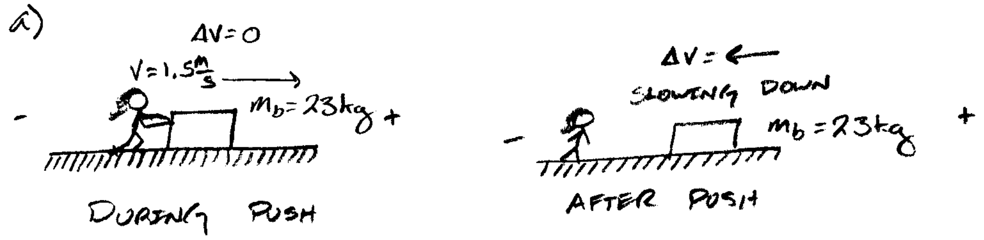
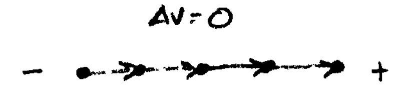
PROBLEM 1

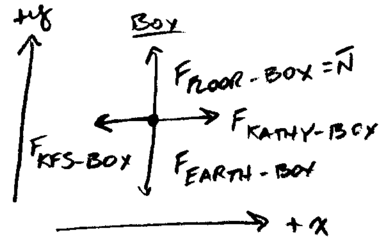
a)



b)

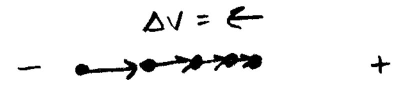


c)

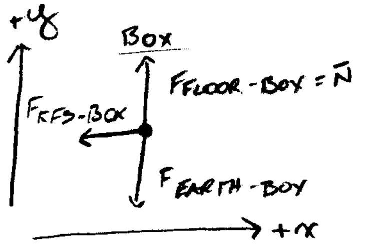


d) yes, they are consistent. The object is in equilibrium (no unbalanced force) and the $\Delta V = 0$

e)

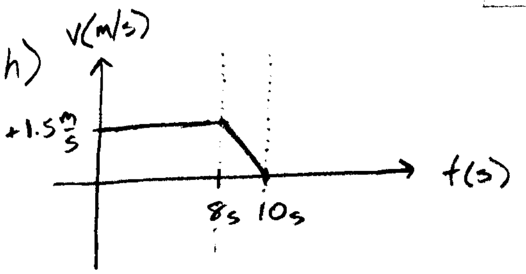


f)

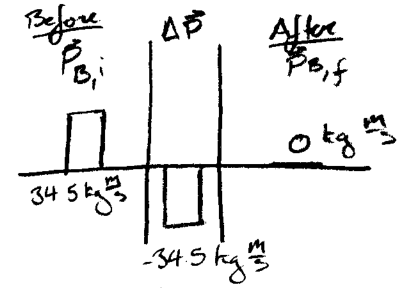


g) yes, they are consistent. The object has an unbalanced force exerted on it in the $-x$ direction, the ΔV is also in the $-x$ direction.

h)



i)



$\Delta\vec{P}$ caused by $F_{KFS-BOX}$ exerted by floor on box.

$\vec{P}_{B,i} = m_b \vec{V}_{b,i}$

$= (23\,kg)(1.5\,\frac{m}{s})$

$= \underline{34.5\,kg\,\frac{m}{s}}$

$\vec{P}_{B,f} = m_b \vec{V}_{b,f}$

$= (23\,kg)(0\,\frac{m}{s}) = \underline{0\,kg\,\frac{m}{s}}$

j) $a_x = \dfrac{\Delta V_x}{\Delta t}$

$\Delta V_x = V_{f,x} - V_{i,x} = 0\,\frac{m}{s} - 1.5\,\frac{m}{s}$

$= -1.5\,\frac{m}{s}$

$\Delta t = 2$ seconds

$= \dfrac{-1.5\,\frac{m}{s}}{2\,s}$

$\boxed{= -0.75\,\frac{m}{s^2}}$

k) $F_{KFS-BOX} = \mu_K \bar{N}$

$\mu_K = \dfrac{F_{KFS-BOX}}{\bar{N}}$

We know that:

$\Sigma F_{on Box,x} = F_{KFS-BOX}$

$a_x = \dfrac{\Sigma F_{on Box,x}}{m_b}$

$\Sigma F_{on Box,x} = a_x m_b$

$\therefore F_{KFS-BOX} = a_x m_b$

We know that:

