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PHYSICS
ASSIGNMENT-1

(1) (a) by the boy

$X = 0$

$Y = 20t - \frac{g}{2}t^2$.

(b) by observer on the ground.

$X = 100t$

$Y = 20t - \frac{g}{2}t^2$

(2) $\Delta n = \frac{2l}{\lambda}\frac{v^2}{c^2}$

$0.005 = \frac{2(11)}{5900 \times 10^{-10}} \times \frac{v^2}{(3\times10^8)^2}$

$v = \sqrt{\frac{5\times10^{-3} \times 59\times10^{-8} \times 9\times10^{16}}{22}}$

$= \sqrt{12.068\times10^{6}}$

$= 3.47\times10^{3}\ m/s$ Ans.

(3) $x = 100 Km,\ y = 10 Km,\ z = 1 Km,\ t = 5\times10^4 sec.$

$x' = \frac{x - vt}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{100\times10^3 - 0.8(3\times10^8)(5\times10^4)}{\sqrt{1-(0.8)^2}}$

$= \frac{10^5 - 12\times10^{12}}{0.6}\ m$

$y = y' = 10 Km$

$z = z' = 1 Km$

$t' = \frac{t - \frac{vx}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}}$

$$t' = \frac{5\times10^{4} - \frac{0.8\times10^{5}}{3\times10^{8}}}{0.6}$$

$$t' = \frac{5\times10^{4} - 2.66\times10^{-4}}{0.6} \text{ sec. } \underline{\text{Ans}}.$$

(5) $l_0^3 = 1000\ cm^3$

$l_0 = 10\ cm$.

So, Vol. $= l_0 \times l_0 \times l_0 \sqrt{1-\frac{v^2}{c^2}}$

$= l_0^3 \sqrt{1-\frac{v^2}{c^2}}$

$= 1000 \sqrt{1-\frac{(0.8c)^2}{c^2}}$

$= 600\ cm^3$

(4) Given:-

$\Delta x_0 = 600\,m$

$\Delta t_0 = 8\times10^{-7}\ ms$

$\Delta t' = 0$

$$\Delta t' = \frac{\Delta t_0 - \frac{\Delta x_0 v}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}} \Rightarrow 0 = \frac{8\times10^{-7} - \frac{600v}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$8\times10^{-7} = \frac{600\,v}{c^2}$$

$$v = \frac{\cancel{8}\times10^{-7}\times 9\times10^{16}}{\cancel{6}\times10^{2}}$$

$= 12\times10^{7}$

$v = 1.2\times10^{8}\ m/s$ $\underline{\text{Ans}}$.

(7) $\Delta t_0 = 0 \qquad \Delta x_0 = 600\,m.$

$$L = L_0 \sqrt{1-\frac{v^2}{c^2}}$$

$$600 = 1200 \sqrt{1-\frac{v^2}{c^2}}$$

$$1-\frac{v^2}{c^2} = \frac{1}{4}.$$

$$v = -\frac{\sqrt{3}}{2}c.$$

$$\Delta t' = \frac{\Delta t_0 - \frac{\Delta x_0 v}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{0+\frac{600\sqrt{3}\,c}{2c^2}}{\sqrt{1-\frac{3}{4}}}.$$

$$= \frac{600\sqrt{3}}{c} = 200\sqrt{3}\times 10^{-8}\,s.$$

$$= 3.46\times 10^{-6}\,s \quad \underline{\text{Ans}}.$$

(8) Given equation : $x^2+y^2+z^2+c^2t^2=0$

also at origin $t=t'=0$

$$\Rightarrow \left(\frac{x'+vt'}{\sqrt{1-\frac{v^2}{c^2}}}\right)^2 + (y')^2+(z')^2 \mp c^2 \frac{\left(t'+\frac{vx'}{c^2}\right)^2}{\left(\sqrt{1-\frac{v^2}{c^2}}\right)^2} = 0$$

$$\frac{1}{1-\frac{v^2}{c^2}}\left[x'^2+v^2t'^2+2x'vt' \mp c^2\left(t'^2+\frac{v^2x'^2}{c^4}+\frac{2t'vx'}{c^2}\right)\right]+y'^2+z'^2$$

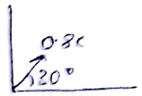
$$\frac{1}{1-\frac{v^2}{c^2}}\left[\frac{c^2x'^2+c^2v^2t'^2-c^4t'^2-v^2x'^2}{c^2}\right]+y'^2+z'^2=0.$$

$$\frac{1}{1-\frac{v^2}{c^2}}\left[(x'^2-c^2t'^2)\left(\frac{c^2-v^2}{c^2}\right)\right]+y'^2+z'^2=0.$$

$$x'^2+y'^2+z'^2-c^2t'^2=0$$

<u>proved</u>.

