[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 1244 **F**

Unique Paper Code : 2222011203

Name of the Paper : Electrical Circuit Analysis (DSC-6)

Name of the Course : **B.Sc. (Hons.) Physics**

Semester : II

Duration : 2 Hours Maximum Marks : 60

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. All questions carry **equal marks.**
3. **Question No. 1** is compulsory and attempt **any three** from the remaining four questions.
4. Use of non-programmable scientific calculator is allowed.

P.T.O.

1. Attempt all questions. Each question carries equal marks. (3x5=15)

(a) Determine the form factor and peak factor for a half-rectified sinusoidal wave.

(b) What is the principle of duality in network analysis? How can it be used to solve problems in network analysis?

(c) Calculate average and rms values of the current, $i(t) = 10 + 10 \sin \omega t$.

(d) A 0.1 μF capacitor is first charged and then discharged through a 10MΩ resistor. Find the time in which the potential will fall off half of its maximum value.

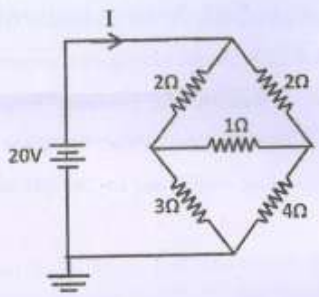
(e) Discuss briefly how a voltage source can be converted into a current source and vice-versa.

2. (a) Derive an expression for resonance frequency of a series LCR circuit having an alternating voltage source. Calculate the resonant frequency and quality factor of the circuit for given values of C = 550 nF, R = 60 Ω and L= 260 mH respectively. (8)

(b) A series LCR circuit with R= 6Ω, X_L=10Ω and X_C = 12 Ω is driven by a sinusoidal voltage source, $v(t) = 20 \cos (4000t)$ volts. Determine the equivalent impedance of the circuit. Also, draw its phasor diagram. (7)

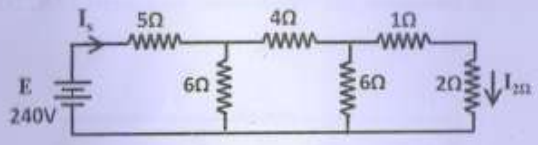
P.T.O.

3. (a) Determine the value of current I in the given diagram by using the Star-delta conversion method.



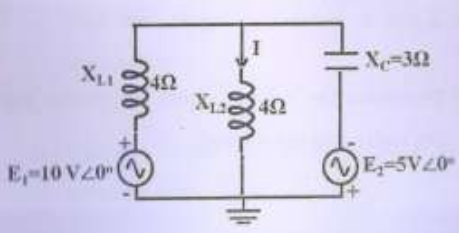
(8)

(b) Find out source current I_s and current through the resistance 2Ω ($I_{2\Omega}$) in the circuit given below.



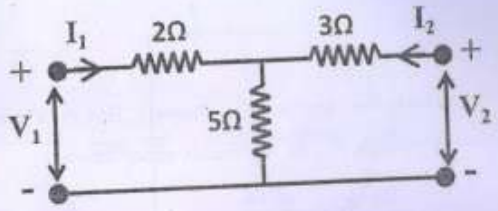
(7)

4. (a) Using the superposition theorem, find the current I through X_{L2} in the circuit given below.



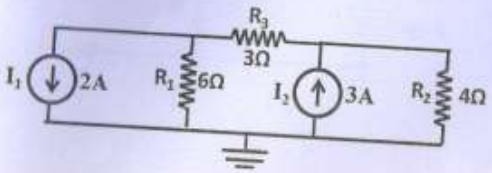
(8)

(b) Determine the transmission parameters (ABCD) of the given network.



(7)

5. (a) Determine the voltage across R_3 resistor using the nodal analysis method.

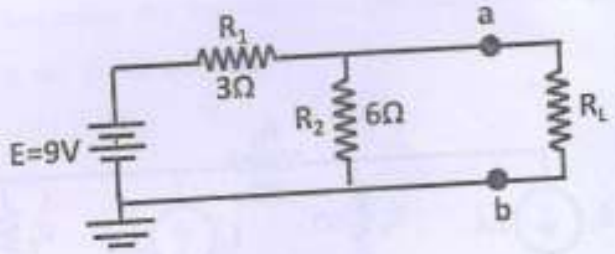


(5)

(b) A series RL circuit with R = 560 Ω and L = 350 mH is driven by a sinusoidal current source, $i(t) = 30 \cos(\omega t + 25°)$ ampere, where $\omega = 1000$ rad/s. Find the voltage drop across R and L and the input voltage. (5)

(c) Find the Norton equivalent circuit at ab of the given network.

P.T.O.



(5)

May-June-2023

[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 4550 **E**

Unique Paper Code : 32221201

Name of the Paper : Electricity and Magnetism

Name of the Course : **B.Sc. (Hons) Physics (CBCS – LOCF)**

Semester : II

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question No. **1** is compulsory.
3. Answer any **four** of the remaining **six** questions.

1. Attempt all parts of this question : (5×5=25)

P.T.O.

(a) A point charge 'q' is located at the centre of a cube having edge of length 'd'. What is the value of flux over one face of the cube? If the charge is placed at one corner of the cube, then what will be the value of electric flux through each face of the cube?

(b) Suppose the electric field in some region is found to be, $E = kr^3 r$ in spherical coordinates where, is a constant with appropriate units.

(i) Find the charge density.

(ii) Find the total charge contained in a sphere of radius R centered at the origin.

(c) Find the magnetic field at origin corresponding to the vector potential $\vec{A} = \left(y\cos(ax)\right)\hat{i} + \left(y + e^x\right)\hat{k}$.

(d) What is displacement current? How is it different from the conduction current.

(e) State and prove maximum power transfer theorem. What is the maximum efficiency of any circuit.

2. (a) Find the electric field at a distance s from an infinitely long straight wire which carries a uniform line charge λ. (6)

(b) Derive the expression for the magnetic field at a point on the axis of a circular coil of radius a and carrying current I. Obtain an expression for the magnetic dipole moment of loop. (6.5)

3. (a) A spherical condenser consists of two concentric conducting spheres of radii a and b (a > b). The outer sphere is grounded and a charge Q is placed on the inner sphere. The outer conductor then contracts from radius a to c. Find the work done by the electric force? (6.5)

(b) The magnetic field intensity is H = 1200 Amp/m in a material when B = 2 Wb/m^2. When H is reduced to 400 Amp/m, B = 1.4 Wb/m^2, calculate the change in the magnetization M. (4)

(c) Explain why diamagnetism is temperature independent. (2)

4. (a) A sphere of radius R, filled with material of dielectric constant k, have a small concentric spherical cavity of radius a. A free point charge q is placed at the center. Find the polarization vector P and bound charges σ_b and ρ_b. (3.5,3)

(b) Derive the expression for quality factor Q and bandwidth β of a series RLC circuit. (3,3)

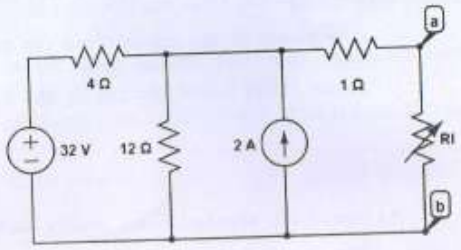
5. (a) A point charge 'q' is placed inside a hollow grounded, conducting sphere of inner radius 'a'. Using the method of images,

(i) Find the potential inside the sphere. (4)

(ii) Find the induced surface-charge density. (2)

P.T.O.

(b) Find the Thevenin equivalent of the circuit below and find the current through R1 = 6Ω.



(5,1.5)

6. (a) In a parallel plate air capacitor having plate separation 0.04 mm, an electric field of 4×10^4 V/m is established between the plates. The battery is then removed and a metal plate of thickness 0.03 mm is inserted between the plates of the capacitor. Determine the potential difference across the capacitor,

(i) before the introduction of metal plates (2)

(ii) after the introduction of metal plates (2)

(iii) if dielectric slab with dielectric constant 2.5 and same thickness is inserted instead of the metal plates (2)

(b) Find the emf induced in a rectangular loop due to a current carrying long wire placed in the plane of the loop. Also find the induced emf when the loop moves away from the wire with a constant speed v so that it's orientation w.r.t. the wire does not change. (3,3.5)

7. (a) A thin metal sphere of radius b has a charge Q.

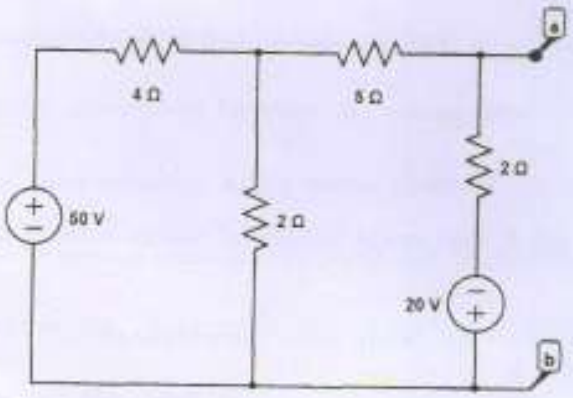
(i) What is its capacitance? (2)

(ii) What is the E-field energy density at a distance r from the center of the sphere? (1)

(iii) What is the total energy of the field? (2)

(iv) Compute the work expended in charging the sphere by carrying infinitesimal charge from infinity. (1.5)

(b) Using the node voltage method, find V_{oc} and I_{sc} at the terminal ab of the following network :



(6)

[This question paper contains 4 printed pages.]

Your Roll No.....

F

Sr. No. of Question Paper : 1225

Unique Paper Code : 2222011202

Name of the Paper : Electricity and Magnetism

Type of the Paper : DSC

Name of the Course : **B. Sc. (H)**

Semester : II

Duration : 3 Hours Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. **Question 1** is compulsory.
3. Attempt **any four** questions from question numbers 2-6.
4. All questions carry equal marks.

1. Attempt **all** parts of this question: (6×3=18)

   (a) Find the electric field at the centre due to a uniformly charged semi-circular arc.

P.T.O.

(b) Find the potential for the region between two concentric right circular cylinders when $V_1 = 0$ at V at r = 1 mm and V_2 =150 V at r = 20 mm.

(c) What is the interpretation of Gauss's law in the case of static charge and steady current, respectively.

(d) An infinite solenoid (**N** turns per unit length, current **I**) is filled with linear material of susceptibility χ_m. Find the magnetic field inside the solenoid.

(e) A dielectric cube of side '*a*' centered at the origin carries a polarization $\vec{P}=k\vec{r}$ where **k** is a constant. Find the bound charges densities σ_b and ρ_b ?

(f) Why the nature of magnetic susceptibilities in paramagnet, diamagnet and ferromagnet are different?

