PH 571.2

Reg. No.

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

July - 2022

MATHEMATICAL PHYSICS - II

Time: 3 Hours

Max. Marks: 70

PART - A

Answer all questions choosing one from each unit.   (15x4=60)

UNIT -I

1. a) $(\ln z)$ is a complex function. Express it as a sum of real and imaginary parts.   (5)

   b) What are singularities? Classify them with examples.   (5)

   c) Evaluate $\int_0^\infty \frac{\sin x \, dx}{x}$.   (5)

OR

2. a) For an analytic function $f(z) = u + iv$, given a vector $\vec{F} = v\hat{i} + u\hat{j}$, show that $\vec{\nabla} \cdot \vec{F} = 0 \, \& \, \vec{\nabla} \times \vec{F} = 0$ are equivalent to CR conditions.   (6)

   b) State and prove Cauchy's integral formula and hence evaluate $I = \oint_c \frac{dz}{z^2 + z}$, where 'C' defines a circle $|z| > 1$.   (9)

UNIT -II

3. a) What is homomorphism? Mention few properties of a homomorphic group.   (4)

   b) Given a set $S = \{1, w, w^2\}$, 'w' being cube root of unity, show that 'S' forms a (finite) abelian group under multiplication.   (5)

   c) From a mathematical perspective, define "rotation", derive the form & hence, mention the properties of a rotation matrix.   (6)

OR

4. a) Solve the Poisson equation in electrostatics using Green's function method.   (9)

   b) What is Orthogonality theorem? What does it signify?   (6)

UNIT -III

5. a) What is an integral transform? List a few well known forms along with their respective kernels.   (6)

   b) Solve the following differential equation using Laplace's Transform $\frac{d^2y}{dx^2} + 2\frac{dy}{dx} + 5y = e^{-x} \sin x$, where $y(0) = 0$ and $y'(0) = 1$.   (9)

OR

6. a) Prove the modulation theorem for a Fourier transform. Where is this property useful in practical application?   (8)

   b) If the Laplace transform of $F(t)$ is $f(r)$, then show that the Laplace transform of $F(a, t) = \frac{1}{a} f(\frac{s}{a})$, where 'a' is a constant. What does this property signify?   (7)

7. a) What is interpolation? Establish the interpolation formula for equal intervals. (8)

 b) For a function bounded in an interval $x = a$ to $x = b$, use trapezoidal rule and obtain the formula to evaluate $\int_a^b f \, dx$ (7)

OR

8. a) Solve $\frac{dy}{dx} = x + y$ using Runge-Kutta method of fourth order for $x = 0$ to 0.4 in an interval $h = 0.1$, given the initial conditions: $(x_0 = 0, y_0 = 1)$ (8)

 b) Given a system of linear equations, outline the procedure to solve them using Gaussian elimination. (7)

PART - B

Answer any TWO questions:　　　　　(2x5=10)

9. a) What is Dirac delta function? How is it different from Kronecker delta? Mention a few properties.

 b) Define "Representation" of a group. What is their importance and application in physics?

 c) What kind of differential equations can be solved by Green's function method? What are its advantages?

 d) What are Cauchy Riemann conditions? Why are they important?

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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) Starting from the Schrodinger wave equation, obtain the continuity **(9)** equation.

   b) Consider the wave function:

   $\Psi(x) = Ae^{-\lambda(x-a)^2}$, Where A, λ and a are positive real constants.

   Find i) the normalization constant A

        ii) the probability current density.   **(6)**

OR

2. a) Prove that the time rate of change of the expectation value of the **(9)** momentum operator is the negative gradient of the potential.

   b) Consider the wave function: **(6)**

   $$\Psi(x,t) = A exp\left[-a\left(\frac{mx^2}{\hbar} + it\right)\right]$$

   Where A, m and a are positive real constants. Find the expectation values of $\hat{x}$ and $\hat{p}$.

UNIT- II

3. a) Define i)adjoint of an operator ii)Hermitian operators. Show that the expectation value of a Hermitian operator is real and that of an anti- **(8)** Hermitian operator is imaginary.

   b) Prove the following properties of the delta function: **(7)**

   i) $\delta(ax) = \frac{1}{|a|}\delta(x)$

   ii) $[\delta(x-a)(x-b)] = \frac{1}{|a-b|}[\delta(x-a) + \delta(x-b)]$

OR

4. a) Explain the physical meaning of eigenvalues and expansion coefficients **(5)** of a wave function.

   b) Prove that momentum operator is Hermitian.   **(5)**

   c) Evaluate the commutator of position and momentum operators.   **(5)**

UNIT- III

5. a) Derive the reflection and transmission coefficients for a particle incident (10) on a rectangular potential barrier with the particle energy less than the barrier height.

b) Explain quantum mechanical tunneling. (5)

OR

6. a) Solve the Schrodinger equation for a quantum harmonic oscillator and (10) obtain expression for eigenvalues and eigenfunctions.

b) Reduce the time- dependent Schrodinger equation to the time – (5) independent form.

UNIT- IV

7. a) Slove the Schrodinger equation for a rigid rotor and obtain the (10) eigenvalues of eigenfunctions.

b) Construct the $R_{20}(r)$ state of Hydrogen atom using the recursion formula

$$C_{j+1} = \frac{2(j+l+1-n)}{(j+1)(j+2l+2)} C_j$$

(5)

OR

8. a) Determine the eigenvalues of $\hat{L}^2$ and $\hat{L}_z$ operators. (10)

b) Derive the relation between scattering amplitude and differential (5) scattering cross –section.

