

3. (a) Attempt any one: -
- (i) Obtain the boundary conditions for the fields: Electric field \vec{E} , Electric Magnetic field \vec{B} at the interface between two linear media. 10
 - (ii) Derive maxwell's equation in material media. 10
- (b) Attempt any one: -
- (i) How Maxwell (Fixed) modified the Amper's Law? 5
 - (ii) In a medium of permittivity $5 \epsilon_0$, the maximum current is equal to maximum conduction current at frequency of 10^6 Hz. What is the conductivity of the medium? ($\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2$) 5
4. (a) Attempt any one: -
- (i) Consider a wave travelling along z - axis in a medium with refractive index n_1 . If it is incident on the medium with refractive index n_2 normally, calculate the reflection coefficient. 10
 - (ii) State Poynting's work energy theorem. Show that $\frac{dw}{dt} = -\frac{\partial}{\partial t} \int_V (u_e + u_m) dv - \oint_S \vec{S} \cdot \hat{n} da$. Symbols have their usual meaning 10
- (b) Attempt any one: -
- (i) Derive the wave equation for the electric field in vacuum. 5
 - (ii) For a certain medium $\epsilon = 17.7 \times 10^{-12} \text{ C}^2/\text{Nm}^2$ and $\mu = 4\pi \times 10^{-7} \text{ N/A}^2$. Find the velocity of plane EM wave in the medium. Also find the refractive index of the medium? ($c = 3 \times 10^8 \text{ m/s}$, $\epsilon_0 = 12.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2$) 5
5. Attempt any Five: -
- (i) Find the energy of a uniformly charged spherical shell of total charge $3 \mu\text{C}$. 3
 - (ii) Find the work done to a move a charge of 2 Coulombs under the influence of potential difference 3 Volts. 3
 - (iii) A vector field is given by $\vec{B} = 3yz \hat{i} + 2zx \hat{j} + 4xy \hat{k}$ Find the current density in the field at point (2, 4, -1). $\mu_0 = 4\pi \times 10^{-7} \text{ SI units}$. 3

- (iv) Find the magnetic field of an infinite uniform surface current $K = K\hat{x}$, flowing over the XY plane 3
- (v) The magnetization is given by $\vec{M} = a [3xy\hat{i} + 5yz\hat{j} + 5xz\hat{k}]$ where 'a' is a constant find \vec{J}_b and $\vec{\nabla} \cdot \vec{J}_b$ 3
- (vi) Show that $\vec{\nabla} \cdot \vec{J}_b = 0$. 3
- (vii) An electromagnetic wave is incident normally on the surface of glass from air. Find the coefficient of transmission. Given ($n_2=1.5$) 3
- (viii) Electromagnetic wave in empty space has amplitude of electric field 400V/m. Find the value of amplitude of magnetic field ($c=3 \times 10^8$ m/s) 3

Time: 2 1/2 Hours.

Total marks: 75

N.B.:

1. All questions are compulsory.
2. Figures to the right indicate full marks.
3. Draw neat diagrams wherever necessary.
4. Symbols have usual meaning unless otherwise stated.
5. Use of non-programmable calculator is allowed.

1. (a) Attempt any one: -
 - (i) Set up Schrödinger's equation for hydrogen atom. Solve it by the method of variable separation to obtain three independent equations. **10**
 - (ii) Explain the experimental set up and working of Stern Gerlach's experiment and explain how it was able to prove the existence of intrinsic spin of electron. **10**
- (b) Attempt any one: -
 - (i) Explain briefly symmetric and anti-symmetric wave functions. **5**
 - (ii) For a d-electron, draw space quantization diagram. Also calculate cosine of angle between each orientation of \vec{L} and Z-axis **5**
2. (a) Attempt any one: -
 - (i) State Zeeman effect. Describe the experimental set up for observing Zeeman effect, in detail. Comment on the observed Zeeman components. **10**
 - (ii) Prove that an electron undergoing transition from higher energy level E_m to lower energy level E_n , emits radiation of frequency $\nu = \frac{E_m - E_n}{h}$, according to quantum mechanics. **10**
- (b) Attempt any one: -
 - (i) Using proper vector diagram, explain J-J coupling in detail. **5**
 - (ii) Due to Spin-orbit interaction, spectral line from 3P to 3S transition in Sodium atom, splits up into two components $\lambda_1 = 5890 \text{ \AA}$ and $\lambda_2 = 5896 \text{ \AA}$. Calculate the magnetic field experienced by the spinning electron in 3P state due to its orbital motion. **5**
Given: $h = 6.63 \times 10^{-34} \text{ Js}$; Speed of light $c = 3 \times 10^8 \text{ m/s}$
3. (a) Attempt any one: -
 - (i) Explain the construction and working of absorption IR spectrometer with the schematic diagram. **10**
 - (ii) Explain the rotational energy levels of a diatomic molecule. **10**
- (b) Attempt any one: -
 - (i) Explain briefly pre-dissociation of a molecule with a neat diagram. **5**
 - (ii) Calculate the moment of inertia and energy of rotational $J = 2$ level in HCl molecules. $M(\text{H}) = 1.66 \times 10^{-27} \text{ Kg}$, $M(\text{Cl}) = 5.81 \times 10^{-26} \text{ Kg}$, bond length = 2.1 \AA . **5**

