CENTRAL UNIVERSITY OF HARYANA

Term End Examinations, May/June 2018

Programme: M. Sc. Physics | **Session: 2017-18**

Semester: II (Second) | **Max. Time: 3 Hours**

Course Title: Classical Electrodynamics | **Max. Marks: 70**

Course Code: SPMS PHY 01 202 CC 3104

Instructions:

1. Question no. 1 has seven sub parts and students need to answer any four. Each sub part carries three and half Marks.

2. Question no. 2 to 5 have three sub parts and students need to answer any two sub parts of each question. Each sub part carries seven marks.

Question No. 1. (4X3.5=14)

a) Show that the charge distribution $\rho = q\prod_{i=1}^{n}(a_i.\vec{\nabla})\delta(r)$ gives rise to the potential $\phi(r) = q\prod_{i=1}^{n}(a_i.\vec{\nabla})\frac{1}{r}$

b) Determine the potential of a charged sphere of radius 'R'. The surface density of charge varies according to the law $\sigma = \sigma_0 \cos\theta$

c) Starting with the differential expression $d\vec{B} = \frac{\mu_0 I}{4\pi} d\vec{l'} \times \frac{\vec{r}-\vec{r'}}{|\vec{r}-\vec{r'}|^3}$ for the magnetic induction at a point P with coordinate $\vec{r}$ produced by an increment of current $Id\vec{l'}$ at $\vec{r'}$, show that for a closed loop carrying a current I the magnetic induction at P is $\vec{B} = \frac{\mu_0 I}{4\pi}\vec{\nabla}\Omega$ where Ω is the solid angle subtended by the loop at the point P.

d) The average light intensity on the earth's surface is 1.3×10^6erg/cm^2/s. What are the peak values of $\vec{E}$ and $\vec{B}$.

e) Find the number of resonances that can exist in a rectangular cavity with dimensions; 2cm, 3cm and 4cm within frequency range $\nu = 5 \times 10^9 Hz$ to $\nu = 10^{10} Hz$.

f) Consider a metal with free electron density of 6×10^{22}cm^{-3}. Find the lowest cutoff frequency below which the metal is not transparent to EM radiation.

g) Consider a rectangular waveguide with transverse dimensions $2m \times 1m$driven with an angular frequency $\omega = 10^9 rad/s$. Which TE modes will propagate in this waveguide.

Question No. 2. (2X7=14)

a) Derive Gauss Law for electrostatics and show that the discontinuity of the normal component of the electrical field is given by σ/ϵ_0 and that of the scalar potential is given by D/ϵ_0 where σ is the surface charge density and D is the surface dipole moment density.

b) Define Green's function corresponding to an electrostatic boundary problem. Obtain a formal solution of the Poisson's equation in terms of Green's function for a problem with Dirichlet type boundary conditions.

c) Show that the solution of the Laplace's equation in spherical polar coordinates is the Legendre equation with its solution given by the Legendre polynomial and hence derive the recurrence relation for the Legendre polynomial.

Question No. 3. (2X7=14)

a) Calculate the magnetic field at a distance 'a' from an infinitely long straight wire in which a current $\vec{I}$ is flowing using Biot-Savart Law. Show that the same result may be obtained by using Ampere's law.

b) State Poynting's Theorem. Show that law of conservation of energy and momentum are consequences of Poynting's theorem.

c) Show that for the Coulomb's Gauge the scalar potential satisfies Poissons equation and the wave equation for the vector potential can be expressed completely in terms of the transverse current density.

Question No. 4. (2X7=14)

a) Derive the Snell's law of reflection and refraction for dielectric media. Discuss the phenomenon of total internal reflection and show that while the electric field does penetrate into the second medium but there is no flow of energy into it.

b) Discuss the propagation of EM waves in plasma and find the expression of plasma frequency. Do EM waves penetrate inside a plasma below the plasma frequency. Discuss your answer.

c) Consider a resonant cavity with dimensions 'a', 'b', and 'd' along the x-, y- and z-axes respectively. Find the expression for the resonant frequency of the resonant cavity. What should be the third dimension 'd' of the cavity having a cross-section of 1cmX1cm which can operate a TE_{103} mode at 24GHz frequency.

Question No. 5. (2X7=14)

a) Calculating the electric and magnetic fields of an oscillating magnetic dipole in the radiation zone. Find the Poynting's vector and total power radiated by the oscillating magnetic dipole.

b) An electric dipole of strength p_0 initially lies along the x-axis centered at the origin. The dipole rotates in the x-y plane about the z-axis at an angular frequency ω. Calculate the radiation field and the radiated power as seen by an observer in the x-z plane at an angle θ to the z-axis.

c) Obtain the continuity equation from Maxwell's equations represented in terms of the field tensor $F^{\mu\nu}$ and dual tensor $G^{\mu\nu}$.

