Birla Institute of Technology and Science - Pilani, Pilani Campus

Semester I (Session 2023-24)

Mid-Semester Examination (Closed Book)

Particle Physics (PHY F413)

Date : 11/10/2023 Weightage : 25 %

Time: 90 Mints. Max. Marks: 25

Note: (1) All symbols used in QP have their usual meaning.

(2) Write your answers precise and clean.

Q1: (a) For an elastic scattering process; $A + A \rightarrow A + A$, show that the Mandelstam's variables are expressed as; $s = 4(k^2 + m^2)$, $t = -2k^2(1 - \cos\theta)$, $u = -2k^2(1 + \cos\theta)$, where k is the three CM momentum of the incident particle, m is the mass of the particle and θ is the angle of scattering in the CM frame. (b) Write the relativistic energy momentum relation for a particle of mass m and momentum $\vec{p}$ in NUs and use the same to determine the energy of the particle in MeV, if $p = 0.9c \times 10^{-10}$ kg m/sec and mass 9.0×10^{-10} kg. [3+2]

Q2: Assuming collision process to be $P + Q + R \rightarrow 1 + 2 + 3$; Write an expression for dN (no. of available states for particles having momentum in the range $\vec{p}$ to $\vec{p} + \vec{dp}$) using Dirac-delta function for momentum conservation. Also write relation between H_{fi} and Lorentz invariant matrix element M_{fi}. [5]

Q3: (a) Write Klein-Gordon equation for an electron moving under the action of an em. field expressed as A^μ and identify interaction term. (b) For scattering process $A + B \rightarrow C + D$, draw the simplest t-channel Feynman's diagram. Using QED Feynman's rules involving spin-less particles, write an expression for Lorentz invariant amplitude $-iM$. [5]

Q4: (a) For two body scattering process, show that the incoming flux, $F = 4E_a\,E_b(v_a + v_b)$ is Lorentz invariant. Here E_a and E_b are energy and v_a and v_b are velocity of incoming particles, respectively. (b) Assume an em. field A^μ created by a moving muon which produces a four current J^μ. Write an equation relating A^μ and J^μ. Use an appropriate identity to find A^μ in terms of J^μ. Use the above result to write an expression for T_{fi} for a $e^-\mu^- \rightarrow e^-\mu^-$ scattering process. [2+3]

Q5: For a two body scattering process, $A + B \rightarrow 1 + 2$, write an expression for the scattering cross-section using Fermi's golden rule in terms of 6-D three momentum integral. Then integrate it to obtain the final expression for the scattering cross-section in CM frame of reference. [5]

**** Best Wishes ****