = (30.0) V_{1f} + (20.0)(-1.25)$

$V_{1f} = -1.5\,m/s$ or $\boxed{1.5\,m/s \text{ left}}$

⑤



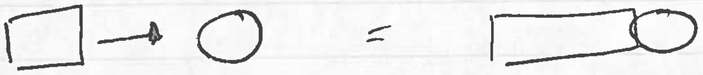
inelastic

$m_1 V_1 + \cancel{m_2 \cdot V_2} = m_+ \cdot V_+$

$(4.50 \times 10^3\,kg)(5.00\,m/s) = (4.50 \times 10^3\,kg + 6.50 \times 10^3\,kg)\,V_+$

$\boxed{V_+ = 2.05\,m/s \text{ east}}$

⑥



inelastic

$m_1 V_1 + \cancel{m_2 V_2} = m_+ V_+$

$925\,kg \cdot 18.0\,m/s = (925 + m_2)\,6.50\,m/s$

$\frac{925\,kg \cdot 18.0\,m/s - 925\,kg\ 6.50\,m/s}{6.50\,m/s} = m_2$

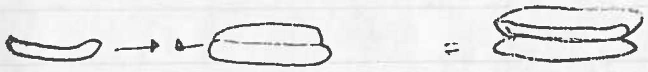
$\boxed{m_2 = 1640\,kg}$

⑦  inelastic

$m_1 V_1 + \cancelto{0}{m_2 V_2} = m_+ V_+$

$0.050\,kg \cdot V_1 = (0.050\,kg + 7.00\,kg)\, 5.00\,m/s$

$\boxed{V_1 = 705\,m/s}$

⑧  inelastic

$m_1 V_1 + m_2 V_2 = m_+ V_+$

$(0.040\,kg)\cdot(9.00\,m/s) + (0.055\,kg)(-6.00\,m/s) = (0.040\,kg + 0.055\,kg)\, V_+$

$\boxed{V_+ = 0.316\,m/s}$

⑨ $\Delta p = 0$

student cream pie

$\cancelto{0}{m_T V_T} = m_1 V_1 + m_2 V_2$

$0 = (76\,kg)\, V_1 + (0.20\,kg)(-22\,m/s)$

$\boxed{V_1 = 0.058\,m/s \text{ right}}$

⑩ turkey turkey launcher

$\cancelto{0}{m_+ V_+} = m_1 V_1 + m_2 V_2$

$0 = (25\,kg)(325\,m/s) + (1.1 \times 10^3\,kg)\, V_2$

$V_2 = -7.386\,m/s$

$V_2 = \boxed{7.4\,m/s \text{ West}}$

⑪ gases vehicle

$\cancelto{0}{m_+ V_+} = m_1 V_1 + m_2 V_2$

$0 = (4.5 \times 10^2\,kg)(1.4 \times 10^3\,m/s) + (m_2)(-45\,m/s)$

$\boxed{m_2 = 1.4 \times 10^4\,kg}$

4.3 - Implulse

① $\Delta p = m \cdot \Delta V = F_{net} \cdot t$

$$\Delta V = \frac{F_{net} \cdot t}{m} = \frac{(1.5 \times 10^5\, N)(15\, s)}{(9.5 \times 10^3\, kg)} = \boxed{237\, m/s}$$

② $m \cdot \Delta V = F_{net} \cdot t$

$$F_{net} = \frac{m \cdot \Delta V}{t} = \frac{263\, kg\, (-21.0\, m/s)}{2.60\, s} = -212\, N = \boxed{\begin{matrix}212\, N \\ \text{south}\end{matrix}}$$

③ $\Delta p = m \cdot \Delta V = 15.0\, kg\, (10.0\, m/s - 0\, m/s) = \boxed{150\, N \cdot s \text{ south}}$

④ $\Delta p = F_{net} \cdot t = (25.0\, N) \cdot (7.20 \times 10^{-1}\, s) = \boxed{18\, N \cdot s \text{ North}}$

⑤ $\Delta p = m \cdot \Delta V = 5.00\, kg \cdot (15.0\, m/s - 0\, m/s) = 75\, N \cdot s$ East

