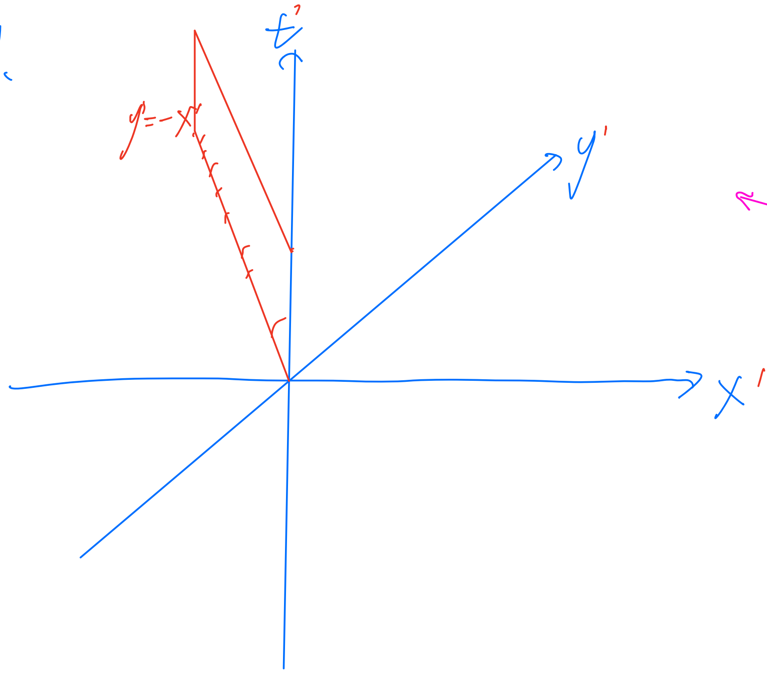
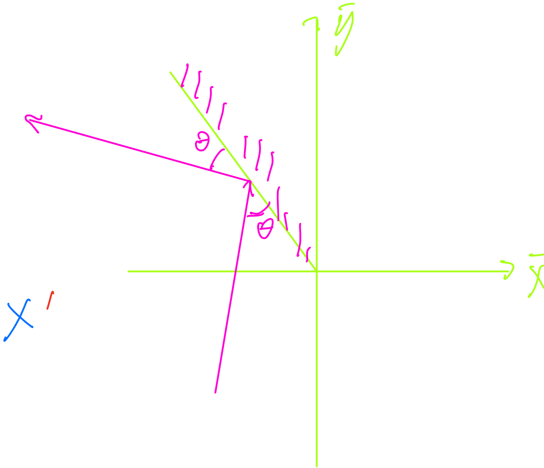
1.