CENTRAL UNIVERSITY OF HARYANA

Term End Examinations, May/June 2018

Programme: M.Sc. (physics) **Session: 2017-18**

Semester: Second **Max. Time: 3 Hours**

Course Title: Mathematical Methods in Physics-II **Max. Marks: 70**

Course Code: SPMS PHY 01 203 CC 3104

Instructions:

1. Question no. 1 has seven sub parts and students need to answer any four. Each sub part carries three and half Marks.

2. Question no. 2 to 5 have three sub parts and students need to answer any two sub parts of each question. Each sub part carries seven marks.

Question No. 1. (4X3.5=14)

a) Find the Laplace transform of waveform f(t) = (2t/3), $0 \leq t \leq 3$

b) Prove $J_{-n}(x) = (-1)^n J_n(x)$, where n is positive integer.

c) Define Hermitian and skew Hermitian matrix with example.

d) Define compactness and connectedness of a group with example.

e) Bring Bessel equation in the form of Sturm Liouville differential equation

f) Define vector space and give any two examples of vector space.

g) Find Laplace transform of complimentary error function.

Question No. 2. (2X7=14)

a) Find the general solution of Legendre's equation:

$(1-x^2)\,y'' - 2xy' + ny = 0$, where n is a positive integer.

b) Prove the recurrence relation $\frac{d}{dx}\{x^{-n}J_n(x)\} = -x^{-n}J_{n+1}(x)$ for Bessel function.

c) Using convolution theorem, find $L^{-1}\left\{\frac{s^2}{(s^2+a^2)((s^2+b^2)}\right\}$, here a≠b

Question No. 3. (2X7=14)

a) Show the Hermite polynomials are orthogonal over (-∞,∞) with respect to weight function e^{-x^2} such that $\int_{-\infty}^{\infty} e^{-x^2} H_m(x)\, H_n(x)dx = 2^n n!\sqrt{\pi}\delta_{nm}$, where $\delta_{nm} = \begin{cases} 0, if\ n \neq m \\ 1, if\ n = m \end{cases}$

b) Define spherical harmonics and find value of spherical harmonics for all possible values of m when l=1.

c) Define linearly dependent and linearly independent vectors in a vector space and give examples for both.

Question No. 4. (2X7=14)

a) Let $A = \begin{bmatrix} 6 & -2 & 2 \\ -2 & 3 & -1 \\ 2 & -1 & 3 \end{bmatrix}$, find matrix P such that $P^{-1}AP$ is diagonal matrix.

b) With the help of given functions $1, x, x^2$ construct three function $\emptyset_1, \emptyset_2$ and $\emptyset_3$ which are orthogonal with respect to e^{-x} over $0 \leq x \leq \infty$.

c) Prove recurrence relation for Laguerre polynomial

$$(n+1)L_{n+1}(x) = (2n+1-x)L_n(x) - nL_{n-1}(x)$$

Question No. 5. (2X7=14)

a) Solve the differential equation using Laplace transform method.

$$\frac{\partial u}{\partial t}(x,t) = \frac{\partial^2 u}{\partial x^2}(x,t), \quad 0 < x < 2, \quad t > 0$$

$$u(0,t) = 0,\ u(0,t) = 0, u(x,0) = 3\sin(2\pi x)$$

b) Show that

(i) $P_n^{-m}(x) = (-1)^n P_n^m(x)$ (ii) $P_n^m(-x) = (-1)^{n+m} P_n^m(x)$

c) A rotation $R(\emptyset)$ by an angle $\emptyset$ in 2-dimension can be written as $R(\emptyset) = e^{\emptyset x}$ $x = \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}$. Verify that $e^{\emptyset x} = I\cos\emptyset + x\sin\emptyset$, where I is the 2-dimentional unit matrix.

CENTRAL UNIVERSITY OF HARYANA

Term End Examinations May /June 2018

Programme: M.Sc.(Physics) **Session: 2017-18**

Semester: II **Max. Time: 3 Hours**

Course Title: Statistical Mechanics **Max. Marks: 70**

Course Code: SPMS PHY 01 201 CC 3104

Instructions:

1. Question no. 1 has seven sub parts and students need to answer any four. Each sub part carries three and half Marks.

2. Question no. 2 to 5 have three sub parts and students need to answer any two sub parts of each question. Each sub part carries seven marks.

Question No. 1. (4X3.5=14)

a) State and prove the equipartition theorem.

b) Find the energy of the highest level (eV) occupied at temperature T = 0 K for gas of conduction electrons of density 1 kg/m.

c) Show that the particles tend to move from regions of higher chemical potential to lower chemical potential as the system approaches equilibrium.

d) Calculate the critical temperature at which condensation begins in a gas obeying B-E statistics.

e) Show that the entropy of a degenerate Fermi gas vanishes at absolute zero.

f) A test is conducted which is consisting of 20 MCQs (multiple choices questions) with every MCQ having its four options out of which only one is correct. Determine the probability that a person undertaking that test has answered exactly 5 questions wrong.

g) Discuss application of thermodynamics to analyze dielectric materials.

h) Explain effect of mixing of gases on entropy and resolution of Gibbs paradox.

