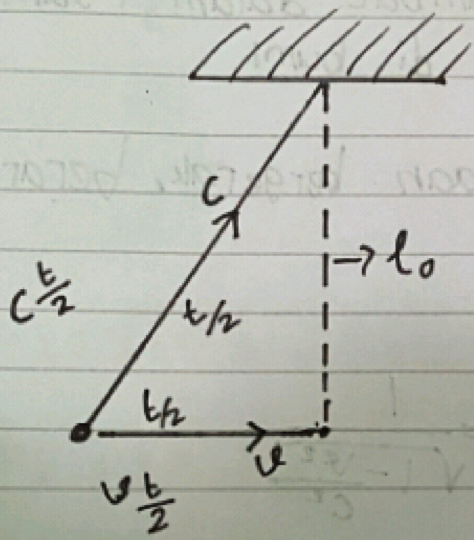
Pemuaian Waktu



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

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

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

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

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

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

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

Date

Contoh

- Berapa kelajuan roket yang lonceng nya berjalan 1 detik terlambat dalam 1 jam relatif terhadap lonceng di bumi

Dik: lonceng dalam keadaan bergerak, berarti

$t = 3600$ detik, maka

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

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

$$v^2 = c^2\left(1 - \frac{t_0^2}{t^2}\right)$$

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

$$= 3.10^8 \sqrt{1-\left(\frac{3600}{3601}\right)^2}$$

Sekarang mari kita bahas Efek Doppler

$$t = t_0\left(\frac{1+v/c}{1-v/c}\right)$$

v = kecepatan pengamat

v' = kecepatan sumber

Efek Dopler Transversal Cahaya

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

v = kec. Pengamat

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

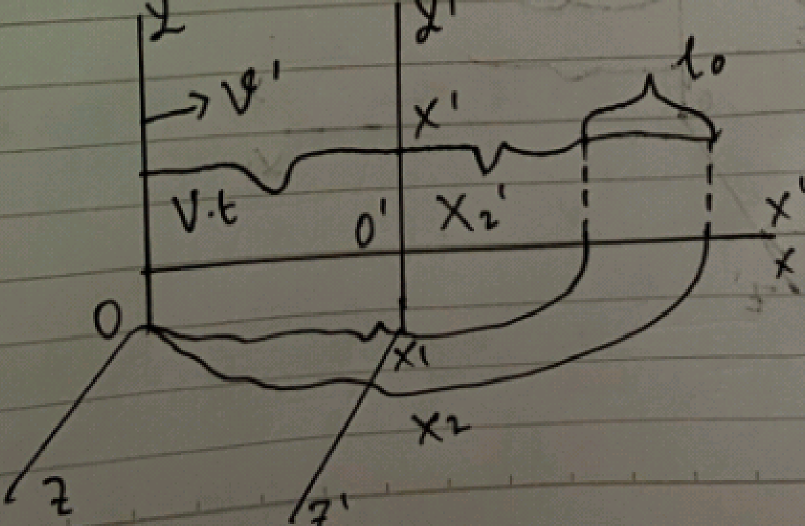
$$t = t_0\sqrt{1-\frac{v^2}{c^2}}$$

Selanjutnya Pelajari kembali Efek Doppler

$$t = t_0\sqrt{\frac{1+v/c}{1-v/c}}$$

- Penyusutan Panjang

Benda yang bergerak dengan kec. v akan nampak lebih Pendek dari Panjang mula-mula (l_0)



$l_0 = x_2' - x_1'$

$l = x_2 - x_1$

$$X_1' = \frac{x_1 - v.t}{\sqrt{1-\frac{v^2}{c^2}}} , \quad X_2' = \frac{X_2 - v.t}{\sqrt{1-v^2/c^2}}$$

$$X_1 = v.t + x_1'\sqrt{1-v^2/c^2}$$
$$X_2 = v.t + X_2'\sqrt{1-v^2/c^2}$$

$$x_2 = V_t \times x_2'\sqrt{1-v^2/c^2}$$
$$X_1 = V_t + x_1'\sqrt{1-v^2/c^2}$$

$$X^2 - X_1 = (x_2' - x_1')\sqrt{1-v^2/c^2}$$
$$L = L_0\sqrt{1-v^2/c^2}$$

Jadi akan nampak lebih Pendek dari Panjang mula-mula kalau benda tersebut bergerak dengan kecepatan v