2. (a) A uniformly charged disc of radius **R** having surface charge density c is placed in the **x-y** plane with its center at the origin. Find the electric field intensity along the **z**-axis at a distance **Z** from origin. (9)

(b) Verify that the differential version of Ampere's Law implies the integral version, using Stokes' Theorem. (6)

(c) Is the choice of the vector potential corresponding to a given magnetic field unique? Justify. (3)

3. (a) Obtain the boundary conditions for the electric field and displacement vector at the interface of two dielectric media having dielectric constants ε_1 and ε_2 respectively. (6)

(b) Which one of these is an impossible electrostatic field? Justify.

(i) $\vec{E}=k[xy\hat{i}+2yz\hat{j}+3xyz\hat{k}]$

(ii) $\vec{E}=k[y^2\hat{i}+(2xy+z^2)\hat{j}+2yz\hat{k}]$ (6)

(c) A solenoid of length 30 cm and area of cross-section 10 cm^2 has 1000 turns wound over a core of constant mu = 600. Another coil of 500 turns is wound over the same coil at its middle. Calculate the mutual inductance between them. (6)

4. (a) Calculate the divergence of electrostatic field due to a point charge **q** located at **r'** from the origin. Give the physical interpretation of your result. (9)

(b) A current distribution generates a vector potential $\vec{A}=xy\hat{i}+yz\hat{j}-4xyz\hat{k}$ Wb/m. Calculate the flux of magnetic field through the surface defined by $z = 1$, $0 \le x \le 1$ and $-1 \le y \le 4$ (6)

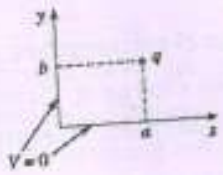
P.T.O.

(c) Moist soil has a conductivity of 10^{-3} S/m and relative permittivity 2.5. Find J_c and J_D where $E = 6 \times 10^{-6} \sin(9 \times 10^9 t)$ V/m (3)

5. (a) Two infinitely long grounded metal plates at y=0 and y=π are connected at x=+a and x=-a by a metal strip maintained at potential V_0. Find the potential inside the rectangular pipe for V=0 when y=0 & y = π and V=V_0 at x = +a & x=-a. (12)

(b) What is the significance of Maxwell's displacement current, and how is it different from conduction current? (3+3)

6. (a) Two semi-infinite grounded conducting planes meet at right angles. In the region between them there is a point charge q. Find the location and magnitude of all image charges. (9)



(b) An infinitely long circular cylinder carries a uniform magnetization M parallel to its axis. Find the magnetic field inside and outside the cylinder. (9)

(2500)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 1272 **F**

Unique Paper Code : 2222511201

Name of the Paper : Electricity and Magnetism

Name of the Course : **B.Sc. (Prog.)**

Semester : II

Duration : 2 Hours Maximum Marks : 60

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt four questions in all. All questions carry equal marks.
3. **Question No. 1** is compulsory.
4. Non-programmable calculator is allowed.

1. Attempt all of the following : (5x3)

(a) A certain parallel plate capacitor with capacitance $C = 12\ \mu F$ is connected to a source of EMF with potential 3 V. A material of dielectric constant 4 is then inserted between the plates of capacitor.

P.T.O.

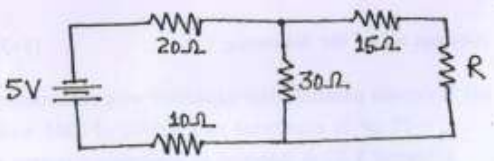
By how much does the energy stored in the capacitor change?

(b) State and deduce the Gauss's law in differential form.

(c) Define $\vec{B}, \vec{M}$ and $\vec{H}$. Establish the relation $\vec{B} = \mu_0(\vec{H} + \vec{M})$.

(d) A solenoid has a length of 50 cm and a radius of 1 cm. If the number of turns in the solenoid is 500 and relative permeability of the material on which the turns are wounded is 800, calculate the coefficient of self-inductance.

(e) Determine Thevenin's equivalent circuit for the given network across the load resistance R



2. (a) What is an electric dipole? Derive the expressions for the electric potential and electric field intensity due to an electric dipole at any point. (10)

(b) Three identical charges q = 1μC are placed in the (x,y) plane at coordinates (-1,0), (1,0) and (0, 1). How much work is needed to move the charge placed at the initial position (0, 1) to a new position (0,0), while holding the other two charges in their original positions. (all the distances are in meter) (5)

3. (a) State and explain Biot-Savart's law. Derive an expression for the magnetic field at a point on the axis ofa circular coil carrying a steady current using Biot-Savart's law. (10)

(b) A uniform solenoid 100 mm in diameter and 400 mm long has 100 turns of wire. If a current of 3 A is flowing through it, calculate the magnetic field at its center. (5)

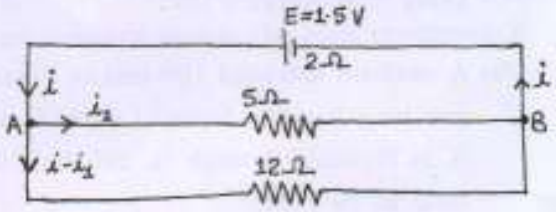
4. (a) What is electromagnetic Induction? State and explain Faraday's and Lenz's law of electromagnetic induction. Explain the fact that Lenz's law in accordance with the law of conservation of energy (10)

P.T.O.

(b) Write the Maxwell's Equations with their physical significance. (5)

5. (a) Write the statement of Superposition and Maximum Power transfer theorem for linear circuit and make necessary diagram to explain. What is the maximum power transferred to a load resistance R_L by a voltage source of 8 Volts connected in series with a resistance of 100Ω ? (10)

(b) A cell of E.M.F. 1.5 volt has internal resistance 2 Ω. Find the current given by the cell and the current through each resistance in given figure by using Kirchhoff s law. (5)



Constants:

$\mu_0 = 4\pi \times 10^{-7}$ henry/metre (free space)

$\epsilon_0 = 8.85 \times 10^{-12}$ $C^2/N.m^2$ (free space)

(1000)

[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 2043 **F**

Unique Paper Code : 2224001201

Name of the Paper : Electricity and Magnetism

Name of the Course : **G.E.**

Semester : II

Duration : 3 Hours Maximum Marks : 90

Instructions for Candidates

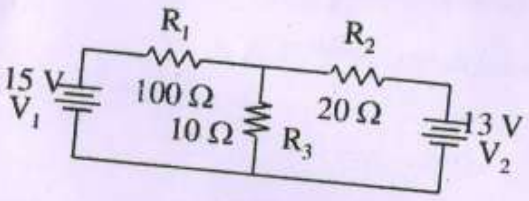
1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Answer five questions in all.
3. Question No. 1 is compulsory
4. All questions carry equal marks.
5. Use of Simple Calculator allowed.

P.T.O.

1. Attempt all of the following: (6×3)

(a) Prove the conservative nature of electrostatic field.

(b) Find the current through R_3 using superposition theorem.



(c) Derive the relation $\mathbf{D} = \epsilon_0 \mathbf{E} + \mathbf{P}$.

(d) If A and B are irrotational vectors then prove that A x B is solenoidal.

(e) What distinguishes the electric field caused by a fluctuating magnetic flux from the electric field caused by static charge?

(f) Write the continuity equation and describe its physical meaning.

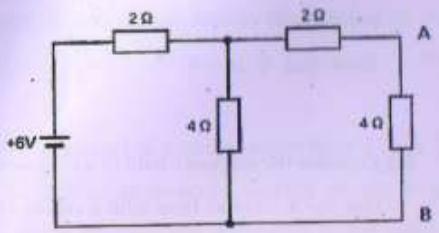
2. (a) State Stoke's theorem and verify it for $\mathbf{A} = (y-z+2)\,\mathbf{i} + (yz+4)\,\mathbf{j} - (xz)\,\mathbf{k}$. where S is the surface of the cube x=0, y=0, z=0 , x=2, y=2, z=2 above the xy plane. (12)

(b) Give the physical significance of divergence ofa vector field. Evaluate the divergence of the vector function $\mathbf{A} = x^2\,\mathbf{i} + 3xz^2\,\mathbf{j} + 2xz\,\mathbf{k}$. (6)

3. (a) State and prove maximum power transfer theorem. Explain with example. (9)

(b) A large plane charged sheet having surface charge density $\sigma = 2.5 \times 10^{-6}\ Cm^{-2}$ lies in the x-y plane. Find the flux of the electric field through a circular area of radius 1 cm lying completely in the region where x, y and z are all positive and with its normal, making an angle of 30° with the z axis. (3)

(c) Calculate the current through the resistance of 4Ω across AB by applying Norton's Theorem.



(6)

4. (a) Define electric potential and derive the expressions for electric potential inside and outside a uniformly charged spherical shell. (12)

(b) State Gauss' law and derive its differential form. (6)

5. (a) Explain Biot-Savart law for the flux density at point due to current flowing in a current element. Show that $\nabla . B = 0$. (9)

(b) Compute the magnetic field of a long straight wire that has a circular loop with a radius of 0.08 m. The reading of the current flowing through this closed loop is 2.5 A. (3)

(c) At the boundary of two dielectric mediums of different dielectric constants, show that the tangential components of electric fields are equal. Assume that there are no free charges on the surface of two dielectrics. (6)

6. (a) Write down the differential form of Maxwell's Equations. Explain the physical significance of each of them. (9)

(b) When a current in a coil changes from 6 A to 2 A in 0.2 s, an average voltage of 60 V is produced. Find the self-inductance of the coil. (3)

(c) Two wires each carrying a current of 500 Ampere in the opposite direction are placed with their axis 0.1 m apart. Calculate the force per meter length between them. Will the force be of attractive or repulsive? (6)

Constants:

$\mu_0 = 4\pi \times 10^{-7}$ henry/metre (free space)

$\epsilon_0 = 8.85 \times 10^{-12}$ $C^2/N.m^2$ (free space)

[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 5714 **E**

Unique Paper Code : 42221201

Name of the Paper : Electricity, Magnetism and EMT

Name of the Course : **B.Sc. Prog. – CBCS Core**

Semester : II

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **Five** questions in all.
3. Question No. **1** is compulsory.
4. Attempt **four** questions from the rest of the paper.
5. Use of non-programmable calculator is allowed.

P.T.O.

1. Attempt any **five** of the following: (5×3=15)

(a) Given a vector $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$. Show that $\iint_S \vec{r}.d\vec{S} = 3V$, where V is volume enclosed by surface S.

(b) Prove that the electric field at any point can be expressed as the negative gradient of potential at that point.

