Nama : Annisa Putri Arifa
Npm : 2213022014
Matkul : Teori Relativitas

1.) Diketahui
- Lonceng roket terlambat 1 detik dalam 1 jam relatif terhadap lonceng dibumi
- 1 jam = 3600 detik (dibumi)

Menurut roket, selang waktu sebenarnya $\Delta t_0 = 3600 - 1 = 3599$ detik

$$\Delta t = \gamma \Delta t_0$$

$$3600 = \gamma \times 3599$$

$$\gamma = \frac{3600}{3599}$$

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

$$\frac{1}{\sqrt{1 - v^2/c^2}} = \frac{3600}{3599}$$

$$\sqrt{1 - v^2/c^2} = \frac{3599}{3600}$$

$$1 - \frac{v^2}{c^2} = \left(\frac{3599}{3600}\right)^2$$

$$\frac{v^2}{c^2} = 1 - \left(\frac{3599}{3600}\right)^2$$

$$\frac{v^2}{c^2} = \frac{3600^2 - 3599^2}{3600^2}$$

$$\frac{v^2}{c^2} = \frac{7199}{3600^2}$$

$$\frac{v^2}{c^2} = \frac{\sqrt{7199}}{3600}$$

$$\sqrt{7199} = 84.85$$

$$\frac{v}{c} = \frac{84.85}{3600} = 0.02357$$

$$v = 0.0236\,c$$

$v = 7.08 \times 10^6$ m/s (atau $0.0236c$)

2.) Diketahui
- Terbentuk diketinggian 200 km
- $v = 0.99c$, $T_0 = 2.5 \times 10^{-8}$ s (waktu hidup proper).

Ditanya : ketinggian saat meluruh menurut pengamat bumi.

Waktu hidup menurut bumi :

$$T = \gamma T_0$$

$$\gamma = \frac{1}{\sqrt{1-0.99^2}} = \frac{1}{\sqrt{0.0199}} = \frac{1}{0.141067} = 7.0888$$

$$T = 7.0888 \times 2.5 \times 10^{-8} = 1.7722 \times 10^{-7}\ s$$

Jarak tempuh menurut bumi

$$L = VT = 0.99 \times 3 \times 10^8 \times 1.7722 \times 10^{-7}$$

$$L = 52.62\ m$$

ketinggian awal 200 km = 200.000 m

Jadi, ketinggian saat meluruh

$$200000 - 52.62 = 199947.38\ m = 199.95\ km$$

3.) Diketahui

$v = 0.97c$

$f_s = 10^9$ pulsa/s (sumber)

karena menjauh, terjadi redshift doopler relativistik

$$f_r = f_s \sqrt{\frac{1-\beta}{1+\beta}} \quad \beta = 0,97$$

$$\frac{1-\beta}{1+\beta} = \frac{0,03}{1,97} = 0,015228$$

$$\sqrt{0,015220} = 0,1234$$

$$f_r = 10^9 \times 0.1234 = 1234\ \text{pulsa/s}$$

4.) Diketahui

$v = 0,6c$

$L_p = 45\ m$ → panjang peron menurut pengamat peron

$L_K = 45\ m$ → panjang kereta menurut peron

Jawab :

a.) $$t = \frac{45}{0,6 \times 3 \times 10^8} = \frac{45}{1,8 \times 10^8} = 2,5 \times 10^{-7}\ s$$

b.) $L_K = L_0 / \gamma$

$$\gamma = \frac{1}{\sqrt{1-0,6^2}} = 1,25$$

$$45 = \frac{L_0}{1,25} \Rightarrow L_0 = 45 \times 1,25 = 56,25\ m$$

c.) $L'_p = \frac{L_p}{\gamma} = \frac{45}{1,25} = 36\ m$

d.) $L_0 = 56.25\ m$

$v = 0.6c$

$t' = \frac{L_0}{v} = \frac{56.25}{0.6 \times 3 \times 10^8} = \frac{56.25}{1.8 \times 10^8} = 3.125 \times 10^{-7}\ s$

e.) $\Delta t' = \frac{56.25 - 36}{0.6c} = \frac{20.25}{1.8 \times 10^8} \simeq 1.125 \times 10^{-7}\ s$

5.) Diketahui

$v_A = 0.9c$ relatif terhadap bumi

$v'_R = 0.5c$ relatif terhadap pesawat A (Rusia menyusul Amerika)

a.) klasik

$v_R = v_A + v'_R = 0.9c + 0.5c = 1.4c$

b.) relativistik

$v_R = \frac{v_A + v'_R}{1 + \frac{v_A v'_R}{c^2}} = \frac{0.9c + 0.5c}{1 + 0.9 \times 0.5}$

$= \frac{1,4c}{1 + 0,45} = \frac{1,4c}{1,45} = 0,9655\ c$

6.) Diketahui

$m_0 = 100\ kg$

$m = 101\ kg$

$m = \gamma m_0$

$\gamma = \frac{101}{100} = 1.01$

$1,01 = \frac{1}{\sqrt{1 - v^2/c^2}}$

$\sqrt{1 - v^2/c^2} = 1 / 1.01 = 0,990099$

$1 - v^2/c^2 = 0.980296$

$v^2/c^2 = 0.019704$

$v/c = 0,14037$

$v \simeq 0.14c \approx 4.21 \times 10^7\ m/s$

7.) $U = 5\,mu, e = 1{,}6 \times 10^{-19}\,C$, $m_0c^2 = 0{,}511$ MeV

a.) $K = eV = 5$ MeV (karena q elektron = e, dan $V = 5$ MV)

b.) $E = K + m_0c^2 = 5 + 0{,}511 = 5{,}511$ MeV

$m = E/c^2$ dalam unit energi $/c^2$

$m = 5.511$ MeV$/c^2$

dalam kg : $m = \frac{5.511}{0.511}\, m_0 \approx 10.785 \times 9.11 \times 10^{-31}$ kg $\approx 9{,}83 \times 10^{-30}$ kg

c.) $E = \gamma m_0c^2 \rightarrow \gamma = \frac{5.511}{0.511} \approx 10.785$

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

$= c\sqrt{1 - 1/116{,}3}$

$= c\sqrt{1 - 0{,}0086}$

$v = c\sqrt{0.9914}$

$= 0{,}9957\,c$