C 83541 (Pages : 3) Name..................................

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

SECOND SEMESTER P.G. DEGREE EXAMINATION, APRIL 2020

(CCSS)

M.Sc. Physics

PHY 2E 03—COMPUTATIONAL TECHNIQUES AND FORTRAN PROGRAMMES

(2019 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

Twelve Short questions answerable within 5 minutes.
Answer **all** *questions, each carries 2 marks.*

1. State and explain Location of roots theorem.
2. Explain the principle of the false position method of finding the roots of a transcendental equation.
3. Define forward differences. The fourth differences for a given set of data are constants and the fifth differences are zeros. What is the significance ?
4. Prove the uniqueness theorem for the interpolating polynomial.
5. Give the essence of finite difference approximation.
6. Write down and explain Laplace equation. Give one physical example where such equation is relevant.
7. What is Crammer's rule ? What is its application ?
8. Explain how successive elimination of unknowns in a system of linear equation is effected via division by the leading co-efficients.
9. What is the principle of the Trapezoidal rule for numerical integration.
10. Explain any *two* modes in which a file may be opened in fortran. Give examples.
11. Briefly explain how a two dimensional array is declared and used in a Fortran code, giving an example.
12. Explain formatted input and output statements in Fortran, with an example each.

($12 \times 2 = 24$ marks)

Section B

Four essay questions answerable within 30 *minutes.*

Answer any **two** *questions, each carries* 14 *marks.*

13. (a) Explain the principle of the linear least squares fit method for fitting a given (x, y) data set.

    (b) Establish expressions for the relevant parameters of the fit.

14. (a) Derive Simpson's 3/8 rule for numerical integration.

    (b) Compare with the Trapezoidal rule in terms of the error involved.

15. (a) Illustrate how a set of simultaneous equations can be solved by matrix methods, bringing out clearly the principles involved.

    (b) Establish the condition on the matrix of the co-efficients for a non trivial solution to exist.

16. (a) What are conditional statements ? When are they necessary in a fortran program ?

    (b) Discuss the two types of conditional statements used in fortran using 'if' with examples, explaining the use of "else".

(2 × 14 = 28 marks)

Section C

six *problems answerable within* 15 *minutes.*
Answer any **four** *questions, each carries* 7 *marks.*

17. Apply the Newton-Raphson method to find out one extremum value of the function $f(x) = f(x) = 3x^3 - 10x^2 - 56x + 5$. Ascertain if it is a minimum or a maximum.

18. Carry out a linear least squares analysis of the following set of (x, y) data :

X	– 2	3	8	11	15
Y	– 52.1	– 20.3	14	37.5	72

Find out the value of y at $x = 3.5$.

19. Solve the initial value problem numerically, by applying Euler's method :

$y' = x + 2y$ given $y(0) = 0$, using steps of size $h = 0.25$.

Find a value for the solution at $x = 1$, and using steps of size $h = 0.25$.

20. Obtain the determinant of the matrix :

$$A = \begin{matrix} 4 & 3 & 2 \\ 3 & 6 & 1 \\ 2 & 7 & 5 \end{matrix}$$

Check whether the matrix is orthogonal.

21. Obtain the two roots of the quadratic equation $x^2 - 3x + 1 = 0$ by applying the bisection method. Compare with the correct values.

22. Given the three points (x_1, y_1), (x_2, y_2) and (x_3, y_3), it is required to check whether they are collinear. Write a Fortran program for carrying out this task. The co-ordinates of the three points are to be read from the keyboard. Save the output to a file.

(4 × 7 = 28 marks)

C 83538 (Pages : 2) Name...

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

SECOND SEMESTER P.G. DEGREE EXAMINATION, APRIL 2020

(CCSS)

M.Sc. Physics

PHY 2C 09—STATISTICAL MECHANICS

(2019 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

Answer all **twelve** *questions.*
Each question carries 2 *marks.*

1. What is a macrostate ? Give an example.
2. What is Ω for N particle ideal gas ?
3. Why is phase space necessary in statistical mechanics ?
4. What is the bridging equation in canonical ensemble ?
5. What is the partition function for N particle quantum harmonic oscillator in 3 dimension ?
6. What is density matrix ?
7. What are distinguishable particles ? Give examples.
8. How is pressure and energy of an ideal Fermi gas related.
9. How is entropy for a photon gas related to temperature.
10. What is Fermi temperature ?
11. What is Brownian motion ?
12. What are fluctuations ?

(12 × 2 = 24 marks)

Section B

Answer any **two** *questions.*
Each question carries 14 *marks.*

13. Explain microcanonical ensemble method of obtaining Sackur Tetrode equation.
14. State and prove Liouvillies theorem.

Turn over

15. Obtain equation of state of an ideal gas using grand canonical ensemble.

16. Discuss Ising model in zeroth approximation.

(2 × 14 = 28 marks)

Section C

Answer any **four** *questions.*
Each question carries 7 marks.

17. Find an expression for the entropy of an ideal gas using canonical ensemble without Gibbs paradox.

18. Find an expression for adiabatic expansion of a photon gas.

19. Starting from black body distribution obtain Wien's displacement law.

20. If number density of electrons in a metal placed in room temperature 300K is $10^{28}/m^3$, what is the Fermi temperature ? Is the system degenerated.

21. A large number N of Brownian particles in one dimension start their diffusive motion from the origin at time $t = 0$. The diffusion co-efficient is D . Find the number of particles crossing a point at a distance L from the origin, per unit time.

22. 2 particles are to be distributed in 3 states in a system. Find the number of microstates if the system is obeying Bose, Fermi and Maxwell distributions.

(4 × 7= 28 marks)

C 83537 (Pages : 2) Name..............................

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

SECOND SEMESTER P.G. DEGREE EXAMINATION, APRIL 2020

(CCSS)

M.Sc. Physics

PHY 2C 08—MATHEMATICAL PHYSICS—II

(2019 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

Answer **all** *questions.*
Each question carries 2 *marks.*

1. Show that z^* is not analytic.
2. What is meant by singularity ?
3. What are residues ?
4. State rearrangement theorem.
5. What are subgroups ?
6. What is isomorphism ?
7. What are unitary representations ?
8. What are SU(2) groups ?
9. What is Rayleigh Ritz variational technique ?
10. What are Lagrange multipliers.
11. What is Sturm Liouville operator ? Give example.
12. What are the properties of Green's function ?

(12 × 2 = 24 marks)

Section B

Answer any **two** *questions.*
Each question carries 14 *marks.*

13. State and prove Cauchy's integral theorem.
14. State and prove Schur's Lemmas.

Turn over

15. Explain the method of Lagrange multipliers. Using it show that for minimum energy the shape of the box for a quantum particle is a cube.

16. Define Greens function. Obtain expressions for Green's functions based on its properties. Give the formula for the solution of a non-homogeneous differential equation in terms of Green's function.

(2 × 14 = 28 marks)

Section C

Answer any **four** *questions.*
Each question carries 7 marks.

17. Show that z^2 is analytic.

18. Integrate using Cauchy integral formula :

$$\oint \frac{dz}{z(z+2)}.$$

19. Obtain the symmetry representations of an equilateral triangle.

20. Show that

$$\sigma_2 = \begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix}$$

is the generator of SO(2) group.

21. Find an integral equation equivalent to linear oscillator equation

$$y'' + \omega^2 y = 0.$$

22. Derive the Green's function for the operator $-\frac{d^2}{dx^2}$ with the boundary conditions $y(0) = 0$ and $y(1) = 0$. Hence find the solution.

(4 × 7 = 28 marks)

C 83536 (Pages : 2) Name.......................................