(c) Two concentric spheres of diameters 10 cm and 12 cm where medium between the spheres is air and the outer sphere is earthed make a spherical capacitor. Find the charge on the inner sphere if the potential difference between the spheres is 10,000 volt.

(d) Differentiate between diamagnetic and paramagnetic material (mention any two points). Give one example of each.

(e) In a coil an emf of 6 V is induced when the current in the coil changes at the rate of 100 Amp per second. Find coefficient of self-inductance of the coil.

(f) What is Lenz's law? Show that it is in accordance with the law of conservation of energy.

(g) How does the electric field produced by the varying magnetic field differ from the electric field of stationary charges?

2. (a) Find the directional derivative of $\phi = 4xz^3 - 3x^2y^2z$ at (2, −1, 2) in the direction $2\hat{i} - 3\hat{j} + 6\hat{k}$. (5)

(b) Prove that $\nabla^2 r^n = n(n+1)r^{n-2}$ where n is constant. (5)

P.T.O.

(c) Given $\vec{A} = (3x^2 + 6y)\hat{i} - 14yz\hat{j} + 20xz^2\hat{k}$. Evaluate the line integral from (0, 0, 0) to (1, 1, 1) along the following paths c: $x = t$, $y = t^2$, $z = t^3$. (5)

3. (a) Using Gauss's theorem, find an expression for the electric field due to an infinite line charge of uniform charge density X at a perpendicular distance 'a' from it. (5)

(b) Derive expressions for the electric potential due to a uniformly charged spherical shell at points inside and outside the shell. Show that the electric potential due to the shell at any point inside is equal to the value of the potential on its surface. (7)

(c) Show that the potential function $V = a(x^2 + y^2 + z^2)^{1/2}$ does not satisfy Laplace's equation. (3)

4. (a) What do you understand by polarization of a dielectric? Define three electric vectors $\vec{D}$, $\vec{E}$ and $\vec{P}$. Establish the relation between them. (7)

(b) How does the capacitance of a parallel plate capacitor change when a dielectric slab of dielectric constant K is inserted between the plates and it completely fills the space between the plates? (4)

(c) A parallel plate capacitor with plate area 1 m^2 is completely filled with a dielectric material of dielectric constant 5. The capacitor is charged to a potential of 200 volt. If the distance between the plates is 0.01 cm, find the energy stored in the capacitor. (4)

5. (a) Starting from Biot Savart's law, derive an expression for the magnetic vector potential at a distance $\vec{r}$ from the current element. (5)

(b) Derive an expression for magnetic field of a small current loop. (5)

(c) Using Biot Savart's law calculate the magnetic field due to a finite current element. (5)

6. (a) Explain Faraday's law and Lenz's law of Electromagnetic induction. (4)

(b) Define coefficient of self-inductance. Derive an expression for self-inductance of a solenoid. (2+3=5)

(c) A solenoid of 80 cm length has 550 turns and 2 cm diameter. Calculate :

(i) the self-inductance of the solenoid.

(ii) the magnetic flux linked with coil when the current in the solenoid is 2 A.

(iii) the rate of change of current in the solenoid that will produce a self- induced emf of 0.3 volts. (6)

7. (a) Write Maxwell's equations for electromagnetic field in integral and differential form in free space. Obtain the wave equations for the electric and magnetic field vectors in vacuum. (7)

(b) An electromagnetic wave propagates along the x direction, the magnetic field oscillates at a frequency of 10^{10} Hz and has an amplitude of 10^{-5} T, acting along the y-direction. Write down the expression of the electric field and compute the wavelength of the wave. (4)

(c) Derive the equation of continuity using Maxwell's equation and give its significance. (4)

Physical Constants :

$\varepsilon_0 = 8.854 \times 10^{-12}$ C/N-m^2;

$\mu_0 = 4\pi \times 10^{-7}$ Wb/A-m;

$c = 3 \times 10^8$ m/s.

$e = 1.6 \times 10^{-1}$ m/s

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 1206 **F**

Unique Paper Code : 2222011201

Name of the Paper : Mathematical Physics - II (DSC - 4)

Name of the Course : **B.Sc. (Hons.) Physics- core**

Semester : II

Duration : 2 Hours Maximum Marks : 60

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt FOUR questions in all
3. Question No. 1 is compulsory.
4. Use of non-programmable scientific calculator is allowed.

P.T.O.

1. Attempt ALL questions. Each question carries equal marks. (3×5=15)

(a) Let u_1, u_2, u_3 be orthogonal coordinates. Prove that $|\nabla u_p| = h_p^{-1}, p = 1,2,3$

(b) Write the expression only of the general solution near x = −1 using Frobenius method of

$$y'' + xy' + (2x-1)y = 0$$

(c) Using the expression of the generating function of the Legendre Polynomials $P_n(x)$ find the expression for $P_2(x)$ and $P_3(x)$.

(d) Evaluate using Beta function property $\int_0^\infty \frac{z^{m-1}}{1+z}\,dz = \frac{\pi}{\sin m\pi}$ the integral $\int_{-\infty}^{\infty} \frac{e^{2u}}{1+e^{3u}}\,du$

(e) Is the given function periodic, $f(t) = \sin(10+\pi)t$. If yes, what is its period?

2. (a) Find the Fourier series expansion of the function

$$f(x) = x^2 \ , \ 0 < x < 2\pi \qquad (10)$$

(b) Plot the even and odd components of a function defined by $f(t) = \begin{cases} e^{-t} & , t > 0 \\ 0 & , t < 0 \end{cases}$ (5)

3. (a) Derive the expression for $\nabla^2\varphi$ in cylindrical coordinates. (10)

(b) Represent the vector $\vec{A} = z\hat{\imath} - 2x\hat{\jmath} + y\hat{k}$ in cylindrical coordinates (ρ, ϕ, z). Thus determine A_ρ, A_ϕ and A_z (5)

4. (a) Prove that $P_n(x)$ is the coefficient of t^n in the expansion of $\frac{1}{\sqrt{1-2xt+t^2}}$ in the ascending powers of t. Hence find the value of $P_n(1)$ (10)

(b) Evaluate using the orthonormalization property of Legendre polynomial

(i) $\int_{-1}^{1} P_3(x)\,P_4(x)\,dx$,

P.T.O.

(ii) $\int_{-1}^{1}[P_2(x)]^2\,dx$ (5)

5. (a) Find the general solution near x = 0 using Frobenius method of :

$$x\,y'' + (1-2x)\,y' + (x-1)\,y = 0 \qquad (10)$$

(b) Identify and name the nature of singularities

$$(1-x^2)^2\,y'' + x(1-x)\,y' + (1+x)\,y = 0 \qquad (5)$$

[This question paper contains 6 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 4670 **E**

Unique Paper Code : 32221202

Name of the Paper : Wave and Optics

Name of the Course : **B.Sc. (Hons) Physics CBCS**

Semester : II

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Answer any **five** questions in all.
3. Q. No. **1** is compulsory.

1. Attempt any **five** questions. Each question carries **3** marks. (3×5=15)

   (a) Two pendulums, P and Q, are set up alongside each other. The period of P is 1.90 s and the period of Q is 1.95 s. How many oscillations are made by pendulum Q between two consecutive instants when P and Q move in phase with each other?

(b) A Llyod's mirror of length 5 cm is illuminated with monochromatic light (λ = 5460 A°) from a narrow slit 0.1 cm from its plane, and 5 cm measured in that plane, from its near edge. Find the separation of the fringes at a distance of 120 cm from the slit & the total width of the pattern observed.

(c) What are coherent sources? How spatial and temporal coherence are different?

(d) A convex lens of focal length 20 cm is placed after a slit of width 0.6 mm. If a plane wave of wavelength 600 nm falls on the slit normally, calculate the separation between the second minima on either side of central maximum.

(e) Define Fizeau's and Haidinger's fringes. Give one example for each.

(f) A telescope of aperture 3 cm is focused on a window at 80 m distance fitted with a wire mesh of spacing 2 mm. Will the telescope be able to observe the wire mesh with an illuminating light of wavelength 550 nm?

(g) State and explain Huygen's principle.

(h) A wave is represented by $y(x, t) = (0.5) \sin[(314\, t - 12.56\, x)]$; where y and x are in meters and t in seconds. Determine the amplitude, wavelength, angular frequency, wave number, time period and the velocity of the wave.

2. (a) A particle is subjected to two simple harmonic motions at right angle to each other, of equal amplitudes A, equal frequencies ω and a constant initial phase difference $\pi/2$. Derive an expression and trajectory for the resultant oscillation of the particle.

(b) Graphically construct the Lissajous figures traced by a particle subjected to two simple harmonic motions at right angle to each other, of unequal amplitudes, frequencies in the ratio 1:2, and a constant initial phase difference of (i) $\pi/2$ (ii) $\pi/4$

(c) The dispersion relation for surface waves propagating in a fluid is given $\omega^2 = \alpha k + \beta k^3$ where α and β are constants. Evaluate the value of propagation constant when the phase velocity is equal to the group velocity. (7+5+3)

P.T.O.

3. (a) Derive the classical wave equation using the model of a longitudinally vibrating air column. Hence deduce the expression for velocity of longitudinal harmonic waves propagating along the given air column.

(b) Obtain the frequencies of the normal modes of vibration of a longitudinally vibrating air column in a tube closed at one end and open at the other. Hence show that all the even harmonics of fundamental mode frequency are absent in this case. Sketch the first two normal modes of this case.

(c) A 2m long wire having a linear mass density of 0.0025 kg/m is stretched between two fixed supports such that two adjacent harmonic frequencies are 252 Hz and 336 Hz.

(i) Calculate the fundamental frequency of the wire.

(ii) Determine the tension in the wire. (7+5+3)

4. (a) Discuss the theory of interference due to a parallel thin film. Show that the result obtained in reflected and transmitted components are complementary to each other.

(b) Schematically show the experimental arrangement to obtain interference pattern due to Fresnel's biprism.

(c) In a bi-prism experiment bands of width 0.0195 cm are observed at 100 cm from the slit. On introducing a convex lens 30 cm away from the slit, two images of slit are seen 0.7 cm apart at 100 cm distance from the slit. Calculate the wavelength of light used. (7+5+3)

5. (a) Give the theory of Michelson interferometer. How different types of fringes are formed in it. How can Michelson interferometer be used to determine the difference between two close wavelength?

(b) Define Visibility of fringes. How can it be used to check whether a source of light is monochromatic or composite?

(c) A thin transparent plate of refractive index 1.5 displaces 10 fringes when introduced in one of the arms of Michelson's interferometer. Calculate the thickness of the plate. Wavelength of light is 6000 A°. (7+5+3)

6. (a) Using the expression for intensity distribution in Fraunhofer Single Slit Diffraction Pattern, obtain the intensity distribution in the far-field pattern

for an array of N equally spaced identical slits under normal monochromatic illumination. Discuss the characteristic features of the given diffraction pattern.

