"What is essential for calculating in Special Relativity"

1 Notation

The most important step is to get used to the notation !

- Usually the speed of light is set to one: $c = 1$
  - $\Rightarrow$ so I will do it for the rest of the notes (opposite to Griffiths)
  - but that means, you have to know the physical dimensions of your quantities!
- the most important quantity is the fourvector, especially the four-momentum:

$$p^\mu = \begin{pmatrix} p^0 \\ \vec{p} \end{pmatrix} = (p^0, \vec{p}) \tag{1}$$

- the scalar product of fourvectors can be written as

$$(p.q) = p^\mu q_\mu = p_\mu q^\mu = g_{\mu\nu} p^\mu q^\nu = \eta_{\mu\nu} p^\mu q^\nu = p^0 q^0 - \vec{p} \cdot \vec{q} \tag{2}$$

  - where the metric $g_{\mu\nu} = \eta_{\mu\nu}$ defines the scalar product
    - $g_{\mu\nu}$ for a general space and $\eta_{\mu\nu}$ for Minkovsky space
    - since our general space is Minkovsky space, both are equal in SR
  - $\vec{p} \cdot \vec{q}$ is the "normal" scalar product in 3D

2 important concepts

inertial frame is a coordinate system that is not accelerated

- that does not feel an external force

Lorentz transformation (LT) is the linear transformation between inertial frames

- parametrized by the relative velocity $\vec{v}$ or the rapidity η

CM-frame is the coordinate system where the sum of all 3-momenta is zero: $0 = \sum_i \vec{p}_i$

rest-frame is the coordinate system where the object A (that defines the rest-frame) does not move: $\vec{p}_A = 0$

mass is the energy content of an object in its rest-frame

Lab-frame is the coordinate system of the Laboratory;

- usually all measured quantities are understood to be given in the Lab-frame
- it is the usual starting point of a calculation

time dilation and length contraction are effects of the LT between frames

- decaying objects that move last longer
- length measurements on moving objects seem shorter