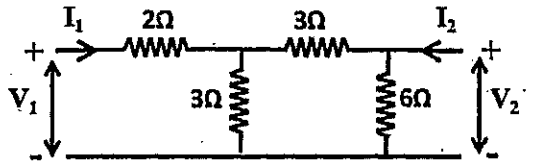
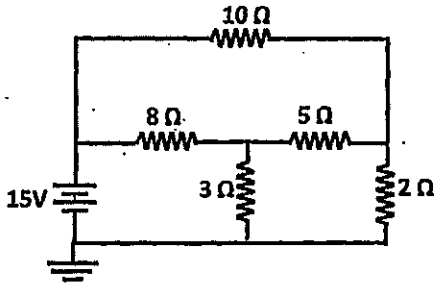
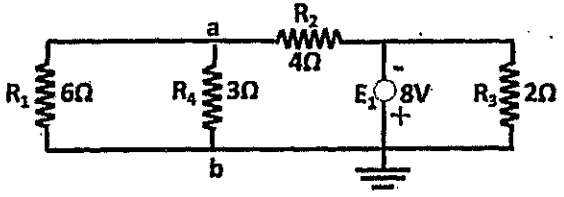


5. (a) Find the value of current through the 10-Ω resistor using Mesh analysis. (5)



(b) Derive an expression for sharpness of resonance of a series LCR circuit, driven by a sinusoidal source. (5)

(c) Draw the Thevenin's equivalent circuit at terminals ab (R_4) for the given network. (5)



[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 4161 **H**

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.

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

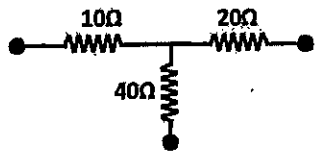
   (a) Define an ideal and a real voltage source with the help of a diagram. Draw their V-I characteristic curves.

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

   (c) State superposition theorem and give one of its limitations.

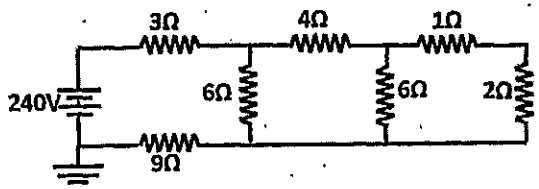
   (d) What is the difference between transient and steady state response in a dc network? How does the time constant affect the transient state response?

   (e) Convert Y (star) configuration into its equivalent Δ (delta) configuration.



2. (a) Derive an expression to calculate voltage across the capacitor at any given time during charging and discharging process for a RC network. (8)

   (b) Find the voltage across the 2Ω resistor using nodal analysis for the given network. (7)



3. (a) A circuit with components L, C and R are connected parallel to each other and with an ac voltage source. Given, R = 10 Ω, L = 300 mH and v(t) = 10 cos 5000t. Find the value of C at resonance, when the value of resonant frequency is 460 Hz. Determine the voltage across C and the current i(t) in the circuit using phasor notation. (8)

   (b) A series RL circuit with R = 560 Ω and L = 350 mH is driven by a sinusoidal voltage source with angular frequency (ω) = 1000 rad/s. Determine the equivalent impedance to the series RL circuit. Draw its impedance diagram. (7)

4. (a) State and prove Maximum Power Transfer theorem for an ac network. (8)

   (b) Determine z-parameters of the given two-port network. (7)

P.T.O.

(b) State the second uniqueness theorem and under what condition(s) it will reduce to the first one. (3)

(c) In a material for which $\sigma = 5.0$ S/m, $\varepsilon_r = 1$ and electric field intensity is $E = 250\sin 10^{10}t$ V/m. Find the conduction and displacement current densities and the frequency at which they have equal magnitudes. (6)

6. (a) An infinitely long cylinder, of radius R, carries a "frozen-in" magnetization, parallel to the axis, $\vec{M} = kr\hat{r}$ where k is a constant and r is the distance from the axis (there is no free current anywhere). Find the magnetic field inside and outside the cylinder

(i) Locate all the bound currents, and calculate the field they produce.

(ii) Use Ampere's law to find $\vec{H}$, and then get $\vec{B}$. (3+3+3+3)

(b) Two coaxial solenoids each carrying current I, but in opposite directions. The inner solenoid of radius a has N_1 turns per unit length and the outer of radius b has N_2 turns per unit length. Find $\vec{B}$ in each of the three regions : (i) inside the inner solenoid, (ii) between them and (iii) outside the outer solenoid. (2+2+2)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 4123 **H**

Unique Paper Code : 2222011202

Name of the Paper : Electricity and Magnetism

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

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) Two uniform infinite sheets of electric charge densities $+\sigma$ and $-\sigma$ intersect at an angle of 45°. Find the magnitude and direction of the resultant electric field.

(b) Calculate the charge density in an enclosed region due to the potential

$$V = x^2 + y^2 + z^2.$$

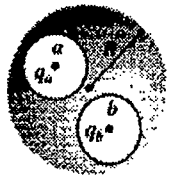
(c) Show that equation of continuity is a consequence of Maxwell's equations.

(d) Given that $\vec{E_1}=2\hat{i}-3\hat{j}+5\hat{k}$ (V/m) at the charge-free dielectric interface between two different dielectric materials of 2 and 5, respectively. Find $\vec{E_2}$ and $\vec{D_2}$.

(e) Determine whether the following elements are paramagnetic or diamagnetic (i) Chlorine Atoms (Atomic No. = 17, Atomic Mass = 35.43 u), and (ii) Copper atoms (Atomic No. = 29, Atomic mass = 63.55 u)

(f) A current sheet of width 4 m lies in the $z = 0$ plane and contains a total current of 10 A in a direction from the origin to (1, 3, 0) m. Find an expression for $\vec{K}$.

2. (a) Two spherical cavities, of radii a and b, are hollowed out from the interior of a (neutral) conducting sphere of radius R. At the center of each cavity a point charge placed q_a and q_b. Find the surface charge densities on the walls of both the cavities and the surface of the conductor. What is the force experienced by q_a and q_b? (9)



(b) A block of iron ($\mu = 5000\ \mu_0$) is placed in a uniform magnetic field with 1.5 Wb/m^2. If iron consists of 8.5×10^{28} atoms/m^3, calculate (i) the magnetization M (ii) the average dipole moment. (9)

3. (a) A point charge q is located at a from the center of a grounded conducting sphere of radius R along y axis such that (a > R). What is the potential outside the grounded conducting sphere? (9)

(b) In spherical coordinates, V = 0 for r = 0.10 m and V = 100 V for r = 2.0 m. Assuming free space between these concentric spherical shells, find E and D. (9)

4. (a) Calculate the Laplacian of electrostatic potential at any arbitrary point P due to a point charge q located at r' from the origin. (9)

(b) Is it true that in a uniform material with magnetic susceptibility χ_m and electric conductivity 0, the bound current distribution can only be a surface current (assume no time dependence). Justify. (3)

(c) Using Ampere's law obtain magnetic flux density B inside and outside the toroid. (6)

5. (a) A very long cylinder of linear dielectric material is placed in an uniform electric field E_0. Find the resulting field within the cylinder. (The radius is R, the susceptibility χ_r and the axis is perpendicular to E_0.) (9)

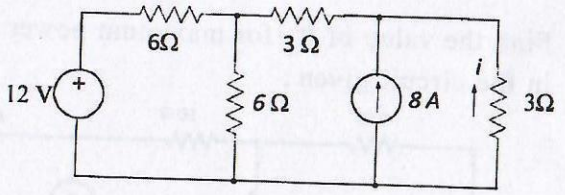
P.T.O.

6. (a) The space between two concentric spherical shells (radii a, b) of a spherical capacitor is filled with the dielectric material of relative permittivity $\epsilon_r = \frac{k}{r}$, where k is a constant. Find the capacitance of the capacitor. (6)

(b) Derive an expression for self-inductance of a long solenoid. A coil of wire of certain radius has 600 turns and a self-inductance of 108 mH. What will be self-inductance of a similar coil which has 500 turns. (3,3.5)

7. (a) Eight positive charges, each of magnitude q, are kept at comers of a cube of side a. Calculate the Potential energy of the system if -2q is placed at the center of the cube. (6)

(b) Use nodal analysis to find the value of 'i' for the circuit shown : (6.5)



11 May-2024

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Your Roll No.....

Sr. No. of Question Paper : 2917 **H**

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)

(a) Two charges each of 2μC but opposite in sign are 1 cm apart. Calculate electric field at a point distant 10 cm from the mid-point on axial line of the dipole.

(b) Prove that electrostatic forces are conservative in nature.

(c) Show that $\vec{\nabla}.\vec{B}=0$. What is its physical significance?

(d) State Faraday's laws of Electromagnetic Induction. The magnetic flux threading a coil change from 12×10^{-3} to 6×10^{-3} Wb in 0.01 seconds. Calculate the induced e.m.f.

(e) Explain superposition theorem with an example of your choice.

2. (a) What is Gauss law? Using Gauss law to find the expression for electric field due to uniformly charged sphere at

(i) Point outside the charged sphere.

(ii) Point inside the charged sphere. (6)

(b) Obtain an expression for magnetic field due to a straight line conductor carrying current I. Calculate the magnetic field induction at the center of a coil bent in the form of a square of side 10 cm carrying a current of 10 A. (4,2.5)

3. (a) If the electrostatic potential is $V = a/(x^2+y^2+z^2)^{1/2}$, show explicitly that it satisfies Laplace equation. (6.5)

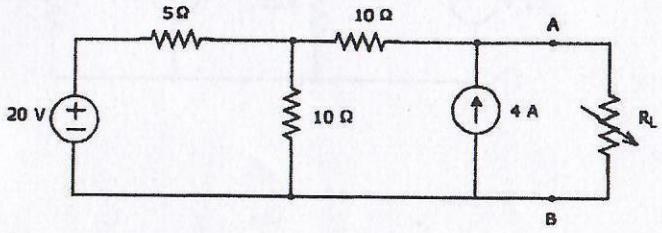
(b) What is residual magnetism of a material? A magnetizing field of 1600 A/m produces a magnetic flux of 2.4×10^{-5} Wb in a bar of iron of cross section 0.2 cm^2. Calculate magnetic permeability and susceptibility of the bar. (2,4)

4. (a) Obtain the expressions for capacity of parallel plate capacitor when filled with i) conducting slab of thickness t between the plates ii) dielectric slab of thickness t between the plates. (6.5)

(b) A sinusoidal voltage of peak value 70V and frequency 50Hz is applied to a series LCR circuit in which R = 3Ω, L = 25mH and C= 796μF. Find (i) The impedance of the circuit (ii) phase difference between voltage across the source and current (iii) the power dissipated in the circuit and (iv) the power factor. (6)

5. (a) Using the method of images, obtain the expressions for potential and field due to point charge placed near conducting sphere which is earthed. (6)

(b) Find the value of R_L for maximum power transfer in the circuit given : (3,3.5)



P.T.O.

