'समानो मन्त्रः समितिः समानी'

UNIVERSITY OF NORTH BENGAL

B.Sc. Honours 4th Semester Examination, 2024

GE2-P2-PHYSICS

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.

The question paper contains GE-4A and GE-4B. Candidates are required to answer any *one* paper from the *two* papers and they should mention it clearly on the Answer Book.

GE-4A

ELECTRICITY AND MAGNETISM

GROUP-A

1. Answer any ***five*** questions from the following: $1\times5=5$

   (a) What do you mean by polarization of electromagnetic wave? 1

   (b) Give examples of paramagnetic and ferromagnetic materials each. 1

   (c) Write down the condition for which the vector $\vec{V}$ is solenoidal. 1

   (d) Write down the dimension of permittivity of free space. 1

   (e) What is the S.I. unit of capacitance? 1

   (f) What is the relation between 'Tesla' and 'Gauss'? 1

   (g) What do you mean by Curie temperature of a ferromagnetic material? 1

   (h) The direction of induced emf in a circuit is given by 1

   (i) Faraday's law (ii) Fleming's left hand rule

   (iii) Lenz's law and (iv) None of these

GROUP-B

Answer any *three* questions from the following $5\times3=15$

2. (a) State Gauss's law of electrostatics. 1

   (b) Applying Gauss's law, find the electrostatic field near a charged plane conductor. 3

   (c) Write down the Laplace's equation of electrostatics. 1

3. (a) Obtain an expression for the capacitance of a parallel plate capacitor. 3

   (b) A spherical conductor has radius of 1.2 m. Calculate the value of capacitance of the conductor in vacuum. 2

4. (a) Find out a unit normal vector to the surface $z^2 = x^2 + y^2$ at the point (1, 0, –1). 3

(b) If $\vec{A}$ and $\vec{B}$ are irrotational vectors, prove that $\vec{A} \times \vec{B}$ is solenoidal. 2

5. (a) If $\vec{F} = x\hat{i} + 2y\hat{j} + 3z\hat{k}$, then show that $\oint_S \vec{F} \cdot d\vec{S} = 6V$, where V is the volume enclosed by the closed surface S. 3

(b) Prove that the divergence of the curl of a vector is zero. 2

6. (a) Derive an expression for the magnetic field intensity at a point on the axis of a current carrying circular coil. 3

(b) What do you mean by the 'Magnetic susceptibility' and 'Magnetic permeability' of a material? 2

GROUP-C

Answer any *two* questions from the following 10×2 = 20

7. (a) Evaluate $\vec{\nabla}\left(\frac{1}{r^2}\right)$, where $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$. 3

(b) Establish a relation among $\vec{D}$, $\vec{E}$, and $\vec{P}$, where $\vec{D}$ = electric displacement vector, $\vec{E}$ = intensity of electric field and $\vec{P}$ = polarization vector inside a dielectric medium. 3

(c) Find the expression for electric field at a point due to an electric dipole. 4

8. (a) State and explain Lenz law of electromagnetic induction. 2

(b) Show that magnetic force does not work. 3

(c) Derive an expression for the co-efficient of self-inductance of a long uniformly wound solenoid. 3

(d) The equipotential surfaces do not intersect each other. — Explain. 2

9. (a) Write down the Maxwell's equation for a non-conducting medium. Use them to derive the electromagnetic wave equation. 2+4

(b) Obtain the energy density of an electromagnetic field. 3

(c) Write down the significance of the equation $\vec{\nabla} \cdot \vec{B} = 0$, where $\vec{B}$ = magnetic induction vector. 1

10.(a) State and explain Gauss-divergence theorem. 3

(b) If $\vec{F} = 2z\hat{i} - x\hat{j} + y\hat{k}$, evaluate $\iiint_v \vec{F}\, dv$, where v is the region bounded by the surfaces $x = 0$, $y = 0$, $x = 2$, $y = 4$, $z = x^2$, $z = 2$. 3

(c) What is the Poynting vector? Find its relation with electric and magnetic field vectors. 1+3

GE-4B

WAVES AND OPTICS

GROUP-A

1. Answer any ***five*** questions from the following: 1×5 = 5

   (a) Write down the Sabine's formula for the reverberation of sound wave. 1

   (b) What is the necessary and sufficient condition for interference of light wave to be observable? 1

   (c) What is a beat? 1

   (d) What do you mean by optically active medium? 1

   (e) What is the nature of the central fringe in a Newton's ring experiment with reflected wave? 1

   (f) What is grating element? 1

   (g) It is desired to use a plate of glass to determine polarization of light. If the refractive index of glass is 1.5, what is the polarizing angle? 1

   (h) State the factors on which the speed of a transverse wave on a string depend. 1

