ABRHS PHYSICS (H) NAME: KEY

Relativity Problems II-a

1. a. What is the Lorentz factor for an object moving at 35 m/s?

$\beta = \frac{35}{3\times10^8} = 1.17\times10^{-7}$ $\gamma = \frac{1}{\sqrt{1-\beta^2}} = \frac{1}{\sqrt{1-(1.17\times10^{-7})^2}} = 1$

b. What is the Lorents factor for an object moving at 0.5c?

$\gamma = \frac{1}{\sqrt{1-.5^2}} = 1.15$

c. What is the Lorentz factor for an object moving at 2.9×10^8 m/s?

$\beta = \frac{2.9}{3} = 0.967$ $\gamma = \frac{1}{\sqrt{1-.967^2}} = 3.91$

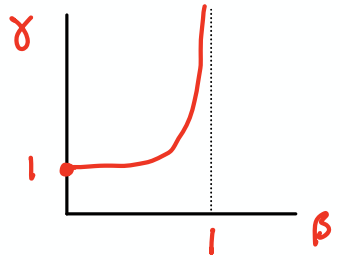
d. How fast does something have to travel for the Lorentz factor to be 3?

$3 = \frac{1}{\sqrt{1-\beta^2}}$ $9 = \frac{1}{1-\beta^2}$ $9-9\beta^2 = 1$ $\beta^2 = \frac{8}{9}$ $\beta = 0.943$

e. How fast does something have to travel for the Lorentz factor to be 10?

$10 = \frac{1}{\sqrt{1-\beta^2}}$ $100 = \frac{1}{1-\beta^2}$ $100-100\beta^2 = 1$ $\beta^2 = \frac{99}{100}$ $\beta = 0.995$

2. Sketch the Lorentz factor vs the speed factor. (γ vs β)



3. a. Who measures the proper time (t_0) between two events?

The one reference frame in which the two events happen at the same coordinate.

b. Who measures a time-dilated time (t) between two events?

Everyone else (so whenever the two events happen at different coordinates.)

4. A spaceship flies by the earth with a relative speed of v. On the ship, there is a blinking light.
   a. On the ship, the time between flashes of light is 1 second. If the ship flies by the earth at 0.9c, what is the time interval between flashes as seen on the earth?

$\beta = 0.9$

$t_0 = 1$ s

$\gamma = \frac{1}{\sqrt{1-.9^2}}$ $t_0 = 1s$

$\gamma = 2.29$

$t = \gamma t_0 = (2.29)(1)$

$t = 2.29$ s

Relativity Problems II-a

b. If the flashes are 0.01 seconds apart on the ship, and 0.1 seconds apart on the earth, how fast is the ship traveling?

$t_0 = 0.01$ s

$t = 0.1$ s

$t = \gamma t_0$

$0.1 = \gamma (0.01)$

$\gamma = 10$

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

$10 = \frac{1}{\sqrt{1-\beta^2}}$

$\beta = 0.995$

c. The ship flies by at 0.95c. If the flashes are 2 seconds apart on earth, how far apart are they on the ship?

$\beta = 0.95$

$t = 2$ s

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

$\gamma = \frac{1}{\sqrt{1-.95^2}}$ $\gamma = 3.20$

$t = \gamma t_0$

$2 = (3.2) t_0$

$t_0 = 0.62$ s

5. A rocket flies across a field at a speed of 0.8c. People on the field determine that it takes the rocket 2.5 μs to cross the field. How long does it take according to the rocket?

$\beta = 0.8$

$t = 2.5\ \mu s$

$\gamma = \frac{1}{\sqrt{1-.8^2}}$

$\gamma = 1.667$

$t = \gamma t_0$

$2.5 = (1.667)\, t_0$

Note: $\mu s = 10^{-6}$ s "micro-second"

$t_0 = 1.5\ \mu s$

6. An electron traveling at 0.99c takes 4 μs to travel down a particle accelerator tube, according to the electron. How long does it take to the scientists at the accelerator?

$\beta = .99$

$t_0 = 4\ \mu s$

$\gamma = \frac{1}{\sqrt{1-.99^2}}$

$\gamma = 7.089$

$t = \gamma t_0$

$t = (7.089)(4)$

$t = 28.4\ \mu s$

7. You watch the length of a spaceship pass by you in 0.6 μs. If the ship is traveling at 0.85c, how long did that take according to the ship?

$\beta = 0.85$

$t_0 = 0.6\ \mu s$

$\gamma = \frac{1}{\sqrt{1-.85^2}}$

$\gamma = 1.898$

$t = \gamma t_0$

$t = (1.898)(0.6)$

$t = 1.14\ \mu s$

Answers:

1. a) 1 b) 1.15 c) 3.91 d) 0.94c e) 0.995c

3. a) the RF with the 2 events at the same coordinates b) the RF with the 2 events at different coordinates

4. a) 2.29 sec b) 0.995c c) 0.62 sec 5) 1.5 μs 6) 28.4 μs 7) 1.14 μs