(c) What is the path difference between two successive waves reflected from upper and lower surfaces of a transparent medium of thickness t and refractive index μ? State the interference conditions for maxima and minima in reflected light. (4+3+8)

6. (a) Discuss the intensity distribution of Fraunhoffer diffraction pattern obtained with a single slit, illuminated by a parallel beam of monochromatic light.

(b) What is the ratio of intensity of the secondary maxima to the intensity of the central maximum?

(c) Explain why a circular aperture with small enough radius will have Fraunhofer diffraction pattern consisting only of a disk. (8+4+3)

7. (a) Derive the expression for Fresnel's integrals.

(b) Using Cornu's spiral explain Fresnel diffraction pattern at a straight edge. (8+7)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 2971 **H**

Unique Paper Code : 32221202

Name of the Paper : Wave and Optics

Name of the Course : **B.Sc. (H) 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. Attempt **five** questions in all, including Question No. **1** which is compulsory.
3. Symbols have their usual meanings.

1. Answer the following : (5×3=15)

(a) Distinguish between longitudinal and transverse waves.

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

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

(d) Why is a broad source of light needed for "division of amplitude" interference experiment?

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

2. (a) State the principle of superposition. Show that it holds only for linear homogenous differential equations.

(b) Show that two simple harmonic motions at right angle to each other, of equal amplitudes and equal frequencies but with phases differing by $\pi/2$, are equivalent to a uniform circular motion, the radius of the circle being equal to the amplitude of either oscillation.

(c) Two tuning forks A and B are used in an experiment to produce Lissajous figures. Frequency of fork A is 288 Hz. It is found that the sequence of figures repeats every 20 seconds. When fork B is loaded with a little wax, the time taken for sequence of the figures is found to repeat every 10 seconds. Determine the original frequency of fork B. (5+6+4)

3. (a) Determine the expression for fundamental frequency of vibration in a stretched string. Plot the first normal mode configuration.

(b) Discuss how diameters of two wires can be compared in a stretched string experiment.

(c) A flexible string of length 0.88 m is stretched by a force of 55 N. The mass of the string is 1 gram. Calculate the frequency of vibration of the string if it vibrates in 5 segments. (7+4+4)

4. (a) With the help of a labelled diagram, describe the construction and working of Fabry-Parot interferometer. Derive Airy's formula for the intensity of the transmitted light.

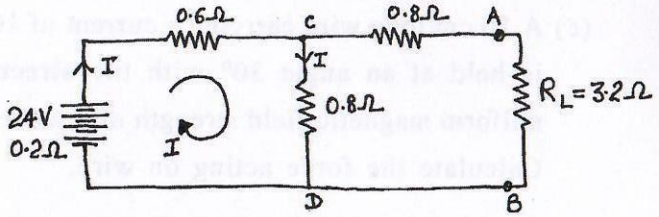
(b) In a Michelson's interferometer 150 fringes cross the field of view when the movable mirror is displaced through 0.04418 mm. Calculate the wavelength of monochromatic light used. (12+3)

5. (a) On the basis of the Stoke's treatment, discuss the phase change due to reflection of light from the surface of a denser medium.

(b) How are the circular fringes obtained in Michelson interferometer different from those obtained in the Newton's Ring experiment?

5. (a) State the maximum power transfer theorem. Show that power lost in the internal generator is equal to the power delivered to the load and the power efficiency is only 50%. (7)

(b) Draw the Thevenin's equivalent for the following circuit. Calculate the current through the load resistance. (5)



(c) State and explain Norton's Theorem with example. (3)

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 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 4026 **H**

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 : (5×3)

(a) Define the electric flux. A square frame of edge 10 cm is placed with a positive normal making an angle of 60° with a uniform electric field of 20 V/m, find the flux of the electric field through the surface bounded by the frame.

(b) What is Displacement Current?

(c) Define Magnetic permeability and susceptibility. Establish the relation $\mu = \mu_0(1 + \chi)$.

(d) Calculate the coefficient of self-induction of a coil of 1000 turns when a current of 2.5 Ampere produces a magnetic flux of 0.5 micro-Weber.

(e) State Kirchhoff's Current and Voltage law.

2. (a) State and prove Gauss's theorem in electrostatics. (7)

(b) What is the potential at the center of the square, if the four charges are placed at the corner of the square : $q_1 = +1.0 \times 10^{-8}$ C, $q_2 = -2.0 \times 10^{-8}$ C, $q_3 = +3.0 \times 10^{-8}$ C, $q_4 = +2.0 \times 10^{-8}$ C and side of square is 1.0 meter. (5)

(c) The voltage between parallel plates of a capacitor is V_1. The plates are isolated electrically. A dielectric slab of dielectric constant k is inserted between the plates and completely fills the volume between them. Find the new potential V_2. (3)

3. (a) State and explain Biot-Savart's law. Derive an expression for the magnetic field at a point due to an infinitely long straight current carrying conductor using Biot-Savart's law. (7)

(b) What are the characteristics of diamagnetic, paramagnetic and ferromagnetic substances. Illustrate by simple experiment. (5)

(c) A 10 cm long wire carrying a current of 10 ampere is held at an angle 30° with the direction of a uniform magnetic field strength of 1 weber/metre^2. Calculate the force acting on wire. (3)

4. (a) Explain the phenomenon of self-induction. Derive an expression for the coefficient of self-inductance of a long uniformly wound solenoid. Hence find the self-inductance of a toroidal coil of circular cross-section of radius r. (7)

(b) Calculate the mutual-inductance of a solenoid of 1 metre length having 500 turns in primary and 100 turns in secondary coil and the area of cross-section of solenoid is 5 cm^2. (5)

(c) Write the equation of continuity and explain its physical significance. (3)

5. (a) Classify the singular points of the following equations as ordinary, regular or irregular :

$x^2y'' + (\sinh x)\, y' + (\cosh x)y = 0$ (5)

(b) Find the solution using the method of Frobenius about the singular point :

$x^2y'' + x^3 y' + (x^2 - 2)y = 0$ (10)

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[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 4085 **H**

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. Answer **FOUR** questions in all.
3. Question No. **1** is compulsory
4. Use of non-programmable scientific calculator is allowed.

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

(a) Prove that a cylindrical coordinate system is orthogonal.

(b) Predict the radii of convergence, about x = 1 point of the Frobenius power series solution to

$$(1 + x^2)y'' + xy' + 6x^2y = 0$$

(c) Legendre polynomials denoted by $P_n(x)$ have the generating-function formula

$$\frac{1}{\sqrt{1-2xt+t^2}} = \sum_{n=0}^{\infty} P_n(x)\, t^n, \quad |t|<1$$

Derive a recurrence formula (for integer n) connecting three P_n of consecutive n.

(d) Show using, $\Gamma(n,x) = \int_x^{\infty} u^{n-1}\, e^{-u}\, du$, that if n is a positive integer

$$\Gamma(n,x) = (n-1)!\; e^{-x} \sum_{k=0}^{n-1} \frac{x^k}{k!}$$

(e) Find the period of the function $f(t) = \cos\frac{2t}{3} + \cos\frac{t}{6}$.

2. (a) Plot the given function. Expand the given function as a Fourier cosine series

$$f(x) = \begin{cases} x & , 0 < x < \pi/2 \\ \pi - x & , \pi/2 \le x < \pi \end{cases} \qquad (10)$$

(b) Show that any function can be expressed as the sum of two component functions of which one is even and other odd. (5)

3. (a) Derive the expression for the curl of a vector $\vec{A}$ in orthogonal curvilinear coordinates. (10)

(b) Using the above derived relation express $\nabla \times \vec{A}$ in (i) cylindrical and (ii) spherical polar coordinates. (5)

4. (a) Obtain the Rodrigue's formula for the Legendre polynomials. Hence evaluate the value of $P_3(x)$. (10)

(b) Show that the function $\varphi_1(x) = 1$ and $\varphi_2(x) = x$ are orthogonal in the interval $-1 < x < 1$, and determine the constants A and B such that the function $\varphi_3(x) = Ax + Bx^2 - 2$ is orthogonal to both $\varphi_1(x)$ and $\varphi_2(x)$ on that interval. (5)

[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 3366 **H**

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. Attempt **four** questions from the rest of the paper.
4. Use of non-programmable calculator is allowed.

P.T.O.

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

(a) If a vector $\vec{A}$ is irrotational, show that $\vec{A}\times\vec{r}$ is solenoidal where $\vec{r}=x\hat{i}+y\hat{j}+z\hat{k}$.

(b) A short electric dipole placed in free space has the dipole moment of 3×10^{-9} Cm. Find the electric potential due to the dipole at a far-off point distant 0.3 m from the centre of the dipole situated on

(i) The axial line

(ii) The equatorial line

(c) Show that the electric polarization, $\vec{P}=\varepsilon_0(\varepsilon_r-1)\vec{E}$, where $\vec{E}$ is the electric field in a linear medium.

(d) An electron circulates around a nucleus in an orbit of radius 5.1×10^{-11} m with constant speed of 0.7×10^{-2} c (where c= 2.998×10^{8} m/sec). Calculate magnetic field at the center of the orbit.

(e) Prove that $\vec{B}$ is a solenoidal vector.

(f) A current of 10 A in the primary of a circuit is reduced to zero at a uniform rate in 10^{-3} sec. If the coefficient of mutual inductance is 3 H, evaluate the induced emf in the secondary circuit?