$\Sigma F_{on Box,y} = F_{FLOOR-BOX} + F_{EARTH-BOX} = 0$

$F_{FLOOR-BOX} = \bar{N}$

$F_{EARTH-BOX} = m_b g$

$\bar{N} + m_b g = 0$

$\underline{\bar{N} = -m_b g}$

$\mu_K = \dfrac{a_x \cancel{m_b}}{-\cancel{m_b} g} = \dfrac{a}{-g} = \dfrac{-0.75\,\frac{m}{s^2}}{-(-10\,\frac{m}{s^2})}$

$\boxed{\mu_K = 0.075 \text{ (get rid of } -)}$

l) Many ways to do this part:

① $x_f = \frac{1}{2}at^2 + V_0t + x_0$

$x_f - x_0 = \frac{1}{2}at^2 + V_0t$

$\Delta x = \frac{1}{2}at^2 + V_0 t$

$a = -0.75 \frac{m}{s^2}$

$V_0 = 1.5 \frac{m}{s}$

$t = 2s$

$\Delta x = \frac{1}{2}(-0.75 \frac{m}{s^2})(2s)^2 + (1.5 \frac{m}{s})(2s)$

$= -1.5m + 3m = \boxed{1.5m}$

② $V_f^2 = V_i^2 + 2a\Delta x$

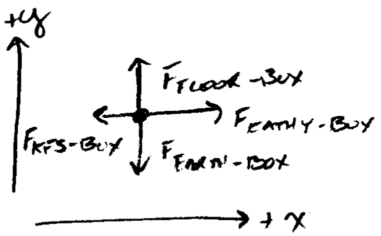
$V_f^2 - V_i^2 = 2a\Delta x$

$\Delta x = \frac{V_f^2 - V_i^2}{2a}$

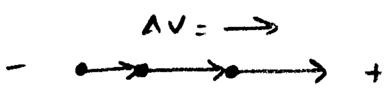
$\Delta x = \frac{(0\frac{m}{s})^2 - (1.5\frac{m}{s})^2}{2(-0.75\frac{m}{s^2})} = \boxed{1.5m}$

m) If things come out of the box the box's mass will decrease. This means the normal force would be less and therefore the force of kinetic friction on the box would decrease since $F_{KFS\text{-}Box} = \mu_K \bar{N}$.

If Kathy kept pushing the same, the force diagram would look like this:



Then the motion diagram would look like this:



The box would be accelerating instead of staying at a constant speed.

PROBLEM 2

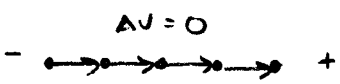
a) 0-5 sec - moving at a constant velocity of $+5\frac{m}{s}$

5-15 sec - moving in + direction, slowing down to a stop at 15 s

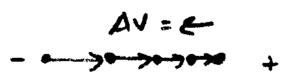
15-25 sec - moving in - direction, speeding up until 25 s

25-30 sec - comes to an abrupt stop at 25 s, stays stopped

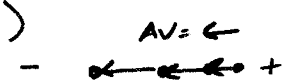
b)



c)



d)



e) $V_f = at + V_0$

$V_0 = 5\frac{m}{s}$ @ 5 seconds

$a = \frac{\Delta V}{\Delta t}$ choosing $t_1 = 5$ sec

$t_2 = 15$ sec

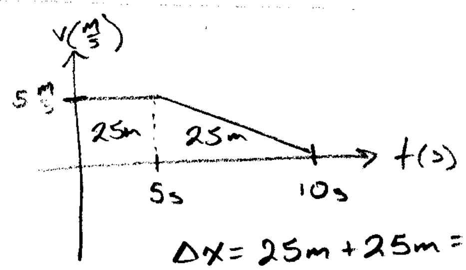
$$a = \frac{V_2 - V_1}{t_2 - t_1} = \frac{0\frac{m}{s} - 5\frac{m}{s}}{15s - 5s} = \frac{-5\frac{m}{s}}{10s} = \underline{-0.5\frac{m}{s^2}}$$

$$\boxed{V_f = \left(-0.5\frac{m}{s^2}\right)t + 5\frac{m}{s}}$$

f) $x_f = x_i + \Delta x$

x_f @ 15 seconds = +67 m

Δx = area between graph & axis



$\Delta x = 25m + 25m = 50m$

$x_i = x_f - \Delta x$

$= +67m - 50m = \boxed{17m}$

g) $t_1 = 9s$ $t_2 = 21s$

$\Delta t = t_2 - t_1 = 21s - 9s = 12s$

$\underline{m} = 8.4kg$ $\Delta V = V_2 - V_1 = -3\frac{m}{s} - 3\frac{m}{s} = \underline{-6\frac{m}{s}}$