(b) Distinguish between resolving power and dispersive power of a plane transmission grating. Explain how a grating having higher dispersive power than another does not necessarily have a higher resolving power.

(c) Two distant stars subtend an angle of one second of an arc 4.84×10^{-6} radians and the wavelength of the light used be 5000 A^0, Calculate the diameter of the objective of the telescope required to just resolve the stars. (7+5+3)

7. (a) Using Fresnel's integral how Comu's spiral can be constructed? What are its properties?

(b) Explain how Cornu's spiral can be used to obtain intensity distribution in the Fresnel diffraction pattern due to a straight edge.

(c) For a wavelength of light $\lambda = 6 \times 10^{-7}$ m and the radius of the first half period zone is 6×10^{-4} m, a zone plate brings rays to focus at its brightest spot. Find the focal length of the equivalent lens. (7+5+3)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 6552 **E**

Unique Paper Code : 32221202_OC

Name of the Paper : Waves and Optics

Name of the Course : **B.Sc. Hons.-(Physics) Core (Old Course)**

Semester : II

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Answer any **five** questions in all. Question No. 1 is compulsory.

1. Attempt any **five** from the following.

   (a) At time t=0, the displacement of a point, x(0) in a linear oscillator is -8.6 cm, its velocity, v(0) is -0.93m/s and its acceleration a(0) is $48 m/s^2$. Calculate the angular frequency and the phase constant.

   (b) Find the fundamental, first overtone and second overtone frequency of an open organ pipe of length 20cm.

P.T.O.

(c) Give two differences between Haidinger and Fizeau fringes with one example for each.

(d) A parallel beam of sodium light (λ = 5890 Å) strikes an oil film floating on water. When viewed at an angle of 30° from the normal, 8th dark band is seen. What is the thickness of the film? Take μ_{oil} = 1.5.

(e) Why is interference fringe obtained in Fabry Perot interferometer sharper than that obtained in Michelson interferometer?

(f) How many orders of spectrum will be visible with a diffraction grating if wavelength of light used is 5000Å and the number of lines per inch on the grating is 2620?

(g) Find the radius of first half period element on a zone plate behaving like a convex lens of focal length 50 cm. Take wavelength equal to 500 nm. (5×3=15)

2. (a) Deduce an expression for the total energy of a vibrating string which is fixed at its ends and initially displaced vertically from the equilibrium position.

(b) Give the graphical representation for motion of a particle subjected to two perpendicular oscillations as given below.

$$x = A \cos 2\omega t$$

$$y = A \sin 2\omega t \quad (7, 8)$$

3. (a) Explain the meaning of lateral shift in Fresnel's bi-prism experiment. How do you measure it? How can the wavelength of light be determined by using a bi-prism?

(b) Describe a method with the necessary formula for the measurement of wavelength of light using Newton's rings. Show that the fringes obtained from Newton's ring appear to be circular? Why do Newton's rings get closer as the order of the rings increases? (7,8)

4. (a) Derive the expression for intensity distribution due to Fraunhofer diffraction by a rectangular aperture.

(b) What is Cornu's spiral? Illustrate the intensity distribution curve due to a straight edge using Cornu's spiral. (7,8)

5. (a) What are beats? Give an analytical treatment of the phenomena of beats.

P.T.O.

(b) Describe the Fresnel diffraction pattern formed due to a thin wire and explain the features of intensity distribution in the diffraction pattern. How does the intensity pattern change when the wire is thick? (7,8)

6. (a) Use the rotating vector representation to obtain the resultant motion of a particle subjected simultaneously to two SHMs in the same direction and having equal amplitudes and equal frequencies.

(b) Plot the intensity distribution for a plane diffraction grating having 6 slits and the width of the opaque portion being three times the slit width. Show the positions of minima, secondary maxima and missing orders along with principal maxima. (7,8)

7. (a) How are the circular fringes obtained in Michelson interferometer different from those obtained in the Newton's Ring experiment? A Michelson interferometer is illuminated by sodium doublet having wavelength 589.5923 nm and 588.9953 nm. One mirror is moved continuously and the fringe pattern fades in and out periodically. Compute how much the mirror travels corresponding to a shift in visibility from maximum to minimum.

(b) Explain Rayleigh's criterion for limit of resolution. Obtain an expression for the resolving power of a diffraction grating. (7,8)

(100)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 4812 **E**

Unique Paper Code : 32221403

Name of the Paper : Analog Systems and Applications

Name of the Course : **B.Sc. (Hons.) Physics-CBCS**

Semester : IV

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all.
3. Question No. **1** is compulsory.
4. Use of scientific calculators is allowed.

1. Attempt any **five** of the following: (5×3=15)

   (a) Define drift and diffusion currents in doped semiconductors.

   (b) Explain the difference in physical mechanisms of avalanche and Zener breakdown in p-n. junction.

P.T.O.

(c) Draw I-V characteristics of the ideal diode and compare it with that of a practical diode, under forward bias and reverse bias conditions?

(d) A common emitter circuit has beta of 98, a collector current of 50 mA and base current of 500 μA. Calculate the reverse saturation current.

(e) Distinguish between Class A, Class B and Class C amplifiers with the help of load line and Q point.

(f) Define PIV, ripple factor and rectification efficiency in a rectifier circuit.

(g) An Op-Amp has a CMRR value of 55 dB and a differential mode gain of 1200. Find the common mode gain.

2. (a) For an abrupt p-n junction find the expression for potential V_B as a function of x for the case where N_a and N_d are of comparable magnitudes. Hence show that the barrier potential is given as follows :

$$V_B = q.N_a.N_d(W_p+W_n)^2 /2*\varepsilon(N_a + N_d)$$

wherein W_p and W_n are depletion widths on p and n sides respectively and all other symbols have their usual meaning. (10)

(b) Find the conductivity of a bar of pure Silicon of length 1 cm and cross-sectional area 1 mm^2 at 300K. Given $\mu_n = 0.13\ m^2/Vs$, $\mu_p = 0.05\ m^2/Vs$, $n_i = 1.5 \times 10^{16}\ m^{-3}$ and $e = 1.6 \times 10^{-19}$ C. (5)

3. (a) Explain the working of a center-tap full wave rectifier using suitable diagrams and obtain the expressions for (i) ripple factor and (ii) rectification efficiency. (10)

(b) What is a tunnel diode? Draw the I-V characteristics of the tunnel diode and briefly explain them. (5)

4. (a) Derive the stability factors for "voltage divider bias circuit" and "fixed bias circuit" and hence explain why "voltage divider bias circuit" is preferred over "fixed bias circuit". (10)

(b) Describe "DC load line" and "Q-point" of a transistor in CE configuration with appropriate diagram. (5)

5. (a) Draw the circuit diagram of a two stage RC coupled amplifier using transistors and also its frequency response curve. Why does the gain fall in low frequency range and high frequency range? (10)

P.T.O.

(b) What do you understand by the term small signal analysis? Draw the equivalent circuit in hybrid parameters for an n-p-n transistor in (i) CE configuration and (ii) CB configuration configurations. (5)

6. (a) Draw the circuit and explain the working of a 4-bit R-2R ladder network DAC using op- amp. In a 4-bit DAC, 0001 input results into 0.8 V output. What is the maximum output voltage of this DAC? (10)

(b) Draw the circuit of a voltage comparator using op-amp to give $+V_{sat}$ at the output if the input voltage is less than - 2V and $-V_{sat}$ for input more than +2V. (5)

7. (a) Draw the circuit of an Op-amp as a basic differentiator and find an expression for its output. Draw the output waveform when the input to the differentiator is a square wave. (10)

(b) A five -bit D/A converter produces an output of 9mV for a digital input of 10010. Find the output voltage for a digital input of 11011. Also find its full scale output voltage. (5)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 4638 **E**

Unique Paper Code : 32223902

Name of the Paper : Computational Physics

Name of the Course : **B.Sc. Hons. – (Physics) SEC**

Semester : IV

Duration : 2 Hours Maximum Marks : 50

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt any **four** questions in total.
3. **All** questions carry equal marks.

1. (a) Draw a flowchart to arrange three number in increasing order. What is the difference between on page and off page connectors? (6)

   (b) Write a FORTRAN program for integration using trapezoidal rule. What is the use of IMPLICIT NONE in FORTRAN? From which integer value do loop starts from in FORTRAN? (6.5)

P.T.O.

2. (a) Explain, with examples logical if, arithmetic if and block if statements in FORTRAN. (6)

   (b) Explain jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) along with the examples. How do we declare variable in FORTRAN? (6.5)

3. (a) Briefly explain the structure of a Latex document. Explain, with example, how can you add glossary and bibliography to your document. In the same example, add different entries starting with lowercase and uppercase letters to your glossary. What is the difference between citep and citet? (6)

   (b) Briefly explain any four working environments for Latex. What is the difference between table and tabular? How can we add clickable links in Latex? (6.5)

4. (a) What is wrong with the following code. What would be the output after correcting the error.


```
\begin{tabular} {|1|c|r|}
$x^2$ & $y^2$ & $R(\deg)$\\
\ hline
    1 & 2    & 3 & \\
    5 & 6    & 7
\ hline
\ end{tabular)
```

(6)

   (b) Write code to write the following equation in Latex :

$$\int \cdots \int_V \mu(u_1,\ldots,u_k)du_1 \ldots du_k$$

   What is syntax for writing backlash in Latex. Also give syntax for writing any Greek two letter. (6.5)

5. (a) What would be the output of the following code in gnuplot :

```
set style line 1 lw 2 lc rgb "gold"
set style line 2 lw 2 lc rgb "purple"
set style line 4 lw 1 lc rgb "sea-green"
set style increment user
plot sin(x), cos(x), tan(x), x
```

(6)

(b) Write syntax to plot a Gaussian distribution with $\mu = 3$ and $\sigma = 0.5$ in gnuplot using user-defined function. What would be the syntax to save the same plot in .png format? What is-the use of call command? (6.5)

6. (a) How to plot an external data file in gnuplot'? How to check default reading format of any external data file? How can you change the default field separator from white space to the alphabet m? How can you change default comment character to !? (6)

(b) Give syntax to fit a third order polynomial to some data saved in a text file. How can you save your progress to a text file. What are the uses of index and every commands in gnuplot. Explain with examples. (6.5)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 4639 **E**

Unique Paper Code : 32223903

Name of the Paper : Electrical Circuits and Network Skill

Name of the Course : **B.Sc. Hons.-(Physics)_SEC Paper**

Semester : IV

Duration : 3 Hours Maximum Marks : 50

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all. **All** questions carry equal marks.
3. Use of non-programmable scientific calculators is permitted.
4. Use simple diagrams to elaborate your answers.

