2015

PHYSICS — HONOURS

Third Paper

Full Marks – 100

The figures in the margin indicate full marks

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

Question No. 1 is compulsory. Answer ***any eight*** questions taking ***four*** from each **Unit**

1. Answer ***any ten*** of the following questions : 2×10

(a) An amplifier with mid gain $|A| = 500$ has negative feedback $|\beta| = 0.01$. If the upper cut-off frequency without feedback was at 50 kHz, then calculate its value with feedback.

(b) Derive an expression of the output voltage as a function of input frequency when a sine wave is applied to the input of a practical integrator with OPAMP.

(c) What do you mean by 'forbidden' condition in a flip-flop ?

(d) Magnetic vector potential is given by $\overline{A} = e^{-x}\sin y\hat{i} + (1+\cos y)\hat{j}$. Calculate the magnetic induction.

(e) Show that in a magnetized material where there is no free current, $\overline{H}$ can be written as the gradient of a scalar potential which satisfies Laplace's equation.

(f) An AC circuit connected to a 220V, 50 Hz supply contains a 20H coil of resistance 100Ω connected in series with a 1μF capacitor. Calculate the power factor of the circuit.

(g) Charges of amount 'q' are placed on the vertices of a regular pentagon. Determine the electric field at its centre.

(h) Find the quadrupole moment of a real dipole with two opposite charges separated by a distance 'a'.

(i) A metal sphere of radius 'a' is surrounded out to a radius 'b' by a linear dielectric material of permittivity ε. Determine the capacitance of the sphere.

(j) How can you test the optical flatness of a glass plate by using Newton's ring ?

(k) What is meant by resolving power of a plane transmission grating ?

(l) What is Brewster's law ?

Unit – 5

2. (a) Consider a class A CE-amplifier having resistive load. Prove that power dissipation in the transistor will depend on the amplitude of amplified signal. 3

(b) Draw an analog computer circuit using OPAMP to solve the following simultaneous equations : (i) $5x + 2y = 12$, (ii) $2x + 3y = 6$. 3

(c) What is a power amplifier ? How does it differ from a voltage amplifier and a current amplifier ? 4

3. (a) What are the basic requirements for getting steady oscillation at a fixed frequency from an oscillator ? 2

(b) Derive the expression of impedance of a vibrating piezoelectric crystal. Plot the impedance vs. frequency. Draw a circuit diagram of a crystal oscillator operating in a parallel resonant mode. 2+1+1

(c) Tank circuit of a Hartley oscillator consists of a capacitor 250 pF and two coils each of inductance 1.5 mH. If the mutual inductance between the coils is 0.5 mH, what is the frequency of oscillation ? 2

(d) The peak-to-peak voltage of an AM wave is 2.24 V and the dip-to-dip voltage is 0.96 V. Calculate the percentage modulation. 2

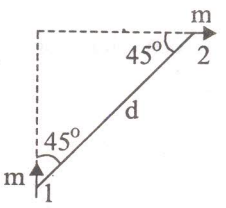
4. (a) Distinguish between combinational and sequential logic circuits. 2

(b) Design a 4 to 1 multiplexer using basic gates. 3

(c) Draw the circuit diagram of a 4 bit ripple counter using 4 JK flip-flops(FF). Explain its working. 3

(d) What are the advantages of synchronous counter over asynchronous counter ? 2

5. (a) Two magnetic dipoles of magnitude 'm' each are placed in a plane as shown. Calculate the energy of interaction. 3



(b) A proton moving with a velocity 0.6 c is placed at a distance of 10 cm from an infinitely long wire carrying a current of 1 A parallel to the direction of motion of the proton. Calculate the force experienced by the proton. Given that $\mu_0 = 4\pi \times 10^{-7}$ H/m. 3

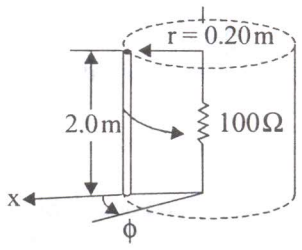
(c) Two long rigid wires separated by a distance 'd' and placed parallel, carry current I in the same direction. Determine the force developed / length. Now a third wire is placed in between the rigid wires, keeping it parallel and carrying same current in opposite direction. Determine the type of motion if this wire is displaced by a small amount 'x' ($x << d$) normal to its length. (Three wires are coplanar.) 4

6. (a) Derive the general expression of reluctance of a magnetic circuit. What is its unit ? 3