(g) The electric field of a plane electromagnetic wave in free space is given by

$$\vec{E}=\hat{j}50\, e^{j(10^8 t+kx)}\ V/m$$

Find

(i) The direction of wave propagation

(ii) The value of k

(iii) Wavelength λ of the wave

2. (a) Show that $\vec{F}=\left(2xy+z^3\right)\hat{i}+x^2\hat{j}+3xz^2\hat{k}$ is a conservative force field and hence find its scalar potential ϕ. (9)

(b) Find the unit outward drawn normal to the surface $(x-1)^2+y^2+(z+2)^2=9$ at the point $(3, 1, -4)$. (6)

3. (a) State Gauss's theorem of electrostatics. Express it in its integral and differential form. (5)

(b) Using Gauss's theorem of electrostatics, calculate electric field inside and outside a uniformly charged solid sphere placed in free space. Also write these expressions when the sphere is placed in a medium of dielectric constant K. (5)

(c) Show that the potential difference between any two points in an electric field is given by the line integral of the electric field taken over a path joining these two points. (5)

4. (a) Show that $K = 1 + \chi_e$; where K is dielectric constant and χ_e is electric susceptibility. (5)

(b) Obtain the expression for the capacitance of a spherical condenser when the outer sphere is earthed. (5)

(c) A parallel plate capacitor filled with mica having $\varepsilon_r = 5$ is connected to a 10 V battery. The area of the parallel plate is 6 m^2 and separation distance is 6 mm. After the capacitor is fully charged, the battery is disconnected and the dielectric is removed carefully. Calculate the values of capacitance, stored energy and charge. (5)

5. (a) Differentiate between diamagnetic, paramagnetic and ferromagnetic material on the basis of their properties, response to magnetic field and temperature. Give one example of each. (6)

(b) Derive an expression for magnetic field at a point on its axis of a circular coil carrying current. Use it to prove that magnetic field at the ends of a long solenoid is one-half of that at the center. (9)

6. (a) Derive an expression for the differential form of Faraday's law. (4)

(b) Define coefficient of mutual inductance and state reciprocity theorem. Derive an expression for coefficient of coupling between the coils having turns N_1 and N_2, coupled in such a way that whole of the magnetic flux from one coil links with the other coil. (4+4=8)

(c) Calculate the magnetic energy stored in an inductor. (3)

7. (a) What is modified Ampere's circuital law? Discuss its significance in terms of Maxwell theory and obtain an expression for displacement current density. (7)

(b) Prove that the electromagnetic wave is transverse in nature. (8)

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

Roll No. .....

Sl No of QP	:	4142A
Name of the Department	:	Department of Physics and Astrophysics
Name of Course	:	B.Sc. Hons. - (Physics)_NEP: UGCF-2022__DSCC-12
Name of the Paper:	:	Analog Electronics
Semester	:	IV - Semester
Unique Paper Code	:	2222012403
Duration	:	2 hours
Max. Marks	:	60 marks

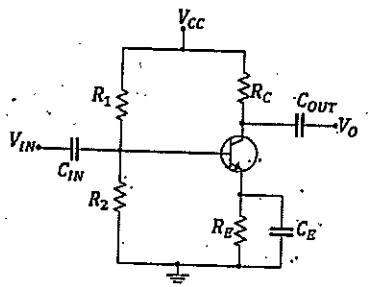
Instructions for Candidates:

a) ***Write your Roll No. on the top immediately on receipt of this question paper.***
b) ***Attempt any Four questions in all. Question No. 1 is compulsory.***
c) ***Simple non-programmable calculators are allowed.***

1. Attempt all parts of the following: (3X5=15)

a) In a common emitter transistor configuration, the current amplification factor is 0.9. If the emitter current is 1mA and leakage current is assumed zero, determine the value of the base current for the common base configuration.
b) For what voltage will the reverse current in a Germanium pn junction diode reach 80% of its saturation value at room temperature?
(Given $\eta = 1,\ k = 1.38 \times 10^{-23}\ J/K\ ;\ q = 1.6 \times 10^{-19}$C)
c) Why do we need positive feedback in designing oscillator ciruits.
d) Explain the role of coupling capacitor (C_C) and Emitter capacitor in (C_E) based transistor amplifier circuits.
e) An Op-Amp in open loop inverting configuration is driven by a 1kHz triangular wave of 100 mV peak signal value. Draw the output waveform of the circuit with respect to this input.

2. (10,5)
a) A transistor amplifier with voltage divider biasing circuit has the following specifications ; $V_{CC} = 22V,\ R_1 = 39k\Omega,\ R_2 = 3.9k\Omega,\ R_C = 10k\Omega,\ R_E = 1.5k\Omega,$ $C_{IN} = C_{OUT} = 10\mu F,\ C_E = 50\mu F$ and $\beta = 140$. Determine the dc bias voltages and the quiescent point parameters. Also show the quiescent point on the dc load line for the circuit.



Roll No. .....

Sl No of QP	:	4142A
Name of the Department	:	Department of Physics and Astrophysics
Name of Course	:	B.Sc. Hons. - (Physics)_NEP: UGCF-2022__DSCC-12
Name of the Paper:	:	Analog Electronics
Semester	:	IV - Semester
Unique Paper Code	:	2222012403
Duration	:	2 hours
Max. Marks	:	60 marks

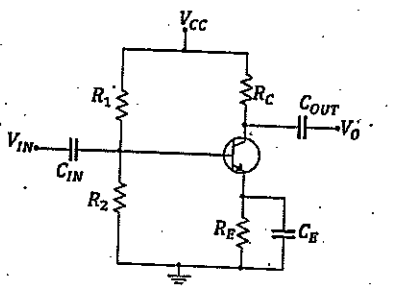
Instructions for Candidates:

a) ***Write your Roll No. on the top immediately on receipt of this question paper.***
b) ***Attempt any Four questions in all. Question No. 1 is compulsory.***
c) ***Simple non-programmable calculators are allowed.***

1. Attempt all parts of the following: (3X5=15)

a) In a common emitter transistor configuration, the current amplification factor is 0.9. If the emitter current is 1mA and leakage current is assumed zero, determine the value of the base current for the common base configuration.
b) For what voltage will the reverse current in a Germanium pn junction diode reach 80% of its saturation value at room temperature?
(Given $\eta = 1,\ k = 1.38 \times 10^{-23}\ J/K\ ;\ q = 1.6 \times 10^{-19}$C)
c) Why do we need positive feedback in designing oscillator ciruits.
d) Explain the role of coupling capacitor (C_C) and Emitter capacitor in (C_E) based transistor amplifier circuits.
e) An Op-Amp in open loop inverting configuration is driven by a 1kHz triangular wave of 100 mV peak signal value. Draw the output waveform of the circuit with respect to this input.

2. (10,5)
a) A transistor amplifier with voltage divider biasing circuit has the following specifications ; $V_{CC} = 22V,\ R_1 = 39k\Omega,\ R_2 = 3.9k\Omega,\ R_C = 10k\Omega,\ R_E = 1.5k\Omega,$ $C_{IN} = C_{OUT} = 10\mu F,\ C_E = 50\mu F$ and $\beta = 140$. Determine the dc bias voltages and the quiescent point parameters. Also show the quiescent point on the dc load line for the circuit.



b) Define the four h-parameters with reference to a CE transistor configuration. Explain how these parameters can be determined from the static characteristic curves of the configuration.

3. (5,10)

a) A sinusoidal peak-to-peak voltage of $60 \sin 100\pi t$ is applied to a full wave rectifier with load resistance of 500 Ω and forward diode resistance of 50 Ω. Find the maximum DC current component, rms current component, PIV of the semiconductor diode, ripple factor and rectification efficiency.

b) Define line regulation and load regulation for a Zener diode based voltage regulator. Explain with help of a circuit diagram the working of Zener diode as a voltage regulator. Derive the relations for the minimum value of load resistance, the minimum and the maximum value of the supply voltage that can be regulated by a given Zener diode.

4. (9,3,3)

a) Derive the expresson for the oscillation frequency of a transistor based Hartley Oscillator.

b) A transistor based Colpitts oscillator has a frequency of oscillation $f = 100kHz$. If the value of two of the frequency determining components is $L = 100mH$ and $C_1 = 0.01\mu F$. Determine the value of the third component.

c) Calculate the frequency of oscillation for the transistor based RC phase shift oscillator having $R_C = 2k\Omega, R = 5k\Omega$ and $C = 0.01\mu F$.

5. (8,4,3)

a) Explain the working of a basic differentiator circuit designed using Op-amp. Explain the problems associated with the basic circuit and how they are rectified in a practical differentiator. Explain the response curve for the circuit.

b) Design an practical Op-amp integrator for the frequency range from 1 to 10 kHz. Choose the capacitor value as 0.1 µf.

c) Calculate the output voltage for an op-amp based inverting summing amplifier for the following sets of voltages and resistors:
(i) $V_1 = 1V, V_2 = 2V, V_3 = 3V, R_1 = 500k\Omega\ R_2 = 1M\Omega\ R_3 = 1M\Omega$ and $R_F = 1M\Omega$
(ii) $V_1 = -2V, V_2 = 3V, V_3 = 1V,\ R_1 = 200k\Omega\ R_2 = 500k\Omega\ R_3 = 1M\Omega$ and $R_F = 1M\Omega$

b) Define the four h-parameters with reference to a CE transistor configuration. Explain how these parameters can be determined from the static characteristic curves of the configuration.

3. (5,10)

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(ii) $V_1 = -2V, V_2 = 3V, V_3 = 1V,\ R_1 = 200k\Omega\ R_2 = 500k\Omega\ R_3 = 1M\Omega$ and $R_F = 1M\Omega$

(ii) $V_1 = -2V$, $V_2 = 3V$ and $V_3 = 1V$, $R_1 = 200$ KΩ, $R_2 = 500$ KΩ and $R_3 = 1$ MΩ

(5)

[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 3118 **H**

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) State law of mass action. A silicon sample is doped with 5×10^{22} cm^{-3}. Find the concentration of electrons and holes in the sample. Given $n_i = 2 \times 10^{13}$ cm^{-3}.

(b) What is 'Early' effect in transistor? Draw the input characteristics of an n-p-n transistor in a common-emitter (CE) configuration.

(c) Draw the I-V characteristics of a Solar cell for different intensities of light.

(d) Draw the output characteristics of a transistor in CE mode and identify the active, cut off and saturation regions.

is 20 and input to the third stage is 15 V peak to peak, determine

(i) The overall voltage gain

(ii) Voltage gain of 2nd and 3rd stages.