P.T.O.

1. (a) State Thevenin's Theorem and Norton's Theorem?

   (b) Define linear and non linear devices with examples. (5,5)

2. (a) State Kirchhoff's laws for DC circuits with suitable diagram.

   (b) Discuss the real and imaginary components of AC power with mathematical derivations. (5,5)

3. (a) Describe the Construction and working of a Bridge rectifier. How is better than a center tapped full wave rectifier?

   (b) Describe R.M.S. and mean values of electrical signals with mathematical expressions and suitable diagrams. (5,5)

4. (a) Discuss the construction and working of a DC Generator with the help of suitable diagram.

   (b) Differentiate between AC motor and AC generator on the basis of their construction and working Principle. (5,5)

5. (a) Explain what is the effect of phase reversal on three phase induction motor.

   (b) What is power factor correction and what are its advantages? (5,5)

6. (a) Describe working principle of Relay. What are different types of Relays.

   (b) An extension board has 4 switch and sockets of 5 Amp rating. What should be the minimum rating of fuse and why? (5,5)

7. Write Short note on any **two** of the following: (5,5)

(a) Ladder Diagrams

(b) Relay as a protective device

(c) Circuit breakers

(d) Superposition theorem

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper	:	**4688**	**E**
Unique Paper Code	:	32221402	
Name of the Paper	:	Elements of Modern Physics	
Name of the Course	:	**B.Sc. (Hons) Physics –CBCS Core**	
Semester	:	IV	

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all
3. **Question 1** is compulsory
4. **All questions** carry equal marks
5. **Symbols** have their usual meanings
6. Use of **non-programmable** calculators is allowed

Answer **any five** questions from the following.

1. (a) The irradiated power of a body at 333^0C is 1000 J/s. If the temperature of this body is raised to 666°C, find the radiated power of the body.

   (b) What is the physical significance of a wave function? What conditions must be satisfied by an acceptable wave function?

   (c) What voltage must be applied to an electron microscope to produce electrons of wavelength 0.20Å.

(d)The spectral line of wavelength 450 nm has a width of 10^{-4} nm. Find the average time that the atomic system remains in the corresponding energy state?

(e) How is the time dependent Schrodinger wave equation obtained from the time independent Schrodinger equation.

(f) What inferences can be drawn from the single and double slit/s experiment with electrons?

(g) Find the penetration depth of an electron having kinetic energy 10 keV when it strikes a potential step of height 15 keV.

(h) Determine the approximate density of a nucleus treating it as a uniform sphere. (Given: mass of a nucleon = 1.7×10^{-27} kg.) (3×5=15)

2. a) Draw the Energy vs wavelength curve of a blackbody for three different temperatures $T_1 < T_2 < T_3$. Show that the Wein's law and Rayleigh Jeans law of black body radiation are the special cases of Planck's law. (5)

(b) The threshold wavelength of potassium is 558 nm. What is the work function for potassium? What is the stopping potential when light of 400 nm is incident on potassium? (5)

(c) Calculate the energy in electron volt of a photon of wavelength 10 Å. What is the momentum of this photon? (5)

3. (a) Distinguish between phase velocity and group velocity and obtain an expression for both. Derive the relation between them. (5)

(b) Show that the Compton wavelength is independent of the nature of the scatterer and the original wavelength of the incident beam. (5)

(c) An electron has a deBroglie wavelength equal to that of a photon, show that the ratio of the kinetic energy of the electron to the energy of photon is

$$\frac{(m^2c^4 + h^2v^2)^{\frac{1}{2}} - mc^2}{hv} \quad (5)$$

4. (a)Show mathematically the value of wavelength calculated from the Davisson Germer experiment matches the value of the wavelength calculated from the deBroglie's hypothesis. (5)

(b) Estimate the minimum energy of a proton existing inside the nucleus using Heisenberg's uncertainty principle: (Size of the nucleus= 1×10^{-15}m) (5)

(c)Explain why it is plausible to define probability current density in quantum mechanics by the following expression

$$J = (\underline{e\hbar}/2m)\,(\psi^* \text{ grad } \psi - \psi \text{ grad } \psi$$

The symbols have the usual meaning (5)

5. (a) What is quantum mechanical tunneling? Obtain an expression for the transmission probability for a beam of particles each with mass m and energy E ($E<V_0$) incident on a rectangular potential barrier:

$$V(x) = 0 \quad \text{for } x<0$$

$$= Vo \quad \text{for } 0<x<a$$

$$= 0 \quad \text{forx}>a \quad (10)$$

(b) Obtain and draw the first two normalized wave functions for a particle in a one dimensional potential box. (5)

6 (a) What are nuclear forces and their characteristics? Also draw the N-Z plot and explain the stability of the nucleus. (5)

(b) Calculate the binding energy of an alpha particle from the following data in MeV and Joules. (Given: mass of He atom= 4.00260 amu, mass of neutron = 1.008665amu, mass of proton=1.007276amu) (5)

(c) Calculate the total energy released if 1.2 kg of 235 U undergoes fission, taking the disintegration energy per event to be Q = 208 MeV. (5)

7. (a) Explain why electron positron pair creation necessarily requires the presence of a nucleus. (5)

(b) Calculate the time required for 20% of a sample of thorium to disintegrate. Assume the half life of thorium to be 1.4×10^{10} years. Calculate the mean life time of thorium nucleus. (5)

(c) Bring out the differences between atomic absorption, spontaneous emission and stimulated emission of photons in a laser system? Discuss the main criteria that must be met to achieve laseraction. Which method is used to achieve this criteria? (5)

Some useful constants

1. Planck constant, $h = 6.626 \times 10^{-34}$ J.s
2. $\hbar = 1{,}05\times 10^{-34}$ J.s
3. Boltzmann constant, $K = 1.38 \times 10^{-23}$ J.K^{-1}
4. Mass of electron, $m_e = 9.1 \times 10^{-31}$ kg
5. Charge of electron, $e = 1.6 \times 10^{-19}$ C
6. Speed of light in vacuum, $c = 3 \times 10^{8}$ m.s^{-1}
7. Stefan-Boltzmann constant, $\sigma = 5.67 \times 10^{-8}$ W.m^{-2}.K^{-4}
8. Rest mass energy of electron = 512 KeV
9. Velocity of electron in free space= 3×10^{8} m/s

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper	:	**4532**	**E**
Unique Paper Code	:	32221401	
Name of the Paper	:	Mathematical Physics III	
Name of the Course	:	**B.Sc. (H) Physics**	
Semester/Annual	:	IV	

Duration : 3 Hours

Maximum Marks : 75

Instructions

1. Write your Roll Number on the top immediately on the receipt of the question paper.
2. Attempt five questions in all.
3. Question number 1 is compulsory. Attempt two questions each from section A and B.
4. The Principal Branch of argument of complex number z in all the questions is taken to be $-\pi < \theta \leq \pi$
5. Use the following definition for the Fourier transform of $f(x)$:
$$\mathcal{F}(f(x)) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty} f(x)e^{-ikx}dx$$
6. Use the following definition for the Fourier Sine transform of $f(x)$:
$$\mathcal{F}_s(f(x)) = \sqrt{\frac{2}{\pi}}\int_{0}^{\infty} f(x)sin(kx)dx$$
7. Use the following definition for the Fourier Cosine transform of $f(x)$:
$$\mathcal{F}_c(f(x)) = \sqrt{\frac{2}{\pi}}\int_{0}^{\infty} f(x)cos(kx)dx$$
8. The definition of convolution of two functions $f(x)$ and $g(x)$ for Fourier transform is:
$$(f * g)(x) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty} f(y)g(x-y)dy$$
9. Some useful Fourier and Laplace Transforms are given at the end.

P.T.O.

Q1. Attempt **any *five*** parts. All parts carry equal marks. (5 × 3 = 15)

a) Obtain the rectangular form of the ellipse $|z + 3| + |z - 3| = 10$.

b) Find the principal branch of i^i.

c) Without evaluating the integral, show that $\left|\int_\Gamma \frac{dz}{1+z}\right| \leq \frac{3\pi}{4}$; where Γ is the arc of circle $|z| = 3$ from $z = 3$ to $z = 3i$ lying in the first quadrant.

d) Given, Laplace Transform, $\mathcal{L}(J_0(t)) = \frac{1}{\sqrt{1+s^2}}$, find the Laplace Transform, $\mathcal{L}(e^{-at}J_0(bt))$.

e) Find Inverse Laplace Transform of $\frac{1}{(s^2+a^2)(s^2+b^2)}$.

f) Find the Fourier Transform of $cos(ax)$ in terms of Dirac-delta functions.

g) If $g(x) = f(bx + a)$ and F(k) is the Fourier transform of $f(x)$, determine the Fourier transform of $g(x)$.

h) Solve the integral $\int_0^5 (sin\, x)\, \delta[(x - 2)(x - 4)]\, dx$

Section – A

Q2.

a) Using de-Moivre's theorem prove that:

$$cos(4\theta) = 8cos^4(\theta) - 8cos^2(\theta) + 1$$

and hence show that

$$cos\frac{\pi}{8} = \left(\frac{2+\sqrt{2}}{4}\right)^{1/2}$$ 6, 2

b) Prove:

$$coth^{-1}z = \frac{1}{2}ln\left(\frac{z+1}{z-1}\right)$$ 7

Q3.

a) Prove that the function $u(x, y) = 2x(1 - y)$ is harmonic. Find its conjugate function $v(x, y)$ such that $f(z) = u + iv$ is analytic. 7

b) Evaluate the following integrals using Cauchy's Integral Formulae where C: |z| = 3

i. $\frac{1}{2\pi i}\oint_C \frac{e^{zt}}{(z^2+1)^2}dz,\ t>0$

ii. $\oint_C \frac{\sin^6(z)}{\left(z-\frac{\pi}{6}\right)^3}dz$ 4, 4

Q4.

a) Use Residue theorem to evaluate **any one** integral of the following: 9

i. $\int_0^\infty \frac{x^2}{(x^2+9)(x^2+4)^2}dx$

ii. $\int_0^{2\pi} \frac{d\theta}{a+b\cos\theta+c\sin\theta};\ a^2>b^2+c^2$

(b).Expand the function $f(z)=\frac{z}{(z-1)(2-z)}$ in a Laurent series valid for

i. $1<|z|<2$

ii. $|z-1|>1$ 3, 3

Section – B

Q5.

a) Find the Fourier transform of

$$f(x)=\begin{cases}(1-x^2), |x|<1\\ 0, |x|>1\end{cases}$$ 7

b) Verify the Convolution theorem (Fourier transform) for the functions

$$f(x)=g(x)=e^{-x^2}$$ 8

Q6.