Question No. 2. (2X7=14)

a) Define normal distribution and describe its properties and applications.

b) Explain Poisson distribution and list its applications. What are constants of this distribution?

c) Explain linkage of central limit theorem to Gaussian distribution. A watch makes an error of at most ±1/2 minute per day. After one year, what's the probability that the watch is accurate to within ±25 minutes? Assume that the daily errors are uniform in [-1/2, 1/2].

Question No. 3. (2X7=14)

a) State and prove Nernsts heat theorem and as application derive the coefficient of thermal expansion of a pure solid.

b) Define the free energy functions F and G and explain the importance of these functions. Using these, derive the corresponding thermodynamic relations of Maxwell.

c) Write down the fundamental equation of thermodynamics for a paramagnetic salt when its magnetization changes in a magnetic field. Write Maxwell's relations in this case. If the salt is demagnetized adiabatically, derive the expression for change in temperature.

Question No. 4. (2X7=14)

a) Describe the canonical ensemble and calculate the internal energy and equation of state of a perfect gas. Explain how the entropy can be derived.

b) Define partition function and calculate its value for a grand canonical ensemble. Use it to derive expressions for chemical potential, Helmholtz free energy and Gibb's free energy.

c) Describe phase transitions of first and second kind with suitable examples. How cooperative phenomenon accounts for phase transitions of second kind?

Question No. 5. (2X7=14)

a) For a gas of N bosons of mass m contained in a vessel V, obtain the expression for specific heat and discuss its variation with temperature.

b) Derive Planck's formula for black-body radiation using Bose-Einstein statistics. Using this result, deduce the Stefan-Boltzman law.

c) Describe specific heat in a solid and derive the Debye theory. Define Debye temperature and explain variation of specific heat with temperature.

CENTRAL UNIVERSITY OF HARYANA

Reappear Examinations, May/June 2018

Programme: M. Sc. **Session: 2017-18**

Semester: II **Max. Time: 3 Hour**

Course Title: Statistical Mechanics **Max. Marks: 70**

Course Code: SPMS PHYS 01 201 CC 3104

Instructions:

1. Question no. 1 has seven sub parts and students need to answer any four. Each sub part carries three and half Marks.

2. Question no. 2 to 5 have three sub parts and students need to answer any two sub parts of each question. Each sub part carries seven marks.

Question No. 1. (4X3.5=14)

a) Show that a binomial distribution is normalized.

b) Define reversible and irreversible processes with examples. State Clausius inequality.

c) Use canonical partition function to find average energy of an ideal gas.

d) Draw curves for Maxwell velocity and speed distributions. How a change in temperature affects the nature of the curves.

e) What is a thermal wavelength? Discuss its role in taking quantum effects into account.

f) Define Fermions and Bosons on the basis of symmetric or anti-symmetric wave functions. Explain Slater determinant.

g) Write down expression of energy density $\rho(\omega, T)$ as function of temperature known as Planck's radiation law. Draw curves for different temperatures.

Question No. 2. (2X7=14)

a) Consider a binomial distribution. Show that in a certain limit it transforms into a Gaussian distribution.

b) Find mean and standard deviation for a Poisson distribution.

c) Discus central limit theorem in detail.

Question No. 3. (2X7=14)

a) An ideal gas undergoes a reversible transformation along the path $P = aV^b$. Where a and b are constants and a>0. Find the heat capacity C along this path.

b) Discuss Gibb's paradox in detail.

c) Using first law of thermodynamics and Clausius inequality, set up the conditions of equilibrium for following cases:

(i) Fixed entropy S and volume V

(ii) Fixed temperature T and volume V.

Question No. 4. (2X7=14)

a) Define probability distribution for a canonical ensemble. Using this distribution show that $\langle \Delta E^2 \rangle = kT^2 C_V$.

b) Define and derive the most probable speed of an ideal gas using Maxwell-Boltzmann distribution.

c) For a P, V , T system, explain the coexistence of phases. Discuss Ehrenfest's classification of phase transitions.

Question No. 5. (2X7=14)

a) Define density matrix in quantum statistical mechanics. Write down the density operators for canonical and grand canonical ensembles. Deduce the variance of energy for canonical case.

b) Show that at a high temperature both FD and BE statistics goes to MB statistics.

c) Write brief notes on followings :

(i) White Dwarfs

(ii) Pauli paramagnetism

CENTRAL UNIVERSITY OF HARYANA

Term End Examinations May /June 2018

Programme: M.Sc. (Physics) **Session:.2017-18**

Semester: II **Max. Time: 3 Hours**

Course Title: Advanced Quantum Mechanics I **Max. Marks: 70**

Course Code: SPMS PHY 01 202 DCEC 3104

Instructions:

1. Question no. 1 has seven sub parts and students need to answer any four. Each sub part carries three and half Marks.

2. Question no. 2 to 5 have three sub parts and students need to answer any two sub parts of each question. Each sub part carries seven marks.