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

SECOND SEMESTER P.G. DEGREE EXAMINATION, APRIL 2020

(CCSS)

M.Sc. Physics

PHY 2C 07—QUANTUM MECHANICS–I

(2019 Admissions)

Time : Three Hours | Maximum : 80 Marks

Section A

12 Short questions answerable within 5 minutes.
Answer **all** *questions.*
Each question carries 2 *marks.*

1. Explain the properties of Pauli spin matrices.
2. What is the quantum mechanical operator representing energy ?
3. What is the condition for two eigen vectors to be orthogonal ?
4. Give the basic features of interaction picture.
5. Explain what is meant by a Hilbert space.
6. Why time reversal operator is not linear ?
7. Explain the matrix representation of a wave function.
8. Define general angular momentum operator.
9. The energy of a state does not depend on the spin wave function. Why ?
10. Define differential cross section and total cross section. What is the unit in which they are measured ?
11. Conservation of angular momentum is a consequence of the rotational invariance of the system. Substantiate.
12. Discuss the validity of Born Approximation.

($12 \times 2 = 24$ marks)

Section B

4 Essay questions answerable within 30 minutes.
Answer any **two** *questions.*
Each question carries 14 *marks.*

13. What is phase shift ? Explain the nature of phase shift in the case of attractive square well potentials.

Turn over

14. Apply Schrödinger picture to get the energy eigen values of linear harmonic oscillator.

15. What are clebsch Gordan co-efficients ? Mention their properties and selection rules.

16. Explain what is mean by a Hermitian operator. Show that :

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

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

(2 × 14 = 28 marks)

Section C

6 Problems answerable within 15 minutes.

Answer any **four** *questions.*

Each question carries 7 marks.

17. For the operators A, B and C show that [[A, B], C] + [[B, C],A] + [[C, A], B] = 0.

18. Prove that the operators $i\left(\frac{d}{dx}\right)$ and $\frac{d^2}{dx^2}$ are Hermitian.

19. Evaluate the scattering amplitude in the Born approximation for scattering by the Yukawa potential $V(r) = V_0 \exp\frac{-\alpha r}{r}$.

20. A bullet of mass 0.03 kg is moving with a velocity 500 m/s. The speed is measured up to an accuracy of 0.02%. Calculate the uncertainty in x. Also comments on the result.

21. Calculate the expectation value of position $\langle x \rangle$ and of the momentum $\langle p_x \rangle$ of the particle trapped in the one-dimensional box.

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

(4 × 7 = 28 marks)

C 83535 (Pages : 2) Name..................................

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

SECOND SEMESTER P.G. DEGREE EXAMINATION, APRIL 2020

(CCSS)

M.Sc. Physics

PHY 2E 03—COMPUTATIONAL TECHNIQUES AND FORTRAN PROGRAMMES

(2017 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

Answer **all** *questions.*
Each question carries two marks.

1. When does bisection method is more useful than Newton-Raphson method ?
2. Derive Newton-Raphson iteration formula.
3. Explain midpoint rule.
4. What is Jacobi's iteration ?
5. What is the meaning of pivoting in solving linear systems.
6. Explain how complex roots of a nonlinear equation is determined.
7. Discuss briefly how the least square method is used for fitting a linear function.
8. Why is Householders algorith used ?
9. Explain the concept of pointers in Fortran 90.
10. How a file can be opened and write data into it ?
11. What is the difference between functions and subroutines ?
12. Write a program for exchanging the values of two variables.

(12 × 2 = 24 marks)

Section B

Answer any **two** *questions.*
Each question carries 14 *marks.*

13. (a) Explain false position method for finding the roots of non-linear equation ; (b) Write a program for solving nonlinear equation $f(x) = 0$ employing false position method ; (c) Explain the geometric meaning of this method.

Turn over

14. Derive trapezoidal rule and Simpson's 1/3 formula for the determination of definite integral. Apply both of these methods for evaluation of $\int_1^3 \frac{1}{x} dx$, using 4 strips and compare error in each case.

15. Discuss the theory and algorithm for Lagrange's interpolation method.

16. Discuss Euler method for the solution of ordinary differential equation. Explain how this can be applied to the case of Newton's equation of motion for a particle moving in one dimension, under a given force function, $f(x, \dot{x}, t)$.

(2 × 14 = 28 marks)

Section C

Answer any **four** *questions.*
Each question carries 7 mark.

17. Write a program for finding the factorial of a positive integer, with and without using recursive function definition.

18. Given $\frac{fy}{dx} = y - x$ where $y(0) = 2$, find $y(0.1)$ and $y(0.2)$ correct to four decimal places using Runge-Kutta method.

19. Discuss error in Euler's algorithm.

20. Derive Newton's forward interpolation formula.

21. Reduce the matrix :

$$\begin{bmatrix} 1 & 3 & 4 \\ 3 & 2 & -1 \\ 4 & -1 & 1 \end{bmatrix}$$

to tridiagonal form.

22. Write a program for solving system of 3 linear equations in 3 unknowns.

(4 × 7 = 28 marks)

C 83534 (Pages : 2) Name.......................................

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

SECOND SEMESTER P.G. DEGREE EXAMINATION, APRIL 2020

(CCSS)

M.Sc. Physics

PHY 2C 09—STATISTICAL MECHANICS

(2017 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

Answer all **twelve** *questions.*
Each question carries 2 *marks.*

1. Distinguish between extensive and intensive properties with examples.
2. Explain Gibb's paradox.
3. What is an ensemble ? Give the characteristics of the three ensembles in statistical mechanics.
4. Establish the relationship between partition function and Helmholtz energy.
5. Define phase trajectory. Show that the phase trajectory of classical harmonic oscillator is an ellipse.
6. Define Fugacity. Explain its significance.
7. Write down the quantum mechanical version of Liouville's theorem. On the basis of it explain density matrix.
8. Distinguish between bosons and fermions.
9. Define thermal wave length. What is its limiting value for a classical system ?
10. Explain lambda (λ) transition with reference to ^4He.
11. What do you understand by the term co-operative phenomena ? What are their important characteristics ?
12. What is William Bragg approximation ?

($12 \times 2 = 24$ marks)

Section B

Answer any **two** *questions.*
Each question carries 14 *marks.*

13. Give classical micro canonical treatment of ideal gas and derive its thermodynamic properties.

14. Explain how a system in thermal equilibrium can be treated under canonical ensemble and hence derive the thermodynamic properties.

15. Discuss the properties of an ideal Bose gas leading to Bose Einstein condensation. Derive the criterion for the condensation to occur.

16. Give an account of Langevin's theory of Brownian motion.

(2 × 14 = 28 marks)

Section C

Answer any **four** *questions.*
Each question carries 7 *marks.*

17. One Joule of heat is supplied to 1 litre of water. Find out the increase in number of microstates accessible to the system.

18. A solid containing non interacting paramagnetic atoms each having magnetic dipole moment equal to one Bohr magneton, is placed in a field of flux density 4 Tesla. Find the temperature to which the solid has to be cooled for more than 60% of the atoms are polarized with their magnetic moments parallel to the field.

19. Show that $\langle E^2 \rangle - \langle E \rangle^2 = kT^2 C_v$ where the symbols have their usual meaning.

20. Find out the mean energy of a quantum mechanical oscillator in equilibrium with a thermal reservoir at temperature T K.

21. Calculate the Fermi temperature and Fermi energy of the valence electrons of sodium metal. Density of Sodium = 0.97 gm/cc and its atomic weight is 23 u.

22. Define Fermi-Dirac function $f(z)$.Derive its relationship with $f_{v-1}(z)$. Establish the equation of state of ideal Fermi gas using $f_v(z)$.

(4 × 7 = 28 marks)

C 83533 (Pages : 2) Name.....................................

