1. Calculate the spin-averaged square of the amplitude $\langle |M|^2 \rangle$ for the lowest-order elastic e^+e^- (Bhabha) scattering; see Excercise 10.3. You can assume the ultrarelativistic limit, $m_e \to 0$.

2. Let us consider $e^+e^- \to q\bar{q}$ scattering. Show that you obtain the cross-section σ on page 146, starting from $\langle |M|^2 \rangle$ given there.

3. Consider inelastic electron-proton scattering, as presented in the lecture notes. Thus, k and k' are 4-momenta of the incoming and outgoing electron, and p is the 4-momentum of the incoming proton. $q = k - k'$ is the 4-momentum of the exchanged virtual photon. Let us assume that we are in the lab frame where the target proton is at rest, and θ is the scattering angle of the electron.

   a) Express the variables $Q^2 = -q^2$ and $x = Q^2/(2p \cdot q)$ (Bjorken x) in terms of θ and $E' = k'^0$.

   b) Show that $0 \le x \le 1$.

   c) Show that, for *elastic* scattering, $x = 1$.