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T.Y.B.Sc. (NCF-NEP) (Sem. - V) Examination October - 2025

Physics (Mathematical Methods And Quantum Theory)

(Paper -PH-MJ3-503)

Time: 2 Hours] **[Total Marks: 25**

સૂચના : / Instructions

(1) ઉપરોક્ત દર્શાવેલ વિગતો ઉત્તરવહી પર અવશ્ય લખવી.
Fill up strictly the above details on your answer book
(2) Draw neat diagrams wherever necessary.
(3) Symbols used in the paper have their usual meaning.
(4) Figures to the right indicate full marks of the question
(5) Scientific non-programmable calculator may be used.

Seat No.:

Student's Signature

Q. 1. Answer any five of the following questions in short: (05)

i. What is the order and degree of the differential equation given by

$$\left(\frac{d^2y}{dx^2}\right)^4 + \left(\frac{dy}{dx}\right) = 3$$

ii. State the usefulness of the concept of singularity in differential equations.

iii. What are differential equations? How are they useful?

iv. What is a wave function (ψ)?

v. What is the angular momentum of an electron in a hydrogen atom in d state?

vi. What is Zeeman effect? What is its significance?

Q. 2. (A) Attempt any one of the following questions: (07)

(i) What are partial differential equations? Give examples of few commonly encountered partial differential equations in physics and discuss the significance of any five of them.

(ii) Discuss the method of separation of variables for solving a partial differential equation in the spherical polar coordinate system.

(B) Attempt any one of the following. (03)

(i) Show that the time dependent one dimensional Schrodinger's equation $i\hbar\frac{\partial\Psi}{\partial t} = -\frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial x^2} + V(x,t)\Psi$ is a parabolic differential equation.

(ii) Prove that y = $A\ Sin\ (\omega t - kx)$ is a solution of $\frac{d^2y}{dx^2} = \left(\frac{k^2}{\omega^2}\right)\frac{d^2y}{dt^2}$.

Q. 3. (A) Attempt any one of the following questions: (07)

(i) Derive the Schrodinger's equation for a hydrogen atom in the spherical polar coordinates and discuss it.

(ii) Explain the phenomenon of space quantization and discuss how the magnetic quantum number **(m_l)** dictates the orientation of a hydrogen atom in the presence of an external magnetic field.

(B) Attempt any one of the following. **(03)**

(i) If the azimuthal wave function for a hydrogen atom is $\Phi(\varphi) = A.e^{i.m_l\varphi}$ then show that the value of the normalization constant A is $\frac{1}{\sqrt{2\pi}}$ in the range 0 to 2π.

(ii) If the azimuthal wave function for an electron in the hydrogen atom is $\Phi_{ml}(\phi) = \frac{1}{\sqrt{2\pi}}$ exp $(im_l\,\phi)$ then verify the orthogonality for this wave function by proving the $\int_0^{2\pi} \Phi^*_{m_l}\Phi_{m'_l}d\phi = 0$ for $m_l \neq m_{l'}$..