Phenomenology course: Problem Sheet 1

1. In the lecture I approximated the quark mass threshold by a step function. What actually happens at the threshold ?

2. Since $R(e^+e^-)$ is the only quantity for which we have NNNLO results, it is our only chance to calibrate how good different schemes for fixing μ are. Looking at the figure for the μ scale dependence, $K^{(n)}$ vs μ, discuss the relative merits of the three schemes defined there.

3. Convince yourself, without any algebra, that the thrust of a three-parton configuration is given by $\max(x_1, x_2, x_3)$, where $x_i = 2E_i/\sqrt{s}$, with E_i being the parton energy and $\sqrt{s}$ the collider energy.

4. Draw all the Feynman diagrams for the following three processes

$$1. \qquad e^+(1)e^-(2) \to q(3)\bar{q}(4)g(5)g(6)$$

$$2. \qquad e^+(1)e^-(2) \to q(3)\bar{q}(4)Q(5)\bar{Q}(6)\ [q \neq Q]$$

$$3. \qquad e^+(1)e^-(2) \to q(3)\bar{q}(4)Q(5)\bar{Q}(6)\ [q = Q]$$

   (Include only diagrams of order $\alpha^2\alpha_s^2$ and ignore Z propagators, only use photon ones.) Note down the relative signs among all diagrams in each case (beyond those that emerge from adopting the QED and QCD Feynman rules). Justify the relative signs in terms of Bose-Einstein and Fermi-Dirac statistics.