Elementary Particle Physics - Exercises	**Problem sheet 01**	October 23, 2015

[Tutorials on Thursdays: 8-10 in C01-148 and 16-18 in U2-135]

Exercise 1.1:
Express the gravitational constant $G_N = 6.67 \times 10^{-11}$m^{3}kg^{-1}s^{-2} in natural units, that is in GeV. The Planck mass is defined as $G_N^{-1/2}$, how large is it? What is its physical meaning?

Exercise 1.2:
At CERN in the LEP experiment electrons e^- and positrons e^+ were collided so that the total energy of the system matched the mass of the Z boson, $m_Z = 91$ GeV. How large was the velocity of the particles?

Exercise 1.3:
In the atmosphere at the altitude of about 15km muons $\mu^\pm$ are generated by cosmic background radiation and they approach the earth almost with the speed of light, $v = 0.9997$. They decay into one electron/positron $e^\pm$ and 2 neutrons: $\mu^- \to e^- + \bar{\nu}_e + \nu_\mu$ or $\mu^+ \to e^- + \bar{\nu}_\mu + \nu_e$, respectively with a mean lifetime of 2.2×10^{-6}s in their rest frames.

1. On which altitude should a detector be placed in order to observe muons?

2. Which particles arrive on earth?

Exercise 1.4:
Consider the decay of a particle with mass M into two particles with masses m_j and momenta $\vec{p}_j$, $j = 1, 2$, in its system of rest. Find the momenta. In the next step consider the decay into three particles and think about a generalization of the previous results. Convince yourself that the amount of the momentum $|\vec{p}_1|$ is not restricted to a specific value.
This fact caused Wolfgang Pauli to postulate the existence of the (electron) neutrino generated in β-decay: $n \to p + e^- + \bar{\nu}_e$. Which quantum numbers are conserved in this process?