Total No. of Printed Pages—7

4 SEM TDC PHYH (CBCS) C 8

2026

(May/June)

Sibsagar Girls' College · Central Library & Information Centre · Date .....

PHYSICS

(Core)

Paper : C–8

(Mathematical Physics—III)

Full Marks : 53
Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions.

1. Choose the correct answer : 1×5=5

(a) The cross product between two complex numbers z_1 and z_2 is defined as

(i) $\vec{z}_1 - \vec{z}_2$

(ii) $\vec{z}_1 \cdot \vec{z}_2$

(iii) $|z_1| \times |z_2| \cos\theta$

(iv) $|z_1|\,|z_2| \sin\theta$

(b) According to the convolution theorem, the Fourier transform of $f(t)* g(t)$ is

(i) $F(\omega) + G(\omega)$

(ii) $F(\omega) - G(\omega)$

(iii) $F(\omega) \cdot G(\omega)$

(iv) $\frac{F(\omega)}{G(\omega)}$

(c) The Laplace transform of $f(t) = e^{at}$ is

(i) $\frac{1}{s-a}$

(ii) $\frac{1}{s+a}$

(iii) $s+a$

(iv) $1+as$

(d) The change of scale property in Laplace transform states that $L\{f(at)\}$ is

(i) $\frac{1}{a}F(s)$

(ii) $F(as)$

(iii) $\frac{1}{a}F\left(\frac{s}{a}\right)$

(iv) $aF(s)$

(e) The Laplace transform of the first derivative of $f(t)$, $L\{f'(t)\}$, is

(i) $sF(s) - f(0)$

(ii) $sF(s) + f(0)$

(iii) $\frac{F(s)}{s} - f(0)$

(iv) $\frac{F(s)}{s} + f(0)$

2. Answer any *four* of the following : 2×4=8

(a) Consider the parametric equation $z = z_0 + Re^{i\theta}$, where $|z - z_0| = R$. Represent the equation in the complex plane and explain its meaning.

(b) Show that the function $f(z) = |z|^2$ is continuous but not differentiable.

(c) Integrate $\sqrt{z}$ along the unit circle taking the branch cut along the positive real axis.

(d) Solve the equation $z^2+z+1=0$ for $z=(x, y)$.

(e) Differentiate between Laplace and Fourier transformation.

3. Show that if a function $f(z)$ is analytic on and inside a closed contour C, then

$$\oint_C f(z)\,dz = 0$$ 3

4. Using Cauchy's integral formula, evaluate

$$\oint_C \frac{e^{2z}}{(z+1)^4}\,dz$$

where C is the circle with $|z|=3$. 3

5. Obtain the first few terms of the Laurent series expansion of

$$f(z)=\frac{5z-3}{z(z^2+z-2)}$$

which converges in the annular region $1<|z|<2$. 4

Or

Expand $f(z)=\sin z$ in a Taylor series about $z=\pi/4$ and determine the region of convergence of this series.

6. Prove that

$$\int_0^{2\pi}\cos^{2n}\theta\,d\theta=\frac{1.3.5.\ldots(2n-1)}{2.4.6.\ldots 2n}2\pi$$

where $n=1, 2, 3, \ldots$ 4

7. Find the residues at the respective poles of the following function : 4

$$f(z)=\frac{z}{(z-1)(z+1)^2}$$

8. Find the Fourier transform of the function $f(x)=e^{-ax^2}$, where $a>0$ is a constant. Use the definition of the Fourier transform

$$F(\omega)=\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty}f(x)e^{i\omega x}dx$$

to compute the result. Provide your answer in terms of a and ω. 4

9. Find the Fourier transform $F(\omega)$ of the function $f(x)$, defined as

$$f(x)=\begin{cases}1, & \text{if } |x|\le a\\ 0, & \text{if } |x|>a\end{cases}$$