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

SECOND SEMESTER P.G. DEGREE EXAMINATION, APRIL 2020

(CCSS)

M.Sc. Physics

PHY 2C 08—MATHEMATICAL PHYSICS–II

(2017 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

Answer **all** *questions.*
2 *marks each.*

1. List the Cauchy Riemann conditions for analytic functions.
2. Identify the type of singularity in (a) $e^{1/z}$; (b) $\frac{\sin z}{z}$.
3. Give all the group axioms.
4. Define an invariant subgroup.
5. Write any 3 properties of group homomorphism.
6. Give the rules for construction of character tables.
7. State Schur's second lemma.
8. Show that character is identical for all members inside a class.
9. Define Fredholm integral of first and second kind.
10. What is Euler Lagrange equation in calculus of variations ? What are the boundary conditions on its functional ?
11. Discuss the physical interpretations of Green's function.
12. What is Rayleigh-Ritz variational method ?

(12 × 2 = 24 marks)

Section B

Answer any **two** *questions.*
14 *marks each.*

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

    (b) Expand $f(z) = \frac{1}{z-5}$ in Laurent series where $|z| < 5$.

Turn over

14. Discuss any symmetry group with multiplication table. Then find its classes. How classes are related to irreducible representations ?

15. Explain the method of Rayleigh Ritz variational technique. Use it to obtain ground state energy and wavefunction of an atomic system.

16. Solve quantum mechanical scattering problem using a suitable Green's function.

(2 × 14 = 28 marks)

Section C

Answer any **four** *questions.*
7 marks each.

17. Given (a) $\sin z$; (b) $|z|^2$. Find the analytic function(s).

18. Show that G = {1, – 1, i, – i} is a group under multiplication. Identify its generators.

19. Find the value of $\int_0^{2\pi} \frac{d\theta}{a+b\cos\theta}$; $a > b > 0$.

20. Show that set of orthogonal matrices with determinant +1 forms a group under matrix multiplication.

21. Ground state energy of a particle in a box of sides a, b, c is given by $E = \frac{\pi^2\hbar^2}{2m}\left(\frac{1}{a^2}+\frac{1}{b^2}+\frac{1}{c^2}\right)$.

Find the shape of box using Lagrange undetermined multipliers for minimum energy.

22. Convert $\frac{d^2y(x)}{dx^2} = 0$ into an integral equation ; Given that $y(0) = 1, y'(0) = 0$.

(4 × 7 = 28 marks)

C 83532 (Pages : 3) Name..........................

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

SECOND SEMESTER P.G. DEGREE EXAMINATION, APRIL 2020

(CCSS)

M.Sc. Physics

PHY 2C 07—QUANTUM MECHANICS—I

(2017 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

Answer all **twelve** *questions.*

Each question carries 2 *marks.*

1. Check whether the following set of functions is linearly independent / dependent : $f(x) = x$, $g(x) = x^2$ and $h(x) = x^3$.

2. What is Hilbert space ?

3. Consider the states $|\psi\rangle = 3i|\varphi_1\rangle - 7i|\varphi_2\rangle$ and $|\chi\rangle = -|\varphi_1\rangle + 2i|\varphi_2\rangle$ where $|\varphi_1\rangle$ and $|\varphi_2\rangle$ are ortho-normal. Evaluate $\langle\psi/\chi\rangle$ and $\langle\chi/X\rangle$. Are they equal ?

4. What is the importance of the super-position principle in Quantum Mechanics.

5. Evaluate the commutator $[x^3, p_x]$.

6. What are the Ehrenfest's theorems ?

7. What are the essential features of the Schrödinger and Heisenberg pictures of time development.

8. Evaluate $[x, [x, H]]$, where H is the Hamiltonian operator.

9. Evaluate $[L_z, \cos(\varphi)]$, where L_z denotes the z-component of the orbital angular momentum.

10. Evaluate $L_z(\cos^2(\varphi) - \sin^2(\varphi) + 2I\sin(\varphi)\cos(\varphi))$.

Turn over

11. With a schematic diagram describe a scattering experiment. Define "differential scattering cross-section" and total scattering cross-section".

12. What is a Slater determinant ? What are it's properties ?

(12 × 2 = 24 marks)

Section B

Answer any **two** *questions.*
Each question carries 14 *marks.*

13. What are "position" and "momentum" representations ? Derive the connection between the position and momentum representations. Derive the expression for the momentum operator in the position representation.

14. Derive an expression for the energy levels of a linear harmonic oscillator using the Schrödinger equation method.

15. Explain the Schrödinger and Heisenberg pictures.

16. Outline the method of partial wave analysis. Describe scattering by a hard sphere.

(2 × 14 = 28 marks)

Section C

Answer any **four** *questions.*
Each question carries 7 *marks.*

17. 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.

18. A particle of mass m is confined to move inside an infinitely deep *asymmetric* potential well. Derive an expression for the quantized energy levels of the system. Show that in the limit of large n, the difference of energy between levels is zero.

19. Using $\left[\hat{X}, \hat{P}\right] = i\hbar$, calculate the commutation relation between T_1 and T_2, where $T_1 = \frac{1}{4}\left(\hat{P}^2 - \hat{X}^2\right)$ and $T_2 = \frac{1}{4}\left(\hat{X}\hat{P} + \hat{P}\hat{X}\right)$.

20. Prove, if A and B are two vectors which commute with σ (the Pauli's matrices) but not necessarily with each other, that $(\sigma \cdot A)(\sigma \cdot B) = A \cdot B + i\,\sigma \cdot (A \times B)$.

21. Show that if $\hat{H}$ is invariant under : (i) A time translation, the energy of an isolated system is conserved ; and (ii) A spatial transformation, the linear momentum is conserved.

22. Consider s-wave scattering by a finite square well of depth $-V_0$ and radius R. In region $1\,(0 <= r <= R)$ the radial wave function is $U_1(r) = A \sin(Kr)$ where $\hbar^2 K^2\, 2m(E + V_0)$ and in region 2 $(R <= r <= \infty)$, the radial wave function is $U_2(r) = \sin(kr + \delta)$ where $\hbar^2\, k^2 = 2\,m\,E$. Find an expression for the phase-shift δ.

(4 × 7 = 28 marks)

C 63478 (Pages : 2) Name..

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

SECOND SEMESTER M.Sc. (SSE) DEGREE EXAMINATION, APRIL 2019

Physics

PHY 204—ELECTRODYNAMICS

(2003 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

Answer any **five** *questions.*
Each question carries 4 *marks*

1. What is displacement current ? What does it mean ?
2. What are electromagnetic waves ?
3. Write a short note on cavity resonators.
4. What are scalar potential and vector potential ?
5. Obtain the trajectory of a charged particle in electrostatic field.
6. What is plasma confinement ?
7. Define Poynting vector. What is its physical significance ?
8. What is electromagnetic field tensor ?

(5 × 4 = 20 marks)

Section B

Answer **all** *questions.*
Each question carries 20 *marks.*

9. (A) (a) Obtain wave equation in vacuum from Maxwell's equations.

(b) Discuss TM waves in a rectangular wave guide.

Or

(B) (a) Explain the potential formulation of electrodynamics.

(b) Derive the moment equation of plasma physics using Boltzmann equation.

Turn over

10. (A) (a) Discuss oblique incidence of electromagnetic wave at a plane surface separating two dielectric media.

(b) Describe plane electromagnetic waves in a lossless medium and a lossy medium.

Or

(B) (a) Discuss the reflection of electromagnetic wave at a conducting surface.

(b) Explain how electric and magnetic fields transform in relativistic electrodynamics.

($2 \times 20 = 40$ marks)

Section C

Answer any **two** *questions.*
Each question carries 10 *marks.*

11. Obtain Maxwell's equations.

12. What are TE waves ? What TE mode can propagate in a rectangular wave guide of sides 2.28 cm and 1.01 cm for the frequency 1.7×10^{10}Hz ?

13. Obtain the fundamental hydrodynamical equation.

14. Calculate the reflection and transmission coefficients when light passes from water of refractive index 1.33 to glass of 1.5 to show that the sum of coefficients is unity.

($2 \times 10 = 20$ marks)

C 63477 (Pages : 2) Name.....................................

