

This question paper contains 2 printed pages.

Your Roll No.

90

May 2025

1285

Sl. No. of Ques. Paper:

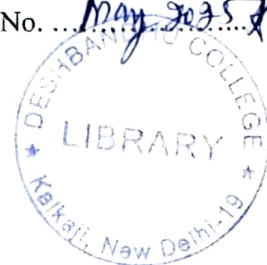
Unique Paper Code : 32221401

Name of the Paper : Mathematical Physics-III

Name of the Course : B. Sc. (Hons.) Physics (CBCS-LOCF)

Semester : IV

Duration : 3 hours



Maximum Marks : 75

Instructions for students:

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt five questions in all including Q. No. 1 which is compulsory.
3. Use of Non-programmable scientific calculator is allowed.

1. Attempt **ALL** the questions:

(5 × 3 = 15)

- (a) Find the polar form of the complex number $z = 2 + i$.
- (b) Determine and classify all the singularities of the function: $\cot \frac{1}{z}$
- (c) Solve : $z^4 + 1 = 0$.
- (d) If Fourier transform of $f(x)$ is $F(k)$, find Fourier transform of $f'(x)$.
- (e) Show that the Dirac δ -function can be expressed as $\delta(x) = \lim_{b \rightarrow \infty} \frac{\sin bx}{\pi x}$

2. (a) Prove the identity:

(8)

$$\cos^4 \theta = \frac{1}{8} \cos 4\theta + \frac{1}{2} \cos 2\theta + \frac{3}{8}$$

- (b) Evaluate $\int_C \bar{z} dz$ from $z = 0$ to $z = 4 + 2i$ along the curve C given by $z = t^2 + it$.

(7)

3. (a) Evaluate the following integral using Cauchy's integral theorem

(8)

$$\oint_C \frac{e^{zt}}{(z^2 + 1)^2} dz,$$

if C is the circle $|z| = 3$

- (b) Expand $f(z) = \frac{1}{z+1}$ in Taylor series about $z = 1$

(7)

4. Using contour integration, prove any **two** of the following integrals:

(7.5 × 2 = 15)

(i) $\int_0^\infty \frac{1}{x^4 + 1} dx = \frac{\pi}{2\sqrt{2}}$

(ii) $\int_0^\pi \frac{a d\theta}{a^2 + \sin^2 \theta} dx = \frac{\pi}{\sqrt{a^2 + 1}}; a > 0$

$$(iii) \quad \int_0^{\infty} \frac{\cos \pi x}{x^2 + 1} dx = \frac{\pi}{2} e^{-\pi}$$

5. (a) Find Fourier sine transform of $f(x) = x e^{-x^2/2}$ (8)
 (b) Prove that the Fourier transform of an odd function is an odd function. (7)
6. (a) Using the convolution theorem, find inverse Laplace transform of the function:

$$\frac{1}{s^2(s-a)} \quad (8)$$

 (b) Using Laplace transform, evaluate: $\int_0^{\infty} \frac{e^{-t} - e^{-3t}}{t} dt$ (7)
7. (a) Solve the following differential equation using the method of Laplace transforms

$$y'' - 4y' + 4y = 0$$

 with $y(0) = 0, y'(0) = 3$ (8)
 (b) State and prove the convolution theorem for Fourier transform. (7)

Sr. No. of Question Paper

: 1286

23/5/25

Name of the Course

: B.Sc. Hons_Physics Core_Repeat Paper

Semester

: IV- Semester

Name of the Paper

: Elements of Modern Physics

Unique Paper Code

: 32221402

Duration : 3 Hours

Maximum Marks : 75



Instructions for the candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt five questions in all.
3. Q1 is compulsory,
4. All questions carry equal marks.
5. Use of non-programmable scientific calculator is allowed.

1. Attempt any five questions:

(5x3=15)

- (a) In an experiment, the work function of potassium surface is found to be 2.1eV. Calculate the threshold wavelength. What should be the wavelength of incident radiation if the stopping potential for electrons is 0.43 v?
- (b) Determine the de Broglie wavelength of a bullet of mass 20.0 g fired at a velocity of 700m/s?
- (c) State the conditions for a physically accepted wave function?
- (d) If $f(x) = e^{\beta x}$, where β is some constant, show that $f(x)$ is an eigenfunction of the operator $\frac{d^2}{dx^2}$. Also find the eigenvalue.
- (e) Derive the expressions for energy and momentum operators starting from the expression for the wave function of a free particle.
- (f) Show that the nuclear density is independent of the number of nucleons?
- (g) One gram of radium is reduced by 2.1 mg in 5 years by α -decay. Calculate the decay constant of radium.

