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Mata kuliah : Teori Relativitas

Tugas 1.

1. Sebuah roket melaju dengan kecepatan v, lonceng nya berbunyi 1 detik terlambat dalam 1 jam relatif terhadap lonceng di bumi. Berapa kecepatan roket tersebut?

jawab : Diketahui :

- lonceng roket terlambat 1 detik dalam 1 jam relatif terhadap lonceng di bumi
- 1 jam = 3.600 detik (dibumi)
- menurut roket $\Delta t_0 = 3600 - 1 = 3599$ detik

$$\Delta t = \gamma \Delta t_0$$
$$3600 = \gamma \times 3599$$
$$\gamma = \frac{3600}{3599}$$
$$\frac{1}{\sqrt{1 - v^2/c^2}} = \frac{3600}{3599} \rightarrow \gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$$
$$\sqrt{1 - v^2/c^2} = \frac{3599}{3600}$$
$$1 - \frac{v^2}{c^2} = \left(\frac{3599}{3600}\right)^2$$
$$\frac{v^2}{c^2} = 1 - \left(\frac{3599}{3600}\right)^2$$
$$\frac{v^2}{c^2} = \frac{3600^2 - 3599^2}{3600^2}$$
$$\frac{v^2}{c^2} = \frac{7199}{3600^2}$$
$$\frac{v}{c} = \frac{\sqrt{7199}}{3600}$$
$$\sqrt{7199} \approx 84.85$$
$$\frac{v}{c} \approx \frac{84.85}{3600} \approx 0,0236\ c$$

jawaban $v \approx 7.08 \times 10^6$ m/s atau $0,0236\ c$

2. Diketahui

- Terbentuk di ketinggian 200 km
- $v = 0,99\ c$ $T_0 = 2,5 \times 10^{-8}$ s
- Ketinggian saat meluruh menurut pengamat bumi.

Waktu hidup menurut bumi

$T = \gamma T_0$

$\gamma = \frac{1}{\sqrt{1-0,99^2}} = \frac{1}{\sqrt{0,0199}} \approx \frac{1}{0,141067} \approx 7,0888$

$T \approx 7,0888 \times 2,5 \times 10^{-8} \approx 1,7722 \times 10^{-7}$ s

Jarak tempuh menurut bumi

$L = VT \approx 0,99 \times 3 \times 10^8 \times 1,7722 \times 10^{-7}$

Ketinggian awal 200 km = 200.000 m

$200.000 - 52.62 \approx 199947,38$ m $\approx 199,95$ km

Jadi ketinggian saat meluruh sekitar 199,95 km diatas permukaan laut.

3. Diketahui:

$v = 0,97\ c$

$f_s = 10^4$ Pulsa/s

Ditanya : Pada laju berapo data itu diterima?

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

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

$\sqrt{0,015228} \approx 0,1234$

$f_T \approx 10^4 \times 0,1234 \approx 1234$ Pulsa/s

4. Diketahui

- $v = 0,6\ c$
- $L_p = 45$ 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

• $v = 0,6\,c$ → kecepatan relatif peron terhadap kereta

$$t' = \frac{L_0}{V} = \frac{56,25}{0,6 \times 3 \times 10^8} = \frac{56,25}{1,8 \times 10^8} \approx 3,125 \times 10^{-7}\ s$$

e). $$\Delta t' = \frac{56,25 - 36}{0,6\,c} = \frac{20,25}{1,8 \times 10^8} \approx 1,125 \times 10^{-7}\ s$$

5. Diketahui :

• $v_A = 0,9\,c$ relatif terhadap bumi

• $v'_R = 0,5\,c$ relatif terhadap pesawat A (Rusia menyusul Amerika)

jawab :

a). $v_R = v_A + v'_R = 0,9\,c + 0,5\,c = 1,4\,c$

b). $$v_R = \frac{v_A + v'_R}{1 + \frac{v_A + v'_R}{c^2}} = \frac{0,9\,c + 0,5\,c}{1 + 0,9 \times 0,5}$$

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

6. Diketahui : $m_0 = 100$ kg

$m = 101$ kg

$m = \gamma m_0$

$$\gamma = \frac{101}{100} = 1,01$$

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

$$\sqrt{1 - v^2/c^2} = 1/1,01 \approx 0,990099$$

$$1 - v^2/c^2 \approx 0,980296$$

$$v^2/c^2 \approx 0,019704$$

$$v/c \approx 0,14037$$

$$v \approx 0,14\,c \approx 4,21 \times 10^7\ m/s$$

7. $V = 5$ mv, $e = 1,6 \times 10^{-19}$ 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: $m = \frac{5,511}{0,511}\ m_0 = 10,785 \times 9,11 \times 10^{-31}\ kg = 9,83 \times 10^{-30}\ kg$

c). $E = \gamma m_0 c^2 \longrightarrow \gamma = \frac{5,511}{0,511} = 10,785$

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

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

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

$v = c\sqrt{0,9914}$

$= 0,9957\ c$