1) The picture at the right represents an observation of an object moving at v =$\sqrt{\frac{3}{4}}c$. Which of the following pictures best represents the actual shape of the object (in its own frame).

A)

B)

C)

MOVING OBJECTS ARE SHORTER IN DIRECTION OF MOTION.

D)

E)

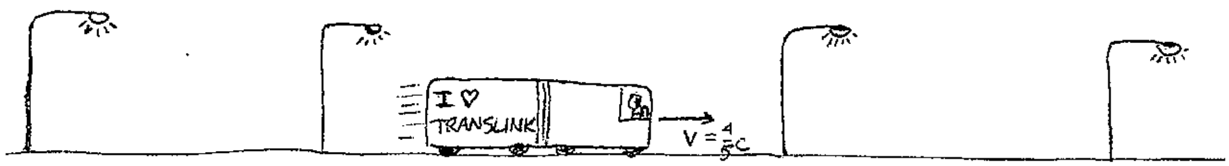
2) An unstable particle has an average lifetime of 10^{-8} seconds in its rest frame. A beam of these particles is produced with speed 4/5c. How far on average do the particles travel before decaying?

A) 1.44 m
B) 2.4 m
C) 3 m
D) 4 m

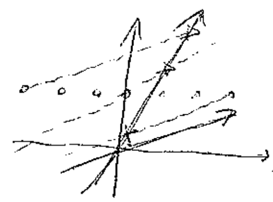
$\gamma = \frac{1}{\sqrt{1-16/25}} = 5/3$

$\tilde{T} = \gamma \cdot 10^{-8} = \frac{5}{3} \cdot 10^{-8}$

$d = \frac{4}{5} c \tilde{T} = \frac{4}{5} 3 \cdot 10^{8} \, \frac{5}{3} \cdot 10^{-8} = 4 m$



5) The 98 B-Line bus travels down Granville Street at speed 4/5c. At 7:00pm, streetlights on Granville Street all turn on simultaneously (in the frame of the street). In the reference frame of the bus, the streetlights ahead of the bus turn on



A) At the same time as the streetlights behind the bus
B) After the streetlights behind the bus
C) Before the streetlights behind the bus

6) A flying ant traveling at v=3/5c passes a meter stick. How much time elapses on the ant's clock between the time it passes the front of the stick and the time it passes the back of the stick?

A) 1m/c
B) 5/3 m/c
C) 25/12 m/c
D) 4/3 m/c
E) 4/5 m/c

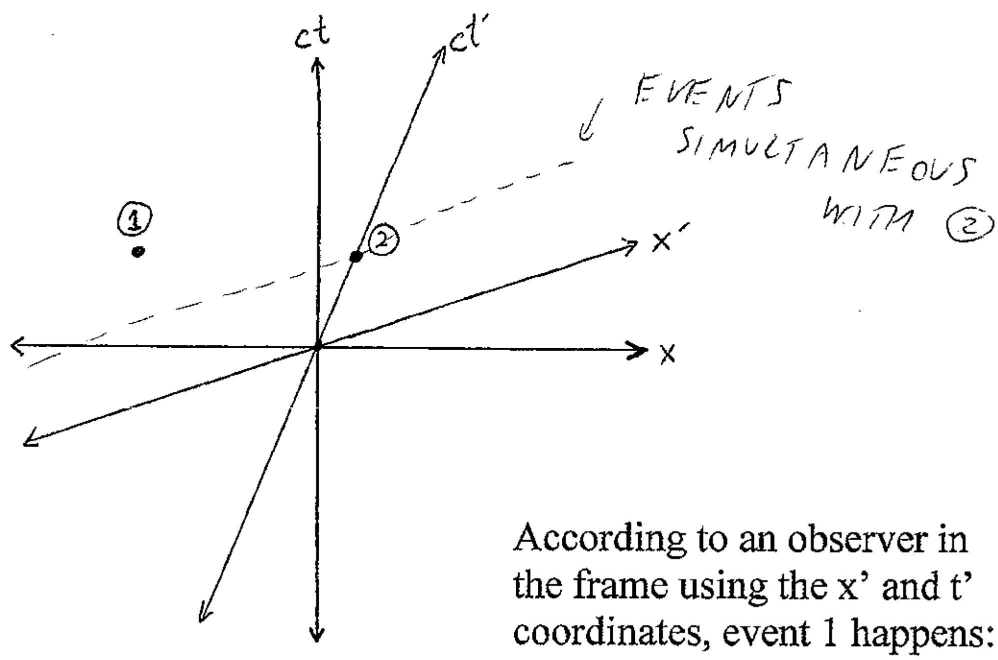
$t = \frac{1m}{3/5\,c}$ $\gamma = \frac{1}{\sqrt{1-9/25}} = \frac{5}{4}$