(iii) Input voltage of the 2nd stage. (5)

7. (a) Describe the working of an op-amp based integrator and hence design a practical op-amp integrator to integrate an input signal that varies in the frequency range of 1 KHz to 15 KHz. (10)

(b) Calculate the output voltage for an op-amp based inverting summing amplifier for the following sets of voltages and resistors with $R_F = 1$ MΩ for both the cases

(i) $V_1 = 1V$, $V_2 = 2V$ and $V_3 = 3V$, $R_1 = 500$ KΩ, $R_2 = 1$ MΩ and $R_3 = 1$ MΩ

5. (a) What factors affect the bias stability of a transistor? Obtain the general expression for stability factor of common emitter configuration. Quantitatively show that the emitter resistance improves the stability of the fixed bias circuit. (10)

(b) In a Colpitt's oscillator $C_1 = 0.1\ \mu F$, $C_2 = 0.01\ \mu F$ and $L = 50$ mH, find the frequency of oscillation. (5)

6. (a) Draw the circuit diagram of an RC phase shift oscillator using transistor and state the Barkhausen criterion for sustained oscillations. Derive an expression for its frequency. (10)

(b) Three amplifier stages are working in cascade with 0.05V peak to peak input providing 150 V peak to peak output. If the voltage gain of the first stage

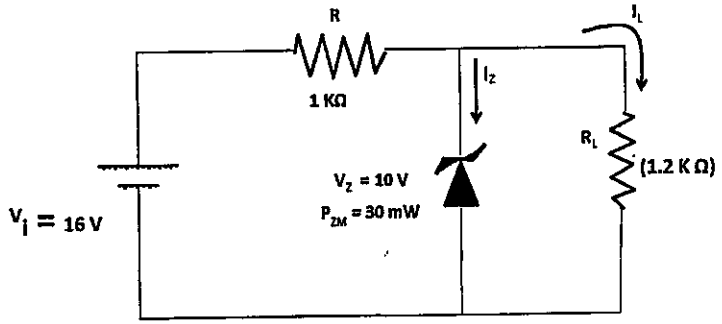
(e) What are the roles of DC load line and Q-point? Where should be the location of operating point for designing an amplifier?

(f) Draw the frequency response curve of a practical op-amp differentiator circuit.

(g) Establish the relation $I_c=\alpha/(1-\alpha)\ I_b+1/(1-\alpha)\ I_{cbo}$ where the symbols have their usual meaning.

2. (a) Explain the formation of depletion layer in pn junction diode. Derive an expression for the electric field and potential in pn junction diode. Show the variations of electric field and potential in pn junction diode. (10)

(b) For the zener diode circuit show below, determine (i) V_L (across R_L), (ii) V_R (across R), (iii) I_Z and (iv) P_Z. (5)



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

(b) In a centre tapped full wave rectifier, the load resistance R_L = 1KΩ. Each diode has a forward dynamic resistance r_d of 10Ω. The voltage across half the secondary winding is 220 sin 314t. Find (a) peak value of current (b) the dc or average value of current (c) the rms value of current (d) the ripple factor. (5)

4. (a) Using 'h' parameters, obtain expressions for current gain, voltage gain, input impedance and output impedance for transistor in CE configuration. (10)

(b) Plot the output characteristics of a transistor in CB configuration and indicate the various regions of operation on it. Also explain the shape of the characteristics thus obtained. (5)

P.T.O.

$$V(x)=\begin{cases}\infty & x<-a/2\\ 0 & -a/2\le x\le a/2\\ \infty & x>a/2\end{cases}$$

Find the wave function associated with the particle and its energy E.

(b) What are quantum dot particles? How are they related with quantum mechanics? (10,5)

6. (a) On the basis of the liquid drop model of a nucleus, explain the various terms of semi-empirical mass formula for calculation of binding energy of a nucleus.

(b) Gold $^{197}_{79}Au$ is the most ductile metal. Calculate is average radius, nuclear volume and nuclear density. (10,5)

7. (a) Discuss the variation of binding energy per nucleon with mass number, A, and hence explain the concept of (i) nuclear stability, (ii) nuclear fission, and (iii) nuclear fusion.

(b) Consider the following decay process:

$$^{238}_{92}U \rightarrow ^{234}_{90}Th + ^{4}_{2}He + Q$$

Determine the kinetic energies of the α-particles and the daughter nuclei. (10,5)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 3007 **H**

Unique Paper Code : 32221402

Name of the Paper : Elements of Modern Physics

Name of the Course : **B.Sc. Hons Physics Core Repeat 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.
3. **Q1** is compulsory.
4. **All** questions carry equal marks.
5. Use of non-programmable scientific calculator is allowed.

1. Attempt any five questions : (3×5=15)

(a) Find the minimum energy of an electron confined in a one-dimensional box of size 10 nm.

(b) What is the number of photons that strike a surface of $1cm^3$ in one second if the incoming light of 650nm wavelength has an intensity of 100 watts/ m^2?

(c) What are spontaneous and stimulated emissions? Why stimulated emission is necessary for lasing action?

(d) The wavefunction associated with a particle is given as $\psi(x) = A \cos\left(\frac{n\pi x}{L}\right)$ in region $0 \leq x \leq L$. Find the value of normalization constant A.

(e) The position and momentum of a 1 KeV electron are simultaneously measured, if the position is located within 0.1 nm, what is the percentage of uncertainty in momentum?

(f) The binding energy of $^{24}Mg_{12}$ is 198.28 MeV. Find its atomic mass, (take mass of neutron to be 1.674×10^{-27}kg and mass of proton to be 1.672×10^{-27}kg)

(g) The half-life of ^{24}Na is 15 hours. How long will it take for 70% of sample of this nuclide to decay?

2. (a) What is photoelectric effect? Discuss the observations of the experiment illustrating photoelectric effect. How does the classical electromagnetic theory fail to explain these results?

(b) If blue light of wavelength 460 nm impinges on a metal surface, a stopping potential of 1.1 eV is obtained. What will be the work function of the given metal? (10,5)

3. (a) State Heisenberg's uncertainty principle for position and momentum and illustrate it using gamma ray microscope thought experiment.

(b) A photon is emitted in a process characterized by a time interval of 1.0 millisecond. What will be the inherent uncertainty in the energy and frequency of the emitted photon. (7,8)

4. (a) Obtain the time independent Schrodinger's wave equation from the time dependent Schrodinger equation.

(b) Prove the relation $\partial P/\partial t + \nabla.J = 0$, where J is the probability current density and P is the probability density. Give the physical interpretation of the equation. What are the states called for which $\nabla.J = 0$. (5,10)

5. (a) A particle of mass m is confined in a one dimensional infinitely rigid box having potential

(b) At what temperature will the average speed of molecules of Hydrogen gas be double the average speed of Oxygen molecules at 300K? (3)

5. (a) Derive the expression for Planck's law of black body radiation. Show that this reduces to Wein's law for small wavelengths and Rayleigh - Jeans law for large wavelengths. (9)

(b) Spectra of three stars A, B and C show maximum brightness for the respective wavelengths of 6500, 4800 and 5600 Å. Compare their temperatures, T_A, T_B and T_C. (6)

6. (a) Define Internal Energy (U), Enthalpy (H), Helmholtz free energy (F), Gibb's free energy (G) and hence derive Maxwell's relations. (12)

(b) With the help of Clausius-Clapeyron equation, explain why the boiling point of some solids decreases with increase in pressure. (3)

7. (a) Derive an expression for thermodynamic probability and the most probable distribution function for a system obeying Fermi-Dirac statistics. (9)

(b) Explain the distinguishing features of Maxwell Boltzmann, Bose Einstein and Fermi Dirac statistics giving at least three differences including their distribution functions. (6)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 1169 **H**

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 $(k_B) = 1.38 \times 10^{-23}\ m^2kgs^{-2}K^{-1}$)

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

(a) A gas is confined in a cylinder and 500 cal of heat is added to it. As a result, it expands against the atmospheric pressure. If the change in internal energy of the gas is 420 J, calculate the increase in volume. (1 atm = 1.013×10^5 N m^{-2}).

(b) Draw the T-S diagram of Carnot cycle and hence deduce the expression for efficiency of a Carnot engine.

(c) Consider an ideal gas undergoing a thermodynamic process characterized by $PV^n = A$, where A is a constant, n is an index positive or negative. For what value of n would the process be

(i) Isobaric

(ii) Isothermal

(iii) Adiabatic

(d) Define the mean free path of gas molecules. What factors does it depend on?

(e) Using Maxwell's relations, show that the internal energy of an ideal gas is independent of its volume.

(f) Write the expressions for average velocity, rms velocity and most probable velocity of a gas molecule in terms of Temperature (T) and Boltzmann constant (k_B) and find ratio between them.

(g) Calculate the number of different ways of arranging eight bosons in six phase space cells.

2. (a) State Zeroth Law of thermodynamics. Establish the concept of temperature on the basis of the Zeroth Law of Thermodynamics. (6)

(b) Give the differential form of the first law of thermodynamics explaining all terms. (3)

(c) A certain mass of a diatomic gas at STP is expanded to three times its volume adiabatically. Calculate the change in temperature and pressure. (6)

3. (a) Derive the equation of state for a reversible adiabatic process in a perfect gas. Also show that the slope of an adiabatic curve is y times the slope of an isothermal curve, where y is the ratio of the specific heats, C_P and C_V. (12)

(b) Starting from the equation, $C_P - C_V = T\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_P$, show that for a perfect gas $C_P - C_V = R$. (3)

4. (a) Derive the Maxwell's law of distribution of velocities of gas molecules. Give one method of its experimental verification. (8,4)

6. (a) Explain with example, the use of any four terminals available in gnuplot. (5)

(b) Describe with example how latex is used to include graphic image files and tables in LaTeX document. (5)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 2885 **H**

Unique Paper Code : 32223902

Name of the Paper : Computational Physics Skills (SEC)

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

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. Question No. **1** is compulsory.
3. Attempt any **Four** from rest of the questions.

1. (a) Write a FORTAN programme to print first 10 even numbers.

(b) Draw a flow chart to convert a set of Cartesian Coordinates to Spherical Polar Coordinates.

(c) Write the command used to create fraction in LaTeX.

(d) Calculate Euler number using first four terms in e^x series evaluated at $x = 1$.

(e) What is gnuplot? (2×5=10)

2. (a) Write a FORTRAN subroutine to sort a given set of numbers in ascending order. Write main FORTRAN program that uses this subroutine to sort a set of numbers (56, 85, 23, 37, 98, 11, 73) and output the sorted set. (5)

(b) Explain GOTO statement in FORTRAN. Also explain the difference between computed and assigned GOTO statement with the help of one example. Why the GOTO statement is not recommended in structured programming? (5)

3. (a) Discuss the use of Allocatable and Dimension command in Arrays in FORTRAN with examples. (5)

(b) Write a FORTRAN program for multiplication of two matrices using dimension command. (5)

4. (a) Write the statements involved in plotting the function $f(x) = \sin(x)$ in gnuplot in the range $-5\pi < x < 5\pi$ into file filename.jpg using terminal jpg. (5)

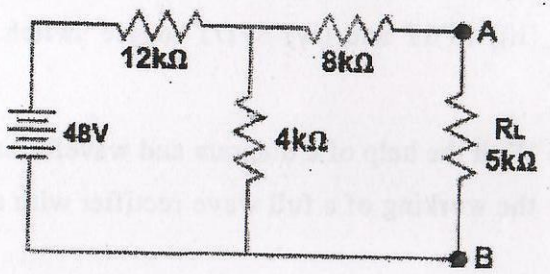
(b) Write the gnuplot script to plot x^2 and log x versus x using multiplot command from the datafile "filename.txt" which is having values of x, x^2 and log x in 3 columns for $1 < X < 100$. (5)

5. (a) What do you mean by LaTeX environment. Give three examples. (5)

(b) Write the output of the following LaTeX code : (5)

```
$ y=ax+b\\$
$y^2=ax^2+\ln(x^2)$\\
$x\simeq \frac{x+\frac{y}{2}}{x^2_1+y^2_1}$\\
$\sum_{i=1}^{\noindent}i = \frac{n(n+1)}{2} $\\
$\int_{0}^{infty}tan^2 \,dx $\\
$\lim_{n\to\infty} \frac{1}{k^2}=\frac{pi^2}{6} $
```

P.T.O.