Question No. 1. (4X3.5=14)

a) Write down the Klein Gordon equation. Why it is called relativistic wave equation?

b) Investigate the effect of time reversal operation on free Dirac particle.

c) Write down the golden rule of time-dependent perturbation theory.

d) Briefly explain Noether's theorem.

e) Define creation and annihilation operators with suitable examples.

f) What is the significance of Slater determinant?

g) **'Helicity** is the projection of the *spin vector* upon *moment" Justify the statement.*

Question No. 2. (2X7=14)

a) Describe the unitary transformation from the Schrodinger to the interaction picture.

b) Why time operator reversal is not linear?

c) What is symmetry transformation? Prove that a symmetry transformation conserves probabilities?

Question No. 3. (2X7=14)

a) Show that the parity operator commutes with the orbital angular momentum operator.

b) Obtain expression for Probability density and probability current density in the Dirac Formalism.

c) What are negative energy states? What is a hole?

Question No. 4. (2X7=14)

a) In a one dimensional box of length a, the potential is perturbed so that it is raised by a constant potential V_1 in the left half of the box, and lowered by V_1 in the right half. What is the first order change in energy for the state n=1.

b) What is adiabatic approximation and sudden approximation time dependent perturbation theory and under what conditions they are valid?

c) Derive Equation of motion using Lagrangian density?

Question No. 5. (2X7=14)

a) Apply Slater's determinant to particles with wave functions of different symmetries.

b) Using appropriate continuum limit, determine the expression for ground state energy of a non-interaction fermi gas.

c) Drive an expression for spin function of many electron system and verify the results for two particles system?

CENTRAL UNIVERSITY OF HARYANA

Term End Examinations, May 2018

Programme: M.Sc. (Physics) **Session: 2017-18**

Semester: IV **Max. Time: 3 Hours**

Course Title: Superconductivity: Conventional and High Temperature Superconductors **Max. Marks: 70**

Course Code: SPMS PHY 01 406 DCEC 3104

Instructions:

1. Question no. 1 has seven sub parts and students need to answer any four. Each sub part carries three and half Marks.

2. Question no. 2 to 5 have three sub parts and students need to answer any two sub parts of each question. Each sub part carries seven marks.

Question No. 1. (4X3.5=14)

a) Give three examples of Hard superconductors with their critical temperature.

b) What is dc Josephson effect? Explain briefly.

c) What is Silsbee's rule in superconductors?

d) Draw and explain the layering scheme of Nd_2CuO_4.

e) Discuss the effect of magnetic field on a superconductor.

f) Explain "Type-I" superconductors with suitable example.

g) Differentiate between a perfect conductor and superconductor.

Question No. 2.

a) Calculate the T_c and H_c at 4.3 K for a superconductor if critical currents are 1.43×10^6 amp/m and 4.20×10^6 amp/m at 14.9 K and 12.7 K, respectively. (7)

b) (i) Show that magnetic susceptibility of a superconductor is -1 and relative permeability is 0. (4)

(ii) What is the uniqueness of Platinum and Niobium in the view of superconductivity. (3)

c) (i) Explain the terms "Magnetic lavitation" and "Persistent currents". (5)

(ii) Write four particle uses of superconductors. (2)

Question No. 3.

a) (i) The critical temperature of Pb is 7.2 K. Determine the penetration depth in Pb at 5.1 K if penetration depth at absolute temperature is 480 Å. (4)

(ii) Explain briefly the Ginzburg-Landau theory for Homogeneous system. (3)

b) Establish the Rutgers formula for the specific heat of superconductors. (7)

c) Write short notes on (i) Ginzburg-Landau parameter (ii) Thermal conductivity of a superconductor (3.5+3.5)

Question No. 4.

a) What is Josephson effect? Explain. Show that a dc voltage of 1 μV produces a frequency of 483.6 MHz. (7)

b) What are Cooper pairs? Give qualitative idea of BCS theory of superconductivity. (7)

c) Write short notes on (i) BCS Hamiltonian (ii) SQUIDs (3.5+3.5)

Question No. 5.

a) Write five characteristics of cuprate superconductors. Discuss the crystal structure and family formula for **Hg** based high temperature superconductors. Also mention their layering schemes (n=0, 1,2). How many CuO_2 planes in them? (7)

b) Answer the following questions in brief for Y-123 superconductor (7)

c)

(i) Which type of crystal structure is this?
(ii) How many CuO_2 planes are there in it?
(iii) Mention the variation of coherence length in ab-plane and c-direction (iv) Nature of Fermi velocity

c) Write short note on (i) Origin of of superconductivity in $YBa_2Cu_3O_{6.93}$ (ii) NCCO-phase diagram. (3.5+3.5)

CENTRAL UNIVERSITY OF HARYANA

Term End Examinations, May/June 2018

Programme:	**M. Sc. (Physics)**	**Session: 2017-18**
Semester:	**IV**	**Max. Time: 3 Hours**
Course Title:	**Nonlinear Dynamics**	**Max. Marks: 70**
Course Code:	**SPMS PHY 01 403 DCEC 3104**	

Instructions:

1. Question no. 1 has seven sub parts and students need to answer any four. Each sub part carries three and half Marks.

2. Question no. 2 to 5 have three sub parts and students need to answer any two sub parts of each question. Each sub part carries seven marks.