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

SECOND SEMESTER M.Sc. (SSE) DEGREE EXAMINATION, APRIL 2019

Physics

PHY 203—STATISTICAL AND THERMAL PHYSICS.

(2003 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

Answe any **five** *questions.*
Each question carries 4 *marks.*

1. Obtain the expression for mean number of particles in A Fermi Dirac distribution.
2. What is Phase Space ? Deduce the significance of density matrix.
3. State the postulates of classical statistical mechanics.
4. How does specific heat of an ideal Fermi gas vary with temperature.
5. Write a brief note on the theory of ensembles.
6. How do you classify particles into Fermions and Bosons ?
7. Discuss the feature of super fluid order parameter.
8. Explain the concept of chemical potential.

(5 × 4 = 20 marks)

Section B

Answer **both** *questions.*
Each question carries 20 *marks.*

9. (a) (i) Explain Gibb's paradox.

(ii) Derive Maxwell-Boltzmann distributing laws.

(10 + 10 = 20 marks)

Or

(b) (i) Explain the quantum cluster expansion.

(ii) Deduce the expression for the second viral co-efficient.

(10 + 10 = 20 marks)

Turn over

10. (a) (i) Compare the three statistics.

(ii) Discuss statistical theory of white dwarfs.

(10 + 10 = 20 marks)

Or

(b) (i) Obtain the equation of state of an ideal Fermi gas.

(ii) Solve the one dimensional Ising model.

(10 + 10 = 20 marks)

Section C

Answer any **two** *questions.*
Each question carries 10 *marks.*

11. State and derive equipartition theorem.

12. Explain Pauli paramagnetism using F-D statistics.

13. Prove that entropy differs as a function of log N in canonical ensembles.

14. Explain Bose-Einstein condensation.

(2 × 10 = 20 marks)

C 63476 (Pages : 2) Name.......................................

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

SECOND SEMESTER M.Sc. (SSE) DEGREE EXAMINATION, APRIL 2019

Physics

PHY 202—NUMERICAL TECHNIQUES AND COMPUTER PROGRAMMING

(2003 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

Answer any **five** *questions.*
Each question carries 4 *marks.*

1. Find Taylor's series for $f(x) = e^x$ about $x = 0$.
2. Explain Newton-Raphson method for finding a real root of the equation $f(x) = 0$.
3. State and explain Simpson's 1/3 rule for evaluating definite integral.
4. State Milne's predictor- corrector formula for solving the equation $dy/dx = f(x, y)$ with initial condition $y(x_0) = y_0$.
5. What are the rules for naming integer and real variables in Fortran ?
6. Give the general form and flow chart symbol for arithmetic IF statement in Fortran.
7. Distinguish between While loop and do.. While loop.
8. Explain how is a function declared and defined in C.

(5 × 4 = 20 marks)

Section B

Answer **all** *questions.*
Each question carries 20 *marks.*

9. (a) (i) Obtain Lagrange's interpolation formula.

(ii) Find Lagrange's interpolation polynomial fitting the points $y(1) = -3$, $y(3) = 0$ $y(4) = 30$ and $y(6) = 132$ and find $y(5)$.

Or

(b) Explain the Euler's method for solving differential equations.

Using Euler's method find approximate value of y corresponding to $x = 1$, given $\frac{dy}{dx} = x + y$ where $y = 1$ when $x = 0$. Choose $h = 0.1$.

Turn over

10. (a) (i) Explain with examples valid integer and real expressions in FORTRAN.

(ii) Explain with example hierarchy of arithmetic operations in FORTRAN.

Or

(b) (i) What is an operator ? Explain various operators used in C.

(ii) What is a file ? What is the need of a file ? Explain basic file operations in C.

(2 × 20 = 40 marks)

Section C

Answer any **two** *questions.*
Each question carries 10 *marks.*

11. Find a real root of $x^3 - x^2 - 1 = 0$ using bisection method, correct to three decimal places.

12. Evaluate the integral $\int_1^2 \frac{dx}{x}$ using Trapezoidal rule taking $h = 0.25$. Compare the result with exact value.

13. Write a program in Fortran to find the transpose of a matrix.

14. Write a C program find the factorial of a number using function.

(2 × 10 = 20 marks)

C 63475 (Pages : 2) Name.......................................

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

SECOND SEMESTER M.Sc. (S.S.E.) DEGREE EXAMINATION APRIL 2019

Physics

PHY 201—MATHEMATICAL PHYSICS—II

(2003 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

Answer any **five** *questions.*
Each question carries 4 *marks.*

1. State Cauchy's integral formula.
2. Show that the functions z and e^z are analytic functions everywhere.
3. Define conjugate elements and classes.
4. Explain the idea of direct product of groups.
5. Write a brief note on SU(3) group.
6. Using Euler's equation show that the shortest distance between two points on a plane is given by straight line.
7. Explain the idea of universality in the case of discrete maps.
8. What do you mean by Chaos ?

(5 × 4 = 20 marks)

Section B

Answer **both** *questions.*
Each question carries 20 *marks.*

9. (a) (i) What do you mean by analytic functions ? Derive Cauchy-Riemann conditions.

(ii) Explain the idea of Laurent series expansion.

(10 + 10 = 20 marks)

Or

(b) (i) Explain the idea of group isomorphism and homomorphism with examples.

(ii) Explain the idea of calculus of variations.

(10 + 10 = 20 marks)

Turn over

10. (a) (i) Discuss the concepts of metric tensor. Write down the metric tensors for Cartesian and cylindrical co-ordinates.

(ii) Describe the dynamics of a damped and driven oscillators.

(10 + 10 = 20 marks)

Or

(b) (i) Discuss chaos in the context of the Logistic map and find its fixed points.

(ii) Write a detailed note on the dynamics of van der Pol oscillator.

(10 + 10 = 20 marks)

[2 × 20 = 40 marks]

Section C

Answer any **two** *questions.*
Each question carries 10 *marks.*

11. Given that $f(z) = u(x, y) + iv(x, y)$ is an analytic function and $u(x, y) = x^2 - y^2$ find $v(x, y)$.

12. For a contour defined by $|z| = 10$ evaluate the contour integral,

$$\oint \frac{dz}{(z-2)(z+1)}.$$

13. Show that the set $\{I, a, a^2, a^3\}$ with $a^4 = I$ form a group and write down its multiplication table.

14. Show that the set of all 3 × 3 real orthogonal matrices form a group under multiplication.

(2 × 10 = 20 marks)

C 63452 (Pages : 2) Name..................................

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

SECOND SEMESTER M.Sc. (SSE) DEGREE EXAMINATION, MARCH 2019

Physics

PHY 201—MATHEMATICAL PHYSICS—II

(2008 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

Answer any **two** *sub-questions from each question.*
Each question carries 3 *marks.*

I. (a) Write down the necessary and sufficient condition for a function to be analytic.

(b) Find the general analytic complex function with real part $u = x^2 - y^2 - x$.

(c) Write a note on Laurent's series.

II. (a) What is a Cyclic group ? Explain.

(b) What are called conjugate elements of a group ? Give the properties.

(c) Define Homomorphism. Give an example.

III. (a) Write a short note on representation of group.

(b) What is called character of a representation ?

(c) State and prove Schur's First Lemma.

IV. (a) Outline any two variational methods.

(b) If $J = \int f dx$ is extremum along the path $y(x)$, then show that Euler equation has the form $f - y\frac{\partial f}{\partial y} = C$ where C is a constant provided f does not depend on x explicitly.

(c) Find the minimization of function $f(x, y, z)$ subjected to the constraint $g(x, y, z) = C$.

V. (a) Explain Fredholm equation of first kind and second kind.

(b) Express general second order linear differential equation with boundary conditions as an integral equation.

(c) What are the properties satisfied by the Greens function of a linear operator ?