(2,8)

6. Describe the construction and working of a bridge rectifier. What will be the effect of a capacitor connected in parallel with the load on the output of the bridge rectifier? (7,3)

7. Write short notes on any *two* of the following :

   (a) Conduits and Cable trays

   (b) Star and delta connection in wiring

   (c) Surge Protection device (5,5)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 2886 **H**

Unique Paper Code : 32223903

Name of the Paper : Electrical Circuits and Networks Skills

Name of the Course : **B.Sc. Hons_Physics_SEC**

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. **All** questions carry equal marks.
3. Question No. **1** is compulsory.
4. Attempt **five** questions in all.
5. Use of Scientific calculator is allowed.

1. Attempt any **five** of the following questions with brief answers

   (a) Give examples of ohmic and non-ohmic components and draw I-V characteristics of a non-ohmic component.

   (b) An AC supply of 230V is applied to a half wave rectifier circuit through a transformer of turn ratio 10:1. Find the value of output DC voltage.

   (c) Two resistors R_1 and R_2 are connected in series and have an equivalent resistance of 100Ω and their equivalent resistance becomes 24Ω. when connected in parallel. Calculate R_1 and R_2.

   (d) State Maximum Power Transfer theorem.

   (e) Write two properties of a fuse wire element.

   (f) What is the use of a bimetallic strip in a circuit breaker?

   (g) Why an ammeter is used in series in a circuit to measure current? (5×2=10)

2. (a) What is a ladder diagram? What are the important conventions adopted in making a ladder diagram? Draw a ladder diagram showing a lamp controlled by a hand switch.

   (b) Draw the symbols of (i) Fuse (ii) Transformer (iii) SPST and (iv) SPDT toggle switch. (6,4)

3. (a) With the help of a diagram and waveforms, explain the working of a full wave rectifier with a C filter.

   (b) Draw the frequency response of a capacitor and inductor to an AC source. (6,4)

4. (a) Describe the construction and working of a transformer with a diagram. List its two applications.

   (b) A transformer of efficiency 75% works at 2kW and 100V. If the secondary voltage is 240V. Find the primary and secondary currents. (7,3)

5. (a) State Thevenin's Theorem.

   (b) Draw the Thevenin equivalent circuit for the given circuit and calculate the current through R_L in the following circuit using Thevenin's Theorem.

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Your Roll No .....

Sr. No. of Question Paper : 3430
Unique Paper Code : 42224412
Name of the Course : B.Sc. (Prog.) Physical Science
Name of the Paper : Waves and Optics
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 any Five questions in all. Question No. 1 is compulsory.
3. Simple non-programmable calculators are allowed.
4. All questions carry equal marks.

1. Attempt all of the following: (3x5=15)
(a) What are coherent sources? Give examples.
(b) How will you test the flatness of surface by interference of light?
(c) Compare the action of zone plate and convex lens.
(d) Refractive index of water is 1.33. Calculate the angle of polarization of light reflected by the surface of pond.
(e) What do you understand by half and quarter wave plates?

2 (a) Two colinear simple harmonic motions are acting simultaneously on a particle. Show that the resultant motion of particle is simple harmonic motion. Also, obtain the expression for amplitude and phase constant of the resultant motion in term of their amplitudes and phase difference. (8)

(b) Two colinear simple harmonic motions acting simultaneously on a particle are given by $x_1=0.3 \cos 2\omega t$ and $x_2=0.2 \sin(2\omega t-\pi/3)$. where x is expressed in cm and t in seconds. Write down the expression for the resultant displacement as a function of time. (7)

3 (a) State the principle of superposition and prove that it holds only for linear differential equations. (8)
(b) Deduce the expression for the velocity of transverse waves on a long-stretched string. (7)

4 (a) Give the theory of formation of Newton's rings by reflected monochromatic light and prove that radii of these rings are proportional to the square root of natural numbers. (10)

(b) The diameter of the tenth bright ring in Newton's rings experiment is 0.5 cm in reflected system. Calculate the thickness of air film corresponding to this ring and the radius of curvature of the lens. (Given λ= 5890 Å). (5)

5 (a) How thickness of thin glass or mica strip is measured using Fresnel's biprism. Derive the necessary formula used. (10)

(b) A thin mica sheet (refractive index =1.6) of 7 micron thickness introduced in path of the interfering beams in the biprism arrangement shifts the central fringe to the position normally occupied by 7^{th} bright fringe from the centre. Find the Wavelength of light used. (5)

6 (a) Give the theory of Fraunhofer diffraction due to single slit. (10)
(b) In the Fraunhofer diffraction due to a narrow slit, a screen is placed 2 metres away from the lens to obtain the pattern in its focal plane. Find the slit width if the first minima lie 5 mm on the either side of the central maxima when the plane waves of wavelength 6×10^{-5} cm are incident on the slit. (5)

[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 2953 **H**

Unique Paper Code : 32221401

Name of the Paper : Mathematical Physics III

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

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 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) :

$$\mathcal{F}(f(x)) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} f(x) e^{-ikx} dx$$

P.T.O.

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.

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

(a) Find all the roots of the equation $z^4 + z^2 + 1 = 0$.

(b) Obtain the principal value of $\cos^{-1}(3)$.

(c) Argue that the integral $\int_\Gamma z\exp(z^2)\,dz$ is independent of path, and hence compute the integral if Γ is a path joining z = 0 and z = i.

(d) Given Laplace Transform $\mathcal{L}(\sin(t)) = \frac{1}{1+s^2}$, compute $\int_0^\infty t\,e^{-3t}\sin(t)\,dt$.

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

[Given: Inverse Laplace Transform of $\frac{s}{(s^2+a^2)^2}$ is $\frac{1}{2a}t\sin(at)$]

(f) Find the Fourier transform of $f(x) = e^{-a|x|}$, $-\infty < x < \infty$, $a > 0$.

(g) If $g(x) = e^{iax}f(bx)$ and F(k) is the Fourier transform of f(x), determine the Fourier transform of g(x).

(h) Evaluate $\int_0^{4\pi}(\cos x)\,\delta(x^2-\pi^2)dx$.

P.T.O.

Section – A

2. (a) Use de Moivre's theorem to prove that :

$$\frac{\sin(4\theta)}{\sin(\theta)} = 8\cos^3(\theta) - 4\cos(\theta) \qquad (6)$$

(b) Prove :

$$\tanh^{-1} z = \frac{1}{2}\ln\left(\frac{1+z}{1-z}\right) \qquad (6)$$

(c) Determine and classify the singularities of the following function in the finite complex plane :

$$f(z) = \frac{z}{e^z - 1} \qquad (3)$$

3. (a) Prove that the function $u(x,y) = 3x^2y + 2x^2 - y^3 - 2y^2$ is harmonic. Find its conjugate function $v(x, y)$ such that $f(z) = u + iv$ is analytic. (7)

(b) Verify Cauchy's theorem by integrating $f(z) = e^z$ along the boundary of the triangle with vertices at the points $-1+i$, $1+i$ and $-1-i$. (8)

4. (a) Use Residue theorem to evaluate any one integral of the following : (9)

(i) $$\int_{-\infty}^{\infty} \frac{dx}{\left(x^2+4x+5\right)^2}$$

(ii) $$\int_0^{\infty} \frac{\sin(mx)}{x\left(x^2+a^2\right)}\,dx,\ m>0,\ a>0$$

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

(i) $0 < |z-1| < 1$

(ii) $|z| > 2$ (3,3)

Section – B

5. (a) Evaluate the Fourier cosine transform of e^{-ax^2}; $a>0$. (8)

(b) Prove that

$$\mathcal{F}^{-1}\left(\frac{1}{k^2+5ik+6}\right) = \frac{\sqrt{2\pi}}{7}\left[H(x)\, e^{-x} + H(-x)\, e^{6x}\right]$$

here, H(x) is a Heaviside step function. (7)

6. (a) If f(t) is a periodic function with period T > 0, prove that the Laplace Transform of f(t) is

$$\frac{\int_0^T e^{-st} f(t)\,dt}{1-e^{-sT}}$$

Use this result to find the Laplace Transform of square wave

$$f(t) = \begin{cases} +1, & 0 < t < 1 \\ -1, & 1 < t < 2 \end{cases}$$

and f(t + 2) = f(t). (3)

(b) Taking the Laplace Transform of $f(t) = \int_0^\infty \frac{\cos(tx)}{1+x^2}dx$,

show that $f(t) = \frac{\pi}{2}e^{-t}$ for t > 0. (7)

7. (a) An inductor of 2 H, a resistor of 16Ω. and a capacitor of 0.02 F are connected in series with an emf of E = 300 V. At t = 0, the charge Q(t) on the capacitor and current I(t) in the circuit are zero. Using Laplace Transform, find the charge and current at any time t > 0. Given equation of the circuit is

$$2\frac{d^2Q}{dt^2} + 16\frac{dQ}{dt} + 50Q = 300$$ (7)

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

$$f(x) = \theta(x) = e^{-x}H(x)$$

here, H(x) is a Heaviside step function. (8)

Some useful Laplace Transforms :

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

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

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

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

P.T.O.

Useful Fourier Transform:

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

Useful Inverse Fourier Transforms:

$$\mathcal{F}^{-1}\left(\frac{1}{a + ik}\right) = \sqrt{2\pi}\ e^{-ax}\ \mathrm{H(x)}$$

$$\mathcal{F}^{-1}\left(\frac{1}{a - ik}\right) = \sqrt{2\pi}\ e^{ax}\ \mathrm{H(-x)}$$

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 formulas:

$$\mathrm{H(y)\ H(x - y)} = \begin{cases} 0, & y < 0 \text{ and } y > x \\ 1, & 0 < y < x \end{cases}$$

$\int_0^x dy = x\,H(x)$; H(x) is a Heaviside step function

$$\int_0^\infty \mathrm{e}^{-ax^2}\ dx = \frac{1}{2}\sqrt{\frac{\pi}{a}};\ a > 0$$

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[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 4104 **H**

Unique Paper Code : 2222012402

Name of the Paper : Solid State Physics

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

Semester : IV

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. Attempt **Five** question in all.
3. Each question carry **18** marks.
4. Question No. **1** is compulsory and each part carries 3 marks.
5. Use of non-programmable scientific calculators is allowed.