$\tau = \frac{t}{\gamma} = \frac{1m}{3/4\,c} = \frac{4}{3}\, m/c$

7) In a certain frame of reference, two firecrackers explode at times 10^{-8} seconds apart at locations separated by 4 meters. Which of the following is true: $c\Delta t = 3\,m$ $\Delta x = 4\,m$ $s^2 < 0$

A) There is a frame of reference in which both firecrackers explode at the same time. SPACE-LIKE
B) There is a frame of reference in which both firecrackers explode at the same location.
C) Both A and B are true.
D) Neither A nor B are true.

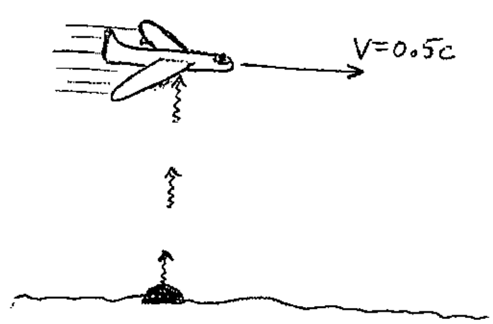
3)



According to an observer in the frame using the x' and t' coordinates, event 1 happens:

A) Earlier than event 2
B) At the same time as event 2
C) Later than event 2
D) None of the above: the concepts of earlier and later do not apply when we consider velocities comparable to the speed of light

4) A signal on the ground sends pulses of light directly upwards. If one of these pulses is observed by a plane traveling at 0.5c parallel to the ground, what speed do the observers in the plane measure for the pulse?



A) $\sqrt{c^2 - (0.5c)^2}$
B) $0.5c$
C) c
D) $1.5c$
E) $\sqrt{c^2 + (0.5c)^2}$

LIGHT ALWAYS MOVES W. C

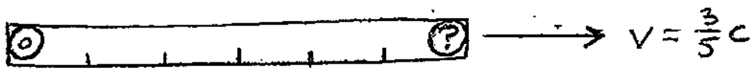
$0.8c \longleftarrow$ ② $\quad 0.5c \longleftarrow$ ① $\quad \longrightarrow \hat{x}$

8) What is the velocity of ball 1 in the reference frame of ball 2?

A) $-0.5c\ \hat{x}$
B) $-0.3c\ \hat{x}$
C) $0.3c\ \hat{x}$
D) $0.5c\ \hat{x}$
E) None of the above

$$\tilde{u} = \frac{u - V}{1 - \frac{uV}{c^2}} = \frac{(-0.5 + 0.8)c}{1 - 0.4} = \frac{0.3c}{0.6} = 0.5c$$

PART II) SHOW YOUR WORK!



9) A ruler with proper length of 6m travels at v=3/5c in the direction along its length. If the clock at the back end of the ruler is observed to read time 0, what is the clock at the front end of the ruler observed to read at the same instant? Assume that the two clocks are synchronized in the frame of the ruler. (3 points)

IN RULER'S FRAME, THE EVENT AT THE RIGHT END IS AT $\tilde{x} = L$ AND $\tilde{t}$ = UNKNOWN

L. T:

$$x = \gamma (L + v\tilde{t})$$

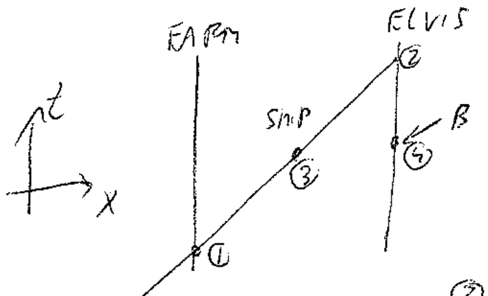
$$t = \gamma \left(\tilde{t} + \frac{v}{c^2} L\right) = 0$$

$$\tilde{t} = -\frac{v}{c^2} L = -\frac{3/5}{c}(6m) = -\frac{18}{5}\frac{m}{c} = -\cancel{0.36}\ m/c$$

