

**2023**

**Time - 3 hours**

**Full Marks - 60**

*Answer all groups as per instructions.*

*Figures in the right hand margin indicate marks.*

*Candidates are required to answer  
in their own words as far as practicable.*

**GROUP – A**

1. Fill in the blanks. (all) [1 × 8
- (a) A neutral body when negatively charged gains \_\_\_\_\_.
- (b) The energy of an electric dipole of moment  $\mathbf{P}$  in an electric field  $\mathbf{E}$  is \_\_\_\_\_.
- (c) The electric field intensity just outside the charged conductor of surface charge density  $\sigma$  is \_\_\_\_\_.
- (d) The differential form of Ampere's law for steady current is \_\_\_\_\_.
- (e) The closed magnetic field lines of forces are represented by equation \_\_\_\_\_.
- (f) The relation between susceptibility and temperature of para-magnetic gas is \_\_\_\_\_.

[ 2 ]

- (g) The electrical inertia is represented by \_\_\_\_\_.
- (h) The time constant of L-R circuit is \_\_\_\_\_.

**GROUP – B**

2. Answer any eight of the following questions within two to three sentences each. [1½ × 8

- (a) What is Lorentz force ?
- (b) What is magnetic scalar potential ?
- (c) Explain the term power factor.
- (d) Write Gauss law in a dielectric medium.
- (e) Find Q-factor in a purely inductive circuit.
- (f) State Lenz's law.
- (g) What is Helmholtz coil ?
- (h) Write the expression for electrostatic energy of system of n charges.
- (i) What is the working principle of a Ballistic galvanometer ?
- (j) Write Laplace equation in three dimensional spherical polar co-ordinate system.

GROUP – C

3. Answer any eight of the following questions within 75 words each.

[2 × 8]

(a) The electric potential in a region of space is given by :

$$V(x, y, z) = 50x^2 - 75y$$

where V in volts and x, y and z in metres. Find the magnitude of electric field at point (1, 1, 0).

- (b) State Thevenin's theorem.
- (c) A capacitor of capacity  $0.5 \mu\text{F}$  and resistance  $10 \text{ M}\Omega$  (mega ohm) is charged to a potential difference of 10 volt. Find the time constant.
- (d) Define uniqueness theorem.
- (e) Assuming the earth be a spherical conductor of radius 6400 km, calculate its capacitance.
- (f) Define magnetic susceptibility and magnetic permeability.
- (g) Find the force on a current carrying conductor of length 'l' in magnetic field 'B'.
- (h) What is Logarithmic damping ?
- (i) Explain briefly B-H curve for ferromagnetism.
- (j) Find the differential form of Gauss law of electrostatics.

[ 4 ]

GROUP – D

4. Answer any four of the following questions within 500 words each.

(a) Explain the growth and decay of current in RC circuit. [6]

(b) Find the expression for resonant frequency in parallel LCR circuit. [6]

(c) Define **D**, **E** and **P**. Establish a relation between them. [3 + 3]

(d) Explain the construction and working of a ballistic galvanometer. [6]

(e) Deduce Faraday's law of electromagnetic induction in differential form : [6]

$$\text{curl } \mathbf{E} = \frac{-\partial \mathbf{B}}{\partial t}.$$

(f) Find electric field and potential due to a dipole at any axial point. [6]

(g) State and prove Ampere's circuital law. Apply it to find magnetic field due to a current carrying solenoid at its internal points. [3 + 3]

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**GROUP – A**

1. Answer all questions and fill in blanks as required. [1 × 8]
- (a) The condition for minimum spherical aberration for two thin lenses of focal lengths  $f_1$  and  $f_2$  separated by distance  $d$  is \_\_\_\_\_.
- (b) If focal length of eye lens in Ramsden's eyepiece is  $f$ , then separation between two lenses is \_\_\_\_\_.
- (c) What is dispersion of light ?
- (d) The distance between two successive compression zones in a medium in which a sound wave of 40 cm wavelength is travelling, is \_\_\_\_\_.
- (e) The relation of coherence length ( $L$ ) with quality factor  $Q$  is \_\_\_\_\_.

[ 2 ]

- (f) In Fresnel's biprism, the central fringe is \_\_\_\_\_.
- (g) In Michelson interferometer, where mirrors  $M_1$  and  $M_2$  are made slightly inclined, the fringes obtained are \_\_\_\_\_.
- (h) The intensity of principal maximum in the spectrum of grating having  $N$  slits is proportional to \_\_\_\_\_.

**GROUP – B**

2. Answer any eight of the following questions within two to three sentences each. [1½ × 8

- (a) Write down the relation between area of second half period Zone ( $A_2$ ) and that of the first half period Zone ( $A_1$ ).
- (b) Why does a zone plate have multiple foci ?
- (c) What is grating element of a diffraction grating ?
- (d) What would be the minimum number of lines drawn on diffraction grating so as to resolve the first order sodium doublet having a difference of wavelengths  $6 \text{ \AA}$  at a wavelength of  $5893 \text{ \AA}$  ?
- (e) How can you obtain circular fringes in the Michelson's interferometer.
- (f) Light of wavelength  $5896 \text{ \AA}$  falls normally on a thin wedge shaped film of refractive 1.5 forming fringes that are 2.5 mm apart. Find the angle of wedge.

