ABBAS ZAHEER

F-36

PHYSICS ASSIGNMENT

24BCD001

Unit -1

Relativity

Q1/-

Ans 1/- To show :- $x^2+y^2+z^2-c^2t^2=0$

for transformation

$\Rightarrow x'^2+y'^2+z'^2-c^2t'^2 = x^2+y^2+z^2-c^2t'^2$

$\Rightarrow \dfrac{(x-vt)^2}{1-\frac{v^2}{c^2}} + y^2 + z^2 - \dfrac{c^2\left(t-\frac{vx}{c^2}\right)^2}{\left(1-\frac{v^2}{c^2}\right)}$

$\Rightarrow \dfrac{x^2+v^2t^2-2xvt-c^2t^2-\frac{v^2x^2}{c^2}+2tvx-cx^2+z^2}{\left(1-\frac{v^2}{c^2}\right)}$

$\Rightarrow x^2 - t^2\dfrac{\cancel{(1-v^2/c^2)}}{\cancel{1-v^2/c^2}}\times c^2 + y^2+z^2$

$\Rightarrow x^2+y^2+z^2-c^2t^2 = 0$ Proved to be invariant

Q2

Sol $x^2-c^2t^2 = x'^2-c^2t'^2$

$16-c^2\cdot 144 = x^2 \cdot 64$

$x^2 = 16-72c^2$

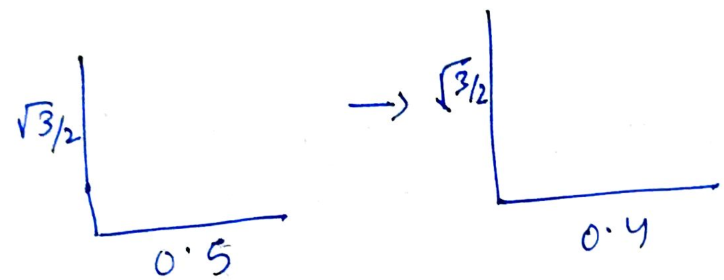
Q3

Sol Given $L_0 = 1m$ $V = 0.6c$

(i) $\theta = 0°$

$L = \frac{L_0}{\gamma} = L_0\sqrt{1-\frac{v^2}{c^2}} = L_0\sqrt{1-0.6^2} = 0.8m$

(ii) $\theta = 60°$

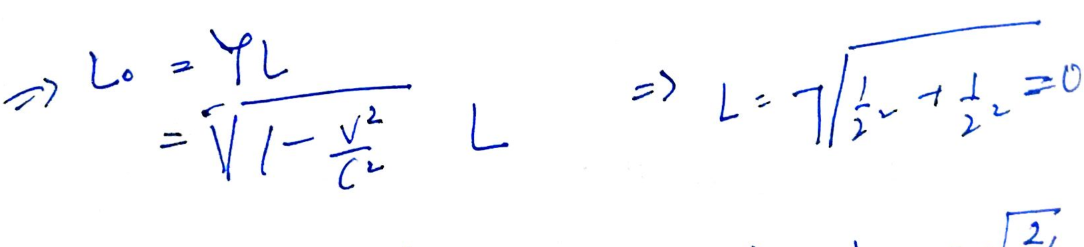


$L_0 \cos\theta \sqrt{1-v^2/c^2} \Rightarrow 0.5 \cdot 0.8 = 0.4$

$L = \sqrt{\frac{3}{4}^2 + 0.4^2} = 0.95$

Q4/-

Ans



$\Rightarrow L_0 = \gamma L$

$= \sqrt{1-\frac{v^2}{c^2}}\; L$

$\Rightarrow L = \sqrt{\frac{1}{2^2} + \frac{1}{2^2}} = 0.7m$

$\sqrt{3}/2 = \frac{1}{2} \times \frac{1}{\sqrt{1-v^2/c^2}}$ $\Rightarrow 1-x^2 = \frac{1}{3}$ $\Rightarrow \sqrt{2/3}\, x$

$\boxed{V = 0.8c}$

Q5/-

(3)

Sol/- flux will fall 1/2 times when it has half life

$\Rightarrow t_0 = 2\times10^{-6}$ sec $\Rightarrow t' = \dfrac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$

