C 23370 (Pages : 3) Name..................................

Reg. No..................................

SECOND SEMESTER M.Sc. DEGREE [REGULAR/SUPPLEMENTARY] EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 2C 08—COMPUTATIONAL PHYSICS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section/Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section/sub part/sub division may be ignored.*
4. *There will be an overall ceiling for each Section/Part that is equivalent to the maximum weightage of the Section/Part.*

Section A

(8 Short questions answerable within 7.5 minutes)
(Answer **all** *questions, each carry weightage 1)*

1. Explain the numeric data types in python programming.
2. What are global variables?
3. Write a python program to plot a sine wave from 0 to 2π.
4. What are the steps involved for reading a text file in python ?
5. Explain the process of curve fitting.
6. Give the basic differences between initial value and boundary value problems.
7. Write a program to create a NumPy array of integers {1, 2, 3, 4, 5}.
8. What is a dictionary in python ?

($8 \times 1 = 8$ weightage)

Turn over

C 23370 (Pages : 3) Name.......................................

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SECOND SEMESTER M.Sc. DEGREE [REGULAR/SUPPLEMENTARY] EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 2C 08—COMPUTATIONAL PHYSICS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

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Section A

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1. Explain the numeric data types in python programming.
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8. What is a dictionary in python ?

($8 \times 1 = 8$ weightage)

Turn over

Section B

(4 essay questions answerable within 30 minutes)

(Answer any **two** *questions, each carry weightage 5)*

9. Explain the least square curve fitting method for a polynomial of nth degree.

10. Using Newton's forward difference formula, derive a general formula for numerical integration and hence establish Simpson's one-third rule.

11. Explain the Runge-Kutta method of fourth order. Using this method, evaluate the value of y (0.2) for the function :

$$\frac{\partial y}{\partial x} = 1 + y^2 \,;\, x_0 = 0 \,;\, y_0 = 0.$$

12. Write a python program to estimate the value of π using Monte Carlo simulation method.

(2 × 5 = 10 weightage)

Section C

(7 problems answerable within 15 minutes)

(Answer any **four** *questions, each carry Weightage 3)*

13. Write a Python program to find the factorial of a number provided by the user.

14. Write a Python program to analyse the Fourier series of a triangular wave function.

15. The function $y = \sin(x)$ is tabulated below :

x	$y = \sin(x)$
0	0
π/4	0.70711
π/2	1.0

Find the value of sin(π/6) using Lagrange's interpolation formula.

16. Approximate the area under the curve, $y = \frac{1}{x}$, between $x = 1$ and $x = 5$ using the trapezoidal rule with $n = 4$ sub-intervals.

17. Use Simpson's rule with $n = 4$ to approximate the integral :

$$\int_0^8 \sqrt{x}\, dx.$$

18. Write a short note on Numerov's method in numerical analysis.

19. Write a python program to obtain the trajectory of a freely falling body using Euler method.

(4 × 3 = 12 weightage)

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SECOND SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 2C 07—STATISTICAL MECHANICS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
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4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

8 *Short questions answerable within* 7.5 *minutes.*
Answer **all** *questions, each question carries weightage* 1.

1. Differentiate between μ-space and Γ-space.
2. Explain Gibb's paradox.
3. A system has three energy levels $\in, 2\in$ and $3\in$. Determine the partition function
4. What do you mean by a grand canonical ensemble and write an expression for the density function?
5. State the postulates of equal a priori probability.
6. Why is the electronic contribution to the specific heat of a metal vary with temperature at low temperatures ?
7. How is Bose-Einstein condensation different from the ordinary condensation of a gas in physical space ?
8. What do you mean by an ideal Fermi Gas ?

($8 \times 1 =$ 8 weightage)

Turn over

Section B

4 essay questions answerable within 30 minutes.
Answer any **two** *questions, each question carries weightage 5.*

9. Derive Liouville's theorem and explain its consequences.
10. Explain microcanonical ensemble. Find the quantum states and the phase space of linear harmonic oscillator.
11. Derive Plank's formula for black body radiation using Bose-Einstein statistics. Using the result, deduce Stefan's-Boltzmann law.
12. Explain Pauli Para magnetism and obtain the expression for susceptibility.