GROUP-B

Answer any *three* questions from the following 5×3 = 15

2. (a) What do you mean by circularly polarized and elliptically polarized light? 2

   (b) State and explain "Brewster's law" of polarization of light. 3

3. A wave group is formed by the superposition of two waves of equal amplitudes but slightly different frequencies and wavelength. Show that if v_g is the group velocity and v is the phase velocity, then 5

   (i) $v_g = v - \lambda \cdot \frac{dv}{d\lambda}$

   (ii) $v = \frac{w}{k}$ and $v_g = \frac{dw}{dk}$

4. Discuss the formation of Lissajous figures by the superposition of two simple harmonic motion when 3+2

   (i) The periods are in the ratio 1:2 and the amplitude and phases are different.

   (ii) The periods are the same but the amplitude and phases are different.

5. (a) What is a coherent source of light? Why two different sources of light cannot produce sustained interference? 1+2

   (b) What do you mean by 'Zone plate'? 1

   (c) What is damped oscillation? 1

6. Deduce the expression for the position of n^{th} bright fringe in a Young's double slit experiment. Comment on nature of fringes. 5

GROUP-C

Answer any *two* questions from the following $10\times2 = 20$

7. (a) Explain how interference is achieved in a Fresnel's bi-prism set up. Sketch the diagram and show the region of interference. 5

   (b) Write down the expression for the position of n^{th} dark and n^{th} bright fringe. 2

   (c) Obtain an expression of the fringe width of the fringe pattern observed in the region of interference. 3

8. (a) State Huygen's principle of propagation of wave. Explain how one can use it to explain the reflection of light from a plane interface. 2+4

   (b) Explain the working mechanism of Lloyd's single mirror for the production of interference. 4

9. (a) What do you mean by forced oscillation? Establish the differential equation of it. Mention the condition for the resonance. 1+3+2

   (b) Two linear simple harmonic motions of equal amplitude but frequencies ω and 2ω are imposed simultaneously on a particle along the x and y axes, respectively. If the initial phase difference between them is $\frac{\pi}{2}$, find out the resultant path followed by the particle. 4

10.(a) Briefly discuss the formation of stationary waves for the transverse vibration of a string under tension, and fixed at the two ends. 6

   (b) Find out the highest order of spectrum which may be seen with sodium light of $\lambda = 5\times10^{-5}$ cm by means of a grating with 3000 lines per cm? 4

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GE-4A

ELECTRICITY AND MAGNETISM

GROUP-A

1. Answer any ***five*** questions from the following: $1\times5 = 5$

   (a) Mention the names of one paramagnetic material and one ferromagnetic material.

   (b) Write down the relation between the two units 'Tesla' and 'Gauss'.

   (c) State Ampere's circuital law.

   (d) What do you mean by electric flux in an electric field?

   (e) What is the physical significance of divergence of a vector?

   (f) Write down the mathematical expression of 'Lorentz' force acting on a charged particle in a magnetic field.

   (g) Write down the Laplace's equation in electrostatics.

   (h) What do you mean by polarization of electromagnetic wave?

GROUP-B

Answer any *three* questions from the following $5\times3 = 15$

2. Applying Gauss' theorem find out the expressions of intensity of electric field at 3+2

   (i) a point inside of a uniformly charged solid dielectric sphere.

   (ii) a point outside of a uniformly charged solid dielectric sphere.

3. (a) Find the expression of capacitance of a parallel plate capacitor. 3

   (b) A spherical conductor has radius of 1.2 m. Calculate the value of capacitance of it in vacuum. 2

4. (a) What do you mean by 'Magnetic susceptibility' and 'Magnetic permeability' of a material? 2

(b) Establish the relation $\vec{D} = \varepsilon_0 \vec{E} + \vec{P}$, where 3

$\vec{D}$ = Electric displacement vector,

$\vec{E}$ = Intensity of electric field,

$\vec{P}$ = Polarization vector inside a dielectric medium.

5. (a) Calculate the value of divergence of a vector $\vec{A} = y\hat{i} + xz\hat{j} + xy\hat{k}$ at the point $(2, 1, -1)$. 3

(b) Find out the expression of gradient of $\frac{1}{r}$, where $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$. 2

6. (a) Show that $\oint_S \vec{r} \cdot d\vec{S} = 3V$, where V is the volume enclosed by the closed surface S. 2

(b) Prove that curl of the intensity of an electrostatic field is zero. 2

(c) Write down the significance of the equation, $\vec{\nabla} \cdot \vec{B} = 0$, where $\vec{B}$ = Magnetic Induction Vector. 1

GROUP-C

Answer any *two* questions from the following $10 \times 2 = 20$

7. (a) Applying Biot-Savart law, find out the expression of magnetic field at a point due to a straight thin current carrying conductor of finite length. 4+2

Extend the result to find the expression of magnetic field at a point due to a straight thin current carrying conductor of infinite length.