a) If Laplace transform of f(t) is $\mathcal{L}(s)$ then prove that Laplace transform of $\frac{f(t)}{t}$ is $\int_s^\infty \mathcal{L}(u)du$. Use this result to evaluate Laplace transform of $\frac{\sin(t)}{t}$. 8

b) Taking the Laplace Transform of $f(t)=\int_0^\infty \frac{x\sin(tx)}{1+x^2}dx$, show that $f(t)=\frac{\pi}{2}e^{-t}$ for $t>0$. 7

Q7.

a) A particle moves along a line so that its displacement x from a fixed point O at any time t is given by $x''(t)+4x'(t)+5x(t)=80$. Initial conditions are $x(0)=x'(0)=0$. Using Laplace Transform, find its displacement at any time $t>0$. 8

P.T.O.

b) Prove that

$$\mathcal{F}^{-1}\left(\frac{1}{k^4+5k^2+4}\right) = \frac{\sqrt{2\pi}}{12}\left(2\,e^{-|x|} - e^{-2|x|}\right) \qquad 7$$

Some useful Laplace Transforms:

$$\mathcal{L}(sin(at)) = \frac{a}{s^2+a^2}, Re(s) > 0, s \neq \pm ia$$

$$\mathcal{L}(cos(at)) = \frac{s}{s^2+a^2}, Re(s) > 0, s \neq \pm ia$$

$$\mathcal{L}(e^{at}) = \frac{1}{s-a}, Re(s) > a$$

$$\mathcal{L}(t^a) = \frac{\Gamma(a+1)}{s^{a+1}}, Re(s) > a$$

Useful Fourier Transform:

$$\mathcal{F}(e^{-ax^2}) = \frac{1}{\sqrt{2a}} e^{-k^2/(4a)}, a > 0$$

Useful Inverse Fourier Transform:

$$\mathcal{F}^{-1}\left(\frac{1}{a^2+k^2}\right) = \frac{\sqrt{2\pi}}{2a} e^{-a|x|}$$

also, $\mathcal{F}^{-1}[a\,g(k) + b\,h(k)] = a\,\mathcal{F}^{-1}[g(k)] + b\,\mathcal{F}^{-1}[h(k)]$

(a and b are constants)

Useful Integral:

$$\int_{-\infty}^{\infty} e^{-ax^2+bx}\,dx = e^{b^2/(4a)}\sqrt{\frac{\pi}{a}}\,;\ a > 0,\ b \text{ can be purely imaginary also.}$$

[This question paper contains 4 printed pages.]

Your Roll No.....

E

Sr. No. of Question Paper : 6214

Unique Paper Code : 32225415

Name of the Paper : Thermal Physics and Statistical Mechanics

Name of the Course : **B.Sc. Hons.-(Physics)_GE Paper**

Semester : IV

Duration : 3 Hours

Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all, including Question No. **1** which is compulsory.
3. **All** question carry equal marks.
4. Symbols have their usual meaning.
5. Given value of Boltzmann Constant (k_B) = 1.38×10^{-23} $m^2kgs^{-2}K^{-1}$).

P.T.O.

1. Answer any **five** of the following : (3×5=15)

(a) Two moles of a perfect monoatomic gas, initially kept in a cylinder at STP, are made to expand until its volume is doubled. Show the process on a P-V diagram if it is carried out (i) adiabatically, (ii) isobarically, (iii) isothermally.

(b) Two ideal gases at initial pressure P_1 and volume V_1 are made to expand adiabatically to a final volume equal to four times the original volume. If the values of γ for these gases are 1.67 and 1.40, respectively, compare their final pressures.

(c) A reversible heat engine converts one sixth of the heat input into work. When the temperature of the sink is reduced by 62°C, its efficiency is doubled. Calculate the temperatures of the source as well as the sink.

(d) Establish the expression for work done during an adiabatic process.

(e) Name the three transport phenomena in a gas. What role is played by molecular collisions in these phenomena?

(f) Show that the ratio of the adiabatic and isothermal elasticities for any substance is equal to the ratio of their specific heats at constant pressure and volume.

(g) Define the terms microstate and macrostate of a thermodynamic system.

2. (a) Explain reversible, irreversible and quasistatic processes with the help of examples. (6)

(b) On the basis of the first law of thermodynamics, establish the expression for $C_p - C_v$ for a perfect gas. (5)

(c) The temperature of 5 g of air is raised by 1°C at constant volume. Calculate the increase in its internal energy in Joules. (Given C_v = 0.172 cal g^{-1} $°C^{-1}$ and 1 cal = 4.18 J) (4)

3. (a) Explain Carnot's cycle with the help of a diagram. Derive the expression for the efficiency of a Carnot engine. (10)

(b) Calculate the change in entropy when 1 kg water at 27°C is converted into superheated steam at 200°C under constant atmospheric pressure. Specific heat capacity of liquid water is 4180 J/kg/K; temperature dependence of specific heat capacity of steam is given by the relation (1670 + 0.49 T) J/kg/K at T Kelvin. Take latent heat of steam as 23×10^5 J/kg. (5)

4. (a) State the law of equipartition of energy and apply it to derive the specific heat of monoatomic, diatomic and linear triatomic gases. (8)

(b) Derive the expression for the coefficient of viscosity on the basis of kinetic theory of gases. What are the factors on which viscosity depends? (5,2)

5. (a) Explain the distribution of energy of a black body at different temperatures by drawing the graphs. Discuss the laws which explain the energy spectrum. (5,5)

(b) Two large closely spaced concentric black body spheres are maintained at temperatures of 400K and 600K respectively. The space between the two spheres is evacuated. Calculate the net rate of energy transfer between the two spheres. (5)

6. Describe the Joule-Thomson porous-plug experiment and discuss the results. Hence obtain the expression for Joule-Thomson coefficient. What is temperature of inversion? (7,5,3)

7. (a) Derive an expression for thermodynamic probability and the most probable distribution function for a system obeying Bose-Einstein statistics. (10)

(b) Derive the expression $S = k_B \log W$ where symbols have their usual meanings. (5)

(1000)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 5778 **E**

Unique Paper Code : 42224412

Name of the Paper : Waves and Optics

Name of the Course : **B.Sc. (Prog.) Physical Science**

Semester : IV

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. **Question no. 1** is compulsory.
3. Attempt **any five** questions in all.
4. **All** questions carry equal marks.

any 5 parts need to be attempted

1. (a) State the principle of superposition in the context of two collinear harmonic oscillations of same frequency.

P.T.O.

(b) What are beats? Writean expression for the frequency of beats.

(c) Compare the intensity pattern obtained by Young's double slit interference experiment and Fraunhofer diffraction due to a double slit.

(d) Write two differences between travelling and stationary waves.

(e) Distinguish between Fizeau and Haidinger Fringes? Give examples.

(f) Distinguish between Fraunhofer and Fresnel's class of diffraction.

(g) Calculate the change in intensity level when the intensity of sound increases 100 times its original intensity.

2. (a) What do you understand by Lissajous figures? (3)

(b) Find the resultant of two perpendicular simple harmonic motions whose amplitude are ~~in the ratio~~ equal, 1:2 and the phase difference is 90°. (12)

frequencies are in the ratio 1:2 &
the phase difference is 90°.

3 (a) What are normal modes of vibration in a stretched string?Discuss the possible modes of vibration of a stretched string of finite length fixed at both ends. (8)

(b) What do you mean by wave velocity and group velocity? Derive the relation between them in a dispersive medium. (7)

4. (a) Explain how sound waves are produced. What do you understand by intensity and loudness of sound? (7)

(b) How does a noise is different from musical notes? Discuss in detail how musical scales are made? (8)

5. (a) Explain the phenomenon of interference of light due to thin films and find the condition for maxima and minima. (10)

(b) An oil film (μ=1.47) of thickness t=0.12 μm rests on a pool of water. If light strikes the film at an angle of 60°, what is the wavelength reflected in the first order? (5)

P.T.O.

6. (a) Describe the construction and working of Michelson's interferometer. Explain how it is used to determine wavelength of monochromatic light. (10)

(b) When the movable mirror of Michelson interferometer is moved through 0.06854 mm, a shiftof 220 fringes is observed. Find the wavelength of light used. (5)

7. (a) Explain with theory, Fresnel type of diffraction due to straight edge. (7)

(b) Explain the theory of plane transmission grating. How it can be used to find the wavelength of light? (8)

8. (a) What do you mean by plane polarised light? What are the various ways to produce it? (7)

(b) Describe how one can produce and detect circularly-polarised and elliptically-polarised light with the help of Nicol prism and quarter-wave plate. (8)

[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 4762 **E**

Unique Paper Code : 32227626

Name of the Paper : Classical Dynamics (DSE – Paper)

Name of the Course : **B.Sc. (Hons.) Physics (CBCS – LOCF)**

Semester : VI

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **four** questions in all including Question No. 1 which is compulsory.

1. Attempt any **four** of the following :

   (a) What are generalized coordinates? Derive expressions for the generalized displacement and generalized velocity.

P.T.O.

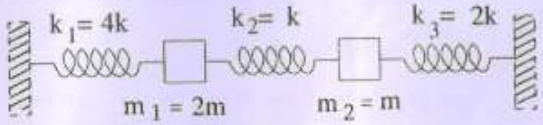
(b) A particle of mass m is attached to a point by inverse square law. Find the Hamiltonian and canonical momentum.

(c) In an inertial frame S, photon emitted from the light source at origin gets reflected by the mirror normal to x–axis. If the mirror is placed at x = 7 units, draw the world lines of mirror, emitted photon and that of reflected photon.

(d) At what speed does a clock moves if it runs at a rate which is one-half of the rate of a clock at rest?

(e) Differentiate between laminar flow and streamline flow. Give examples.

(f) Consider two masses $m_1 = 2m$ and $m_2 = m$ connected by three springs with spring constants as shown in the figure below. Find the kinetic energy (T) and potential energy (V) matrices for the system. (4×6=24)



(4×6=24)

2. (a) State Hamilton's principle. Derive Lagrange's equation of motion from Hamilton's principle for a conservative system. (2,7)

(b) A particle of mass m moves in a central force field of potential V. Find its Hamiltonian and Hamilton's equations of motion. (4,4)

3. (a) Consider a spring pendulum: a simple pendulum in which massless string is replaced by a massless spring (unstretched length r_0, spring constant k). The bob of mass m oscillates in a vertical plane about its equilibrium position. If the instantaneous

position of this bob is (r, θ). obtain the Lagrangian of this system and hence find the equation(s) of motion.

