WEST BENGAL STATE UNIVERSITY

B.Sc. Honours PART-II Examinations, 2018

PHYSICS-HONOURS

PAPER-PHSA-III

Time Allotted: 4 Hours | Full Marks: 100

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.

Use separate Answer Books for Unit-III-A and Unit-III-B

UNIT-III-A

Answer Question Number 1 and any *four* questions from the following

1. Answer any ***five*** questions from the following: 2×5 = 10

   (a) Show that the dimension of $\frac{\varepsilon}{\sigma}$ is the dimension of time. Where ε and σ denote the permittivity and conductivity of the medium respectively.

   (b) Show that the electrostatic field of a point charge is irrotational.

   (c) Obtain Coulombs law from Gauss's theorem.

   (d) The vector potential $\vec{A}$ and the scalar potential ϕ in a certain region of space are given by $\vec{A}=\frac{3}{2}(x\hat{j}-y\hat{i});\ \phi=\frac{3}{4}(x^2+y^2)$. Find the electric field corresponding to these potentials.

   (e) Show that the force on a closed current loop placed in an uniform magnetic field is zero.

   (f) The electric field in a region is given by $\vec{E}=8x\hat{i}-4y\hat{j}-4z\hat{k}$. Find the equation of lines of force in the plane $(z=0)$.

   (g) What is magnetomotive force? What is its unit?

   (h) State maximum power transfer theorem in electrical circuits.

2. (a) State Gauss's theorem in electrostatics and express it in differential form. 1+2

   (b) State and explain uniqueness theorem. 2

   (c) Using Coulomb's law of electrostatics and the principle of superposition of electric field, prove that the electric field $\vec{E}$ generated by any static charge distribution obeys the relation $\vec{\nabla}\times\vec{E}=0$. 2

   (d) Two uniform infinite sheets of electric charge densities $+\sigma$ and $-\sigma$ intersect at right angles. Find the magnitude and direction of the electric field and sketch the lines of *E*. 2+1

3. (a) What are polar and nonpolar molecules? 2

   (b) Show that the energy of a dipole in a uniform electric field E is given by $U = -\vec{P} \cdot \vec{E}$, where $\vec{P}$ is the dipole moment. 3

   (c) Determine the interaction energy between two electric dipoles of moments $\vec{p}_1$ and $\vec{p}_2$ separated by a distance $\vec{r}$. Hence find the condition for minimum energy. 3+2

4. (a) A small spherical cavity is cut in a dielectric where the electric field $\vec{E}$ is uniform. If $\vec{P}$ be the uniform polarization in the dielectric, prove by the method of boundary condition that the field inside a spherical cavity within an isotropic dielectric is given as $E_0 = \vec{E} + \frac{\vec{P}}{3\varepsilon_0}$. 2

   (b) Write down the solution to Laplace's equation in spherical polar coordinates assuming azimuthal symmetry. 2

   (c) Write down the boundary conditions when an uncharged grounded sphere of radius a is placed in a uniform field $\vec{E}_0 = E_0\hat{z}$. 2

   (d) Assuming the potential of form mentioned in (b) and using the boundary conditions in (c) show that the dipole moment due to induced charges on the sphere is $\vec{p} = 4\pi a^3 \varepsilon_0 E_0 \hat{z}$. 4

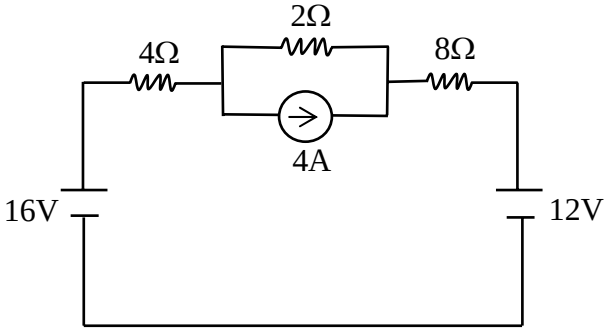
5. (a) What is meant by Hysteresis? Find an expression for the work done due to Hysteresis. 1+3

   (b) The vector potential $\vec{A}$ in a certain region is given by $\vec{A} = 2x\hat{j} - 3y\hat{i}$. Explain how will the lines of force look like. What is the direction of magnetic field $\vec{B}$ in the given space? 2+1

