LOYOLA COLLEGE (AUTONOMOUS), CHENNAI – 600 034

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

FOURTH SEMESTER – APRIL 2017

PH 4810- QUANTUM MECHANICS - II

Date: 18-04-2017 Dept. No. Max. : 100 Marks
09:00-12:00

PART A

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

1. Write a note on Rabi cycle.
2. Write the condition under which stimulated emission equals spontaneous emission.
3. Write down the expression for the kinetic energy of a relativistic particle and verify that it reduces to $\frac{1}{2}mv^2$ when the speed of the particle $v << c$, the speed of light
4. State work-energy theorem.
5. Write down the Dirac matrices in terms of the (2x2) Pauli spin matrices and unit matrix
6. Write a short note on Lamb Shift.
7. Show that the Eigen values of a particle exchange operator are ±1.
8. Distinguish between parahelium and orthohelium.
9. What do you understand by a field?
10. Write a short note on Mollar scattering.

PART B

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

11. 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 harmonically with,

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

12. (a) If a particle's kinetic energy is n times its rest energy, what is its velocity? (b) Two events occurring at the same place in an inertial frame are separated by a time interval of 6 secs. What is the spatial separation between these two events in an inertial frame in which the events are separated by time interval of 4 secs. (4+3.5)
13. For a Dirac particle moving in a central potential, show that the orbital angular momentum is not a constant of motion.
14. The base vectors of a representation are $\binom{1}{0}$ and $\binom{0}{1}$. Construct a transformation matrix U for transformation to another representation having the base vectors $\begin{pmatrix} \frac{1}{\sqrt{2}} \\ \frac{i}{\sqrt{2}} \end{pmatrix}$ and $\begin{pmatrix} \frac{1}{\sqrt{2}} \\ \frac{-i}{\sqrt{2}} \end{pmatrix}$. Also show that the matrix is unitary.
15. Describe in detail the quantization of a real scalar field.
16. Explain in detail the structure of Spacetime.

PART – C

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

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

18. **(a)** A pion at rest decays into a muon and a neutrino. Find the energy of the outgoing muon in terms of the two masses, m_π and m_μ (assume m_ν=0). Also find the velocity of the outgoing muon.

    (b) Two lumps of clay, each of rest mass (m), collide head-on at $\frac{3}{5}$ c if they stick together, what is the mass (M) of the composite lump? (8+4.5)

19. If $\vec{\alpha}$ and β are Dirac matrices prove that

    i. $\alpha_x = \frac{1}{2}[\alpha_x \alpha_y, \alpha_y]$

    ii. $\alpha_x \alpha_y \alpha_z = \frac{1}{2}[\alpha_x \alpha_y \alpha_z \beta, \beta]$

    iii. Trace $(\vec{\alpha}.B)(\vec{\alpha}.C) = 4$ B. C [3+3+6.5]

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) 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. [6+6.5]

21. What do you understand by Feynman's diagram? What are the rules followed in these diagrams?

22. Klein-Gordon equation is considered as a relativistic equation for a system of arbitrary number of particles and their antiparticles. Why?