Impulse = $\Sigma F \Delta t = m\Delta V$

$$\boxed{I = (8.4kg)\left(-6\frac{m}{s}\right) = -50.4 kg\frac{m}{s} \text{ -or- } N\cdot s}$$

Net force

h) $\Sigma F \Delta t = m\Delta V$

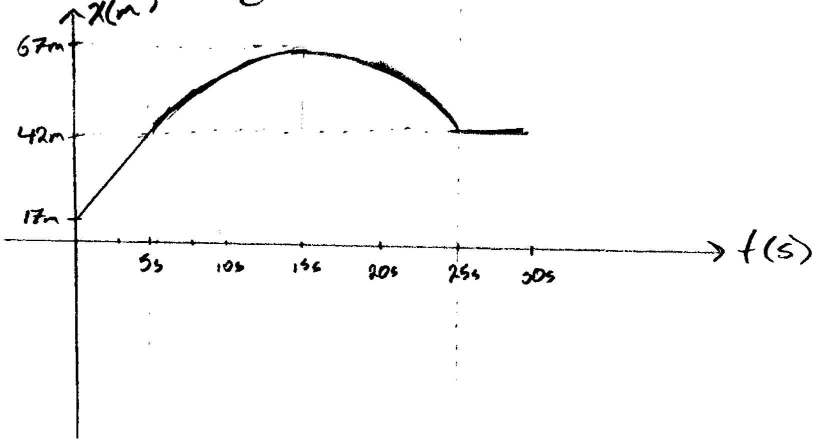
$\Sigma F = \frac{m\Delta V}{\Delta t}$

$= \frac{-50.4 N\cdot s}{12 s}$

$\boxed{= -4.2N}$

i) A soccer player is moving at a constant velocity for 5 seconds, she begins to slow down over the next 10 seconds then turns around and speeds up in the negative direction. after another 10 seconds she abruptly stops.

j)



PROBLEM 3

a) $F_{SFS\,on\,O} = \mu_s \bar{N}$ $\qquad a = \frac{\Sigma F_{on\,O}}{m}$

FOR CAR A:

$F_{ROAD\text{-}A} = \bar{N}_A$

$\Sigma F_y = 0 = F_{ROAD\text{-}A} + F_{EARTH\text{-}A} \qquad a_{A,y} = 0$

$F_{ROAD\text{-}A} = -F_{EARTH\text{-}A}$

$\bar{N}_A = -F_{EARTH\text{-}A} = -m_A g$

$F_{SFS\,on\,A} = -\mu_{sA} m_A g = \Sigma F_{x,A}$

$a_{x,A} = \frac{\Sigma F_{x,A}}{m_A} = \frac{-\mu_{sA} \cancel{m_A} g}{\cancel{m_A}}$

$= -\mu_{sA} g = -(0.5)(10\frac{m}{s^2})$

$\boxed{a_{x,A} = -5\frac{m}{s^2}}$

check sign on force diagram, unbalanced force going in $-x$ dir so sign is okay!

FOR CAR B:

$F_{ROAD\text{-}B} = \bar{N}_B$

$\Sigma F_y = 0 = F_{ROAD\text{-}B} + F_{EARTH\text{-}B} \qquad a_{B,y} = 0$

$F_{ROAD\text{-}B} = -F_{EARTH\text{-}B}$

$\bar{N}_B = -F_{EARTH\text{-}B} = -m_B g$

$F_{SFS\,on\,B} = -\mu_{sB} m_B g = \Sigma F_{x,B}$

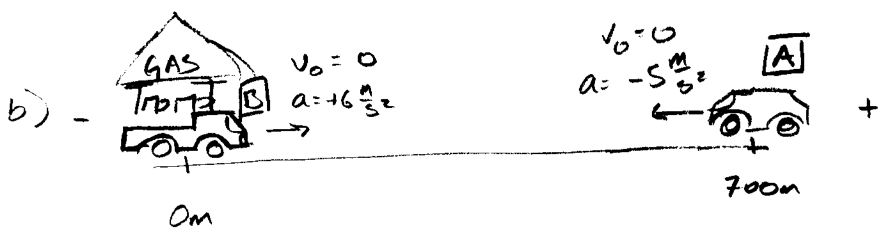
$a_{x,B} = \frac{\Sigma F_{x,B}}{m_B} = \frac{-\mu_{sB} \cancel{m_B} g}{\cancel{m_B}}$

