1) Quark model. Six observed hadrons have the quantum numbers $(Q, B, S, C, \widetilde{B})$ = (2, 1, 0, 1, 0), (0, 1, -2, 1, 0), (0, 0, 1, 0, -1), (0, 1, -1, 1, 0), (0, -1, 1, 0, 0) and (-1, 1, -3, 0, 0) respectively. Identify their quark constituents.

2) Time-of-flight. Two particles of masses m_1 and m_2, and common momentum p travel between two scintillation counters that are a distance L apart. Show that the difference in their flight times decreases like p^{-2} for large momenta. Calculate the minimum flight path necessary to distinguish pions from kaons if they have momentum 3 GeV/c and the time-of-flight can be measured with an accuracy of 200 ps.

3) In the Stanford Linear Collider electrons and positrons were accelerated to energies of 20 GeV in a beam pipe 3 km long but only a few centimeters in diameter. Steering an electron through such a narrowly defined path seems a difficult task. But how long is the accelerator in the rest frame of the electron? Assuming that increments of energy are uniform and that the injection energy is 10 MeV, find the effective length of the accelerator to an electron.

4) We calculated the energy threshold for the production of antiprotons for the case where the target proton was at rest. In reality however the target proton is bound inside a nucleus and has considerable momentum of the order of 200 MeV/c. Show that due to this effect (Fermi momentum) the threshold is lowered to

$$E'_{THR} \approx \left(1 - \frac{p}{m_p c}\right) E_{THR}$$

where E_{THR} is the threshold for case of a proton target at rest.