# Particle Physics Phenomenology I

HS 10, Series 4

Due date: 22.10.2010, 1 pm

**Exercise 1** Show that the Dirac spinors

$$u_\pm(p) = \sqrt{p^0 + m} \begin{pmatrix} \chi_\pm \\ \frac{\vec{\sigma} \cdot \vec{p}}{p^0 + m} \chi_\pm \end{pmatrix}, \qquad v_\pm(p) = \sqrt{p^0 + m} \begin{pmatrix} \frac{\vec{\sigma} \cdot \vec{p}}{p^0 + m} \chi_\mp \\ \chi_\mp \end{pmatrix}$$

where

$$\chi_+ = \begin{pmatrix} 1 \\ 0 \end{pmatrix}, \qquad \chi_- = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$$

satifsfy the Dirac equation.

$$(\gamma^\mu p_\mu - m)u_\pm = 0$$
$$(\gamma^\mu p_\mu + m)v_\pm = 0$$

*Hint*:You may use (and proof) that $(\vec{\sigma} \cdot \vec{p})^2 = |\vec{p}|^2 = (p^0 - m)(p^0 + m)$. Alternatively you can choose an appropriate coordinate system.

**Exercise 2** Derive the spin sum formulae

$$\sum_{s=+,-} u^s(p)\bar{u}^s(p) = \not{p} + m \tag{1}$$

$$\sum_{r=+,-} v^r(p)\bar{v}^r(p) = \not{p} - m. \tag{2}$$