CENTRAL UNIVERSITY OF HARYANA

Second Semester Term End Examinations August-September 2022

Programme: M.Sc. Physics **Session: 2021-22**

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

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

Course Code: SBS PHY 01 202 CC 3104

Instructions:

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

2. Question no. 2 to 5 have three parts and student are required to answer any two parts of each question. Each part carries seven marks.

Q 1. (4X3.5=14)

a) How far are we justified in assuming $\rho = 0$ for conducting medium like metals?

b) Bring out the difference between Dirichlet and Neumann boundary condition.

c) Using Stoke's theorem, find line integral of a vector field $-y\hat{i} + x\hat{j}$ over a circle of radius a with centre at the origin in the x-y plane.

d) How does the Lorentz condition lead to the concept of displacement current?

e) What are Stoke's parameters?

f) What is the significance of Hertz potential?

g) A uniform wave propagating in a medium has $E = 2e^{-\alpha z}\sin(10^8 t - 5z)a_y$. If medium is characterized by $\varepsilon_r=1$, $\mu_r = 20$ and $\sigma = 3$ mho/m, find α, β and H.

Q 2. (2X7=14)

a) Derive an expression for energy of a charge distribution in Dielectric Media.

b) Obtain boundary conditions for all the field vectors D, E B and H.

c) Consider a point charge q at a distance d from the center of a grounded conducting sphere of radius a using method of images. Calculate the surface density of induced charge and the force between the sphere and the charge q.

Q3. (2X7=14)

a) Derive law of conservation of energy for em field and hence define the Poynting vector.

b) In an unbounded homogeneous medium, show that a plane monochromatic wave travels with a phase velocity $c/\sqrt{\mu\varepsilon}$.

c) Derive an expression for skin Depth in conductors. What is the ratio of skin depth in Cu at 10^{14} Hz to that at10^{10} Hz. Given that $\sigma = 5\text{x}10^{17}\text{s}^{-1}$.

Q 4. (2X7=14)

a) Derive Dispersion Relation and hence differentiate between Normal and Anomalous Dispersion.

b) Bring out the difference between induced polarization and orientational polarization. What is the effect of temperature on them?

c) Derive TE and TM modes of electromagnetic waves in a Waveguide.

Q 5. (2X7=14)

a) In the long wavelength approximation, calculate the radiation field produced by a system of harmonically oscillating source.

b) Show that there will be no emission of radiation in dipole approximation for systems consisting of particles having same e/m ratio.

c) What are retarded potentials? Obtain limiting conditions on these potentials.

CENTRAL UNIVERSITY OF HARYANA
Jant-Pali, Mahendergarh, Haryana
Term End Examination August-September-2022

Name of Programme : M.Sc. Physics
Year & Semester : September 2022, Second Semester
Course Name : Introduction to Astronomy and Astrophysics
Course Code : SBS PHY 01 204 DCEC 3104
Maximum Marks : 70 **Duration : 3 Hrs**

Note:
Attempt any Four parts in Question No. 1, each part carries 3.5 marks.
Attempt any Two parts from each of the remaining questions. Each part carries 7 marks.

Q1.

a. **The luminosity of Betelguese is 27500 times the luminosity of the sun. If thetemperature of Betelguese is 3400 K. Determine the size of Betelguese compared to the sun. Given that temperature of sun is 5500 K.**

b. **Apparent magnitude of a star is -26.74. This value changes to 4.83 if the staris placed at 10 parsec from the observer. Find the actual distance of the star from observer.**

c. **Using the rules of spherical trigonometry prove that the celestial equator cuts the horizon at an angle of $90-\varphi$ where φ is the lattitude of the observer.**

d. **Define sidereal time, apparent solar time and mean solar time.**

e. **How do stellar motions and atmospheric extinction affect the distance measurement of stars?**

f. **What do you understand by Photosphere? What is the cause of granulation on photosphere of the sun?**

g. **Define and classify different types of intrinsic variable stars.**

Q 2.

