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PH 571.2

Reg. No: [ ]

St Aloysius College (Autonomous)
Mangaluru
Semester II - P.G. Examination - M.Sc. Physics
April 2018
MATHEMATICAL PHYSICS II

Time: 3 Hours | Max.Marks:70

PART A

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

UNIT - I

1. a) Show the existence of the derivative of a complex function at a point z_0 if the function is analytic. **(7)**

   b) Evaluate the integral by the method of residues $\int_0^{\infty} \frac{x^2 dx}{(x^2+4)^3}$. **(8)**

OR

2. a) Derive the Cauchy Riemann conditions for a function of complex variables to be analytic at a point. **(5)**

   b) Explain the meaning of isolated singularity and m^{th} order pole. **(5)**

   c) Find value of $\oint \frac{(z+1)dz}{z^2+2z+5}$ if C is a circle $|z+1| = 1$. **(5)**

UNIT - II

3. a) Define a group and subgroup. Show that the one parameter family of matrices of the form $\begin{bmatrix} cos\theta & sin\theta \\ -sin\theta & cos\theta \end{bmatrix}$ where $0 \le \theta \le 2\pi$ forms a group under multiplication. **(9)**

   b) Do the following matrices form a group (Group multiplication = matrix multiplication) $\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} w & 0 \\ 0 & w^2 \end{pmatrix} \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$ where $w = e^{\frac{2\pi i}{3}}$, $(w^3 = 1)$. If not, add to them other 2×2 matrices needed to complete a group (or smallest order possible). Divide the elements of the group into classes. **(6)**

OR

4. a) Show that the symmetry transformations of an equilateral triangle form a group. **(6)**

   b) Define character of a group element in a representation. State and prove orthogonality theorem of group characters. **(9)**

UNIT - III

5. a) Define the Laplace transform of a function. Discuss the general properties of Laplace transforms. **(7)**

   b) Find the inverse Laplace transform of $L^{-1}\left[\frac{1}{(s-1)(s+2)(s+4)}\right]$. **(4)**

Contd...2

c) Discuss the application of Laplace transforms in solving differential equations with given boundary or initial conditions. (4)

OR

6 a) Define Fourier transform of a function f(x). List any three properties of the Fourier transforms. (6)

b) Using the Fourier Transform, obtain the integral representation of the Diarc delta function. (5)

c) Find the Fourier sine transform of $f(x) = N\{exp(-ax^2)]$, where 'N' and 'a' are constants. (4)

UNIT - IV

7 a) Derive Simpson's 1/3 rule for numerical integration of a function. (6)

b) Apply the method to evaluate $\int_0^2 \frac{dx}{4+2x^2}$ using 8 steps. (9)

OR

8 a) Solve the system of equations by Gauss elimination method. (9)

$4p + 3q + 2r + 2s = 0, \quad 2p - q + r + 7s = 0, \quad p + 2q - 3s = 0$

b) Obtain Newton's formula for backward interpolation. (6)

PART - B

Answer any two questions **(5x2=10)**

9. a) Define the class of a group and mention its properties.

b) Obtain Trapezoidal rule from general formula for integration.

c) State and prove Jordan's lemma.

d) Find the inverse Laplace transform f(t)= cosat.

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PH 572.2

Reg. No:

St Aloysius College (Autonomous)

Mangaluru

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

April 2018

QUANTUM MECHANICS - I

Time: 3 Hours **Max.Marks:70**

PART A

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

UNIT - I

1. a) Write name of a phenomena / experiment which shows wave nature of matter particles. Describe how particle picture fails to explain it and wave picture successfully explains it. **(7)**

b) Explain the meaning of ΔE and ΔT in energy time uncertainty principle. **(3)**

c) An electron of rest mass m_0 is accelerated by an extremely high potential of V volts. Show that its wavelength is **(5)**

$$\lambda = \frac{hc}{\sqrt{eV(eV + 2m_0C^2)}}$$

OR

2. a) Write the Schrodinger equation for a free particle in one dimension. Solve it and explain box normalization. **(7)**

b) Write a short note on probability interpretation of wavefunction. **(3)**

c) Show that the phase velocity of relativistic electron is $V_p = c\sqrt{1 + \frac{mo^2c^2\lambda^2}{h^2}}$ where λ is its de Broglie wavelength. **(5)**