y axis ~~contriated~~ contracted by $\sqrt{1-v^2}$

$y = \bar{y} \cdot \sqrt{1-v^2}$

so the angle of the wall relative to x axis

is contrat by $\tan^{-1}(\sqrt{1-v^2})$

use w as ball's v,

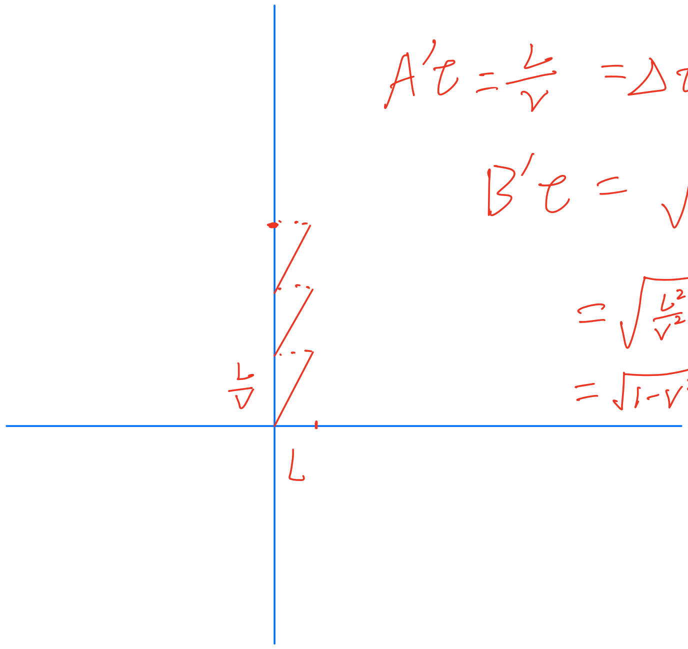
2/

$A't = \frac{L}{v} = \Delta t$

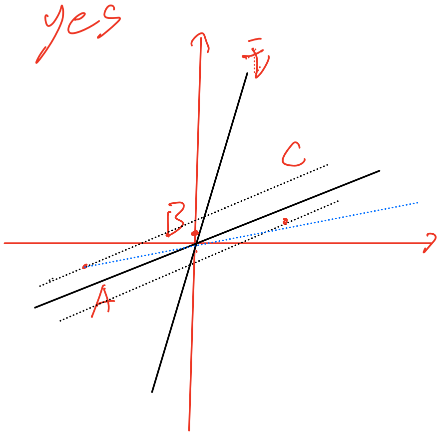
$B't = \sqrt{\Delta t^2 - \Delta x^2}$

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

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

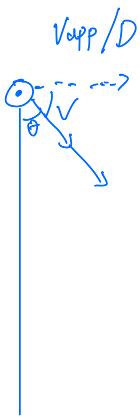


3. yes



in $\bar{O}$, C happen fist, then B then A.
dot line are line of simultaneity
blue line repersent X axis of a coordinate that A C B

4/



gas emit at $t=0$, arrive our eyes at $t_0 = \frac{D}{c}$
gas at t_{00} arrave at point that projection is
$V \cdot \frac{D}{c} \sin\theta$, for this arrve our eye the take $\frac{L}{c}$
which $t_{01} = \frac{D}{c} + \frac{L}{c}$
for $\frac{L}{c}$, gas trava $V \cdot \frac{D}{c} \sin\theta$ in our eyes

$$v_{app} = v\frac{D}{c}\sin\theta \Big/ \frac{L}{c} = v\frac{D}{L}\sin\theta$$

$$L = \left(D - v\cdot\frac{D}{c}\cos\theta,\ v\cdot\frac{D}{c}\sin\theta\right)$$

$$= \sqrt{\left(D - v\cdot\frac{D}{c}\cos\theta\right)^2 + \left(v\cdot\frac{D}{c}\sin\theta\right)^2}$$

$$= \sqrt{D^2\left[\left(1 - \frac{v}{c}\cos\theta\right)^2 + \frac{v^2}{c^2}\sin^2\theta\right]}$$

$$= D\sqrt{1 - 2\frac{v}{c}\cos\theta + \frac{v^2}{c^2}\cos^2\theta + \frac{v^2}{c^2}\sin^2\theta}$$

$$= D\sqrt{\frac{v^2}{c^2} + 1 - 2\frac{v}{c}\cos\theta}$$

$$v_{app} = \frac{v\sin\theta}{\sqrt{1+v^2-2v\cos\theta}}$$

$$v^2\sin^2\theta > 1+v^2-2v\cos\theta$$

$$\sin^2\theta > 2-2\cos\theta \quad \checkmark$$

5

0.106 GeV 2.19×10^{-6} s

1km

$$0.106\cdot\gamma = 1000$$

$$\gamma = 9434 = \frac{1}{\sqrt{1-v^2}} \qquad 1-v^2 = \frac{1}{9434^2}$$

$t = e \cdot 9434 = 0.021\,s$

$0.021 \cdot c / \pi\,km = 0.021 \cdot 3 \cdot 10^5 / \pi$

$= 6300/\pi$

$= 2006.4$

radian $= 12600$

6

a

$$\frac{\partial X_i}{\partial \lambda} = (1, 2(\lambda - 1), -1)$$

at $p = (1, -2, -1)$

$$\frac{\partial X_i}{\partial u} = (-\sin u, \cos u, 1)$$

at $p = (-\sin 1, 1, 1)$

$$\frac{\partial X_i}{\partial 6} = (26, 36^2 + 26, 1)$$

at $p = (2, 0, 1)$

(b)

$$\frac{df}{d\lambda} = \frac{d}{d\lambda}\left[\lambda^2 + (\lambda-1)^4 + \lambda(\lambda-1)^2\right]$$