P.T.O.

1. (a) Why lower branch of the dispersion curve for a linear diatomic crystal is called acoustic branch, even though the frequency associated with it is in IR (Infra-red) region?

(b) Calculate the Hall voltage in a sample when the magnetic field of 1 Tesla is applied perpendicular to the current direction. The injected current is 300 mA and thickness of the sample is 0.4 mm. The charge carrier concentration in the sample is 10^{21} m^{-3}.

(c) In CsCl, the Cs atoms are located at the comers of a cube and Cl at the body centre. What is the Bravais lattice for this material? Draw the Bravias lattice and identify the basis/motiff.

(d) X-rays of wavelength 0.3 Å are allowed to fall on a crystal whose interplanar spacing for a particular set of planes is 3 Å. Determine the smallest angle at which the X-rays are diffracted by the crystal.

(e) Describe the characteristic properties of ferroelectric crystals and which symmetry element is missing in these types of crystals.

(f) Explain the concept of the orbital magnetic dipole moment of an electron in an atom and derive an expression for it in terms of angular momentum of the electron.

2. (a) If 'a' is the lattice constant of a cubic unit cell, draw the planes which makes an intercept, in terms of 'a, along the coordinate axis as

(i) 1/2, 1/3, ∞

(ii) -1/2, ∞, ∞

(iii) What does <100> and [100] signifies?

(5)

(b) Silver crystallizes in fee structure and every silver atom gives one electron to the crystal. If the interplanar separation is 2.87 Å, determine density and electron concentration in it. Atomic weight of silver is 107.68 amu. (5)

(c) Draw a square reciprocal lattice and explain the Ewald's construction and its significance? Derive vector form of the Bragg's law from the construction and explain its physical significance. (8)

3. (a) State Bloch's theorem. What is the idea behind Writing the electron wave-function as Bloch function? What are the assumptions of Kronig-Penney model? Show that for one dimensional crystal having finite length L with N number of primitive unit cells of lattice constant 'a', the total number of allowed k-values in the first Brillouin zone is equal to the number of unit cells. (9)

(b) Discuss Meissner effect and distinguish between Type I and Type II Superconductors. (6)

(c) Calculate the effective mass of an electron near the top of the valence band in potassium crystal. The E-K relationship for the crystal is $E(k) = 2 - 8\cos\left(\frac{ka}{2}\right)$ and lattice constant is 5.328 Å. (3)

4. (a) Derive an expression for the dispersion relation of a linear monoatomic crystal. The mass of the atoms is 'm' and force constant between them is 'c'. Sketch the dispersion curve within the first Brillouin zone and explain the various characteristics of the crystal dynamics. (9)

(b) Estimate the Debye temperature of Gold if its atomic weight is 197 amu, density is 1.9×10^4 Kg/m^3 and the sound velocity in it is 2100 ms^{-1}. (5)

P.T.O.

(c) Determine the critical field required to destroy superconductivity at 5K in Pb whose Tc is 7.19 K and $H_c(0) = 0.0803$ T. (4)

5. (a) What is local electric field of an atom? Deduce the Lorentz relation for E_{local} inside a dielectric. (9)

(b) Give a schematic sketch of the variation of the total polarizability of a dielectric material as a function of frequency, explaining the physical origin of the various contributions and the relative frequency ranges. (6)

(c) A potential 12V is applied across the plates of a parallel plate capacimtor having an area $6.45 \times 10^{-4} m^{-2}$ and a plate separation of 2×10^{-3}m. If a material having a dielectric constant 5.0 is positioned within the region between the plates, compute the polarization. (3)

6. (a) Describe the classical theory of diamagnetism. Explain the concept of Larmour precession. Derive the expression of the Larmor frequency. (9)

(b) What are ferromagnetic domains? Using the concept of domains, explain the B-H hysteresis curve. What does the area under the curve signify? (6)

(c) A paramagnetic material has 10^{28}atoms/m^3. Its susceptibility at 350K is 2.8×10^{-4}. Calculate the susceptibility at 300K. (3)

Values of Constants

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

$N_A = 6.02 \times 10^{23}$ mol^{-1}

$h = 6.63 \times 10^{-34}$ Js

$\mu_0 = 4\pi \times 10^{-7}$ Hm^{-1}

$\mu_B = 9.27 \times 10^{-24} Am^2$

$\epsilon_0 = 8.85 \times 10^{-12} Fm^{-1}$

$m_e = 9.1 \times 10^{-31} kg$

$e = 1.6 \times 10^{-19} C$

[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 4066 **H**

Unique Paper Code : 2222012401

Name of the Paper : Modern Physics

Name of the Course : **B.Sc. Hons. – (Physics)**
NEP: UGCF-2022

Semester : IV

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. Attempt only **five** questions.
3. Question No. **1** is compulsory.
4. **All** questions carry equal marks.
5. Use of non-programmable scientific calculator is allowed.

P.T.O.

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

(i) Discuss how Classical Physics fails to explai the main features of photoelectric effect.

(ii) Write the conditions required for physica acceptability of wave function. State the Borr probabilistic interpretation of the wave function.

(iii) Consider an electron is confined to a one-dimensional infinite potential well of width L=1.0 nm. Calculate the energies of the ground state and the first two excited states.

(iv) Explain the terms "stimulated emission" and "spontaneous emission", clarifying the difference.

(v) Discuss the meson theory of nuclear forces. Give the main properties of these forces.

(vi) A cyclotron with the applied potential of 20KeV across the dees of radius of 28 cm is subjected to a transverse magnetic field of 1.1 Tesla. Calculate them energy to which a proton can be accelerated. Why the cyclotrons cannot be used to accelerate electrons?

2. (i) Discuss the Compton scattering in terms of the interaction between the high energy incident photons and the target matter. A photon of energy 1.02MeV is scattered through 90° by a free electron. Find the energy carried away by the recoil electron. (8)

(ii) Explain that the Heisenberg's uncertainty principle has significance in quantum mechanics. Using the uncertainty principle, calculate the

value of the first Bohr's radius and the value of the ground state energy of the hydrogen atom. (10)

3. (i) What are the time dependent and time independent Schrodinger's equations? Starting from Schrodinger's time dependent equation, obtain Schrodinger's time independent equation. (10)

(ii) Write the expressions of the probability density, $\rho(x, t)$ and the probability current density, $\vec{J}(x, t)$. Find the current density, $\vec{J}(x, t)$ carried by a plane wave,

$$\psi(x, t) = A \exp(ikx)$$

in one dimension. Can a real wave function have a current? (8)

(i) Explain quantum mechanical tunnelling phenomenon. Give example of any process which can be explained on the basis of this phenomenon. (3)

(ii) A particle of mass "m" is trapped inside a one-dimensional infinite potential well of length "L". Solve the time independent Schrodinger's equation for the system and obtain the eigen values and normalized eigen functions of the particle. Determine the three lowest normalized wave functions for an electron inside a one-dimensional infinite potential well of width 2×10^{-10} m. (15)

5. (i) Write the general equation of the lines of hydrogen spectrum and draw the energy level diagram of various series in the hydrogen spectrum. Assume that the electron in a hydrogen atom is replaced by a muon of mass $m \approx 200\ m_e$, where m_e is the mass of an electron. Determine the change in the wavelength of the H_α line of Balmer series. Assume $m << m_p$) where m_p is the mass of a proton. (10)

(ii) State the differences between the laser light and the ordinary light. Explain the working principle of a 4-level laser with diagram. Which type of laser is the He-Ne laser? (8)

6. (i) What is the average binding energy of a nucleus and how is it different from the binding energy? Discuss how does the average binding energy varies with the mass number (M) with the help of graph between the average binding energy versus the mass number. (8)

(ii) State the principle of linear accelerator (LINAC). For a LINAC, deduce the velocity of the emergent ion at nth tube and length of this tube. Protons are accelerated in a drift tube portion of a LINAC from 0.75 MeV to 100 MeV and if the length of the first tube is 3 cm. Find the frequency of the applied AC voltage.

(10)

Useful data :

mass of the proton = 1.67×10^{-27} kg = 1.00081 amu

charge of an electron = 1.602×10^{-19} C

electron mass = 9.1×10^{-31} kg

velocity of light in vacuum, $c = 3 \times 10^8$ m/s

r_0 = 1.2 fm

Compton wave length λ_C = 2.426 pm

Mass of neutron = 1.65×10^{-27}kg = 1.0089 amu

Planck's constant, $h = 6.63 \times 10^{-34}$Js

$\varepsilon_0 = 8.8541 \times 10^{-12}$ $C^2/N.m^2$

5. (a) A set of 8 tuning forks is arranged in a series of increasing frequencies. If each fork gives 4 beats per second with the preceding one and the frequency of the last fork is an octave of the first, find the frequencies of the first and the last fork. (5)

(b) Give Stokes treatment of reflection and refraction. (5)

(c) A parallel beam of light of wavelength 5890 Å in incident on a glass plate (μ=1.5) such that the angle of refraction into the plate is 60°. Calculate the smallest thickness of the plate which will make it dark by reflection. (5)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 4022 **H**

Unique Paper Code : 2222512401

Name of the Paper : Waves and Optics

Name of the Course : **B.Sc. Physical Sciences**

Semester : IV

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. **All** questions carry equal marks.
4. Question No. **1** is compulsory.
5. Use of non-programmable scientific calculator is allowed.

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

   (a) Show that superposition principle is true only in case of homogeneous linear equations.

   (b) What are stationary waves? How are they formed?

   (c) In Young's double slit experiment, the separation of four bright fringes is 2.5 mm and the distance from the slit to the screen is 80.0 cm. Calculate the separation between two slits when the wavelength of the light used is 5896 Å.

   (d) Distinguish between Division of amplitude and Division of wavefront categories of interference.

   (e) What is the highest order spectrum which may be seen with a monochromatic light of wavelength 5000 Å with a diffraction grating having 5000 lines/ cm?

