UG/II/PHS/H/III/17(Old)

2017

PHYSICS

[Honours]

PAPER – III

Full Marks : 90

Time : 4 hours

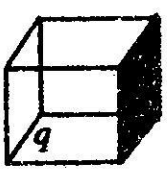
The figures in the right hand margin indicate marks

[OLD SYLLABUS]

GROUP – A

Answer any **two** questions : 15×2

1. (*a*) A change q sits back corner of a cube. What is the flux of $\vec{E}$ through the shaded side.



2

(*b*) A hollow spherical shell carries a change density $\rho = \frac{k}{r^2}$ in the region $a < r < b$. Find the electric field in the three regions (*i*) $r < a$, (*ii*) $a < r < b$, (*iii*) $r > b$. 4

(*c*) A dielectric sphere of radius and a permitivity ϵ_1 is placed in a uniform electric field $\vec{E}$ in a medium of permitivity ϵ_2. Using Laplace's equation find the electric field at the internal and the external point. Also show that the polarization induced in the sphere is given by $\vec{P} = \frac{3\epsilon_1\epsilon_2}{\epsilon_1 + \epsilon_2}\vec{E}$. Find the induced surface change density. 6 + 2 + 1

2. (*a*) A wire carrying current *I* is bent into the form of a regular hexogon. The distance of any vertex from the centre of the polygon is *r*. Find the megnetic field at its centre. Extend this result for the *n* sided polygen ($n \to \alpha$) and discuss on this results. 4 + 2 + 1

(*b*) Verify that the magnetic vector potential $\vec{A}$ due to uniform magnetic field $\vec{B}$ is given by

$$\vec{A} = -\frac{1}{2}(\vec{r} \times \vec{B}).$$ 4

(*c*) Find the mutual inductance between two parallel coaxial loops, one loop being small compared with the second loop. 4

3. (*a*) Write down Maxwell's equations in a conducting medium. Derive the wave equations. Hence, show that a plane electromagnetic wave is attenuated as it propagates through the medium. What is skin depth ? Indicate region of the electromagnetic spectrum in which the surface of a pure silver wave guide and that of a silver coated brass wave guide appear to be identical. 2 + 2 + 2 + 2 + 1

(*b*) The intensity of sunlight reacting the earth's surface is about 1300 wm^{-2}. Calculate the strength of electric and magnetic fields of the incoming sunlight. 4

(*c*) Consider a parallel plate capacitor immersed in sea water. The change on the capacitor is varied according to $q = q_0 \sin 2\pi \nu t$, where $\nu = 4 \times 10^8$ Hz. At this frequency sea water has permitivity $\epsilon = 81\ \epsilon_0$ and resistivity $\rho = 0.23\ \Omega$/m. Compare the amplitude of the conduction and the displacement current between the plates. [$\epsilon_0 = 8{\cdot}85 \times 10^{-12}$ F/m] 2

4. (*a*) Explain the concept of space change. How does it affect the potential distribution in the space between two parallel plane electrodes of a vacuum diode. 1+ 2

(*b*) Derive child language law for the space change limited current in a vacuum diode. 5

(*c*) Extend childs law for diode valve to triode valve. Hence discuss the dependence of triode parameters on plate current. 1 + 2

(*d*) Convert form binary system to decimal system 11·1101. 2

(*e*) Establish the following identity of Boolean algebra.

$$AB + \bar{A}C + BC = AB + \bar{A}C \qquad 2$$

GROUP – B

Answer any **five** questions : 8×5

5. (*a*) Draw the small signal low frequency hybrid parameter equivalent circuit of a CE amplifier and derive expression for current gains and input impedance. 2+ 2 + 2

(*b*) A transistor in CE mode is connected with a resistance 5 kΩ and a power supply of 5V in the collected circuit. If $\alpha = 0{\cdot}998$ and the voltage drop across the 5 kΩ resistor is 5V, find the base current (assume the transistor is in active region). 2

6. (*a*) A Sinusoidal voltage $v = V_0 \cos wt$ is applied to a series LCR circuit. 1 + 1 + 2 + 1

(*i*) Find an expression for the instantaneous current in the circuit.

(*ii*) Find the value of w at which power consumed by the circuit becomes maximum.

(*iii*) Find the two half power frequencies and hence, the Q of the circuit.

(*b*) How the logic function $A\bar{B}+\bar{A}B$ can be realised by using NAND only. 3

7. (*a*) A sphere of radius R carries a charge density $\rho(r) = kr$ (k is a constant). Find the energy of the configuration. 4

(*b*) Show that the dipole moment of an arbitrary change distribution is independent of the choice of the origin in the total change of the distribution is zero. 2

(*c*) Calculate the dipole moment for a spherical shell of radius R, which carries a surface change $\sigma = k\cos\theta$. 2

8. (*a*) A point change q is placed at a distanced from the centre of a grounded conducting sphere of radius a ($d > a$). Using the method of images find the potential at an external point and find the density of induced surface change on the sphere. 5

(*b*) Design a 10V regulated power supply of 10 mA current rating using a pair of zener diodes and an unregulated supply 12 to 15V. Assume $I_{z,\,min} = 0{\cdot}2$ mA. 3

9. (*a*) What do you mean by normal and anomalous dispersion ? 2

(*b*) A mono chromatic plane EM wave of angular frequency w is incident on a gaseous mediums containing N molecules per unit volume. Set up the equation of motion for the bounded electrons. Find the dielectric constant of the medium. 5

(*c*) The dielectric constant of water under static condition is about 80. So its refractive index (n) to be about $\sqrt{80}$. But from optics we know that $n \cong 1.33$. Explain the discrepancy. 1

10. An EM wave is propagating through a non-conducting medium characterised by permitivity $5 \in_0$ and permeability $2 \mu_0$. The magnetic field associated with the wave is

$\vec{H} = \hat{y}\, 2\cos(3z - wt) A/m$. 1+2+1+2+2

(*i*) Find the value of w.

