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St Aloysius College (Autonomous)
Mangaluru
Semester II – P.G. Examination – M.Sc. Physics
May/June – 2023

MATHEMATICAL PHYSICS - II

Time: 3 Hours

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Max. Marks: 70

PART - A

Answer all questions choosing one from each unit. (15×4=60)

UNIT - I

1. a) State and prove Cauchy-Riemann conditions. Explain their significance and their role as harmonic functions. (9)
- b) Evaluate $\int_0^\pi \frac{d\theta}{2+\cos\theta}$. (6)

OR

2. a) For $f(z) = \frac{\sin z}{z}$, obtain the singularity and classify it. (4)
- b) Find the residues for $f(z) = \frac{z}{(2z+1)(5-z)}$. (5)
- c) For a complex function $f(z) = \frac{e^z}{z^2+a^2}$, where are the singularities? Hence, find its residues. (6)

UNIT - II

3. a) Define a group and mention a few examples. How is it different from a class? (5)
- b) Show that the 2D rotation matrix forms a group under multiplication. Verify if it is abelian and mention its properties. (10)

OR

4. a) Briefly outline the method of solving differential equations using Green's function. (8)
- b) What is "isomorphism"? Mention a few properties of an isomorphic group and how is it different from a homomorphism? (7)

UNIT - III

5. a) Given a Gaussian distribution $f(x) = N \exp(-ax^2)$, 'N' & 'a' being constants, obtain the Fourier transform and hence, plot the function obtained graphically. (10)
- b) Find $L(t^n)$, where 'n' is an integer ≥ 0 . (5)

OR

6. a) Starting from the Fourier sine and cosine series, obtain the Fourier transform. Mention briefly the physical application of this methodology. (8)
- b) In the context of Laplace transform, what is convolution theorem? Explain. (7)

Contd...2

UNIT -IV

7. a) Evaluate $\int_0^1 \frac{dx}{1+x}$ upto 3 decimal places using trapezoidal rule and Simpson's one-third rule, taking $h=0.25$. Comparing the respective answers, comment on the accuracy of the methods used. (8)
- b) Outline the method of solving linear simultaneous equations using iterative method. (7)

OR

8. a) Given $I = \int_0^2 (x^2 - 3x + 4)dx$, use trapezoidal rule with $h=0.5$ to evaluate. Further, evaluate the integral exactly and estimate the error in the first method. (6)
- b) Solve the equation $\frac{dy}{dx} = x + y$ for $x = 0$ to 0.4 in the interval $h = 0.1$ using Runge-Kutta fourth order method. (Initial conditions: $x_0 = 0$, $y_0 = 1$) (9)

PART - B

Answer any TWO questions:

(2x5=10)

9. a) Write a note on Laurent series expansion of a complex function.
- b) What are reducible and irreducible representations? What is their significance?
- c) Define Lie group and Lie algebra. In this context, what are $SU(n)$ groups? Give physical meaning for these concepts.
- d) Write a note on interpolation and its utility.

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QUANTUM MECHANICS - I

Time: 3 hrs.

Max Marks: 70

PART - A

Answer all questions choosing ONE from each unit. (4x15=60)

UNIT- I

1. a) Derive the continuity equation from the Schrodinger equation. (9)
- b) Set up the time dependent Schrodinger equation for a particle in a force field. (6)

OR

2. a) Prove that

$$\frac{d\langle \hat{p} \rangle}{dt} = - \langle \vec{\nabla} \cdot \hat{V} \rangle . \quad (9)$$

- b) Discuss the following: i) box normalization (6)
- ii) expectation value
- iii) probability interpretation of wave function.

UNIT- II

3. a) Define unitary operators. Prove that the eigenvalues of a Hermitian operator are real and the eigenvectors that has no degenerate eigenvalues are mutually orthogonal. (10)
- b) Discuss the basic postulates of quantum mechanics. (5)

OR

4. a) Prove that $\delta(ax) = \frac{1}{|a|} \delta(x)$. (5)
- b) Prove that momentum operator is Hermitian. (5)
- c) Simplify the commutator $[\hat{A}, [\hat{B}, \hat{C}]\hat{D}]$. (5)

UNIT- III

5. a) Obtain the normalized eigenvalues and eigenfunctions for a particle in a one dimension potential well. Plot the probability densities for n=1,2 and 3. (10)
- b) Reduce the time dependent Schrodinger equation to time independent form. (5)

Contd...2

OR

6. a) Solve the Schrodinger equation for the quantum harmonic oscillator and obtain expressions for eigenvalues and eigen functions. (10)
- b) Let the state Ψ of a quantum system at $t=0$ be given as a linear combination of two stationary states ϕ_1 and ϕ_2 as: (5)

$$\Psi(x, 0) = c_1 \phi_1(x) + c_2 \phi_2(x)$$

What is the wave function and probability density at a later instant of time t ? Is this state $\Psi(x, t)$ stationary?

UNIT- IV

7. a) Reduce the time independent Schrodinger equation for a central potential into radial and angular parts. (10)
- b) Evaluate the following commutation relations:
 $[\hat{L}_x, \hat{L}_y]; [\hat{L}^2, \hat{L}_x]$ (5)

OR

- 8.a) Find the wave function and the allowed energies for a three dimensional square well. (10)
- b) Derive the relation between scattering amplitude and differential scattering cross -section. (5)

PART - B

Answer any **TWO** of the following questions: (2x5=10)

- 9.a) Explain Heisenberg uncertainty principle. Estimate the uncertainty in the position of a neutron moving at $6 \times 10^6 \text{ ms}^{-1}$.
- b) Give the physical interpretation of i) eigenvalues and eigenvectors of operators
ii) expansion coefficients of a wave function.
- c) Explain quantum mechanical tunneling.
- d) Explain Born approximation.

