H.W. Solution Chapter 37 Phys 201
Term 112

37.2

$$\gamma = \frac{1}{\sqrt{1-\beta^2}} \Rightarrow 1-\beta^2 = \frac{1}{\gamma^2} \qquad \beta = v/c$$

$$\beta^2 = 1 - \frac{1}{\gamma^2} \Rightarrow \beta = \sqrt{1-\frac{1}{\gamma^2}}$$

a) $\gamma = 1.01$

$\beta = 0.14037076$

b) $\gamma = 10.0$

$\beta = 0.99498744$

c) $\gamma = 100.0$

$\beta = 0.99995000$

d) $\gamma = 1000.0$

$\beta = 0.99999950$

37.4

$\Delta t = ?$ $v = 0.98c$ or $\beta = 0.98$

Δt is the time dilation measured by observer in S.

Δt_0 is the proper time measured by observer in S'.

when $\beta = 0$ $\Delta t_0 = 8$ s (from the graph). This is the proper time the clock is at rest with respect to S'.

Use the time dilation formula $\Delta t = \gamma \Delta t_0$

when $\beta = 0.98$ $\quad \gamma = \dfrac{1}{\sqrt{1-\beta^2}} = \dfrac{1}{\sqrt{1-(0.98)^2}} = 5.03$

$\Rightarrow \quad \Delta t = 5.03 \times 8 = \underline{\underline{40.2\ s}}$

37.9 $\quad L_0 = 1.7\,m \qquad v = 0.63c$

$L = \dfrac{L_0}{\gamma}$ (length contraction)

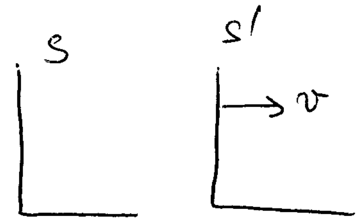
$L = 1.7\sqrt{1-(0.63)^2} = \underline{1.32\,m}$

37.14 $\quad L = \dfrac{L_0}{2} = \dfrac{L_0}{\gamma} \Rightarrow \gamma = 2$

a) $\quad \beta = \sqrt{1 - \dfrac{1}{\gamma^2}} = \underline{\underline{0.866}}$

b) $\quad \Delta t = \gamma\, \Delta t_0 \quad \Rightarrow \quad \dfrac{\Delta t}{\Delta t_0} = \gamma = \underline{\underline{2.}}$

37.16



$v = 0.6\,c$

at $t = t' = 0 \qquad x' = x = 0$

<u>in S</u> event 1 $\quad (0, 0)$

event 2 $\quad (3\,km, 4\,\mu s)$

a) Lorentz transformations

<u>in S'</u>

event 1
$$\begin{cases} x_1' = \gamma(x - vt) = 0 \\ t_1' = \gamma\left(t - \dfrac{vx}{c^2}\right) = 0 \end{cases}$$

<u>because</u> $x = 0$ and $t = 0$

b) event 2 in S' $\qquad \gamma = \dfrac{1}{\sqrt{1-\beta^2}} = 1.25$

$$x_2' = 1.25\left(3000 - 0.6 \times 3\times10^8 \times 4\times10^{-6}\right) = 2850\,\text{m} = \underline{2.85\,\text{km}}$$

$$t_2' = 1.25\left(4\times10^{-6} - \frac{0.6\times\cancel{3\times10^8}\times 3000}{(3\times10^8)^{\cancel{2}}}\right)$$

$$= \underline{-2.5\times10^{-6}\,\text{s}}$$

In S' event 2 happens before event 1 !!!
(very strange indeed)

c) Observer in frame S sees event 1, then event 2

Observer in frame S' sees event 2, then event 1 !

37.21

a) $v = 0.6c$ $\qquad \gamma = \dfrac{1}{\sqrt{1-(0.6)^2}} = \underline{1.25}$

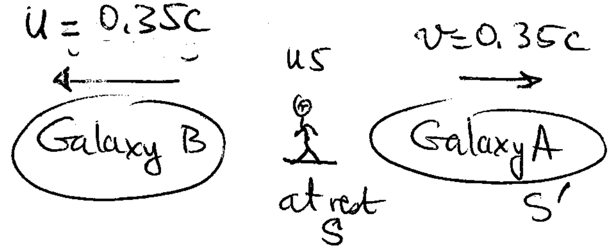
b) We have two times, one in the laboratory frame S (fixed) on one in the moving frame with the clock S'.

