1. a) Explain the phenomena of running coupling constants in QED and how and why this differs from QCD. Include in your answer sketches of the variation of the coupling constants in both theories with $\left|q^2\right|$. {4}

b) Why are calculations in QED generally more accurate than in QCD? {2}

c) A possible form of the QCD potential between a quark and an anti-quark is

$$V_{QCD} = -\frac{4}{3}\frac{\alpha_s}{r} + Kr$$

where K is a constant and r is the separation distance. Sketch the force as a function of r. {2}

d) A quark-antiquark pair is produced in a collision at the centre of a modern high energy physics detector, such as those that were used at LEP. Sketch what will be observed in the experimental detector. {2}

e) Describe how quark confinement leads to this observed signature. {2}

f) Discuss why jets were difficult to observe in early low energy experiments, and why higher energies were required to observe them well. {2}

g) Explain how the direct observation of jets led to the first direct observation of the gluon. {2}