1. (a) A π^0 meson with energy 10 GeV is created at the centre of a modern particle physics collider experiment and decays into two photons.

(i) How far does the π^0 travel in the detector frame before it decays ? **{2}**

(ii) How can the π^0 be observed and identified in the detector ? **{2}**

(iii) One of the photons is measured with an energy of 4 GeV. Calculate the energy of the other photon and predict where it will be observed with respect to the first photon. **{4}**

The π^0 *mass is* 135 MeV/c^2 *and its average lifetime is* 0.8×10^{-16} s.

(b) The R-measurement in e^+e^- collisions is defined as:

$$R = \frac{\sigma\left(e^+e^- \rightarrow \text{hadrons}\right)}{\sigma\left(e^+e^- \rightarrow \mu^+\mu^-\right)}$$

(i) Sketch R as a function of centre of mass energy from 0 to 60 GeV, marking any significant features. **{2}**

(ii) For a centre of mass energy of 30 GeV, calculate the value of R predicted by the simple quark parton model. **{2}**

(iii) How is the value and shape of R altered in QCD when gluon radiation is taken into account? **{2}**

(iv) What centre of mass energy would be required to observe a change in R due to top quark production ? (*The top quark mass is* 172 GeV/c^2.) **{2}**