54

1M2A24099 (Pages : 2) Reg. No:.....

Name: .....

FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

Second Semester M.Sc Physics Degree Examination, April 2024

MPH2C05 – Quantum Mechanics - 1

(2022 Admission onwards)

Time: 3 hours Max. weightage : 30

Section A

Answer all questions, each carry weightage 1

1. What is meant by Hilbert space?
2. What is the associative axiom of multiplication, and how does it differ from the commutative axiom of multiplication?
3. What is a projection operator? Show that the operator $|\psi\rangle\langle\psi|$ is a projection operator only when $|\psi\rangle$ is normalized
4. Distinguish between Schrodinger and Heisenberg pictures.
5. Outline the probability interpretation of wave function
6. Explain the significance of Ehrenfest's theorem
7. What are ladder operators? Why are they called so?
8. Why $L \times L$ is non zero?

Total Weightage 8X1=8

Section B

Answer ANY TWO questions, each carry 5 weightage

9. Explain the Canonical commutation relation. Using operator method discus the linear harmonic oscillator problem in quantum mechanics
10. What are Clebsch Gordan coefficients? Mention their properties and selection rules
11. Write the Schrodinger equation for a particle moving in a central potential and deduce the radial part solution.
12. a) Conservation of angular momentum is the consequence of rotational invariance of the system. Substantiate

    b) Show that parity operator commute with orbital angular momentum operator.

Total Weightage 2X5=10

Section C

Answer ANY FOUR questions, each carry 3 weightage

13. Define the uncertainty (ΔA) in the measurement of a dynamical variable A. State and explain general uncertainty relation.
14. Write position operator in momentum representation and show that commutators are representation independent.
15. Show that $Tr\left(\hat{A}\hat{B}\right)=Tr\left(\hat{B}\hat{A}\right)$ and also show that the trace of a commutator is always zero.
16. Discuss the condition for these operators to be unitary.

    a) $\frac{\left(1+i\hat{A}\right)}{\left(1-i\hat{A}\right)}$ and b) $\frac{\left(\hat{A}+i\hat{B}\right)}{\sqrt{\hat{A}^2+\hat{B}^2}}$

17. Prove that $\frac{d}{dt}\langle R\rangle=\frac{\langle P\rangle}{m}$ and $\frac{d}{dt}\langle P\rangle=-\langle\nabla V\rangle$
18. Derive the energy eigen function for a particle in a one dimensional potential step
19. Show that $(\sigma\cdot A)(\sigma\cdot B)=A\cdot B+i\sigma\cdot(A\times B)$ where σ is Pauli's spin matrices and A and B are arbitrary vectors.

Total Weightage 4X3=12

55

1M2A24100 (Pages : 2) Reg. No:.....

Name: .....

FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

Second Semester M.Sc Physics Degree Examination, April 2024

MPH2C06 – Mathematical Physics – II

(2022 Admission onwards)

Time: 3 hours Max. weightage : 30

Section A

(Answer all questions, each carry weightage 1)

1. What is Cauchy – Riemann Conditions in polar coordinates?
2. Test whether the function $f(z) = \frac{1}{z}$ is analytic or not.
3. State Cauchy's Residue theorem.
4. Explain isomorphism between groups.
5. What are generators of SU(2) group?
6. Show that the shortest distance between two points in Euclidean plane is straight line.
7. Explain the variational method in the presence of constraints.
8. Show that Green's function is symmetric.

(Total 8 x 1 = 8 weightage)

Section B

(Answer ANY TWO questions, each carry weightage 5)

9. What is Laurent series expansion of given function? Obtain the Laurent series expansion of $f(z) = \frac{1}{(z-1)(z-2)}$ between the annular region z=1 and z=2.
10. Establish the homomorhism between SO(3) and SU(2) groups.
11. Explain the concept of variational principle. Solve Brachistochrone problem(The curve of fastest descent under the action of gravity).
12. Find out the solution of $\emptyset(x) = x + \int_0^x (t-x)\emptyset(t)dt$ by Neumann series method.

(Total weightage 2x 5 = 10)

Section C

(Answer ANY FOUR questions, each carry weightage 3)

13. Evaluate $\oint \frac{dz}{(z^2-1)}$, the closed path is along a circle with $|z| = 1$.
14. Express orbital angular momentum as the generators of SO(3) group.
15. Construct the symmetry group of a square. Find its classes and subgroups.
16. Find the critical angle at which a log placed on a cylindrical surface fly off from the surface.
17. Using seperable Kernel method solve $\emptyset(x) = x + \int_0^1 (1 + xt)\emptyset(t)dt$.
18. Find the Green's function of $\frac{d^2y}{dx^2} - k^2y = f(x); y(\pm\infty) = 0$.
19. Convert the differential equation into an integral equation

$y''(x) - 3y'(x) + 2y(x) = 5sinx, y(0) = 1;$ y' (0) =-2

(Total weightage 4x 3 = 12)

56

1M2A24101 (Pages : 2) Reg. No:.....