(10 × 3 = 30 marks)

Section B

Answer any **two** *questions.*
Each question carries 15 *marks.*

VI. State and prove Cauchy's integral formula.

VII. Construct the character table of C_{4v}.

Turn over

VIII. Obtain Euler equation. Hence find the curve passing through two fixed end points with minimum surface area of revolution.

IX. Find the Greens function for Laplace operator. Hence find the general solution for Poisson's equation in electrostatics.

(2 × 15 = 30 marks)

Section C

Answer any **two** *questions.*
Each question carries 10 *marks.*

X. Integrate the following function around the circle $|z| = \frac{3}{2}$.

$$g(z) = \frac{\tan(z)}{z^2 - 1}.$$

XI. By drawing the multiplication table show that the set G = {1, – 1, *i*, – *i*} form a group under multiplication, where $i = \sqrt{-1}$.

XII. Find the Geodesic equation using variational method.

XIII. Using eigenfunction expansion find the Green's function associated with the following problem :

$$\frac{d^2y}{dx^2} = S(x)$$

where $y = 0$ at $x = 0$ and $\frac{dy}{dx} = 0$ at $x = 1$.

(2 × 10 = 20 marks)

C 4760 (Pages : 3) Name.......................................

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

SECOND SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, APRIL 2021

(CBCSS)

Physics

PHY 2C 08—COMPUTATIONAL PHYSICS

(2019 Admissions)

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. *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 1 weightage.

1. Distinguish lists and tuples in Python.
2. What is pickling and unpickling in Python ?
3. List out the built-in data types in python programming.
4. Write a python program to plot a cosine wave from 0 to 2π.
5. Give the differences between interpolation and curve fitting.
6. Explain the two-point boundary value problem.
7. Write a program to create a NumPy array of five zeros of dimension 1.
8. What is Logistic map equation ?

(8 × 1 = 8 weightage)

Turn over

Section B

4 essay questions answerable within 30 minutes.

Answer any **two** *questions.*

Each question carries 5 weightage.

9. Derive Newton's forward and backward difference interpolation formula.

10. Explain the least square curve fitting for an exponential function of the form, $y = Ae^{Bx}$.

11. Outline the Shooting method and Numerov's method in numerical analysis.

12. Explain the Euler method. Write a python program to obtain the trajectory of a simple harmonic motion using Euler method.

(2 × 5 = 10 weightage)

Section C

7 problems answerable within 15 minutes.

Answer any **four** *questions.*

Each question carries 3 weightage.

13. Write a Python program to display all the prime numbers within the interval {10, 50}.

14. Write a python code to calculate the Fourier coefficients of a square wave and to plot the wave.

15. Using Lagrange's interpolation formula, find the form of the function $y = f(x)$ from the following table :

X	y
0	–12
1	0
3	12
4	24

16. Using Trapezoidal rule, evaluate

$$I = \int_0^1 \frac{1}{1+x}\,dx$$

correct to three decimal places. (Assume $h = 0.5, 0.25$).

17. Approximate the area under the curve, $y = f(x)$, between $x = -4$ and $x = 8$ using Simpson's rule with $n = 6$ subintervals.

x	–4	–2	0	2	4	6	8
$f(x)$	1	3	4	4	6	9	14

18. Using the Runge-Kutta method of fourth order, evaluate the value of y (0.1) correct to four decimal places for the function :

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

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

(4 × 3 = 12 weightage)

C 4759 (Pages : 2) Name..............................

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

SECOND SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, APRIL 2021

(CBCSS)

Physics

PHY 2C 07—STATISTICAL MECHANICS

(2019 Admissions)

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. *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. What are the expected values of S and Ω for a system at T = 0 K ?
2. Differentiate between distinguishable and indistinguishable particles.
3. Define partition function. What is the significance of partition function in statistical mechanics ?
4. What is an Ensemble ? Write down the probability distribution function of a micro canonical ensembles ?
5. Which are the different motions a diatomic molecule is capable of performing ?
6. What is Bose-Einstein condensation ? Which property of boson is responsible for this phenomenon ?
7. Define black body radiation. What are its characteristic properties ?
8. Show that the Fermi distribution curve is symmetrical about the Fermi energy E_F.

(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. Derive expressions for energy fluctuations in the case of canonical ensemble.

10. Describe the thermodynamic behaviour of an ideal Bose gas.

11. Derive the equation for thermodynamic probability of an ideal gas from micro-canonical ensemble. Hence derive thermodynamics of the system.

12. Describe the thermodynamic behaviour of an ideal Fermi gas.

($2 \times 5 = 10$ weightage)

Section C

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

13. How does the number of microstates of 1 g of H_2 gas change, if its volume gets doubled by a process of reversible adiabatic expansion?

14. The entropy of a microstate of a system is 1 JK^{-1} while that of another one is 1.001 JK^{-1}. How many times more likely is the second microstate as compared to the first one ?

15. A system in contact with a heath bath at temperature T has two accessible energy states with energies 0 and 0.1 eV. If the probability of the system being in the higher energy state is 0.1 eV, find the temperature of the heath bath.

16. Find the condensation temperature for liquid helium with a density of 145 kgm^{-3}.

17. What is Gibb's paradox ? How is it resolution ?

18. The peak wavelength of radiation coming out of a hole in an enclosure is 5 μm. Find the total energy density inside the cavity.

19. The density of electrons in copper is $8.51 \times 10^{28} m^{-3}$. Find (i) the fermi energy of copper ; (ii) The average zero point energy of a free electron in copper ; and (iii) The degeneracy pressure of the electron gas in copper.

($4 \times 3 = 12$ weightage)

C 4758 (Pages : 2) Name.......................................

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

SECOND SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, APRIL 2021

(CBCSS)

Physics

PHY 2C 06—MATHEMATICAL PHYSICS-II

(2019 Admissions)

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. *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. State and provide proof of Cauchy's integral formula.
2. Explain isomorphism.
3. Explain the method of Lagrange Multipliers briefly.
4. Describe a Fredholm integral equation of the second kind.
5. Explain the symmetry property of Dirac-delta function.
6. Discuss about the generators of the SU (2) group.
7. Mention any two problems solved using the variation principle.
8. Enlist different types of integral transforms. Represent the mathematical form of any one of the integral transform.

(8 × 1 = 8 weightage)

Section B

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

9. Discuss the representation of the two dimensional unitary group SU (2).

Turn over

10. Obtain the Green's function for a one-dimension operator.

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 question carries weightage 3.

13. Evaluate the integral $\oint_c \frac{dz}{z^2 + z}$.

14. Prove that a group of order 4 may or may not be a cyclic group. Give example in both cases.

15. Find the residue of $f(z) = \frac{e^z}{z^2 + a^2}$ at its singularities.

16. Maximize $\mathrm{I}(y) = \int_{x1}^{x2} 1 + y'^2 dx$ where $y(x1) = y(x2) = 0$.

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

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

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

(4 × 3 = 12 weightage)

C 4757 **(Pages : 2)** Name..

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

SECOND SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, APRIL 2021

(CBCSS)

Physics

PHY 2C 05—QUANTUM MECHANICS—I

(2019 Admissions)

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. *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. Prove that an operator in a linear vector space can be represented by a square matrix.
2. What is the quantum mechanical operator representing energy ?
3. What are Hermitian operators ? Give their important properties.
4. Briefly explain the features of interaction picture.
5. Are the rigid rotator energy levels degenerate ? Explain.
6. What are the admissibility conditions on a wavefunction ?
7. Explain the principle of indistinguishability in quantum mechanics.
8. Discuss the conservation law associated with space inversion symmetry.

($8 \times 1 = 8$ weightage)

Section B

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

9. Describe the Sequential Stern-Gerlach experiment and the conclusions which lead to the basics of quantum mechanics.

Turn over

10. Establish the Schrodinger equation for one dimensional harmonic oscillator and solve it to obtain the energy eigen values and eigen functions. Also discuss the significances of zero-point energy.