$= -\mu_{sB} g = -(0.6)(10\frac{m}{s^2})$

$\boxed{a_{x,B} = +6\frac{m}{s^2}}$

check sign on force diagram, unbalanced force is positive, must change to positive!

b)



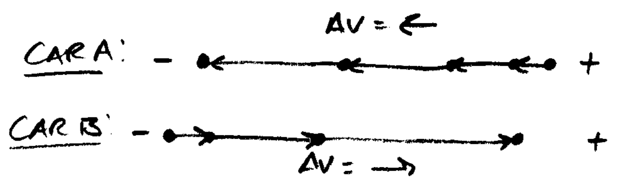
c) CAR A: $x_{fA} = \frac{1}{2}at^2 + V_0 t + x_0$

$x_{fA} = \frac{1}{2}(-5\frac{m}{s^2})t^2 + 700m$

CAR B: $x_{fB} = \frac{1}{2}at^2 + V_0 t + x_0$

$x_{fB} = \frac{1}{2}(6\frac{m}{s^2})t^2 + 0m$

d)



e) To determine where they crash you have to know that when they crash they are in the <u>same</u> position. Set the position vs. time equations equal to each other.

$$\underline{\text{CAR A}} \qquad\qquad \underline{\text{CAR B}}$$

$$\frac{1}{2}\left(-5\,\frac{m}{s^2}\right)t^2 + 700m = \frac{1}{2}\left(6\,\frac{m}{s^2}\right)t^2$$

solve for t

$$\left(-2.5\,\frac{m}{s^2}\right)t^2 + 700m = \left(3\,\frac{m}{s^2}\right)t^2$$

$$\left(-5.5\,\frac{m}{s^2}\right)t^2 = -700m$$

$$t^2 = \frac{700}{5.5}\,s^2$$

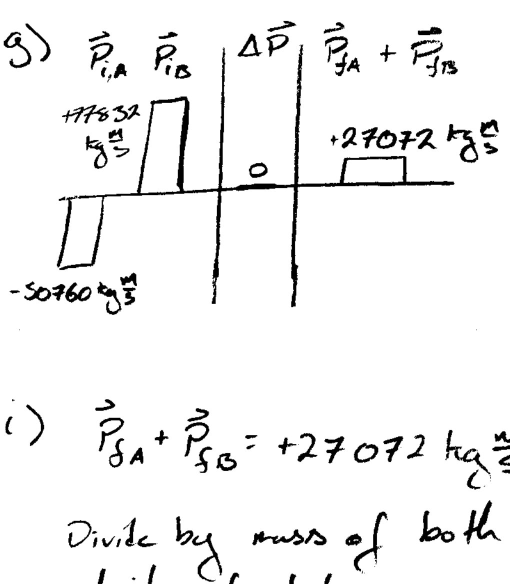
$$\boxed{t = \sqrt{\frac{700}{5.5}\,s^2} = 11.28\,s}$$

f) Find velocity as a function of time equations: $V_f = at + v_0$

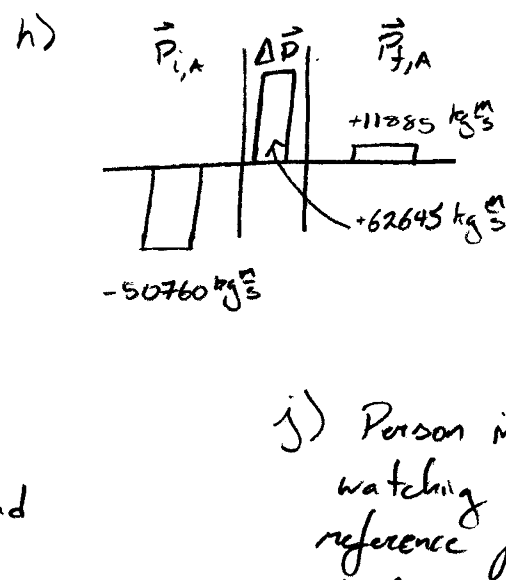
$\underline{\text{CAR A}}$: $V_{fA} = \left(-5\,\frac{m}{s^2}\right)t$ $\qquad V_{fA} = \left(-5\,\frac{m}{s^2}\right)(11.28\,s) = -56.4\,m/s$