(9) for observer O.



$U_x = 0.8c \cos 30°$

$= 0.4\sqrt{3}c.$

$U_y = 0.8c \sin 30°$

$= 0.4c.$

$v = 0.6c$

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

$$= \frac{0.4\sqrt{3}c - 0.6c}{1 - 0.6(0.4\sqrt{3})}$$

$$= \frac{0.092823 \times 10^8 \text{ m/s}}{0.58432}$$

$= 4.76 \times 10^7$ m/s. Ans.

$$U_y' = \frac{U_y\sqrt{1-\frac{v^2}{c^2}}}{1 - \frac{v}{c^2}U_x} = \frac{0.4c \times 0.8}{0.58432}$$

$$= \frac{0.32 \times 3 \times 10^8}{0.58432}$$

$= 1.64 \times 10^8$ m/s Ans.

(10) $$V_{eL} = \frac{V_{eN} + V_{NL}}{1 + \frac{V_{eN}V_{NL}}{c^2}} = \frac{0.9c + 0.5c}{1 + (0.9)(0.5)} = \frac{1.4c}{1 + 0.45}$$

$= 0.965c = 2.895 \times 10^8$ m/s.

(11)

$\underset{0.95c}{\overrightarrow{(A)}} \qquad \overset{O}{} \qquad \underset{0.95c}{\overleftarrow{(B)}}$

$V_{AO} = 0.95c \qquad V_{BO} = -0.95c$

$$V_{BA} = \frac{V_{BO} + V_{OA}}{1 + \frac{V_{BO} \cdot V_{OA}}{c^2}}$$

$$= \frac{-0.95c - 0.95c}{1 + (0.95)(0.95)}$$

$$= \frac{-1.9c}{1.9025} = -0.998c$$

$$= -2.996 \times 10^8 \, m/s.$$

(12) $m_1' = \dfrac{m_1}{\sqrt{1 - \frac{v_1^2}{c^2}}} = \dfrac{3}{\sqrt{1-(0.8)^2}} = \dfrac{3}{0.6} = 5 \, Kg.$

$m_2' = \dfrac{m_2}{\sqrt{1 - \frac{v_2^2}{c^2}}} = \dfrac{5}{\sqrt{1-(0.6)^2}} = \dfrac{5}{0.8} = 6.25 \, Kg.$

$\therefore Mc^2 = m_1' v_1^2 + m_1 c^2 + m_2' v_2^2 + m_2 c^2$

$M\cancel{c^2} = 5(0.8)^2 \cancel{c^2} + 3\cancel{c^2} + 6.25(0.6)^2 \cancel{c^2} + 5\cancel{c^2}$

$= 3.2 + 3 + 2.25 + 5$

$M = 13.45 \, Kg$

$\therefore$ ~~of~~ Rest mass of original body $= 13.45 \, Kg.$

$\therefore$ Rest mass isn't conversed.

(13)

$\underset{\text{Obs.}}{O} \xrightarrow{0.8c}$ (e⁻) $\xrightarrow{0.6c}$

$V_{eL} = 0.6c$
$V_{oL} = 0.8c$

$$V_{eo} = \frac{V_{eL} \mp V_{Lo}}{1 \mp \frac{V_{eL}V_{Lo}}{c^2}}$$

$$= \frac{(0.6 \mp 0.8)c}{1 \mp 0.6 \times 0.8}$$

$$\cancel{= \frac{1.4c}{1.48} = 0.945c}$$

$$V_{eo} = -0.38c$$

$$\therefore E = Mc^2 = \frac{m_0}{\sqrt{1 - \frac{V_{eo}^2}{c^2}}} c^2$$

$$= \frac{9.1 \times 10^{-31} \times 9 \times 10^{16}}{0.9249}$$

$$= 8.85 \times 10^{-14} \text{ J.}$$

(14)

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$2 m_0 = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$1 - \frac{v^2}{c^2} = \frac{1}{4}$$

$$\frac{v^2}{c^2} = \frac{3}{4}.$$

$$\therefore v = \frac{\sqrt{3}}{2}c = 2.598 \times 10^{8} \text{ m/s}$$

(15) $V = c/2$ rest mass = m_0

$$m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{m_0}{\sqrt{1-\frac{1}{4}}} = \frac{2m_0}{\sqrt{3}}$$

