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Reg. No. : .....

Name : .....

Ph.D. ENTRANCE EXAMINATION, NOVEMBER 2022

FACULTY OF SCIENCE

PHYSICS

Time : 3 Hours Max. Marks : 100

Instructions **:**

1) *Answer **any ten** questions each from* Section ***A*** *and* ***B.***
2) *Each question carries **5** marks.*
3) *No additional Answer sheets will be provided.*
4) *Candidates should clearly indicate the section, Question number in the answer booklet.*

Section – A

Research Methodology

I. Answer any **ten** questions. All questions carry equal marks.

1. Explain the concept of hypothesis and its importance in research.
2. Give brief account of the steps in the scientific method.
3. Explain any two ethical problems encountered in physics research.
4. Discuss the discovery of Newton's law of gravitation as an example of the scientific method.
5. What are systematic and random errors? How is systematic error reduced in measurement?
6. Write a note the statistical testing of hypothesis.

7. Consider an experiment to determine the dispersive power of the material of a prism, in which a spectrometer is used. Derive expressions for the relative (proportional) error in refractive index and dispersive power.

8. Write short notes on :

   (a) intellectual property, and

   (b) patent.

9. What is sampling? What are the important steps in sampling?

10. What is standard deviation ? How it is used in measurement? Give an example.

11. What is meant by regression analysis? How it is used in research?

12. (a) Explain how Boyle's law verified from pressure-volume data measured at constant temperature?

    (b) Explain how the resistance of a galvanometer determined?

13. What are primary and secondary sources? How are they used in formulating a research problem?

14. How is original signal recovered from noisy signal?

15. What is lock-in detection?

(10 × 5 = 50 Marks)

Section – B

Physics

II. Answer any **ten** questions. All questions carry equal marks.

1. Show that a particle of mass *m* projected along X axis from origin with initial velocity V_0, in a medium which offers resistance proportional to velocity, I.e., $F = -kmv$, covers a distance x in time t, where :

$$x(t) = \frac{v_0}{k}\left(1 - e^{kt}\right)$$

2. Determine the symplectic matrix J for a system of *n* degrees of freedom, where the Hamilton's equation is written as $\dot{\eta} = J\xi$, when $\eta = (q_1,...,q_n, p_1,..p_n)^T$, and $\xi_i = \frac{\partial H}{\partial \eta_i}$ are elements of column vector. Show that J is orthogonal.

3. Explain the formal procedure of constructing the Hamiltonian of a problem. Illustrate this procedure using the example of a one dimensional Harmonic oscillator.

4. What are the assumptions of free electron model? Derive Drude's formula : $\sigma = \frac{n e^2 \tau}{m}$.

5. Consider a plane *hkl* in a crystal lattice.

   (a) Prove that the reciprocal lattice vector $G = h b_1 + k b_2 + l b_3$ is perpendicular to this plane.

   (b) Prove that the distance between two adjacent parallel planes of the lattice is $2\pi / |G|$.

6. Consider a system consisting of two particles, each of which can be in any one of three quantum states 0, ε or 3ε. The system is in contact with a heat reservoir at temperature $T = (k_B \beta)^{-1}$

   (a) What is the partition function if the particles obey BE statistics?

   (b) What is the partition function if the particles obey FD statistics?

7. Verify that $u = x^2 - y^2 - y$ is harmonic in the whole complex plane and find a conjugate harmonic function v of *u*.

8. (a) Derive Newton - Raphson iteration formula.

   (b) Show that when Newton's method is used to compute $\sqrt{R}$, the sequence of iterates is defined by $x_{n+1} = \frac{1}{2}\left(x_n + \frac{R}{x_n} \right)$.

9. As a model of light nuclei, consider a spherical charge distribution given by $\rho(r) = \rho_0 \left(1 - \frac{r^2}{a^2} \right), (r \le a)$.

   (a) Find the total charge, assuming charge density is zero for $(r > a)$

   (b) Determine the electric field and potential inside and outside of the sphere.

   (c) Determine the radius at which field is maximum.

10. Explain the working of a 5-bit shift register.

11. The electric field in a plane monochromatic wave moving in free space is given by $E=(2k-3j)\times10^{-3}\sin\left(10^{7}\,(x+2y+3z-\beta t)\right)$

    (a) What is the direction of propagation?

    (b) Show that the wave is transverse.

    (c) Determine B.

12. Find $\psi(x,t)$ for a particle in a one-dimensional box with walls at $(0,a)$, for which the initial state is given by :

$$\psi\,(x,0)=\sqrt{\frac{2}{a}}\,\frac{\sin\,(2\pi x/a)+2\,\sin(\pi x/a)}{\sqrt{5}}.$$

13. How is spontaneous emission explained?

14. (a) Why can't a positively charged quark and an electron form an 'atom'?

    (b) How shell model explain magic numbers?

15. (a) Express Lorentz transformation in matrix form.

    (b) State Frank Condon principle.

(10 × 5 = 50 Marks)

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