UNIT - II

3 a) Prove that operators having common set of eigen functions commute. **(5)**

b) Show that operator $-i\hbar\frac{d}{dx}$ is Hermitian. **(6)**

c) What do you mean by

i) Normalization of a function? **(2)**

ii) Closure property of eigen functions? **(2)**

OR

4.a) Prove that commuting operators have common set of eigen functions? **(5)**

b) If A and B are Hermitian operators, show that (AB+BA) is Hermitian and (AB-BA) is non - Hermitian. **(5)**

c) Write two postulates of a quantum mechanics. **(5)**

UNIT - III

5.a) Consider a particle of mass m and energy E approaching from the left, a one dimensional potential step given by **(10)**

$$V(x) = \begin{cases} 0 & x < 0 \\ V_0 & x > 0 \end{cases}$$

Discuss the motion classically and quantum mechanically for the $E<V_0$ case. Obtain the reflection and transmission coefficients.

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b) What is the zero-point energy of a harmonic oscillator? How is it explained? (3)

c) What is quantum tunneling? (2)

OR

6 a) A beam of particles, each of mass m and energy E, is incident on the potential barrier (10)

$$V(x) = \begin{cases} 0 & x < 0 \\ V_0 & 0 < x < a \\ 0 & x > a \end{cases}$$

Calculate the tunneling probability when $E < V_0$.

b) For an electron in a one-dimentional infinite deep potential well of width 1 A^0. Calculate : i) the separation between two lowest energy levels. (4)

ii) The frequency of the photon corresponding to a transition between these two levels. (1)

UNIT - IV

7 a) Calculate the energy eigen values by solving the radial Schrodinger equation of hydrogen atom. (10)

b) A rigid rotator is constrained to rotate about a fixed axis. Find out its normalized eigen functions and energy eigen values. (5)

OR

8 a) Deduce the following commutation relations for the components L_x, L_y, L_z components of the orbital angular momentum operator.

i) $[\hat{L}_z, \hat{L}_x]$ ii) $[\hat{L}^2, \hat{L}_y]$ (3+3)

b) By applying the partial waves analysis obtain the total scattering cross-section formula. (9)

PART - B

Answer any two questions (5x2=10)

9. a) Using uncertainty principle show that an electron cannot exist inside a nucleus. (5)

b) What are dynamical variables? What type of operators represent them? What is meant by expectation value of a dynamical variable? (5)

c) Show that a particle in a finite deep potential well can also be found outside the potential well. (5)

d) The radial wave function for the ground state (n=1, l=0) of the hydrogen atom is (5)

$$R_{10}(r) = \frac{1}{a_0^{\frac{3}{2}}}\, 2\, e^{\frac{r}{a_0}}$$

Where $a_0 = \frac{\hbar^2}{me^2}$, the Bohr radius. Obtain the expression of radial probability density and draw its rough sketch with radial distance (r)

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St Aloysius College (Autonomous)
Mangaluru
Semester II – P.G. Examination – M. Sc. Physics
April - 2018

STATISTICAL MECHANICS

Time: 3 Hours **Max. Marks: 70**

PART – A

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

UNIT - I

1.a) Arrive at the Maxwell relations of thermodynamics. (10)

b) Define entropy and discuss the principle of entropy increase. (5)

OR

2.a) State and explain Liouville's theorem (10)

b) What are the Helmholtz and Gibbs functions? Discuss. (5)

UNIT – II

3.a) What are the ensembles? How are they classified? What are their properties? (6)

b) Discuss the Sackur-Tetrode Equation. (9)

OR

4.a) What is "Partition Function"? What are the Types? (5)

b) Discuss Equipartition Theorem. (10)

UNIT - III

5.a) Apply Bose-Einstein Statistics to a photon gas. (10)

b) What are the applications of Fermi-Dirac statistics? (5)

OR

6.a) Using Fermi-Dirac Statistics, arrive at the distribution function. (10)

b) What is Bose- Einstein condensation? (5)

UNIT - IV

7.a) What is Wiener-Khinchine Theorem? (10)

b) Write a note on Fluctuations. (5)

OR

8.a) Discuss Langevin's equation for Brownian motion. (10)

b) What is Nyquist theorem? (5)

PART – B

Answer any <u>TWO</u> questions. **(5x2=10)**

9.a) What is phase space? Explain.

b) What is Gibbs paradox?

c) What are Fermi temperature and Fermi velocity?

d) Write a note on Brownian motion.

