2M2A25099 (Pages : 2) Reg. No:..............................

Name: ....

FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

Second Semester M.Sc Physics Degree Examination, April 2025

MPH2C05 – Quantum Mechanics - 1

(2022 Admission onwards)

Time: 3 hours Max. weightage : 30

Section A

Answer all questions, each carry weightage 1

1. State and explain general uncertainty relation.
2. Differentiate between inner product and outer product
3. What is meant by basis vectors? Explain how basis vectors are transformed
4. Explain the concept of creation and annihilation operators in quantum mechanics
5. Distinguish between eigen value and expectation value
6. What are stationary states? In stationary states show that the probability current density is constant in time.
7. The definition of angular momentum given by $L = r \times p$ is not a general one why? Define a general angular momentum operator.
8. What are Clebsch-Gordan coefficients? Explain their significance

Total Weightage 8X1=8

Section B

Answer ANY TWO questions, each carry 5 weightage

9. What is meant by a Hermitian operator? Show that Hermitian operators have real eigen values and eigen functions belonging to different eigen values are orthogonal.
10. Write a note on matrix representation of angular momentum and find the matrix representations of J^2, J_x, J_y and J_z for J=1.
11. Derive the energy eigen values and eigen vectors of an isotropic harmonic oscillator
12. a) Explain the concept of symmetric and anti-symmetric wave functions of a system of identical particles.

    b) Using the symmetries of the wave functions discuss the ground state energy of helium atom.

Total Weightage 2X5=10

Section C

Answer ANY FOUR questions, each carry 3 weightage

13. A particle is in a state $|\psi\rangle = \left(\frac{1}{4\pi}\right)^{\frac{1}{4}} \exp\left(-\frac{x^2}{2}\right)$. Find Δx and Δp_x. Hence evaluate the uncertainty product $\Delta x \Delta p_x$

14. Find the eigen values and eigen vectors of matrix $A = \begin{pmatrix} 7 & 0 & 0 \\ 0 & 1 & i \\ 0 & i & -1 \end{pmatrix}$

15. Derive the energy eigen function for a particle in a one dimensional square well potential

16. a) Using canonical commutation relation show that $\left[\hat{X}^m, \hat{P}_x\right] = im\hbar\hat{X}^{m-1}$, with m>1.

    b) Prove that the time dependent Schrodinger equation satisfies the equation of continuity

17. What are time evolution operators? Give its properties.

18. Calculate the expectation value of position $\langle X \rangle$ and momentum $\langle P_x \rangle$ of the particle trapped in the one dimensional box.

19. Prove that

    a) $\sigma_j \sigma_k = \delta_{j,k} + \varepsilon_{jkl}\sigma_l$

    b) $e^{i\alpha\sigma_j} = i\cos\alpha + i\sigma_j \sin\alpha$. Where σ is Pauli's spin matrices and α is a constant.

Total Weightage 4X3=12

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(Pages : 2)

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

Name: ....

FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

Second Semester M.Sc Physics Degree Examination, April 2025

MPH2C06 – Mathematical Physics – II

(2022 Admission onwards)

Time: 3 hours

Max. weightage : 30

Section A

(Answer all questions, each carry weightage 1)

1. What ispole of a complex function? Find the pole for the function $f(z) = \frac{1}{(z-1)(z-2)}$
2. Show that the function $f(z) = e^{x}(\cos y + i \sin y)$ is analytic.
3. State Cauchy's integral theorem.
4. Explain homorphism between groups.
5. What are generators of SO(3) group?
6. Explain variational method with Fermat's principle as an example.
7. Explain Rayleigh Ritz variational technique.
8. Define Green's function and mention its application.

(Total 8 x 1 = 8 weightage)

Section B

(Answer ANY TWO questions, each carry weightage 5)

9. State and prove Cauchy's residue theorem. Find the residue of the poles of the functionf$(z) = \frac{e^z}{z^2+a^2}$.
10. Show that all the symmetry transformations of square forms a group. Also construct its group multiplication table.
11. Derive one dependent and three independent variable Euler Lagrange's equation in variational analysis. Arrive Laplace equation in electrostatics by minimizing electrostatic energy in a given volume.
12. Classify integral equations and one example for each case Convert differential equation of harmonic oscillator into integral equation with boundary conditions y(0) = 0 and y(b) = 0.

(Total weightage 2x 5 = 10)

Section C
(Answer ANY FOUR questions, each carry weightage 3)

13. Integrate using complex variable, $\int_0^{2\pi} \frac{d\theta}{a+b\sin\theta}$.
14. What is a group multiplication table. State and prove group rearrangement theorems.
15. Construct the symmetry group of an equilateral triangle.
16. What is Lagrangian undetermined multiplier in the calculus of variation? Illustrate this with simple pendulum as an example.
17. Using seperable Kernel method solve $\emptyset(x) = x + \int_{-1}^{1}(t+x)\emptyset(t)dt$.
18. Find the Green's function of $\frac{d^2y}{dx^2} + k^2y = f(x); y(0) = y(l) = 0$ as eigen function $0 \leq x \leq l$.
19. Convert the differential equation into an integral equation

$$y''(x) + xy'(x) + y(x) = 0, y(0) = 1; y'(0) = 0$$

(Total weightage 4x 3 = 12)

2M2A25101 (Pages : 2) Reg. No:............................