a. **Illustrate with diagrams, the Horizon, Equatorial, Ecliptic and galactic system of coordinates.**

b. The star Aldebaran has Right Ascension 4h36m, declination +16°31'. What are its ecliptic coordinates?

c. Describe the evolution of a star from H-R diagram

Q 3.

a. Define apparent magnitude and absolute magnitude of a star. If the absolute magnitude of a star is larger than the absolute magnitude of the Sun by 5, what is the luminosity of that star,
expressed in solar luminosity

b. What do you understand by black body spectrum? How is this used to calculate the temperature of stellar objects?

c. A star in nearby star cluster has been photographed 10 years apart and found to have moved by 3" during this period. If the radial velocity (Doppler Shift) of the star is 2 AU per year, find the distance of the star.

Q 4.

a. What do you understand by binary stars? Define visual and spectroscopic binaries.

b. The α Centauri system is 1.338 pc distant with a period of 79.92 years. The A and B components have a mean separation of 23.7 AU (although the orbits are highly elliptical). What is the total mass of the system?

c. Write a short note on Supernovae.

Q 5.

a. Describe the babcock model for formation of sunspots.

b. What do you understand by Corona of the sun? Describe Parker Model of Solar wind.

c. Describe the cause of solar rotation and solar magnetic field.

CENTRAL UNIVERSITY OF HARYANA

Second Semester Term End Examinations August-September 2022

Programme: M.Sc. Physics **Session: 2021-22**

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

Course Title: Solar Energy and Physics of Photovoltaics **Max. Marks: 70**

Course Code: SBS PHY 03 806 DS 4004

Instructions:

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

Q 1. **(4x3.5=14)**

a) Define and explain the following with neat diagrams:-
i) Solar azimuth angle ii) Declination angle

b) What do you mean by Direct and Indirect Band gap semiconductors. Give examples.

c) Define solar constant, Air Mass and Zenith.

d) State the limitation of Solar Cell efficiency.

e) Explain solar air heating.

f) Explain the working of a Zener diode. How is it used for voltage stabilization ?

Q 2. **(2x7=14)**

a) Explain the construction and working of solar flat plate collectors. Discuss the thermal analysis of flat plate collector?

b) Explain the principle of solar collector tracking system with neat diagram. Give the merits and demerits of collector tracking system.

c) Classify the different solar energy measuring equipments. What is the difference between a Pyrheliometer and a pyranometer.

Q3. **(2x7=14)**

a) Explain the construction and working of a solar pond with neat sketch. What are its advantages and disadvantages?

b) Explain the need for energy storage solar systems? Describe mechanisms of sensible heat energy storage.

c) Explain the working principle, construction and elements of combined solar heating and cooling systems by giving their applications.

Q 4. **(2x7=14)**

a) What is p-n junction ? Discuss the function of p-n junction and explain its working in forward and reverse bias. Calculate the density of electron at 300 K if band gap energy for semiconductor is 0.7 eV. $k = 1.38 \times 10^{-23}$ J/K and $m = 9.1 \times 10^{-31}$ kg.

b) What are the steps involved in Si wafer fabrication? Explain Czochralski and Float zone techniques in detail.

c) What is Fermi distribution function? Show that fermi level for an intrinsic semiconductor lies exactly in the middle of valence band and conduction band. There are 2.54×10^{22} free electrons per cm^3 in sodium. Calculate its Fermi energy, Fermi velocity and Fermi temperature. ($h = 6.63 \times 10^{-34}$ Js, $k = 1.38 \times 10^{-23}$ J/K and $m = 9.1 \times 10^{-31}$ kg and 1 eV = 1.6×10^{-19} J).

Q 5. **(2x7=14)**

a) What is Photovoltaic Effect? Draw the typical current-voltage and power- voltage characteristics of a solar cell and explain its salient points. A solar cell is made from single crystal silicon and the array consists of 24 modules, each model consists of 36 cells with 10.4x 10.4 cm size. It is given that the inverter efficiency is 85 %. calculate power output in watts.

b) Define fill factor of solar PV system. A solar cell (0.9 cm^2) receives solar radiation with photons of 1.8 eV energy having an intensity of 0.9 mW/cm^2. Open circuit voltage is 0.6 V/cm^2, short circuit current is 10 mA/cm^2 and the maximum current is 50% of the short circuit current. The efficiency of the cell is 25%. Find the maximum voltage that the cell can give and the fill factor.

c) Explain the working mechanism of a perovskite and tandem solar cell giving a neat sketch. Is it more efficient than single junction solar cell? Justify.