4. (a) Attempt any one:-

- (i) Discuss pure rotational Raman spectra of linear molecules and show that Stokes and anti Stokes lines are symmetrically placed about the parent line. 10
- (ii) What is the basic principle of Nuclear Magnetic Resonance? Explain with neat diagram Nuclear Magnetic Resonance (NMR) spectrometer. 10

(b) Attempt any one:-

- (i) What is Raman effect? State the observations on Raman effect. 5
- (ii) Calculate the Electron spin resonance (ESR) frequency for free electrons required at a magnetic field strength of 2 T 5
(Given g - factor = 2.002, Bohr magneton $\mu_B = 9.274 \times 10^{-24}$ J/T, Planck's constant $h = 6.63 \times 10^{-34}$ J.s)

5. Attempt any Five:-

- (i) What is Bohr Magneton? Calculate its value. 3
- (ii) A beam of electrons enters a uniform magnetic field 1.2 weber/m². Find the energy difference between the electrons whose spins are parallel and anti-parallel to the field. 3
- (iii) Calculate the values of Lande's g -factor for $3^2S_{1/2}$ and $3^2P_{3/2}$ states. 3
- (iv) Calculate the specific charge e/m of electron when a spectral line of 4000 \AA is subjected to magnetic field of 0.5 Tesla and the Normal Zeeman shift is 0.03735 \AA . 3
- (v) The masses of Mercury and Chlorine are 33.2×10^{-26} Kg and 5.81×10^{-26} Kg respectively. If the bond length of HgCl is 2.23×10^{-10} m. Find the moment of inertia of HgCl molecule. 3
- (vi) The first absorption line in CO rotational spectrum occurs at 1.153×10^{11} Hz. Calculate the moment of inertia of CO molecule. 3
- (vii) A Stokes line of wavelength 5000 \AA was observed in a Raman spectrum when the radiation of wavelength 4800 \AA was scattered by a medium. Calculate the Raman frequency of the corresponding Anti-Stokes line. 3
Given: $h = 6.63 \times 10^{-34}$ Js ; Speed of light $c = 3 \times 10^8$ m/s
- (viii) The nuclear spin quantum number of ^{37}Cl is $3/2$, calculate its nuclear angular momentum. 3
Given: $h = 6.63 \times 10^{-34}$ Js

Time: 2 ½ Hours.

Total Marks: 75

N.B.:

1. All questions are **compulsory**.
2. **Figures to the right** indicate **full marks**.
3. Draw **neat diagrams** wherever **necessary**.
4. Symbols have usual meaning unless otherwise stated.
5. Use of **non-programmable** calculator is allowed.

Constants: Boltzmann Constant: $k = 1.38 \times 10^{-23} \text{ J}^\circ\text{K}$
 Planck's Constants: $h = 6.63 \times 10^{-34} \text{ J-sec}$

1. (A) Attempt any **one**: -
 - (i) State and explain probability theorems. 10
 - (ii) Explain the Normal or Gaussian-distribution. 10
 (B) Attempt any **one**: -
 - (i) Write a short note on "Sample Space". 5
 - (ii) Three coins are tossed; what is the probability that two are tails and one head? What is the probability of getting two consecutive tails and then a head? If there was at least one tail, what is the probability of all tails? 5

2. (A) Attempt any **one**: -
 - (i) Explain terminology and notation of a complex number. Find x, y, r, θ of given complex number z . Plot the number and label it and find its complex conjugate. 10
 - a) $z = 3 + 3i$
 - b) $z = 2 \left(\cos \frac{\pi}{6} + i \sin \frac{\pi}{6} \right)$
 - (ii) Explain hyperbolic functions of complex numbers. Using these prove that 10
 - a) $\cosh^2 z - \sinh^2 z = 1$
 - b) $\frac{d}{dz} \cosh z = \sinh z$
 (B) Attempt any **one**: -
 - (i) Prove: $\cos z = 2$ 5
 - (ii) A particle moves in (x, y) plane so that its position (x, y) as a function of time t is given by 5

$$z = 5e^{i\omega t}$$
 Calculate the magnitude of velocity and acceleration.