2. (a) What is Compton effect? Derive an expression for the change in wavelength of a photon if it strikes an electron at rest.

(b) An X-ray photon is found to have doubled its wavelength on being scattered by 90° . Find the energy and the wavelength of the scattered photon. (10,5)

3. (a) Derive Heisenberg's uncertainty principle from de-Broglie's wave concept. Hence, obtain the time energy uncertainty principle from it.

(b) A π^0 - meson has a very short lifetime of $\sim 8 \times 10^{-17}$ s before it decays into two γ - rays. Determine $\Delta m/m$ in its mass measurement if its rest mass energy is 135 MeV. (10,5)

4. (a) Explain the double slit experiment with electrons. What inference can be drawn from the experiment and hence show that how it explains the dual nature of particles.

(b) For following wavefunction

$$\psi(x) = A(\cos kx + iB\sin kx)$$

where A, B, k are real constants. Calculate probability density and probability current density. (10,5)

5. (a) A particle of mass m and energy $E > V_0$ travelling along x direction has a potential barrier defined as:

$$V(x) = \begin{cases} 0 & x < 0 \\ =V_0 & x \geq 0 \end{cases}$$

Derive an expression for the reflection coefficient.

(b) Electrons of energy 2.0 eV are incident on a barrier 3.0 eV high and 0.4 nm wide. Find the transmission probability. (10,5)

6. (a) Discuss the concept of nuclear stability with reference to Neutron-Proton plot. Why do stable nuclei have more neutrons than protons?

(b) The mass of Lithium atom is 7.01822 a.m.u. Calculate the binding energy in Joules and electron volts of ${}^7\text{Li}_3$ nucleus. Given mass of proton = 1.00814 a.m.u; mass of neutron = 1.00893 a.m.u; mass of electron = 0.00055 a.m.u. (9,6)

7. (a) Define mean lifetime, half-life and activity of a radioactive sample. Hence, find the relation between them.

(b) A sample of a radioactive material contains 3.5 μg of pure ${}^{11}_6\text{C}$. If $T_{1/2}$ of ${}^{11}_6\text{C}$ is 20.4 minutes, calculate N_0, R_0 and $R(t = 8\text{h})$. (6, 9)

1287

27/5/25 n

Roll No.

Name of the Department : Department of Physics and Astrophysics
 Name of Course : B.Sc. Hons.-(Physics)_Core -
 Semester : IV - Semester
 Name of the Paper: : Analog Systems and Applications
 Unique Paper Code : 32221403
 Question paper Set number :
 Duration : 3 hours
 Max. Marks : 75 marks



Instructions for Candidates:

- Write your Roll No. on the top immediately on receipt of this question paper.
- Attempt any Five questions in all. Question No.1 is compulsory.
- Non-programmable calculators are allowed.

(Given: $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$; $k = 1.38 \times 10^{-23} \text{ J/K}$; $q = 1.6 \times 10^{-19} \text{ C}$)

1. Attempt any FIVE of the following:

(3 X 5=15)

- A germanium diode has a reverse saturation current of $10 \mu\text{A}$ at room temperature (300K). Determine the saturation current at 500K.
- The resistivity of an intrinsic germanium at 300 K is $50 \Omega\text{cm}$. Find the intrinsic carrier concentration of the semiconductor if the electron and hole mobilities respectively are: $\mu_n = 3900 \text{ cm}^2/\text{volt.sec}$ and $\mu_p = 1900 \text{ cm}^2/\text{volt.sec}$.
- Define the term β_{dc} for a transistor. How is it related to α_{dc} ?
- Mention the characteristics of an ideal and practical Op-Amp.
- Define the following specifications for a D/A converter.
 - Resolution
 - Settling Time
- List the two types of feedbacks. Which one is used in linear applications like amplification?

2.

