Krane Chapter 2

Problem 5

(a)

$$\Delta t = \frac{\Delta t_0}{\sqrt{1-(u/c)^2}} = \frac{100.0ns}{\sqrt{1-(0.960)^2}} = 357.1ns$$

(b)

$$d = v\Delta t = 0.960(3.00\times 10^8)(357.1\times 10^{-9} = 103\ m$$

(c)

$$d = v\Delta t_0 = 0.960(3.00\times 10^8)(100\times 10^{-9} = 28.8\ m$$

Probelm 16

O measures t_1 and t_2 , and O' measure t_1' and t_2'. Using eq 2.23d

$$t_1' = \frac{t_1 - ux/c^2}{\sqrt{1-(u/c)^2}} \qquad and \qquad t_2' = \frac{t_2 - ux/c^2}{\sqrt{1-(u/c)^2}}$$

The same coordinate x appears in both wxpressions, because the bulb is at rest according to O. Subtraction yields

$$t_2' - t_1' = \frac{t_2 - t_1}{\sqrt{1-(u/c)^2}} \qquad or \qquad \Delta t' = \frac{\Delta t}{\sqrt{1-(u/c)^2}}$$

Problem 24

$$E^2 = \frac{(mc^2)^2}{1-(u/c)^2} = (mc^2)^2 + \frac{mc^2u^2}{1-(u/c)^2} = (mc^2)^2 + (pc)^2$$

$$E = \sqrt{(mc^2)^2 + (pc)^2}$$

Problem 32

Since the electric charge magnitude is the same for both the proton and the electron, the KE energy equals the change in Potential energy, or $q\Delta V = K = 10$ MEV. Using .5 Mev for the Rest Mass of the electron gives $E = K + mc^2$. So

$$p = \frac{\sqrt{E^2 - (mc^2)^2}}{c} = \frac{\sqrt{(10.5)^2 - (0.5)^2}}{c} = 10.488\ \ Mev/c$$

Using classical formulas

$$p = \sqrt{2mK} = \sqrt{2\times .511\times 10} = 3.1969\ Mev/c$$

which is far different from the relativistic result. This is typical when the kinetic energy exceeds the rest mass energy.

For the proton, the rest mass enmergy is 938.3 Mev which is far larger than the kinetic energy of 10 Mev. The relativistic computation will be very close to the classical computation:

$$p = \sqrt{2MK} = \sqrt{2\times 938.3\times 10} = 137.99\ Mev/c$$

$$p = \frac{\sqrt{E^2 - (\mathrm{M}c^2)^2}}{c} = \frac{\sqrt{(948.3)^2 - (938.3)^2}}{c} = 137.35\ \ Mev/c$$

Problem 35

$$\boxed{E1 + E2 = 9700\ Mev = \frac{2Mc^2}{\sqrt{1-(u/c)^2}} = \frac{2\times 938.3}{\sqrt{1-(u/c)^2}}}$$

$$\boxed{1-(u/c)^2 = \left(\frac{2\times 938.3}{9700}\right)^2 = 0.0374 \quad so \quad u = 0.981c}$$