3. (A) Attempt any **one**: -
 - (i) Define partition function. Obtain an expression for translational partition function. Find translational partition function for A_r (mass $6.63 \times 10^{-26} \text{ kg}$) confine to a volume of 1 liter at 298 K. 10
 - (ii) Derive an expression for total energy for two-level system. Determine the total energy of an ensemble consisting of N particles that have only two energy levels separated by energy $h\nu$. 10

- (B) Attempt any one: -
- (i) Write a short note on degeneracy of energy states. 5
- (ii) What is the weight associated with the configuration corresponding to observing 40 heads after flipping a coin 100 times? How does this weight compare to that of the most probable outcome? 5
4. (A) Attempt any one: -
- (i) Imagine N identical but distinguishable balls are randomly distributed within a large box that is divided into k cells, each with a different area. How can we demonstrate that the number of balls in each cell will be proportional to the cell's area? 10
- (ii) How can we derive the Bose-Einstein distribution law that describes how bosons occupy various energy states in a thermodynamic system? 10
- (B) Attempt any one: -
- (i) Derive the expressions for the mean velocity of gas molecules that adhere to the Maxwell-Boltzmann distribution law." 5
- (ii) Three identical particles can be in any of the five states. What are the number of possible ways of distributing them in various states according to Maxwell-Boltzmann (MB), Bose-Einstein (BE), and Fermi-Dirac (FD) statistics? 5
5. Attempt any Five: -
- (i) There are 10 chairs in a row and 8 people to be seated. In how many ways can this be done? 3
- (ii) Define probability of an event. A three-digit number is selected "at random". What is the probability that all three digits are same? 3
- (iii) Find the absolute value of given complex number z . 3
- $$z = \frac{25}{3+4i}$$
- (iv) Evaluate: $i^{\ln i}$ 3
- (v) What is the difference in energy between $n = 2$ and $n = 1$ states for molecular oxygen ($mass = 5.31 \times 10^{-26}$ kg) constrained by a one-dimensional box having length of 1.00 cm? 3
- (vi) Using the given partition function $q = 1.58$, calculate the probability of an oscillator occupying the first three energy levels ($n = 0, 1 \& 2$) 3
- (vii) A large box of area 200 m^2 is divided into small square cells. If 10^6 balls are thrown at random in the box, find the most probable number of balls which fall in the square cell of side 10 cm. 3
- (viii) A black body cavity is cubical with each side of length 10 cm. calculate the number of modes in the wavelength region 6000 \AA to 6002 \AA . 3

Time: 2 ½ hrs.

Marks: 75

N.B.:

1. All questions are compulsory.
2. Figures to the right indicate full marks.
3. Draw neat diagrams wherever necessary.
4. Symbols have usual meaning unless otherwise stated.
5. Use of non-programmable calculator is allowed.

Constants: Boltzmann Constant: 1.38×10^{-23} J/K
 Planck's Constants: 6.626×10^{-34} Js
 Charge of electron $e = 1.6 \times 10^{-19}$ C
 Mass of electron $m_e = 9.109 \times 10^{-31}$ kg
 Avogadro's number $N_A = 6.023 \times 10^{26}$ /kg mole

1. (a) Attempt any one: -
 - (i) With the help of a neat labelled diagram, explain seven types of crystal systems of fourteen types of Bravais lattice? Explain Miller indices of lattice plane. 10
 - (ii) Derive an expression for separation between the Miller planes in a simple cubic crystal in terms of Lattice parameter. 10
- (b) Attempt any one: -
 - (i) Explain the terms: 5
 - a) Basis
 - b) Coordination number
 - c) Primitive cell
 - (ii) The atomic radius of Silver having FCC structure is 0.152 nm. Find the interplanar spacing of (2 3 1) and (1 1 0) planes. 5
2. (a) Attempt any one: -
 - (i) What is Wiedemann-Franz law? Derive the relation between electrical conductivity and the thermal conductivity using classical free electron theory. 10
 - (ii) Explain quantum free electron theory and discuss the failure of Sommerfeld's free electron theory. 10
- (b) Attempt any one: -
 - (i) Discuss the Fermi distribution function in details. 5
 - (ii) Show that heat capacity of the electron gas is $0.015R_u$. (where R_u is the universal gas constant) 5