(2 × 5 = 10 weightage)

Section C

7 problems answerable within 15 minutes.
Answer any **four** *questions, each question carries weightage 3.*

13. The energy of a mole of an ideal gas at constant volume is doubled. How would the total number of available microstates change ?
14. A composite system has two interacting systems 1 and 2 having thermodynamic probabilities $\Omega_1 = 8 \times 10^{20}$ and $\Omega_2 = 3 \times 10^{19}$,
    (i) Calculate the individual entropies S_1 and S_2 of the two systems.
    (ii) Also calculate the total entropy and the thermodynamic probability of the composite system.
15. A system in a canonical ensemble is at a temperature of 400 K. If the probability of the system being in a microstate 1 is 3 times the probability of it being in microstate 2, which of the two states has higher energy and by how much ?
16. Find the condensation temperature for the vapour of Rb^{87} atom at a number density of $n = 2.5 \times 10^{12}$ cm^{-3} treating it as a B.E gas.
17. Derive the density matrix for a system in a canonical ensemble.
18. TheFermi energy in silver is 5.49 eV. What is the average energy of a free electron in silver at 0K ? At what temperature would the molecules of an ideal classical gas have this much average energy ?
19. The cosmic microwave background radiation (CMBR) has a temperature of ≈ 2.7 K. Find out the wavelength λ_m corresponding to maximum spectral density of the cosmic background radiation. What photon energy corresponds to the maximum U_λ ?

(4 × 3 = 12 weightage)

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Reg. No.................................

SECOND SEMESTER M.Sc. DEGREE [REGULAR/SUPPLEMENTARY] EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 2C 06—MATHEMATICAL PHYSICS—II

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
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4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

(8 short questions answerable within 7.5 minutes)
(Answer all questions, each question carries weightage 1.

1. How can a function $f(z)$ be expanded where $f(z)$ is singular ? Briefly explain.
2. Show that three cube roots of unity form an abelian group under multiplication.
3. Discuss about the generators of the SU (2) group.
4. Using the variation principle discuss the problem on curve of shortest length connecting two points in a plane.
5. Explain the role of Lagrange Multipliers.
6. Define an integral equation and explain its significance.
7. Explain the symmetry property of Dirac-delta function.
8. State and provide proof of Cauchy's integral formula.

(8 × 1 = 8 weightage)

Turn over

Section B

(4 essay questions answerable within 30 minutes)

Answer any **two** *questions, each question carries weightage* 5.

9. Obtain the solution to the Poisson's equation using Green's function.

10. Show that a twofold homomorphism exists between the group of 2 × 2 unitary matrices and the SO (3) group.

11. Explain the Rayleigh-Ritz variation technique for the computation of approximate solutions to partial differentiation equations.

12. Deduce the Cauchy-Reimann condition for a function to be analytic.

(2 × 5 = 10 weightage)

Section C

(7 problems answerable within 15 minutes)

(Answer any **four** *questions, each carry Weightage 3)*

13. Find Laurent series of function $f(z) = \frac{1}{(1 - z^2)}$ with centre at $z = 1$.

14. Construct the group multiplication table for the Vierrer group.

15. Find the residues of $f(z) = \frac{ze^z}{(z = a)^3}$ at $z = a$.

16. Obtain the eigen functions for Green's function.

17. Find the extremals of the functional $\int_{x_0}^{x_1} \frac{y'^2}{x^3}\, dx$.

18. Prove that the inverse of the product of two elements of a group is the product of the inverse in reverse order.

19. Solve the integral equation $s = \int_0^s e^{s-t}\, g(t)\, dt$.

(4 × 3 = 12 weightage)

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SECOND SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 2C 05—QUANTUM MECHANICS–I

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
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4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

(8 *short questions answerable within* 7.5 *minutes*)
(*Answer* **all** *questions, each carry weightage* 1).