7 (a)

$$X^{\mu}{}_{\nu} = \eta_{\alpha\nu} \cdot X^{\mu\nu}$$

$$= \eta_{00} \cdot X^{\mu 0} + \eta_{11} \cdot X^{\mu 1} + \eta_{22} \cdot X^{\mu 2} + \eta_{33} \cdot X^{\mu 3}$$

$$= \begin{pmatrix} -2 & 0 & 1 & -1 \\ 1 & 0 & 3 & 2 \\ 1 & 1 & 0 & 0 \\ 2 & 1 & 1 & -2 \end{pmatrix}$$

(b) $$X_{\mu}{}^{\nu} = \begin{pmatrix} -2 & 0 & -1 & 1 \\ -1 & 0 & 3 & 2 \\ -1 & 1 & 0 & 0 \\ -2 & 1 & 1 & -2 \end{pmatrix}$$

(c) $X^{(\mu\nu)} = \frac{1}{2}\left(X^{\mu\nu} + X^{\nu\mu}\right)$

(d) $X_{\mu\nu} = \begin{pmatrix} 2 & 0 & -1 & 1 \\ 1 & 0 & 3 & 2 \\ 1 & 1 & 0 & 0 \\ 2 & 1 & 1 & -2 \end{pmatrix}$

$X_{[\mu\nu]} = \frac{1}{2}\left(X_{\mu\nu} - X_{\nu\mu}\right)$

(e) $X^{\mu}{}_{\nu} = \begin{pmatrix} -2 & 0 & 1 & -1 \\ 1 & 0 & 3 & 2 \\ 1 & 1 & 0 & 0 \\ 2 & 1 & 1 & -2 \end{pmatrix}$

$X^{\lambda}{}_{\lambda} = -4$

(f) $V_{\mu} = \begin{pmatrix} 1 \\ 2 \\ 0 \\ -2 \end{pmatrix}$

$V^{\mu}V_{\mu} = -1 + 4 + 0 + 4$

$= 7$

9

$$V_\mu X^{\mu\nu} = \begin{pmatrix} 2 & 0 & 1 & -1 \\ -2 & 0 & 6 & 4 \\ 0 & 0 & 0 & 0 \\ 4 & -2 & -2 & 4 \end{pmatrix}$$

$$= (4, -2, 5, 7)$$

8

space derivative of momentum

basically mean changing of momentum with space displement.

9

$$T^{\alpha\beta} = \eta^{\alpha\mu} \eta^{\beta\nu} T_{\mu\nu}$$

$$T^{\mu\nu} = \sum_a \frac{p^{\mu(a)} p^{\nu(a)}}{p^{0(a)}} \delta^{(3)}(x - x^{(a)})$$

10

a

$$F_{\mu\nu} = \begin{pmatrix} 0 & -E_1 & -E_2 & -E_3 \\ E_1 & 0 & B_3 & -B_2 \\ E_2 & -B_3 & 0 & B_1 \\ E_3 & B_2 & -B_1 & 0 \end{pmatrix}$$

$$F^{\mu'\nu'} = \Lambda^{\mu'}{}_{\mu} \Lambda^{\nu'}{}_{\nu} F^{\mu\nu}$$

$$A^{\alpha}{}_{\beta} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & 0 & \sin\theta \\ 0 & 0 & 1 & 0 \\ 0 & -\sin\theta & 0 & \cos\theta \end{pmatrix} \to$$

