LOYOLA COLLEGE (AUTONOMOUS), CHENNAI – 600 034

M.Sc. DEGREE EXAMINATION – **PHYSICS**

FOURTH SEMESTER – **APRIL 2016**

PH 4810 - QUANTUM MECHANICS - II

Date: 21-04-2016 Dept. No. Max. : 100 Marks

Time: 09:00-12:00

PART A

Answer **ALL** questions: **(10 x 2 = 20 marks)**

1 Explain the Fermi golden rule.

2 What is Dipole approximation?

3 Calculate the velocity of an elementary particle whose mass is 10 times its rest mass.

4 Obtain the relation between proper velocity and ordinary velocity.

5 If α and β are Dirac matrices, prove that $\alpha_x \alpha_y \alpha_z = \frac{1}{2}[\alpha_x \alpha_y \alpha_z \beta, \beta]$

6 What is a hole, with reference to a free Dirac particle?

7 Explain a particle exchange operator.

8 Show that the symmetry character of a wave function does not change with time.

9 Write a short note on Bhabha scattering.

10 Describe Bremsstrahlung and pair production.

PART B

Answer **ANY FOUR** questions **(4x7.5=30 marks)**

11 What are Einstein's coefficients? Outline the way in which absorption and emission of radiation is explained in quantum mechanics?

12 Explain invariant interval. Two events occurring at the same place in an inertial frame are separated by a time interval of 4s. What is the spatial separation between these two events in an inertial frame in which the events are separated by a time interval of 6s?

13 Explain how Klein - Gordon equation leads to positive and negative probability density values.

14 If $\psi_+(r)$ and $\psi_-(r)$ are the eigen functions of the parity operator belonging to even and odd eigen states, show that they are orthogonal.

15 The energy momentum tensor for fields is defined by $T_{\mu\gamma} = \sum_\alpha \pi_{\mu\alpha} \partial_\gamma \psi_\alpha - L\, \partial_{\mu\gamma}$, show that $\frac{\partial T_{\mu\gamma}}{\partial x_\mu} = 0$

16 A system in an unperturbed state n is suddenly subjected to a constant perturbation $H'(r)$ which exists during time 0 → t. Find the probability for transition from state n to state k and show it varies simple harmon ically with,

$$\text{Angular frequency} = \frac{E_k - E_n}{2^k} \quad \text{and} \quad \text{Amplitude} = 4\,\frac{|H'_{kn}|^2}{(E_k - E_n)^2}$$

PART –C

Answer any **FOUR** questions: **(4 x 12.5 = 50 marks)**

17 Discuss time-dependent perturbation theory with reference to sinusoidal perturbation and obtain expression for transition probability.

18 Explain the structure of space time. What is a 4-vector? Describe relativistic energy and momentum.

19 Solve the Dirac equation for a free particle and obtain its energy spectrum.

20 (a) Explain how symmetric and antisymmetric wave functions are constructed from unsymmetrized solution of the Schrodinger equation of a system of indistinguishable particles. (b) N non-interacting Bosons are in an infinite potential well defined by v(x) =0 for 0<x<a, v(x) = ∞ for x<0 and for x>a. Find the ground state energy of the system. What would be the ground state energy if the particles are fermions? **(5+7.5)**

21 Discuss the procedure for quantization of complex scalar field. From the discussion explain the annihilation, creation and particle number operators.

22 (a) Explain Compton's scattering and find an expression for the change in wavelength of the scattered X- ray beam. (b) Discuss the work-energy theorem in relativity.

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