(Assume $r > r_0$ and $\theta = 0$ is the equilibrium position) (5,4)

(b) An electron is accelerated from rest by a potential difference of 350 V. Then it enters a magnetic field $\vec{B}$ of magnitude 200 milli-Tesla with its velocity perpendicular to $\vec{B}$. Find the

(i) speed of an electron.

(ii) radius of the path in magnetic field.

(4,4)

4. (a) If $\tilde{P} = (E/c, \vec{p})$ is the 4-momentum, show that $E^2 = c^2p^2 + m_0^2c^4$. (5)

(b) In an inertial frame S, a particle describes a path with parametric equations :

$x(t) = at + b\sin(\omega t)$; $y(t) = b\cos(\omega t)$; $z(t) = 0$.

Calculate the velocity, acceleration, 4-velocity and 4-acceleration of this particle. (2,2,4,4)

5. (a) Starting from the 4-displacement vector, $\tilde{X} = (ct, x, y, t) = (ct, \vec{r})$, prove that $\tilde{U} \bullet \tilde{A} = 0$ where $\tilde{U}$ is 4-velocity and $\tilde{A}$ is 4-acceleration. (9)

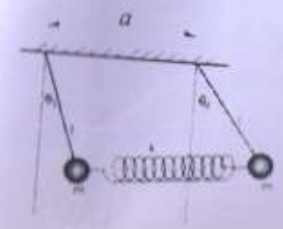
(b) In an inertial frame S, proton has 4-momentum, $\tilde{P} = (E/c, \vec{p})$ and an observer has 4-velocity, $\tilde{U} = \gamma_u(c, \vec{u})$. Show that the proton's energy, as measured by this observer is $\tilde{U} \bullet \tilde{P} = 0$. where

P.T.O.

$$\gamma_u = \frac{1}{\sqrt{1-(u/c)^2}}. \qquad (4)$$

(c) An unstable atom of rest mass M_o at rest decays into two daughter atoms a (rest mass m_{oa} and speed (u_a) and b (rest mass m_{ob} and speed (u_b). Using 4-vector approach or otherwise, find the energy of daughter atom a. (4)

6. Coupled pendulums are executing simple harmonic oscillations as shown below. The generalized coordinates are (θ_1, θ_2) and the relaxed length of spring is a. Find the kinetic energy T and the potential energy V matrices, and hence find the angular frequencies of small oscillations. (5,7,5)



7. (a) A charged particle (mass m, charge q) is moving in x – y plane. At time t = 0, this particle is at the origin having velocity v_0 at an angle 45° with the x–axis and uniform crossed electric and magnetic fields : $\vec{E} = E_0\hat{y}$ and $\vec{B} = B_0\hat{z}$ are switched on. Find its velocity at time $t > 0$. (8)

(b) Draw the analogy between fluid flow in a pipe and current flow in a circuit. Two capillaries of radius r and R and same length are connected to each other in series, $r << R$. A liquid of viscosity

coefficient η is flowing through them. Find an expression for the volume flow rate for the arrangement. (3,6)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : **4756** **E**

Unique Paper Code : 32227613

Name of the Paper : Communication System

Name of the Course : **B.Sc. (Hons.) Physics-CBCS--DSE**

Semester : VI

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **FIVE** questions in all.
3. **All questions** carry equal marks.
4. **Question No. 1** is compulsory.
5. Scientific (non-programmable) calculators are allowed.

1. Answer **any five** of the following questions: (5×3=15)

   (a) Write the requirements of FM detector circuit.

   (b) Prove that in amplitude modulation, maximum average power transmitted by an antenna is 1.5 times the carrier power.

   (c) What is flat top sampling? What is the advantage of using such sampled signals?

P.T.O.

(d) How would you use an AND gate to obtain PAM?

(e) What are the advantages of PCM over PAM?

(f) What is the frequency spectrum? Explain the frequency spectrum for an amplitude modulated (AM) wave.

(g) What do you mean by a Satellite Transponder?

(h) Explain the basic structure of a cellular system.

2. (a) Define the term SSB in amplitude modulation. Explain any method for generation of single side band (SSB) signal using suitable block diagram. Derive an expression for power saved in transmission of SSB signal over DSB-SC signal. (8)

(b) Explain amplitude demodulation using diode detector. What are the types of distortions which can occur in the detection of AM signal using diode detector? (7)

3. (a) Define frequency modulation and derive mathematical expression for frequency Modulated wave. Derive expression for phase modulated wave from frequency modulated wave. (10)

(b) A carrier wave of 1 MHz frequency and amplitude of 3 V is frequency modulated by a sinusoidal modulating signal frequency of 500 Hz and peak amplitude of 1 V. The frequency deviation is 1 kHz. If the peak level of the modulating wave form is changed to 5V and the modulating frequency is changed to 2 kHz, write the expression for the modulated wave in both the cases. (5)

4. (a) What are the advantages of pulse modulation over analog modulation.Explain in details PAM, PWM and PPM signals by using appropriate wave forms. (8)

(b) State sampling theorem. An analog signal is expressed by the equation

$$x(t) = 3\cos(50\pi t) + 8\sin(300\pi t) - 4\cos(100\pi t)$$

Calculate the Nyquist rate and sampling frequency for this signal. (7)

5. (a) Draw the block diagram of the PCM generator and properly explain the function of each block. What is the role of regenerative repeaters in the PCM transmission path. (10)

(b) What is the difference between PSK and BPSK.Sketch ASK waveform for the sequence 1100110110. (5)

6. (a) Briefly explain the concept of Frequency reuse in the cellular system. Explain the uplink and downlink models of satellite communication system with the help of a block diagram. Also, explain the down conversion achieved by the transponder. (10)

(b) What are SIM and IMEI numbers in mobile network systems? (5)

7. (a) Explain CDMA, FDMA and TDMA systems in detail. (6)

(b) Explain the structure of a mobile phone handset. Discuss the concepts of 2G, 3G and 4G systems. (9)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper	:	**4880**	**E**
Unique Paper Code	:	32227613	
Name of the Paper	:	Communication System	
Name of the Course	:	**B.Sc. (Hons.) Physics-CBCS--DSE**	
Semester	:	VI	

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **FIVE** questions in all.
3. **All questions** carry equal marks.
4. **Question No. 1** is compulsory.
5. Scientific (non-programmable) calculators are allowed.

1. Answer any five of the following questions: (5×3=15)

   (a) Represent the data stream 11001011 in all of the following line encoding schemes:

   (i) Polar NRZ

   (ii) Bipolar RZ

   (iii) Manchester

P.T.O.

(b) Draw the AM wave, if a carrier wave is given by $y_c = 5 \times \cos(6 \times 10^6 t)$ and amplitudemodulated base-band signal is given by $y_m = 3 \times \cos(100t)$

(c) Determine the number of channels per cluster and the total channel capacity for a cellular phone area comprised of 10 clusters with 7 cells in each cluster and 10 channels in each cell.

(d) Calculate the amount of power transmitted (in percentage) for an ideal AM wave if the carrier and one side band are completely suppressed.

(e) Write the advantages of single side-band (SSB) over double side-band (DSB) transmission of an AM wave.

(f) What are the different ways to increase the capacity of a cell in cellular network.

(g) Differentiate between PAM, PWM and PPM by drawing suitable wave-forms.

2. (a) Explain the working of an emitter modulator for the generation of amplitude modulation using a suitable circuit diagram. Write the use of various components in the circuit. (7)

(b) Discuss the phasing method of single side band (SSB) signal generation using suitable block diagram. A SSB generator has a 2 MHz carrier input and a modulating signal input of 1 kHz. Calculate the centre frequency, a filter must have to pass the lower side band (LSB) (8)

3. (a) With the help of a block diagram explain Global System for Mobile Communication. Describe in detail about different components and the interfaces between them. (7)

(b) Explain the concept of cell sectoring and cell splitting with the help of appropriate block diagram. (8)

4. (a) What is the need of digital transmission? Explain the three basic operations performed in Pulse Code Modulation (PCM). Explain the advantages and disadvantages of PCM. (10)

(b) Explain the function of regenerative repeaters with the help of a block diagram. What do you mean by Binary Phase Shift Keying (BPSK)? (5)

5. (a) Explain the generation of FM wave using VCO. Write the advantages of FM over AM modulation techniques. (7)

(b) Discuss the mathematical analysis of AM wave using frequency spectrum. A 30 MHz carrier signal with a voltage of 6 V amplitude is modulated by a sine wave of 10 kHz with a voltage of 3V. Draw the frequency spectrum of AM wave. (8)

6. (a) What are the Ground station and Earth stations? Give a block diagram of the Earth Station explaining the working of each section. (10)

(b) In a satellite communication system, free space conditions may be assumed. The Satellite is at a height of 36,000km above earth, the frequency used is 4000MHz, the transmitting antenna gain is 15dB and the receiving antenna gain is 45dB. Calculate

(i) The free space transmission loss and

(ii) The received power when the transmitted power is 200W. (5)

7. (a) What do you mean by Multiplexing? What is Time Division Multiplexing (TDM)? How is it different from Frequency Division Multiplexing (FDM)? (7)

(b) What is the advantage of Flat Top Sampling over Natural Sampling? With suitable block/circuit diagram explain the generation of PAM signal. (8)

(000)

(4)

[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 4514 **E**

Unique Paper Code : 32221601

Name of the Paper : Electromagnetic Theory

Name of the Course : **B.Sc. Hons. – (Physics)**

Semester : VI

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question No. **1** is compulsory.
3. Answer any **four** of the remaining **six**.
4. Use of non-programmable scientific calculator is allowed.

1. Attempt any **five** questions :

   (a) How do you optically distinguish between quarter wave plate and half wave plate.

P.T.O.

(b) A polarimeter tube of 25 Cm long containing a sugar solution of unknown concentration rotates the plane of polarization of electromagnetic wave by 10 degrees. Specific rotation of sugar is given as 60 degrees per decimeter/gm/cc, find the concentration of the sugar solution.

(c) In case of electric field vector E be perpendicular to the plane of incidence, find the reflection and transmission coefficient for normal incidence on a air-glass interface ($n_1 = 1$, $n_2 = 1.5$).

(d) The conduction current density in a dielectric is given by $J=0.02 \sin (10^9 t)$ Amp/m^2. Find the displacement current density if $\sigma = 10^3$ mho/m and $\epsilon_r = 6.5$.

(e) What is the plasma frequency and minimum penetration depth for a collision free plasma having 10^{12} electrons/m^3 ?

(f) Calculate Numerical Aperture and Acceptance angle for a fiber if $n_1 = 1.458$ and $(n_1 - n_2)/n_1 = 0.01$.

