MANIPAL
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Reg. No. | | | | | | | | | | |

DEPARTMENT OF SCIENCES, M. Sc. (Physics)
II SEMESTER, END SEMESTER EXAMINATIONS
JUNE 2018
Subject: Quantum Mechanics II (PHY-4206)
(REVISED CREDIT SYSTEM - 2017)

Time: 3 Hours **Date: June 2018** **MAX. MARKS: 50**

Note: (i) Answer all the questions.
(ii) Answer the questions to the point.

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1. (i) Prove that $J_+|\lambda, m >= C_+|\lambda, m+1 >$, where C_+ is a constant. [5]
(ii) Using the WKB method, calculate the transmission coefficient for the potential barrier

$$V(x) = \begin{cases} V_0\left(1 - \frac{|x|}{\lambda}\right), & |x| < \lambda \\ 0, & |x| > \lambda. \end{cases} \qquad [5]$$

2. (i) Use time dependent perturbation theory to obtain an expression for the transition in first order approximation. [5]
(ii) A quantum mechanical system is initially in the ground state $|0>$. At $t = 0$, a perturbation of the form $H'(t)$, $H_0 e^{-\alpha t}$, where α is a constant, is applied. Calculate the probability of finding the system in state $|1>$ after long time. [5]
3. (i) Estimate the energy levels of a particle moving in the potential

$$V(x) = \begin{cases} \infty, & x < 0; \\ Ax, & x > 0. \end{cases}$$

where A being a constant. [5]
(ii) Calculate the scattering amplitude for a particle moving in the potential

$$V(r) = V_0 \frac{c - r}{r} exp\left(-\frac{r}{r_0}\right)$$

where V_0 and r_0 are constants. [5]
4. (i) Obtain the expression of differential scattering cross-section in terms of beam luminosity. [4]

(ii) In scattering from a potential V(r); the wave function $\psi(r)$ is written as an incident plane wave plus an outgoing scattered wave: $\psi = exp(ikz) + f(r)$. Derive a differential equation for $f(r)$ in the first Born approximation. [6]

5. (i) Why do we need a separate quantum theory for relativistic systems? How the negative energy anomaly was resolved? [5]
(ii) Show that the Dirac matrices are traceless and can be of even order only. [5]

Useful formulae:

$$\nabla^2 t = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial t}{\partial r}\right) + \frac{1}{r^2 sin\theta}\frac{\partial}{\partial\theta}\left(sin\theta\frac{\partial t}{\partial\theta}\right) + \frac{1}{r^2 sin^2\theta}\frac{\partial^2 t}{\partial\phi^2}$$

$$\int_0^\infty exp(-a^2x^2)cos(bx)\,dx = \frac{\sqrt{\pi}}{2a}exp\left(-\frac{b^2}{4a^2}\right)$$

$$\int_0^\infty x^n exp(-ax)\,dx = \frac{n!}{a^{n+1}}, \quad \textbf{where} \quad n \geq 0, \quad a > 0$$