Question No. 1. (4X3.5=14)

a) Consider following dynamical equation: $\dot{x} = x^2 - x - 2$. Find the fixed points (FPs), perform stability analysis of the FPs and draw corresponding phase portrait with arrows.

b) For the scaled undamped pendulum equation: $\ddot{x} = -\sin x$, find FPs, do the stability analysis and draw corresponding phase curve.

c) For the following dynamical equation perform the stability analysis and discuss the nature of bifurcation with phase curves : $\dot{x} = rx - x^3$. Further, draw the bifurcation diagram. Here, r is a parameter.

d) Consider the 2d Henon map :

$$x_{n+1} = 1 - a{x_n}^2 + y_n$$
$$y_n = bx_n$$

Here, a and b are positive parameters. Determine the Jacobian for this and find the values of the parameter for which the system is dissipative, conservative or volume expanding.

e) Determine the fractal dimension of Sierpinski triangle.

f) Consider following coordinate transformations and show that it is canonical.

Q = p cos ϕ – q sin ϕ and P = q sin ϕ + p cos ϕ

g) Determine action for 1d harmonic oscillator for a given Hamiltonian:

$$H = \frac{p^2}{2m} + \frac{1}{2}m\omega^2 q^2$$

Question No. 2. (2X7=14)

a) Consider the dynamical equations given as

$$\dot{x} = rx - x^3$$
$$\dot{y} = -y$$

Find FPs, do the stability analysis and discuss the bifurcation for different values of the parameter r. State the type of bifurcation, draw corresponding phase curves and bifurcation diagram.

b) What is a limit cycle? Discuss it for the following dynamical equations:

$\dot{r} = r(1 - r^2)$, $\dot{\theta} = 1$. Where r is the radius. Draw relevant phase curves.

c) Consider the logistic map :

$x_{n+1} = ax_n(1 - x_n)$, where n =0,1,2.... . Assume $0 \leq x \leq 1$ and $0 \leq a \leq 4$.

Perform the stability analysis and discuss bifurcation for the parameter a.

Question No. 3. (2X7=14)

a) Consider van der Pol oscillator : $\dot{x} = y$, $\dot{y} = b(1 - x^2)y - x$. Here b is the damping parameter which can take both positive and negative values. Discuss the nature of the system, i.e, whether it is conservative, dissipative of volume preserving for different values of parameter b. Further discuss Hopf bifurcation in this context with appropriate phase curve.

b) What is period doubling phenomena? Consider logistic map such that if x_1^* and x_2^* are two FPs for a 2-periodic case. Show that for stability $|f'(x_1^*)f'(x_2^*)| < 1$.

c) Construct a Cantor set and discuss its fractal dimension.

Question No. 4. (2X7=14)

a) Consider following Hamiltonian for the central force problem in polar coordinates :

$H = \frac{1}{2m}\left(p_r{}^2 + {p_\theta}^2/_{r^2}\right) - \frac{k}{r}$. Find the corresponding Hamilton-Jacobi equation. Determine actions for r and θ coordinates and find the transformed Hamiltonian as a function of actions.

b) Show that the following transformation is canonical :

$$Q = \ln\left(\frac{\sin p}{q}\right), \qquad P = q \cot p$$

and determine the generating function $F_2(P, q)$.

c) Discuss perturbation theory and show that the generating function diverges for rational frequency ratios.

Question No. 5. (2X7=14)

a) Write down a 2d diffusion equation. Use Euler's discretization method to find the resultant discretized equation.

b) Discuss followings :

(i) Integrability and completely integrable systems

Quantum chaos

c) Write a brief note on any two of the followings :

(i) Pattern formation

(ii) Solitons

(iii) Turbulence

CENTRAL UNIVERSITY OF HARYANA

Term End Examinations, May/June 2018

Programme: M.Sc. (Physics) **Session: 2017-18**
Semester: IV **Max. Time: 3 Hours**
Course Title: Thin Film and Integrated Devices **Max. Marks: 70**
Course Code: SPMS PHY 01 405 DCEC 3104

Instructions:

1. Question no. 1 has seven sub parts and students need to answer any four. Each sub part carries three and half Marks.
2. Question no. 2 to 5 have three sub parts and students need to answer any two sub parts of each question. Each sub part carries seven marks.