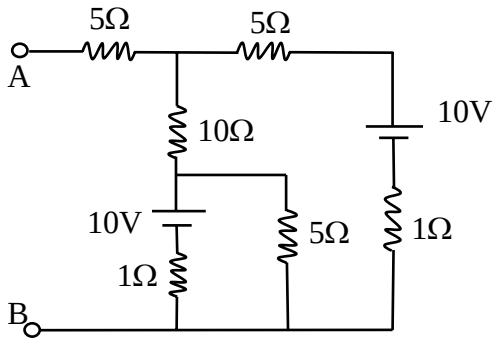
   (c) A 4.0 Mcv proton is falling vertically downwards in uniform field of magnetic induction 1.2 Weber/m^2, pointing horizontally from South to North. Find the force exerted on it. [Mass of proton = 1.7×10^{-27} Kg, Charge of proton = 1.6×10^{-19} C]. 3

6. (a) State and explain Thevenin's theorem. 2

   (b) Find the current flowing through 8-ohm resistor of the circuit given below using Superposition theorem. 4



(c) Thevenize the circuit given below: 4



7. (a) The magnetic flux linked with a coil is $\phi = 3t^2 + 4t + 8$ milliweber. Calculate the magnitude of e.m.f. induced in the loop when time t = 3 sec. 2

(b) Calculate the magnetic dipole moment due to the orbital motion of an electron. 2

(c) Examine the possibilities of magnetic field. 2+1

(i) $\vec{B} = 5x\hat{i} + 3y\,\hat{j} - 6z\hat{k}$, (ii) $\vec{B} = 2x\hat{i} - 5y\,\hat{j} + 3z\,\hat{k}$.

Hence find the steady current density that can give rise to the magnetic field $\vec{B}$.

(d) Show that equivalent inductance of two coils of self-inductance L_1, L_2 and mutual inductance M connected in parallel is given by $L_{eq} = \dfrac{L_1 L_2 - M^2}{L_1 + L_2 \mp 2M}$. 3

UNIT-III-B

Answer Question No. 8 and four other questions, at least, one from Question Numbers 9 & 10, one from 11 & 12 and one from 13 & 14

8. Answer any ***five*** questions from the following: 2×5 = 10

(a) In a medium of dielectric 5, the maximum conduction current at a frequency of 1 MHz. What is the conductivity of the medium?

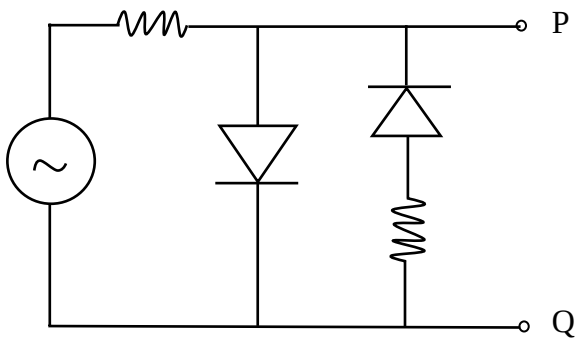
(b) What are major losses of a transformer? How can they be minimized?

(c) In a series LR circuit $X_L = R$ and the power factor of the circuit is P_1. When a capacitor with capacitance C such that $X_C = X_L$ is put in series, the power factor becomes P_2. Find out $\dfrac{P_1}{P_2}$. Where X_L and X_C denote the capacitive and inductive reactance respectively.

(d) What is sharpness of resonance? How is it relates with Q-factor?

(e) An electric bulb of P watt radiates energy isotropically. Assuming it to be a point source find the electric field intensity at a distance r away from it.

(f) Consider the following circuit with two identical Si diodes. The input waveform has peak voltage 2 V, draw the output waveform across *PQ*.



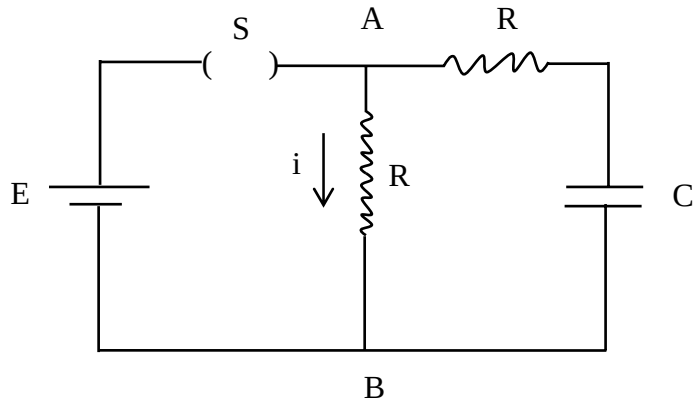
(g) Without using truth table show that

$$ABC + A\overline{B}C + AB\overline{C} = A(B + C)$$

(h) What do you mean by base width modulation in a bipolar junction transistor?