- Define depletion region and barrier height for a p-n junction diode. Show that the width of the depletion region for a step junction p-n diode in thermal equilibrium is given by

$$W = \sqrt{\frac{2\epsilon V_0 (N_A + N_D)}{q N_A N_D}}$$

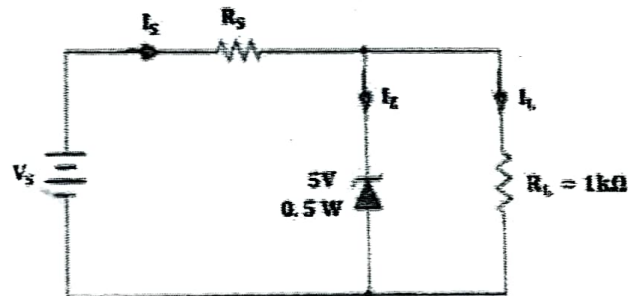
where the symbols have their usual meanings.

- b) A germanium p-n step junction has donor density $N_d = 10^{17} \text{ cm}^{-3}$ on n-side and acceptor density $N_a = 10^{15} \text{ cm}^{-3}$ on p-side. Calculate the built-in potential at the junction if intrinsic carrier density $n_i = 10^{13} \text{ cm}^{-3}$. Assume $\frac{kT}{q} = 26 \text{ mV}$.

(10,5)

3.

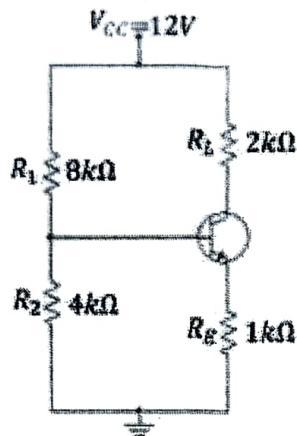
- a) Explain the working of a full wave bridge rectifier using suitable diagrams and obtain expressions for its ripple factor and rectification efficiency.
- b) For the given Zener regulator circuit, find the range over which the supply voltage V_s can be varied without the loss of regulation. The Zener diode has the specifications $V_Z = 5 \text{ V}$, $P_Z = 0.5 \text{ W}$ and $I_{Z\min} = 5 \text{ mA}$. The value of $R_L = 1 \text{ k}\Omega$ and $R_S = 100 \Omega$



(10,5)

4.

- a) Draw the circuit to study the I - V characteristics of the transistor in common base configuration. Sketch its input and output characteristics. Also indicate the active, saturation and cut off regions.
- b) The voltage divider bias circuit given below uses a silicon transistor Calculate its operating point and draw the D.C. load line. Given $V_{BE} = 0.7 \text{ V}$.



(8,7)

5.

- a) Obtain the expression for stability factor S_{ICO} for a voltage divider bias configuration.
- b) Draw the circuit diagram of an RC coupled CE amplifier. Explain the role of all components in the circuit. Draw the AC equivalent circuit in low, mid and high frequency range and state the associated assumptions for each frequency range.

(7, 8)

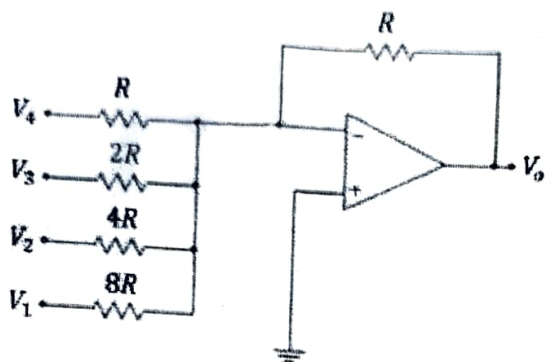
6.

- a) Derive the relation between A_f (gain with feedback) and A (gain of internal amplifier) for an amplifier with negative feedback with feedback factor B .
- b) Give the circuit diagram of Hartley oscillator and derive the expression for frequency of oscillations.

(5,10)

7.

- a) Explain the concept of virtual ground in an Op-Amp?
- b) Draw the circuit diagram for an ideal differentiator using Op-Amp and hence derive the expression for the output signal. .
- c) Derive the expression for the output V_o for the op-amp circuit given below.



(3,6,6)

[This question paper contains 2 printed pages.]