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

St Aloysius College (Autonomous)
Mangaluru
Semester II – P.G. Examination – M.Sc. Physics
April - 2018

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) Explain how to construct a reciprocal lattice for a direct lattice. Show that the reciprocal lattice for a body centred cubic is a face centred cubic. (9)

b) What are Miller indices? How do you find Miller indices of a given plane ? Draw (1 2 0) and $(\bar{1}\ 0\ 1)$ plane in cubic unit cell. (6)

OR

2.a) Discuss the basic symmetry elements associated with crystals. (8)

b) Define geometric structure factor. Discuss it for a BCC crystal and monatomic FCC crystal? (7)

UNIT – II

3.a) Explain in detail the normal and Umklapp processes. How these two will contribute to the thermal resistance of a material? (8)

b) Obtain the dispersion relation for elastic waves in a linear monatomic chain with nearest neighbour interaction. (7)

OR

4.a) What are ionic crystals? Explain the formation of ionic crystal and obtain an expression for its cohesive energy. (8)

b) Obtain the dispersion relation for the diatomic lattice vibration and explain the optical and acoustics branch. (7)

UNIT – III

5.a) Based on Sommerfeld theory, obtain the expression for electrical conductivity of metals. (9)

b) Explain (i) Magnetoresistance (ii) Concept of holes (iii) constant energy surface. (6)

OR

6.a) What is density of energy states in metals ? Derive an expression for density of states. (8)

b) State and prove Bloch theorem. (7)

Contd...2

All questions papers 1st & 2nd Sem

UNIT IV

7.a) Derive an expression for electron concentration in the conduction band of an n-type semiconductor. (8)

b) Obtain an expression for carrier concentration in an intrinsic semiconductor. (7)

OR

8.a) What are intrinsic and extrinsic semiconductors? Show the position of Fermi level in case of intrinsic and extrinsic semiconductors. (8)

b) Discuss the quantum Hall effect in two dimensional semiconductors. (7)

PART – B

Answer any TWO questions. (5x2=10)

9.a) Derive Laue condition for X-ray diffraction.

b) Write a short note on hydrogen bonded crystals.

c) Find the temperature at which there is 1% probability that a state with energy 0.5 eV above Fermi energy will be occupied.

d) Explain briefly degenerate and organic semiconductors.

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Reg. No:

St Aloysius College (Autonomous)
Mangaluru
Semester II - P.G. Examination - M.Sc. Physics
April 2019
MATHEMATICAL PHYSICS II

Time: 3 Hours Max.Marks:70

PART A

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

UNIT - I

1. a) State and prove Cauchy's residue theorem. (6)

b) Apply residue theorem to evaluate the integral $\int_0^\infty \frac{x^2dx}{(x^2+9)(x^2+4)^2}$. (9

OR

2. a) Find the analytic function $w(z) = u(x,y) + iv(x,y)$ if $v(x,y) = e^{-y} \sin x$. (5)

b) Obtain the Laurent expansion of $(z-1)e^{\frac{1}{z}}$ about $z = 0$. (5)

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

UNIT - II

3 a) Define reducible and irreducible representations of a group. Explain the method of decomposing a reducible representation into irreducible ones. (7)

b) Define the group SU (2) and obtain its two dimensional representation. (8)

OR

4.a) Show that every representation of a group can be brought into unitary form by a similarity transformation. (10)

b) State and prove Shur's first lemma. (5)

UNIT - III

5.a) Explain the method of obtaining the Fourier transform of a function starting with Fourier series. (7)

b) Expand $f(x) = -x; -a \leq a$ and f(x)=0 elsewhere, in a Fourier series. (8)

OR

6 a) Define the Laplace transform of a function. Discuss the general properties of Laplace transforms. (9)

b) Find the inverse Laplace transform of $f(s) = (s^2+1)^{-1}$. (6)

UNIT - IV

7 a) Outline the Gauss-elimination method of solving a system of linear equations. (7)

Contd...2

b) Use the fourth order Runge-Kutta method to solve the differential equation $\frac{dy}{dx} = y - x$ where $y(0) = 2$ and compute y(0,1) correct up to four decimal places $(h = 0.1)$. (8)

OR

8 a) Obtain the Newton's forward interpolation formula. (8)

b) Derive the trapezoidal rule to integrate a function $f(x)$ bounded between the limits $x = a$ and $x = b$. (8)

PART - B

Answer any two questions (5x2=10)

9. a) Find the Fourier transform of a normalized Gaussian distribution.

b) Define homomorphism and isomorphism between two groups. Give an example.

c) Derive Newton's forward formula for numerical differentiation.

d) Evaluate the integral $\int_0^{\pi} \frac{d\theta}{2+cos\theta}$.