Name: ....

FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

Second Semester M.Sc Physics Degree Examination, April 2025

MPH2C07 – Statistical Mechanics

(2022 Admission onwards)

Time: 3 hours Max. weightage : 30

Section A

(Answer all questions, each carries weightage 1)

1. State the postulate of *equal a priori* probabilities.
2. What is thermodynamic limit? Explain its importance.
3. What is the importance of Hamilton's canonical equations in classical statistics?
4. State and explain virial theorem.
5. Define the term *fugacity*. How it is related to the chemical potential of a system?
6. Write down Fermi Dirac distribution function. Explain how it varies with temperature.
7. What is the thermodynamic meaning of Fermi energy?
8. Write a short note on Bose Einstein condensation.

Total weightage 8x1=8

Section B

(Answer ANY TWO questions, each carries weightage 5)

9. Define canonical partition function. How can you obtain various thermodynamic quantities of a system from it? Also discuss the energy fluctuation in canonical ensemble.
10. Explain the quantum mechanical treatment of paramagnetism to obtain Curie's law, by using canonical ensemble theory?
11. Discuss the significance of density matrix in quantum mechanical ensemble theory. Derive the Liouville's theorem in quantum statistics.
12. Discuss the thermodynamics of an ideal fermi gas.

Total weightage 2x5=10

Section C

(Answer ANY FOUR questions, each carries weightage 3)

13. Two interacting systems 1 and 2 have thermodynamic probabilities $\Omega_1 = 2x10^{12}$ and $\Omega_2 = 8x10^{11}$ respectively. Calculate (i) the individual entropies S_1 and S_2 of the systems and (ii) the total probability and total entropy of the composite system.
14. The entropy of a classical ideal gas is given by,= $Nk \ln\left[a\frac{V}{N}\left(\frac{E}{N}\right)^{\frac{3}{2}}\right] + \frac{5}{2}Nk$, where N is the number of particles, V is the volume, E is the internal energy of the system and$a$ is a constant. Obtain the pressure $P$and Helmholtz free energy $A$of the system.
15. A particle of unit mass is executing SHM in one dimension. Find its trajectory in phase space. Obtain the phase space volume corresponding to an Eigen state.
16. Seven Bosons are arranged in two compartments. The first compartment has 8 cells and the second compartment has 9 cells of equal size. Find the total number of microstates for the macrostatein which four particles are in the first compartment and three in the second compartment.
17. Find the BE condensation temperature of liquid helium of density 125 kg m^{-3}.
18. The density of a metal is $8.92x10^3$ kg.m^{-3}. If the atomic mass is 63.5, and each atom contributes an electron to the conduction,find (i) the fermi energy and (ii) fermi temperature of the metal.
19. Electromagnetic radiation inside a cavity of volume V is in equilibrium at temperature T. If the temperature of the cavity is halved, by what factor does the pressure change? How does this compare with a classical monoatomic gas under similar conditions?

Total weightage 4x3=12

2M2A25102 (Pages : 2) Reg. No:............................

Name: ....

FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

Second Semester M.Sc Physics Degree Examination, April 2025

MPH2C08 - Computational Physics

(2022 Admission onwards)

Time: 3 hours Max. Weightage : 30

Section A

(Answer *all* questions. Each carries weightage of 1)

1. Explain the methods for handling inputs and outputs in Python
2. What is meant by pickling in python?
3. Give any two commands for data visualisation in python
4. What is the purpose of the 'reshape' function in NumPy?
5. Explain the concept of polynomial interpolation and mention a common use
6. What is the main advantage of using the Fast Fourier transform over the standard Discrete Fourier transform?
7. Outline the key steps involved in Numerov's method for solving differential equations.
8. List the advantages of Runge-Kutta metho over the Euler method.

(8x1=8 weightage)

Section B

(Answer *any two* questions. Each carries weightage of 5)

9. Explain the functionalities of Numpy module in Python. Give its applications with example.
10. Define boundary value problems in the context of ordinary differential equations. Explain the numerical methods to solve boundary value problems
11. Write down the algorithm and python code to plot the trajectory of a charged particle in a uniform magnetic field.
12. Explain the numerical methods to solve second order differential equations. Solve planetary motion using Runge Kutta method

(2x5=10 weightage)

Section C

(Answer *any four* questions. Each carries weightage of 3)

13. What is the purpose of conditionals and iteration in programming. How are they implemented in Python?

14. Write the algorithm and python program to find the cross product and dot product of two vectors.

15. Using fourth-order Runge-Kutta method, solve $\frac{dy}{dx} = \sin 2x$ in the interval 0 to $\pi/2$. Given $y(0) = 1$. Write down the python program

16. Write down the program and algorithm of Monte Carlo method to simulate radioactivity.

17. Find $\sqrt{159}$ using the following table

x	$\sqrt{x}$
152	12.32883
154	12.40967
156	12.49000
158	12.56981
160	12.64911
162	12.72792

18. The function of the form $y = ae^{bx}$ fits to the following data. Find a and b

x	y
1	1.5
2	4.6
3	13.9
4	40.1
5	125.5
6	299.1

19. Apply trapezoidal rule and Simpson's rule to integrate $f(x) = \int_0^1 \sqrt{1-x^2}\,dx$ with n=2 and 4.

(4x3=12 weightage)