(*ii*) Find the electric field associated with the wave.

(*iii*) What is the direction of the propagation of the wave ?

(*iv*) Find the time average of Poynting's vector.

(*v*) Find the total time average power carried by the wave through 100 cm^2 of area on the plane $y + 2z = 5$.

11. (*a*) Describe Millikan's oil drop method of measuring the electronic change. What correction did Millikan apply and why? 4 + 2

(*b*) A relay has an inductance of 10H and a resistance of 100 Ω and operates with a current of 2mA. How long will the relay take to operate when a voltage 0·5V is suddenly applied across it? 2

12. (*a*) Find the mutual force between two current carrying parallel circular coaxial coils of nearly the same radius. For what distance between the coils the force would be maximum? 2 + 2

(*b*) Suppose a long cylinder of radius a carries a magnetisation $\vec{M} = kr^2\hat{\theta}$ (k = constant), r is the distance from the axis and $\hat{\theta}$ is usual unit vector in (r, θ, z) cylindrical coordinate system. Find magnetic field due to $\vec{M}$ both inside and outside the cylinder. 4

GROUP – C

Answer any **five** questions : 4×5

13. (*a*) Eleven equal changes q, are situated at in corner of a regular 12 sided polygon of which one corner is free from charge. What is the net force on a test change Q at the centre. 2

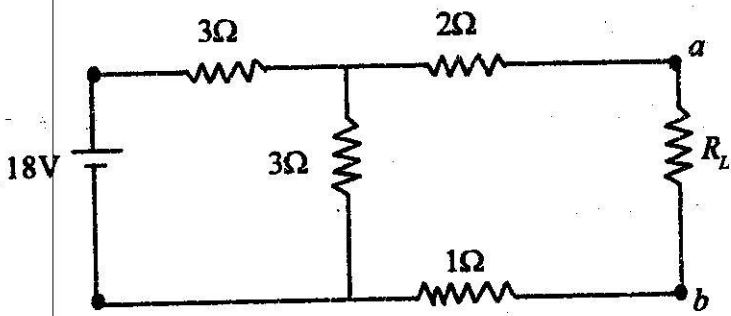
(*b*) Find the capacitance per unit length of two coaxial metal cylindrical tubes of radii a and b. 2

14. The electronic change in a hydrogen atom is distributed in the following way :

$$\rho(r) = -\frac{e}{\pi a^3} e^{-2r/a}$$

where a is the Bohr radius. The proton is located at the centre. When a small external electric field is applied, the protein moves relative to the centre of electronic charge cloud. Find the polarizability of a hydrogen atom. 4

15. Consider the following ckt. find the value of R_L such that maximum power is delivered to it. Also find the value of maximum power. 4



16. (*a*) A closed ring of ferromagnetic material having mean diameter 20 cm and cross-sectional area 3 cm^2 is wound over by 100 turns of wire. What current must be passed through these turns to produce a magnetic flux of 6×10^{-4} wb in the ring (relative permeability = 1500). 2

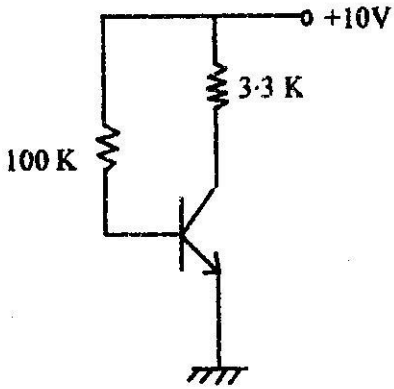
(*b*) If the above ring is cut into two spices and kept separated from each other by two equal gaps of width 0·5 mm. Find the current required to produce the same flux. 2

17. Suppose a wire of radius a, length l and resistance R is carrying a steady current I with a potential difference V across its length. Find $\vec{E}$ and $\vec{H}$ on the surface of the wire. Calculate the Poyntings vector $\vec{S}$ and show that it represents a flow of energy into the wire form the space. Interpret in the results. 4

18. A plane polarized EM wave with its electric vector parallel to the plane of incidence is incident obliquely on the interface between two simple dielectric. Obtain the expressions for the amplitude reflection coefficient. Hence establish Brewster's law. 4

19. The transistor in the fig. has $\beta = 100$ and $I_{CBO} = 20$ nA. Calculate I_B, I_C, V_{CE} and hence

decide in which region the transistor operates. Given $(V_{BE})_{active} = 0{\cdot}7\ V$; $(V_{BE})_{sat} = 0{\cdot}8\ V$; $(V_{CE})_{sat} = 0{\cdot}2\ V$. 4



20. A bridge rectifier feeds a load resistance of 2500 Ω from a 30V (rms) supply. Each diode of the rectifier has a forward resistance of 50 Ω. Calculate

(*i*) The dc load voltage at output

(*ii*) The ripple voltage at the output

(*iii*) The percentage regulation

(*iv*) The efficiency of rectification. 4