PS1FPHC550 Reg. No: | | | | | | | | |

St Aloysius (Deemed to be University)

Mangaluru

Semester II – P.G. Examination – M.Sc. Physics

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April - 2025

MATHEMATICAL PHYSICS II

Time: 2 ½ Hours **Max. Marks: 60**

PART - A

Answer any FOUR questions (Each question carries 10 marks) **(4x10=40)**

1. Derive the Cauchy integral formula. Also derive Cauchy integral formula for first and higher order derivatives.
2. Show that group of rotations of coordinate axes has a matrix representation that forms a group under matrix multiplication.
3. Find the Fourier sine intergral represenation of $f(x) = \begin{cases} a-x & if 0 < x < a \\ 0 & if x > a \end{cases}$
4. Evaluate $\int_0^{\frac{\pi}{2}} \sin\theta d\theta$ using Simpson's rule $\frac{1}{3}$rd with $h = \frac{\pi}{12}$.
5. Solve by Gauss Seidel method.

$$6x + y + z = 105$$
$$4x + 8y + 3z = 155$$
$$5x + 4y - 10z = 65$$

6. Evaluate the integral by the method of residues $\int_0^{\infty} \frac{dx}{1+x^4}$.

PART - B

Answer any FOUR questions (Each question carries 5 marks) **(4x5=20)**

7. Define homomorphism and isomorphism. Explain with example.
8. Write a note on Lie groups and Lie algebra.
9. Find the Laplace transform of $e^{-2t}\sin 4t \cos 6t$.
10. What is finite difference? Show how the forward difference of all orders can be formed.
11. Form a table of difference for the function $f(x) = x^2 + 5x - 7$ for $x = -1,0,1,2,3,4,5$
12. Define
    1. simple closed path
    2. simply connected regions
    3. multiply connected regions.

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CLASSICAL ELECTRODYNAMICS

Time: 2 ½ Hours **Max. Marks: 60**

PART - A

Answer any FOUR questions (Each question carries 10 marks) **(4x10=40)**

1. Arrive at the multipole expansion for vector potential. Comment on monopole term and dipole term.
2. State and prove Poynting theorem.
3. Derive the Fresnel equations for reflection at oblique incidence.
4. Express Maxwell's equations in four vector notations.
5. How do fields transform between various inertial frames?
6. Derive the Larmor's formula for the total power radiated by an accelerated charged particle.

PART - B

Answer any FOUR questions (Each question carries 5 marks) **(4x5=20)**

7. What are TE and TM modes? Explain.
8. Explain length contraction and time dilation.
9. Prove $\oint \vec{E}.\vec{da} = \frac{Q_{enc}}{\epsilon 0}$. Arrive at the differential form of the same.
10. Arrive at Maxwell's equations in matter.
11. Show that electric and magnetic fields are perpendicular to each other for electromagnetic waves.
12. Explain $\vec{\nabla} \times \vec{E} = 0$. Arrive at scalar potential using the same.

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QUANTUM MECHANICS II

Time: 2 ½ Hours **Max. Marks: 60**

PART - A

Answer any FOUR questions (Each question carries 10 marks) **(4x10=40)**

1. State and prove General Uncertainty Principle.
2. Define ladder operators. Using the same solve the problem of linear harmonic oscillator.
3. For a time independent degenerate perturbation arrive at the expression for first order correction in energy.
4. Explain the Dirac equation for a free particle and the role of Dirac matrices. Discuss the physical significance of the negative energy solutions.
5. Derive the eigenvalues and eigenfunctions of $\hat{L}^2$ and $\hat{L}_z$ for a system with angular momentum l.
6. Find the Clebsch Gordan coefficients for the addition of spin of two electrons.

PART - B

Answer any FOUR questions (Each question carries 5 marks) (4x5=20)

7. Prove the theorem $E_g \leq \langle H \rangle$ and find the ground state energy for the one dimensional harmonic oscillator using variational method.
8. For an electron moving in an electromagnetic field, show that Dirac's Hamiltonian commutes with total angular momentum.
9. Derive the expression for the first order correction in energy and wave function for non degenerate stationary perturbation theory.
10. What were the justifications used by Dirac to set up the new Hamiltonian? Show that it obeys continuity equation for probability density.
11. Derive the Heisenberg equation of motion for an operator $\hat{A}_H(t)$ in the Heisenberg picture.
12. What are Pauli matrices and write their properties.

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April - 2025

CONDENSED MATTER PHYSICS I

Time: 2 ½ Hours **Max. Marks: 60**

PART - A

Answer any FOUR questions (Each question carries 10 marks) (4x10=40)

1. Define geometric structure factor and obtain and expression for the same. Explain systematic absences in crystal structure.
2. a) What are ionic crystals? Explain the formation of ionic crystals and obtain an expression for its cohesive energy.
   b) Discuss phonon-phonon interaction in solids.
3. Describe the behaviour of electrons in periodic potential using Kronig-penney model.
4. Obtain an expression for ionization energy of impurities in a semiconductor.
5. For a two-dimensional square lattice, draw the first three Brillouin zones and explain how to identify them
6. Obtain the vibrational spectrum of a linear diatomic lattice and show that the spectrum consists of two branches. Discuss the main features of the branches.

PART - B

Answer any FOUR questions (Each question carries 5 marks) (4x5=20)

7. Discuss Hall effect in metals.
8. The intrinsic carrier density at room temperature in germanium is 2.3x10^19/m^3. If the electron and hole mobilities are 0.38 m^2/Vs and 0.18 m^2/Vs, respectively, calculate the resistivity of the intrinsic germanium.
9. Distinguish between a primitive unit cell and a conventional unit cell. Classify crystal systems.
10. Explain briefly I) molecular bonded crystals II) hydrogen bonded crystals.
11. Calculate the probability of an electron occupying an energy level 0.02 eV above the Fermi level at 200 K and 400 K in a material.
12. Find conductivity of intrinsic Si at 300 K, when hole concentration is $1.5x10^6$ m^{-3}. Given that mobility of electrons and holes is 0.13 m^2/VS and 0.05m^2/Vs respectively. Also find conductivity when one donor impurity is added in 108 Si atoms. Given that Si has $5x10^{16}$ atoms per m^3.

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