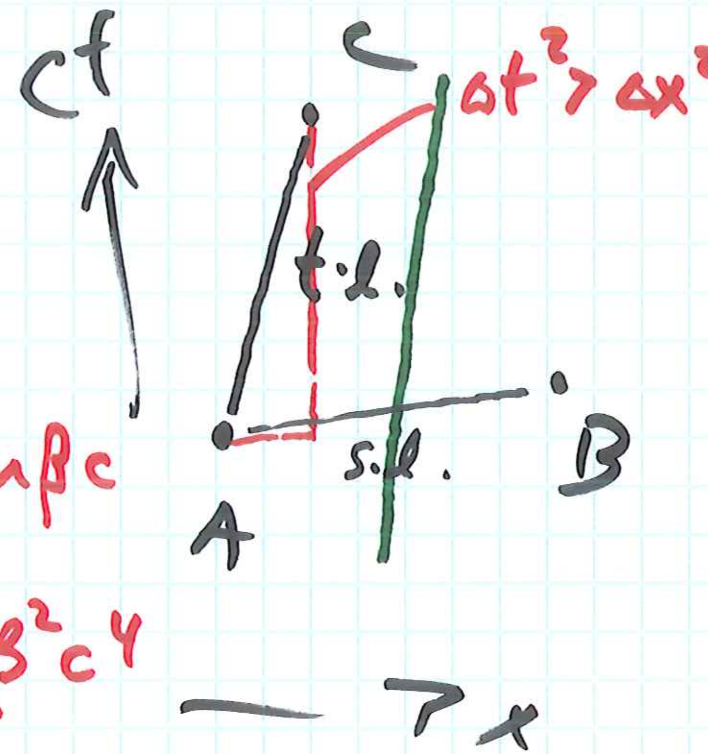
NYU Physics I — 2016-12-08.

Agenda — reading — Chs. 4, 5, 6.

— QS

— 4-vectors.

— Exam 5.



$E = \gamma mc^2 \qquad \vec{p} = \gamma m\vec{v} = \gamma m\beta c$

$E^2 - p^2c^2 = \gamma^2 m^2 c^4 - \gamma^2 m^2 \beta^2 c^4$

$E^2 - p^2c^2 = m^2c^4$

4-vectors:

4-displacement: $(c\Delta t, \Delta x, \Delta y, \Delta z) = \vec{\Delta s}$

- transforms according to the L.T.
- square of magnitude of $\vec{\Delta s}$ is $|\vec{\Delta s}|^2 \equiv c^2\Delta t^2 - \Delta x^2 - \Delta y^2 - \Delta z^2$

4-velocity: $\dfrac{\text{4-displacement}}{\text{proper time}} : \dfrac{\vec{\Delta s}}{\Delta\tau}$

$$\vec{u} = \left(c\frac{\Delta t}{\Delta\tau}, \frac{\Delta x}{\Delta\tau}, \frac{\Delta y}{\Delta\tau}, \frac{\Delta z}{\Delta\tau}\right)$$

- @ rest: $\vec{u} = (c, 0, 0, 0)$ $\quad |\vec{u}|^2 = c^2$

moving @ β, γ in x-dir $\quad \vec{u} = \left(c\frac{\Delta t}{\Delta\tau}, \frac{\Delta x}{\Delta\tau}, 0, 0\right)$ $\quad \Delta\tau = \sqrt{(\Delta t)^2 - \left(\frac{\Delta x}{c}\right)^2}$

$\vec{u} = (c\gamma, c\gamma\beta, 0, 0)$ $\quad \Delta\tau = \dfrac{\Delta t}{\gamma}$

4-momentum = 4-velocity * (rest mass)

$(c\gamma m, c\gamma\beta m, 0, 0)$ x-dir.

$(\underbrace{\gamma mc}_{E/c}, \underbrace{\underbrace{\gamma m \beta c}_{\gamma m v}, 0, 0}_{\text{3-momentum}})$

- Spatial part of a 4-vector <u>is</u> a 3-vector.
  hence: $\vec{p} = \gamma m \vec{v}$ (3-momentum)
- momentum conservation — spatial translation symmetry
  energy conservation — time translation symmetry

$$|\vec{p}|^2 = \gamma^2 m^2 c^2 - \gamma^2 m^2 \beta^2 c^2 = m^2 c^2$$

$$\frac{|\vec{p}|^2}{c^2} \equiv m^2 \quad \text{rest mass definition}$$

photons: $\frac{E^2}{c^2} = p^2$ so $m^2 = 0$.

real things — $\frac{E^2}{c^2} > p^2$!

$$10\,\frac{m}{s^2} = |\vec{g}| = \frac{G M_\oplus}{R_\oplus^2}$$