PP4: Example Sheet 1

Basic Constituents, Units

1. List all fundamental fermions in the Standard Model. Write down *all* possible electromagnetic fermion-fermion-photon vertices.

2. Draw the Feynman diagram for a charged weak current. Suggest the possible decay modes of the W^- into quark- and lepton-pairs.

3. Explain why the decays $\mu^- \to e^-\bar{\nu}_e\nu_\mu$ and $\mu^+ \to e^+\nu_e\bar{\nu}_\mu$ are allowed and why $\mu^+ \to e^+\gamma$ and $\mu^+ \to e^+e^-e^+$ are forbidden.

4. In natural units, the dimensionless fine structure constant is given by $\alpha = e^2/4\pi$. Restore the factors of $\hbar$, c and ϵ_0 and calculate its value. (You may wish to consider Gauss's law and the Coulomb force law for point charges in order to understand the dimensions of e and ϵ_0.)

5. Construct mesons of the form $H\bar{q}$, where the H is a s, c, or b quark, and $\bar{q}$ is either a $\bar{u}$ or $\bar{d}$ quark, respectively. Try to assign these mesons to one of the following: K^-, $\bar{K}^{*0}$, D^0, D^+, D^{*+}, $\bar{B}^0$ and B^-.
Hint: If you cannot find this information, use the Particle Listings of the Particle Data Group at URL http://durpdg.dur.ac.uk/lbl .
What is the significance of the * in the name?

6. In each of the following decays try to draw a quark level Feynman diagram and determine which force is responsible.

$$\begin{array}{ll} \mathrm{D}^{\star+} \longrightarrow \mathrm{D}^0\pi^+ & \qquad \Sigma^0 \longrightarrow \Lambda\gamma \\ \mathrm{D}^+ \longrightarrow \overline{\mathrm{K}}^0\pi^+ & \qquad \tau^- \longrightarrow \rho^-\nu_\tau \\ \mathrm{K}^{*0} \longrightarrow \mathrm{K}^+\pi^- & \qquad \pi^0 \longrightarrow \gamma\gamma \end{array}$$

Hints: The photon only interacts electromagneticly, the neutrino only weak. First establish the relevant quark flavour quantum numbers of the initial and final states. Always draw the simplest possible diagrams.
Do your answers agree with the observed lifetimes?