PRABHAT KUMAR COLLEGE, CONTAI

M.Sc. 4th Semester Examinations 2021
(Under CBCS pattern)

Subject : Physics
PAPER/COURSE – PHS: 401

FULL MARKS : 40

TIME : 02 Hrs.

Candidates are required to give their answers in their own words as far as practicable.

The figures in the right-hand margin indicate full marks.

401.1: Particle Physics

Attempt any Two (02) of the following: ***2 X 10***

1. (a) What do you mean by "exchange and internal symmetries" of the particles?
   (b) Show that a scalar meson cannot decay into three pseudo scalar mesons.
   (c) Write down the hexagons of the baryon decuplet and also write it in terms of quarks with explanations.
   (d) What do you mean by "homomorphism and isomorphism"? [3+2+3+2]

2. (a) State which of the following processes are allowed and which are forbidden, giving reasons in terms of conservation laws and stating the dominant interaction in the case of allowed processes:
   (i) $e^- + p \rightarrow \nu_e + n$ (ii) $\pi^- + p \rightarrow \Sigma^+ + K^-$
   (b) Define Mandelstam variables in $2 \rightarrow 2$ process and show that $s + t + u = \sum_{t=a}^{d} m_i^2 = constant$.
   (c) Write Young diagrams of irreducible representation of S_4
   (d) Suppose we have a set of transformation $x' = f(x, a)$. Also assume that an identity transformation exists and that the transformations are associative. Write down the requirements to form a Lie group. [3+3+2+2]

3. (a) Calculate the generators of the SO(3) group.
   (b) Show that SU(2) has the same Lie algebra as SO(3)
   (c) Construct the Hamiltonian density of QED. [4+4+2]

PRABHAT KUMAR COLLEGE, CONTAI

4. (a) Find the basis functions of S_3.
(b) For Compton scattering process, find the Feynman amplitude and show that it is gauge invariant. Also show that for some choice of the gauge, the amplitude can be written as $M = ie^2\bar{u}(p_f, s_f)\Gamma u(p_i, s_i)$, where symbols have their usual meaning.

[4+(2+2+2)]

(Internal Assessment - 05)

401.2: Statistical Mechanics II

Attempt any Two (02) of the following: ***2 x 10 = 20***

1. Starting from the following relations for the free Fermi gas

$$\frac{P}{kT} = \frac{f_{5/2}(z)}{\lambda^3} \text{ and } \frac{N}{V} = \frac{f_{3/2}(z)}{\lambda^3}$$

Show that

(a) $S = \frac{U-A}{T} = Nk\{\frac{5}{2}\frac{f_{5/2}(z)}{f_{3/2}(z)} - \ln z\}$ and

(b) $P_0 \propto n^{5/3}$, where P_0 is the zero point pressure and n is the particle number density.

[5+5=10]

2. (a) For a one dimensional Ising system of N spins in a field h, determine the partition function in terms of eigenvalues of the matrix.

$$\begin{pmatrix} e^{\beta(J+h)} & e^{-\beta J} \\ e^{-\beta J} & e^{\beta(J-h)} \end{pmatrix}$$

(b) Show that only large eigenvalue will contribute to the free energy.

(c) Further show that at zero magnetic fields the magnetisation is zero for all temperatures.

[5+3+2]

3. (a) What is thermodynamic probability? How entropy and thermodynamic probability are related.
(b) For a black body radiation what is the mean value of ε_s.
(c) For particles with spin S, obtain the maximum number of particles per Landau level.
(d) In mean field theory of Ising model, magnetization is given by

PRABHAT KUMAR COLLEGE, CONTAI

$$m = \tanh(qJm + h)\beta$$

Where h is the applied field. Obtain the graphical solution of this self-consistent equation at T_c, below T_c and above T_c. [2+2+3+3]

4. Investigate the Pauli paramagnetism of an ideal gas of fermions with intrinsic magnetic moment μ^* and spin $J\hbar(J = ½, 3/2....)$ and derive expressions for the low temperature and high temperature susceptibilities of the gas. [10]

(All the symbols have their usual meaning)

Internal Assessment: 05

PRABHAT KUMAR COLLEGE, CONTAI