Particle Physics - Exercises

1. Relativistic Kinematics

1. Prove that the squares of four-vectors are relativistically invariant!   **[ ]**

2. Prove that the products of four-vectors are relativistically invariant!   **[ ]**

3. Show that the square of the four-velocity is equal 1!   **[ ]**

4. An electron and a proton have the same curvature in a magnetic field.
The electron moves twice as fast as the proton.
What is the momentum of both particles?   **[2]**

5. Due to its large mass the top quark has a large decay width of 1.5 GeV.
What are the lifetime and decay length of the top quark?   **[2]**

6. A particle decays in flight into a proton and a pion with masses
$m_p = 0.938$ GeV and $m_\pi = 0.140$ GeV. Their momenta are measured to be
p_p = (-0.178, 0.033,-1.343) GeV   and p_π = (-0.030,-0.018,-0.059) GeV.
What is the mass of the decay particle? Which particle was it?   **[3]**

7. In 1987 the supernova SN1987A exploded at a distance of 180.000 light years.
Assume it simultaneously emitted photons and neutrinos with a momentum of
3 MeV. Calculate the relation between the neutrino mass and the time
difference of the arrival of the photons and neutrinos on Earth!   **[3]**

8. In the LEP collider at CERN in Geneva electrons and positrons were
accelerated to 100 GeV and brought to collision.
- How large was the reaction energy in the centre-of-mass system?   **[1]**
- To which energy should one accelerate a positron beam in order to
reach the same reaction energy on an electron at rest?   **[3]**