In frame S' we measure the proper time, in S we measure time dilation.

in S $\qquad d = v\Delta t \Rightarrow \Delta t = \dfrac{d}{v} = \dfrac{180}{0.6\times3\times10^8} = \underline{1\times10^{-6}\,\text{s}}$

in S' $\qquad \Delta t = \gamma\,\Delta t_0 \Rightarrow \Delta t_0 = \dfrac{\Delta t}{\gamma} = \underline{0.8\times10^{-6}\,\text{s}}$

37. 27 receding = moving away



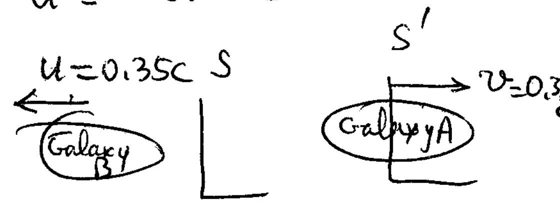
a) Galaxy A will find the speed of our Galaxy to be receding by $0.35c$!

b) use Lorentz transformation for velocities

$$u' = \frac{u - v}{1 + \frac{uv}{c^2}}$$

$v = +0.35c$

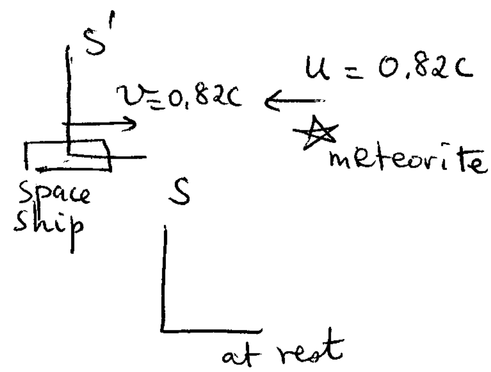
$u = -0.35c$



$$u' = \frac{-0.35c - 0.35c}{1 - (-0.35)(+0.35)}$$

$$\frac{u'}{c} = \frac{-0.7}{1 + 0.1225} = -0.62$$

37.33



a) $L_o = 350m$ $v = 0.82c$

let us calculate the velocity of the meteorite as measured by the ship

$$u' = \frac{u - v}{1 - \frac{uv}{c^2}} = \frac{(-0.82 - 0.82)c}{1 - (-0.82\cancel{c})(0.82\cancel{c})/\cancel{c^2}}$$

$= -0.98c$ (moving to the left) see figure.

this is the velocity of the meteorite wrt the ship (S' frame)

proper length

b) $\Delta t = \frac{d}{u'} = \frac{350}{0.98c}$

$\Delta t = 1.2 \times 10^{-6} s = \underline{1.2 \mu s}$

37.35

$$v = \frac{\Delta\lambda}{\lambda} c = \frac{620\,nm - 540\,nm}{620\,nm} \times \underbrace{3\times10^{8}}_{c}\ m/s$$

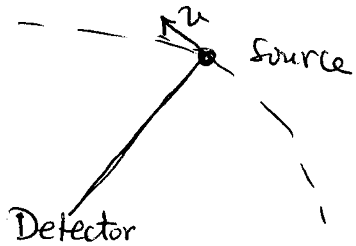
$$= 0.13\,c = 3.87\times10^{7} = \underline{\underline{0.387\times10^{8}\ m/s}}$$

of Course this speed is unrealistic !

37.38

$v = 0.1\ c$ Doppler Shift for light (transverse)

$\lambda_0 = 589\ nm$



$$f = f_0\sqrt{1-\beta^2}$$

$$\frac{c}{\lambda} = \frac{c}{\lambda_0}\sqrt{1-\beta^2}$$

$$\lambda = \frac{\lambda_0}{\sqrt{1-\beta^2}} \Rightarrow \lambda - \lambda_0 = \lambda_0\left(\frac{1}{\sqrt{1-\beta^2}} - 1\right)$$

$$\Delta\lambda = \lambda - \lambda_0 = 589\left(\frac{1}{\sqrt{1-(0.1)^2}} - 1\right) = \underline{\underline{2.97\,nm}}$$

37.42

$$p + {}^{19}F \longrightarrow \alpha + {}^{16}O$$

$m(p) = 1.007825\,u$ $m(F) = 18.998405\,u$

$m(\alpha) = 4.002603\,u$ $m(O) = 15.994915\,u$

$$Q = \Delta M c^2 = (M_i - M_f)c^2$$

$$M_i = (1.007825 + 18.998405)u = 20.006230u$$

$$M_f = (4.002603 + 15.994915)u = 19.997518u$$

$$\Delta M = 8.7 \times 10^{-3}\ u$$

$$c^2 = 931.494013\ \frac{MeV}{u}$$

$$\Rightarrow \underline{\underline{Q = 8.12\ MeV}}$$

In this problem the final mass is less than the initial mass, the mass is changed to energy!

37.46

$$K = (\gamma - 1) m_o c^2$$

m_o is the rest mass of the electron

$$\frac{K}{m_o c^2} = \gamma - 1 \Rightarrow \gamma = 1 + \frac{K}{m_o c^2} \qquad m_o c^2 = 0.511\ MeV$$

a) $K = 1\ keV \Rightarrow \gamma = 1 + \frac{1}{511} = 1.001956947$

$$\underline{\gamma = 1.0019570}$$

b) $\beta = \sqrt{1 - \frac{1}{\gamma^2}} = \underline{0.06246947 4}$

c) $K = 1\ MeV \qquad \gamma = 2.9569514 \qquad$ d) $\beta = 0.94107924$

e) $K = 1\ GeV \qquad \gamma = 1957.9514 \qquad$ f) $\beta = 0.99999987$