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Semester II - P.G. Examination - M.Sc. Physics
April 2019
QUANTUM MECHANICS - I

Time: 3 Hours Max.Marks:70

PART A

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

UNIT - I

1. a) Write name of a phenomena / experiment which shows particle nature of light. Describe how wave picture of light fails to explain it and particle picture of light successfully explains it. **(7)**

b) Explain the meaning of uncertainties in position (Δx) and momentum (Δp) in position momentum uncertainly principle. **(3)**

c) Calculate the de Broglie wavelength of an electron having a kinetic energy 1000eV. Compare the result with the wavelength of x-rays having the same energy. **(5)**

OR

2. a) Define the position probability density and the probability current density in the context of a quantum mechanical wave function. Obtain the equation connecting these quantities and give the physical interpretation of this equation. **(8)**

b) Prove that the group velocity of a wave packet is equal to the velocity of a freely moving particle. **(3)**

c) The average lifetime of an excited atomic state is 10^{-9}s. If the spectral line associated with the decay of this state is 6000 A^0, estimate the width of the line. **(4)**

UNIT - II

3 a) Prove that the eigen values of Hermitian operators are real. **(5)**

b) Show that $\hat{x}$ operator is Hermitian. **(5)**

c) What do you mean by
   i) Orthonormal functions? **(1)**
   ii) Completeness of eigen functions. **(2)**

d) Why do we normalize a wavefunction in quantum mechanics? **(2)**

OR

4.a) Prove that any two eigen functions of a Hermitian operator that belong to different eigen values are orthogonal. **(5)**

b) Show that $\frac{d^2}{dx^2}$ operater is Hermitian. **(5)**

c) What do you mean by **(1 ½)**
   i) Degenerate states?
   ii) Orthogonal functions? **(1 ½)**

d) Write the properties of a quantum mechanical wave function. **(2)**

Contd...2

UNIT - III

5.a) Calculate the energy eigen values and normalized eigen functions for a particle in an infinite deep potential well. (5)

b) Show that superposition states formed by non-degenerate states are non stationary. (5)

c) The ground state wave function of a harmonic oscillator is given as

$$f(x) = \left(\frac{mw}{\pi\hbar}\right)^{\frac{1}{4}} exp\left(\frac{-mwx^2}{2\hbar}\right).$$

i) Where is the probability density maximum? (3)

ii) What is value of maximum probability density (2)

OR

6 a) Consider a particle of mass m and energy E approaching from the left, a one dimensional potential step given by (10)

$$V(x) = \begin{cases} 0 & x < 0 \\ V_0 & x > 0 \end{cases}$$

Discuss the motion classically and quantum mechanically for the case $E<V_0$. Obtain the reflection and transmission coefficients.

b) The strongest IR absorption band of $^{12}C\ ^{16}O$ molecule occurs at 6.43×10^{-13}Hz. If the reduced mass $^{12}C\ ^{16}O$ molecule is 1.185×10^{-26} kg, calculate i) the approximate zero-point energy, (5)

ii) the force constant of the $^{12}C\ ^{16}O$ bond.

UNIT - IV

7 a) Calculate eigen values and normalized eigen functions of $\hat{L}_z$ operator. (5)

b) Evaluate i) $[\hat{L}_x, \hat{L}_y]$ ii) $[\hat{L}^2, \hat{L}_x]$ (3+3)

c) Write a note on Space Quantization. (4)

OR

8 a) Set up the time-independent Schrodinger equation for a hydrogen atom in spherical polar coordinates $(r, \theta, \emptyset)$. Split this equation into three equations corresponding to the three variables (8)

b) Define differential scattering cross-section and total cross-section. (4)

c) Discuss the validity conditions for the born approximation. (3)

PART - B

Answer any two questions (5x2=10)

