name: **group:**

Exercise Sheet 1 – Particle Physics – SS 2016

hand in: Tue 26$^{\text{rd}}$ April (after the lecture or at INF 226, 3.104 by 4 pm)

These problems serve as a reminder of the subjects discussed in PEP5.

You can find the particle masses, quark contents, etc. on the website of the particle data group: **pdg.lbl.gov**

1.1 Conservation Laws and Feynman Graphs (10 points)

Which of the following reactions are forbidden in the Standard Model? Why? For the allowed ones draw the dominant Feynman diagram (use quark lines for hadrons and assuming sufficient energy available in two particle initial states, mark the direction of the fermion flow).

a) $\tau^+ \to e^+ + \nu_e + \overline{\nu}_\tau$
b) $\nu_\mu + n \to \mu^- + p$
c) $K^0 \to \pi^+ + \pi^-$
d) $K^0 \to \pi^+ + \pi^- + \pi^+ + \pi^-$
e) $e^+ + e^- \to \mu^+ + \mu^-$
f) $B^+ \to \overline{D}^0 + \mu^+ + \nu_\mu$
g) $\Lambda_c \to p + K^- + \pi^+$
h) $e^+ + e^- \to \gamma$
i) $\phi \to K^+ + K^-$
j) $\mu^- + p \to \Lambda + K^0$

1.2 e^+e^- Collisions (5 points)

What is the minimal electron energy needed to produce pairs of charged B-mesons (B^+B^-) in asymmetric e^+e^- collisions if the positron energy is 3.1 GeV?

Hint: Compare all involved masses to the beam energies.

1.3 Two-Body Decay (5 points)

Particle A is at rest and decays into particles B and C: $A \to B + C$.

a) Show that the energy of particle C, E_C, in the rest frame of A is given by

$$E_C = \frac{m_A^2 + m_C^2 - m_B^2}{2m_A}. \tag{1}$$

b) What is the energy E_B?
c) Use this result to briefly discuss the observed electron energy spectrum in β-decays.