Phys 201 F'09 Exam 1 Solutions

1. $\frac{\lambda_{obs}}{\lambda_{src}} = \left(\frac{1+\beta}{1-\beta}\right)^{1/2} = 1.01$

$\approx \left((1+\beta)(1+\beta)\right)^{1/2} = 1+\beta$ assuming $\beta \ll 1$.

$\Rightarrow \beta \approx 0.01$ consistent with $\beta \ll 1$.

$\boxed{v = 0.01\,c}$

2. a) $t_{Phelps} = \frac{1\ c\cdot min}{4c/5} = \boxed{\frac{5}{4}\ min}$

b) $t_{Thorpe} = \frac{1/2\ c\cdot min}{2c/5} = \boxed{\frac{5}{4}\ min}$

c) In Phelps' frame, $t' = t/\gamma$.

$\gamma = \left(1 - \frac{v_{Phelps}^2}{c^2}\right)^{-1/2} = \left(1-\left(\frac{4}{5}\right)^2\right)^{-1/2} = \frac{5}{3}$

$t' = \left(\frac{5}{4}\ min\right)\cdot\frac{3}{5} = \frac{3}{4}\ min = 45\ sec$

Time on Phelps' watch $\boxed{12{:}00 \text{ and } 45\ sec.}$

d) $u_y' = \frac{u_y}{\gamma} = \frac{2c/5}{5/3} = \boxed{\frac{6}{25}c}$

e) In the $t' = \frac{3}{4}$ min, Thorpe travels a distance

$u_y'\,t' = \left(\frac{6}{25}c\right)\left(\frac{3}{4}\ min\right) = \boxed{\frac{9}{50}\ c\cdot min}$

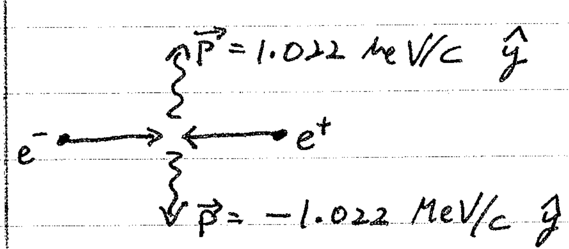
f) Extra distance Thorpe needs to travel

$\Delta d = \frac{1}{2}\,c\cdot min - \frac{9}{50}\,c\cdot min = \frac{8}{25}\,c\cdot min$

During the head start Phelps is not swimming, so the extra time needed by Thorpe is $\frac{\Delta d}{u_y} = \frac{8/25\ c\cdot min}{2/5\ c} = 4/5\ min$

$= \boxed{48\ sec}$

3.



$$\vec{P}_{Tot} = 0$$
$$= m_{e^-} \vec{u}_{e^-} \gamma_{e^-} + m_{e^+} \vec{u}_{e^+} \gamma_{e^+}$$
$$m_{e^-} = m_{e^+} \equiv m_e \rightarrow \vec{u}_{e^-} = -\vec{u}_{e^+}$$

$$E_{tot} = 2pc = 2.044 \text{ MeV}$$
$$= 2 m_e c^2 \gamma$$
$$= 2(0.511 \text{ MeV}/c^2) c^2 \gamma$$
$$\Rightarrow \gamma = \frac{2.044}{1.022} = 2$$

$$\left(1 - \frac{u^2}{c^2}\right)^{-1/2} = 2$$

$$1 - \frac{u^2}{c^2} = \frac{1}{4} \Longrightarrow \boxed{u = \frac{\sqrt{3}}{2} c}$$