UG/II/PHS/H/III/16(Old)

2016

PHYSICS

[Honours]

PAPER – III

Full Marks : 90

Time : 4 hours

The figures in the right hand margin indicate marks

Candidates are required to give their answers in their own words as far as practicable

Illustrate the answers wherever necessary

[OLD SYLLABUS]

GROUP – A

Answer any **two** questions : 15 × 2

1. (*a*) What is magnetic vector potential ? Using the concept of vector potential deduce Biot-Savart law. 2 + 3

(*b*) State and establish Poynting's theorem. Show that the theorem can be expressed by

$$\frac{\partial u}{\partial t} + \vec{\nabla} \cdot \vec{S} = 0$$

where $\vec{S} = \frac{1}{\mu_0}(\vec{E} \times \vec{B})$ and u is the total electromagnetic energy density. 1 + 3 + 1

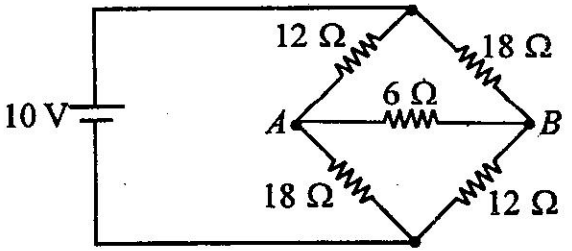
(*c*) Write down the expression for $\vec{B}$ due to a straight current carrying conductor at a distance '*r*' from it. Use this to obtain the field at the center of a square loop carrying current I. If R denotes the distance from the centre to the side, estimate the field when $I = 1$ amp and $R = 10$ cm. 1 + 3 +1

2. (*a*) Consider normal incidence of electromagnetic wave at the boundary between two non-conducting media. Write down the electric and magnetic field vectors for the incident, reflected and transmitted wave assuming the boundary to be *y*-*z* plane. Write down the boundary conditions and obtain transmittance. 2 + 2 + 2

(*Continued*)

(*b*) Find Brewster's angle in terms of the refractive indices, of the two media. Show that the angle between reflected and transmitted beams is 90° when beam is incident at Brewster's angle. 2 + 2

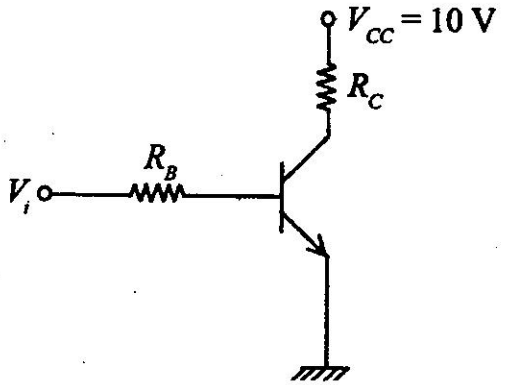
(*c*) Using Thevenin's theorem find current through 6Ω (connected across AB) in the following ckt : 5



3. (*a*) Write down the relationship between the current and voltage in a *p-n* junction diode. Using this expression explain the variation of the current with voltage for a diode in both the reverse and forward biased condition. 4

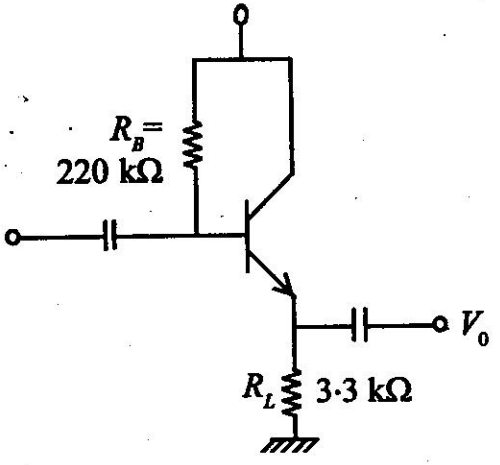
(*b*) Establish the relation $I_C = \beta I_B + (1 + \beta) I_{CBO}$ for a transistor in active CE mode. 3

(*c*) In the given NOT circuit calculate R_B and R_C



Input voltage V_i is 0V or 10V; $\beta = 250$, $(I_C)_{sat} = 10$ mA. 3

(*d*) Consider the emitter follower configuration, in the fig. Assuming $h_{fe} = 100$, $h_{ie} = 1260\ \Omega$, $h_{re} = h_{oe} \cong 0$. Calculate the input and output impedances and the voltage gain. 2 + 2 +1



4. (*a*) What is 2's complement ? Convert a decimal number-18 into an equivalent binary convert a hexadecimal number D6A3·52 to a decimal number. 1 + 1 + 2

(*b*) State de Morgans theorem's in Boolean algebra. 2

(*c*) Show that in a conductor the electric and magnetic field of a propagating em wave are no longer in phase. 4

(*d*) Make a comparative study between a magnetic circuit and an electric circuit.

