

Fisika Modern

- ① Sebuah roket bergerak dengan kecepatan v , dan teramati memendek 2%. Berapa kecepatan roket tersebut?

Diketahui

$$\Delta L = 2\% = 0,02$$

Ditanya

$$v = \dots ?$$

Jawab

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

$$L = L_0 (1 - 0,02) = 0,98 L_0$$

$$0,98 = \sqrt{1 - \frac{v^2}{c^2}}$$

$$(0,98)^2 = 1 - \frac{v^2}{c^2}$$

$$0,9604 = 1 - \frac{v^2}{c^2}$$

$$\frac{v^2}{c^2} = 1 - 0,9604$$

$$\frac{v^2}{c^2} = 0,0396$$

$$v = c \sqrt{0,0396} = c \times 0,199 \text{ atau } 19,9\%$$

- ② Diameter Bumi = 12.740 km. Bumi melintas dengan kecepatan $v = 2 \times 10^8$ m/s. Berapa penurunan diameter Bumi (kontraksi panjang) saat itu?

Diketahui:

$$L_0 = 12.740 \text{ km} = 1,274 \times 10^7 \text{ m}$$

$$v = 2 \times 10^8 \text{ m/s}$$

$$c = 3 \times 10^8 \text{ m/s}$$

Ditanya

$$\Delta = \dots ?$$

Jawab

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

$$\frac{v^2}{c^2} = \left(\frac{2 \times 10^8}{3 \times 10^8} \right)^2 = \left(\frac{2}{3} \right)^2 = \frac{4}{9} = 0,4444$$

$$L = L_0 \sqrt{1 - 0,4444}$$

$$L = 1,274 \times 10^7 \times 0,7454$$

$$L = 9,49 \times 10^6 \text{ m}$$

$$L = 9,49 \times 10^6 \text{ m}$$

$$\Delta L = L_0 - L$$

$$\Delta L = 1,274 \times 10^7 - 9,49 \times 10^6$$

$$\Delta L = 3,25 \times 10^6 \text{ m}$$

$$= 3.250 \text{ km}$$

- ③ Sebuah batang pipa PVC panjangnya 1m membentuk sudut 60° terhadap sumbu x. berapa panjang batang pipa tersebut jika batang bergerak sepanjang sumbu x dengan kecepatan $0,8c$? Apakah sudutnya berubah?



Diketahui

$$L_0 = 1 \text{ m}$$

$$v = 0,8c$$

$$\theta = 60^\circ$$

Ditanya

a) L'

b) θ

Jawab

$$a) L_x = L_0 \cos \theta = 1 \times \cos 60^\circ = 0,5 \text{ m}$$

$$L_y = L_0 \sin \theta = 1 \times \sin 60^\circ = 0,866 \text{ m}$$

$$L'_x = L_x \sqrt{1 - \frac{v^2}{c^2}}$$

$$= 0,5 \sqrt{1 - (0,8)^2}$$

$$= 0,5 \sqrt{1 - 0,64}$$

$$= 0,5 \sqrt{0,36}$$

$$= 0,5 \times 0,6$$

$$= 0,3 \text{ m}$$

$$L'_y = 0,866 \text{ m}$$

$$L' = \sqrt{(L'_x)^2 + (L'_y)^2}$$

$$= \sqrt{(0,3)^2 + (0,866)^2}$$

$$= \sqrt{0,09 + 0,75}$$

$$= \sqrt{0,84}$$

$$= 0,916 \text{ m}$$

$$b) \tan \theta' = \frac{L'_y}{L'_x}$$

$$= \frac{0,866}{0,3}$$

$$= 2,887$$

$$\theta' = \tan^{-1}(2,887)$$

$$\theta' = 70,9^\circ$$

4) Sebuah bus bergerak dgn kecepatan 15 m/s Seorang penumpang berjalan didalam bus arah depan dengan kec 2 m/s. Berapa kec absolut terhadap pengamat

Jawab

Diketahui

$$V_{\text{bus}} = 15 \text{ m/s}$$

$$V_{\text{penumpang}} = 2 \text{ m/s}$$

Ditanya

a) V_{total}

b) V

$$a) V_{\text{total}} = V_{\text{bus}} + V_{\text{penumpang}}$$

$$= 15 + 2$$

$$= 17 \text{ m/s}$$

$$b) V = \frac{V_1 + V_2}{1 + \frac{V_1 V_2}{c^2}}$$

$$= \frac{15 + 2}{1 + \frac{(15)(2)}{(3 \times 10^8)^2}}$$

$$= 17 \text{ m/s}$$

- 5) Seorang Pengamat di bumi melihat pesawat A dan B datang dari arah berlawanan masing-masing dgn kec $0,8c$ dan $0,6c$