[ 3 ]

- (g) What will happen when Young's double slit experiment is performed in water ?
- (h) Find the values of  $A$  and  $\theta$  such that  $\sin wt + \cos wt = A \cos (wt + \theta)$  in CGS units.
- (i) What is the most fundamental property of a wave and why ?
- (j) Why Ramsden's eye piece is called positive ?

**GROUP – C**

3. Answer any eight of the following questions within 75 words each.

[2 × 8

- (a) The equivalent focal length of an Huygen's eye piece is 6 cm. Calculate focal length of the field lens.
- (b) In a ripple tank, 10 full ripples per second are produced. The distance between a trough and a crest is 15 cm. Calculate (i) the frequency (ii) wavelength and velocity of ripples.
- (c) Why cannot we use a monochromatic wave for transmission of a signal ?
- (d) Light of wavelength 700 nm has coherence length  $14 \times 10^{-6}$  m. Find coherence time.
- (e) State Huygen's principle of wave theory of light.
- (f) What will happen to Newton's rings if monochromatic light is replaced by white light.

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- (g) In Young's double slit experiment, light of wavelength  $5000 \text{ \AA}$  is used to get an interference pattern on a screen. The fringe width changes by  $2.5 \text{ mm}$  when the screen moves towards the double slit by  $100 \text{ cm}$ . Find the distance between two slits.
- (h) Distinguish between Fresnel and Fraunhofer diffraction.
- (i) What is the difference between diffraction patterns produced by a single and a double slit ?
- (j) Find the radius of the first half period zone of a zone plate that behaves like a convex lens of focal length  $80 \text{ cm}$ . Given  $\lambda = 8000 \text{ \AA}$ .

**GROUP – D**

4. Answer any four of the following questions within 500 words each.
- (a) Discuss Fermat's principle in brief and prove laws of refraction with its help. [6]
- (b) Describe the construction, working and ray diagram of Ramsden's eye-piece. [6]
- (c) Show that the intensity of a progressive wave is independent of  $x$  and  $t$ . [6]
- (d) Explain how Newton's rings are formed and describe the method for determination of wavelength of light using Newton's rings. [6]



[ 5 ]

- (e) Discuss the Fraunhofer's diffraction at a single slit. [6]
- (f) What is a zone plate and how is it made ? Explain how a zone plate acts like a convergent lens having multiple foci. Derive an expression for its focal length. [6]
- (g) Explain the principle of Fabry Perot Interferometer. Obtain an expression for the intensity of transmitted light with the help of this interferometer. [6]

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**GROUP – A**

1. Fill in the blanks. (all) [1 × 8
- (a) Number of oscillations per second is called as \_\_\_\_\_.
- (b) During resonance, the amplitude of vibration becomes \_\_\_\_\_.
- (c) Entropy is the measure of \_\_\_\_\_ of a system.
- (d) Efficiency of a heat engine depends on the temperature of \_\_\_\_\_ and cold bodies.
- (e) The unit of moment of Inertia in S.I. system is \_\_\_\_\_.
- (f) Strain have \_\_\_\_\_ unit.
- (g) The maximum value of power factor is \_\_\_\_\_.
- (h) N-type semiconductor is electrical \_\_\_\_\_.

[ 2 ]

GROUP – B

2. Answer any eight of the following questions within two to three sentences each. [1½ × 8

- (a) Write down an expression for Lorentz Force.
- (b) Taking R, L and C as fundamental physical quantity, find dimensional formula for time.
- (c) What is reversible process ?
- (d) Write down Clausius Clapeyron equation.
- (e) Write down the condition of under-damped in damped harmonic motion.
- (f) Write down the formula for velocity of transverse wave in a stretched string.
- (g) A satellite of mass  $m$  is revolving in an orbit of radius  $R$  around earth of mass  $M$ . How much energy is needed to take it an orbit of radius  $2R$  ?
- (h) Write down the formula for moment of inertia of a solid sphere of mass  $m$  and radius  $R$  about its tangent.
- (i) What is a Cantilever.
- (j) What do you mean by forced vibration ?

[ 3 ]

**GROUP – C**

3. Answer any eight of the following questions within 75 words each.

[2 × 8

- (a) Draw the characteristics (V-I curve) of JFET.
- (b) Define  $\alpha$  and  $\beta$  for CB and CE circuits respectively.
- (c) Write down the condition of resonance in LCR series circuits.
- (d) Discuss about filter circuits.
- (e) Write down Planck radiation formula.
- (f) Write down Maxwell's thermodynamic relations.
- (g) State and explain perpendicular axis theorem.
- (h) Write down Poiseuille's formula.
- (i) Under what condition(s), we get 100% efficiency in Carnot engine ?
- (j) What are ripples and ripple factor ?

**GROUP – D**

4. Answer any four of the following questions within 500 words each.

- (a) Derive an expression for gravitational potential and field due to a thin spherical shell at an external point. [6

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[ 4 ]

- (b) Derive relations among elastic constants. [6]
- (c) What is Simple Harmonic Motion ? Show that acceleration is proportional to displacement in simple harmonic motion. [6]
- (d) Discuss about Lissajous figures for superposition of two orthogonal simple harmonic vibrations with same frequency. [6]
- (e) Derive differential equation for flow of heat in one dimension. [6]
- (f) Discuss about Growth and Decay of currents in LR circuit. [6]
- (g) State Gauss law of electrostatics and using it derive electrostatic field due to a linear charge distribution. [6]