(b) Establish the relation among the vectors $\vec{B}$, $\vec{H}$ and $\vec{M}$, where 2

$\vec{B}$ = Magnetic Induction Vector

$\vec{H}$ = Intensity of Magnetic field

$\vec{M}$ = Magnetisation Vector.

(c) Find the magnetic induction field at the centre of a short circular coil 15 cm in diameter, containing 10 turns and carrying a current of 10 Ampere. 2

8. (a) Write down Faraday's laws of electromagnetic induction. 3

(b) "Lenz's law supports the principle of conservation of energy" — Explain with justification. 3

(c) Considering the length of the coil is much greater than the radius, find out the expression of self inductance of the coil in the form of a solenoid. 4

9. (a) What is displacement current? Which physical fact does it stand for? 1+2

(b) In a dielectric material conduction current is $0.02\sin(10^9 t)$ A/m^2. If electric conductivity and relative electric permitivity of the material are 10^3 s /m and 6.5, respectively, find out the expression of displacement current. 3

(c) Find the expression of electric potential at a point due to a very small electric dipole. 4

10.(a) State Gauss-divergence theorem and Stoke's theorem of vectors. 3

(b) What do you mean by transverse nature of electromagnetic wave? 2

(c) What is Poynting vector? State and explain the Poynting theorem. 1+2

(d) If a 100 Watt lamp is considered to be a point source of light emitting in all directions equally, calculate the value of Poynting vector at a distance of 10 m from the centre of the lamp. 2

GE-4B

WAVES AND OPTICS

GROUP-A

1. Answer any ***five*** questions from the following: $1\times5 = 5$

(a) What do you mean by beats?

(b) What is a Lissajous figure?

(c) What is the basic difference between interference and diffraction?

(d) What do you mean by extra-ordinary ray?

(e) It is desired to use a plate of glass to determine the polarization of light. If the refractive index of glass is 1.5, find out the polarizing angle.

(f) What happens in a medium when a harmonic wave passes through it?

(g) Explain why the equation $\psi(x, t) = a\sin(\omega t - kx)$ represents a plane wave.

(h) Define decibel.

GROUP-B

Answer any *three* questions from the following $5\times3 = 15$

2. Explain the formation of Newton's rings and deduce an expression for the diameters of the rings. 2+3

3. (a) An electromagnetic wave of angular frequency ω and wave vector k is propagating along the z-axis. Is it linearly polarized in the x-direction? Write down the equations representing the advancing electric and magnetic fields. 1+1

(b) Define half period zone. How can a plane wavefront be devided into a number of half period zones with respect to an external point? 1+2

4. Suppose two sound waves of equal amplitude and wavelength interfere with each other. Show that the distance between two consecutive minima is equal to the wavelength. 5

5. Discuss how reverberation time is measured. 5

6. Derive an expression for intensity of diffraction pattern produced by a single slit. 5

GROUP-C

Answer any *two* questions from the following $10\times2 = 20$

7. (a) Distinguish between the amplitude resonance and the velocity resonance. Show that at velocity resonance, 2+(2+2)

   (i) the maximum velocity is inversely proportional to damping parameter.

   (ii) the velocity of the oscillator is in phase with the driving force.

   (b) Give examples of vibrating systems which exhibit sharp and flat resonance responses. 4

8. (a) Three simple harmonic motions of same frequency act on a particle simultaneously in the same direction. Their amplitudes are 1 cm, 1.5 cm and 2 cm respectively. The phase angle of the second with respect to the first is 60° and that of the third with respect to the second is 30°. Obtain the resultant amplitude and phase angle relative to the first. 4

   (b) State Fourier's theorem and express it in mathematical terms. 2

   (c) Briefly discuss the requirements for good acoustics in a hall and auditorium. 4

9. (a) How can the wavelength of a monochromatic light be determined by a plane transmission grating? 3

   (b) Calculate the thickness of a quartz half wave plate for the line 600 nm for which ordinary and extra-ordinary refractive index are $\mu_0 = 1.54184$ and $\mu_e = 1.55085$ respectively. 4

   (c) Compare grating spectrum and prism spectrum. 3

10. (a) Describe Young's double slit arrangement and explain how coherent waves are obtained in this arrangement. Find out the width of fringes in a particular arrangement. 2+2+3

    (b) Calculate the distance between two successive positions of the movable mirror of a Michelson's interferometer giving distinct fringes in the case of sodium having lines of wavelength 5890 Å and 5896 Å. 3

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