$t' = x$

$\Rightarrow x = \dfrac{2\times10^{-6}}{\sqrt{1-\frac{0.96c^2\times0.96}{c^2}}}$

$\therefore x = 7.14\times10^{-6}$ sec

So, In Lab frame

$d = x \times 0.96c$

$d = 7.14\times10^{-6}\times 3\times10^{8}\times0.96$

$d = 2.057$ Km

Q6

Sol $v = 0.96c$

$y = \sqrt{1-\frac{v^2}{c^2}} = \sqrt{1-(0.96)^2\frac{v^2}{c^2}} = \sqrt{1-0.076} = 0.95$

$y = 0.95$ — (A)

$\Rightarrow t' = t_0 \frac{1}{y} \Rightarrow t' = \frac{t}{\sqrt{0.095}}$

$\Rightarrow t' = 3\,\text{not}$

↳ when u is increased by 5%

$V_{new} = V + 0.05V = 0.99555c$

$y = \sqrt{1-\frac{0.995v^2}{c^2}} = 14.14$

$t' = 14.14t$ — (B)

Q3

(4)

$\Delta t = 14.141 - 3.205$

$\Delta t = \frac{10.94}{3.20} \times 100 \approx 342.5\%$

(07)

Sol $V = 0.99c$ $l = 5.4 km$

$t = \left(\frac{5.4 \times 10^3}{0.99 \times 3} \times 10^{-8}\right)\sqrt{1-0.99^2} = 2.565 \times 10^{-6}$

$L' = \frac{5.4}{\gamma} = 5.4\sqrt{1-0.99^2} = 0.761 = 761.5 m$

(06)

Sol Event (1)

$O(1m, 6m, -3m, 3 \times 10^{-8} sec)$

$O'(1m, 0.75m, -3m, 2.25 \times 10^{-8} sec)$

$\Rightarrow \frac{6}{0.75} = \frac{(0.75 - v \cdot 2.25 \times 10^{-8})\cancel{\gamma}}{(6 + v \times 10^{-8})\cancel{\gamma}}$

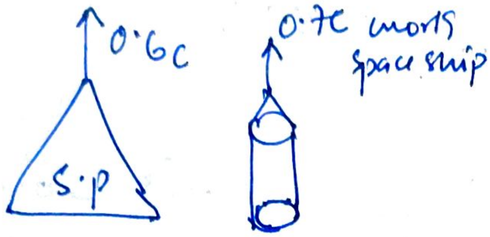
$\Rightarrow \frac{6}{0.75} = \frac{0.75 - v_0(2.25 \times 10^{-8})}{6 + v \cdot 3 \times 10^{-8}}$

$\Rightarrow 36 + 18 \times 10^{-8} \times v = 0.5625 - 1.687 \times 10^{-8}$

$\Rightarrow V = 0.6c$

Q9

Sol (1)



$\Rightarrow u' = 0.7c$

$V = 0.6c$

$\Rightarrow u'_x = \frac{u_x - V}{1 - \frac{V u_x}{c^2}}$

$\Rightarrow u_x = \frac{u'_x + V}{1 + \frac{V u'_x}{c^2}}$

$= \frac{0.7 + 0.6}{1 + 0.7 \times 0.6} = \boxed{0.915c}$

(ii) when rocket moves toward the earth

$\Rightarrow V = 0.6c$

$u' = -0.7c$

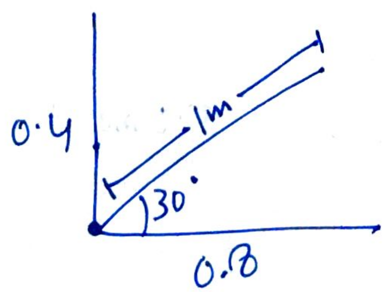
$u = \frac{u' + v}{1 + \frac{u'v}{c^2}}$

$= \frac{-0.7c + 0.6c}{1 - \frac{0.7 \times 0.6c}{c^2}}$

$= \frac{-0.1c}{1 - 0.42} \Rightarrow \boxed{u = -0.172c}$

Q10

Sol



$V = -0.6c$

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

$$u'_x = \frac{0.69 + 0.6}{1 + 0.6 \times 0.69} = 0.912$$

$$u'_y = \frac{u_y}{\left(1 - \frac{v u_x}{c^2}\right)\gamma} = \frac{0.4}{(1 + 0.6 \times 0.69)} \sqrt{1 - 0.6^2} = 0.226$$

