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4 SEM TDC PHYH (CBCS) C 8

2024

(May/June)

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 option : 1×4=4

(a) If z_1 and z_2 denote two complex numbers, then

(i) $|z_1 + z_2| \geq |z_1| - |z_2|$

(ii) $|z_1 + z_2| \leq |z_1| - |z_2|$

(iii) $|z_1 + z_2| \leq |z_1| - |z_2| + |z_1 z_2|$

(iv) $|z_1 + z_2| \leq |z_1| + |z_2| + |z_1 z_2|$

(b) The function $f(z) = \dfrac{2z^2}{(z^2-1)}$ has

(i) pole of order 1 at $z=1$

(ii) pole of order 2 at $z=1$

(iii) poles of order 1 at $z=1$ and at $z=-1$

(iv) None of the above

(c) If Fourier transform of the function $f(t)$ is $g(w)$, according to the property of change of scale, Fourier transform $f(at)$ is

(i) $g\left(\dfrac{w}{a}\right)$ (ii) $ag\left(\dfrac{w}{a}\right)$

(iii) $\dfrac{1}{a}g(w)$ (iv) $\dfrac{1}{a}g\left(\dfrac{w}{a}\right)$

(d) The Laplace transform $f(s)$ of $F(t) = 8$ is

(i) 8 (ii) $\dfrac{8}{s}$

(iii) $\dfrac{s}{8}$ (iv) None of the above

2. Answer the following : 2×5=10

(a) Express the complex number $2+2\sqrt{3}i$ in polar form.

(b) Using Cauchy's theorem, show that the value of integral $\oint_C \dfrac{dz}{z}$ is $2\pi i$, if the curve C encloses the origin.

(c) Describe in brief the residue of a complex form.

(d) Find the Fourier sine transform of $f(x) = \dfrac{1}{x}$.

(e) Illustrate the change of scale property of Laplace transform.

3. (a) Write down the Cauchy-Riemann equations in polar coordinates. If the analytic function $f(z) = u + iv$, find $f(z)$ such that $u = x^3 - 3xy^2 + 3x^2 - 3y^2 + 1$. 1+4=5

(b) State the Cauchy's integral formula. Evaluate the integral

$$\oint_C \frac{\sin \pi z^2 + \cos \pi z^2}{(z-1)(z-2)}\, dz$$ 1+4=5

(c) Find the residues of $f(z) = \dfrac{z}{(z-1)(z+1)^2}$ about its poles. Find the value of the integral $\oint \dfrac{zdz}{(z-1)(z+1)^2}$. 3+2=5

(d) What are Taylor and Laurent's series expansion of a complex function? Find the Taylor series expansion of a function

$$f(z) = \frac{1}{(z-1)(z-3)}$$

about the point $z=4$. Find its region of convergence. 2+3+1=6

4. Find the Fourier transforms of the following functions (any *two*) : 3×2=6

(i) $f(x) = \frac{1}{\varepsilon}, \ |x| \leq \varepsilon$

$= 0, \ |x| \geq \varepsilon$

(ii) $f(x) = e^{-ax^2}, \ a > 0$

(iii) $f(t) = t$, for $|t| < a$

$= 0$, for $|t| > a$

5. Find the Laplace transforms of the following functions (any *two*) : 3×2=6

(i) $f(t) = t^2 \cos at$

(ii) $f(t) = t + t^2 + t^3$

(iii) $f(t) = e^{at} \cos \omega t$

6. Write short notes on any *two* of the following : 3×2=6

(a) Cauchy's theorem for multiply connected region

(b) Laurent's series

(c) Parseval's identity

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4 SEM TDC PHYH (CBCS) C 9

2024

(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 option : 1×5=5

(a) The minimum energy required to remove an electron from the surface of a given metal is called

(i) stopping potential

(ii) work function

(iii) kinetic energy

(iv) None of the above

(b) Electrons cannot exist within the nuclei of atoms is understood from

(i) Heisenberg's uncertainty principle

(ii) de Broglie's hypothesis

(iii) Bohr's atomic model

(iv) None of the above

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

(i) infinity

(ii) unity

(iii) zero

(iv) None of the above

(d) Which of the following is true for nuclear force?

(i) They obey the inverse square law of distance

(ii) They are short range force

(iii) They are electromagnetic force

(iv) They are dependent of nature of charges

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

(i) Plutonium

(ii) Uranium

(iii) Cadmium

(iv) Heavy water

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

(a) State and write the mathematical expression for Planck's law of blackbody radiation.

(b) How can we determine the time of existence and range of a virtual particle using Heisenberg's uncertainty principle?

