[This question paper contains 8 printed pages.]

Your Roll No.....

12 MAY 2023

Sr. No. of Question Paper : 4514 E

Unique Paper Code : 32221601

Name of the Paper : Electromagnetic Theory

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

Semester : VI

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

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

1. Attempt any **five** questions :

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

P.T.O.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

P.T.O.

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

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

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

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

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

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

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

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

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

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

[This question paper contains 4 printed pages.]

15 MAY 2023

Your Roll No.....

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

Duration : 3 Hours Maximum Marks : 75

Instructions

1. Write your Roll Number on the top immediately on the receipt of the question paper.
2. Attempt five questions in all.
3. Question number 1 is compulsory. Attempt two questions each from section A and B.
4. The Principal Branch of argument of complex number z in all the questions is taken to be $-\pi < \theta \leq \pi$
5. Use the following definition for the Fourier transform of $f(x)$:

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

6. Use the following definition for the Fourier Sine transform of $f(x)$:

$$\mathcal{F}_s(f(x)) = \sqrt{\frac{2}{\pi}} \int_0^{\infty} f(x) \sin(kx) dx$$

7. Use the following definition for the Fourier Cosine transform of $f(x)$:

$$\mathcal{F}_c(f(x)) = \sqrt{\frac{2}{\pi}} \int_0^{\infty} f(x) \cos(kx) dx$$

8. The definition of convolution of two functions $f(x)$ and $g(x)$ for Fourier transform is:

$$(f * g)(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} f(y) g(x-y) dy$$

9. Some useful Fourier and Laplace Transforms are given at the end.

P.T.O.

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

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

b) Find the principal branch of i^i.

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

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

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

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

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

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

Section – A

Q2.

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

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

and hence show that

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

6, 2

b) Prove:

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

7

Q3.

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

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

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

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

Q4.

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

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

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

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

i. $1<|z|<2$

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

Section – B

Q5.

a) Find the Fourier transform of

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

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

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

Q6.

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

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

Q7.

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

P.T.O.

b) Prove that

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

Some useful Laplace Transforms:

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

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

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

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

Useful Fourier Transform:

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

Useful Inverse Fourier Transform:

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

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

(a and b are constants)

Useful Integral:

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

[This question paper contains 8 printed pages.]

31 MAY 2023 **Your Roll No.....**

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

Unique Paper Code : 32221201

Name of the Paper : Electricity and Magnetism

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

Semester : II

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

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

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

P.T.O.

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

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

(i) Find the charge density.

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

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

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

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

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

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

P.T.O.

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

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

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

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

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

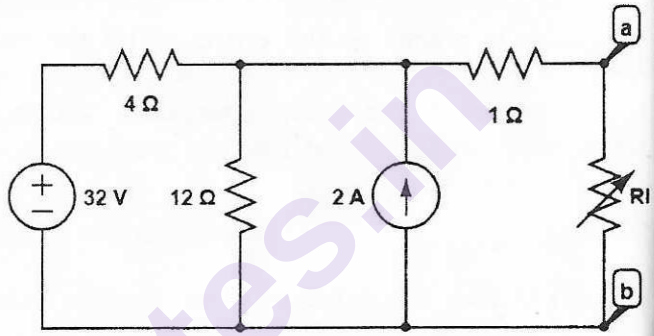
5. (a) A point charge 'q' is placed inside a hollow grounded, conducting sphere of inner radius 'a'. Using the method of images,

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

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

P.T.O.

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



(5,1.5)

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

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

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

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

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

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

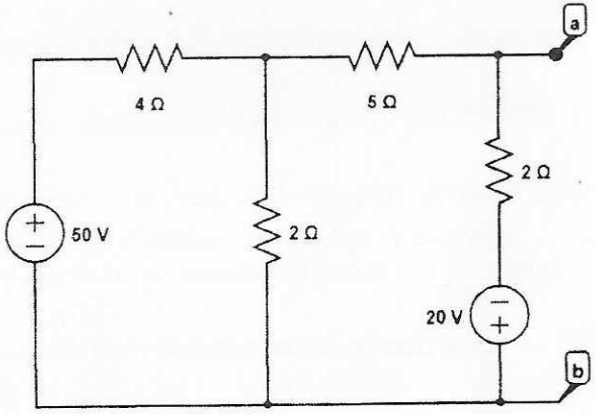
(i) What is its capacitance? (2)

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

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

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

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



(6)

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 4641 E

Unique Paper Code : 32223905

Name of the Paper : Renewable Energy and Energy Harvesting

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

Semester : CBCS Part-II (Sem-IV) SEC

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. Answer any 5 questions.
3. Question Number 1 is compulsory.

