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PHYS 230 Midterm Formula Sheet
11 October 2016

Galilean Transformations:

Where $\mathcal{V}$ is the relative speed between frames.

$$\begin{aligned} x' &= x - \mathcal{V}t & v'_x &= \frac{\mathrm{d}x'}{\mathrm{d}t'} = \frac{\mathrm{d}(x-vt)}{dt} = v_x - \mathcal{V} \\ y' &= y & v'_y &= \frac{\mathrm{d}y'}{\mathrm{d}t'} = v_y \\ z' &= z & v'_z &= \frac{\mathrm{d}z'}{\mathrm{d}t'} = v_z \\ t' &= t \end{aligned}$$

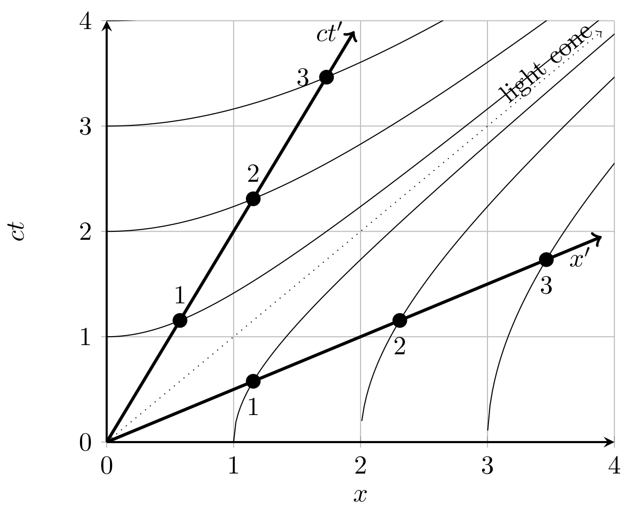
Lorentz Transformations:

Where $\gamma = \frac{1}{\sqrt{1-\frac{\mathcal{V}^2}{c^2}}}$ and $\mathcal{V}$ is the relative speed between frames.

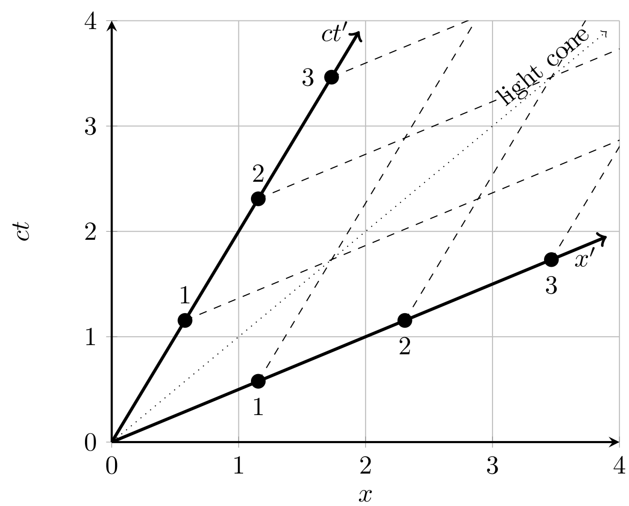
$$\begin{array}{cc|cc} x' = \gamma(x - \mathcal{V}t) & v'_x = \frac{\mathrm{d}x'}{\mathrm{d}t'} = \frac{\frac{\mathrm{d}x'}{\mathrm{d}t}}{\frac{\mathrm{d}t'}{\mathrm{d}t}} = \frac{v_x - \mathcal{V}}{1-\frac{v_x\mathcal{V}}{c^2}} & x = \gamma\left(x' + \mathcal{V}t'\right) & v_x = \frac{v'_x + \mathcal{V}}{1+\frac{v'_x\mathcal{V}}{c^2}} \\ y' = y & v'_y = \frac{\mathrm{d}y'}{\mathrm{d}t'} = \frac{\frac{\mathrm{d}y'}{\mathrm{d}t}}{\frac{\mathrm{d}t'}{\mathrm{d}t}} = \frac{v_y\sqrt{1-\frac{\mathcal{V}^2}{c^2}}}{1-\frac{v_x\mathcal{V}}{c^2}} & y = y' & v_y = \frac{v'_y\sqrt{1-\frac{\mathcal{V}^2}{c^2}}}{1+\frac{v'_x\mathcal{V}}{c^2}} \\ z' = z & v'_z = \frac{\mathrm{d}z'}{\mathrm{d}t'} = \frac{\frac{\mathrm{d}z'}{\mathrm{d}t}}{\frac{\mathrm{d}t'}{\mathrm{d}t}} = \frac{v_z\sqrt{1-\frac{\mathcal{V}^2}{c^2}}}{1-\frac{v_x\mathcal{V}}{c^2}} & z = z' & v_z = \frac{v'_z\sqrt{1-\frac{\mathcal{V}^2}{c^2}}}{1+\frac{v'_x\mathcal{V}}{c^2}} \\ t' = \gamma\left(t - \frac{\mathcal{V}D}{c^2}\right) & ct' = \gamma\left(ct - \frac{\mathcal{V}D}{c}\right) & t = \gamma\left(t' + \frac{\mathcal{V}D'}{c^2}\right) & ct = \gamma\left(ct' + \frac{\mathcal{V}D'}{c}\right) \end{array}$$

Minkowski Spacetime:

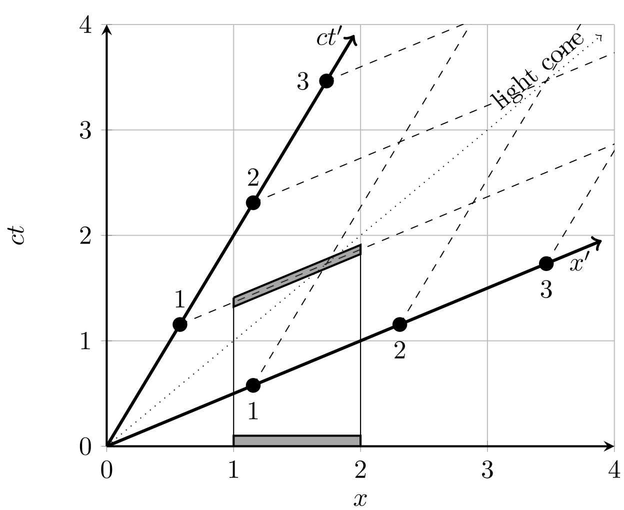
$\frac{\mathcal{V}}{c} = \frac{1}{2}$



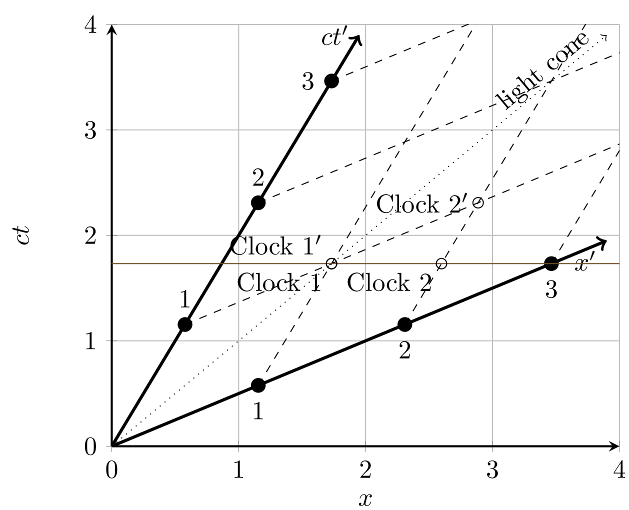
$\frac{\mathcal{V}}{c} = \frac{1}{2}$

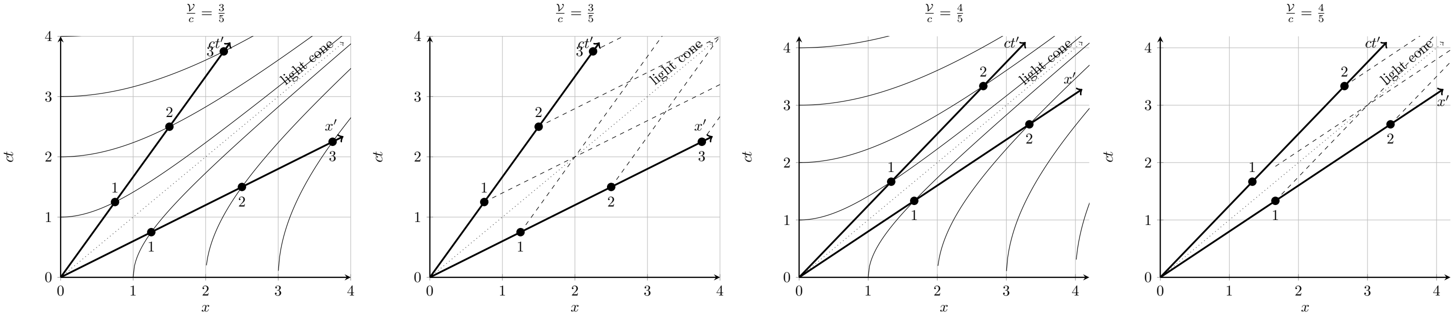


$\frac{\mathcal{V}}{c} = \frac{1}{2}$, Length Contraction



$\frac{\mathcal{V}}{c} = \frac{1}{2}$, Clocks in-sync in S'





Invariant:

$$(x')^2 - (ct')^2 = x^2 - (ct)^2 = \pm a^2$$

Einstein's Postulates

1. Absolute uniform motion cannot be detected.
2. The velocity of light does not depend upon the velocity of its source.

Momentum and Energy:

Where v in $\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ is given by $v = |\mathbf{v}| = \sqrt{v_x^2 + v_y^2 + v_z^2}$ the speed of the particle in that particular frame of reference and is different between two frames.

$$P_\mu = (P_0, P_x, P_y, P_z) \qquad P_0' = \frac{P_0 - \frac{\mathcal{V} P_x}{c}}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$P_\mu = \left(\frac{mc}{\sqrt{1-\frac{v^2}{c^2}}}, \frac{mv_x}{\sqrt{1-\frac{v^2}{c^2}}}, \frac{mv_y}{\sqrt{1-\frac{v^2}{c^2}}}, \frac{mv_z}{\sqrt{1-\frac{v^2}{c^2}}} \right) \qquad P_x' = \frac{P_x - \frac{\mathcal{V} P_0}{c}}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$(P_\mu)_{\text{initial}} = (P_\mu)_{\text{final}} \qquad P_y' = P_y \quad P_z' = P_z$$

$$E = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} mc^2 \qquad E = mc^2 + KE$$

$$KE = \left(\frac{1}{\sqrt{1-\frac{v^2}{c^2}}} - 1 \right) mc^2 \qquad E^2 = m^2c^4 + p^2c^2$$