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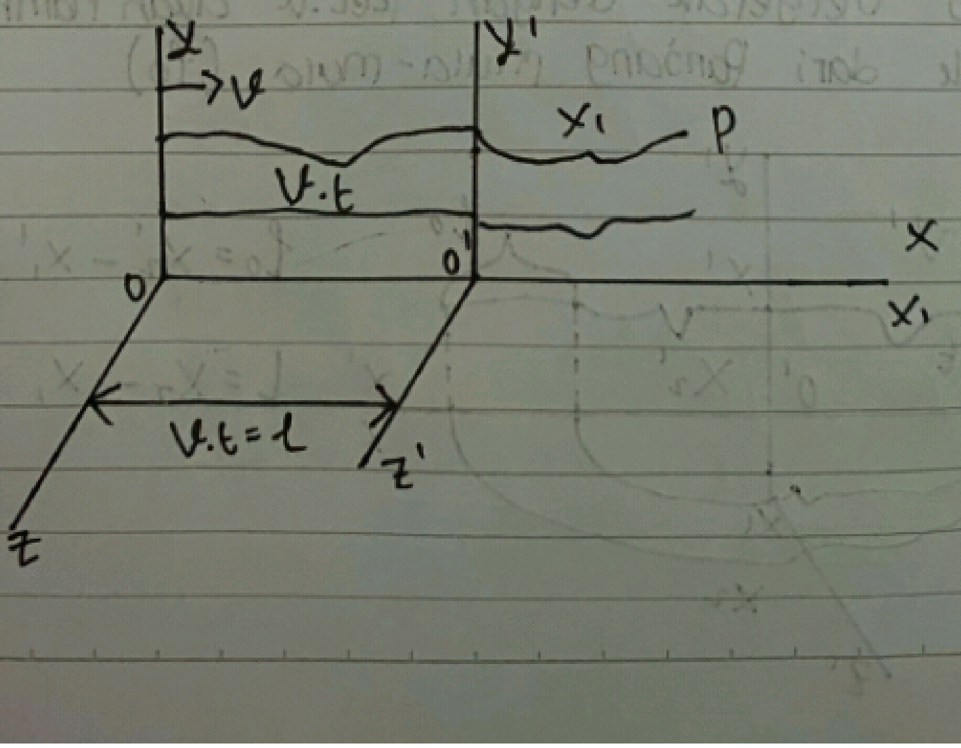
Kontraksi Lorenzt



Date

t

$$t = t' + \frac{x'}{c^2}\cdot v \rightarrow t = \frac{t' + \frac{x'}{c^2}v}{\sqrt{1 - v^2/c^2}}$$

$$v = v + v' \rightarrow v = \frac{v_1 + v_2}{\left(1 - \frac{v_1 v_2}{c}\right)}$$

$x = x' + v.t$

Secara relativistik $x = \dfrac{x' + v.t}{\sqrt{1 - \frac{v^2}{c^2}}}$

Selanjutnya

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

Bagaimana Prosesnya?

Perhatikan Gambar!

Posisi P dilihat dari x

$$x = x' + v.t \ldots (1)$$
$$= x' + \ell$$
$$\downarrow$$

atau Pembuktian dengan kontraksi Panjang

Dalam relativitas klasik kita memperoleh

$$x = x' + v.t \rightarrow x = \frac{x' + v.t}{\sqrt{1 - \frac{v^2}{c^2}}}$$

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

Problem (Masalah)

Jawaban

1.) Diketahui Panjang = 2%
Panjang terukur

$L = 0,98\, L_0$
$L = L_0\sqrt{1-\frac{v^2}{c^2}}$

$L = L_0\sqrt{1-\frac{v^2}{c^2}}$
$0,98\, L_0 = L_0\sqrt{1-\frac{v^2}{c^2}}$

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

$\frac{v^2}{c^2} = 1-0,98 \Rightarrow v = 0,199c$

2.) $L_0 = 12,790 \text{ km} = 1,279 \times 10^7 \text{ m}$
$v = 3 \times 10^4 \text{ m/s}$
$c = 3 \times 10^8 \text{ m/s}$
$L = L_0\sqrt{1-\frac{v^2}{c^2}}$

$L = (1,279 \times 10^7) \times \sqrt{1-\left(\frac{3\times10^4}{3\times10^8}\right)^2}$

$L = 1,279 \times 10^7 \times \sqrt{1-10^{-8}}$
$L = 1,279 \times 10^7 - 6,37 \text{ cm}$

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3.) $L_0 = 1 m$ $\quad v = 0,95$

$\theta_0 = 60°$

$L_x = L_0 \cos 60° = 1 \times 0,5 = 0,5 m$

$L_0 = L_0 \sin 60° = 1 \times 0,866 = 0,866 m$

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

$L_x' = 0,5 \times \sqrt{1 - 0,81}$

$L_x' = 0,5 \times 0,4125$

$L' = \sqrt{L_x'^2 + L_x^2}$

$L' = \sqrt{0,047 + 0,75}$

$L' = 0,892 m$

$\tan \theta' = \frac{L_y}{L_x'}$

$\tan \theta' = 3,99$

$\theta' = 75,9°$

4.) a.) $V = v' + v = 2 m/s + 0,1 c$

b.) $v = \dfrac{2 m/s + 0,1c}{1 + \frac{2 m/s (0,1c)}{c^2}}$

$v = 0,1 c + 2 m/s$

5.) $v' = \dfrac{0,8c + 0,6c}{1 + \frac{\cancel{08} (0,6)}{c^2}} = 0,946c$