9. (a) A fully charged capacitor is suddenly connected to a pure inductor L. Find out expressions for charge in the capacitor and current in the circuit. Find also the expressions for electric, magnetic energies and express them graphically. 2+1+1+1+1

(b) Fig. shows a circuit with an ideal battery of e.m.f. E. The capacitor is initially uncharged. The switch is closed at $t = 0$. Find the expression for current 'i' through the branch AB as a function of time. 4

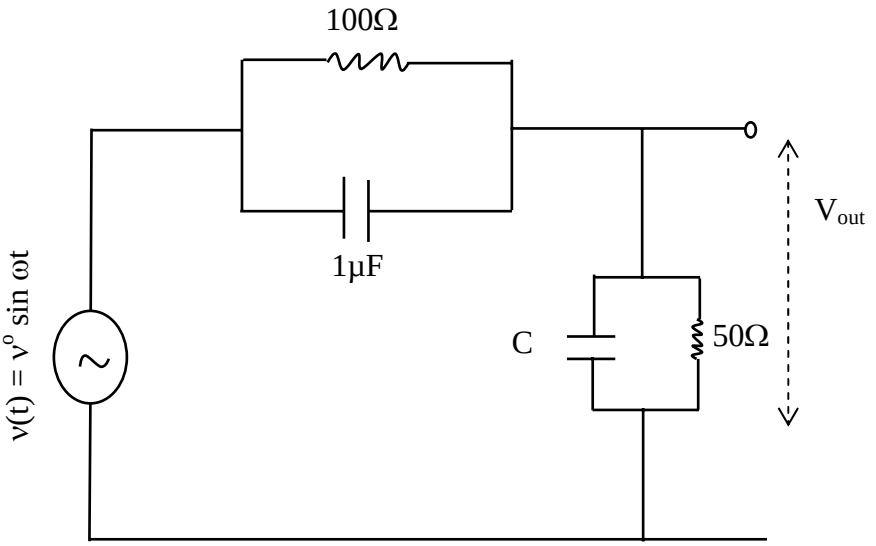


10.(a) Explain physically why the reactance of an inductor increases and that of a capacitor decreases with the increase in frequency. 2

(b) Why is a parallel LC circuit inductive but a series LC circuit is capacitive resonant frequency? 2

(c) A coil of inductive reactance 3Ω and resistance 4Ω is connected in parallel with a capacitor branch having a capacitive reactance 8Ω and series resistance 6Ω. The applied line voltage is 1100 V (rms) at a frequency of 50 Hz. Calculate the power factor. 3

(d) Determine the component relationships for the circuit shown in Fig. in order to achieve a frequency independent voltage divider. 3



11.(a) State the Poynting theorem. Establish the differential form of this theorem. 1+3

(b) Show that the average energy density in a harmonic electromagnetic field is 2

$$< u >= \frac{1}{4}\mathrm{Re}[\vec{E}\cdot\vec{D}^{*} + \vec{H}\cdot\vec{B}^{*}]$$

Where $\vec{D}^{*}$ and $\vec{B}^{*}$ are complex conjugates of $\vec{D}$ and $\vec{B}$.

(c) Starting from Maxwell's equations show that in a homogeneous isotropic dielectric medium of permittivity ε and permeability μ the velocity of an electromagnetic wave is given by $v = \frac{1}{\sqrt{\mu\varepsilon}}$. 2

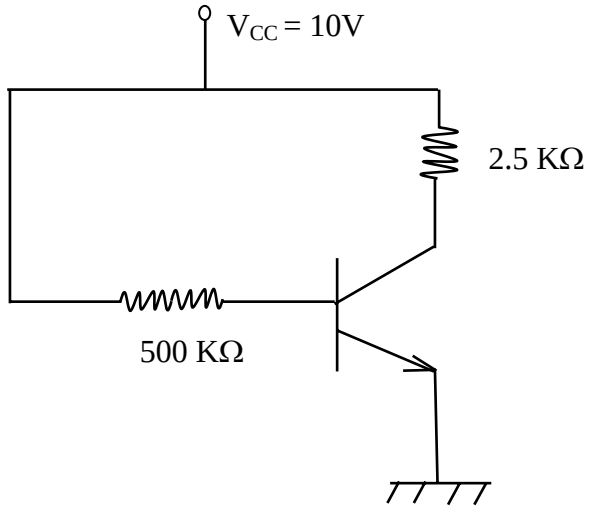
(d) Light waves fall normally on water-glass interface. If the refractive index of water and glass are respectively 1.3 and 1.5. Find the percentage of incident energy transmitted into glass. 2