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 proton moving at $8 \times 10^6 \, ms^{-1}$

b) Prove the following identities involving commutators:

[A,BC]= [A,B]C+B[A,C]

[AB,C]= A[B,C]+[A,C]B

c) What are stationary states? Discuss their properties.

d) Explain Born Approximation.

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PH 573.2

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July - 2022

CONDENSED MATTER PHYSICS - I

Time: 3 Hours

Max. Marks: 70

PART - A

Answer all questions choosing one from each unit.   (15x4=60)

UNIT -I

1. a) What are the properties of reciprocal lattice? Construct Ewald's sphere and obtain the vector form of Bragg's equation. **(8)**

   b) Explain Von Laue treatment for X-ray diffraction in space lattice. Deduce Bragg's condition from Laue equations. **(7)**

OR

2. a) Explain in detail the importance of crystallographic point groups and space groups. **(8)**

   b) Derive the general expression for the atomic scattering factor. **(7)**

UNIT -II

3. a) Describe inelastic scattering of photons by phonons. Obtain an expression for frequency of phonons generated when a photon is scattered inelastically at an angle θ. **(8)**

   b) Derive an expression for the dispersion relation of a linear monoatomic lattice. **(7)**

OR

4. a) Explain the mechanism of bonding in

   i) ionic   ii) covalent   and   iii) molecular crystals **(8)**

   b) Define lattice thermal conductivity and obtain expression for the same. **(7)**

UNIT -III

5. a) Describe Kronig-Penney model of electrons moving in a periodic potential. Explain how does it lead to the formation of forbidden energy gap? **(8)**

   b) Obtain an expression for density of states in a metal. **(7)**

OR

6. a) Obtain an expression for magneto resistance and show that it is proportional to the square of the magnetic field. **(8)**

   b) Discuss the theory of Hall effect in metals and mention its significance. **(7)**

UNIT -IV

7. a) Show that the product of electron and hole concentrations in a semiconductor is constant at a given temperature. How is the energy gap determined from the measurement of electrical conductivity of a semiconductor?   (8)

   b) Explain the concept of effective mass of electrons and holes.   (7)

OR

8. a) What are intrinsic and extrinsic semiconductors? Give a qualitative description on the location of Fermi level in intrinsic and extrinsic semiconductors.   (7)

   b) Arrive at an expression for the temperature dependent electrical conductivity in intrinsic semiconductor.   (8)

PART - B

Answer any TWO questions: (2x5=10)

9. a) Find the Miller indices of a plane that makes an intercept of $3 A°$, $4 A°$ and $5 A°$ on the coordinate axes of an orthorhombic crystal with a:b:c=1:2:5.

   b) Show that the Made lung constant for an infinite linear chain of alternating positive and negative ions at an equilibrium separation is 2ln2. Given

   $$ln(1 + x) = x - \frac{x^2}{2} + \frac{x^3}{3} - \frac{x^4}{4} + \cdots$$

   c) Determine the temperature at which the probability that an energy state with energy 0.1 ev above the Fermi level will be occupied by an electron is 5%.

   d) The intrinsic carrier density at room temperature in germanium is $2.37 \times 10^{19}/m^3$. If the electron and hole mobilities are 0.38 m^2/V/s and 0.18 m^2/V/s respectively then calculate the resistivity of the intrinsic germanium.

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PS 574.2

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RESEARCH METHODOLOGY AND ETHICS

Max Marks: 70

Time: 3 hrs.

PART - A

Answer all questions choosing ONE from each unit.   (3x18=54)

UNIT- I

1. a) Explain the need and importance of research.   **(5)**

   b) What are the objectives of research? Explain its role in nation building.   **(8)**

   c) Write a note on the concept of theory building- deduction, induction and abduction.   **(5)**

OR

2. a) What are publication ethics? Briefly discuss the conflicts of interest.   **(7)**

   b) Explain the process of identifying the right journals for publication of your manuscript using various criteria/tools of selection.   **(7)**

   c) Write a brief note on various types authorship and contributor ship with examples.   **(4)**

UNIT- II

3. a) Explain the various criteria to be considered while doing literature review.   **(5)**

   b) Describe the various statistical analysis techniques in scientific research.   **(8)**

   c) Write briefly about various elements of a good research report.   **(5)**

OR

4. a) Write a note on data acquisition and data sampling fundamentals with relevant examples.   **(8)**

   b) Explain the process of error analysis.   **(5)**

   c) Mention a few characterization tools used in materials research and explain its relevance.   **(5)**

UNIT- III

5. a) What are the different types of Intellectual properties? Explain each of them briefly.   **(8)**

   b) Discuss briefly the process of filing and registering for IPR.   **(5)**

   c) Explain the importance of trademarks with suitable examples.   **(5)**

OR

6.a) What are the features of scholarly research article? How do you   (5)
       identify them?

   b) Explain the steps involved in patenting.   (8)

   c) Write a brief note on various research metrics, which will help us to   (5)
       identify the quality of the publication.

PART - B

Answer any FOUR questions.   (4x4=16)

7.a) Write a note on predatory journals.

   b) Describe any two standard referencing styles with one suitable example each.

   c) Discuss the process of scientific writing.

   d) Explain the importance industrial design and geographical indicators.

   e) What is standard deviation? Explain its importance in research.

   f) Describe briefly, the various research strategies.

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