

(Set-1)

M.Sc.-4th (AP)
Quantum Field Theory

Full Marks : 70

Time : 3 hours

Q. No. 1 is compulsory and answer any five questions from the rest

The figures in the right-hand margin indicate marks

1. Answer all the questions : 2 × 10

- (a) What are the motivations for formulating Dirac equation?
- (b) Discuss the necessity of quantum field theory.
- (c) Define energy projection operators and discuss their properties.
- (d) Show that the current density

$$j_{\mu} = -\frac{i}{2}(\phi \partial_{\mu} \phi^{*} - \phi^{*} \partial_{\mu} \phi)$$

satisfies the continuity equation, $\partial^{\mu} j_{\mu} = 0$.

- (e) What do you mean by renormalization?
- (f) Show that $\gamma_{\mu} \gamma^{\nu} \gamma^{\mu} = -2\gamma^{\nu}$.
- (g) Write down the Feynman function for scalar field.
- (h) What do you mean by normal order product of operators and fields?
- (i) What is the charge of the particles associated with real and complex scalar field?

(j) State Wick's theorem.

2. (a) Derive the Klein-Gordon equation for a relativistic particle with zero spin. Discuss the probability density and continuity equation. 8
- (b) Discuss the drawbacks of Klein-Gordon equation. 2
3. (a) Solve the Dirac equation for a free particle in motion. 8
- (b) Discuss the properties of the Dirac matrices. 2

(Turn Over)

4. (a) What are bilinear covariants? Show how the vector and axial vector transform under proper orthochronous Lorentz transformation and space inversion. 7
- (b) Show that the particle described by the Dirac equation corresponds to a spin $\frac{1}{2}$ particle. 3
5. (a) Discuss what happens to the Lagrange equation and quantization conditions on going from a discrete to a continuous system. 3
- (b) State Noether's theorem. Find the conserved quantities arising out of rotational invariance. 7
6. (a) Quantize the complex Klein-Gordon field and find the momentum and charge of the field. 7
- (b) Discuss the time-ordered product of operators. 3
7. (a) Quantize the Dirac field and find the momentum, energy and charge of the field. 7
- (b) Discuss the photon propagator for real Dirac field. 3

8. Write short notes on any two : 5 + 5
- (i) Klein paradox
- (ii) Renormalization group equations
- (iii) Quantum electrodynamics.

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