(g) Show that in a good conductor the magnetic field lags the electric field by 45°. (3×5=15)

2. (a) A plane em wave propagating in a conducting medium is characterized by the parameters ϵ, μ and σ and show that propagation constant is complex in this case. (8)

(b) In a homogeneous region, where $\mu_r = 1$ and $\varepsilon_r = 50$

$E = 20\ \pi \exp i(\omega t - \beta z)\ a_x$ Volt/m

$H = H_0 \exp i(\omega t - \beta z)\ a_y$ Tesla

Here a_x and a_y are unit vectors in the x and y directions. Find ω and H_0 if the wavelength is 1.78m. (4)

(c) Derive the expression of skin depth for a good conductor. (3)

3. (a) State and prove Poynting theorem for a linear isotropic homogeneous medium. Explain the physical significance of each term. What is the physical significance of Poynting vector? (10)

(b) If all the energy from a 1000 W lamp is radiated uniformly, calculate the average value of the intensities of electric and magnetic fields of radiation at a distance of 2m from the lamp. (5)

4. (a) Show that Maxwell's equations can be written as two coupled second order differential equations in terms of scalar potential V and vector potential A. What is Lorentz condition and how can these equations be uncoupled using it? (8)

(b) For the propagation of electromagnetic wave through plasma derive an expression for the cut-off frequency ω_p and explain its significance. (7)

5. (a) Discuss the phenomenon of total internal reflection on the basis of electromagnetic theory. Prove that though the wave fields do exist in the second medium yet the energy flow through the surface into the second medium is zero.

(b) An electromagnetic wave whose electric field is polarized parallel to plane of incidence, is incident from free space to non-magnetic, non-conducting medium having $\varepsilon = 3\varepsilon_0$, here the wave is not reflected back from the interface. Determine the angle of transmission. (5)

6. (a) Starting from Maxwell's equations, obtain the eigen value equation for wave propagation through an optical planar waveguide for TE mode. Write its solution for the symmetric TE mode. (8)

(b) Distinguish between a step index and graded index optical fiber. Plot the variation of the refractive index with radial distance for step index and the graded index fibers. A pulse of light propagates through 1 km length of a step index fiber having a core of refractive index 1.5 and a cladding of refractive index 1.49. Calculate the pulse dispersion suffered by light on passing through the fiber. (7)

7. (a) Derive Fresnel's formulae for wave propagation in an anisotropic medium and explain the phenomenon of double refraction with the help of this. (10)

(b) A plate of 0.10 mm thickness is used as a retardation plate. For what wavelength in the visible region (400nm – 800nm) will it act as (i) quarter wave plate and (ii) half wave plate. For calcite $n_0 = 1.5443$ and $n_e = 1.5533$. (5)

Given : $\varepsilon_0 = 8.85 \times 10^{-12}$ Farad/m

$\mu_0 = 4\pi \times 10^{-7}$ Henry/m

$c = 3 \times 10^8$ m/s

$m_e = 9.11 \times 10^{-31}$ kg

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 5883 **E**

Unique Paper Code : 42227637

Name of the Paper : Solid State Physics

Name of the Course : **B.Sc. Physical Sciences (DSE)**

Semester : VI

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all.
3. Question No. **1** is compulsory.

1. Attempt any **five** of the following : (5×3=15)

(a) Find the reciprocal lattice vectors for

$a = 3i$, $b = 3j$, $c = i+j+k$

P.T.O.

(b) Define the Mobility, Drift velocity, and conductivity of a semiconductor.

(c) Derive the relationship between displacement vector D, polarization vector P, and electric field intensity E through diagram.

(d) Give one experimental evidence that led to the phenomenon of Superconductivity.

(e) Differentiate between conductors, semiconductors, and insulators on the basis of energy level diagram.

(f) What is the difference between Ferroelectricity and Piezoelectricity?

(g) Calculate the Hall coefficient of sodium based on the free electron model. Given that sodium has BCC structure and the side of the cube is 4.28Å.

2. (a) What is the reciprocal lattice to FCC lattice? (4)

(b) Show the following : (122), (111), (201), and [101] in a simple cubic lattice. (4)

(c) What is the difference between Atomic and Geometrical structure factors? Derive the relation for the intensity of the diffracted beams. (7)

3. (a) Find the expression for the dispersion relation of a monoatomic lattice. How is it different from that of a continuous string? (7)

(b) Discuss Hall effect and derive the formula for the Hall coefficient. (4)

(c) Explain how the measurement of the Hall coefficient helps one to determine the mobility of electrons in metals. (4)

4. (a) Discuss the Kronig-Penny model for the motion of electrons in a periodic potential. Show from E-K graph that the materials can be classified into conductors, insulators, and semiconductors. (10)

(b) Define the effective mass of an electron. Give its physical significance. (5)

5. (a) Obtain the Lorentz relation for the local electric field at an atom. Outline the difference between E, Maxwell's field, and E_{loc}, the Lorentz field. (10)

(b) Differentiate between Normal and Anomalous dispersion. (5)

6. (a) What is ferromagnetism? Describe classical Weiss's theory of ferromagnetism and give the significance of Curie's temperature. (10)

(b) A paramagnetic salt contains 10^{28} ions/m^3 with magnetic moment of one Bohr magneton. Calculate the paramagnetic susceptibility and the magnetization produced in a uniform magnetic field of 10^6 A/m at room temperature. (5)

7. (a) Describe the significance of critical temperature, critical magnetic field and critical current for superconductors. (10)

(b) Write short notes (i) Hard superconductors (ii) High temperature superconductors. (5)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper	:	**4794**	**E**
Unique Paper Code	:	32221602	
Name of the Paper	:	Statistical Mechanics	
Name of the Course	:	**B.Sc. (Hons) Physics**	
Semester	:	VI	

Duration : 3 Hours

Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all.
3. **Question No. 1** is compulsory.
4. **All** questions carry equal marks.
5. **Non- programmable Scientific calculators** are allowed.

1. Attempt any ***five*** of the following:

   (a) Draw a phase space for a one-dimensional classical linear harmonic oscillator of mass $m$having total energy $E = p^2/2m + m\omega^2x^2/2$. Calculate the total number of microstates available to it, if the energy of a harmonic oscillator lies between 0 and E.

   (b) Discusswhether law of equipartition of energy can be applied to the following systems or not:

P.T.O.

(i) classical harmonic oscillators

(ii) gas consisting of free particles moving non- relativistically

(iii) nucleons in a nucleus.

(c) Assume a system of N bosons, each of mass m, is confined to a one-dimensional box of length L at temperature T = 0 K. The energy levels of the system are given by $E_n = n^2h^2/(8mL^2)$, where n= 1, 2,... and $h$is Planck's constant. Find the total energy of the system in terms of N, L, and h.

(d) Plot the variation of specific heat with temperature for ideal Bose-Einstein gas and explain its behavior in the strongly degenerate and classical regions.

(e) For Silver atom, with one electron per atom at room temperature, the number density $n = 5.86\times10^{28}m^{-3}$. Find the nature of the degeneracy of the system under consideration.

(f) A cubical cavity of side $1m$ is filled with black body radiation. Calculate the number of independent standing waves with wavelengths in the range 8.0 mm and 9.0 mm.

(g) Calculate the normal radiation pressure generated by an incandescent bulb of $200W$ at a distance of $1m$.

(5×3=15)

2. (a) Using the partition function of classical ideal monoatomic gas consist of N indistinguishable particles at fixed temperature T in volume V: $Z(N,V,T) = (V^N/N!)[2\pi mk_BT/h^2]^{3N/2}$:

Derive the Sackur-Tetrode relation assuming N >>1. Show that the entropy given by the Sackur- Tetrode equation is an extensive parameter.

(b) A partition divides a box into two chambers 1 and 2, each of volume V. Assume that chamber 1 and 2 chamber contain the same ideal gas consisting of $2N$particlesand N particles respectively attemperature T. Using the Sackur-Tetrode relation, calculate the entropy of mixing after the partition is removed and the contents are allowed to mix to reach at equilibrium (Assume that the temperature remain constant throughout the process). (8, 7)

3. (a) Consider an isolated paramagnetic salt consisting of dipoles of magnetic moment μ,located in an external magnetic field B. Out of these N dipoles, n dipoles are parallel to B and rest are anti-parallel. Show that the total energy E, the entropy S and the absolute temperature T of the system are given respectively as

(i) $E = (N-2n)\,\mu B$

(ii) $S = -Nk_B\,[x\,ln\,(x) + (1-x)\,ln\,(1-x)]$, where $x = n/N$

(iii) $1/T = [k_B/2\,\mu B]\,ln\,(n/(N-n))$

(b) A system consists of 12 identical butdistinguishable particles which can occupy non-degenerate energy levels. Initially, the system is in the macrostate which is defined by (6,3,2,1) particles in the energy levels $(0, \varepsilon, 3\varepsilon, 5\varepsilon)$.

(i) Calculate the number of microstates and entropy of the system in its initial state.

(ii) If a small amount of energy is added to the above-mentioned system such that only one particle is raised from the ground level (zero energy) to first excited level (ε), calculate the number of microstates available in this final microstate.Hence, find the change of entropy when system undergoes from initial to final state. (8, 7)

4. (a) Consider a completely degenerate non-relativistic gas of electrons in3 –dimensions. Obtain the expressions for average energy per particle, Fermi velocity and Fermi pressure.

(b) Consider the model of a white dwarf star: a sphere consisting of helium gas of mass $M = 10^{30}\ kg$ at a density of $\rho = 10^{10}\ kg\ m^{-3}$ and temperature T of the order of $10^6 K$. Using these data, find the nature of electron gas inside a white dwarf star. (Given: mass of proton $\approx 10^{-27}\ kg$, mass of electron $\approx 10^{-30}\ kg$) (8, 7)

5. (a) Prove that for photon gas, internal energy (U) and (S) entropy at given temperature T are related by the following relation: $TS = 4U/3$.

(b) How does Bose–Einstein condensation explain the superfluid properties of liquid $4He$? (10,5)

6. (a) A blackbody cavity at temperature T is filled with N_0, N_1, N_2, ... oscillators having energies 0, $h\nu$, $2h\nu$, ...respectively. Calculate the total number of oscillators and determine average energy of the oscillators. If Planck's constant tends to zero, what would be the effect on the average energy of the oscillators?

(b) Calculate the average energy of a Planck oscillator, vibrating with frequency 3×10^{14} Hz at 2000 K. Compare it with a classical oscillator. (10,5)

Constants:

$k_B = 1.38 \times 10^{-23} JK^{-1}$

$m_e = 9.11 \times 10^{-31} kg$

$h = 6.626 \times 10^{-34} Js$

$c = 3 \times 10^8\ ms^{-1}$

$\sigma = 5.67 \times 10^{-8}\ J\,m^{-2}s^{-1}K^{-4}$

(2000)