$\therefore$ momentum $= mv$

$$= \frac{2m_0}{\sqrt{3}} \times \frac{c}{2}$$

$$= \frac{\sqrt{3}m_0 c}{3} \quad \text{Ans.}$$

Total Energy $= \cancel{mv^2} + \cancel{m_0c^2}\ mc^2$

$$= \frac{2m_0}{\sqrt{3}}c^2$$

$$= \frac{2\sqrt{3}}{3}m_0c^2.$$

Kinetic Energy $= (m - m_0)c^2$

$$= \left(\frac{2}{\sqrt{3}} - 1\right)m_0c^2$$

(16) Total power received by earth $= 1.4 \times 2\pi r^2$ KW

$$= 1.4 \times 2\pi (1.5 \times 10^{11})^2$$

$$= 6.37 \times 10^{22}\ \text{KW}$$

$\therefore$ Energy loss per sec $= 6.37 \times 10^{25}$ J.

$$E = mc^2$$

$$m = \frac{6.37 \times 10^{25}}{9 \times 10^{16}} = 2.198 \times 10^9\ \text{Kg}$$

$\therefore$ Mass lost per sec $=$ ~~2.7×10~~ 2.198×10^9 Kg.

(17) total time taken acc. to person on earth.

$= 2 \times \frac{40}{8} = 10$ yrs.

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

$$\Rightarrow t_0 = t\sqrt{1-\frac{v^2}{c^2}} = 10\sqrt{1-(0.8)^2} = 6 \text{ yrs.}$$

$\therefore$ The twin who went in the spaceship will be younger by ~~40~~ 4 yrs.

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

$l = 20\sqrt{1-\frac{v^2}{c^2}}$

$\therefore$ ~~2.6×10^{-8}~~ $= t = \frac{L}{V}$.

$$2.6\times10^{-8} = \frac{20\sqrt{1-v^2/c^2}}{v}$$

$$(1.3\times10^{-9}v)^2 = 1-\frac{v^2}{c^2}$$

$$1.69\times10^{-18}v^2 = 1-\frac{v^2}{c^2}$$

$$v^2(1.69\times10^{-18}+11.1\times10^{-18}) = 1.$$

$$v^2 = \frac{1}{12.79\times10^{-18}}$$

$$= 7.8\times10^{16}$$

$$\therefore v = 2.79\times10^{8} \text{ m/s.}$$

(19) $60 = \frac{59}{\sqrt{1-\frac{v^2}{c^2}}}$

$\left(\frac{59}{60}\right)^2 = 1-\frac{v^2}{c^2}$

$\frac{v^2}{c^2} = 1 - \left(\frac{59}{60}\right)^2$

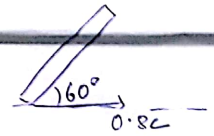
$v = c\sqrt{1-\left(\frac{59}{60}\right)^2}$

$= c\sqrt{0.0330}$

$= 0.18c$

$= 5.4\times10^7$ m/s

(20)



Let the actual length be l.

$\therefore$ ~~l_x~~ $l_x = l\cos 60^\circ = \frac{l}{2}$.

$l_y = l\sin 60^\circ = \frac{l\sqrt{3}}{2}$.

$l_x' = \frac{l_x}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{l}{2\sqrt{1-(0.8)^2}} = \frac{5l}{6}$.

$\therefore$ New length $= \sqrt{\frac{25l^2}{36}+\frac{3l^2}{4}}$

$= \frac{\sqrt{52}}{6}l$.

$= 1.2l$.

$l_x' = l_x\sqrt{1-\frac{v^2}{c^2}} = \frac{l}{2}\sqrt{1-(0.8)^2} = 0.3l$.

$\therefore$ New length, $l' = \sqrt{(0.09+0.75)}\,l = 0.916l$

$\% \text{ contraction} = \frac{l^0 - l'}{l} \times 100$

$= \frac{l - 0.916 l}{l} \times 100$

$= 8.4\%$ Ans

$\therefore$ Apparent orientation $= \frac{l_y}{l_x}$

$\tan\theta = \frac{\sqrt{3}}{2 \times 3} \times 10$

$= 2.886$

$\therefore \theta = \tan^{-1}(2.886)$

$= 1.237$ rad.

(22) Applying conservation of energy,

$E_i = E_f$

$$2\left(\frac{m_0 c^2}{\sqrt{1-\left(\frac{3}{5}\right)^2}}\right) = M c^2$$

$\therefore M = \frac{5 m_0}{2}$ Ans.

(6) Relative vel $= 0.6c$

inframe of O, O' appears to come at speed of 0.6c

& dis is 20m

$\therefore \text{time} = \frac{d}{s} = \frac{20}{0.6 \times 3 \times 10^8}$ sec $= \frac{1}{5} \times 10^{-6}$ sec

$\therefore$ similarly for O', $t = \frac{1}{9} \times 10^{-6}$ sec.