3. (a) Attempt any one: -
- (i) Explain how materials can be classified into conductors, insulators and semiconductors on the basis of the E-K curve for the material. 10
 - (ii) With the help of schematic diagram of energy band structure for an intrinsic semiconductor. Derive the expression for electron concentration (n) in the intrinsic semiconductor at temperature T°K. Write down the expression for hole concentration (p). Obtain the expression for the Fermi energy in the semiconductor. 10
- (b) Attempt any one: -
- (i) Write a short note on p-type and n-type semiconductors. 5
 - (ii) The Hall voltage for the sodium metal is 0.001 mV measured at I = 100 mA and magnetic field 2 wb/m². Thickness of the specimen is 0.05 mm. Calculate the number of carriers per cubic m in sodium. 5
4. (a) Attempt any one: -
- (i) Explain the band structure of an open circuited p-n junction with the help of neat diagram. Derive an expression for the contact difference E_0 of the junction. 10
 - (ii) Explain Meissner effect and hence derive London equation in detail in case of superconductors. 10
- (b) Attempt any one: -
- (i) Draw the volt-ampere characteristics of the p-n junction diode. Explain how they depend on the temperature. 5
 - (ii) The lead material works as a superconductor at a temperature of 7.26 K. If the critical magnetic field at 0K is 8×10^5 A/m then calculate the critical magnetic field in lead at 5 K. 5
5. Attempt any Five: -
- (i) Planes intercepts to the axis $6a, 2b, 4c$. Find the Miller indices. 3
 - (ii) For simple cubic lattice show that, the ratio of density of points in (111) and (110) plane is 0.82. 3
 - (iii) Find the probability of an electronic state being occupied at 300 K temperature, if the energy of the state is 0.2 eV above fermi level. Does the probability remain the same for the state that is 0.2 eV below? 3

- (iv) A uniform silver wire has a resistivity of $1.45 \times 10^{-8} \Omega\text{-m}$ at room temperature. For an electric field of 200 V/m along the wire, calculate the mobility and the average drift velocity of the electrons, assuming that there is 4.8×10^{28} conduction electrons/ m^3 . 3
- (v) For a two-dimensional square lattice of side 0.4 nm , what will be the free electron momentum value of the first Brillouin zone? 3
- (vi) Find the diffusion coefficients for holes of a silicon single crystal at 27°C , if the mobility of holes is $0.025 \text{ m}^2 \text{ V}^{-1}\text{s}^{-1}$ respectively at 27°C . 3
- (vii) Calculate the width of depletion region when p-n junction is forward biased by 0.1 volts . Relative dielectric constant for germanium is 16 . Assume the junction to be abrupt one. 3
- Given: $N_d = 3.2 \times 10^{21}$, $N_a = 1.736 \times 10^{22}$ and
barrier voltage $V_B = 0.131 \text{ V}$.
- (viii) Calculate critical current through Tungsten wire of diameter 2.8 mm and $H_c = 8.51 \times 10^7 \text{ A/m}$. 3

RIZVI COLLEGE OF ARTS, SCIENCE AND COMMERCE
(University of Mumbai)

T.Y.B.Sc. (PHYSICS)

SEM - V

Time : 08:00 AM to 11:00 AM

ELECTRONIC INSTRUMENTATION - I (USACE1501)
(03 Hours)

Total Marks : 75
Date : 28 / 10 / 2024

- N.B. :** (1) All questions are compulsory.
(2) Draw neat diagrams whenever necessary.
(3) Figures to the right indicate full marks.
(4) Use of log table or non-programmable calculator is permitted.

Q1 (A). Attempt any TWO questions. (15M)

- (i) What is thermocouple? State the factors used for the selection of a thermocouple.
- (ii) What is LVDT? Explain its construction and uses.
- (iii) Explain the working of LCD and give its applications.

Q2 (A). Attempt any TWO questions. (15M)

- (i) Draw the block diagram of general purpose CRO and explain the function of the CRO.
- (ii) What is carbon microphone? Describe its working with neat diagram.
- (iii) Explain the working of buck regulator.

Q3 (A). Attempt any TWO questions. (15M)

- (i) Draw a neat circuit diagram of ladder network of D/A converter and explain its construction. Also derive the formula for its output voltage.
- (ii) Explain the successive approximation A/D converter with neat circuit diagram.
- (iii) Explain multi channel data acquisition system with their neat block diagram.

Q4 (A). Attempt any TWO questions. (15M)

- (i) What is ECG? Explain its working with their different probes along with their V-T graph.
- (ii) What is CT scan? Describe how does CT scan machine work?
- (iii) Explain the operating principle of microwave oven with their neat diagram.

Q5 (A). Attempt any FIVE questions. (Each question carry 3 Mark) (15M)

- (i) Discuss the classification of different types of transducers.
- (ii) Discuss wire strain gauge.
- (iii) Discuss the load cell.
- (iv) Write a note on $3\frac{1}{2}$ digits type DMM.
- (v) What is a 10:1 probe in CRO? How it works?
- (vi) With the neat circuit diagram, explain active positive clamper.
- (vii) Explain signal conditioning inputs of data acquisition system.
- (viii) Write a note on EMG.

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