Question No. 1. (4X3.5=14)

a) Explain the concept of Etching.
b) Describe briefly about the thermal oxidation system.
c) What are fick's first and second laws of diffusion?
d) Explain contact resistance with suitable example.
e) What do you mean by baking of photo resist?
f) Give a brief idea of electron beam lithography.
g) Explain the difference between evaporation and sputtering.

Question No. 2. (2X7=14)

a) What do you mean by oxidation in IC fabrication? For what purpose it is used in IC fabrication? Discuss the important functions of SiO_2 in IC technology.
b) Explain diffusion process in semiconductor devices. What are the conditions required to be fulfilled for diffusion to occur.
c) Explain the czochoralski method of growth of single crystals of semiconducting materials. What are the possible areas of applications of single crystals grown by this technique? What is the disadvantage of this method?

Question No. 3. (2X7=14)

a) What is CVD? Explain about the reactors for chemical vapor deposition.
b) Write a short note on the following:
   1. Vacuum science and technology.
   2. CVD applications
c) What is photolithography? Discuss various advantages of photolithography. Also discuss about the photolithographic methods.

Question No. 4. (2X7=14)

a) What is X-ray lithography? Also explain its merits and demerits.
b) Describe the following:
   1. Electron beam evaporation.
   2. Hard baking of photo resists.
c) Differentiate between positive photo resist and negative photo resist.

Question No. 5. (2X7=14)

a) Explain uniform and non-uniform defect densities and derive necessary expression.
b) Describe the following:
   1. Ohmic contact formation.
   2. Die Separation.
c) Differentiate between diffused interconnections and poly silicon interconnections.

CENTRAL UNIVERSITY OF HARYANA
Jant-Pali, Mahendergarh, Haryana
Term End Examination May-2018

Name of Programme	:	M.Sc. Physics
Year & Semester	:	May 2018, Fourth Semester
Course Name	:	Introduction to Astrophysics and Cosmology
Course Code	:	SPMS PHY 01 404 DCEC 3104
Maximum Marks	:	70

Note: (1) All Questions are compulsory. .
(2) Attempt any Four parts in Question No. 1, each part carries 3.5 marks.
(3) Attempt any two out of three parts from Question 2 to Question 5. Each Part carries 7 marks.

Q1.

A. Define the equatorial coordinates of a celestial object in terms of spring equinox ?

B. Describe the reason behind naming AGB stars as such in HR diagram. What are white dwarf stars.

C. Define Brightness temperature and color temperature for an astrophysical object.

D. Define Photosphere-Granulation. What is the reason behind this process.

E Write down the general Robertson-Walker metric. Describe various terms in it.

F . Define Hubble's parameter and deaaceleration parameter of our Universe .

G. What do you understand by period luminosity relation of stars ? Where is it useful ?

Q2.

A. Define virial theorem. Show that average total energy of a gravitationaly bound system is negetive of its kinetic energy.

B. Derive the expression for the Energy and Agular momentun of a planet in an orbit around a star ?

C. Describe the scaling laws involving size and time period of an orbit of a planet around a star.

Q3.
A. Describe various features of the solar spectrum. What are fraunhauffer lines in the solar spectrum.

B. What region of the sun is photosphere ? Describe the convection process of energy transfer in a star.

C. What are different ways in which energy is produced at the core of the sun ? Describe the proton-proton reaction and CNO cycle.

Q4.

A. Write down the formal solution of radiative transfer equation in terms of optical depth and source function of the medium.

B. Using the thermodynamics of a blackbody radiation, derive the Stefan-Boltzmann Law.

C Define Brightness temperature, color temperature and Effective temperature for an astrophysical object.

Q5.

A. What do you understand by rotation curve of a galaxy ? How does its observation help us in identifying dark matter in galaxies.

B. What do you understand by Radiation density, matter density and Cosmological constant. How do these quantities evolve in an expanding universe ?

C. Explain how distances in cosmology are measured? What is angular diameter distance and luminosity distance? Explain why they are related according to $D_L(z) = (1+z)^2 D_A(z)$

CENTRAL UNIVERSITY OF HARYANA
Jant-Pali, Mahendergarh, Haryana
Term End Examination May-2018

Name of Programme	:	**M.Sc. Physics**	
Year & Semester	:	**May 2018, Second Semester (Reappear)**	
Course Name	:	**Classical Electrodynamics**	
Course Code	:	**SPMS PHY 01 202 CC 3104**	
Maximum Marks	:	**70**	**Duration : 3Hrs**

Note:
(1) All Questions are compulsory. .
(2) Attempt any Four parts in Question No. 1, each part carries 3.5 marks.
(3) Attempt any two parts from each of the questions 2 to 5. Every part carries 7 marks.