CENTRAL UNIVERSITY OF HARYANA

Second Semester Term End Examinations August-September 2022

Programme: M.Sc. Physics **Session: 2021-22**

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

Course Title: Environmental Physics **Max. Marks: 70**

Course Code: SBS PHY 01 202 GEC 3104

Instructions:

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

2. Question no. 2 to 5 have three parts and student are required to answer any two parts of each question. Each part carries seven marks.

Q 1. (4X3.5=14)

a) Differentiate between kinetic and potential energy?

b) What is P-E diagram?

c) What is the law of conservation of energy?

d) What is the relationship between heat, internal energy and work done?

e) What is heat capacity?

f) What is greenhouse effect?

g) What do you mean by climate change mitigation?

Q 2. (2X7=14)

a) Describe the importance of energy in our daily life.

b) What is heat transfer? Describe various ways of heat transfer.

c) Explain mechanical, chemical and nuclear energy.

Q3. (2X7=14)

a) Derive an expression for the efficiency of Carnot's engine in terms of temperature of hot body and sink.

b) Define entropy and describe the principle of increase of entropy.

c) Describe the application of second law of thermodynamics in refrigeration process.

Q 4. (2X7=14)

a) How does earth balance its energy?

b) What is climate feedback and describe its importance?

c) Write a note on Paleo-climate?

Q 5. (2X7=14)

a) Describe the relationship between photosynthesis and respiration.

b) What is biomass? Describe alternative sources of energy.

c) Describe fossil fuels and their origin.

CENTRAL UNIVERSITY OF HARYANA

End Semester Examinations September 2022

Programme: Integrated B.Sc. M.Sc. (Chemistry/Mathematics)

Semester: II **Session: 2021-22**

Course Title: Electricity and Magnetism (GE) **Max. Time: 3 Hours**

Course Code: SBS PHY 03 205 GEC 4004 **Max. Marks: 70**

Instructions:

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

Q1. (a) Find divergence of vector function $\vec{A} = \vec{r}/r^3$, where $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$.

(b) A wire of length 4 m is placed along the positive x-axis with one of its end is fixed at origin. Find the total charge on it if the linear charge density is given by $\lambda(x) = 4x$ (C/m).

(c) How much does the capacitance of an isolated spherical capacitor change if we increase its surface area by four times?

(d) Find the integral form of Ampere's law from the following expression $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$, where $\vec{B}$ is magnetic field, $\vec{J}$ is volume current density and μ_0 is magnetic permeability of the free-space.

(e) A rod of magnetic material, 0.5 m in length has a coil of 100 turns over it uniformly. Find $\vec{H}$ and magnetic field $\vec{B}$ if a current of 4 ampere is passed through it. Given $\chi_m = 6 \times 10^{-3}$.

(f) An electric field in free space is given by $\vec{E} = E_0 \cos kx \cos \omega t \ \hat{z}$, where k is propagation vector and ω is angular frequency. Find the magnetic field $\vec{B}$.

(g) Is it true that magnetic forces do no work? Give argument to support your assertion.

$(4 \times 3.5 = 14)$

Q2. (a) If $\vec{a}_1 = 3\hat{i} - 2\hat{j} + 4\hat{k}$ and $\vec{a}_2 = -5\hat{i} + 2\hat{j} - 1\hat{k}$, then what is $(\vec{a}_1 + \vec{a}_2).(\vec{a}_1 \times 4\vec{a}_2)$?

(b) Find the gradient of the magnitude of position vector, i.e., $r = \sqrt{x^2 + y^2 + z^2}$.

