



## DEPARTMENT OF SCIENCES, M. Sc. (Physics) III SEMESTER, END SEMESTER EXAMINATIONS November 2019 Subject: Theoretical Physics I (PHY-5005) (REVISED CREDIT SYSTEM - 2017)

Time: 3 Hours Date: November 2019 MAX. MARKS: 50

Note: (i) Answer all the questions. (ii) Answer the questions to the point.

1. (i) In a two-body scattering event,  $A + B \rightarrow C + D$ , it is convenient to introduce the Mandelstam variables

$$\begin{split} s &\equiv (p_A + p_B)^2/c^2 \\ t &\equiv (p_A - p_C)^2/c^2 \\ u &\equiv (p_A - p_D)^2/c^2 \\ \text{(a) Show that } s + t + u &= m_A^2 + m_B^2 + m_C^2 + m_D^2. \quad [2] \\ \text{(b) Find the CM energy of A, in terms of } s, t, u \text{ and the masses.} \quad [3] \\ \text{(ii) Using energy - momentum conservation show that a free electron/quark can not absorb a photon.} \quad [3] \\ \text{(iii) Examine the following processes, and state for each one whether it is possible or impossible, according to the Standard Model:} \quad [2] \\ \text{(a) } e^+ + e^- \to \mu^+ + \mu^- \\ \text{(b) } p + p \to p + p + p + \overline{p} \end{split}$$

2. (i) How can CP violation address the matter - antimatter ratio in the universe? [5]

(ii) Write the CPT theorem and its consequencs. [3]

(iii) Find the behavior of scalar and pseudoscalar particles under parity transformation? [2]

3. (i) Construct the isospin invariant pion nucleon interaction Lagrangin using SU(2) symmetry group. [5]

(ii) Obtain dimensional (conversion) formula of length in natural units. Using natural units express 1 GeV in length scale. [3]
(iii) Write the multiplets formed for

a) mesons by three flavor quark system.

b) baryons by two flavor quark system. [1+1]

4. (i) Estimate the mass of a proton. Consider spin - spin interactions of quarks as perturbation. Take  $m_u = m_d = 5MeV$  and spin - spin interaction constant  $C = 50(\frac{2m_u}{\hbar})^2 MeV/c^2$ . [5] (ii) Draw all the possible first order Feynman diagrams for the following processes ( do not forget to show the direction of time ): [3] (a)  $e^- + e^+ \rightarrow e^- + e^+$ (b)  $e^- + \mu^- \rightarrow e^- + \mu^-$ (iii) What are RHIC and LHC? Mention at least their one contribution/achievement. [2]

5. (i) Write qualitative introduction of quantum chromodynamics. [5]

(ii) How many types of weak interactions are there? Explain them with examples. [5]