Diketahui

Jawab

$$V_A = 0,8c$$

$$a) V_A = 0,8c$$

$$V_B = 0,6c$$

$$V_B = 0,6c$$

Ditanya

$$a) V_A \text{ dan } V_B$$

$$b) V' = \frac{V_A - V_B}{1 - \frac{V_A V_B}{c^2}}$$

$$b) V'$$

$$c) V'$$

$$= \frac{0,8c - (-0,6c)}{1 - \frac{(0,8c)(0,6c)}{c^2}}$$

$$= \frac{0,8c + 0,6c}{1 + 0,48}$$

$$= \frac{1,4c}{1,48}$$

$$= 0,946c \rightarrow \text{searah}$$

$$c) V' = \frac{V_B - V_A}{1 - \frac{V_B V_A}{c^2}}$$

$$= \frac{-0,6c - 0,8c}{1 - \frac{(0,6c)(0,8c)}{c^2}}$$

$$= \frac{-1,4c}{1,48}$$

$$= -0,946c \rightarrow \text{berlawanan arah}$$

- 2) Diketahui

$$D = 12,740 \text{ km}$$

$$v = 3 \times 10^4 \text{ m/s}$$

$$c = 3 \times 10^8 \text{ m/s}$$

Jawab

$$\gamma = \frac{1}{\left(1 - \frac{v^2}{c^2}\right)} \rightarrow \frac{v^2}{c^2} = \frac{(3 \times 10^4)^2}{(3 \times 10^8)^2} = 10^{-8}$$

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

$$\frac{1}{\sqrt{1-x}} \approx 1 + \frac{1}{2}x$$

$$\gamma = 1 + \frac{1}{2} \times 10^{-8} = 3 \times 10^{-9}$$



$$L_0 - l = l - \frac{L_0}{4}$$

$$L_0 - l = l \left(1 - \frac{1}{4}\right)$$

$$\frac{l}{4} = 1 - \frac{1}{2} \times 10^{-8}$$

No.

Date

$$V_x = V'_{x'} + V$$

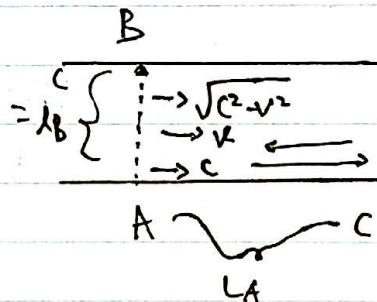
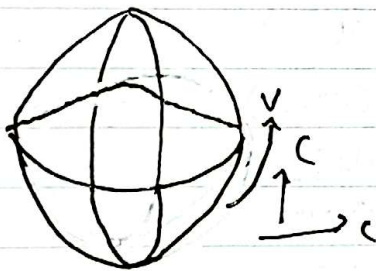
40 m/s
for 10 m/s
bwp kec anak

$v_x \rightarrow$ kec sistem Pengamat diam

$v'_x \rightarrow$ kec benda

$V \rightarrow$ kec anak

Matahari Merambat kembali dengan Perantara (nta).
kecepatan cahaya (c)



$$t_B = \frac{l_B}{\sqrt{c^2 - v^2}} + \frac{l_B}{\sqrt{c^2 + v^2}} = \frac{2l_B}{\sqrt{c^2 - v^2}}$$

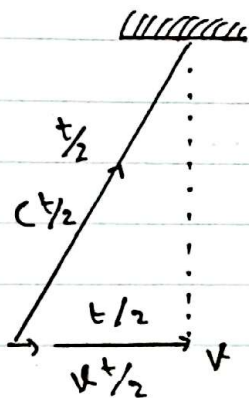
$$\begin{aligned} t_A &= \frac{l_A}{c+v} + \frac{l_A}{c-v} = l_A \left(\frac{1}{c+v} + \frac{1}{c-v} \right) \\ &= l_A \left(\frac{c-v + c+v}{c^2 - v^2} \right) \\ &= l_A \left(\frac{2c}{c^2 - v^2} \right) \end{aligned}$$

Big BOSS

6 mm

$$\frac{t_B}{t_A} = \frac{2L_B}{\sqrt{c^2 - v^2}} = \frac{L_B (c^2 - v^2)}{L_A (c^2 - v^2)} \cdot \frac{2L_A c}{c^2 - v^2} = \frac{L_B}{L_A c} \sqrt{c^2 - v^2}$$

Pemulaian Waktu



$$\left(c \frac{t}{2}\right)^2 = l_0^2 + \left(v \frac{t}{2}\right)^2$$

$$c^2 \frac{t^2}{4} = l_0^2 + v^2 \frac{t^2}{4}$$

$$l_0^2 = \frac{t^2}{4} (c^2 - v^2)$$

$$4l_0^2 = t^2 (c^2 - v^2)$$

$$t^2 = \frac{4l_0^2}{(c^2 - v^2)}$$

$$= \frac{4l_0^2}{c^2 \left(1 - \frac{v^2}{c^2}\right)}$$

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

$$\leftarrow = \frac{4l_0^2/c^2}{\left(1 - \frac{v^2}{c^2}\right)}$$

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

No.

Date

Fold



Syarat-syarat dalam transformasi Waktu

- Pengamat dan objek melihat waktu dalam roket
Mengapa di atas?
- gerak relatif antara roket dan pengamat harus konstan
- Kecepatan v harus lebih kecil dan kecepatan cahaya c yaitu $v < c$