(c) A vector function is given by $\vec{v} = v_x\hat{i} + v_y j + v_z\hat{k}$. Derive the expressions for $\vec{\nabla}.\vec{v}$ and $\vec{\nabla} \times \vec{v}$. Also, discuss the geometrical interpretation of $\vec{\nabla}.\vec{v}$ and $\vec{\nabla} \times \vec{v}$.

$(2 \times 7 = 14)$

Q3. (a) What is a conservative field? Prove that the electrostatic field due to an infinite straight wire is conservative in nature.

(b) Find the expression for capacitance of an isolated spherical capacitor.

(c) Discuss Gauss's law in presence of dielectrics and show that the displacement field is given by $\vec{D} = \epsilon \vec{E}$, where ϵ is permittivity of the material.

$(2 \times 7 = 14)$

Q4. (a) Find the expression for magnetic field at a distance 's' above the centre of a circular loop of radius 'R', which carries a steady current 'I'.

(b) Compare dia, para and ferromagnetic materials on the basis of magnetic moment, spin alignment, susceptibility, relative magnetic permeability (μ_r) and their behaviour in external magnetic field.

(c) Define magnetic susceptibility (χ_m) and magnetic permeability (μ). Establish the relation: $\mu = \mu_0(1 + \chi_m)$.

$(2 \times 7 = 14)$

Q5. (a) Explain why Ampere's law fails for the non-steady currents. Discuss how Maxwell fixed Ampere's law.

(b) Write Maxwell's electromagnetic equations in vacuum and discuss their physical significance.

(c) Define Poynting vector. Find the values of the magnitude of magnetic field ($\vec{B}$), energy density (u) and Poynting vector ($\vec{S}$) if the magnitude of the electric field vector ($\vec{E}$) of an electromagnetic wave is 60π volt/metre.
Given that $c = 3 \times 10^8$ m/s, $\epsilon_0 = 8.85 \times 10^{-12}$ C^2/N-m^2, and $\mu_0 = 4\pi \times 10^{-7}$ N/A^2 .

$(2 \times 7 = 14)$

CENTRAL UNIVERSITY OF HARYANA

Second Semester Term End Examinations August- September 2022

Programme: Integrated B.SC. - M.SC. **Session: 2021-22**

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

Course Title: Electricity and Magnetism **Max. Marks: 70**

Course Code: SBS PHY 03 201 CC 4004

Instructions:

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

2. Question no. 2 to 5 have three parts and student are required to answer any two parts of each question. Each part carries seven marks.

Q 1. (4X3.5=14)

a) Is current density a vector or scaler quantity?

b) How much electronic charge required to make 1 coulomb?

c) Find the electric potential due to a point charge?

d) Prove that div. $\vec{B} = 0$ and explain its significance.

e) Define the following terms

i) Intensity of Magnetization

ii) Magnetic Susceptibility

iii) Magnetic Flux

f) What do you understand by ferromagnetism?

g) Explain scaler and vector potentials.

Q 2. (2X7=14)

a) Prove that the curl of an electrostatic field is zero.

b) If 10 coulomb charge is placed at the centre of a cube of side 10 cm, calculate the flux coming out of any force of the cube.

c) Show that for external points, a spherical symmetric charge distribution behaves as if the entire charge were concentrated at the centre.

Q3. (2X7=14)

a) Derive the relationship between **E, P** and **D.**

b) Explain different types of electric polarization.

c) Describe electric displacement vector and deduce Gauss's law for dielectric.

Q 4. (2X7=14)

a) Explain Biot-Savart law. Obtain the expression for magnetic field due to current in a straight wire.

b) With the help of Ampere's law, derive an expression for magnetic field due to a long solenoid.

c) Derive the relationship between **H, B** and **M.**

Q 5. (2X7=14)

a) State and prove Reciprocity Theorem for Mutual Inductance.

b) State and explain Norton's Theorem.

c) Derive the expression for energy stored in magnetic field

CENTRAL UNIVERSITY OF HARYANA

End Semester Examinations September 2022

Programme: Integrated B.Sc. M.Sc. (Chemistry/Mathematics)

Semester: II | **Session: 2021-22**

Course Title: Electricity and Magnetism (GE) | **Max. Time: 3 Hours**

Course Code: SBS PHY 03 205 GEC 4004 | **Max. Marks: 70**

Instructions:

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(c) How much does the capacitance of an isolated spherical capacitor change if we increase its surface area by four times?

