NAME: KEY

Relativity Problems II-b

1. a. Who measures the proper length of an object?

Anyone at rest with respect to the object.

b. Who measures a length-contracted length of an object?

Anyone moving with respect to the object.

c. Who measures the proper distance between two objects in space that are not moving with respect to each other?

Anyone not moving with respect to the two objects.

2. A stick goes past an observer with a speed of v.
   a. If the stick has a proper length of 2 meters, and has a speed of 0.98c, what is its length as measured by the observer.

$\gamma = \frac{1}{\sqrt{1-.98^2}}$ $\quad \gamma = 5.03$ $\quad L = \frac{L_0}{\gamma}$ $\quad L = \frac{2}{5.03}$ $\quad \boxed{L = 0.398\ m}$

   b. If the stick has a speed of 0.99c, and the observer measures it to be 0.5 meters long, what is the proper length of the stick?

$\gamma = \frac{1}{\sqrt{1-.99^2}}$ $\quad \gamma = 7.09$ $\quad L = \frac{L_0}{\gamma}$ $\quad 0.5 = \frac{L_0}{7.09}$ $\quad \boxed{L_0 = 3.54\ m}$

   c. If the proper length of the stick is 10 meters, but the observer measures it to be 7 meters long, how fast is the stick traveling?

$L = \frac{L_0}{\gamma}$ $\quad 7 = \frac{10}{\gamma}$ $\quad \gamma = 1.429$ $\quad 1.429 = \frac{1}{\sqrt{1-\beta^2}}$ $\quad (1.429)^2(1-\beta^2) = 1$ $\quad \beta^2 = \frac{1.04}{2.041}$ $\quad \boxed{\beta = 0.714}$

3. A spaceship flies by a station at 0.8c. The spacehip measures the station to be 1200 meters long. How long is the station according to people on the station?

$\beta = 0.8$ $\quad L = 1200\ m$ $\quad \gamma = \frac{1}{\sqrt{1-.8^2}}$ $\quad \gamma = 1.667$ $\quad L = \frac{L_0}{\gamma}$ $\quad 1200 = \frac{L_0}{1.667}$ $\quad \boxed{L_0 = 2000\ m}$

Relativity Problems II-b

4. An electron traveling at 0.95c travels down a 1500 meter accelerator tube. How far did the electron travel according to the electron?

$\beta = 0.95$

$L_0 = 1500\text{m}$

$\gamma = \frac{1}{\sqrt{1-.95^2}}$ $\quad L = \frac{L_0}{\gamma}$

$\gamma = 3.203$ $\quad L = \frac{1500}{3.203}$

$L = 468\text{ m}$

5. You watch a rocket go by you at 0.9c. You measure the rocket to be 120 meters long. How long is the rocket according to people on the rocket?

$\beta = 0.9$

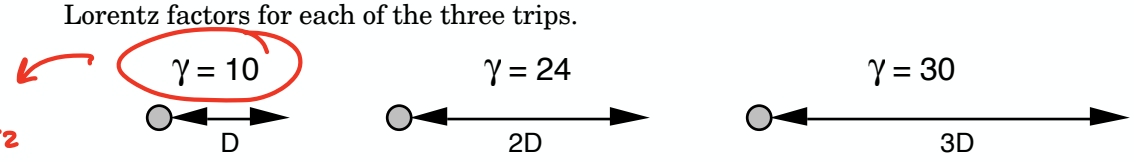
$L = 120\text{m}$

$\gamma = \frac{1}{\sqrt{1-.9^2}}$ $\quad L = \frac{L_0}{\gamma}$

$\gamma = 2.294$ $\quad 120 = \frac{L_0}{2.294}$

$L_0 = 275\text{ m}$

6. A spaceship makes three different round trips from the earth. The diagram shows the distances the ship travels as measured by the earth. The diagram also shows the Lorentz factors for each of the three trips.



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

$100 - 100\beta^2 = 1$

$\beta = 0.995$

a. From the earth's reference frame, rank the trips in order of total time traveled, from least time to greatest time. (Ignore any time for accelerations.)

A B C

Notice the speeds are all just under the speed of light — and so are all almost the same.

But B is twice the distance and C is three times the distance, so the times are ~x2 ~x3.

b. From the ships' reference frame, rank the trips in order of total time traveled, from least time to greatest time. (Ignore any time for accelerations.)

key! Those distances are Proper Lengths! The 3 ships have almost the same speeds, but the "distances going by them" are length-contracted:

$L = \frac{L_0}{\gamma} \Rightarrow$

A	B	C
$\frac{D}{10}$	$\frac{2D}{24}$	$\frac{3D}{30}$
$= \frac{D}{10}$	$= \frac{D}{12}$	$= \frac{D}{10}$

So "B" sees the shortest distance, so takes the least time.

A & C would be the same distance, but C is slightly faster than A, so

B C A

Answers:

1. a) the RF @rest w/respect to object b) the RF moving w/respect to object
c) the RF @ rest w/respect to objects 2. a) 0.4 m b) 3.54m c) 0.71c
3) 2000 m 4) 468 m 5) 275 m 6. a) ABC b) BCA