Q1.
a. What is gauge symmetry ? Define Coloumb Gauge.

b. Write down biot savart law. Show that magnetic forces do not work.

c. Write down Laplace equation in cyllindrial and spherical coordinates.

d. Define dispersion of an electromagnetic wave ? What is anamolous dispersion.

e. What do you understand by four vectors ? Which four vectors are relevant to electrodynamics.

f. Define scalar and vector potential. Express Gauss's Law of electrostatics in terms of scalar potential

g. When light undergoes total internal reflection at an interface between two optical media with indexes n and n′, What is required expression of the incident angle θ ?

Q2.
(a) Express the equation of motion of an accelerated charged particle in terms of the electric and the magnetic fields E and H.

(b) Determine the motion of a charge that is moving relativistically in parallel, uniform, electric and magnetic fields.

(c) Determine the motion of a charge that is moving relativistically in uniform electric and magnetic fields that are perpendicular to each other

Q3.
A. Write down and derive the differential forms of Maxwell's Equations.

B. Find the reflection and transmission coefficients of an Electromagnetic wave that is incident perpendicular to the surface between two medium.

C. Write out an equation for Poynting's theorem in differential form. Explain in words what each term means physically.

Q4.

A. Derive and write an expression that gives the electrostatic field energy density in vacuum.

B. Derive and write Gauss' Law in integral form. State its physical significance.

C, A point charge q is located a distance 'a' above an infinite plane conductor held at zero potential. Use the method of images to find the surface charge density on the plane, as a function of a radial coordinate ρ

Q5.

A. Derive the expression for maxwell's equation in terms of electromagnetic field tensor ?

B. Write down the equation of transformation of electromagnetic field ?

C. Find the expression for electric field due to a moving charge using four vectors.

CENTRAL UNIVERSITY OF HARYANA
Jant-Pali, Mahendergarh, Haryana
Term End Examination May-2018

Name of Programme	:	M.Sc. Physics
Year & Semester	:	May 2018, Second Semester (Reappear)
Course Name	:	Advanced Quantum Mechanics I
Course Code	:	SPMS PHY 01 202 DCEC 3104
Maximum Marks	:	70 Duration : 3Hrs

Note: (1) All Questions are compulsory. .
(2) Attempt any Four parts in Question No. 1, each part carries 3.5 marks.
(3) Attempt any two parts from Question No. 2 to Question No. 5. Each part carries 7 marks

Q1.

A. Verify the statement : If a linear operator U produces a symmetry transformation on all ket vectors, then it must commute with the hamiltonian.

B. What do you understand by symmetry. Give example of continuous and discrete symmetry.

C. Define total scattering cross section. Explain briefly that the low-energy scattering to be dominated by the partial wave with l = 0.

D. What properties of identical Bosons is guiding principle behind LASERs and Bose Einstein condensation ?

E. What is the condition for sudden approximation of time dependent perturbation ?

F. What is/are the basic characterestic(s) of four-vector ? Give examples of four-vector.

G. Define antiparticle in context of Dirac equation in Relativistic Quantum Mechanics.

Unit-I

Q2.

A. Show that generator of spatial translation and time translation symmetry is linear momentum and Hamiltonian operator respectively.

B. A particle is in a potential $V(x) = V_0 sin(2\pi x/a)$ which is invariant under translations x→x+ma, where m is an integer. Is momentum conserved? Why or why not?

C. What is rotation symmetry? Describe the rotation symmetry operator in three dimension.

Unit-II

Q3.

A. Show that general wavefunction for two indistinguisshable particles can be either symmetric or antisymmetric. Distinguish between Fermionic and bosonic wave function based upon the above definition.

B. Write all possible wavefunctions of first excited state of He atom also taking care of the spin of electron.

C. $\psi(A,B) = \phi(A)\xi(B)$ is a wave function of two particle system where $\phi(A)$and $\xi(B)$ are wavefunction of individual particles. Is $\psi(A,B)$ representing a distinguishable or indistinguishable particles system ? Explain.

Unit-III

Q4.

A. Describe the evolution of state vecors and operators in Interaction Picture of perturbation theory.

B. Derive a relation between scattering cross section and imaginary part of scattering amplitude using optical theorem.

A. For time dependent perturbation theory, write down the expression for evolution opearator of interacting state vector in terms of Dyson series. ?

Unit-IV

Q5.

A. How does the schrodinger equation modify for Relativistic quantum mechanics.

B. Write down Dirac equation and discuss the properties of dirac matrices.

A. Explain the terms Charge conjugation (C), Parity (P) and time reversal (T) with suitable examples.

CENTRAL UNIVERSITY OF HARYANA
Jant-Pali, Mahendergarh, Haryana
Term End Examination May-2018

Name of Programme	:	**M.Sc. Physics**	
Year & Semester	:	**May 2018, Third Semester (Reappear)**	
Course Name	:	**Solid State Physics**	
Course Code	:	**SPMS PHY 01 303 CC 3104**	
Maximum Marks	:	**70**	**Duration : 3Hrs**

Note:
(1) All Questions are compulsory. .
(2) Attempt any Four parts in Question No. 1, each part carries 3.5 marks.
(3) Attempt any two parts from each of the questions 2 to 5. Every part carries 7 marks.