(d) Find the integral form of Ampere's law from the following expression $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$, where $\vec{B}$ is magnetic field, $\vec{J}$ is volume current density and μ_0 is magnetic permeability of the free-space.

(e) A rod of magnetic material, 0.5 m in length has a coil of 100 turns over it uniformly. Find $\vec{H}$ and magnetic field $\vec{B}$ if a current of 4 ampere is passed through it. Given $\chi_m = 6 \times 10^{-3}$.

(f) An electric field in free space is given by $\vec{E} = E_0 \cos kx \cos \omega t \; \hat{z}$, where k is propagation vector and ω is angular frequency. Find the magnetic field $\vec{B}$.

(g) Is it true that magnetic forces do no work? Give argument to support your assertion.

$(4 \times 3.5 = 14)$

Q2. (a) If $\vec{a}_1 = 3\hat{i} - 2\hat{j} + 4\hat{k}$ and $\vec{a}_2 = -5\hat{i} + 2\hat{j} - 1\hat{k}$, then what is $(\vec{a}_1 + \vec{a}_2).(\vec{a}_1 \times 4\vec{a}_2)$?

(b) Find the gradient of the magnitude of position vector, i.e., $r = \sqrt{x^2 + y^2 + z^2}$.

(c) A vector function is given by $\vec{v} = v_x\hat{i} + v_y j + \hat{v_z}\hat{k}$. Derive the expressions for $\vec{\nabla}.\vec{v}$ and $\vec{\nabla} \times \vec{v}$. Also, discuss the geometrical interpretation of $\vec{\nabla}.\vec{v}$ and $\vec{\nabla} \times \vec{v}$.

$(2 \times 7 = 14)$

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(b) Find the expression for capacitance of an isolated spherical capacitor.

(c) Discuss Gauss's law in presence of dielectrics and show that the displacement field is given by $\vec{D} = \epsilon \vec{E}$, where ϵ is permittivity of the material.

$(2 \times 7 = 14)$

Q4. (a) Find the expression for magnetic field at a distance 's' above the centre of a circular loop of radius 'R', which carries a steady current 'I'.

(b) Compare dia, para and ferromagnetic materials on the basis of magnetic moment, spin alignment, susceptibility, relative magnetic permeability (μ_r) and their behaviour in external magnetic field.

(c) Define magnetic susceptibility (χ_m) and magnetic permeability (μ). Establish the relation: $\mu = \mu_0(1 + \chi_m)$.

$(2 \times 7 = 14)$

Q5. (a) Explain why Ampere's law fails for the non-steady currents. Discuss how Maxwell fixed Ampere's law.

(b) Write Maxwell's electromagnetic equations in vacuum and discuss their physical significance.

(c) Define Poynting vector. Find the values of the magnitude of magnetic field ($\vec{B}$), energy density (u) and Poynting vector ($\vec{S}$) if the magnitude of the electric field vector ($\vec{E}$) of an electromagnetic wave is 60π volt/metre.
Given that $c = 3 \times 10^8$ m/s, $\epsilon_0 = 8.85 \times 10^{-12}$ C^2/N-m^2, and $\mu_0 = 4\pi \times 10^{-7}$ N/A^2 .

$(2 \times 7 = 14)$

CENTRAL UNIVERSITY OF HARYANA

End Semester Examination (August-September 2022)

Programme: Integrated B.Sc. M.Sc. (Physics)
Semester: II **Session: 2021-22**
Course Title: Waves and Optics **Max. Time: 3 Hours**
Course Code: SBS PHY03 202 CC 4004 **Max. Marks: 70**

Instructions: • Q1 has seven parts and students need to answer any four. Each part carries three and half marks.