Name: .....

FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

Second Semester M.Sc Physics Degree Examination, April 2024

MPH2C07 – Statistical Mechanics

(2022 Admission onwards)

Time: 3 hours Max. weightage : 30

Section A
(Answer all questions, each carries weightage 1)

1. Distinguish between microstate and macrostate of a thermodynamic system.
2. What is the importance of Hamilton's canonical equations in classical statistics?
3. Distinguish between microcanonical, canonical and grand canonical ensembles.
4. Define the term *fugacity*. How it is related to the chemical potential of a system.
5. Compare Bose Einstein and Fermi Dirac statistics.
6. What is an antisymmetric wavefunction?
7. Write a short note on Bose Einstein condensation.
8. What is the thermodynamic meaning of Fermi energy?

Total weightage 8x1=8

Section B
(Answer ANY TWO questions, each carries weightage 5)

9. Obtain the entropy of mixing of samples of two dissimilar gases. Explain the Gibbs paradox and how it is corrected.
10. What is a canonical ensemble? Describe the thermodynamics of a system in canonical ensemble.
11. Define density matrix ρ. Discuss its significance in quantum mechanical ensemble theory. Show that the expectation value of a physical quantity G is $\langle G \rangle = \frac{Tr(\rho G)}{Tr(\rho)}$.
12. Explain the Debye theory of specific heat. What are the differences of the theory with Einstein's theory?

Total weightage 2x5=10

Section C

(Answer ANY FOUR questions, each carries weightage 3)

13. Two interacting systems 1 and 2 have thermodynamic probabilities $\Omega_1 = 5x10^{12}$ and $\Omega_2 = 9x10^{11}$ 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 free energy of a photon gas is given by, $A = -aVT^4$, where a is a constant, V is the volume and T is the temperature. Evaluate the entropy S and pressure P of the photon gas.
15. An ideal gas consists of N particles. The energy of each particle of the system in terms of its momentum p is $E = pc$, where c is a constant. Calculate the partition function, Q; internal energy, U and heat capacity at constant volume, C_V of the system.
16. Derive the Liouville's theorem in quantum statistics.
17. Consider an assembly of N particles of a Bose gas. If N_o are in the ground state and N_e are in the excited state, obtain an expression for Bose Einstein condensation temperature.
18. Show that the pressure of a Fermi gas at $T = 0\ K$ is proportional to $n^{5/3}$.
19. 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.

Total weightage 4x3=12

57

1M2A24102 (Pages : 2) Reg. No:.....

Name: .....

FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

Second Semester M.Sc Physics Degree Examination, April 2024

MPH2C08 - Computational Physics

(2022 Admission onwards)

Time: 3 hours Max. Weightage : 30

Section A

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

1. Differentiate between string and tuples in python
2. Differentiate between compilers and interpreters
3. Give the file input command in python
4. How can you restore a saved NumPy array from a file?
5. Explain how NumPy can be used to find the solution of simultaneous equations.
6. What is spline interpolation? Why is it advantageous over simple polynomial interpolation?
7. Briefly explain the bisection method for finding roots of non-linear equations
8. Define discrete Fourier transforms and mention one application where they are commonly used.

(8x1=8 weightage)

Section B

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

9. Explain the Matplotlib module in Python. How does it contribute to data visualization?
10. Discuss the principle, algorithm and python program to simulate two slit photon interference experiment.
11. Explain the applications of Monte Carlo simulations. Write a python program to find the value of π.
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. Write a python program to print the multiplication table of 'n'
14. Using fourth-order Runge-Kutta method, solve $\frac{dy}{dx} = \sin x \cos x$ in the interval 0 to$\pi/2$. Given $y(0) = 1$. Write down the python program
15. Write down the python program to generate the phase space plots for an ideal simple harmonic oscillator and damped oscillator by solving respective differential equations of motion. Consider damping is proportional to velocity.
16. Evaluate $Sin\ (0.213)$ from the following table

x	$Sin\ (x)$
0.15	0.14944
0.17	0.16918
0.19	0.18886
0.21	0.20846
0.23	0.22798

17. Fit an exponential function of the form $y = ae^{bx}$ to the following data

x	y
0	0.1
0.5	0.45
1	2.15
1.5	9.15
2	40.35
2.5	180.75

18. Use trapezoidal rule to integrate $f(x) = \int_0^1 \frac{1}{1+x} dx$ with n=2 and 4. Compare the result with that obtained using Simpson's rule
19. Explain the significance of logistic map. Write a python program to plot the bifurcation diagram of logistic map function.

(4x3=12 weightage)