B.Sc. Part I

Paper I

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Problem :-

A rod has length 1 metre. When the rod is in a satellite moving with velocity 0.8c relative to laboratory, what is the length of the rod as determined by an observer (a) in the satellite and (b) in the laboratory?

Sol :-

(a) The observer in the satellite is at rest relative to the rod, therefore the length of the rod as measured by an observer in the satellite is 1 metre.

(b) The length of the rod in the laboratory is given by

$$l = l_0\sqrt{\left(1-\frac{v^2}{c^2}\right)}$$

Here $l_0 = 1$ metre, $v = 0.8c$, therefore

$$l = 1.\sqrt{\left[1-\left(\frac{0.8c}{c}\right)^2\right]}$$

$$= 1.\sqrt{(1-0.64)} = 1.\sqrt{0.36} = 1\times 0.6 = 0.6 \text{ metre}$$ Ans

The length of a rocket ship is 100 metres on the ground. When it is in flight its length observed on the ground is 99 metres, calculate its speed.

Sol :- we have,

$$l = l_0\sqrt{\left(1-\frac{v^2}{c^2}\right)} \quad \text{or} \quad \frac{l}{l_0} = \sqrt{\left(1-\frac{v^2}{c^2}\right)}$$

Here, $l_0 = 100$ metres

$l = 99$ metres

$$\therefore \quad \frac{99}{100} = \sqrt{\left(1-\frac{v^2}{c^2}\right)}$$

or $$v = \frac{\sqrt{(199)}}{100}c = 4.23\times 10^7 \text{ m/sec}$$

If L_0 is the length of one edge of the cube in reference system S, what will be its volume as viewed from system S' which is moving with velocity v along one edge of the cube?

Sol:- Suppose that one edge of the cube is parallel to x-axis in reference system S at rest, and system S' is moving with velocity v parallel to +ve direction of x-axis.

We have volume of the cube in system $S = L_0^3$, since L_0 is length of each edge of cube.

We have to find its volume in S' which is moving with velocity v parallel to x-axis.

According to Lorentz-Fitzgerald contraction, the length of the body moving with velocity v is contracted by a factor $(\sqrt{(1-\beta^2)})$ in the direction of motion.

Thus the length of the edge which is parallel to x-axis along with S' moves $= l_0\sqrt{(1-\beta^2)}$.

Also we know that the contraction takes place only in the direction of motion, so there is no contraction in the direction perpendicular to the direction of motion of the moving body; thus other two edges of the cube as viewed from system S' remain unchanged. Hence the volume of the cube as viewed from system S'.

$$L_0\sqrt{\left(1-\frac{v^2}{c^2}\right)} \times L_0 \times L_0 = L_0^3\sqrt{\left(1-\frac{v^2}{c^2}\right)}$$ Proved

A body has the dimensions represented by $(5i+3j)$ metre in reference system S'. How these dimensions will be represented in system S, if S' is moving with velocity 0.6c along (+)ve x-axis. [i, j being unit vectors along respective axes].

Sol:- The dimensions of body along x-axis as viewed from system

$$S = 5 \times \sqrt{\left\{1-\frac{(0.6c)^2}{c^2}\right\}} = \cancel{5} \times \frac{4}{\cancel{5}} = 4 \text{ metre}$$

[Since according to Lorentz Contraction $L = L_0\sqrt{\left(1-\frac{v^2}{c^2}\right)}$]

But there is no contraction in the direction of y-axis since motion of system S' is only along x-axis. So the length along y-axis in system S is 3 metre. Consequently the dimensions may be represented by $(4\hat{i} + 3\hat{j})$ metre.