

**Formulas:**

Time dilation; Length contraction :  $\Delta t = \gamma \Delta t' \equiv \gamma \Delta t_p$  ;  $L = L_p / \gamma$  ;  $c = 3 \times 10^8 \text{ m/s}$

Lorentz transformation :

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

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

$$y' = y, \quad z' = z$$

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

$$y = y', \quad z = z'$$

$$t' = \gamma(t - vx/c^2)$$

$$t = \gamma(t' + vx'/c^2)$$

Velocity transformation :

$$u_x' = \frac{u_x - v}{1 - u_x v / c^2}$$

$$u_x = \frac{u_x' + v}{1 + u_x' v / c^2}$$

$$u_y' = \frac{u_y}{\gamma(1 - u_x v / c^2)}$$

$$u_y = \frac{u_y'}{\gamma(1 + u_x' v / c^2)}$$

Spacetime interval:  $(\Delta s)^2 = (c\Delta t)^2 - [\Delta x^2 + \Delta y^2 + \Delta z^2]$

**Justify all your answers to all problems**