9. a) Show that the wave packet having the minimum uncertainty product has a Gaussian shape. (5)

b) Evaluate $[\hat{x}, \hat{p}_x]$ (5)

c) Draw the harmonic oscillater potential. Write the expressions of it's Hamiltonian and nth state energy eigen values. Give interpretation of zero point energy of the harmonic oscillator. (5)

d) Write a note on parity. (5)

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

St Aloysius College (Autonomous)
Mangaluru
Semester II – P.G. Examination – M. Sc. Physics
April - 2019
STATISTICAL MECHANICS

Time: 3 Hours — Max. Marks: 70

PART – A

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

UNIT - I

1.a) Arrive at the expression for specific heat at constant volume for ideal gas. **(10)**

b) Discuss thermal equilibrium and how it is attained. **(5)**

OR

2.a) Discuss Boltzmann's equation for entropy and its significance. **(12)**

b) What is phase space? Explain. **(3)**

UNIT – II

3.a) Arrive at the ideal gas equation using suitable partition function. (9)

b) Derive Maxwell- Boltzmann distribution function. (6)

OR

4.a) What is Gibbs paradox? How is it resolved? (9)

b) What are ensembles? How are they classified? (6)

UNIT - III

5.a) Arrive at Planck's formula for blackbody radiation using the appropriate statistics. **(10)**

b) Mention a few applications of Fermi-Dirac statistics? **(5)**

OR

6.a) Arrive at the distribution function for fermions. **(10)**

b) What are Bose- Einstein condensates? Explain **(5)**

UNIT - IV

7.a) Arrive at the mobility relations for Brownian motion. **(10)**

b) What are Fluctuations? Explain **(5)**

OR

8.a) Discuss the Fokker –Planck equation and its significance. **(10)**

b) What is noise? What are its features? **(5)**

PART – B

Answer any TWO questions. **(2x5=10)**

9.a) What is Liouville's theorem?

b) What is partition function? What are the types?

c) Discuss the variation of Fermi –Dirac distribution function with temperature.

d) What is power spectral density? Explain its significance in Statistical Mechanics.

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St Aloysius College (Autonomous)

Mangaluru

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

April - 2019

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) State and explain the Bragg's law for X-ray diffraction. Show that Laue's and Bragg's equations are equivalent. (8)

b) Explain with neat diagram, the power method of determining the crystal structure. (7)

OR

2.a) Define geometric structure factor and obtain an expression for the same. Explain systematic absences in FCC structure. (8)

b) Define the screw symmetry. Discuss the screw symmetry operation. (7)

UNIT – II

3.a) Write a note on ionic crystals, covalent crystals, molecular crystals and hydrogen bonded crystals. (8)

b) Explain an inelastic scattering of photons and neutrons by phonons. (7)

OR

4.a) Derive an expression for the binding energy in an ionic crystal and hence obtain an expression for Madelung constant. (8)

b) Obtain the dispersion relation for the diatomic lattice vibration and explain the optical and acoustics branch. (7)

UNIT – III

5.a) Discuss the behaviour of electrons in a periodic potential employing the one dimensional Kronig –Penny model. (9)

b) Explain different types of thermoelectric effects. (6)

OR

6.a) Explain the specific heat of a metal and obtain an expression for electronic specific heat. (8)

b) What is Hall effect? Deduce the expression for Hall coefficient in metals and mention its significance. (7)

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I & II Sem M.Sc Physics
Nov - 2018, April - 2019

UNIT IV

7.a) Obtain an expression for ionization energy of impurities in a semiconductor. (8)

b) Write a note on (i) Direct and indirect gap semiconductors (ii) Effective mass (iii) Organic semiconductors. (7)

OR

8.a) Show that Fermi level lies exactly half way between valence band conduction band in an intrinsic semiconductor. Also show the position of Fermi level in case of extrinsic semiconductor. (8)

b) Discuss quantized Hall effect in semiconductor. (7)

PART – B

Answer any TWO questions. (5x2=10)

9.a) Which one of the following reflections would be missing in a bcc lattice: (100)(110)(111)(100)(200)(210)(211)(220)(221)(222)

b) Explain in details the normal and Umklapp process.

c) Discuss the inadequacies of free electron theory.

d) In a intrinsic semiconductor, electron density in a conduction band is $10^{21} m^{-3}$, life time of an electron 10^{-12} s and effective mass of an electron is 0.1 times its rest mass. Calculate the electrical conductivity of the semiconductor.

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