11. Establish the addition of orbital angular momentum and spin angular momentum. Arrive at Clebsch-Gordan coefficients.

12. Discuss the importance of symmetry of the wavefunctions, taking the example of the ground state of Helium atom.

(2 × 5 = 10 weightage)

Section C

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

13. Show that $(\sigma . A)(\sigma . B) = A . B + i\sigma . (A \times B)$ where A and B are arbitrary vectors.

14. An electron has a speed of 500 m/s with an accuracy of 0.004%. Calculate the certainty with which we can locate the position of the electron.

15. For an electron in a one-dimensional infinite potential well of width 1Å, calculate (i) the separation between two energy levels (ii) the frequency and wavelength of the photon corresponding to a transition between these two levels (iii) in what region of the electromagnetic spectrum is this frequency wavelength ?

16. Evaluate the commutator (i) $\left[x, p_x^2\right]$; and (ii) $\left[xyz, p_x^2\right]$.

17. A beam of electrons is incident from left, normally, on a semi-infinite step potential 5.0 eV height. The incident electrons have kinetic energy E (when to the left of the step potential). What is the relative probability that any given electron will be reflected back by the step potential When E = 10.0 eV.

18. For the operators A, B and C show that [[A, B], C] + [[B, C], A] + [[C, A], B] = 0.

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

(4 × 3 = 12 weightage)

C 4581 **(Pages : 2)** **Name..................................**

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

SECOND SEMESTER M.Sc. DEGREE (SUPPLEMENTARY) EXAMINATION APRIL 2021

(CUCSS)

Physics

PHY 2C 08—COMPUTATIONAL PHYSICS

(2017 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*

Each question carries weightage 1.

1. Differentiate between compilers and interpreters.
2. Discuss data types used in Python.
3. What are vectorized functions ?
4. Write a note on multiple plots.
5. What are uses of colon character in Python ?
6. Discuss Monte Carlo Method.
7. Discuss the operator precedence in python.
8. Give Newton's forward interpolation formula.
9. How can we save and restore a python file ?
10. Write a short note on logistic maps.
11. Obtain modified Euler formula.
12. Discuss Fourier transform.

(12 × 1 = 12 weightage)

Turn over

Section B

Answer any **two** *questions.*

Each question carries weightage 6.

13. What are modules ? Give a short note on math module. With illustration, discuss different ways of importing a function from a module in python.

14. Illustrate Fourier series. Write programs to generate square wave and sawtooth wave using this technique.

15. With program, explain least square method of fitting a straight line and deduce the expression for the constants a and b.

16. With suitable flow chart and program, discuss the motion of a body under central force.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*

Each question carries weightage 3.

17. Create a 4 × 3 matrix and print the sum of its elements using for loops.

18. Write programs to draw a circle which satisfies the equations

    (a) $x^2 + y^2 = a^2$; (b) $x = a \cos (t)$ and $y = a \sin (t)$.

19. Values of x (in degrees) and sin (x) are given in the following table, determine the value of sin (38) :

X	15	20	25	30	35	40
Sin (x)	0.2588	0.3420	0.4226	0.5	0.5735	0.6427

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 falling in viscous medium.

22. Discuss the conditional executions in python.

(4 × 3 = 12 weightage)

C 4580 (Pages : 2) Name.......................................

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

SECOND SEMESTER M.Sc. DEGREE (SUPPLEMENTARY) EXAMINATION APRIL 2021

(CUCSS)

Physics

PHY 2C 07—STATISTICAL MECHANICS

(2017 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

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

1. Define Thermodynamic potentials.
2. State and explain the principle of equal -a-priori probabilities.
3. What are the characteristics of microcanonical ensemble ?
4. What is the reason for the origin of Gibb's paradox ?
5. Define grand partition function. How is it be related to the equation of state ?
6. State Liouville's theorem for quantum statistics.
7. Distinguish between symmetric and antisymmetric wave functions.
8. Find the number of ways for arranging n bosons in g states ($g >> n$).
9. Write down the equation of state and equation for $n = \left(\frac{N}{V}\right)$ for Bose gas in terms of $g_v(z)$.
10. Show that Wein's formula follows from Planks radiation law under high frequency conditions.
11. Explain the variation of fugacity of a Fermi gas with temperature with the help of a graph.
12. Distinguish between non-degenerate and completely degenerate Fermi systems.

(12 × 1 = 12 weightage)

Section B

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

13. Discuss the statistical theory of classical ideal gas and derive Sackur-Tetrode equation for entropy.
14. Discuss the classical theory of paramagnetism in the formalism of canonical ensembe and show that high temperature paramagnetic susceptibility follows Curie law.

Turn over

15. Explain Bose-Einstein condensation. Derive an equation for the critical temperature Tc, critical volume v_c and critical density n_c.

16. Explain the origin of Landaue diamagnetism in a Fermi system. Derive an expression for the temperature dependent low field diamagnetic susceptibility.

(2 × 6 = 12 weightage)

Section C

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

17. Find the number of microstates and 'volume' of a microstate of a classical linear harmonic oscillator of mass m and frequency n in the energy range E to E + Δ .

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

19. Determine the density matrix for an electron in a magnetic field under canonical ensemble.

20. Show that thermal wavelength $\lambda = \dfrac{h}{(2\pi mkT)^{1/2}}$. Express classical limit in terms of λ .

21. For high temperatures show that the equation of state of an ideal Bose gas can be represented as a Virial expansion in powers $n\lambda^3$.

22. Find the Fermi energy and Fermi temperature of Cu assuming each Cu atom contributes one free electron per atom. The density of Cu is 8940 kg/m^3 and its atomic mass is 63.5 u (1u = 1.66 × 10^{-27}kg).

(4 × 3 = 12 weightage)

C 4579 **(Pages : 2)** **Name..................................**

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

SECOND SEMESTER M.Sc. DEGREE (SUPPLEMENTARY) EXAMINATION APRIL 2021

(CUCSS)

Physics

PHY 2C 06—MATHEMATICAL PHYSICS—II

(2017 Admissions)

Time : Three Hours Maximum : 36 Weightage

Part A

Answer all **twelve** *questions.*

Each question carries 1 *weightage.*

1. Check whether the function $f(z) = |z|^2$ is analytic or not.
2. Can a function be differentiable at a point, but not analytic at that point ? Explain.
3. In general group multiplication is not commutative. Prove.
4. What is meant by sub-group ?
5. Write any four use of variational technique ?
6. Explain Hamilton's principle in classical mechanics.
7. Explain the classification of integral equations.
8. Find the Laplace transform of unity.
9. Write four properties of one dimensional Greens function.
10. How Greens function is used in differential equations ?
11. Write an example of a simple pole system.
12. Write one generator of Lie group.

(12 × 1 = 12 weightage)

Turn over

Part B

Answer any **two** *questions.*

Each question carries 6 *weightage.*

13. Express an analytic function $f(z)$ as an infinite Lorentz series.

14. What is meant by group representation ? Explain Reducible and Irreducible representations.

15. Derive Euler Equation using the variational method. Write its alternative forms.

16. Write a note on integral equations. Find the momentum representation of Schrödinger equation.

(2 × 6 = 12 weightage)

Part C

Answer any **four** *questions.*

Each question carries 3 *weightage.*

17. Express the solution of linear oscillator in integral form using the Greens function. Use standard boundary conditions.

18. Evaluate the integral $\int_0^{2\pi} (\cos 3\theta)/(5 - 4\cos\theta)$.

19. Write the group of symmetry transformations of an equilateral triangle.

20. Find the equation of a straight line using Euler equation.

21. Find the integral transform of a Gaussian distribution using the Fourier method.

22. Find an eigen function expansion of Green's function.

(4 × 3 = 12 weightage)

C 4578 (Pages : 2) Name.....................................