After finding $F(\omega)$, evaluate the integral

$$\int_0^{\infty}\frac{\sin(\omega)}{\omega}d\omega$$ 4+4=8

Or

Apply the Fourier transform technique to solve the one-dimensional wave equation

$$\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$$

where $u(x, t)$ represents the displacement at position x and time t, and c is the wave speed. 8

10. Consider the function $f(t)$ defined as

$$f(t) = \begin{cases} t^2 & \text{for } 0 \le t < 2 \\ t-1 & \text{for } 2 \le t < 3 \\ 7 & \text{for } t \ge 3 \end{cases}$$

Calculate the Laplace transform of $f(t)$, defined by $F(s) = \int_0^\infty f(t)e^{-st}dt$. Provide your answer in terms of s. 4

11. Consider the second-order differential equation $y'' - 4y' + 4y = 64\sin(2t)$ subject to the initial conditions $y(0) = 0$, $y'(0) = 1$. Using Laplace transformation, solve the given initial value problem for $y(t)$. 6

Or

Find the inverse Laplace transform of the following functions : 3×2=6

(i) $\mathcal{L}^{-1}\left\{\frac{14s+10}{49s^2+28s+13}\right\}$

(ii) $\mathcal{L}^{-1}\left\{\frac{2s-5}{9s^2-25}\right\}$

★ ★ ★

Total No. of Printed Pages—4

4 SEM TDC PHYH (CBCS) C 9

Central Library ... Sibsagar Girls' College ... Date .....

2026

(May/June)

PHYSICS

(Core)

Paper : C–9

(Elements of Modern Physics)

Full Marks : 53
Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions.

1. Choose the correct answer : 1×5=5

(a) Which particle has the smallest de Broglie wavelength at same kinetic energy?

(i) Electron

(ii) Proton

(iii) Alpha particle

(iv) Photon

(b) A metastable state has lifetime of the order of

(i) 10^{-6} s (ii) 10^{-5} s

(iii) 10^{-4} s (iv) 10^{-3} s

(c) Which of the following is used as a moderator in a nuclear reactor?

(i) Plutonium

(ii) Uranium

(iii) Cadmium

(iv) Heavy water

(d) The existence of zero-point energy is in conformity with

(i) Compton effect

(ii) uncertainty principle

(iii) de Broglie hypothesis

(iv) None of the above

(e) The total probability of finding a particle must be

(i) infinity

(ii) unity

(iii) zero

(iv) None of the above

2. Answer the following questions : 2×5=10

(a) What is Compton effect? Write the expression for Compton shift.

(b) What are three-level and four-level lasers? Give examples of each type.

(c) Define pairing energy. What happens to pairing energy for even-even nuclei?

(d) Show that the phase velocity is half of the group velocity for a non-relativistic free particle.

(e) How did Pauli predict the emission of a neutrino from a nucleus?

3. (a) Normalize the following wave function in one-dimension : 3

$$\psi(x) = Ae^{-\beta x} \text{ for } x > 0$$
$$= Ae^{\beta x} \text{ for } x < 0$$

(b) Briefly explain the two cyclic processes involved in the thermonuclear fusion in driving Stellar energy. 3

(c) Briefly discuss the creation of neutrino and antineutrino in the β-decay process with examples. 3

4. (a) What is a wave function? How can the stationary states of a particle be explained using the concept of wave function? 1+3=4

(b) Show that the half-life of a radioactive substance is inversely proportional to the decay constant. 4

Or

A radioactive material initially contains 8×10^{20} nuclei. After 12 hours, only 1×10^{20} nuclei remain undecayed.

(i) Find the decay constant λ.

(ii) Find the half-life of the radioactive material.

5. *(a)* Explain the concept of quantum confinement of a particle in a one-dimensional infinite potential well. A particle of mass m is confined between $x = 0$ and $x = L$. The wave function is given by $\psi(x) = N \sin^2\left(\frac{\pi x}{L}\right)$. Determine the value of the normalisation constant N. 6

(b) Derive an expression for Planck's law of radiation. 6

(c) Explain the concept of mass deficit in nuclear reactions and derive the energy released using Einstein's mass-energy relation. 6

6. Write a short note on any *one* of the following : 3

(a) Photo-electric effect

(b) Liquid drop model

★ ★ ★

Total No. of Printed Pages—7

4 SEM TDC PHYH (CBCS) C 10

2026

(May/June)

PHYSICS

(Core)

Paper : C–10

Sibsagar Girls' College - Central Library & Information Centre
Date .....