Deduce fundamental equation of a magnetic circuit. 2 + 3

GROUP – B

Answer any **five** questions : 8 × 5

5. (*a*) Find the potential due to an electric dipole of dipole moment $\vec{p}$. 3

(*b*) Show that the potential due to an arbitrary charge distribution of finite extent at a large distance can be expressed as a sum of multipole potentials. 5

6. (*a*) Show that the electric field produced by a polarized dielectric can be given as that, due to a found surface charge density $\sigma = \vec{p} \cdot \hat{n}$ and a volume charge density $\rho = -\vec{\nabla} \cdot \vec{p}$, where $\vec{p}$ is the polarization and $\vec{n}$ is the unit vector normal to the surface of the dielectric. 4

(*b*) Which one of the following is an impossible electrostatic field ?

(*i*) $\vec{E} = \left[xy\hat{i} + 2yz\hat{j} + 3xz\hat{k} \right]$

(*Continued*)

(*ii*) $\vec{E} = y^2\hat{i} + (2xy + z^2)\hat{j} + 2yz\hat{k}$ 4

7. (*a*) A uniformly charged sphere rotates with a constant angular velocity. Calculate the magnetic induction at the centre of the sphere. 4

(*b*) Show that inhomogeneous magnetization, $\vec{M}$, gives rise to a volume current density $\vec{J}_b = \vec{\nabla} \times \vec{M}$ within the matter. Symbols have usual meaning. 4

8. (*a*) Show that the magnetic field at a large distance $\vec{r}$ due to a small current loop having magnetic moment $\vec{m}$, is

$$\vec{B}(\vec{r}) = \frac{\mu_0}{4\pi}\left[\frac{3(\vec{m}\cdot\vec{r})\vec{r}}{r^5} - \frac{\vec{m}}{r^3}\right]$$ 4

(*b*) A sphere of radius R carries a polarization $\vec{p} = k\vec{r}$, where k is a constant and r is the distance measured from the centre of the sphere. Calculate the surface and volume

charge densities. What will be the electric field at a distance larger than R ? 4

9. (*a*) A parallel L-C combination is connected in series, with a resistance R. If a sinusoidal voltage $v_i \sin wt$ is applied to this circuit, calculate the output voltage taken across the L-C combination. You may consider the components ideal. Show that this voltage reaches a maximum when $w = \frac{1}{\sqrt{LC}}$. 4

(*b*) A plane electromagnetic wave falls obliquely on the interface between two dielectrics. The electric field vector is normal to the plane of incidence. Obtain an expression for the reflection and transmission coefficients. 4

10. (*a*) Draw output characteristics, curves of an *n-p-n* transistor in CB mode, clearly showing the three regions of operation. Explain the nature of the curves in the active region. 4

(*b*) Prove the Boolean Identity :

$$AB + B\overline{C} + \overline{A}(B + C) + \overline{B}C + \overline{ABC} + ABC = \overline{A} + B + C \quad 2$$

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

11. (*a*) Given that $\phi = 0$

$$\vec{A} = \begin{cases} \frac{\mu_0 \infty}{4c}\left(ct - |x|\right)^2 & \text{for } |x| < ct \\ 0 & \text{for } |x| > ct \end{cases}$$

Find $\vec{E}$ and $\vec{B}$. 4

(*b*) A three variable truth table has a high output for these input conditions : 111, 010, 100 and 110. Find the Boolean expression and the corresponding logic circuit. 4

12. (*a*) Find the retarded potentials of an oscillating electric dipole. 6

(*b*) When the incident frequency is about the resonant frequency in case of dispersion, in a

dielectric, the refractive index becomes less than 1. How do you explain this ? 2

GROUP – C

Answer any five questions : 4 × 5

13. + q charges are placed on the vertex of a regular pentagon. Determine the electric field at its centre. 4

14. Explain how Maxwell modified Ampere's circuital law, for steady currents. How does the displacement current change, if the frequency of the source is increased. 4

15. An electron(charge e, mass m) revolves around a nucleus, (charge e) in a circular orbit of radius r with speed v. The electrostatic force supplies the necessary centripetal force.

    (*i*) Calculate the current and magnetic dipole moment due to the orbital motion of the electron.

    (*ii*) Write down the force equation.

(*iii*) When the electron is placed in a uniform magnetic field $\vec{B}$ perpendicular to $\vec{v}$, how is the force equation modified ? 2 + 1 + 1

16. Find the vector potential inside and outside of an infinite solenoid, with n turns per unit length, radius R and current I. 4

17. A wire of length 1 meter moves at right angles to its length at a speed of 100 ms^{-1} in uniform magnetic field 1 weber/m^2 which is also acting at right angles to the length of the wire. Calculate the emf induced in the wire when the direction of motion is

(*i*) at right angles to the field

(*ii*) inclined at 30° to the direction of the field. 2 + 2

18. Using Thevenin's theorem find the unbalanced current through the galvanometer of a Wheatstone bridge supplied with an ideal voltage source. Hence find the balance condition of the bridge. 3 + 1

19. Implement the Boolean function $X = AB + \bar{A}C$ with NAND gates. 4

20. Two identical point charges are separated by distance $2d$ in air and an insulated uncharged conducting sphere of radius a, is positioned midway between them. If $a << d$, prove that the introduction of the sphere, reduces the force experienced by either point charge to $[1 - 24a^5/d^5]$ times its original value. 4