⑥ $d = \overset{0}{\cancel{V_0 t}} + \frac{1}{2} a t^2$

$a = \frac{2d}{t^2} = 5.14\, m/s^2$

$V = V_0 + at = 16.44\, m/s$

$\Delta p = m \cdot \Delta V = (11.0\, kg)(16.44\, m/s - 0\, m/s)$

$= 181\, kg\, m/s$

$= \boxed{181\, N \cdot s \text{ west}}$

⑦ $\Delta p = m \cdot \Delta V$

$\Delta V = \frac{\Delta p}{m} = \frac{6.00\, kg \cdot m/s}{1.30\, kg} = 4.615\, m/s = V_f$

$a = 9.8\, m/s^2$

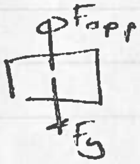
$V_f^2 = \overset{0}{\cancel{V_0^2}} + 2ad$

$$\frac{V_f^2}{2a} = \frac{(4.615\, m/s)^2}{2\, (9.8\, m/s^2)} = \boxed{1.1\, m \text{ down}}$$

⑧ $\Delta p = m \Delta v = F_{net}\, t$

$$m = \frac{F_{net} \cdot t}{\Delta v} = \frac{16.0N \cdot 2.00\times10^{-1} s}{3.50 m/s} = \boxed{0.914\ kg}$$

⑨ ⓐ



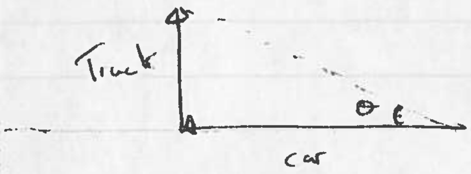
$$F_{net} = F_{app} - F_N$$
$$= 8.20N - (0.500kg)(9.8m/s^2)$$
$$= 3.3N$$

ⓑ $a = \frac{F_{net}}{m} = 6.6m/s^2 \longrightarrow t = \sqrt{\frac{2d}{a}} = 0.6742s$

$$\Delta v = \frac{F_{net} \cdot t}{m} = \frac{(3.3N) \cdot (0.6742s)}{(0.500kg)} = \boxed{4.45 m/s}$$

4.4 - Collisions

①



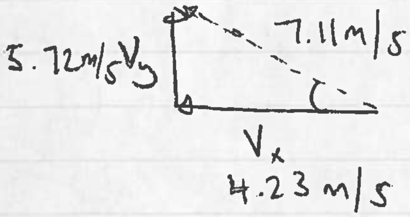
car $= 1.4 \times 10^3$ kg 37.0 km/hr = 10.28 m/s

truck $= 2.0 \times 10^3$ kg 35 km/hr = 9.72 m/s

Break down into components

$$m_{1x} V_{1x} + m_{2x} \cancelto{0}{V_{2x}} = m_{tx} V_{tx}$$

$$V_{tx} = \frac{(1.4 \times 10^3)(10.28)}{(3.4 \times 10^3)} = 4.23 \text{ m/s}$$

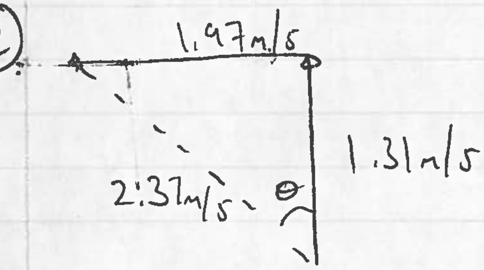


$$m_{1y} \cancel{V_{1y}} + m_{2y} V_{2y} = m_{ty} V_{ty}$$

$$V_{ty} = \frac{(2.0 \times 10^3)(9.72)}{3.4 \times 10^3} = 5.72 \text{ m/s}$$

$$\boxed{7.11 \text{ m/s } 37° \text{ W of N}}$$

②



$$m_{1x} \cancel{V_{1x}} + m_{2x} V_{2x} = m_{tx} V_{tx}$$

$$\frac{(8.0)(3.5)}{(14.2)} = V_{tx} = 1.97 \text{ m/s}$$

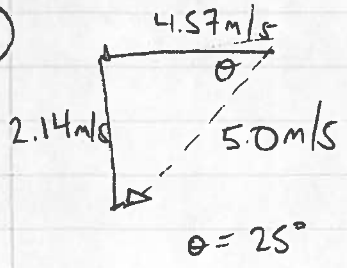
$$m_{1y} V_{1y} + m_{2y} \cancel{V_{2y}} = m_{ty} V_{ty}$$