1. Explain Dirac bra and ket vectors.
2. Explain linear vector space.
3. Give the basic features of interaction picture.
4. State and explain Ehrenfest's theorem.
5. Briefly explain addition of angular momenta.
6. Explain the properties of Pauli spin matrices.
7. Distinguish between symmetric wavefunction and antisymmetric wavefunction.
8. What are the applications of quantum harmonic oscillator ?

(8 × 1 = 8 weightage)

Section B

(4 *essay questions answerable within* 30 *minutes*)
(*Answer any* **two** *questions, each carry weightage* 5).

9. Explain what is meant by a Hermitian operator. Show that :

   (a) The eigen values of a Hermitian operator are real and

   (b) Eigen functions of a Hermitian operator belongs to different eigen values are orthogonal.

10. Discuss the problem of addition if angular momentum in quantum mechanics. Calculate the Clebsch-Gordan co-efficients for $J_1 = \frac{1}{2}$ and $J_2 = \frac{1}{2}$.

11. Describe Schrödinger equation for central potentials and hence describe Hydrogen atom.

12. Solve the problem of simple harmonic oscillator using operator method.

(2 × 5 = 10 Weightage)

Section C

(7 *problems answerable within* 15 *minutes*)
(*Answer any* **four** *questions, each carry weightage* 3).

13. If $[A,L_x]=[A,L_y]=[A,L_x]=0$. What is the value of $[A^2,L^2]$?

14. Show that the expectation value of the momentum P for a bound state of a one particle system is zero for a stationary state.

15. Show that the zero-point energy of a linear harmonic oscillator is a manifestation of the uncertainty principle.

16. Prove that the spin matrices S_x matrix and S_y have $\pm\frac{\hbar}{2}$.

17. The position of an electron is measured with an accuracy of 10^{-6} *m*. Find the uncertainty in the electron's position after 1 s. Comment on the result.

18. Show that the expectation value of an observable, whose operator does not depend on time explicitly, is a constant with zero uncertainty.

19. For Pauli's matrices, prove that (i) $[\sigma_x,\sigma_y] = 2i\sigma_z$. (ii) $\sigma_x\sigma_y\sigma_z = i$.

(4 × 3 = 12 weightage)

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Reg. No.................................

SECOND SEMESTER M.Sc. DEGREE (SUPPLEMENTARY) EXAMINATION APRIL 2022

(CUCSS)

Physics

PHY 2C 08—COMPUTATIONAL PHYSICS

(2017 to 2018 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*
Each question carries weightage 1.

1. What is the different input methods used in python ?
2. Define syntax. Discuss the syntax of while loop.
3. Briefly discuss the different functions used for creating arrays in python.
4. How can we save and restore a python file ?
5. What is meant by curve fitting ?
6. Discuss trapezoidal rule for numerical integration.
7. Define eigen values and eigen vectors.
8. Briefly discuss Euler method for solving ordinary differential equations.
9. Discuss Fourier transform.
10. Write a short note on logistic maps.
11. What are packages ? Give examples.
12. How can we compute the inverse of a square matrix in python ?

($12 \times 1 = 12$ weightage)

Section B

Answer any **two** *questions.*
Each question carries weightage 6.

13. Write an essay on operators used in python. Discuss operator precedence in python language.
14. Illustrate Fourier series. Write python program to generate square wave and sawtooth wave using this technique.

Turn over

15. Explain interpolation and also obtain Newton's forward interpolation formula.

16. With suitable flow chart and program, discuss the motion of a body falling in viscous medium.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*
Each question carries weightage 3.

17. What are functions ? How can we define and call a function ? Give one example.

18. Write programs to draw a circle which satisfies the equation :

    1. $x^2 + y^2 = a^2$.

    2. $x = a\cos(t)$ and $y = a\sin(t)$.