- Q2 to Q5 have three parts and student need to answer any two parts of each question. Each part carries seven marks.
- The use of a personal non-programmable calculator is allowed.

Q1. (a) What is coherence length and coherence time?

(b) Define wave velocity and group velocity. Also find the relation between the two.

(c) Find the velocity with which a transverse plane wave will progress on a wire with diameter 0.8 mm and density 7.9 g/cc stretched by load equivalent to 500 N.

(d) What will be the radius of first half period zone in a zone plate behaving like a convex lens of focal length 60 cm for a light of wavelength 600 nm?

(e) What will be the frequency of the note emitted by a wire of 30 cm in length when stretched by a weight of 25 kg, if two meters of wire weighs 4.79 g?

(f) A thin sheet of transparent material (refractive index = 1.60) is placed in the path of one of the interfering beams in biprism experiment using Na-lamp (wavelength = 589 nm). If the central fringe shifts to a position originally occupied by 12^{th} fringe, calculate the thickness of the sheet.

(g) Derive the expression for radii of half period zones. Also show that area under each half period zone is equal.

$(4 \times 3.5 = 14)$

Q2. (a) Two simple harmonic motions with same phase and slightly different frequencies superimpose over each other. Derive the equation for resultant motion.

(b) Discuss the case of superposition of two simple harmonic motions of the same period at right angle to each other by (i) graphical method, and (ii) analytical method.

(c) A light wave is incident on the boundary separating two media with characteristic impedance Z_1 and Z_2, respectively. Derive the expression for (i) reflection coefficient of energy, and (ii) transmission coefficient of energy. Also show that sum of two coefficients is unity.

(2 × 7 = 14)

Q3. (a) Derive the expression for Newton's formula for sound wave. What is the need of correction to this formula and how Laplace corrected it?

(b) What is a stationary wave? Derive the expression to find the location of nodes and antinodes in case of a stationary wave.

(c) Describe Young's experiment and derive expression for (i) intensity at a point on the screen and (ii) fringe width.

(2 × 7 = 14)

Q4. (a) Derive the relation for maxima and minima in case of interference in thin film of uniform thickness.

(b) Discuss the theory behind Newton's rings experiment to determine the wavelength of a monochromatic light.

(c) Describe Michelson interferometer with a neat diagram. How it can be used to find the difference between two close wavelengths?

(2 × 7 = 14)

Q5. (a) Explain the construction and mode of action of a diffraction grating. Also derive the expression for its resolving power.

(b) Discuss the phenomenon of diffraction due to a straight edge to obtain the position of maximum and minimum intensity.

(c) What is hologram? Describe the recording and reconstruction processes in holography with the help of suitable diagrams.

(2 × 7 = 14)

CENTRAL UNIVERSITY OF HARYANA

Second Semester Term End Examinations September 2022

Programme: M.Sc. Physics **Session: 2021-22**

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

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

Course Code: SBS PHY 01 201 CC 3104

Instructions:

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

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

Q 1. (4X3.5=14)

a) Write the relation for canonical partition function for: (i) non-degenerate energy states, (ii) energy states with degeneracy, and (iii) energy states in thermodynamical limit.

b) Explain the difference between intensive and extensive properties? What do you mean by thermodynamic limit?

c) Write the units and dimensions of Boltzmann's factor. Define fugacity for a grand-canonical ensemble.

d) State and prove Liouville's theorem.

e) What is the entropy change of water when 1000 g of water is heated from 20°C to 80°C? Given that specific heat of water has a constant value of 4.2 J/g-°C.

f) State equipartition and virial theorems.

g) Write the difference between Fermions and Bosons. Draw the distribution function for an ideal Fermi gas.

Q 2. (2X7=14)

a) What do you mean by Brownian motion? Discuss in detail Einstein-Samulchowski theory of Brownian motion.

b) A mass m, of water at temperature, T_1, is isobarically and adiabatically mixed with an equal mass of water at temperature T_2. Show that the entropy change of the universe is found to be $2mC_p * \log_e\left(\frac{T_1+T_2}{2(T_1T_2)^{1/2}}\right)$.

c) State and prove Central limit theorem.