$$\frac{(6.2)(3.0)}{(14.2)} = 1.31 \text{ m/s}$$

$\theta = 56.4°$

$$\boxed{2.37 \text{ m/s } 56.4° \text{ W of N}}$$

③



$\theta = 25°$

$$m_{1x} V_{1x} + m_{2x} \cancel{V_{2x}} = m_{tx} V_{tx}$$

Truck$_1 = 4.08 \times 10^3$ kg

$$V_{tx} = \frac{(4.08 \times 10^3)(8.0)}{(7.141 \times 10^3)} = 4.57 \text{ m/s}$$

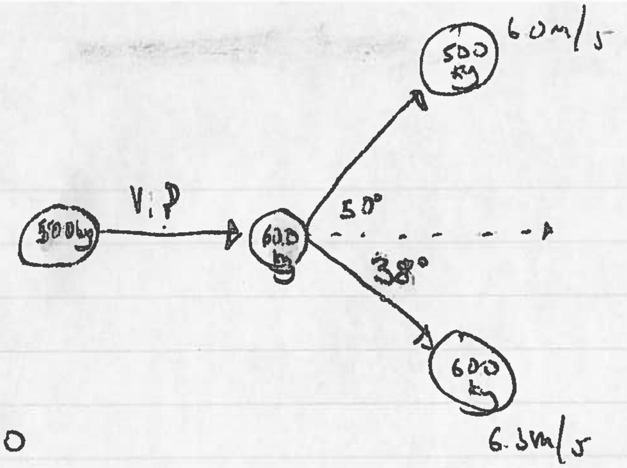
Truck$_2 = 3.06 \times 10^3$ kg

$$m_{1y} \cancel{V_{1y}} + m_{2y} V_{2y} = m_{ty} V_{ty}$$

$$V_{ty} = \frac{(3.06 \times 10^3)(5.0)}{(7.141 \times 10^3)} = 2.14$$

$$\boxed{5.0 \text{ m/s } 25° \text{ S of W}}$$

④



a) $\Delta p_x = 0$

$\sum p_{xi} = \sum p_{xf}$

$$m_{50x} V_{ix} = m_{50x} V_{fx} + m_{60x} V_{fx}$$
$$(50.0)(V_{ix}) = (50.0)(6.0)\cos(55^\circ) + (60.0)(6.3)\cos(38^\circ)$$
$$V_{ix} : V_i = 9.81 m/s$$

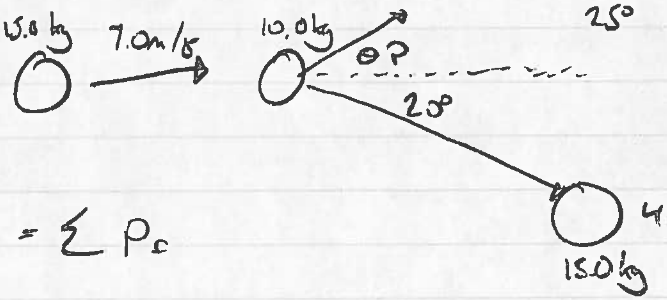
b) does $E_{k_i} = E_{kf}$?

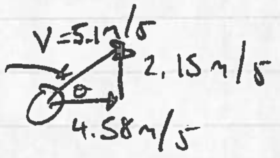
$$E_{ki} = \frac{1}{2} m v^2 = \frac{1}{2}(50)(9.81)^2 = 2.41 \times 10^3 J$$

$$E_{kf} = \frac{1}{2} m v^2 = \frac{1}{2}(50)(6.0)^2 + \frac{1}{2}(60)(6.3)^2$$
$$= 2.09 \times 10^3 J$$

$E_{ki} \neq E_{kf}$ inelastic

⑤





ⓐ

$V_{2f} = \boxed{5.1 m/s\ 25° N of E}$

$\sum p_i = \sum p_f$

$\sum p_{ix} = \sum p_{ix}$

$$m_{1xi} V_{1xi} = m_{1xf} V_{1xf} + m_{2xf} V_{2xf}$$
$$(15.0)(7.0) = (15.0)(4.2) \cdot \cos(20) + 10 V_{2xf}$$
$$\frac{(15.0)(7.0) - (15.0)(4.2)\cos(20)}{10} = V_{2xf} = 4.58 m/s$$

