DMM-1624
M. Sc. (Sem. IV) Examination
April / May - 2016
Physics : PH (T) - 544
(Group Theory & Quantum Field Theory)

Time : 3 Hours] [Total Marks : 70

Instructions :
(1) Fill up strictly the details of signs on your answer book.
Name of the Examination :
M. Sc. (SEM. 4)
Name of the Subject :
PHYSICS : PH (T) - 544

(2) Attempt all questions.
(3) Symbols used have their usual meaning.
(4) Figures to the right indicate marks.
(5) Assume data whenever necessary.
(6) Scientific calculator may be used.

1 Attempt any two questions :

(1) (a) Show that the set of all non-zero complex numbers form a group under multiplication.
(b) Discuss permutation group with an example.

(2) (a) Evaluate $C_4^1 m_2 C_4$ for $m_2, C_4 \in C_{4v}$
(b) What are the elements of the symmetry group $C_{5v}$ of a regular pentagon? Determine the number of classes and number of irreducible representations of this group along with their dimensions.

(3) (a) Write all the elements of the group of symmetries of a square $C_{4v}$.
(b) Show that the matrices obtained by taking the direct product of the matrices of two representations also generate a representation of the group.

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2 Attempt any two questions:

(1) (a) What is meant by connectedness and compactness of a continuous group?  
       (b) Discuss the 3-dimensional rotation group SO(3).  

(2) (a) What is Lie algebra? What is its importance?  
       (b) Find the generators of the group of all orthogonal matrices of order 2 with determinant + 1.  

(3) (a) What is a Casimir operator? Find the Casimir operator(s) of group SO(3).  
       (b) Discuss the pseudo-rotation group O_{1,1}.  

3 Attempt any two questions:

(1) (a) Discuss the Klein-Gordon equation for a free particle and mention the difficulties with this equation.  
       (b) Write the free field Lagrangian density for the spin zero field and obtain the field equation corresponding to the Klein-Gordon equation.  

(2) (a) Define vacuum state of a free scalar field.  
       (b) Find the interaction energy between two nucleons interacting through their real scalar meson fields.  

(3) (a) Write the commutation rules for the free scalar field in terms of creation and annihilation operators.  
       (b) Discuss the Lagrangian formulation and quantization rules for a charged scalar field.  

4 Attempt any two questions:

(1) (a) Write the Feynman diagram with one loop correction in the case of electron-electron scattering with a static charge.  
       (b) Apply the Feynman rules for the above case and express the scattering amplitude.  

(2) (a) Establish the anti-commutation relations for the Dirac field.  
       (b) Discuss in detail the idea of renormalization.  

(3) (a) Discuss the rules for Feynman graphs in momentum space.  
       (b) Consider the electron – Photon interaction Hamiltonian in the covariant form and represent the various terms in the interaction diagrammatically.
5 Attempt any two questions:

(1) (a) Discuss the local Gauge transformation of a Dirac field.
(b) Discuss the Higg's mechanism with reference to spontaneous symmetry breaking.

(2) (a) Discuss the U(1) gauge symmetry for Abelian transformations. Explain how does the gauge invariance force the vector meson to be massless.
(b) Write the interaction Lagrangian and draw the Feynman diagrams for the process: (a) emission of a photon by an electron; (b) electron-positron annihilation.

(3) (a) What are gauge transformations? Explain the gauge principle and gauge fields.
(b) Discuss the spontaneous breaking of global symmetry in Goldstone model.