Q3. (2X7=14)

a) Discuss Gibbs paradox. How is it resolved?

b) Derive the expression for temperature, pressure, chemical potential, Helmholtz free energy, Gibbs free energy and thermal capacities using Sackur-Tetrode equation for entropy of the system.

c) Discuss the thermodynamics for a micro-canonical ensemble.

Q 4. (2X7=14)

a) Discuss in detail about number density fluctuations and energy fluctuations in a grand-canonical ensemble.

b) For given canonical ensemble, show that $C_v = k\beta^2\left[\frac{\partial^2}{\partial\beta^2}\left(ln\, Q_N(V,\beta)\right)\right]_{N,V}$

c) Discuss a system of harmonic oscillators in terms of canonical ensemble and find the Helmholtz energy for the same system.

Q 5. (2X7=14)

a) Write the relation for mean occupation number for different ideal gases. Prove that mean energy is always larger than chemical potential for an ideal Bose gas.

b) Define macrocanonical partition function. Show that A= G-PV = -kT*ln$\left(\frac{Q(z,V,T)}{z^{<N>}}\right)$.

c) Discuss the phenomenon of diffusion and state Fick's first law of diffusion and second law of diffusion. Derive the relation between coefficient of diffusion and viscosity.

CENTRAL UNIVERSITY OF HARYANA

Second Semester Term End Examinations August-September 2022

Programme: M.Sc. Physics | **Session: 2021-22**
Semester: II | **Max. Time: 3 Hours**
Course Title: Quantum Mechanics-II | **Max. Marks: 70**
Course Code: SBS PHY 01 202 CC 3104

Instructions:

1. Question number 1 has seven sub parts and students need to answer any four. Each sub part carries three and half marks.
2. Question number 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 Number 1. (4X3.5=14)

a) Prove that the parity operator is Hermitian and unitary.

b) "Matrix elements of the dipole moment operator vanish between states with the same parity". Prove this statement.

c) A constant perturbation H' is applied to a system for time Δt (where $H'\Delta t \ll \hbar$) leading to a transition from a state with energy E_i to another with energy E_f. If the time of application is doubled, then how will the probability of transition be affected?

d) Consider a system in the unperturbed state described by the Hamiltonian, $H_0 = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$. The system is subjected to a perturbation of the form $H' = \begin{pmatrix} \delta & \delta \\ \delta & \delta \end{pmatrix}$, where $\delta \ll 1$. Determine the energy eigenvalues of the perturbed system using the first order perturbation approximation.

e) Show that the parity operator commute with the orbital angular momentum operator.

f) The second-order correction to the energy of the ground state is always negative. Why?

g) Prove the optical theorem, which relates the total cross-section to the imaginary part of the forward scattering amplitude: $\sigma = \frac{4\pi}{k} Im[f(0)]$.

Question Number 2. (2X7=14)

a) A particle of mass m moves in one dimension in a harmonic-oscillator potential: $H = \frac{\hat{p}^2}{2m} + \frac{1}{2} m\omega^2 x^2$. Find the position operator in the Heisenberg picture at time t.

b) Conservation of angular momentum is a consequence of the rotational invariance of the system. Substantiate.

c) Consider two non-interacting electrons described by the Hamiltonian: $H = \frac{P_1^2}{2m} + \frac{P_2^2}{2m} + V(x_1) + V(x_2)$ where $V(x) = 0$ for $0 < x < a$; $V(x) = \infty$ for $x < 0$ and for $x > a$. If both the electrons are in the same spin state, determine the lowest energy and eigenfunction of the two-electron system?

Question Number 3. (2X7=14)

a) A particle of mass m and charge e oscillates along x-axis in a one-dimensional harmonic potential with an angular frequency ω. If an electric field ε is applied along the x-axis, evaluate the first and second order corrections to the energy of the n^{th} state.

b) A particle, initially (i.e., $t \to -\infty$) in its ground state in an infinite potential well whose walls are located at $x = 0$ and $x = a$, is subject at time $t = 0$ to a time-dependent perturbation $V(t) = \epsilon \hat{x} e^{-t^2}$ where ϵ is a small real number. Calculate the probability that the particle will be found in its first excited state after a sufficiently long time (i.e., $t \to \infty$).

c) Estimate the ground state energy of a one-dimensional harmonic oscillator of mass m and angular frequency ω using a gaussian trial function.

