MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Physics

Physics 8.811 Fall Term 2003

PROBLEM SET 1

Due: September 23, 2003.

Problem 1:

Halzen and Martin, exercise 5.6

Problem 2:

a. Show that Maxwell's equations (Halzen and Martin equation 6.53) are equivalent to

$$\partial_\mu F^{\mu\nu} = J^\nu,$$

where $F^{\mu\nu}$ is written in terms of the 4-potential A^ν as $F^{\mu\nu} = \partial^\mu A^\nu - \partial^\nu A^\mu$.

b. Show that the continuity equation $\partial_\mu J^\mu = 0$ follows from the antisymmetry of the field strength tensor.

Problem 3:

Apply the Euler-Lagrange equations to

$$\mathcal{L} = i\bar{\psi}\gamma^\mu\partial_\mu\psi - m\bar{\psi}\psi - (q\bar{\psi}\gamma^\mu\psi)A_\mu$$

to find the Dirac equation with electromagnetic coupling. Here A_μ is a vector field with the property that it transforms under local gauge transformations as $A_\mu \rightarrow A_\mu + \partial_\mu\lambda$, where λ is some function of of the space-time coordinates x_μ.

Problem 4:

Determine the total amplitude for pair annihilation, $e^+ + e^- \rightarrow \gamma + \gamma$.

Problem 5:

Find the spin-averaged amplitude and differential cross-section for electron-muon scattering in the CM frame, in the regime for which $m_e, M_\mu \rightarrow 0$. (See Griffiths problem 7.35).