$\underline{\text{CAR B}}$ $V_{fB} = \left(+6\,\frac{m}{s^2}\right)t$ $\qquad V_{fB} = \left(6\,\frac{m}{s^2}\right)(11.28\,s) = 67.68\,m/s$

g)



h)



i) $\vec{P}_{fA} + \vec{P}_{fB} = +27072\,kg\frac{m}{s}$

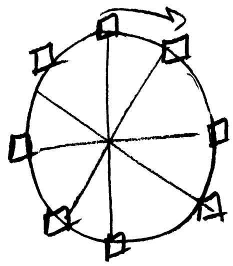
Divide by mass of both to find velocity of stuck cars.

$$\frac{\vec{P}_{fA} + \vec{P}_{fB}}{(m_A + m_B)} = \frac{+27072\,kg\frac{m}{s}}{(900kg + 1150kg)} = \boxed{13.21\,\frac{m}{s}}$$

j) Person inside the car is watching from a non-inertial reference frame. His motion diagram and force diagram for the boot would be inconsistent.
Person outside the car is in an inertial reference frame. Diagrams would be consistent.

PROBLEM 4

a)

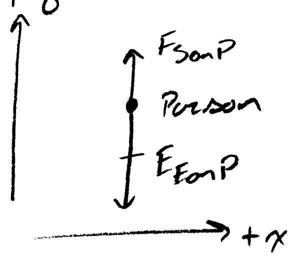


$d = 24m$

$r = 12m$

b)

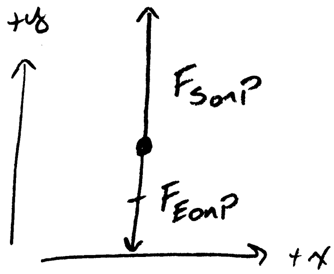
TOP



Person feels lighter b/c seat is not pushing as hard as 'normal'

c)

Bottom



Person feels heavier b/c seat is pushing harder than 'normal'

d) $\Delta t = 90s$ ← Time it takes to go around once.

$\frac{\text{Circumference}}{\text{time}}$ = how fast charlotte is going

$$\frac{24\pi\ m}{90s} = \boxed{0.84\ m/s}$$

e) $a = \frac{v^2}{r} \Rightarrow \frac{(0.84\ m/s)^2}{12m} = \boxed{0.0588\ m/s^2}$

f) @ Top, unbalanced force is down ∴ acceleration is negative!

$$a = \frac{\Sigma F}{m} \Rightarrow a = \frac{F_{EonC} + F_{SonC}}{m_c}$$

$$F_{SonC} = am_c - F_{EonC}$$

$$F_{SonC} = (-0.0588\ m/s^2)(45\ kg) - (-9.8\ m/s^2)(45\ kg)$$

$$\boxed{F_{SonC} = 438.4\ N}$$

↳ feels 2.6N lighter!

g) Bottom, unbalanced force is up ∴ acceleration is positive!

$$F_{SonC} = (+0.0588\ m/s^2)(45\ kg) - (-9.8\ m/s^2)(45\ kg)$$

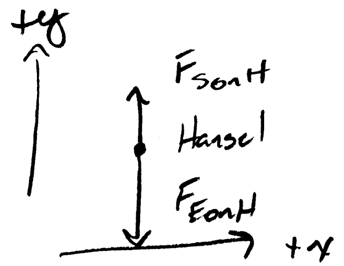
$$\boxed{F_{SonC} = 433.6\ N}$$

↳ feels 2.6N heavier!

h) $a_{orig} = \frac{(v_{orig})^2}{r}$ $\quad a_{new} = \frac{(\frac{1}{5} v_{orig})^2}{r} \Rightarrow a_{new} = \frac{(\frac{1}{5})^2 (v_{orig})^2}{r} \Rightarrow a_{new} = \frac{1}{25} \frac{v_{orig}^2}{r}$

$$\boxed{\frac{1}{25} a_{orig} = a_{new}}$$

i) Hansel is 3/4th as heavy → meaning the seat is pushing 3/4 ths as much as usual!



① $F_{SonH} + F_{EonH} = \Sigma F$

② $F_{SonH} = -\frac{3}{4} F_{EonH}$

(1+2) $-\frac{3}{4} F_{EonH} + F_{EonH} = \Sigma F$

$$\frac{1}{4} F_{EonH} = \Sigma F$$

1/4th Force of Earth on Hansel if he were free falling ∴

$$a = \frac{1}{4}(-9.8\,m/s^2) = \boxed{-2.45\,m/s^2}$$

j) $a = \frac{v^2}{r}$

↑ magnitude of centripetal acceleration!

$v^2 = ar \Rightarrow v = \sqrt{ar}$

$$v = \sqrt{(2.45\,m/s^2)(7m)} = \boxed{4.14\,m/s}$$