12.(a) Starting from the equation of motion for electrons in a radiating field, find the frequency dependence of refractive index. Show the dependence in graph. Hence derive Cauchy's law of dispersion. 3+1+2

(b) What do you mean by TE, TM waves? Show that TEM waves cannot occur in a hollow guide. 2+2

13.(a) What are the factors responsible for the shift of operating point (*Q*-point) of a transistor amplifier? 2

(b) Determine the operating point for Si-transistor circuit given below: 4



Given: $\beta = 100$ and $V_{BE} = 0.7$ V.

(c) Establish NAND gate as an universal gate. 3

(d) Find the hexadecimal equivalent of $(0.25)_{10}$. 1

14.(a) What factors determine the colour and intensity of the emitted light in a LED? 2

(b) What are the advantages of using h-parameters in transistor equivalent circuit? 2

(c) Draw the NOR gate using discrete circuit elements (diodes, transistors, resistances etc.). 2

(d) The decimal number 65 is converted to 1001 in a number system, find the base of the number system. 2

(e) An equality detector gives an output 1 when both inputs are same – Implement the circuit. 2

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PHYSICS-HONOURS

PAPER-PHSA-IV-A

Time Allotted: 2 Hours | Full Marks: 50

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.

Answer Question. No. 1 and any *four* questions from the rest, taking at least *one* from each group.

1. Answer any ***five*** questions from the following: 2×5 = 10

   (a) Why does an eyepiece consist of two lenses instead of one?

   (b) Construct the translation matrix under paraxial approximation.

   (c) Define linear and angular magnification of an optical system.

   (d) Explain the term wavefront and ray.

   (e) Distinguish between Fresnel and Fraunhofer type of diffraction.

   (f) What is meant by specific rotation of an optically active substance? What are the physical parameters that it depends on?

   (g) What is meant by Rayleigh's criterion of resolution? Explain with diagram.

   (h) In Young's double slit experiment, what happens to the spacing between the fringes if (i) wavelength of incident light is decreased and (ii) slit separation is increased.

Group-A

2. (a) State Fermat's principle and using it drive the laws of refraction at a spherical surface. 1+4

   (b) Consider a system of two convex lenses of focal length 20 cm and 10 cm situated at a distance of 10 cm apart in air. Find the equivalent focal length, the positions of the two principal focal points and the two nodal points. 5

3. (a) Define cardinal points of a lens system. 3

   (b) Consider a sphere of radius 20 cm and refractive index 1.6. Find the position of the paraxial focus and unit planes for the sphere using matrix methods. 4

(c) A prism produces a minimum deviation of 50° for a certain angle of incidence. The same prism produces a deviation of 63° for two angles of incidences namely 40° and 83°. Find the refractive index of the prism. 3

4. (a) What do you mean by magnifying power and resolving power of a compound microscope? 2+2

(b) What do you mean by chromatic aberration of a lens? What is a achromatic doublet? 2+2

(c) Define optical path. 2

Group-B

5. (a) What is a zone plate? Derive an expression for its focal length. 1+3

(b) Explain how circular fringes are produced in a Michelson interferometer. Show that the radii of these circular fringes is proportional to the square root of natural numbers. 3+3

6. (a) Derive an expression for the intensity distribution for Fraunhoffer diffraction pattern formed by a double slit. 4

(b) What is meant by missing orders in a double slit diffraction pattern? 2

(c) In a biprism experiment, the fringe width is 0.3 mm at a distance of 150 cm from the biprism for light of wavelength $\lambda = 6\times10^{-5}$ cm. The biprism is made of glass of refractive index 1.5 and is placed 25 cm away from the illuminated slit. Calculate the vertex angle of the biprism. 4

7. (a) Give Fresnel explanation of rotation of plane of polarisation by an optically active substance. 4

(b) What is meant by rotatory dispersion? 2

(c) What is meant by elliptically polarized light? Show that plane and circularly polarized light are special cases of elliptically polarized light. 4