PH4442 - Problem Sheet 1
(Answers should be returned on 17/01/2006)

1. At the HERA collider of DESY, electrons of $E_e \approx 25\,\mathrm{GeV}$ collide head-on against protons of $E_p \approx 900\,\mathrm{GeV}$. What is the center-of-mass energy of the collisions? (The electron and proton masses are negligible at these energies.)

2. In the ABC theory, if
$$3m_B + 4m_C > m_A > 3m_B + 3m_C > m_B > 2m_C$$
list all the possible decay modes of A, draw an example Feynman diagram for each of them and order them in decreasing partial width. Explain your answer briefly.

3. In Natural Units, what are the dimensions of:

   - cross section?
   - the amplitude $\mathcal{M}$ in a two-body scattering process? (Hint: start from the previous answer)
   - the coupling constant g in the ABC theory? (Hint: start from the previous answer)

4. A pion traveling at speed $\beta (\equiv v/c)$ decays into a muon and a neutrino, $\pi^- \rightarrow \mu^- + \bar{\nu}_\mu$. If the neutrino emerges at $90°$ to the original pion direction at what angle does the muon come off?
   [*Answer:* $\tan\theta = (1 - m_\mu^2/m_\pi^2)/(2\beta\gamma^2)$]