(Analog Systems and Applications)

Full Marks : 53
Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions.

1. Choose the correct answer (any *five*) : 1×5=5

(a) The width of the depletion layer of a junction

(i) is independent of applied voltage

(ii) is increased under reverse bias

(iii) decreases with light doping

(iv) increases with heavy doping

(b) Avalanche breakdown is primarily depended on the phenomenon of

(i) doping

(ii) ionization

(iii) recombination

(iv) collision

(c) The value of α of a transistor is

(i) more than 1

(ii) less than 1

(iii) 1

(iv) 0

(d) The colour of the emitted light of LED depends on the

(i) construction method

(ii) applied voltage

(iii) energy gap of the material used

(iv) None of the above

(e) In CE arrangement, the value of input impedance is approximately equal to

(i) h_{ie}

(ii) h_{oe}

(iii) h_{re}

(iv) None of the above

(f) An oscillator employs

(i) negative feedback

(ii) no feedback

(iii) positive feedback

(iv) None of the above

2. (a) Draw the energy band diagrams of *n*-type and *p*-type semiconductors indicating the position of Fermi level. 3

(b) What happens to the depletion region of junction diode under forward and reverse bias condition? Explain. 4

Or

Distinguish between static and dynamic resistor of a *p-n* junction diode. Do they depend on temperature and bias voltage? 3+1=4

3. *(a)* Draw the circuit diagram of a full-wave rectifier and calculate its ripple factor. 1+2=3

(b) Write about the working and construction of photovoltaic cell. 3

Or

What is the effect of temperature on the conductivity of a semiconductor?

4. *(a)* What is a load line in the transistor characteristics? Explain its significance. 2+2=4

(b) Explain active region, saturation region and cut-off region in transistor operation. 3

Or

A load resistor of 4 kΩ is connected in collector circuit of a common emitter transistor amplifier with $V_{CC} = 12$ V. What are the cut-off point and saturation point of output characteristics of the amplifier? Find the coordinate of the operating point, if the zero signal base current is 20 μA and $\beta = 100$.

5. *(a)* What is transistor biasing? Draw a circuit for voltage divider bias method. What are its advantages and disadvantages? 1+3=4

(b) Derive the expression for the current gain and the voltage gain of a single-stage common emitter transistor amplifier using *h*-parameters. 4

Or

Starting from the two equations for the hybrid parameters, draw the *h*-parameter equivalent circuit for a common emitter transistor circuit.

(c) Describe a Hartley or a Colpitts oscillator circuit and explain its operation. 3

6. *(a)* Explain the operation of a two-stage *R-C* coupled CE transistor amplifier with a neat circuit diagram. 3+2=5

(b) What is non-linear distortion? How can it be minimised? 1+2=3

Or

What is negative feedback? Explain, with necessary frequency response curve, how the bandwidth of an *R-C* coupled amplifier is modified when negative feedback is used. 3

7. *(a)* Calculate the CMRR of OP-AMP. 3

Or

Draw the basic inverting amplifier with an input resistor R_1 and a feedback resistor R_f. Assuming the OP-AMP to be ideal, derive the expression for the voltage gain of the inverting amplifier. 1+2=3

(b) Explain the circuit diagram of an OP-AMP as integrator. 3

Or

Explain the significance of virtual ground of a basic inverting amplifier. What do you understand by closed-loop and open-loop voltage gain of an OP-AMP?

8. Briefly describe the resolution (step size) and accuracy specifications of a D/A converter. 3

Or

What is the function of a DAC? Write the advantage of the R-2R ladder-type DAC over the weighted resistor type DAC.

★ ★ ★