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CONDENSED MATTER PHYSICS - I

Time: 3 hrs.

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PART - A

Max Marks: 70

Answer all questions choosing ONE from each unit.

(4x15=60)

UNIT- I

1. a) What are Bravais lattices? How many distinct types of Bravais lattices can be possible in three- dimensions? Explain. **(8)**
- b) Describe the diffraction of X-rays by a simple space-lattice according to von Laue theory. Explain the concept of zero, first and second order diffractions. **(7)**

OR

2. a) Explain with a neat diagram, powder method of X-ray diffraction and how the lattice constant is calculated using that photograph. **(8)**
- b) Define reciprocal lattice. Arrive at the general reciprocal lattice vector and its relation to direct lattice. **(7)**

UNIT- II

3. a) Obtain the expression for the cohesive energy between the atoms in solid and hence arrive at an expression for equilibrium separation in term of powers of repulsive and attractive terms: **(8)**
- b) Describe the dispersion relation of monatomic lattice with its nearest neighbour's interaction. **(7)**

OR

4. a) Distinguish between ionic and covalent bonds. Explain molecular bond. What is the nature of bonds in NaCl and diamond? **(8)**
- b) What are Normal and Umklapp processes? Discuss briefly the importance of Umklapp process in explaining the thermal conductivity in non-metallic solids. **(7)**

UNIT- III

5. a) What are density of states in metal? Derive an expression for the density of energy states in metals. **(8)**
- b) State and prove Bloch theorem. **(7)**

OR

6. a) What is Hall effect? Discuss the theory of Hall effect in metals and mention its significance. **(8)**
- b) What is effective mass? Explain based on Kronig-Penny model. **(4)**
- c) The Fermi velocity of the electron in Cs metal is $0.73 \times 10^6 \text{m/s}$. Calculate its Fermi energy in eV. **(3)**

Contd...2

UNIT - IV

- 7.a) Explain intrinsic and extrinsic semiconductors. Discuss the electrical conductivity of intrinsic and extrinsic semiconductors. (8)
- b) Discuss the occurrence of resistivity plateaus in the integral quantum Hall effect. Explain filling factors. (7)

OR

- 8.a) Discuss with necessary theory cyclotron resonance in silicon and germanium semiconductors. (8)
- b) Write a note on (i) direct and indirect band semiconductors. (7)
(ii) degenerate semiconductors.

PART - B

Answer any TWO questions.

(2x5=10)

9. a) Draw the following planes in a cubic unit cell
(010), (110), (222), ($\bar{1}$ 00), and ($\bar{1}$ 11).
- b) In a MX molecule, suppose M atom has an ionization potential energy 5eV and X-atom has an electron affinity of 4eV. What is the energy required to transfer an electron from M to X when they are at a distance of 0.5nm.
- c) Discuss briefly inadequacies of free electron theory.
- d) With the help of Bohr's theory of hydrogen atom, derive an expression for ionization energy of electron of donor impurities.

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RESEARCH METHODOLOGY AND ETHICS

Time: 3 hrs. **ST.ALOYSIUS COLLEGE**

Max Marks: 70

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PART - A

Answer all questions choosing ONE from each unit.

(3x18=54)

UNIT- I

1. a) What is pragmatism? Explain briefly the relevance and assumptions of pragmatism. (8)
- b) Explain the process of identifying the right journals for publication of your manuscript using various criteria/tools of selection. (5)
- c) Explain the different types of research strategies. (5)

OR

2. a) Discuss in detail the scientific misconducts- falsification, fabrication, and plagiarism (8)
- b) What is predatory publishing? Explain in brief. (5)
- c) Discuss the rights and obligations of research participants. (5)

UNIT- II

3. a) What is a research problem? Explain the methods involved in selecting a problem. (8)
- b) Write a note on data acquisition and data sampling. (5)
- c) Explain the various bibliographic styles used in research report. (5)

OR

4. a) What is a literature review? What is its purpose? Explain the methodology of doing it. (8)
- b) How do you identify the research gaps? Discuss briefly. (5)
- c) What is research design? Explain the 2 major types of research design. (5)

UNIT- III

5. a) What do you mean by IPR? Explain the various forms of IPR. (8)
- b) Write a note on impact factor of a journal. (5)
- c) What is plagiarism? How to avoid plagiarism? (5)

OR

6. a) What are the features of scholarly research article? Explain the various features? (8)
- b) Explain the importance of trademarks with suitable examples. (5)
- c) Discuss briefly the IPR issues in physical and biological sciences. (5)

Contd...2

PART - B

Answer any FOUR questions.

(4x4=16)

7. a) Explain the process of error analysis.
- b) What are the Potential Consequences of Ignoring Ethical Principles and Regulations?
- c) Discuss briefly the process of filing and registering for IPR.
- d) What are the steps involved in writing a good research report?
- e) Write a note on g-index and i10 index.
- f) Write a note on IPR issues in social sciences.
