NYU Physics I

2018-12-11

- Final Exam.
- Course evals.
- 4-vectors.

Chs 5, 6, 7.

3-vectors.	4-vector
displacement $(\Delta x, \Delta y, \Delta z)$	4-displacement $(c\Delta t, \Delta x, \Delta y, \Delta z)$ $(c\Delta t, \Delta \vec{r})$
velocity $\vec{v} = \left(\frac{dx}{dt}, \frac{dy}{dt}, \frac{dz}{dt}\right)$	4-velocity
momentum $\vec{p} = \gamma m \vec{v}$ (m: rest mass)	4-momentum
⋮	
acceleration	4-acceleration
force	4-force
⋮	⋮

3-vectors

$\vec{A}$, $\vec{B}$ — magnitude & direction.

$\vec{A}\cdot\vec{A}$, $\vec{A}\cdot\vec{B}$ — scalars.

$\vec{A}+\vec{B}$ — add

$q\vec{A}$ — multiply by a scalar.

4-displacement: ~~###~~

"space-time between 2 events"

$$\Delta s = (c\Delta t, \Delta x, \Delta y, \Delta z)$$
$$= (c\Delta t, \Delta \vec{r})$$

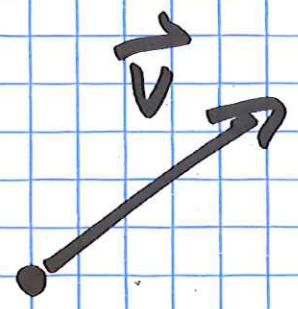
$$\Delta s \cdot \Delta s = (\Delta s)^2 = (c\Delta t)^2 - \Delta x^2 - \Delta y^2 - \Delta z^2$$
$$= (c\Delta t)^2 - \Delta \vec{r} \cdot \Delta \vec{r}$$

(a, b : $\underbrace{a \cdot b}_{\text{scalar}} = \underbrace{a_t b_t - a_x b_x - a_y b_y - a_z b_z}_{\text{same in all frames.}}$)

4-velocity: $\lim_{\Delta\tau \to 0} \frac{\Delta s}{\Delta \tau} = \frac{c\,\Delta s}{\sqrt{(\Delta s)^2}}$

($\frac{\sqrt{(\Delta s)^2}}{c}$ is: "proper time" = $\Delta t / \gamma$)

4-velocity: $u = \left(\gamma c \frac{\Delta t}{\Delta t}, \gamma \frac{\Delta x}{\Delta t}, \gamma \frac{\Delta y}{\Delta t}, \gamma \frac{\Delta z}{\Delta t}\right)$



$= (\gamma c, \gamma \vec{v})$

$u^2 = \gamma^2 c^2 - \gamma^2 \vec{v} \cdot \vec{v}$

$= \frac{1}{1-\beta^2} c^2 (1-\beta^2)$

$= c^2$

4-momentum: mu

rest mass · 4-velocity.

conserved quantity

$$p = (\gamma mc, \gamma m\vec{v}) = \left(\frac{E}{c}, \vec{p}\right)$$

particle energy E/c

$\vec{p}$ = momentum!

$$\lim_{\beta \to 0} \gamma = 1 + \frac{1}{2}\beta^2$$

$$mc^2 + \frac{1}{2}mc\beta^2$$

xc: $mc^2 + \frac{1}{2}mv^2$