Q1.

A. What are Miller Indices. How will you determine them?

B. Discuss briefly the method of crystal structure determination using rotating crystal method.

C. What is group velocity ? In what respects does it differ from phase velocity ?

D. Define density of states. How can you estimate it for a given element ?

E. Distinguish among insulators, semiconductors and conductors on the basis of band theory of solids.

F. What are High Tc superconductors ? In what ways do these differ from superconductors ?

G. Explain DC and AC Josephson's Effect.

Q2.

A. Given the basis vector of hcp structure

$$\mathbf{a} = (\sqrt{3/2}a)\mathbf{i} + (a/2)\mathbf{j}\ ,\ \mathbf{b} = (-\sqrt{3/2}a)\mathbf{i} + (a/2)\mathbf{j}\ ,\ \mathbf{c} = c\mathbf{k}$$

Find the volume of this structure. Also find its reciprocal lattice and to which crystal class does it belong.

B. What are Crystal and Atomic Structure Factors ? Derive an expression for Atomic Structure Factor.

C. Deduce the Bragg's Law from the diffraction condition and show that its geometrical interpretation leads to the concept of Brillioiuin Zones in a crystal.

Q3.

A. Discuss the failures of classical theory of specific heat. How these failures are accounted for in Einstein's Model of specific heat ?

B. Give the modifications incorporated by Debye and derive T^3 law. Calculate the vibrational frequency of carbon whose Debye's Temperature is 1650 K. Given $h = 6.6 \times 10^{-34} Js, k_B = 1.38 \times 10^{23} J/K$

C. What are phonons? Describe the acoustical and optical modes.

Q4.

A. State Bloch's Theorem. Obtain the energy spectrum of an electron in one-dimensional periodic potential.

B. Explain Hall effect. Also find expressions for Hall voltage and Hall coefficient. What are applications of Hall Effect ?

C. Discuss the Drude Model of electrical and thermal conductivity.

Q5.

A. Discuss in details the concepts of 'isotope effect' and 'critical field' in superconductors.

B. What is Meissener effect in superconductors. Enumerate the properties of type 1 and type 2 superconductors.

C. Discuss the BCS theory of superconductivity.

CENTRAL UNIVERSITY OF HARYANA

Reappear Examinations, May/June 2018

Programme: M. Sc. **Session: 2017-18**

Semester: III **Max. Time: 3 Hour**

Course Title: Advanced Statistical Mechanics **Max. Marks: 70**

Course Code: SPMS PHYS 01 310 DCEC 3104

Instructions:

1. Question no. 1 has seven sub parts and students need to answer any four. Each sub part carries three and half Marks.

2. Question no. 2 to 5 have three sub parts and students need to answer any two sub parts of each question. Each sub part carries seven marks.

Question No. 1. (4X3.5=14)

a) What is a metastable state? What do you understand by coexistence of phases?

b) Express Gibb's free energy G(m,T) as a function of order parameter m and temperature T in Landau theory . Draw the curve G(m,T) vs m. Explain phase transition when a system is quenched from a high temperature parent phase to low temperature product phases below the critical temperature.

c) Show that in 1d Ising model there is no phase transition at any finite temperature except when .

d) Express Langevin equation with details of individual terms . State Einstein's relation.

e) Discuss time correlation functions.

f) Derive diffusion equation in 1d using Fick's law.

Question No. 2. (2X7=14)

a) Find critical coefficients using van der Waals equation.

b) Consider a magnet at fixed temperature T and external magnetic field h. Use Bragg-Williams theory to obtain Gibb's free energy G as a function of average magnetization m.

c) Define critical exponents. Show that in mean field theory the magnetization exponent $\beta=1/2$.

Question No. 3. (2X7=14)

a) Discuss kinetic theory of gases. Write down Boltzmann equation. What do you understand by ``molecular chaos"?

b) What do you understand by following :

(i) Irreversibility

(ii) Ergodicity

(iii) Brownian motion

c) Use Langevin equation to derive fluctuation-dissipation relation.

Question No. 4. (2X7=14)

a) Discuss Boltzmann H-theorem and its connection to entropy and second law of thermodynamics.

b) Consider transcendental equation for average magnetization obtained in mean field theory of an Ising model. Discuss its solutions above and below the critical temperature graphically.

c) Write brief notes on followings :

(1) Linear response theory

(2) Onsager relations.

Question No. 5. (2X7=14)

a) Explain collisionless and hydrodynamic regimes. Further define viscosity and Reynolds number.

b) Derive Euler's equation using conservation of momentum for a fluid flow in terms of gradient of its local pressure P.

c) Discuss diffusion and explain the terms "self diffusion" and "mutual diffusion". Consider diffusion of gas particles from one place to other of a gas of uniform temperature T. Find diffusion constant as function of mean free path and most probable velocity.