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

SECOND SEMESTER M.Sc. DEGREE (SUPPLEMENTARY) EXAMINATION APRIL 2021

(CUCSS)

Physics

PHY 2C 05—QUANTUM MECHANICS—I

(2017 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

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

1. Define Dimension and Basis of a vector space. Give any one example of a Linear Vector space that is a Hilbert space.
2. What is an Operator ? What is a Hermitian operator ?
3. Describe the Matrix representation of an eigen value problem.
4. What are the mathematical requirements that a wave function must satisfy to represent a physical system ?
5. Give the operators corresponding to the observables (a) Kinetic energy ; and (b) Angular momentum.
6. What is Ehrenfest Theorem ?
7. Give any *two* properties of spherical harmonics.
8. What are Pauli spin matrices ? How is it related to spin vector ?
9. What is energy eigen value of isotropic Harmonic oscillator ? Examine its degree of degeneracy of ground state and of first excited state.
10. What is exchange degeneracy ?
11. State optical theorem. What does it imply ?
12. What is scattering amplitude and differential cross section ? How are they related ?

($12 \times 1 = 12$ weightage)

Turn over

Section B

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

13. Apply commutator algebra to derive the general relation giving the uncertainty product of two operators.

14. Find the energy eigen values and eigen states of one dimensional harmonic oscillator.

15. Describe the Schrodinger and Heisenberg pictures of time development of systems.

16. Discuss the solutions of Time-independent Schrodinger equation for the hydrogen atom with respect to wave functions.

(2 × 6 = 12 weightage)

Section C

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

17. Find the scalar products $<\varphi|\psi>$ and $<\psi|\varphi>$ where $|\varphi> = 2|\alpha> + i|\beta>$, and $|\psi> = 3i|\alpha> + 5i|\beta>$ and $|\alpha>$ and $|\beta>$ are orthonormal. Also show that $|\psi>$ and $|\varphi>$ satisfy Schwarz inequality.

18. A system whose state is given in terms of an orthonormal set of two vectors : $|\psi_1>$ and $|\psi_2>$ as $\varphi> = \frac{1}{\sqrt{3}}|\psi_1> + \frac{\sqrt{2}}{\sqrt{3}}|\psi_2>$. Calculate the probability of finding the system in any one of the states $|\psi_1>$ and $|\psi_2>$. Also find the total probability.

19. Consider j =1, Find the matrix representing the operator J_x.

20. Show that translational symmetry implies conservation of linear momentum.

21. Calculate the total cross section for the low-energy scattering of a particle of mass m from an attractive square well potential.

22. Evaluate the total scattering cross section for scattering by Yukawa potential by the method of Born approximation.

(4 × 3 = 12 weightage)

C 3994 (Pages : 3) Name..............................

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

SECOND SEMESTER P.G. DEGREE EXAMINATION, APRIL 2021

(CCSS)

Physics

PHY 2E 03—COMPUTATIONAL TECHNIQUES AND FORTRAN PROGRAMMING

(2019 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

12 *Short questions answerable within* 5 *minutes.*
Answer **all** *questions, each question carries* 2 *marks.*

1. Give the geometrical interpretation of the Newton-Raphson method for finding the roots of a transcendental equation.
2. Comment on the convergence of the iterative methods for finding the roots of a transcendental equation.
3. Show that for a (x, y) data set which can be fitted with a polynomial of degree n, the n^{th} differences are constants and the $(n+1)^{st}$ differences are zeros.
4. Bring out two differences between curve fitting and interpolation.
5. What is the principle of the Gauss quadrature method for numerical integration ?
6. What is a parabolic equation ? Give one example. Name one method for solving such equations.
7. What is an eigen value problem ? Develop the Householder method for calculating the eigen values of a symmetric tridiagonal matrix.
8. Briefly describe how a system of linear equations can be solved by resorting to inversion of the matrix of coefficients.
9. Explain the concepts of predictor and corrector in the Runge-Kutta method.
10. Using an example, explain how finite looping is realized in Fortran language.

Turn over

11. What is meant by hierarchy in Fortran language ? List the following operators in decreasing order of the hierarchy scheme : addition, multiplication, paranthesis and exponentiation.

12. What is a format statement ? Explain the formats of reading a real number and an integer.

(12 × 2 = 24 marks)

Section B

4 *essay questions answerable within* 30 *minutes.*
Answer any **two** *questions, each question carries* 14 *marks.*

13. a) Explain in detail the principle of the bisection method for finding the roots of a transcendental equation.

    b) State and explain the location of roots theorem.

14. a) What is meant by least squares fitting as applied to a given data set.

    b) Discuss the techniques for linear and non-linear least squares fitting.

15. a) What is an eigen value problem ?

    b) Develop the Householder method for calculating the eigen values of a symmetric tridiagonal matrix.

16. a) What are subroutine subprogram and function subprogram in Fortran ? Give the structures of these two, pointing out the main differences between the two.

    b) How are they invoked from the main program segment ? Illustrate giving a fortran code for each applied to the two cases.

(2 × 14 = 28 marks)

Section C

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

17. Apply the bisection method to findout one extremum value of the function $f(x) = 2x^3 - 9x^2 + x + 5$. Ascertain if it is a minimum or a maximum.

18. Compute $f(0.3)$ for the data :

x	0	1	3	4	7
f	1	3	49	129	813

using Lagrange's interpolation formula.

19. Use the R-K method of order 4 to solve the initial value problem $y' = x + x^2$, $y(0) = 2$ to obtain $y(0.2)$ using a step size of $h = 0.05$.

20. Show that the two point closed Newton-Cote's formula is equivalent to the Trapezoidal rule.

21. Obtain a solution of the following equations by the Gauss elimination method :

$$5x + 2y = 2$$
$$2x + y - z = 0$$
$$2x + 3y - z = 3.$$

22. Correct the following fortran code, giving valid reasons for the corrections :

```
print*, 'Welcome, please enter the lengths of the 3 sides.
read a, b, c ;
print *, 'Area of triangle : , area (a,b,c)
end


function area (x, y, z)
itheta = arcos ((x**2 + y**2 – z**2) / (2.0 * x * y)
height = x * sin(theta)
area (x, y, z) = 0.5 * y * height
end
```

(4 × 7 = 28 marks)

C 3993 **(Pages : 2)** **Name.....................................**

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

SECOND SEMESTER P.G. DEGREE EXAMINATION, APRIL 2021

(CCSS)

Physics

PHY 2C 09—STATISTICAL MECHANICS

(2019 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

Answer **all** *questions.*
Each question carries 2 *marks.*

1. What is a microstate ? Give an example.
2. What is Sackur Tetrode equation ?
3. State equipartition theorem.
4. What is the bridging equation in micro canonical ensemble ?
5. What is fugacity ?
6. Obtain an expression for internal energy in terms of partition funtion.
7. What are indistinguishable particles ? Give examples.
8. How is pressure and energy of an ideal Bose gas related ?
9. Write Wiens displacement law and explain.
10. What is Fermi temperature ?
11. What is Brownian motion ?
12. What are fluctuations ?

(12 × 2 = 24 marks)

Section B

Answer any **two** *questions.*
Each question carries 14 *marks.*

13. Explain microcanonical ensemble method of obtaining equation of state of an ideal gas.
14. State and prove Liouvillies theorem.
15. Obtain expressions for Maxwell Boltzmann, Bose Einstein and Fermi Dirac distribution functions.
16. Discuss Ising model in zeroth approximation.

(2 × 14 = 28 marks)

Turn over

Section C

Answer any **four** *questions.*
Each question carries 7 marks.

17. Find an expression for the entropy of an ideal gas without Gibbs paradox.

18. Construct the phase space trajectory for a :

    a) free particle bouncing elastically between two walls.

    b) harmonic oscillator.

19. Show that Bose Einstein condensation is not possible in 1 dimension for an ideal gas.

20. If number density of electrons in a white dwarf is $10^{36}/m^3$, what is the Fermi temperature ? Is the system degenerated. Core temperature of the system is 10^7 K.