$$u_{net} = \sqrt{0.912^2 + 0.226^2} = 0.939c$$

$$\phi = \tan^{-1}\left[\frac{0.226}{0.912}\right] = 13.91^\circ$$

Q11/-

Sol/- $f = \frac{dp}{dt} = \frac{d(mv)}{dt} = \frac{d(\gamma m_0 v)}{dt}$

$$= \frac{m_0 v}{\sqrt{1 - \frac{v^2}{c^2}}} \Rightarrow m_0 \left[\frac{\left(\sqrt{1 - v^2/c^2} - \frac{1}{2}\frac{v}{\sqrt{1 - v^2/c^2}}\right) \frac{dv}{dt}}{\left[1 - \frac{v^2}{c^2}\right.}\right.$$

$$= m_0 \left[1 - \frac{v^2}{c^2} - \frac{v}{2}\right] \times \frac{1}{\left[1 - \frac{v^2}{c^2}\right]^{3/2}} \frac{dv}{dt}$$

Q12/-

Sol/- $m = 11\, m_0 \longrightarrow (\gamma = 11)$

$KE = (m - m_0)c^2 = 10 m_0 c^2 = 5.1\, \text{meV}$

momentum =

$$(mc^2)^2 = p^2 c^2 + (m_0 c^2)^2$$

$$= \frac{(mc^2)^2 - (m_0 c^2)^2}{c^2}$$

$\Rightarrow m^2c^2 - m_0^2c^2 = p^2$ (7)

$p = \sqrt{m^2c^2 - m_0^2c^2} = \left(\sqrt{m^2 - m_0^2}\right)c$

$p = \sqrt{99}\, m_0 c = 2.71 \times 10^{-21}$

or $\left[\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}\right] = 1 - \frac{v^2}{c^2} = \frac{1}{\gamma^2} = \sqrt{1 - \frac{1}{\gamma^2}}$

$= v = \sqrt{1 - \frac{1}{11^2}}\, c \Rightarrow \left[v = 0.99585c\right]$

$= \gamma m_0 v = 11 \times 9.1 \times 10^{-31} \times 0.99585 \times 3 \times 10^8$

$= 2.99 \times 10^{-21}$

Q13/

Sol We Know

$\Rightarrow E^2 = (pc^2) - (E_0)^2$

$\Rightarrow (m_0c^2)^2 = (pc)^2 - (m_0c^2)^2$

$\Rightarrow (mc^2)^2 + (m_0c^2)^2 = pc^2$

$\Rightarrow (mc^2)^2 + (m_0c^2)^2 - 2m_0mc^4 = pc^2 - 2mm_0c^4$

$\Rightarrow (mc^2 - m_0c^2)^2 = pc^2 - 2mm_0c^4$

$E_k^2 + 2mm_0c^4 = p^2c^2$

$\boxed{\left(\frac{E_k^2}{c^2} + 2mm_0c\right) = p^2}$

Q14

Sol $E = 6 \times 10^3$ MeV

$p = \frac{3 \times 10^3}{c}$ MeV

$E^2 = (pc)^2 + E_0^2 \longrightarrow \sqrt{\frac{6^2 - 3^2}{c^2}} \times 10^3 = m_0$

$m_0 = 9.337 \times 10^{-27}$

$\Rightarrow$ Electron potential $= 10^5$ V

$\Rightarrow$ K.E $=$ T.E $= eV = 1.6 \times 10^{-14}$ J or 10^5 eV or 0.1 meV

$E = E_K + m_0c^2$

$\rightarrow E_K = (\gamma - 1) m_0c^2 = 0.1 \times 10^6 \times 1.6 \times 10^{-19}$

$\Rightarrow (\gamma - 1) = \left(\frac{0.1 \times 10^6 \times 1.6 \times 10^{-19}}{9.1 \times 10^{-31} \times 3 \times 10^8} \right)$

$\Rightarrow \gamma - 1 = 0.195 = 1.195 = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$

$\frac{1}{\gamma} = 1 - \frac{v^2}{c^2} \quad \Rightarrow v - \left(\sqrt{1 - \frac{1}{\gamma}} \right) c = 0.404c$

Q15

Sol - μ-mass $= 207 m_0$

$t_0 = 2 \times 10^6 \longrightarrow t = 7 \times 10^6$

$\gamma = 7/2$

$m = \gamma m_0 = \frac{7}{2} + 207 m_0 = 724.5 m_0$

$\boxed{m = 725 m_0}$

cuz quatic