(b) Plot the variation of relative permeability of a magnetic material with magnetic field intensity during magnetization. Explain the nature of plot. How can a material be demagnetized from its initial state of magnetization ? Explain with the help of hysteresis loop. 4

(c) Two magnetic media are separated by a plane interface. Establish a relation of angles between the normal to the boundary and the **B** fields on either side. 3

7. (a) The 2.0 m conductor shown in Figure rotates at 1200 rev/minute in the radial field $\overline{B} = 0.1\sin\phi\hat{r}$ (T). Find the current in the closed loop with a resistance of $100\,\Omega$. 3



(b) Determine the self inductance of a toroid with N number of uniform turns. The inner and outer radii of the toroid are r_1 and r_2 respectively. Height of the toroid is h. 3

(c) Two coils with inductances L_1 and L_2 have resistances R_1 and R_2 respectively. They are connected in parallel and fed from an AC source. Determine the mutual inductance between the coils if the currents in the two coils are in phase. 4

Unit – 6

8. (a) Spherical charge distribution has been expressed as :

$$\rho = \rho_0\left(1 - r^2/a^2\right) \quad \text{for} \quad r \le a$$

$$= 0 \quad \text{for} \quad r > a$$

Find the electric field intensity and potential inside (r<a) the charge distribution. 4

(b) Use Laplace's equation to find the capacitance of air-filled spherical capacitor. 3

(c) Determine the force on an electric dipole placed within an inhomogeneous electric field. 3

9. (a) Starting from Coulomb's law, prove that $\overline{\nabla} \times \overline{E} = 0$. Explain its physical significance. The electric field in a region is given by $\overline{E} = kr^3\hat{r}$. Calculate the charge contained within a spherical surface of radius 'a' centered at the origin. 2+1+3

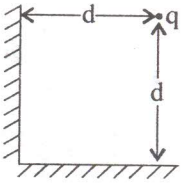
(b) A circular disc of radius 'a' on the xy plane has a surface charge density, $\sigma = \sigma_0 r\cos\theta/a$. Calculate the electric dipole moment of this charge distribution. 4

10. (a) Determine the electrostatic field energy in presence of a dielectric. 2

(b) Show that the electric field produced by a polarized dielectric can be given by the contributions from a bound charge density $\sigma = \overline{P}.\hat{n}$ and a volume charge density $\rho = -\overline{\nabla}.\overline{P}$. 3

(c) Show that the dipole moment of a charge distribution is independent of the choice of the origin if total charge vanishes. 3

(d) A point charge 'q' is placed symmetrically at a distance 'd' from two perpendicularly placed grounded conducting infinite plates. Calculate the net force $\overline{F}$ on the charge 'q'. 2



11. (a) What are Fresnel's half period zones ? Show that the amplitude due to a large wavefront at a point in front of it is just half that due to the first half period zone acting alone. 1+2

(b) A soap film of thickness 5.5×10^{-5} cm. is viewed at an angle of 45^{o}. Its index of refraction is 1.33. Find the wavelengths of light in the visible spectrum which will be absent from the reflected light. 2

(c) How can you measure the thickness of a thin film using Fresnel's biprism ? 3

(d) Prove that in the fringe system formed in a Fabry-Perot interferometer, the ratio of the intensity of maxima to the intensity midway between the minima is given by $\dfrac{\left(1+r^2\right)^2}{\left(1-r^2\right)^2}$. 2

12. (a) Distinguish between Fresnel type and Fraunhofer type of diffraction. Derive the expression for the intensity distribution of Fraunhofer diffraction pattern formed by a double slit. 1+4

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

(c) A plane transmission grating at normal incidence diffracts a line of wavelength 540 nm. for a certain order superposed on another line of wavelength 405 nm. of the next higher order. If the angle of diffraction be 30^{o}, find the grating element. 3

13. (a) Two linearly polarized waves are in phase but have different amplitudes. Let these waves be represented by

$$\overline{E}_1(z,t) = \hat{i}A_1\cos(kz-\omega t) + \hat{j}B_1\cos(kz-\omega t)$$

$$\overline{E}_2(z,t) = \hat{i}A_2\cos(kz-\omega t) + \hat{j}B_2\cos(kz-\omega t)$$

Find the polarization direction of the resultant wave. 2

(b) How will you produce and analyze a circularly polarized light ? 4

(c) What is optical activity ? Give Fresnel's explanation of rotation of plane of polarisation by an optically active substance. 1+3