## Exercise sheet 1

## Hartle 5-6.

Consider a particle moving along the x-axis whose velocity as function of time is

$$\frac{dx}{dt} = \frac{gt}{\sqrt{1+g^2t^2}}$$

where g is a constant.

- a. Does the particle's speed ever exceeds the speed of light?
- b. Calculate the four-velocity u.
- c. Express x and t as function of the proper time  $\tau$  along the trajectory.
- d. Find the components of the four-force and the three-force acting on the particle.

## Charged pion decay.

A charged pion decays mainly via the reaction  $\pi^{\pm} \to \mu^{\pm} + \nu_{\mu}$ . Calculate the energy of the muon if the pion decays at rest. Calculate the maximal and minimal energy of the muon if the pion decays in flight with an energy of 1 TeV.

Use as masses  $m_{\pi^{\pm}} = 139$  MeV,  $m_{\mu^{\pm}} = 106$  MeV, and  $m_{\nu} \approx 0$ .

## Planck units.

The four fundamental constants  $\hbar$  (Planck's constant), c (velocity of light),  $G_N$  (gravitational constant) and k (Boltzmann constant) can be combined to obtain the dimension of a length, time, mass and temperature. Calculate their numerical values.