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1B2A23097 (Pages : 2) Reg. No:.........................

Name: ....

FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

Second Semester M.Sc Physics Degree Examination, April 2023

MPH2C05 – Quantum Mechanics – I

(2022 Admission onwards)

Time: 3 hours Max. Weightage : 30

Section A

Answer all questions, each carry weightage 1

1. What are linear operators ? Give an example of a linear operator
2. What is the Hermitian adjoint of an operator, and how is it related to the concept of an adjoint matrix in linear algebra?
3. Why are only Hermitian operators are associated with physical quantities in quantum mechanics?
4. Explain the concept of selective measurement in quantum mechanics.
5. Distinguish between eigen value and expectation value.
6. Write down the Schrodinger equation for a free particle and show that the wave function admitted is a plane wave
7. What is meant by correlation amplitude ?
8. What is the effective potential in central forced problems?

Total Weightage 8X1=8

Section B

Answer ANY TWO questions, each carry 5 weightage

9. Explain the importance of commutator algebra in quantum mechanics. Hence deduce the general uncertainty relation using commutators.
10. Starting from the radial wave equation for hydrogen atom problem, discus its solution leading to energy levels. What are the quantum numbers for hydrogen atom?
11. Find the eigenvalues for angular momentum operator J^2 and J_Z. Hence obtain matrices for J^2 and J_Z for J=1 systems.
12. Using the symmetries of the wave functions discuss the ground state of helium atom.

Total Weightage 2X5=10

Section C

Answer ANY FOUR questions, each carry 3 weightage

13. Show, for a Hermitian operator, that all of its eigen values are real. Also show that the eigen vectors corresponding to different eigen values are orthogonal.
14. Derive the energy eigen function for a particle in a square well potential
15. Prove that the operators $i\left(\frac{d}{dx}\right)$ and $\left(\frac{d^2}{dx^2}\right)$ are Hermitian.
16. What are time evolution operators? Give its properties.
17. Prove that the spin matrices S_X and S_Y have eigen values $\pm\frac{\hbar}{2}$
18. 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.
19. Derive the degeneracy relation for an isotropic harmonic oscillator.

Total Weightage 4X3=12

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FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

Second Semester M.Sc Physics Degree Examination, April 2023

MPH2C06 – Mathematical Physics – II

(2022 Admission onwards)

Time: 3 hours Max. Weightage : 30

Section A

Answer all questions, each carry weightage 1

1. Explain the significance reducible and irreducible representations.
2. Prove the function f(z) =sinz is analytic.
3. Mention any two problems solved using variation principle.
4. Solve using Neumann method $\Phi(x) = x + \frac{1}{2}\int_{-1}^{1}(t-x)\Phi(t)dt$
5. Explain symmetry property of Green's function .
6. Find the residue of the following function $f(z) = \frac{z\sin z}{(z-\Pi)^3}$ at $z=\pi$
7. Define groups, subgroups and classes using the rotation symmetry of square.
8. Find the eigen values and eigen functions of $\phi(x) = \lambda\int_{-1}^{1}(t+x)\phi(t)dt$

Total weightage 8x1=8

Section B

Answer ANY TWO questions, each carry weightage 5

9. a)State and prove Cauchy's integral formula $f(z_0) = \frac{1}{2\Pi i}\int_c \frac{f(z)dz}{(z-z_0)}$

   b)What is significance of Cauchy's integral theorem.
10. Explain the homomorphism of the groups SU(2) and SU(3)
11. Define Lagrangian multipliers and show that: (a) For a fixed length perimeter, the figure with maximum area is a circle. (b) for a given surface area ,the figure with maximum volume enclosed is a sphere .

12. Define Green's function .What are its properties? Find Green's function required for the boundary value problem $\frac{d^2y}{dx^2}+k^2y=f(x)$. Where f(x)is a known function of x and y(x) satisfies the boundary condition y(0)=0 and y(L)=0

Total Weightage 2x5=10

Section C

(Answer ANY FOUR questions, each carry weightage 3)

13. If an abelian group is constructed with two distinct element a and b such that $a^2=b^2=I$, where I is the group identity, what is the order of smallest abelian group containing a,b,I ?
14. Apply Euler equation to find the shortest distance between two points in Euclidean space.
15. Two dimensional rotation matrix is given below using this write down the four rotation matrices through angle $90^0,180^0,270^0,360^0$ Verify that these 4 matrices form a group under matrix multiplication .Write the Group multiplication table and show that the group is cyclic group of order four.

$$R(\theta)=\begin{bmatrix}\cos\theta & \sin\theta\\ -son\theta & \cos\theta\end{bmatrix}$$

