

PHYSICS

(Paper II)

Time Allowed : Three Hours
Maximum Marks : 300

QUESTION PAPER SPECIFIC INSTRUCTIONS

(Please read each of the following instructions carefully before attempting questions)

There are EIGHT questions divided in two Sections.

Candidate has to attempt FIVE questions in all.

Question Nos. 1 and 5 are compulsory and out of the remaining, any THREE are to be attempted choosing at least ONE question from each Section.

All questions carry equal marks.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Word limit in questions, wherever specified, should be adhered to.

SECTION 'A'

1. Answer any three of the following:

- (a) An electric dipole moment, $\mathbf{p}_2$, is placed at (r, θ) in the electric field of another dipole moment $\mathbf{p}_1$, placed at the origin. Assuming that the electric potential, V , at (r, θ) due to $\mathbf{p}_2$ is $V(r, \theta) = \frac{p_1 \cos \theta}{4\pi\epsilon_0 r^2}$ find the dipole-dipole interaction energy.
- (b) Starting from Biot Savart's law, find the vector potential at a distance r , from a current carrying wire.
- (c) Self inductance of two coils, A and B, connected in series is 25 mH or 10 mH, depending on the relative current directions in the coils. Self inductance of the isolated coil, A, is 10 mH. Calculate mutual inductance M of the pair of coils coupling factor and leakage factor. If the current in coils is changing at the rate of 1000 A/s, find the induced electromotive forces across the coil A.
- (d) Derive the expression for the frequency spectrum of a carrier wave of frequency f_c which is amplitude modulated by a frequency f_m . A certain transmitter radiates 9 kW of power when the carrier wave is unmodulated and 10.12 kW power when the carrier wave is sinusoidally modulated. Calculate the modulation index.

2. (a) A relay has a coil resistance of 10Ω and inductance of 1 H. It is energized by a single voltage pulse of 10 V which remains constant for 250 ms and then falls to 0 V. Relay contact closes when the increasing current reaches 200 mA and opens when the decreasing current is at 100 mA. Calculate the time for which the relay contact is closed.

- (b) An alternating voltage is applied to the circuit shown in Fig. 1. Show that it has two resonant frequencies, f_p and f_s interrelated as

$$f_p = f_s \sqrt{(1 + 1/r)}$$

Where $r = (C_b/C_a)$

[Figure: Fig. 1 – An AC source ($\sim$) connected across two parallel branches; branch 1 is an inductor L in series with a capacitor C_a ; branch 2 is a capacitor C_b alone. The two branches join at a common top node (connected to one terminal of the source) and a common bottom node (connected to the other terminal of the source), and the bottom node is earthed. No component values are given.]

3. (a) Show that electromagnetic propagating in a homogeneous isotropic medium, are transverse in nature.
- (b) Show that attenuation constant α and phase factor β for an electromagnetic wave, propagating in a perfectly conducting medium, are equal. At what frequency the skin depth in silver is $1 \mu\text{m}$. when the conductivity of silver is 30×10^6 Siemens/meter and relative permeability is 1.0?

4. (a) Define ex-OR. Give its truth table and draw the possible logic blocks.
- (b) A Si BJT is connected as shown Fig. Show that it is in active region and works as an amplifier. Calculate its mid frequency gain, given that BJT has $h_{ie} = 1 \text{ k}\Omega$, $h_{oe} = h_{oe'} = 0$ [?], $I_{co} = 20 \text{ nA}$.
- [Figure: Common-emitter BJT (npn) amplifier with voltage-divider bias. Supply +15 V. Base bias divider: 54 k from +15 V to the base and 12 k from the base to ground. Collector resistor 3 k from +15 V to the collector, with collector current marked $I_C = 2 \text{ mA}$ flowing down through it. Emitter resistor 1 k from the emitter to ground. No coupling or bypass capacitors and no input/output terminals are shown.]

SECTION 'B'

5. Answer any three of the following:
- (a) Describe Frank Hertz experiment to establish the quantization of energy levels.
- (b) Taking only the spin motion of electron, proton and neutron and assuming them as point particles, obtain their magnetic moments. How far the values thus obtained agree with experimental values? If not, why? Explain.
- (c) Calculate the velocity and direction of recoil electron for back scattered X-ray photon of Mo K_α of $0.707 \text{ \AA}$ in Compton effect.
- (d) Write a comparative account of the following four processes: (i) β -decay (ii) positron emission (iii) electron capture (iv) inverse β -decay
6. (a) Explain the fine structure of H_α line of H-atom arising due to LS coupling.
- (b) Calculate the bond length and force constant of the bond of $^{12}\text{C } ^{16}\text{O}$ molecule; given $0 \rightarrow 1$ rotational line in $v=0$ state is at 115.3 GHz and the wavelength of the vibrational frequency is $14.7 \text{ }\mu\text{m}$.
7. An electron moving with energy E encounters one dimensional potential step as given below: $V(x)=0 \text{ } x<0 \text{ } V(x)=V_0 \text{ } x>0$
- (a) Suppose the electron has the energy $E > V_0$ and is incident from $(-x)$ direction, find the normalized wave function so corresponds to unit incident flux.
- (b) Solve the above problem for the case $E < V_0$ and discuss the significance of the result with the help of a suitable example.
8. Define parity for a quantum mechanical system. Describe an appropriate experiment proving the parity violation in weak interaction. How can the parity violation in weak interaction be understood? Explain.