$$F_{\mu\nu'} = A^{\nu}{}_{\nu'} F_{\mu\nu} = \sum_{\nu=0}^{3} A^{\nu}{}_{\nu'} F_{\mu\nu}$$

$$= \begin{bmatrix} 0 & -\cos\theta E_1 - \sin\theta E_3 & -E_2 & \sin\theta E_1 - \cos\theta E_3 \\ E_1 & -\sin\theta B_2 & B_3 & -\cos\theta B_2 \\ E_2 & -\cos\theta B_3 + \sin B_1 & 0 & \sin\theta B_3 + \cos\theta B_1 \\ E_3 & -\cos\theta B_2 & -B_1 & -\sin\theta B_2 \end{bmatrix}$$

$$F_{\mu'\nu'} = \Lambda_{\mu'}{}^{\mu} F_{\mu\nu'}$$

$$\begin{pmatrix} 0 & -\cos\theta E_1 + \cos\theta E_3 & -E_2 & -\sin\theta E_1 - \cos\theta E_3 \\ E_1\cos\theta + E_3\sin\theta & 0 & B_3\cos\theta - B_1\sin\theta & -B_2 \\ E_3 & -B_3\cos\theta + B_1\sin\theta & 0 & B_3\sin\theta + B_1\cos\theta \\ E_3\cos\theta - E_1\sin\theta & -B_2 & B_3\sin\theta + B_1\cos\theta & 0 \end{pmatrix}$$

11,

$$\partial_{[\mu} F_{\nu\lambda]} = 0$$

$$\frac{1}{6}\left[\partial_\mu F_{\nu\lambda} - \partial_\lambda F_{\nu\mu} + \partial_\nu F_{\lambda\mu} - \partial_\mu F_{\lambda\nu} + \partial_\lambda F_{\mu\nu} - \partial_\nu F_{\mu\lambda}\right] = 0$$

$$\frac{1}{6}\left[\partial_\mu F_{\nu\lambda} - \partial_\lambda F_{\nu\mu} + \partial_\nu F_{\lambda\mu} - \partial_\mu F_{\lambda\nu} + \partial_\lambda F_{\mu\nu} - \partial_\nu F_{\mu\lambda}\right] = 0$$

$$\frac{1}{6}\left[\underline{\partial_\mu F_{\nu\lambda} + \partial_\mu F_{\nu\lambda}} + \underline{\partial_\lambda F_{\mu\nu} + \partial_\lambda F_{\mu\nu}} + \underline{\partial_\nu F_{\lambda\mu} + \partial_\nu F_{\lambda\mu}}\right] = 0$$

$$\partial_\mu F_{\nu\lambda} + \partial_\lambda F_{\mu\nu} + \partial_\nu F_{\lambda\mu} = 0$$

(b)

$$F_{0k} = E_k \qquad\qquad B_i = \varepsilon^{aji} F_{aj} \;\; \frac{1}{2}\varepsilon^{kji} F_{kj}$$

$$F_{ij} = \varepsilon^{ijk} B_k$$

$$\varepsilon^{ijk}\partial_j F_{0k} + \frac{1}{2}\partial_0 \varepsilon^{ijk} F_{ij} = 0$$

$$\frac{1}{2}\partial_k \varepsilon^{ijk} F_{ij} = 0$$

$$\nabla \cdot B = 0 = \partial_i B^i$$

$$= \partial_i \tfrac{1}{2} \varepsilon^{ijk} F_{jk}$$

$$= \tfrac{1}{2} \partial_{[i} F_{jk]} = 0$$

$$\nabla \times E + \partial_t B = 0$$

$$\varepsilon^{ijk} \partial_j E_k + \partial_0 B^i = 0$$

$$\partial_j E_k + \varepsilon^{ijk} \partial_0 B^i = 0$$

$$\partial_j E_k + \varepsilon^{ijk} \partial_0 B^i = 0$$

$$= \partial_j F_{0k} + \partial_0 F_{jk} = 0$$

$$\partial_0 F_{jk} + \partial_j F_{k0} + \partial_k F_{0j} = 0$$