Physics 142 – October 14, 2010

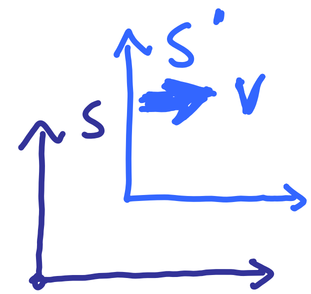
- Presentation groups/Topics

  Suggestions for additional Topics To me by end of Monday

Last time

Time dilation

Time is shortest as measured in **Proper frame**



Suppose $\gamma = 3$

Biff (in S') burps while looking at his watch. His burp lasts 2 seconds.

Buffy (in S) says his burp lasts how many seconds?

Length contraction

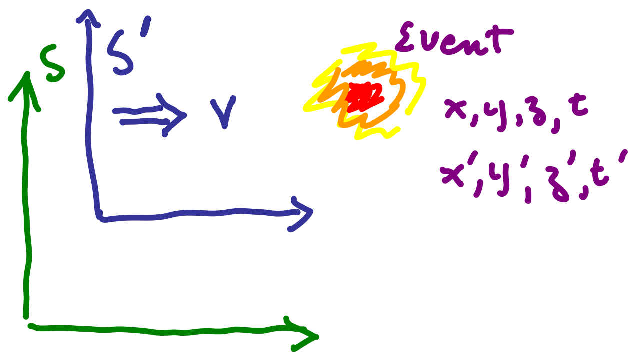
Length is longest as measured in
<u>proper</u> <u>frame</u>

$$\Delta x = \Delta x'$$

where does γ go?

If S' is proper frame

$$\gamma \Delta x = \Delta x'$$

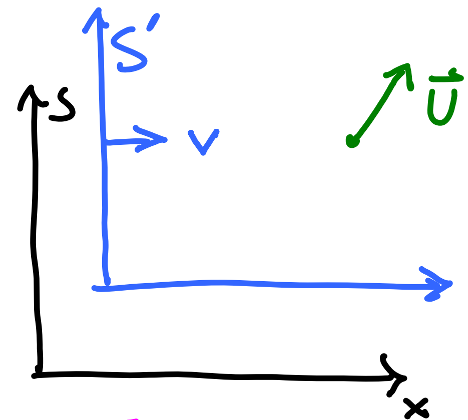


Lorentz Transformations

$$\left\{ \begin{aligned} x' &= \gamma(x - vt) \\ y' &= y \\ z' &= z \\ t' &= \gamma\left(t - \frac{vx}{c^2}\right) \end{aligned} \right\}$$

$V \rightarrow$ small $\Rightarrow \gamma = 1$ $\quad \frac{v}{c} \rightarrow 0$ get Gallilean Transformations

Velocity Transformations



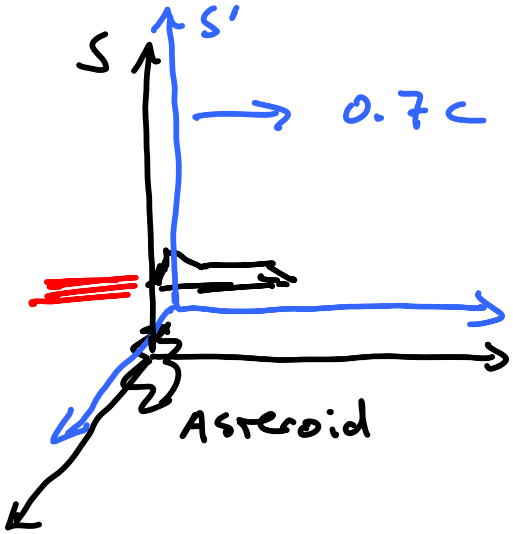
$$U_x' = \frac{U_x - V}{1 - \frac{V}{c^2} U_x}$$

Along direction of relative motion between reference frames

$$U_y' = \frac{U_y}{\gamma\left(1 - U_x \frac{V}{c^2}\right)}$$

$$U_z' = \frac{U_z}{\gamma\left(1 - U_x \frac{V}{c^2}\right)}$$

Components Transverse To direction of relative motion between Reference Frames



$$\gamma = \frac{1}{\sqrt{1-.7^2}} = 1.4$$

Event 1: Rocket passes Asteroid

$t=0, \; t'=0$

Event 2: laser flashes $\underbrace{x = 3\,\text{km}, \; t = 5\,\mu s}_{\text{in } S}$

what does Event 2 look like in S'?

$$x_2' = \gamma(x_2 - v t_2) = 1.4\left[3 - (.7)(3\times10^5)(5\times10^{-6})\right] = 2.73\ \text{km}$$

$$t_2' = \gamma\left(t_2 - \frac{v}{c^2}x_2\right) = 1.4\left[5\times10^{-6} - \frac{.7(3)}{3\times10^5}\right] = -2.8\,\mu s$$

