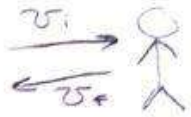
Problem 1

$m_0 = 0{,}4285\,kg$

$t = 0{,}02\,s$

$v_i = 189\frac{km}{h} = 52{,}5\,m/s$

$v_f = 21\frac{km}{h} = 5{,}83\,m/s$



$J = \Delta p = m_0(v_f - v_i)$

$F = \frac{J}{t} = \frac{m_0(v_f + v_i)}{t} = \frac{0{,}4285 \cdot 58{,}33}{0{,}02} =$

$= 1249{,}72\,N$

Answer: $1249{,}72\,N$

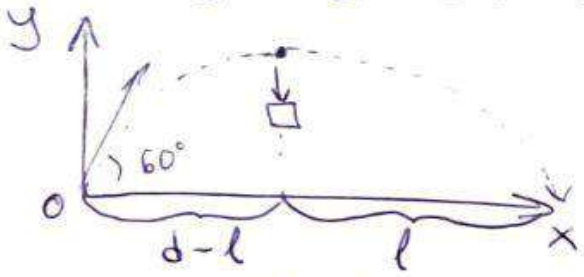
Problem 2

$v_x = v_0 \cos 60° = \frac{v_0}{2}$

$\frac{m v_0}{2} = \frac{m}{2} v_{piece} \iff v_0 = v_{piece}$

Let's find time before the fall:

$0 = y_0 - \frac{gt^2}{2} \iff t = \sqrt{\frac{2y_0}{2}}$



$l = v_0 \sqrt{\frac{2y_0}{2}}$

$y_0 = \frac{v_0^2 \sin^2 60}{2g}$

$r = d - l = v_0 \cos 60° \cdot \frac{v_0 \sin 60}{g} = \frac{v_0^2 \sin 60 \cdot \cos 60}{g}$

$d = l + r = \frac{v_0^2 \sin 60 \cdot \cos 60}{g} + v_0 \sqrt{\frac{2}{g} \cdot \frac{v_0^2 \sin^2 60}{2g}} =$

$= \frac{400 \cdot \frac{\sqrt{3}}{2} \cdot \frac{1}{2}}{9{,}81} + 20 \sqrt{\frac{400 \cdot \frac{3}{4}}{g^2}} = \frac{100\sqrt{3}}{9{,}81} + \frac{20 \cdot 20 \cdot \frac{\sqrt{3}}{2}}{g} =$

$= \frac{300\sqrt{3}}{9{,}81} \approx 52{,}96\,m$

Problem 3

$m_{1i}v_{1i} + m_{2i}v_{2i} = m_1v_{1f} + m_2v_{2f}$ (momentum law for 1-st and 2-nd)

$10m_1 = m_1v_{1f} + m_2v_{2f}$

$m_2v_{2f} = m_3v_{3f}$ (momentum law for 2-nd and 3-rd)

$m_2v_{2f} = 30$

$v_{2f} = \frac{30}{m_2}$

$10m_1 = m_1v_{1f} + 30 \iff v_{1f} = \frac{10m_1 - 30}{m_1}$

Let's write energy law:

$$\begin{cases} \frac{m_1v_{1i}^2}{2} - \frac{m_1v_{1f}^2}{2} = \frac{m_2v_{2i}^2}{2} \\ \frac{m_2v_{2i}^2}{2} = \frac{m_3v_{3f}^2}{2} \end{cases} \iff m_2v_{2f}^2 = 150$$

$100m_1 - v_{1f}^2m_1 = 150$

$m_1 = \frac{150}{100 - v_{1f}^2}$

$v_{1f} = \frac{\frac{1500}{100-v_{1f}^2} - 30}{\frac{150}{100-v_{1f}^2}} \iff \frac{150v_{1f}}{100-v_{1f}^2} = \frac{1500}{100-v_{1f}^2} - 30$

$150v_{1f} - 1500 + 3000 - 30v_{1f}^2 = 0$

$v_{1f}^2 - 5v_{1f} - 50 = 0 \iff \begin{bmatrix} v_{1f} = -5\ m/s \\ v_{1f} = 10\ m/s \end{bmatrix}$

The answer is $v_{1f} = -5\ m/s$, because $v_{1f} = 10\ m/s$ contradicts the statement of a problem.

Problem 4

$J = F_{avg}\Delta t \iff \Delta t = \frac{J}{F_{avg}} = \frac{56 \cdot 85}{120000 - mg} \approx 0{,}04\ s$

$-mg + F = ma \iff a = \frac{-mg+F}{m} = \frac{120000 - 85 \cdot 9{,}81}{85} = 1401{,}96\ m/s^2$

$x = v_0t - \frac{at^2}{2} = 56 \cdot 0{,}04 - \frac{1401{,}96 \cdot 0{,}04^2}{2} \approx 1{,}118m$

$p = mv_0 = 85 \cdot 56 = 4760$

Answer: (a) 1,118m (b) $\Delta t = 0{,}04s$ (c) $4760\ kg\frac{m}{s}$