19. By using Newton's backward interpolation formula, find the value of y for $x = 34$ from the following data :

x	30	35	40	45	50
y	15	18	21	24	27

20. Given $dy/dx = 1 + y^2$ where $y = 0$ when $x = 0$. Find y (0.2), y (0.4) and y (0.6) using fourth order Runge Kutta method.

21. With Suitable flow chart, discuss the motion of a body under central force.

22. Obtain Simpson's one third rule of numerical integration.

(4 × 3 = 12 weightage)

C 23155 (Pages : 2) Name.....................................

Reg. No..................................

SECOND SEMESTER M.Sc. DEGREE (SUPPLEMENTARY) EXAMINATION, APRIL 2022

(CUCSS)

Physics

PHY 2C 07—STATISTICAL MECHANICS

(2017 to 2018 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer all **twelve** *questions.*
Each question carries 1 *weightage.*

1. Define chemical potential. How can it be connected to number of microstates (Ω) ?

2. Explain the importance of the factor $\frac{1}{n!}$ in the enumeration of number of microstates. Illustrate your answer with an example .

3. What is Ensemble ? What is the advantage of ensemble formulation of statistical mechanics

4. State and explain Virial theorem

5. Derive the partition function of an ideal gas.

6. Distinguish between Bosons and Fermions.

7. Explain Slater determinant.

8. Find the number of ways for arranging n fermions in g states $(g >> n)$.

9. Define g-function. Show that $Z \frac{\partial}{\partial z} g_v(z) = g_{v-1}(z)$.

10. Show that Raleigh Jeans formula follows from Planks radiation law under low frequency conditions

11. Explain Landau diamagnetism.

12. Free electron gas at room temperature is a completely degenerate Fermi system-Verify.

(12 × 1 = 12 weightage)

Turn over

Section B

Answer any **two** *questions.*
Each question carries 6 *weightage.*

13. Explain Gibb's Paradox. How is it resolved ?

14. Considering a system as a member of canonical ensemble find the most probable number of systems occupying an energy state E_r. Hence derive the partition function for the system.

15. Define and explain density matrix. Derive an equation of motion for density matrix. What is its importance ?

16. Discuss the thermodynamics of ideal Fermi gas at finite, low tempertures (strongly degenerate)

[2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*
Each question carries 3 *weightage.*

17. Assuming that entropy S and statistical factor Ω are arbitrarily related as $S = f(\Omega)$, show that additive nature of S and multiplicatve nature of Ω necessarily require that $S = k \ln \Omega$.

18. Show that the density fluctuations in grand canonical ensemble is of the order of $\left(1/\sqrt{N}\right)$ where N is the number of particles in a system.

19. 4 particles are to be accommodated in 10 single particle states of equal energy. Calculate the number of ways of distribution if the particles obey i) Fermi-Dirac Statistics ; ii) Bose-Einstein Statistics ; and iii) Maxwell Boltzman Statistics.

20. Show that Bose Einstein condensation involves latent heat.

21. Derive Stefan's law from Plank's radiation formula.

22. Calculte Fermi energy and Femi temperature for electron gas at relativistic energy.

(4 × 3 = 12 weightage)

C 23154 (Pages : 2) Name.......................................

Reg. No...................................

SECOND SEMESTER M.Sc. DEGREE (SUPPLEMENTARY) EXAMINATION APRIL 2022

(CUCSS)

Physics

PHY 2C 06—MATHEMATICAL PHYSICS—II

(2017 to 2018 Admissions)

Time : Three Hours Maximum : 36 Weightage

Part A

Answer all **twelve** *questions.*
Weightage 1 *each.*

1. Check the function $f(z) = \sin z$ is holomorphic or not.
2. What is meant by a harmonic function ? Write an example.
3. Show that the set of all $n \times n$ unitary matrixes forms a group under matrix multiplication.
4. Write any two applications of Group theory in Physics.
5. What is Fermat's principle in connection with calculus of variations ?
6. Write one application of constructing the geodesics on a curved surface.
7. What is the storekeeper's control problem ?
8. Consider a differential equation $y'(x) = f(x, y)$ with $y(x_0) = y_0$. Write an equivalent integral equation.
9. What is the meaning of the property $G(x, s) = G(s, x)$ of Green's function ?
10. Write two properties of one dimensional Green's function.
11. Write two physical quantities which can be expressed as a complex number.
12. The set of complex numbers $G = \{1, i, -1, -i\}$ under multiplication. Write the multiplication table for this group.