(c) Briefly discuss the linear superposition principle.

(d) Define and write the mathematical expression for the binding energy of a nucleus.

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

3. (a) Explain why it is impossible for an electron to be present inside the nucleus of an atom. 3

(b) Briefly discuss the process of nuclear fission with examples. 3

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

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

Or

Show that the group velocity of a wave packet is equal to the particle velocity.

(b) Briefly discuss the construction and working of an He-Ne laser. 4

5. *(a)* Briefly describe the confinement of a quantum dot in an infinitely rigid box. Find the value of N for the wave function of a particle of mass m moving along X-axis between $x = -\frac{\pi}{2}$ to $x = +\frac{\pi}{2}$ is given by $\psi = N \sin^2 x$. 2+4=6

(b) Explain Compton scattering and obtain an expression for the Compton shift. 6

(c) Explain the quantum mechanical tunnelling for a particle across a rectangular potential barrier and obtain the expression for transmission coefficient. 5

6. Write a short note on any *one* of the following : 4

(a) Nuclear shell model

(b) Davisson-Germer experiment

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4 SEM TDC PHYH (CBCS) C 10

2024

(May/June)

PHYSICS

(Core)

Paper : C–10

(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 option : 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) 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

(c) In RC coupled amplifier, voltage gain over mid-frequency range

(i) is increasing

(ii) is constant

(iii) is decreasing

(iv) is zero

(d) Oscillators employ

(i) negative feedback

(ii) no feedback

(iii) positive feedback

(iv) None of the above

(e) Open-loop voltage gain of OP-AMP

(i) is small

(ii) is large

(iii) is zero

(iv) None of the above

2. (a) What happens to the depletion region of junction diode under forward and reverse bias condition? Explain. 3

Or

Define Fermi level in a semiconductor. How does its position change when (i) donor and (ii) acceptor are added to the semiconductor? 1+1+1=3

(b) Derive an expression for the width of depletion layer of a *p-n* junction diode. 4

Or

Define the mobility of charge carriers and conductivity. What is the effect of temperature on the conductivity of a semiconductor?

3. *(a)* Explain with circuit diagram the action of Zener diode as a voltage regulator. 3

(b) Write about working and construction of photovoltaic cell. 2

4. *(a)* What do you mean by quiescent point or Q-point? What is the best position of Q-point on the DC load line in the transistor characteristics? 2

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

Or

The collector leakage current in a transistor is 300 μA in CE arrangement. If the transistor is now connected in the CB arrangement, what will be the leakage current? Given $\beta = 100$.

5. *(a)* Draw a circuit for voltage-divider bias method. What are its advantages and disadvantages? 1+2=3

(b) Derive expression for the current gain and the voltage gain of a single-stage common-emitter transistor amplifier using *h*-parameters. 3

(c) A CE transistor amplifier is connected with a load resistance 2 kΩ. If the *h*-parameters of the transistor are $h_{ie} = 1000\ \Omega$, $h_{re} = 10^{-4}$, $h_{fe} = 100$ and $h_{oe} = 12 \times 10^{-6}$ S, find the current gain, input impedance and voltage gain. 2

6. *(a)* Draw the circuit diagram of an RC coupled transistor amplifier and give its mid-frequency equivalent circuit. Derive an expression for gain at the mid-frequency range. 2+2=4

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

(c) Calculate the Barkhausen's criterion for self-sustained oscillations. 3

Or

An RC phase-shift oscillator has the parameter values $R_L = 3 \cdot 3$ kΩ, $R = 5 \cdot 6$ kΩ and $C = 0 \cdot 01$ μF. Calculate frequency of oscillations and the h_{fe} required for sustaining the oscillations.

3.

7. *(a)* Draw the basic non-inverting amplifier with an input resistance R_1 and a feedback resistance R_f. Assuming the OP-AMP to be ideal, derive the expression for the voltage gain of the non-inverting amplifier. 1+3=4

4.

Or

Calculate the CMRR of OP-AMP. 4

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

Or

The input to the differentiator OP-AMP is a sinusoidal voltage of peak value 10 mV and frequency 2 kHz. Find the output, if $R = 200\ k\Omega$ and $C = 2\ \mu F$.

(c) 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? 3

5.

Or

Consider the inverting OP-AMP with $R_1 = 10\ k\Omega$, $R_f = 100\ k\Omega$, $V_{in} = 1\ V_{pp}$ and power supply voltages ± 18 V. Find *(i)* closed-loop voltage gain and *(ii)* the maximum operating frequency. The slew rate is $0{\cdot}5\ V/\mu s$.

8. Explain the working of a binary weighted-resistor network. 3

Or

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

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