Question Number 4. (2X7=14)

a) Evaluate the scattering amplitude in the Born approximation, for scattering by the Yukawa potential: $V(r) = \frac{V_0 e^{-\alpha r}}{r}$, where V_0 and α are constants. Also show that σ (θ) peaks in the forward direction (θ = 0) except at zero energy and decreases monotonically as θ varies from 0 to π.

b) A particle is scattered by a central potential $V(r) = V_0 r e^{-\mu r}$, where V_0 and μ are positive constants. If the momentum transfer $\vec{q}$ is such that $q = |\vec{q}| \gg \mu$, evaluate the dependency of the scattering cross section on q in the Born approximation, as $q \to \infty$ Use $\int x^n e^{ax} dx = \frac{d^n}{da^n} \int e^{ax}\, dx$].

c) Consider the potential $V(\vec{r}) = \sum_i V_0 a^3 \delta^{(3)}(\vec{r} - \vec{r}_i)$, where $\vec{r}_i$ are the position vectors of the vertices of a cube of length a centered at the origin and V_0 is a constant. If $V_0 a^2 \ll \frac{\hbar^2}{m}$ then calculate the total scattering cross-section in the low-energy limit.

Question Number 5. (2X7=14)

a) Prove that the operator cα, where α stands for Dirac matrix, can be interpreted as the velocity operator.

b) A particle of mass m is in a potential $V = \frac{1}{2} m\omega^2 x^2$, where ω is a constant. Let $\hat{a} = \sqrt{\frac{m\omega}{2\hbar}} \left(\hat{x} + \frac{i\hat{p}}{m\omega}\right)$ Calculate $\frac{d\hat{a}}{dt}$ in the Heisenberg picture.

c) For a Dirac Particle moving in a central potential, show that the orbital angular momentum is not a constant of motion.

CENTRAL UNIVERSITY OF HARYANA

Second Semester Term End Examinations September 2022

Programme: Integrated B.SC. - M.SC. **Session: 2021-22**

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

Course Title: Electricity and Magnetism **Max. Marks: 70**

Course Code: SBS PHY 03 201 CC 4004

Instructions:

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

2. Question no. 2 to 5 have three parts and student are required to answer any two parts of each question. Each part carries seven marks.

Q 1. (4X3.5=14)

a) Is current density a vector or scaler quantity?

b) How much electronic charge required to make 1 coulomb?

c) Find the electric potential due to a point charge?

d) Prove that div. $\vec{B} = 0$ and explain its significance.

e) Define the following terms

i) Intensity of Magnetization

ii) Magnetic Susceptibility

iii) Magnetic Flux

f) What do you understand by ferromagnetism?

g) Explain scaler and vector potentials.

Q 2. (2X7=14)

a) Prove that the curl of an electrostatic field is zero.

b) If 10 coulomb charge is placed at the centre of a cube of side 10 cm, calculate the flux coming out of any force of the cube.

c) Show that for external points, a spherical symmetric charge distribution behaves as if the entire charge were concentrated at the centre.

Q3. (2X7=14)

a) Derive the relationship between **E, P** and **D.**

b) Explain different types of electric polarization.

c) Describe electric displacement vector and deduce Gauss's law for dielectric.

Q 4. (2X7=14)

a) Explain Biot-Savart law. Obtain the expression for magnetic field due to current in a straight wire.

b) With the help of Ampere's law, derive an expression for magnetic field due to a long solenoid.

c) Derive the relationship between **H, B** and **M.**

Q 5. (2X7=14)

a) State and prove Reciprocity Theorem for Mutual Inductance.

b) State and explain Norton's Theorem.

c) Derive the expression for energy stored in magnetic field