P424 Assignment 6

Due Monday, Mar. 9

1) Calculate the scattering cross-section for the reaction $e^+e^- \to q\bar{q}$, where q is an individual quark species of charge e_q. Assume that the incoming particles are not polarized and that the spin projections of the outgoing quarks are not measured. Further assume that the energy of the incoming electrons in the centre-of-mass frame is much larger than the electron or quark masses.

(a) Draw the relevant Feynman diagram(s) for the lowest order process

(b) Use the Feynman rules to determine the matrix element

(c) Use Casimir's trick to calculate the spin-averaged square of the matrix element, $\langle |\mathcal{M}|^2 \rangle$. You can use the approximation $E_e \gg m_q$.

(d) Calculate the scattering cross-section under the conditions listed above. Give your result in the centre-of-mass frame. Don't forget that quarks come in three distinct colors.

(e) Assume the centre-of-mass energy is 30 GeV; what are the total cross-sections for scattering into each of the six quark types? How does the total cross section for scattering into quarks (all flavors) compare with the cross-section for $e^+e^- \to \mu^+\mu^-$ at this energy?