21. Obtain Planck's distribution law.

22. 2 particles are to be distributed in 4 states in a system. Find the number of microstates for a system if it is either Bose or Fermi.

(4 × 7 = 28 marks)

C 3992 (Pages : 2) Name.......................................

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

SECOND SEMESTER P.G. DEGREE EXAMINATION, APRIL 2021

(CCSS)

Physics

PHY 2C 08—MATHEMATICAL PHYSICS-II

(2019 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

Answer **all** *questions.*
Each question carries 2 *marks.*

1. Write Cauchy Riemann conditions and explain.
2. What are analytic functions ?
3. Explain singularity.
4. What is the significance of multiplication table ?
5. What is isomorphism ?
6. What is character of a group ?
7. What is a subgroup ? Give an example.
8. What are Lagrange multipliers ?
9. Find the integral equation equivalent to the differential equation for a linear oscillator.
10. What is Rayleigh Ritz variational technique ?
11. Give the expression for the solution of a nonhomogeneous differential equation in terms of Green's function.
12. What is Green's function technique ?

($12 \times 2 = 24$ marks)

Section B

Answer any **two** *questions.*
Each question carries 14 *marks.*

13. State and prove great orthogonality theorem.
14. Obtain the symmetry transformations of a square. Show that they form a group.

15. Using the method of Lagrange multipliers show that for minimum energy, the shape of the box for a quantum particle is a cube.

16. Obtain the forms and properties of one dimensional Green's function. Show that Greens function will be symmetric.

(2 × 14 = 28 marks)

Section C

Answer any **four** *questions.*
Each question carries 7 marks.

17. For a simple closed curve C, evaluate

$$\oint_C \frac{dz}{z}$$

using Cauchy integral theorem

18. Find the poles and residues of the function

$$f(z) = \frac{e^z}{\left(z^2 + a^2\right)}.$$

19. Show that the following elements form a group under multiplication and also show that they are the elements of SU(2) group

$$\begin{pmatrix} 0 & i \\ i & 0 \end{pmatrix}, \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}, \begin{pmatrix} i & 0 \\ 0 & -i \end{pmatrix}, \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

20. Show that every subgroup of index 2 is a normal subgroup.

21. Using Euler equation determine the shortest distance between two points in the Euclidean xy-plane.

22. Find the Green's function for the operator $-\frac{d^2}{dx^2}$ corresponding to the boundary conditions $y(0) = 0$; $y'(1) = 0$.

(4 × 7 = 28 marks)

C 3991 **(Pages : 2)** **Name..................................**

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

SECOND SEMESTER P.G. DEGREE EXAMINATION, APRIL 2021

(CCSS)

Physics

PHY 2C 07—QUANTUM MECHANICS—I

(2019 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

Twelve short questions answerable within 5 minutes.
*Answer **all** questions, each carry 2 marks.*

1. Briefly explain addition of angular momenta.
2. What is mean by a linear operator ?
3. Explain Ramsasuer Townsend effect.
4. Explain the matrix representation of operator ?
5. The zero-point energy is a manifestation of which principle ?
6. Briefly explain partial wave analysis.
7. State and explain the Schrodinger equation in matrix form.
8. State the principle of super position of waves.
9. Give the essential features of Heisenberg picture ?
10. Give the properties of Pauli matrices.
11. What is slater determinant ? How does it incorporate Pauli Exclusion principle ?
12. What is scattering length ? How is related to zero energy cross section ?

(12 × 2 = 24 marks)

Section B

4 essay questions answerable within 30 minutes.
*Answer any **two** questions, each carry 14 marks.*

13. Obtain the eigen values and eigen functions of L^2 and L_z.
14. Conservation of angular momentum is a consequence of the rotational invariance of the system. Substantiate.

Turn over

15. Using operator method to solve quantum mechanical problems of the harmonic oscillator.

16. Discuss the integral equation and validity conditions for Born approximation.

(2 × 14 = 28 marks)

Section C

six *problems answerable within* 15 *minutes.*
Answer any 4 *questions, each carry* 7 *marks.*

17. Show that $(\alpha \cdot A)(\alpha \cdot B) = (A \cdot B) + i\sigma' \cdot (A \times B)$, where A and B commute with α and $\sigma' \begin{pmatrix} \sigma & 0 \\ 0 & \sigma \end{pmatrix}$.

18. Using Born approximation, calculate the differential and total cross sections for scattering of a particle of mass m off the δ function potential $V(r) = g\,\delta(r)$, where g is constant.

19. Find the eigen values and eigen functions of the operator $\frac{d}{dx}$.

20. For an electron in a one-dimensional infinite potential well of width 1 Å, calculate (i) The separation between two energy levels ; (ii) The frequency and wavelength of the photon corresponding to a transition between these two levels ; and (iii) In what region of the electromagnetic spectrum is this frequency wavelength ?

21. Show that the commutator $[x, [x, H]] = \frac{\hbar^2}{m}$, where H is the Hamiltonian operator.

22. If the position of a 5 keV electron is located within 2 Å, what is the percentage uncertainty in its solution.

(4 × 7 = 28 marks)

C 3987 (Pages : 2) Name.......................................

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

SECOND SEMESTER P.G. DEGREE EXAMINATION, APRIL 2021

(CCSS)

Physics

PHY 2C 07—QUANTUM MECHANICS—I

(2017 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

12 Short questions answerable within 7.5 minutes.
Answer **all** *questions.*
Each question carries 2 marks.

1. Explain Dirac bra and ket vectors. With respect to these vectors define Hilbert space.
2. What are Hermitian operators ? Give their important properties.
3. Obtain the expectation values of x^2 and p for a Gaussian wave packet.
4. Discuss the significance of time-energy uncertainty relationship.
5. What are the admissibility conditions on a wavefunction ?
6. State and prove the selection rules on the allowed values of j and m in Clebsh-Gordan (CG) co-efficients ?
7. Are the rigid rotator energy levels degenerate ? Explain.
8. Discuss the conservation law associated with space inversion symmetry.
9. Distinguish between bosons and fermions.
10. Explain symmetric and antisymmetric wavefunctions.
11. What is scattering amplitude ? How is it related to scattering cross-section ?
12. What is phase shift ? Explain the nature of phase shift in the case of repulsive and attractive square well potentials.

(12 × 2 = 24 marks)

Section B

4 essay questions answerable within 30 minutes.
Answer any **two** *questions.*
Each question carries 14 marks.

13. Outline the different postulates of quantum mechanics ? Define the uncertainty (ΔA) in the measurement of a dynamical variable, where A is a dynamical variable. State and explain the general uncertainty relation ?
14. Derive the equation of motion for states and operators in Schrödinger and interaction pictures ?

Turn over

15. Establish the addition of orbital angular momentum and spin angular momentum. Arrive at Clebsch-Gordan co-efficients.

16. Obtain the scattering amplitude and scattering cross-section in the case of scattering by central potential using partial wave analysis ?

(2 × 14 = 28 marks)

Section C

6 problems answerable within 15 minutes.
Answer any **four** *questions.*
Each question carries 7 marks.

17. Evaluate the commutator (i) $\left[x, p_x^2\right]$; and (ii) $\left[xyz, p_x^2\right]$.

18. A beam of electrons is incident from left, normally, on a semi-infinite step potential 5.0 eV height. The incident electrons have kinetic energy E (when to the left of the step potential). What is the relative probability that any given electron will be reflected back by the step potential when E = 10.0 eV ?

19. For the operators A, B and C show that [[A, B], C] + [[B, C], A] + [[C, A], B] = 0.

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

21. Show that $(\sigma . A)(\sigma . B) = A . B + i\sigma . (A \times B)$ where A and B are arbitrary vectors.

22. For an attractive square well potential, $V(r) = -V_0$ for $0 < r < r_0$ and $V(r) = 0$ for $r > r_0$. Find the energy dependence of the phase shift δ_0 by Born approximation ?

(4 × 7 = 28 marks)