

Relativity Problems

Q1) what will be the length of a meter rod appear to a person travelling parallel to the length of the rod at a speed of $0.8c$ relative to rod?

→ the length of the rod moving with a relative velocity v is given by,

$$L = L_0(1 - v^2/c^2)^{-1/2}$$

Here $L_0 = 1.0\text{m}$ $v = 0.8c = 0.8 \times 3 \times 10^8 \text{m/s}$

$$L = 1.0 (1 - 0.8^2)^{1/2} = 0.6\text{m}$$

Q2) a meter ruler moves past an observer on the earth with a velocity of $2.5 \times 10^{10} \text{ cm/sec}$, along the direction of its length. What is its apparent length with respect to the observer?

→ according to length contraction formula,

$$L = L_0(c^2 - v^2/v^2)^{-1/2}$$

Here, $L_0 = 1.0\text{m}$ and $v = 2.5 \times 10^8 \text{m/s}$

$$L = 1.0 \{(3 \times 10^8)^2 - (2.5 \times 10^8)^2 / (2.5 \times 10^8)^2\}^{-1/2}$$

$$L = 55.27\text{cm}$$

Q3) a spaceship 50m long passes the earth at a speed of $2.8 \times 10^8 \text{ m/s}$. what will be its apparent length?

→ let L_0 be the rest length of spaceship, then its apparent length in flight is given by,

$$L = L_0(1 - v^2/c^2)^{-1/2}$$

$$L = 50 \{1 - (2.8 \times 10^8 / 3 \times 10^8)^2\}^{-1/2}$$

$$L = 18\text{m}$$

Q4) a rocketship is 50m long. When it is on flight its length appears to be 49.5 to an observer on ground. Find the speed of the rocket?

→ according to length contraction formula,

$$L = L_0(1 - v^2/c^2)^{-1/2}$$

Here, $L = 49.5\text{m}$, $L_0 = 50\text{m}$, $V = ?$

$$49.5 = 50 \{1 - v^2/c^2\}^{-1/2}$$

$$1 - v^2/c^2 = 0.98$$

$$V = 0.141c$$

Q5) a certain particle called meson has a life time $2 \times 10^{-6}\text{ sec}$ a] what is the mean life time when the particle is travelling with a speed of $2.9994 \times 10^8 \text{ m/sec}$?

b] how far does it go during one mean life?

→ using time dilation equation,

$$t = t_0 / \sqrt{1 - v^2/c^2}$$

$$t = 2 \times 10^{-6} / \{1 - (2.994 \times 10^8 / 3 \times 10^8)^2\} = 2 \times 10^{-6} / 0.0632$$

$$t = 31.63 \times 10^{-6} \text{ sec}$$

distance travelled by meson during mean life time,

$$= (2.994 \times 10^8)(31.63 \times 10^{-6})$$

$$= 9470\text{m}$$

Q6) the mean life of meson is $2 \times 10^{-8}\text{ sec}$. calculate the mean life of a meson moving with a velocity $0.8c$?

→ time dilation equation is given by,

t

$$t = t_0 / \sqrt{1 - v^2/c^2}$$

$$T_0 = 2 \times 10^{-8}$$

$$V = 0.8c$$

$$t = (2 \times 10^{-8}) / (1 - 0.8^2)^{-1/2} = 2 \times 10^{-8} / 0.6 = 3.3 \times 10^{-8} \text{ sec}$$

Q7)a wrist watch keeps correct time on earth. If it is worn by pilot in spaceship, leaving earth with constant velocity of 10^8 cm/sec. how many seconds does it appear to lose in one day with respect to the observer on the earth.

→ According to time dilation formula,

$$t = t_0 / \sqrt{1 - v^2/c^2}$$

$$24 = t_0 / \sqrt{1 - 1/900}$$

$$24[1 - 1/900]^{-1/2} = t_0$$

Here, $1/900$ is very small wrt 1 \therefore We can use the binomial expansion and neglect higher order terms

$$t_0 = 24 - 1/75 \text{ hours}$$

$$\text{hence loss in 24 hours} = 1/75 = 48 \text{ sec}$$