2. (a) What are Lissajous figures? Give a mathematical analysis to trace graphically the motion of a particle subjected to two perpendicular simple harmonic motions of equal frequencies, different amplitudes and phase differing by (i) zero and (ii) Π/4. (10)

   (b) All simple harmonic motions are periodic but all periodic motions are not simple harmonic. Explain. (5)

3. (a) Explain the theory of formation of Newton's rings and derive an expression for the diameter of dark rings formed by reflected light. (10)

   (b) Newton's rings are observed in reflected light of wavelength 5900 Å. The diameter of the 10^{th} dark ring is 0.5 cm. Find the radius of curvature of the lens. (5)

4. (a) Give the theory of Fraunhofer diffraction due to a single slit. Discuss the intensity distribution pattern obtained in it. (10)

   (b) For Fraunhoffer diffraction with a single slit of width 0.2 mm and screen placed at a distance of 3.0 m from the slit, find the total width of the central maximum, wavelength of light used is 5000 Å. (5)

(b) If two capillaries of radii r_1, r_2 and length L_1, L_2 respectively are joined in series, derive the expression for the rate of flow of liquid through this arrangement using Poiseuille's formula.

(7)

[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 3084 **H**

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) Explain time dilation phenomenon using space-time diagram.

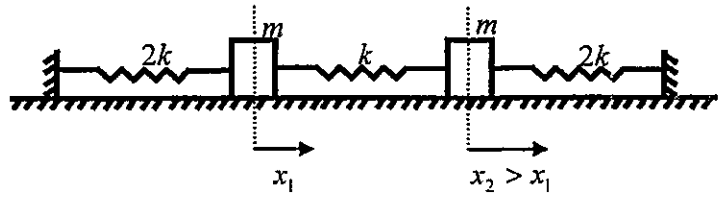
(b) With the help of diagram explain the difference between

(i) steady and unsteady flow

(ii) uniform and non-uniform flow.

(c) What do you mean by length contraction. The rest radius of the earth may be taken as 6400 km and its orbital speed about the sun as 30 km/sec. By how much would the earth's diameter appear to be shortened to an observer on the sun, due to earth's orbital motion?

(d) Show that motion of a charged particle in crossed electric and magnetic field is cycloid. Also determine the maximum height of a cycloid path.



(a) Choosing the displacement of each block from its equilibrium position as generalized coordinates (x_1, x_2), obtain T (kinetic energy) and V (potential energy) matrices and hence find the angular frequencies of small oscillations. (2,2,2)

(b) Find the relations between (x_1, x_2) and normal coordinates (q_1, q_2) and hence obtain the expressions for T and V in terms of (q_1, q_2). (5,3,3)

7. (a) A charged particle (mass m, charge q) is at rest at origin and at t = 0, fields are applied such that $\vec{E} = E_o \hat{y}$ and $\vec{B} = B_o \hat{z}$. Find its position at time $t > 0$. (10)

P.T.O.

5. (a) Using the invariance of the quantity $\omega t - \vec{k} \cdot \vec{r}$, obtain transformation rule for 4-wavevector, $k^{\mu} = \left(\omega/c, \vec{k}\right)$ and hence derive the expression for transverse Doppler effect. (6,3)

(b) An unstable atom at rest (rest mass M_0) decays into smaller atom (rest mass m_0) and photon. Using 4-vector approach or otherwise, prove that the speed of smaller atom is given by $u = c\dfrac{M_o^2 - m_o^2}{M_o^2 + m_o^2}$.

(8)

6. Two blocks and three springs are configured as shown below. These blocks can execute longitudinal simple harmonic oscillations only. When the blocks are at rest, all springs are unstretched.

(e) What do you mean by degrees of freedom. Determine degrees of freedom for the following systems :

(i) four particles moving freely in a space.

(ii) two particles falling under gravity in space.

(f) What is meant by stable, unstable and neutral equilibrium. For a particle moving under the influence of a potential, $V = \frac{1}{2} k x^2$ where k is a constant, determine the kind of equilibrium system holds. (4×6=24)

2. (a) Consider a particle of mass m moving in two dimensions, subject to a force $\vec{F} = -\alpha x \hat{x} + \beta \hat{y}$, where α and β are positive constants.

Using x and y as generalized coordinates, obtain the Lagrangian of this system and hence find the equation(s) of motion. (6,4)

(b) A particle of mass m is moving in three dimension close to the earth's surface, Lagrangian of this system is given as $L=\frac{1}{2}m\left(\dot{x}^2+\dot{y}^2+\dot{z}^2\right)-mgz$, where x, y, z are the generalized coordinates. Identify the cyclic coordinates and find the canonical momentum conjugate to the remaining generalized coordinate. (3,4)

3. A particle of mass m is moving in a central potential V(r), Lagrangian of the system is given by

$$L=T-V=\frac{1}{2}m\left(\dot{r}^2+r^2\dot{\phi}^2\right)-V(r)$$

where r and ϕ are the generalized coordinates. Obtain the Hamiltonian, H and using Hamilton's equations of motion, show that

(i) $\frac{d}{dt}\left(mr^2\dot{\phi}\right)=0$, i. e., angular momentum (l) is constant.

(ii) $\frac{d}{dt}(T+V)=0$, i. e., total energy (E) is constant. (6,6,5)

4. (a) Derive 3-velocity transformation equations using 4-velocity transformation rule. (7)

(b) A car (rest mass m_0) is moving with the speed $2c/\sqrt{5}$ at 45° with x–axis in x – y plane. Find the

(i) 4-momenum of the car

(ii) norm of 4-momentum. (8,2)

6. (a) Draw a block diagram for a Transponder and explain its working. Discuss about the operating frequency of uplink and downlink in C-band.

(b) Define the term satellite visibility? Calculate the visibility of geostationary satellite for earth station located at the equator. (10,5)

7. (a) What is frequency reuse? Draw the frequency reuse patterns for the following cluster sizes: (i) N=4 (ii) N=7. Determine the frequency reuse distance for a mobile system of cluster size 10 and radius of each cell 5 kilometres.

(b) What do you understand by the SIM and IMEI numbers in mobile communication? (8,7)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 3189 **H**

Unique Paper Code : 32227613

Name of the Paper : Communication System

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

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. Use of scientific calculator is allowed.

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

(a) Briefly explain why a signal is required to be converted into passband region from baseband region for communication?

(b) What is multiplexing? Define TDM and FDM.

(c) What is the function of *mixer* in a super heterodyne receiver?

(d) The maximum peak-to-peak value of an AM wave is 45 V. The peak-to-peak value of the modulating signal is 20 V. What is the percentage of modulation?

(e) Write the statement for sampling theorem. What is aliasing?

(f) Calculate the minimum bandwidth for a FSK signal with a bit rate of 200 kbps and S/N of 15dB.

2. (a) Show that there are infinite numbers of frequency bands accommodated in Frequency Modulated wave.

(b) Find out the carrier and modulating frequency, modulation index and the maximum deviation for a frequency modulated wave given as:

$E = 12\text{Sin}\ (6 \times 10^8 t + 5\ \text{Sin}\ 1250\ t)$ (10,5)

3. (a) Draw the circuit diagram for the generation and detection of single side band amplitude modulated wave and explain it's working.

(b) Distinguish between amplitude and frequency modulation. Calculate the power developed by an AM wave in a load of 100 Ω when the peak voltage of the carrier is 100 V and the modulation factor is 0.4. (10,5)

4. (a) Enumerate the merits and demerits of digital communication system. What is the function of Encoder in PCM? Explain different Encoding schemes.

(b) For a PCM coding scheme for 3-bits, determine the quantization voltage, quantization error (e_q) and PCM code for the analog sample voltage of +1.07V. (10,5)

5. (a) Describe in detail the modulation techniques of Pulse Amplitude Modulation (PAM), Pulse Width Modulation (PWM) and Pulse Position Modulation (PPM) with suitable proper diagrams. Explain the advantages and disadvantages of PCM over the Pulsed Modulation scheme.

(b) A FDM channel having total bandwidth of 100 MHz requires 20 kHz bandwidth for the transmission of single signal. How many signals can be transmitted simultaneously using a FDM scheme if the guard band frequency is 2 kHz? (10,5)

P.T.O.

[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 2989 **H**

Unique Paper Code : 32221602

Name of the Paper : Statistical Mechanics

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 **five** questions in all.
3. Question No. **1** is compulsory.
4. **All** questions carry equal marks.
5. Non-programmable scientific calculator is allowed.

P.T.O.

1. Attempt all parts from the following : (5×3=15)

(a) Three identical boxes A, B, C are at same temperature T and have gases of equal number of classical particles, bosons and fermions respectively. Which gas will exert the greatest pressure and which gas will exert the least pressure? Why?

(b) Two isolated systems have thermodynamic probabilities $\frac{2}{3}e^{10}$ and $\frac{3}{2}e^{10}$ respectively. Calculate the total thermodynamic probability of the combination of these systems. Also, calculate the total entropy.

(c) For a system of N atoms, energy of each atom is given as

$$E = \frac{1}{2m}(p_x^2 + p_y^2) + \frac{1}{2}m\omega^2(x^2 + y^2) + \alpha(x + y)$$

where m, ω, α are constants.

Using equipartition theorem, find the average energy of this system.

(d) Why are electrons not ejected out spontaneously from a metal inspite of having tremendous zero point pressure?

(e) How is a Fermi gas different from a Bose gas at T = 0 K?

2. (a) Partition function is given by

$$Z = \sum_i g_i\, e^{-\beta\epsilon_i} \; ; \; \beta = 1/k_B T$$

Prove that

(i) mean energy, $\bar{E} = -\frac{1}{Z}\frac{\partial Z}{\partial \beta}$

(ii) mean pressure, $\bar{P} = \frac{1}{\beta Z}\left(\frac{\partial Z}{\partial V}\right)_{T,N}$

(iii) entropy, $S = k_B \ln Z + \frac{\bar{E}}{T}$. (3,4,5)

(b) Identify the regions in energy vs entropy diagram for two temperatures: –100 K and 100 K for a system with finite maximum energy. Which of the two is hotter? (3)

3. (a) Establish the relation between entropy and thermodynamic probability. (5)

(b) Consider a system of N magnetic dipoles in the presence of magnetic field B such that dipoles can be either parallel or anti-parallel to B.

