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Relativity Problems III

1. A particle flies by your desk at 0.98c. If your desk is 2 meters long, how long does it take the particle to pass your desk, from the particle's frame of reference?

$\beta = 0.98$
$L_0 = 2m$
$t_0 = ?$

$\gamma = \frac{1}{\sqrt{1-\beta^2}}$
$\gamma = \frac{1}{\sqrt{1-.98^2}}$
$\gamma = 5.025$

$L_0 = vt$
$2 = (.98)(3\times10^8)\,t$
$t = 6.8 \times 10^{-9}\,s$

$t = \gamma t_0$
$(6.8 \times 10^{-9}) = (5.025)\,t_0$
$t_0 = 1.35 \times 10^{-9}\,s$

(or $L = \frac{L_0}{\gamma}$ then $L = vt_0$)

2. A spaceship flies by you at 0.95c You measure the time for the spaceship's length to pass you as 9×10^{-7} seconds. What is the proper length of the spaceship?

$\beta = 0.95$
$t_0 = 9 \times 10^{-7}\,s$
$L_0 = ?$

$\gamma = \frac{1}{\sqrt{1-\beta^2}}$
$\gamma = \frac{1}{\sqrt{1-.95^2}}$
$\gamma = 3.203$

$L = vt_0$
$L = (.95)(3\times10^8)(9\times10^{-7})$
$L = 256.5\,m$

$L = \frac{L_0}{\gamma}$
$L_0 = \gamma L = (3.203)(256.5)$
$L_0 = 821\,m$

(OR $t = \gamma t_0$ 1st then $L_0 = vt$)

3. You are in a spaceship and fly by an observer at 0.8c. According to your clocks, it takes 4.5×10^{-7} seconds for the length of your ship to pass the observer. How long does the observer measure your ship to be?

$\beta = 0.8$
$t = 4.5 \times 10^{-7}\,s$
$L = ?$

$\gamma = \frac{1}{\sqrt{1-.8^2}}$
$\gamma = 1.667$

$L_0 = vt$
$L_0 = (.8)(3\times10^8)(4.5\times10^{-7})$
$L_0 = 108\,m$

$L = \frac{L_0}{\gamma}$
$L = \frac{108}{1.667}$
$L = 64.8\,m$

(or $t = \gamma t_0$ then $L = vt_0$)

4. A spaceship flies by a landing strip at 0.7c. People on the ship measure the landing strip to be 2.5 km long. How long does it take the spaceship to cross the landing strip, according to the people on the landing strip.

$\beta = 0.7$
$L = 2500\,m$
$t = ?$

$\gamma = \frac{1}{\sqrt{1-.7^2}}$
$\gamma = 1.400$

$L = vt_0$
$2500 = (.7)(3\times10^8)\,t_0$
$t_0 = 1.19 \times 10^{-5}\,s$

$t = \gamma t_0 = (1.4)(1.19 \times 10^{-5})$
$t = 1.67 \times 10^{-5}\,s$

(or $L = \frac{L_0}{\gamma}$ then $L_0 = vt$)

Relativity Problems III

5. How fast, relative to the earth, would a person have to travel in order to reach the nearest star in only 2 years (according to the person doing the traveling) if the nearest star is 4 light years away (according to the earth)?

$t_0 = 2$ yrs

$L_0 = 4$ ly

$\beta = ?$

($c = 1 \frac{ly}{y}$)

By definition, $c = 1 \frac{\text{light year}}{\text{year}}$, so $v = \beta c \rightarrow v = \beta$.

$t = \gamma t_0$ & $L_0 = \beta t$

$L_0 = \beta \gamma t_0$

$\frac{L_0}{t_0} = \beta\gamma = \frac{\beta}{\sqrt{1-\beta^2}}$

$\frac{4}{2} = \frac{\beta}{\sqrt{1-\beta^2}}$

$4 = \frac{\beta^2}{(1-\beta^2)}$

$4 - 4\beta^2 = \beta^2$

$5\beta^2 = 4$

$\beta^2 = .8$

$\boxed{\beta = 0.89}$

so $v = 0.89c$

Answers:

1) 1.35 x 10^{-9} s 2) 821 m 3) 64.8 m 4) 1.67 x 10^{-5} s 5) 0.89c