30
May 2025
Your Roll No.....

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Sr. No. of Question Paper : 5537

Unique Paper Code : 2222012401

Name of the Paper : Modern Physics (DSC)

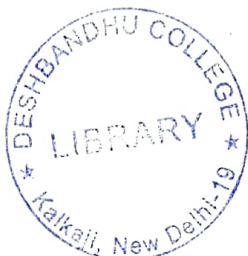
Name of the Course : B.Sc. (Hons.) Physics – NEP UGCF-2022

Semester : IV

Duration : 3 Hours

Maximum Marks : 90

Instructions for Candidates



1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question No. 1 is compulsory.
3. Attempt any four from the remaining five questions.
4. All questions carry equal marks.
5. Use of non-programmable calculators is allowed.

1. Attempt any **six** of the following questions: (6×3=18)
 - (a) In the Compton scattering experiment, radiation scattered at each angle generally consists of two distinct wavelengths. Briefly discuss the origins of these wavelengths?
 - (b) If the uncertainty in a photon's wavelength is one part in a million, determine the uncertainty in its position if the photon's wavelength is 500 nm.
 - (c) Evaluate the commutator (i) $[\hat{x}, \hat{p}_x]$, (ii) $[\hat{x}, \hat{p}_y]$, and (iii) $[\hat{x}, \hat{p}_x^2]$
 - (d) A particle of kinetic energy 8.5 eV is incident on a potential step of height 4.5 eV. Calculate the reflection coefficient.
 - (e) Explain the terms (i) induced absorption (ii) spontaneous emission, and (ii) stimulated emission.
 - (f) State Moseley's law and discuss its significance.
 - (g) Calculate the radius of ^{235}U . What would be the mass of 1 mm³ of nuclear matter? Given: $1\text{u} = 1.66 \times 10^{-17} \text{ kg/m}^3$.
2. (a) Draw the experimental setup for studying photoelectric effect. What are the main features of the observations? Discuss how classical wave theory fails and how Einstein's quantum theory of light successfully explains the phenomenon. (10)

P.T.O.

- (b) Determine the wavelength of the incident photon in Compton scattering if the maximum energy imparted to the electron is 50 keV? (8)

3. (a) Obtain the time-dependent Schrodinger equation in one dimension and discuss the statistical interpretation of wave function. (10)

- (b) A particle is described by the wave function

$$\begin{aligned}\psi(x) &= 0 & x < 0 \\ &= \sqrt{2}e^{-x/L} & x \geq 0\end{aligned}$$

where $L = 2$ nm. Calculate the probability of finding the particle in the region $x \geq 1$ nm.

(8)

4. (a) Sketch the first three wave functions and corresponding probability densities for a particle confined in a one-dimensional box of length L . What are the energy eigenvalues corresponding to these wave functions? Discuss the differences between the classical and quantum mechanical descriptions of such a particle. (10)

- (b) A particle of kinetic energy 2.5 eV is incident on a potential step of height 4.0 eV. Calculate the penetration depth of the particle into the classically forbidden region. (8)

5. (a) On what condition does the quantum physics yield the same results as classical physics according to Bohr correspondence principle. Discuss the validity of the principle on the basis of classical and quantum pictures of the Bohr model for hydrogen atom. (10)

- (b) Calculate the ratio of Einstein's A and B coefficients, and the ratio of probabilities of spontaneous and stimulated emission for a system in thermal equilibrium at room temperature ($T = 300$ K) for transition that occur in the visible region ($h\nu = 2$ eV). Given: $k_B = 1.38 \times 10^{-23}$ J/K. (8)

- 6 (a) Discuss the various contributions to the binding energy of a nucleus of atomic number Z and mass number A , and obtain the Weizsaecker semi-empirical mass formula. (10)

- (b) Calculate the binding energy of α -particle and express it in MeV and joules. Given:

$$m_p = 1.00758 \text{ amu}, m_n = 1.00897 \text{ amu} \text{ and } m_{He} = 4.0028 \text{ amu.} \quad (4)$$

- (c) Calculate the distance in free space over which the intensity of a 2 eV neutron beam be reduced by a factor of one-half? Given: Mass of neutron = 1.67×10^{-27} kg, Decay constant for a free neutron = $1.14 \times 10^{-3} \text{ s}^{-1}$. (4)

[This question paper contains 4 printed pages.]

29/5/25

Your Roll No.....

Sr. No. of Question Paper : 5597

J

Unique Paper Code : 2222012402

Name of the Paper : Solid State Physics

Name of the Course : B.Sc. Hons.-(Physics)_NEP:UGCF-2022

Semester : IV

Duration : 3 Hours

Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt any five questions in total. Question No. 1 is compulsory.
3. All questions carry equal marks.
4. Use of non-programmable scientific calculators is permitted.