(i) Find energy E of the system, enumerate the number of microstates, W(N, E) and hence find the expression for entropy. (2,2,3)

(ii) Show that the maximum entropy for this system is given by

$$S_{max} = Nk_B \ln 2 \qquad (3)$$

4. (a) In what ways Bose-Einstein Condensation (BEC) differ from ordinary condensation? (2)

(b) Derive the expression for temperature (T_c) at which BEC sets in. (5)

(c) Show that at transition temperature ($T=T_c$), the energy of an ideal quantum gas consisting of N particles of spin zero moving non-relativistically in 3-dimensions is given by

$$E(T_c) = 1.5 N k_B T_c \frac{\zeta(5/2)}{\zeta(3/2)} \qquad (8)$$

5. (a) Prove that the average energy of non-relativistic fermions (spin = 1/2) at T = 0 K is given by

$$\overline{E} = \frac{3}{5}\epsilon_F(0)$$

Why $\overline{E} \neq 0$ at T = 0 K? (6,2)

(b) Show that for a strongly degenerate gas of fermions ($0 < T << T_F$), the chemical potential is

$$\mu(T) \approx \epsilon_F \left[1 - \frac{\pi^2}{12}\left(\frac{T}{T_F}\right)^2\right],$$ where $\epsilon_F = \mu(T = 0)$, and $T_F = \epsilon_F / k_B$. (7)

6. (a) State Planck's postulates for blackbody radiation. Write Planck's law of blackbody radiation in terms of wavelength and hence deduce Wien's displacement law. (2,6)

(b) The entropy of a blackbody radiation is given as

$$S = \frac{4}{3}\sigma V^{1/4} E^{3/4};$$ σ is a constant.

Show that the pressure exerted by the radiation is given by

$$P = \frac{E}{3V}$$ (4)

(c) Consider a blackbody radiation inside a cavity maintained at temperature 400 K. Calculate the energy density of photons inside this cavity. (3)

7. In a hypothetical system, 3 particles are distributed over 4 degenerate energy levels (0, ϵ, 2ϵ, 3ϵ) such that the total energy of the system is 3ϵ. Degeneracies of these energy levels are respectively (3, 4, 2, 2). Find all the possible macrostates and their corresponding microstates if particles are

(a) classical (identical and distinguishable)

(b) bosons

(c) fermions (5,5,5)

Some useful constants and integrals :

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

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

$b = 2898\ \mu\text{m K}$,

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

$h = 6.626 \times 10^{-34}\ \text{J s} = 4.136 \times 10^{-15}\ \text{eV s}$,

$k_B = 1.38 \times 10^{-23}\ \text{J/K} = 8.617 \times 10^{-5}\ \text{eV/K}$,

$$\int_0^\infty \frac{x^{n-1}\,dx}{(z^{-1}e^x) - 1} = \Gamma(n)\,g_n(z);\ \ g_n(1) = \zeta(n)$$

$$\int_0^\infty \frac{x^{n-1}\,dx}{(z^{-1}e^x) + 1} = \Gamma(n)\,f_n(z);\ \ f_n(z) = g_n(z) - [2^{1-n} g_n(z^2)]$$

$\zeta(3/2) = 2.612$, $\zeta(5/2) = 1.341$, $f_{3/2}(1) = 0.765$,

$\zeta(2) = \dfrac{\pi^2}{6}$, $\zeta(4) = \dfrac{\pi^4}{90}$, $\Gamma\left(\dfrac{1}{2}\right) = \sqrt{\pi}$

[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 2935 **H**

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.

P.T.O.

1. Attempt any **five** questions :

(a) Explain the concept of displacement current by an example.

(b) Show that although the scalar and vector potentials are not unique in themselves, they define the Electric and Magnetic field uniquely.

(c) A 20 cm column of cane sugar solution of concentration 100 gm/litre produces rotation of 10.6°. Find the purity of cane sugar. Given: specific rotation of pure sugar is 66 $dm^{-1} g^{-1}cm^{-3}$.

(d) A phase retardation plate of quartz has thickness 0.1436 nm. For what wavelength in the visible region, it will act as quarter-wave plate? Given that $\mu_0 = 1.5443$ and $\mu_c = 1.5533$.

(e) Draw a schematic diagram for propagation of plane electromagnetic wave incident normally on a positive uni-axial crystal with its optic axis lying parallel to the plane of incidence and interface.

(f) The relative permittivity of distilled water is 81. Calculate the refractive index and velocity of light in it.

(g) Write the two limitations of Nicol prism.

(3×5)

2. (a) For the propagation of electromagnetic wave in anisotropic medium show that permittivity tensor is symmetric in nature.

(b) Discuss the construction of optical fiber. What is a step index and graded index in an optical fiber? Derive the expression of numerical aperture.

(8,7)

3. (a) Derive Fresnel's relation for reflection and transmission of plane electromagnetic waves at an interface between two dielectric media when an electric vector of the incident wave is perpendicular to the plane of incidence.

(b) Calculate the skin depth of electromagnetic waves of frequency 1 MHz incident on a good conductor having $\sigma = 5.8 \times 10^3$ mhom^{-1}. Assume that inside the conductor $\mu = \mu_0 = 4\pi \times 10^{-7}$ Hm^{-1}. (9,6)

4. (a) Derive the expressions for the components of electric and magnetic fields of a symmetric planar wave guide for transverse electric mode. Setup the Eigen value equation

(b) A dielectric waveguide of 15 μm film thickness has refractive index 1.53 and cover of refractive index 1.50. Calculate the maximum number of modes in the waveguide given free space wavelength $\lambda_0 = 2$ μm. (9,6)

5. (a) Distinguish between positive and negative crystals in terms of double refraction. How are these crystals used to make quarter wave plates? Explain how the quarter wave plate is used in producing elliptically and circularly polarized light.

(b) A step-index fiber has a core diameter of 80 μm, a core refractive index of 1.62, and a numerical aperture of 0.21. Calculate: (a) the acceptance angle, (b) the refractive index that the fiber can propagate at a wavelength of 0.8 μm, (c) the number of modes that the fiber can propagate at a wavelength of 0.8 μm. (9,6)

6. (a) Give an outline of Fresnel's explanation of optical rotation. How does optical rotation due to a material vary with wavelength?

(b) For a calcite crystal, the refractive indices of ordinary and extra ordinary rays are 1.65836 and 1.48641 at λ_0 = 5893 Å respectively. A left circularly polarized beam of this wavelength is incident normally on such crystal of thickness 5.141 μm having its optic axis cut parallel to the surface. What will be the state of polarization of the emergent beam? (9,6)

7. (a) Assume $\mu = \mu_0$, show that the ratio of the amplitudes of the conduction current density and displacement current density (a) is $\sigma/\omega\varepsilon$ for the applied field $E = E_0 \cos\omega t$. (b) What is the ratio of the amplitudes if the applied field is $E = E_0 e^{-t/\tau}$, where τ is real?

(b) The field vectors of a wave of frequency 200 MHz propagating in free space are given by

$$E = 120 \operatorname{Cos}\left(\omega t + \frac{4\pi}{3}x\right)\hat{k} \text{ V/m},$$

$$H = \frac{120}{120\pi}\operatorname{Cos}\left(\omega t + \frac{4\pi}{3}x\right)\hat{j} \text{ A/m}$$

Determine the direction of power flow and the average power crossing the surface bounded by y = 2 m, y = 0, z = 2 m, and z = 0.

(c) Consider a medium for which $\vec{E}(z,t) = 10\, e^{-2z} \cos(10^8 t - 0.3z)\hat{i}$ and $\vec{H}(z,t) = H_0 e^{-az}\cos(\omega t - \beta z + \delta)\,\hat{a}$. Given that $\sigma = 4\ Sm^{-1}$, $\mu = 1.5\ \mu_0$, $\varepsilon = \varepsilon_0$

(i) What is the magnitude H_0 of the magnetic field?

(ii) Find the phase difference (δ) between $\vec{E}$ and $\vec{H}$ vectors.

P.T.O.

(iii) After travelling a distance of lm, how will the amplitude of $\vec{H}$ reduce?

(iv) What is the direction of propagation of wave and $\hat{a}$? (4,5,6)

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

(b) Calculate the Debye specific heat of copper at 10 K, given that the Debye characteristic frequency is 6.55 x 10^{12} *Hz*. (3)

5. (a) What is meant by local field in a dielectric? Obtain an expression for the local field for an atom in a dielectric medium. (8)

(b) Explain Meissner Effect in superconductors with suitable diagram. (7)

6. (a) Obtain an expression for paramagnetic susceptibility on the basis of Classical Langevin's theory. (10)

(b) Discuss difference between Type-I and Type-II superconductors (5)

7. (a) State all the assumptions of the Kronig-Penney model for an electron in a crystal. Draw the E-K relation of an electron for this model and explain the origin of the observation of forbidden gap in solids. (9)

(b) What is Hall Effect? Explain with the help of a suitable diagram the generation of hall voltage in n-type semiconductor. Mention two uses of Hall Effect. (6)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 3538 **H**

Unique Paper Code : 42227637

Name of the Paper : Solid State physics

Name of the Course : **B.Sc. Prog.-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. **All** questions carry equal marks.
3. Attempt **any Five** questions in total.
4. **Question No. 1** is compulsory.

1. Attempt **any five** of the following:- (3x5=15)

(a) Show that the reciprocal lattice vector $\vec{G}_{hkl}$ is perpendicular to the plane (*hkl*).

(b) What are phonons? Mention any one experimental fact which indicates the existence of phonons in solids.

(c) At optical frequencies how does the dielectric constant of a polar dielectric depend on the index of refraction? Explain which polarizibility component contributes to the dielectric constant at optical frequencies.

(d) Distinguish between dia-, para-, ferro- magnetic materials

(e) The critical field and critical temperature of lead (Pb) are $6.5\times10^4 A/m$ and 7.18 K, respectively. To what temperature it must be cooled to become a superconductor in a magnetic field of $2\times10^4 A/m$.

(f) Distinguish between conductors, semiconductors and insulators on the basis of band theory of solids.

(g) How does a superconductor differ from a perfect conductor?

2. (a) Show that the reciprocal lattice of a face centered cubic lattice is a body centered cubic lattice (6)

(b) X-ray of wavelength 1.54 Å are used to calculate the spacing between (200) planes in aluminium. The first order Bragg's angle corresponding to this reflection is 22.4°. Determine the value of lattice parameter of the aluminium crystal. (4)

(c) Construct first, second and third Brillouin Zones for a 2D square lattice. (5)

3. (a) Draw and discuss the dispersion relation for a linear chain of diatomic crystal. How it is different than the linear chain of monoatomic crystal. Discuss the characteristics of the various branches and why they are names acoustic and optical ones. (7)

(b) What is Dulong-Petit's law for heat capacity of solids? How it is different than the observed heat capacity of solids. Draw the necessary plots to explain the difference. Explain what is wrong in the classical theory of crystal heat capacity that it fails miserably at low temperatures. What modifications are required in the model to explain the experimentally observed behavior? (8)

4. (a) What are the main assumptions of the Debye's theory of specific heat of solid? Obtain its high and low temperature limits of the specific heat and show how far it agrees with the experimental results. (12)