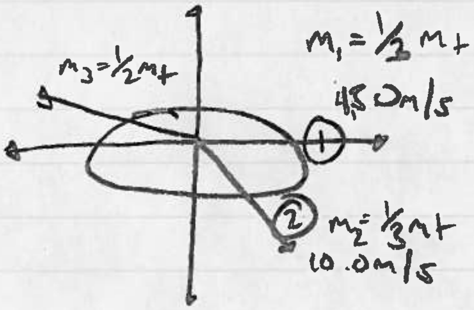
$$0 = m_{1yf} V_{1yf} + m_{2yf} V_{2yf}$$
$$V_{2yf} = -\left(\frac{m_{1yf} V_{1yf}}{m_{2yf}}\right) = \frac{(15.0)(4.2) \cdot \sin(20)}{(10.0)} = 2.15 m/s$$

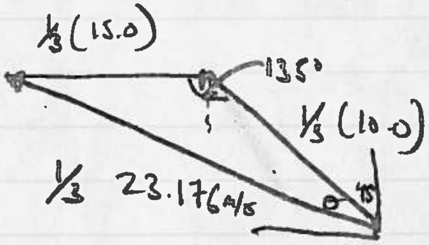
ⓑ does $E_{ki} = E_{kf}$ $\boxed{\text{NO! inelastic}}$

$E_{k_i} = \frac{1}{2}mv^2 = (0.5)(15.0)(7.0\,m/s)^2 = 367.5\,J$

$E_{kf} = (0.5)(15.0)(4.2)^2 + (0.5)(10.0)(5.1)^2 = 262.4\,J$

⑥)





$c^2 = a^2 + b^2 - 2ab\cos(C)$

$c = \sqrt{(15)^2 + (10)^2 - 2(15)(10)\cos(135)}$

$= 23.176\,m/s$

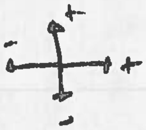
$\frac{\sin(C)}{c} = \frac{\sin(A)}{a}$

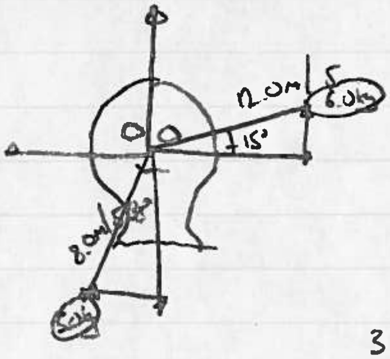
$\frac{a\sin(C)}{c} = \sin A = \left(\frac{15.0}{23.176}\right) \cdot \sin(135) = 0.4576$

$A = \sin(\quad) = 27.24°$

23.2 m/s 17.8° N of E

Special!

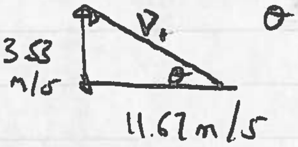




3rd piece = 4.0kg

$V_f = 12.2\ m/s$

$\theta = 16.8°$



$$\Sigma p_x = 0$$

$$\Sigma p_{xi} = \Sigma p_{xf}$$

$$0 = P_{1f} + P_{2f} + P_{3f} = (6.0)(12.0)\cdot\cos(15) + 5.0(-8.0)\cdot\sin(35) + 4.0 V_{3x}$$

$$V_{3x} = \frac{22.9 N\cdot s - 69.54 N\cdot s}{4.0 kg}$$

$$= -11.67 m/s$$

$$\Sigma p_{yi} = \Sigma p_{yf}$$

$$0 = (6.0)\cdot(12.0)\cdot\sin(15) + (5.0)(-8.0)\cdot\cos(35) + 4.0 V_{3y}$$

$$V_{3y} = \frac{32.77 N\cdot s - 18.63 N\cdot s}{4.0 kg} = 3.53 m/s$$

$$\boxed{4.0 kg \text{ piece } 12.2 m/s \ 17° \text{ N of W}}$$