(12 × 1 = 12 weightage)

Turn over

Part B

Answer any **two** *questions.*
Weightage 6 *each.*

13. Derive Cauchy's Integral formulae.

14. What are the properties of a group ? Write the group of symmetry transformations of an equilateral triangle.

15. Explain the method of Lagrangian multipliers in the calculus of variations. Also describe the example of cylindrical nuclear reactor.

16. Describe the Neumann series way of solving integral equations.

($2 \times 6 = 12$ weightage)

Part C

Answer any **four** *questions.*
Weightage 3 *each.*

17. Prove the relation between greens function and Dirac delta function.

18. Find the first four terms of the Taylor series expansion of the complex variable function $f(z) = 1 / \{(z - 3)(z - 1)\}$ about $z = 4$.Find the region of convergence.

19. Write three examples of groups, and explain how they form the specific group.

20. Show that the demand electric field energy be minimum leads to Laplace's equation.

21. Write any three standard integral transforms and their reverse transforms.

22. Find the Green's function corresponding to a linear oscillator using standard boundary conditions.

($4 \times 3 = 12$ weightage)

C 23153 (Pages : 2) Name.......................................

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SECOND SEMESTER M.Sc. DEGREE (SUPPLEMENTARY) EXAMINATION APRIL 2022

(CUCSS)

Physics

PHY 2C 05—QUANTUM MECHANICS—I

(2017 to 2018 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

(Total 12 questions each answerable within 5 minutes)
Answer **all** *questions, each carries weightage* 1.

1. What is a Hilbert space ?
2. Prove that for a Hermitian operator, all of its eigen values are real and the eigen vectors corresponding to different eigen values are orthogonal.
3. Show that the expectation value of an operator that does not depend on time and that commutes with the Hamiltonian is constant in time.
4. What is a wave packet ? Give the physical interpretation.
5. Evaluate $[J_+, J_-]$.
6. Distinguish between Schrodinger and Heisenberg pictures of time development.
7. What are Spherical Harmonics ? How is the Spherical Harmonics related to Legendre polynomials ?
8. The first excited state of isotropic Harmonic oscillator is three fold degenerate. Justify the statement.
9. What is slater determinant ?
10. Show that rotational symmetry implies the conservation of angular momentum.
11. What is differential scattering cross section ? What is its unit ?
12. Under what conditions is the Born approximation for scattering problem is valid ? Justify your answer.

(12 × 1 = 12 weightage)

Section B

(4 Essay questions, each answerable within 30 minutes)
Answer any **two** *questions, each carries weightage 6.*

13. Find the solution of the time-independent Schrödinger equation and energy for the particle of mass m confined to move inside a one dimensional infinitely deep potential well.

14. Discuss on the eigen functions and eigen values of L_z and L^2.

15. Discuss the solutions of radial part of the Time-independent Schrodinger equation for the hydrogen atom.

16. Illustrate the method of partial waves for elastic scattering with respect to spherically symmetric potential.

(2 × 6 = 12 weightage)

Section C

(6 Problem questions, each answerable within 15 minutes)
Answer any **four** *questions, each carries weightage 3.*

17. Evaluate the commutator $[x, p]$ and show that it is representation independent.

18. Show that the transformation matrix which connects two *complete* and *orthonormal* bases is *unitary*.

19. Show that Poisson bracket of any pair of classical variables can be obtained from the commutator between the corresponding pair of quantum operators by dividing it by i.

20. Find the matrix elements of the operator J_y for $j = 1$.

21. Find the energy and wave function for the ground state of Helium atom.

22. Calculate the differential cross section for coulomb potential for the first Born approximation.

(4 × 3 = 12 weightage)