1. Attempt any **six** of the following: (3 x 6 = 18)

(a) Draw (221) and (110) planes in a cubic crystal. Also, show [111] direction in a cubic unit cell.

(b) An X-ray beam of wavelength $1.54 \text{ \AA}$ is diffracted from the (100) planes of a solid with a cubic lattice of lattice constant $3.05 \text{ \AA}$. Find the Bragg's angle at which the first-order diffraction occurs.

P.T.O.

- (c) Hall coefficient of a specimen of a strong n-type silicon is $3.66 \times 10^{-4} \text{ m}^3 \text{C}^{-1}$. The resistivity of the specimen is $8.93 \times 10^{-3} \text{ m}$. Find the mobility and density of the charge carriers.
- (d) Calculate Einstein's frequency for copper (Cu) metal that has an Einstein's temperature $\theta_E = 230^\circ \text{ K}$.
- (e) Discuss various sources of polarizability in a dielectric.
- (f) Explain the B-H curve of a ferromagnetic material.
- (g) Explain Meissner's effect in the superconductor.
2. (a) Explain Ewald's construction and derive Bragg's law $2\vec{K} \cdot \vec{G} + G^2 = 0$ for X-ray diffraction in a reciprocal lattice, where the symbols have their usual meanings. (12)
- (b) Calculate the packing fraction for face-centered cubic (FCC) crystal. (6)
3. (a) For the Kronig-Penney model of electron behaviour in solids, derive the relation $P \frac{\sin(\alpha a)}{\alpha a} + \cos(\alpha a) = \cos(ka)$ where P is proportional to the barrier strength (height and width) between adjacent lattice atoms, a is the lattice constant, k is the wavenumber, and $\alpha = \sqrt{\frac{2mE}{\hbar^2}}$. Sketch the general behaviour of this relation as a function of αa clearly indicating the value of $\alpha a = 0$

and the limiting case $\alpha a \rightarrow \infty$. By considering the above condition clearly indicate on your sketch the ranges of αa that correspond to allowed energy bands. (12)

- (b) Show that in the limit of $P \rightarrow \infty$ the relation leads to discrete allowed energy

$$\text{given by } E_n = \frac{n^2 \hbar^2 \pi^2}{2ma^2}. \quad (6)$$

4. (a) Derive an expression for the lattice specific heat of a solid based on the Debye model and demonstrate that it varies as T^3 at low temperatures. (12)

- (b) Calculate the number of optical and acoustical phonon branches for a NaCl crystal, containing two atoms per primitive unit cell. (6)

5. (a) Describe the Langevin theory of para-magnetism and explain Weiss modification in this theory assuming the existence of an internal molecular field. (12)

- (b) A paramagnetic salt contains 10^{28} ions/m³, each with magnetic moment 9.27×10^{-24} A-m². Calculate paramagnetic susceptibility produced in a uniform magnetic field $H = 10^6$ A/m at 300° K. (6)

6. (a) Define the term "Local electric field" at an atom. Deduce Lorentz relation for E_{Loc} inside a dielectric. (12)

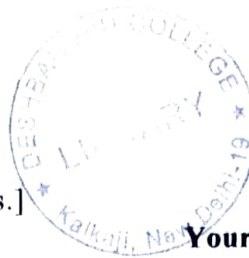
- (b) Draw a typical P-E hysteresis curve for a ferroelectric material and give one example. (6)

Charge of an electron = $1.602 \times 10^{-19} \text{ C}$

Planck's Constant = $6.62 \times 10^{-34} \text{ J-s}$

Boltzmann Constant = $1.38 \times 10^{-23} \text{ J/K}$

$\mu_0 = 4\pi \times 10^{-7} \text{ Kg m s}^{-2} \text{ A}^{-2}$



[This question paper contains 2 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 5676

J

Unique Paper Code : 2222012403

Name of the Paper : Analog Electronics

Name of the Course : B.Sc. Hons. – (Physics)_NEP: UGCF-2022

Semester : IV

Duration : 2 Hours

Maximum Marks : 60

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt any **Four** questions in all. Question No. 1 is compulsory.
3. Simple non-programmable calculators are allowed.

