	Department of Physics University of California San Diego	**Modern Physics (2D) Prof. V. Sharma Quiz #1 (Jan 16 2004)**

Some Relevant Formulae, Constants and Identities

Speed of Light, $c = 3.0 \times 10^8 \mathrm{m/s}$

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$$

$$x' = \gamma(x - vt)$$

$$t' = \gamma(t - \frac{xv}{c^2})$$

$$u' = \frac{u - v}{1 - \frac{uv}{c^2}}$$

$$p = \frac{mu}{\sqrt{1 - u^2/c^2}}$$

$$E = \frac{mc^2}{\sqrt{1 - u^2/c^2}} = K + mc^2$$

$$f_{obs} = \frac{\sqrt{1 + v/c}}{\sqrt{1 - v/c}} f_{source}$$

Pl. write you answer in a Blue book in indelible ink. Make sure your code number is prominently displayed on each page. Ask the proctor if you do not understand the problem.

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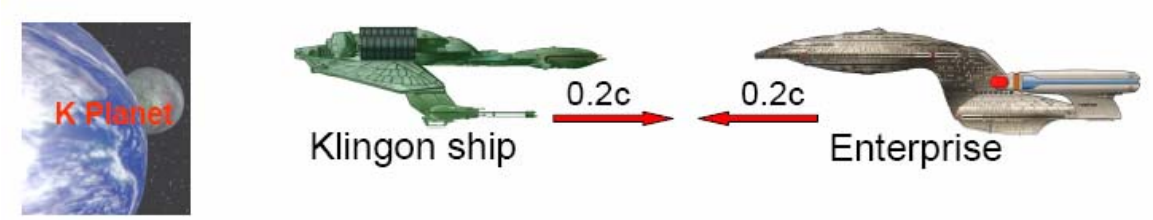
Problem 1: <u>Star Trek [10 pts]</u> A new Klingon battleship has a proper length of 217m and travels at speed of 0.20c with respect to its home planet. The Klingons prepare to battle the ***Enterprise***, which is moving at the same speed with respect to the same planet. If the Klingons are heading straight at the ***Enterprise*** (a) what is the speed of the Klingon battleship relative to the ***Enterprise*** (b) What is the length of the Klingon ship as measured by Captain Kirk of ***Enterprise*** ?

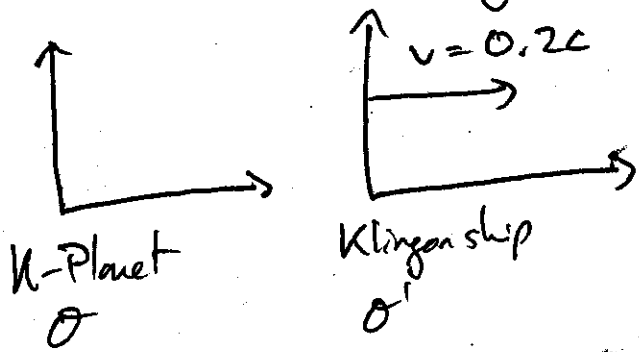


Problem 2: **<u>Houston, We Have A …….Baby ! [10 pts]</u>** Elephants have a gestation period of 21 months. Suppose that a freshly impregnated elephant is placed on a spaceship (The Cosmic Ark) and sent towards a distant space jungle at a velocity v = 0.75c. As soon as the baby is born, a light signal is sent from the spaceship to NASA in Houston which monitors signal transmissions from the spaceship.

Calculate (a) Gestation period in Houston reference frame (b) from Houston's perspective, the distance the rocketship has moved at the time birth signal goes out (c) the time it takes for the signal to travel from the ship to Houston in Houston's reference frame (d) the total time interval in Houston between launch and arrival of the birth signal.

Physics 2D Quiz 1 Solns

1| a| Attach the moving frame to the Klingon ship:



In the K-Planet frame, Enterprise has velocity $u = -0.2c$

So use velocity transformation:

$$u' = \frac{u - v}{1 - \frac{uv}{c^2}} = \frac{-0.2c - 0.2c}{1 - \frac{(-0.2)(0.2)c^2}{c^2}}$$

$$= \frac{-0.4c}{1.04}$$

$$= \boxed{-0.38c}$$

So the Enterprise moves at speed $\boxed{0.38c}$ relative to the Klingon ship.

b| Now do a length contraction of 217m in the Enterprise frame, which moves with speed 0.38c relative to the proper (Klingon ship) frame:

$$\gamma = \frac{1}{\sqrt{1-(0.38)^2}} = 1.0811$$

$$\Rightarrow \text{Length in Enterprise frame} = \frac{217\,m}{1.0811} = \boxed{200.7\,m}$$

2a| Just time dilate 21 months:

$$\gamma = \frac{1}{\sqrt{1-(0.75)^2}} = 1.51$$

So Time in Houston frame $= (1.51)(21 \text{ months})$

$$= \boxed{31.7 \text{ months}} = 2.64 \text{ yr}$$

b| This is just distance = vel × time

$$\Rightarrow \text{dist} = (0.75c)(31.7 \text{ months})$$

$$= (0.75c)(2.64 \text{ yr})$$

$$= \boxed{1.98 \text{ light years}}$$

c] Light travels at speed c across a dist of 1.98 light years, so that takes **1.98 yrs**

d] This is just the answer to a) + answer to c)

$= 2.64\,yr + 1.98\,yr =$ **4,62 yr**