<1.4> 90°. in the cart frame, the cannonball has the same velocity in x direction with the cart.

<1.6> In M frame v_M =0 $v_m = v_0$

After collision v_M =0 v_m =- v_0

In lab frame v_M =- v_0 v_m =-2 v_0

<1.9> (a) v = - $3\times10^4 * 10^4 + 29979\times10^4$ = 29976×10^4 m/s

(b) v = 3×10^4 + 29979×10^4 = 29982×10^4 m/s

(c) v = $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} \Rightarrow \frac{2\sqrt{2}}{3}c$ = 2997900015×10^4 m/s

<1.23> $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ =3 $\Rightarrow$ v= $\frac{2\sqrt{2}}{3}c$ =0.942c

<1.26> (a) $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ R_h = $\frac{5}{3}$

(b) $1.8\times10^{-8}\times\frac{5}{3}$ = 3×10^{-8} s

(c) n= $\frac{36}{3\times10^{-8}\times0.8\times3\times10^{8}}$ =5

N= $N_0\frac{1}{2^n} = \frac{32000}{2^5}$ =1000

(d) n= $\frac{36}{1.8\times10^{-8}\times0.8\times3\times10^{8}} = \frac{25}{3}$

N= $N_0\frac{1}{2^n} = \frac{32000}{2^{\frac{25}{3}}} \approx 99$

<1.29> $\gamma = \frac{40}{32} = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ $\Rightarrow$ v= $\frac{3}{5}$ c= 1.8×10^{8} m/s

<1.31> $\gamma = \dfrac{1}{\sqrt{1-\dfrac{v^2}{c^2}}} = \dfrac{2\sqrt{3}}{3}$

$\Delta y = \Delta y$, $\Delta z = \Delta z^{'}$: y, z direction remain the same

$\Delta x = \dfrac{2\sqrt{3}}{3}\Delta x^{'}$:x direction is compressed when seen in the lab frame

So, sphere will be an ellipsoid seen in the lab frame.

<1.33> suppose the proper length of the stick is l_0

$$\gamma = \frac{1}{\sqrt{1-\dfrac{v^2}{c^2}}} = \frac{5}{3}$$

(a) $l = \dfrac{3}{5} l_0$

(b) $l = l_0$

(c) $x' = \dfrac{l_0}{2}$, $y' = \dfrac{\sqrt{3} l_0}{2}$

$$x = \frac{l_0}{2}\cdot\frac{3}{5} = \frac{3l_0}{10} \quad , \quad y = y' = \frac{\sqrt{3} l_0}{2}$$

$$l = \sqrt{\left(x^2 + y^2\right)} = 0.917\, l_0$$

(d) $x^{'} = l_0 \sin\theta$, $y^{'} = l_0 \cos\theta$

$$\frac{y}{x} = \tan 60^\circ = \sqrt{3} = \frac{y'}{\dfrac{x'}{\gamma}} = \frac{5}{3}\tan\theta .$$

And use $\sin^2\theta + \cos^2\theta = 1$

Then, $\sin^2\theta = \dfrac{27}{52}$, $\cos^2\theta = \dfrac{25}{52}$

$$l = \sqrt{\left(\frac{x'^2}{\gamma^2} + y'^2\right)} = \sqrt{(\frac{3}{5} l_0 \cos\theta)^2 + (l_0 \sin\theta)^2} = 0.832\, l_0$$

<1.39> (a) $x_1 = \dfrac{5}{3}(1500 - 0.8\times 3\times 10^8 \times 5\times 10^{-6}) = 500$ m, $y_1 = z_1 = 0$

$$t_1 = \frac{5}{3}(5\times10^{-6} - \frac{4}{5}\cdot\frac{1500}{3\times10^8}) = \frac{5}{3}\times10^{-6}\,\text{s}$$

(b) $x_2 = \frac{5}{3}(-1500 - 2400) = -6500\,\text{m}, \quad y_2 = z_2 = 0$

$$t_2 = \frac{5}{3}(10\times10^{-6} - \frac{4}{5}\cdot\frac{-1500}{3\times10^8}) = \frac{70}{3}\times10^{-6}\,\text{s}$$

(c) $\Delta t' = 5\times10^{-6}\,\text{s}$

$$\Delta t = (\frac{70}{3} - \frac{5}{3})\times10^{-6} = \frac{65}{3}\times10^{-6}\,\text{s}$$

<1.45> $u = \frac{0.6+0.5}{1+0.6\cdot0.5}c = 0.85c$

<1.46> $u' = \frac{0.9+0.9}{1+0.9\cdot0.9}c = 0.9945c$

<1.49> blueshift : approaching

$$\frac{1+\beta}{1-\beta} = 1.01^2 = 1.0201$$

$$\Rightarrow \quad \beta = \frac{0.0201}{2.0201} = \frac{v}{c} \quad \Rightarrow \quad v = 0.01c$$

<2.9> $\gamma m_0c^2 - m_0c^2 = 2m_0c^2$

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = 3 \quad \Rightarrow \quad v = \frac{2\sqrt{2}}{3}c$$

<2.17> (a) $E = [m_0^2c^4 + p^2c^2]^{\frac{1}{2}}$ =5Gev

(b) $E = \gamma m_0c^2 \quad \Rightarrow \quad \frac{v^2}{c^2} = 1 - \frac{m_0^2c^4}{E^2} = \frac{16}{25} \quad \Rightarrow \quad v = \frac{4}{5}c$