Fly to LA

$\frac{5}{8} c$

$$\frac{dx}{dt} = v$$

meas on ground

Define proper velocity $\eta = \frac{dx}{d\tau}$

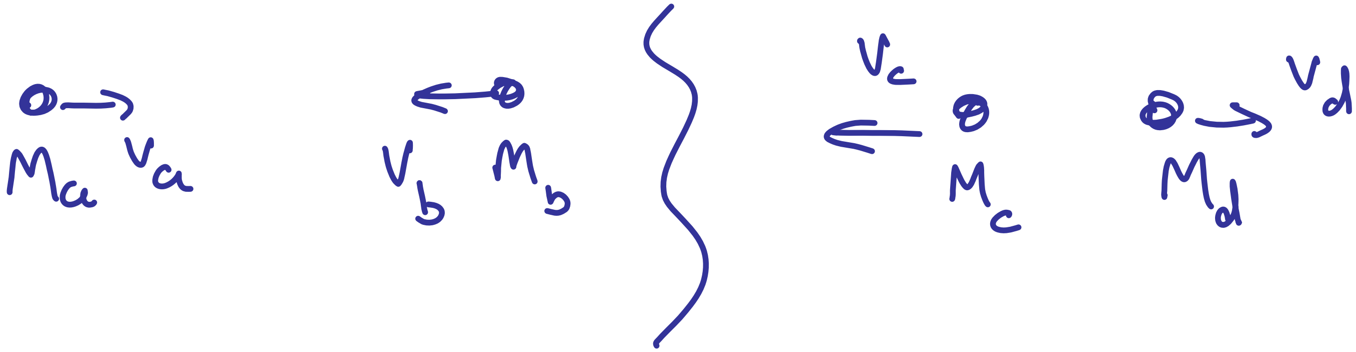
meas on plane

$$\eta_x = \frac{dx}{d\tau} \longrightarrow \text{Transform like } x$$

$$dt = \gamma \, d\tau$$

$$\eta = \frac{dx}{d\tau} = \gamma \frac{dx}{dt} = \gamma v$$

Collision



$p = m\eta \longrightarrow p$ cons. holds

define 4th component $\underbrace{\gamma m c^2}_{\text{Relativistic Energy}}$

$$m_a \eta_a + m_b \eta_b = m_c \eta_c + m_d \eta_d$$

$(\vec{x}, t)$ Spacetime 4 vector

$(\vec{\eta}, E)$ Energy momentum 4 vector

$$E = \frac{mc^2}{\sqrt{1-\left(\frac{v}{c}\right)^2}} = mc^2\underbrace{\left(1-\left(\frac{v}{c}\right)^2\right)^{-1/2}}_{\text{Taylor EXPAND}}$$

$$(1+\alpha)^{-1/2} = 1 - \frac{1}{2}\alpha + \frac{3}{8}\alpha^2 + \cdots$$

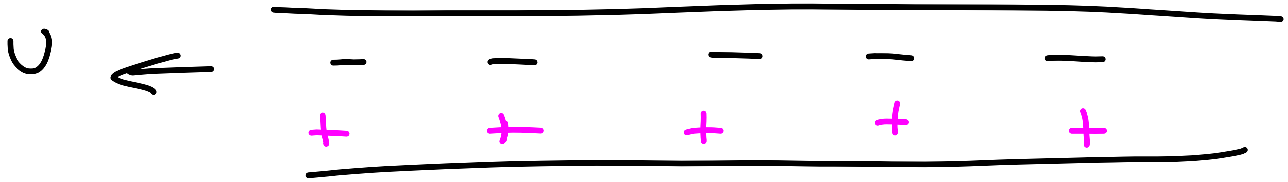
$$E = mc^2 + \frac{mc^2}{2}\left(\frac{v}{c}\right)^2 + \text{higher order terms}$$

$$E = mc^2 + \frac{1}{2}mv^2 + \text{hot}$$

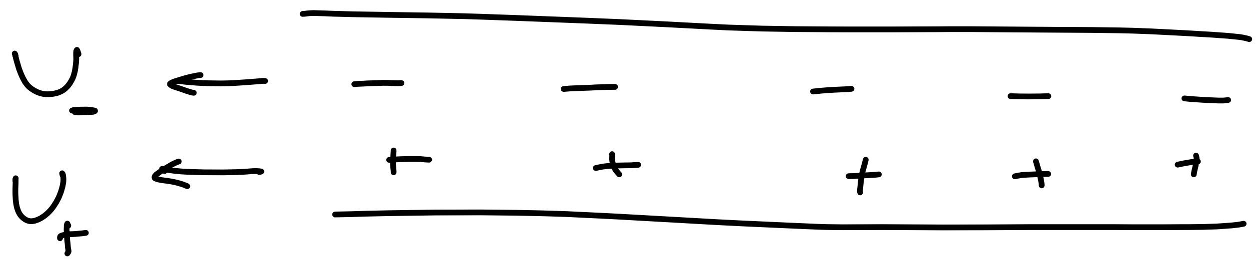
Rel Energy

Rest Energy

KE



$$\lambda_- = \lambda_+$$



$$\lambda_- \neq \lambda_+ \longrightarrow v$$

Magnetism

Magnetostatics

magnetic field $\equiv \vec{B}$

MKS unit Tesla

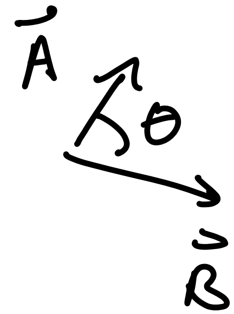
Lorentz Force law

Force on a charged particle moving w/ velocity $\vec{v}$ in region w/ Electric field $\vec{E}$ + Magnetic field $\vec{B}$

$$\vec{F} = q\vec{E} + q\vec{V} \times \vec{B}$$

cross product

$\vec{A} \times \vec{B} \longrightarrow$ vector



$$|\vec{A} \times \vec{B}| = |\vec{A}|\,|\vec{B}| \sin\theta$$

$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix} = \hat{i}\,(A_y B_z - A_z B_y) - \hat{j}\,(A_x B_z - A_z B_x) + \hat{k}\,(A_x B_y - A_y B_x)$$