16. Using method of complex variable show that $\int_0^{2\Pi}\frac{\cos 2\theta}{5+4\cos\theta}d\theta=\frac{\Pi}{6}$
17. Solve the forced oscillator problem using Green's function

$$x''+x=\cos t$$
$$x(0)=4$$
$$x'(0)=0$$

18. Obtain the integral equation corresponding to the boundary value problem

$y''(x)-y(x)=0$ with y(0)=0 y'(0)=1

19. Solve the equation $\phi(x)=x+\int_0^x(t-x)\phi(t)dt$

Total weightage 4x3=12

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FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

Second Semester M.Sc Physics Degree Examination, April 2023

MPH2C07 – Statistical Mechanics

(2022 Admission onwards)

Time: 3 hours Max. Weightage : 30

Section A

(Answer all questions, each carries weightage 1)

Total weightage 8x1=8

1. Explain the terms phase space and representative points.
2. State Liouville's theorem. What are its consequences?
3. Bring out the concept of ensembles in statistical mechanics. How are ensembles classified?
4. State and explain the equipartition theorem.
5. Distinguish between bosons and fermions.
6. What are symmetric and anti-symmetric wavefunctions? Explain
7. Discuss the T^3 law of specific heat of solids.
8. What is meant by Fermi energy?

Section B

(Answer ANY TWO questions, each carries weightage 5)

Total weightage 2x5=10

9. Explain Gibbs paradox and its resolution by deriving Sackur-Tetrode equation.
10. Define canonical partition function. Obtain the partition function for a system of classical ideal gas. How can you obtain various thermodynamic quantities of the system from it? Explain.
11. Discuss the thermodynamics of the black body radiation and obtain Stefan-Boltzmann law.
12. Explain Pauli paramagnetism and obtain the expression for susceptibility.

Section C

(Answer ANY FOUR questions, each carries weightage 3)

Total weightage 4x3=12

13. The free energy of a photon gas is given by the relation, $F = -\frac{a}{3}VT^4$, where a is a constant. Evaluate entropy and the pressure of the photon gas.
14. The entropy of a macro state of a system is 1 J/K while that of another is 1.001 J/K. How many more likely is the second macro state as compared to the first one?
15. Show that for an ideal gas the relative root mean square fluctuation in energy in a canonical ensemble is of the order of $1/\sqrt{N}$.
16. The energy eigen value of a one dimensional harmonic oscillator of frequency ω is, $E = (n + 1/2)\hbar\omega$ where $n = 0,1,2,...$ Find the partition function of the system of N oscillators. Also find the free energy per particle of the system.
17. Derive density matrix for a system in canonical ensemble.
18. Write the expressions for the mean occupation numbers in the cases of bosons, fermions and Maxwell-Boltzmann particles at temperature T, explain it graphically and show that the distinction between quantum and classical statistics tends to disappear as $\exp\{\frac{\varepsilon-\mu}{kT}\} \gg 1$ where μ is the chemical potential of the system and k is Boltzmann constant.
19. Atomic weight of lithium (Li) is 6.94 and its density is 530 kg/m^3. Calculate the Fermi energy and Fermi temperature of electrons in Li.

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FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

Second Semester M.Sc Physics Degree Examination, April 2023

MPH2C08 – Computational Physics

(2022 Admission onwards)

Time: 3 hours Max. weightage : 30

Section A

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

1. What is a random variable? Give example.
2. Write a python program to open a file and write 'Welcome to Python' to it.
3. List and explain any four methods to create a Numpy array.
4. Write a python program to plot the sine function from 0 to 2π.
5. Explain the characteristics of logistic equation.
6. What are dictionaries in PYTHON? Give an example.
7. Write a short note on Discrete Fourier Transform.
8. Discuss any two methods to create polynomials in Python.

(8x1=8)

Section B

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

9. Write down the following iteration commands in python with example
   1. While
   2. For
10. Discuss the principle, algorithm and program to solve second order harmonic oscillator equation using Runge Kutta method.
11. Differentiate between Newton's forward and backward difference interpolation formula.
12. Explain the numerical methods to solve second order differential equations with boundary conditions.

(2x5=10)

Section C

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

13. Write a python program to print prime numbers up to 100.
14. Using fourth order Runge Kutta method, estimate y(0.4) when $y'(x) = x^2 + 2y^2$ with y(0)=0. Design a python program for the problem.
15. Explain the simulation of logistic map using python.
16. Use Simpson's 1/3 rule to integrate $f(x) = \int_0^1 \frac{1}{1+x} dx$, with n=5.
17. Use trapezoidal rule to integrate $f(x) = \int_0^{\frac{\pi}{2}} \sqrt{sinx}\, dx$ with n=4 and 6.
18. Write Python code to solve the following system of equations,

$$2x + 3y + 4z = 8,\ 3x + 4y + 5z = 10,\ 4x - 5y + 6z = 32$$

(4x3=12)