<2.19> $E = m_0c^2 + E_k = 1438Mev$

$$E^2 = m_0^2c^4 + p^2c^2 \quad \Rightarrow \quad p^2c^2 = \sqrt{\frac{E^2}{c^4} - m_o^2} \quad \Rightarrow \quad p = 1348Mev/c$$

$$E = \frac{m_0c^2}{\sqrt{1-\frac{v^2}{c^2}}} \quad \Rightarrow \quad v = 0.76c$$

<2.22> (a) $E^2 = m_0^2c^4 + p^2c^2 \geq p^2c^2$

$$(\gamma m_0c^2)^2 \geq (\gamma m_0v^2)^2$$

$c \geq v$

(b) Equal sign holds for m=0 case, and then v=c, that is photon.

<2.24> $m_e c^2 + m_p c^2 - m_H c^2$ =13.6ev= $\Delta M c^2$

$$\Delta M = 13.6 ev / c^2$$

$$\frac{\Delta M}{m_e + m_p} = 1.44 \times 10^{-8}$$

<2.27> (a) $(\frac{E_\Lambda}{c}, \overrightarrow{p_\Lambda}) = (\frac{E_p + E_\pi}{c}, \overrightarrow{p_\pi})$

$$m_\Lambda^2 c^2 = \frac{E_p^2}{c^2} + (\frac{E_\pi^2}{c^2} - \overrightarrow{p_\pi}^2) + \frac{2E_p E_\pi}{c^2}$$

$E_\pi = \frac{m_\Lambda^2 c^2 - m_\pi^2 c^2 - m_p^2 c^2}{2m_p}$ =184.4Mev

(b) $E_\Lambda = E_p + E_\pi = m_p c^2 + E_\pi$ =938+184.4=1122.4Mev

<2.31> $E_m = E_1 + E_2$, $\overrightarrow{p_m} = \overrightarrow{p_1} + \overrightarrow{p_2}$

$\Rightarrow$ $E_m = (m_1^2 c^4 + p_1 c^2)^{\frac{1}{2}} (m_2^2 c^4 + p_2 c^2)^{\frac{1}{2}}$,

$\overrightarrow{p_m} = p_1 \hat{j} + p_2 \hat{i}$

Then $E_m^2 = m^2 c^4 + |p_m|^2 c^2$

$$[(0.25+4)^{\frac{1}{2}} + (1+2.25)^{\frac{1}{2}}]^2 = m^2 c^4 + 6.25$$

M=2.95Gev/ c^2

$$E_M = \gamma M c^2 \quad \Rightarrow \quad v = 0.42c$$

<2.37> $0 = p_{\gamma 1} + p_{\gamma 2}$, $m_\pi c^2 = E_\pi = 2E_\gamma$

$$\Rightarrow \quad E_\gamma = \frac{E_\pi}{2} = \frac{1}{2} m_\pi c^2 = 67.5 Mev$$

<2.38> $\vec{p}_\pi = \vec{p}_{\gamma 1} + \vec{p}_{\gamma 2} = 2\vec{p}_{\gamma 1}$, $E_{\pi 0} = E_{\gamma 1} + E_{\gamma 2}$

$$\Rightarrow \quad (m_\pi^2 c^4 + p^2 c^2)^{\frac{1}{2}} = |p_{\gamma 1}| c + |p_{\gamma 2}| c = 4 |p_{\gamma 1}| c$$

$$\gamma (12 p_{\gamma 1}^2 c^2)^{\frac{1}{2}} = 4 |p_{\gamma 1}| c$$

$$\Rightarrow \quad \gamma = \frac{2}{\sqrt{3}} \quad \Rightarrow \quad v = \frac{c}{2}$$

<3.2> 1-42 46-60 62-92 are naturally exist.
Others are artificial elements.

<3.12> (a) $A_{helium} = 4$, $A_{carbon} = 12$, $A_{iron} = 56$, $A_{lead} = 207$, $A_{lawrencium} = 260$

$$R = 1.1 \times A^{\frac{1}{3}}$$

$$R_h = 1.745\,fm,\ R_c = 2.498\,fm,\ R_i = 4.203\,fm,\ R_{le} = 6.496\,fm,\ R_{la} = 7.008\,fm$$

(b) $E_{\max} = \frac{-kQ}{r_0^2} = \frac{1.44 \times 7.9 \times 10^{-9}}{(8 \times 10^{-15})^{\frac{1}{2}}} = 1.8 \times 10^{21}$ $V = \frac{4}{3}\pi R^3 = \frac{4}{3}\pi R_0^3 A$

$$\rho = \frac{m}{V} = \frac{A}{V} m_0 = const$$

<3.47> $E_{\max} = \frac{-kQ}{r_0^2}$

So $E_{\max} = \frac{-kQ}{r_0^2} = \frac{1.44 \times 7.9 \times 10^{-9}}{(0.18 \times 10^{-9})^{\frac{1}{2}}} = 3.5 \times 10^{12}$ V/m for Thomson model.

$E_{\max} = \frac{-kQ}{r_0^2} = \frac{1.44 \times 7.9 \times 10^{-9}}{(8 \times 10^{-15})^{\frac{1}{2}}} = 1.8 \times 10^{21}$ V/m for Rutherford model.