SPECIAL RELATIVITY

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

$v/c \to 0 \qquad \gamma \to 1$
(Newtonian)

$v/c \to 1 \qquad \gamma \to \infty$
(Relativity)

<u>example:</u> $M = \gamma M_0$

rel. mass

rest mass

$V \to C \qquad M \to \infty$

no more acceleration

$F = m \cdot a$

HENCE cannot go faster than c

photon has zero M_0

"post-Newtonian" approx.

v^2/c^2 is small but not zero

$(1+\varepsilon)^n = 1 + n\varepsilon + \underbrace{\ldots\varepsilon^2 + \varepsilon^3}_{\text{negligible}}$

$\uparrow$ something small

$\varepsilon \ll 1$

$\Rightarrow (1+\varepsilon)^n \approx \underbrace{1}_{\text{Newtonian}} + \underbrace{n\varepsilon}_{\text{"post-Newtonian" approx}}$ if $\varepsilon \ll 1$.

Earth's orbit: $v = 3 \times 10^4$ m/s

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

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

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

$$= 1 + \frac{1}{2} v^2/c^2 + \ldots \cancel{\left(\frac{v^2}{c^2}\right)^2}$$

ignore

$$m = m_0 \gamma$$

$$= m_0\left(1 + \tfrac{1}{2} v^2/c^2\right)$$

$$= \underset{\uparrow}{m_0} + \underbrace{\tfrac{1}{2} m_0 v^2}_{\downarrow} \frac{1}{c^2}$$

Newtonian

kinetic energy

$$m = m_0 + \frac{K.E.}{c^2} \qquad \boxed{\frac{E}{c^2} = m}$$

mass equivalent
kinetic energy

$m = m_0 \gamma$:	$\frac{v^2}{c^2} \to 0$	Newtonian
	$v^2/c^2 \to 1$	light is a speed limit
	$v^2/c^2 \ll 1$	$E = mc^2$

What is mass?

$F = ma$

$\downarrow$

higher mass requires greater force to accelerate

"inertial mass"

$t = \gamma t_0$ time dilation

$L = \frac{L}{\gamma}$ length contraction

"Lorentz transformations"

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

$$v/c \to 0 \qquad \gamma \to 1$$

$$M_{inertial} = \underbrace{M_{intrinsic}}_{\text{rest mass}}$$

$$\frac{1}{(1 - v^2/c^2)^{1/2}} \approx \underbrace{1}_{\substack{\text{rest} \\ \text{mass}}} + \underbrace{\tfrac{1}{2} v^2/c^2}_{\frac{\text{Kinetic } E}{c^2}} + \ldots$$

Energy : ability to do work

$$E = mc^2$$

total energy

inertial mass

$$m = m_0 + \frac{K.E.}{c^2}$$

kinetic energy

$$\frac{\text{rest energy}}{c^2}$$

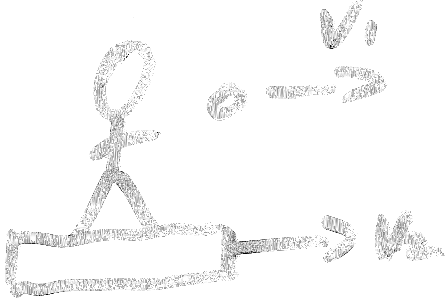
$$E = c^2 m_0 + K.E$$

$$t = \gamma t_0$$

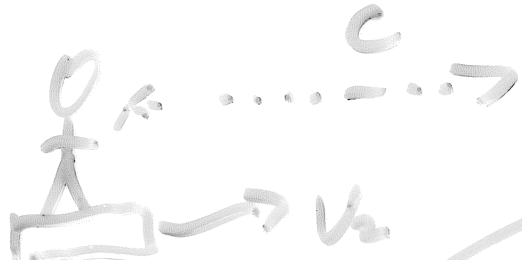
$$\frac{1}{\sqrt{1 - v^2/c^2}}$$

$\Rightarrow$ imaginary

the speed of light is same ~~to all~~ for all observers.



$V_{TOT} = V_1 + V_2$ Newtonian



$V_{TOT} = c$ NOT $c + V_2$

Hmmm... velocity is $\frac{\text{space}}{\text{time}}$

So space are messed up close to c.