***PHY466***

# H O M E W O R K  3

*Homework should be handed in to F10* ***by 4:00 p.m. on Friday, 17 November 2017****.*

1. Explain the detector arrangement and the roles of detector components in the CP-violation experiment of Christenson *et al*. Explain the procedure of data analysis and calibrations. [5]

2. Sketch the deep inelastic electron-nucleon scattering process showing main elements: the exchanged photon, the electron and the target nucleon. Explain how the measurements of the differential cross-section at various energies and angles of the electron in the final state can be used to measure the nucleon structure functions. [5]

3. Neglecting the masses of the electron and neutrinos, the energy spectrum of electrons emitted in muon decay, is given by:

   $\frac{d\Gamma}{dE} = \frac{2G_F^2(m_\mu c^2)^2E^2}{(2\pi)^3(\hbar c)^6}\left(1 - \frac{4E}{3m_\mu c^2}\right)$, where $\frac{G_F}{(\hbar c)^3} = 1.166\times10^{-5}$ GeV$^{-2}$.

   What is the most probable energy for the electron?

   The most probable energy is also the maximum energy of the electron. Integrate the energy spectrum to obtain a formula for the total decay width of the muon, $\Gamma$.
   Using Heisenberg uncertainty principle, $\Gamma\times\tau = \hbar$, calculate the muon lifetime in seconds. [5]

4. The reaction $e^+e^- \rightarrow \mu^+\mu^-$ is studied using colliding beams each of energy 7 GeV (total energy in the centre of mass 14 GeV). The reaction is predominantly electromagnetic at this energy. Draw its Feynman diagram. The differential cross-section of this reaction is given by:

   $\frac{d\sigma}{d\Omega} = \frac{\alpha^2\hbar^2c^2}{4E_{\mathrm{CM}}^2}(1 + \cos^2\theta)$,

   where $E_{\mathrm{CM}}$ is the total centre of mass energy and $\theta$ is the scattering angle with respect to the beam line. Calculate the total cross-section in barns at this energy.
   If a detector can only detect particles that make an angle of at least $30^0$ with respect to the beam line, what fraction of events will be recorded? [5]