1. Answer any 5 questions :

(i) Write two demerits of wind energy harvesting.

(ii) Write basic principle working of solar ponds.

(iii) How mega hydro projects are harmful for ecological balance?

(iv) Define maximum power point of a solar cell.

(v) Write basic principle working of piezoelectric energy generation.

(vi) Is nuclear energy source is renewable? Justify your answer.

(vii) Write the working principle of tidal energy.

(5×2=10)

2. A family in Delhi is living in 2 room flat on the top floor. Average energy consumption in summer and winters is 500 and 700 Kilowatt hour respectively. Design off grid PV solar panels arrangements on the roof top with $40m^2$ area with following specifications Solar Panel 350 W, 15V, Charge

controller, 120 Ah Solar batteries). Give proper circuit diagram for connections. (10)

3. What is micro hydroelectric project? What are essential components of such project? Give appropriate design for setting up a Micro-hydro Power Plant (75 KW) in a village in Arunachal Pradesh with 150 inhabitants where a tributary water tracks down a village to 800m. (10)

4. What are geothermal resources? How can they be harnessed? Give diagrammatic description of the same. (10)

5. How can energy be harnessed from ocean bio mass? Write its merits and demerits of this method. (10)

6. What is carbon credit of a renewable energy harvesting technique? How can it be calculated? Explain it with the help of an example. (10)

P.T.O.

7. What is electromagnetic energy harvesting? Explain the basic principle behind this method. (10)

[This question paper contains 6 printed pages.]

 Your Roll No.....

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

Unique Paper Code : 32221202

Name of the Paper : Wave and Optics

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

Semester : II

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

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

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

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

P.T.O.

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

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

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

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

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

(g) State and explain Huygen's principle.

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

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

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

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

P.T.O.

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

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

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

(i) Calculate the fundamental frequency of the wire.

(ii) Determine the tension in the wire.

(7+5+3)

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

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

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

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

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

(c) A thin transparent plate of refractive index 1.5 displaces 10 fringes when introduced in one of the arms of Michelson's interferometer. Calculate the thickness of the plate. Wavelength of light is 6000 A^0. (7+5+3)

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

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

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

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

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

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

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

(7+5

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : **4688** **E**

Unique Paper Code : 32221402

Name of the Paper : Elements of Modern Physics

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

Semester : IV

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The symbols have the usual meaning (5)

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

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

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

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

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

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

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

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

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

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

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

Some useful constants

1. Planck constant, $h = 6.626 \times 10^{-34}$ J.s
2. $\hbar = 1{,}05\times 10^{-34}$ J.s
3. Boltzmann constant, $K = 1.38 \times 10^{-23}$ $J.K^{-1}$
4. Mass of electron, $m_e = 9.1 \times 10^{-31}$ kg
5. Charge of electron, $e = 1.6 \times 10^{-19}$ C
6. Speed of light in vacuum, $c = 3 \times 10^{8}$ $m.s^{-1}$
7. Stefan-Boltzmann constant, $\sigma = 5.67 \times 10^{-8}$ $W.m^{-2}.K^{-4}$
8. Rest mass energy of electron = 512 KeV
9. Velocity of electron in free space= $3x10^{8}$ m/s

R-1263 - (4)

[This question paper contains 4 printed pages.]

24 MAY 2023

Your Roll No.....

E

Sr. No. of Question Paper : 4756

Unique Paper Code : 32227613

Name of the Paper : Communication System

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

Semester : VI

Duration : 3 Hours

Maximum Marks : 75

Instructions for Candidates

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

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

(a) Write the requirements of FM detector circuit.

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

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

P.T.O.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

[This question paper contains 4 printed pages.]

26 MAY 2023

Your Roll No.....

E

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

Duration : 3 Hours

Maximum Marks : 75

Instructions for Candidates

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

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

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

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

(i) classical harmonic oscillators

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

(iii) nucleons in a nucleus.

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

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

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

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

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

(5×3=15)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Constants:

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

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

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

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

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

(2000)

29 MAY 2023

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 4812

E

Unique Paper Code : 32221403

Name of the Paper : Analog Systems and Applications

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

Semester : IV

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

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

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

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

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

P.T.O.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

P.T.O.

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

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

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

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

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

(1000)