1. Attempt **any five** parts. (3×5=15)
 - (a) Explain the working principle of a photodiode. Also Draw I-V characteristics.
 - (b) Draw the I-V characteristics of a Zener diode and explain its use as a voltage regulator.
 - (c) A diode is used in a half-wave rectifier. If the peak input voltage is 12 V, calculate the average output voltage (assume ideal diode).
 - (d) Why is voltage divider bias preferred over fixed bias in amplifier circuits?
 - (e) A transistor has $\beta = 120$ and base current = 30 μA . Find the collector current.
 - (f) Define the slew rate of an op-amp. If an op-amp has a slew rate of 0.5 V/ μs , how much time will it take to swing from 0 to 3 V?
 - (g) State any three differences between an ideal op-amp and a practical op-amp.
2. (10+5)
 - (a) Explain the construction and working of a full-wave bridge rectifier. Derive expressions for average output voltage and ripple factor.

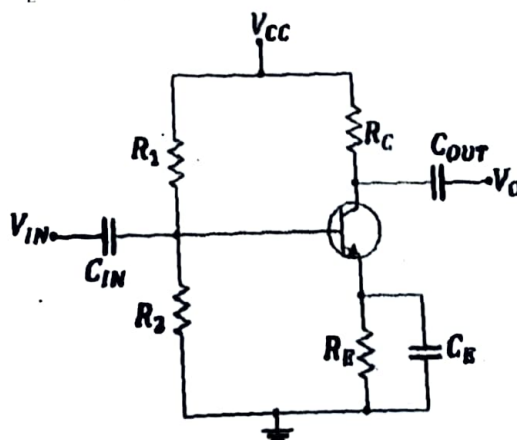
P.T.O.

- (b) A Zener diode voltage regulator circuit is connected with 15 V input and a 9 V Zener. Calculate the current through Zener if the load draws 10 mA and the series resistance is $100\ \Omega$. Also draw the proper circuit diagram of a Zener diode voltage regulator.

3.

(10+5)

- (a) Explain the input and output I-V characteristics of a transistor in CE configuration. Describe the active, cut-off, and saturation regions.
- (b) In the voltage divider bias circuit, $R_1 = 33\ \text{k}\Omega$, $R_2 = 10\ \text{k}\Omega$, $R_C = 2\ \text{k}\Omega$, $R_E = 1\ \text{k}\Omega$, $V_{CC} = 15\ \text{V}$, and $\beta = 100$. Calculate the base voltage V_B , emitter voltage V_E , and collector current I_C . Assume $V_{BE} = 0.7\ \text{V}$, $C_{in} = C_{out} = 10\ \mu\text{A}$ and $C_E = 50\ \mu\text{A}$.



4.

(10+5)

- (a) Explain the construction and working of RC phase shift oscillator. Derive the condition for sustained oscillation and expression for its frequency.
- (b) A Hartley oscillator operates at a frequency of 1 MHz. The capacitor in the tank circuit is 200 pF, and the mutual inductance is 0.002 mH. If both the inductors in the circuit are of same value, calculate the value of L.

5.

(10+5)

- (a) Draw the circuit diagram of a basic integrator using an operational amplifier and derive the expression for its output voltage. Draw the circuit of a practical integrator and explain the need for modifications over the basic integrator.
- (b) A zero-crossing detector is used to process a sinusoidal input signal with a peak-to-peak voltage of 5 V and a frequency of 60 Hz. What will be the period of the output waveform generated by the detector. If the output of the op-amp swings from $-5\ \text{V}$ to $+5\ \text{V}$ and the slew rate of the op-amp is $0.5\ \text{V}/\mu\text{s}$, estimate the minimum time the op-amp takes to complete this transition.

(2000)

SB-1

UNIVERSITY OF DELHI

CORRIGENDUM

Sl. No. of Q.P : 5676
Unique Paper Code : 2222012403
Name of the Paper : Analog Electronics
Course : B.SC. Hons. – (Physics)
Exam : 09/06/2025 Morning
SEMESTER/YEAR : IV
DURATION : 2 Hour
Maximum Marks : 60

Announcement for candidates

Q3. (b) be read as f instead of A

$$C_C = 50 \mu F$$

$$C_{in} = C_{out} = 10 \mu F$$



Joint Registrar (Secrecy)