-3.6 m/c

10) A spaceship passes the Earth traveling at speed 4/5c towards planet Elvis, 4 light years away. $L = 4\,ly$ $\gamma = \frac{5}{3}$

a) In the Earth's frame of reference, planet Elvis suddenly turns blue when the ship is halfway there. In the ship's frame of reference, how far away is the ship from planet Elvis when the planet turns blue? Assume that planet Elvis is stationary in the frame of the Earth. (3 points)

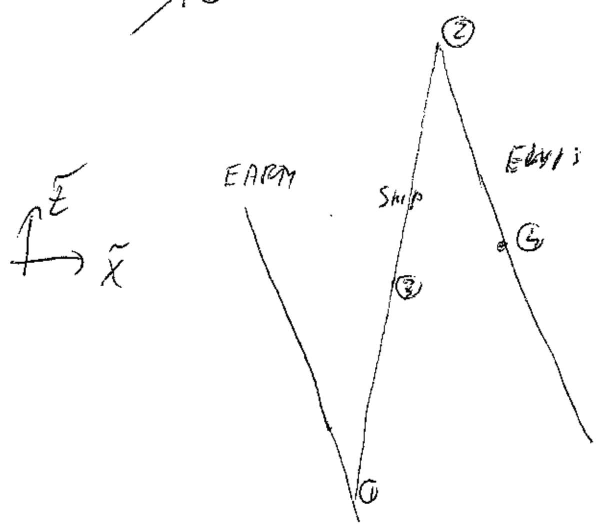


① $t = 0$ $x = 0$

② $t = \frac{L}{v}$ $x = L$

③ $t = \frac{L}{2v}$ $x = \frac{L}{2}$

④ $t = \frac{L}{2v}$ $x = L$



① $\tilde{t} = 0$ $\tilde{x} = 0$

② $\tilde{t} = \gamma\left(t - \frac{v}{c^2}x\right) = \gamma\left(\frac{L}{v} - \frac{v}{c^2}L\right)$

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

$\tilde{x} = \gamma(x - vt) = 0$

③ $\tilde{t} = \gamma\left(t - \frac{v}{c^2}x\right) = \gamma\left(\frac{L}{2v} - \frac{v}{c^2}\frac{L}{2}\right)$

$= \frac{L}{2v}\gamma\left(1 - \frac{v^2}{c^2}\right) = \frac{L}{v}\frac{1}{2\gamma}$

$\tilde{x} = \gamma(x - vt) = \gamma(0) = 0$

④ $\tilde{t} = \gamma\left(\frac{L}{2v} - \frac{v}{c^2}L\right) = \frac{L}{v}\gamma\left(\frac{1}{2} - \frac{v^2}{c^2}\right)$

$\tilde{x} = \gamma\left(L - \frac{L}{2}\right) = \gamma\frac{L}{2}$

AT EVENT ④,

ELVIS IS AT $\tilde{x} = \gamma\frac{L}{2}$

AND SHIP AT $\tilde{x} = 0$

$$\therefore \boxed{\gamma\frac{L}{2} = \frac{5}{3}\,\frac{4\,ly}{2} = \frac{10}{3}\,ly = 3.33\,ly}$$

NB YOU REALLY ONLY NEED TO COMPUTE ④!

b) How much do the people on board the ship age between the time planet Elvis turns blue (in their frame) and the time they reach the planet? (1 point)

④ IS $\tilde{t} = \frac{L}{V}\gamma\left(\frac{1}{2} - \frac{V^2}{c^2}\right) = \frac{4}{4/5}\,\frac{5}{3}\left(\frac{1}{2} - \frac{16}{25}\right) = \frac{25}{3}\left(\frac{-7}{50}\right)$

$= -7/6$ YEARS

② IS $\tilde{t} = \frac{L}{V}\frac{1}{\gamma} = \frac{4}{4/5}\,\frac{3}{5} = 3$

$3 + 7/6 = 4\,1/6 = 4.17$ YEARS

PICTURE