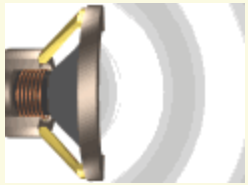
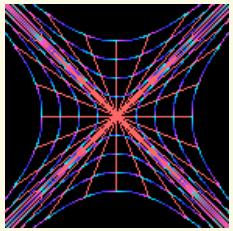
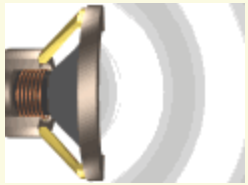


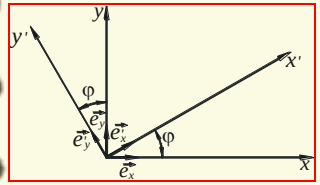
Aula 11: Energia relativista

1. Diagramas de Minkowski
2. Fórmula da massa
3. Fórmula da energia



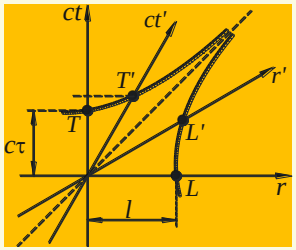


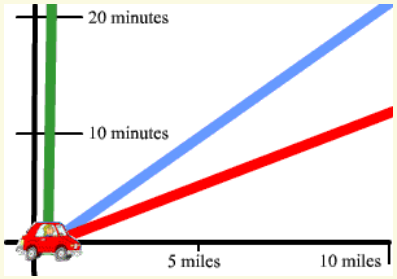
1. Diagramas de Minkowski

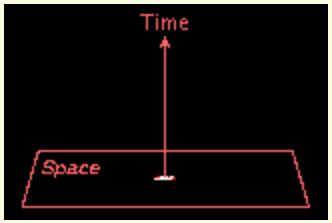


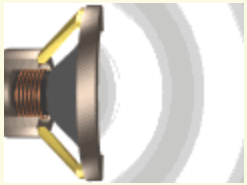
$$x' = x\cos\varphi + y\,\mathrm{sen}\,\varphi$$

$$y' = -x\,\mathrm{sen}\,\varphi + y\cos\varphi$$

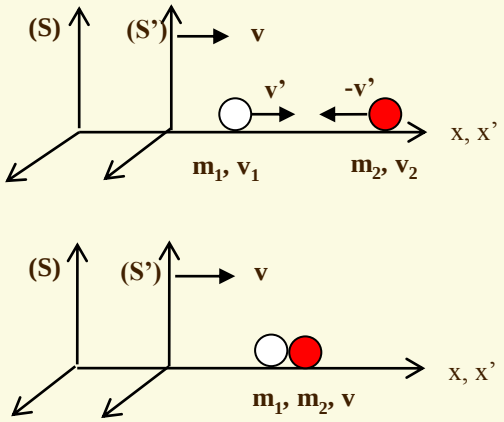






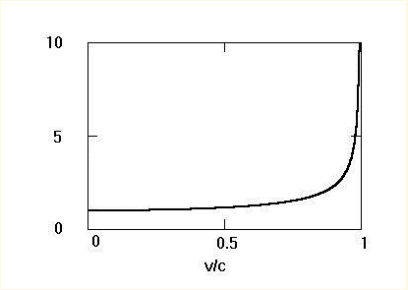


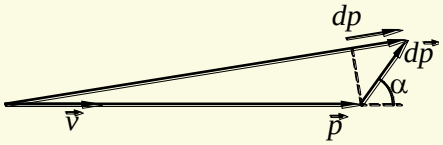
2. Formula da massa

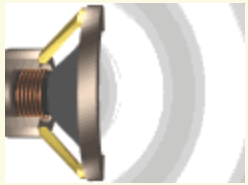


$$m(v) = \gamma m(0) = \frac{m_0}{\sqrt{1 - v^2/c^2}}$$

$$\vec{p} = \frac{m_0 \vec{v}}{\sqrt{1 - v^2/c^2}} = m\vec{v}$$







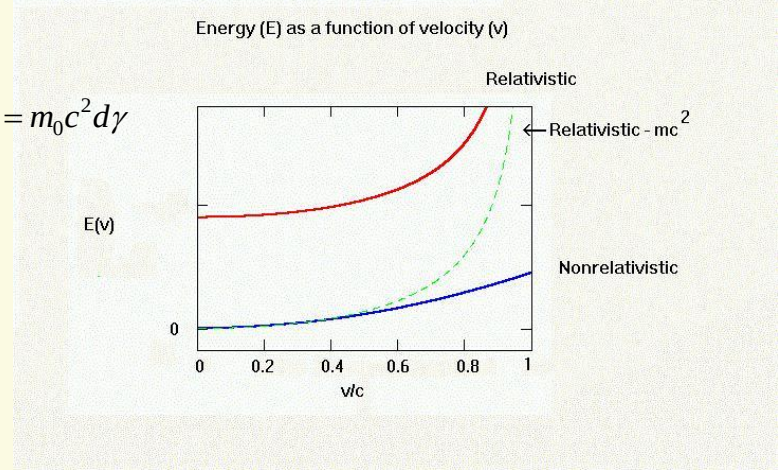
3. Fórmula da energia

$$dE = \vec{F}\cdot d\vec{r} = \frac{d\vec{p}}{dt}\cdot d\vec{r} = d\vec{p}\cdot\vec{v} = vdp$$

$$dE = \frac{m_0 v dv}{\left(1-v^2/c^2\right)^{3/2}} = -\frac{m_0 c^2}{2}\frac{d\left(1-v^2/c^2\right)}{\left(1-v^2/c^2\right)^{3/2}} = m_0 c^2 d\left(\frac{1}{\sqrt{1-v^2/c^2}}\right) = m_0 c^2 d\gamma$$

$$T = m_0 c^2 \int_1^{\gamma} d\gamma = m_0 c^2 (\gamma - 1)$$

$$E = m_0 c^2 \gamma = \frac{m_0 c^2}{\sqrt{1-v^2/c^2}}$$



Relação momento-energia

$$E = m_0 c^2 \sqrt{1+\frac{p^2}{m_0^2 c^2}} \quad \text{or} \quad E^2 = p^2 c^2 + \left(m_0 c^2\right)^2$$