

PH4442 - Problem Sheet 4

(Answers should be returned on 28/02/2006)

1. (From the 2004 exams)

Consider the QED elastic scattering reaction $e^- \mu^- \rightarrow e^- \mu^-$. Neglecting masses, the cross section is given by

$$\frac{d\sigma}{d(\cos\theta)} = \frac{\pi\alpha^2}{s} \frac{1 + \cos^4(\theta/2)}{\sin^4(\theta/2)},$$

where α is the fine structure constant, s is the square of the centre-of-mass energy and θ is the angle of the scattered electron in the $e\mu$ centre-of-mass frame.

(a) Neglecting all masses in the above reaction, show that the change of the electron four-momentum, q^μ , satisfies

$$q^2 = q_\mu q^\mu = -\frac{1}{2}s(1 - \cos\theta).$$

Hence show that the cross section as a function of q^2 is

$$\frac{d\sigma}{d(q^2)} = \frac{2\pi\alpha^2}{q^4} \left[\frac{q^4}{s^2} + 2 \left(1 + \frac{q^2}{s} \right) \right].$$

(b) Deep inelastic scattering of electrons from protons can be described by the reaction $e^- p \rightarrow e^- X$, where X is a hadronic system with $m_X \gg m_p$. Within the quark model, this can be considered to arise from elastic electron-quark scattering. If the scattered quark initially had a fraction x of the proton momentum then, neglecting masses and transverse momentum components, show that the centre-of-mass energy of the electron-quark system, \hat{s} , is related to that of the electron-proton system, s , by

$$\hat{s} = xs.$$