

2023

Time - 3 hours

Full Marks - 60

*Answer all groups as per instructions.
Figures in the right hand margin indicate marks.*

GROUP - A

1. Fill in the blanks. (all)

[1 × 8

(a) The value of i^{53} is _____.

(b) The modulus of $\frac{1+3i}{1-2i}$ is _____.

(c) If $f(z)$ is analytic and $f'(z)$ is continuous at all points in a simple closed curve C then $\oint_C f(z) dz =$ _____.

(d) If $F(w)$ is Fourier transform of $f(t)$, then Fourier transform of $f(at)$ is _____.

(e) Fourier sine transform of $\sin 2x$ in the interval $(0, \pi)$ if $n \neq 2$ is _____.

(f) Laplace transform of e^{at} is _____.

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(g) Laplace transform of $\sin t \cos t$ is _____.

(h) Laplace transform of t^2 is _____.

GROUP - B

2. Answer any eight of the following within two or three sentences each. [1½ × 8

(a) Write Cauchy's Residue theorem.

(b) What is Taylor's series of e^z about $z = 0$.

(c) Express $\sqrt{\frac{1+i}{1-i}}$ in polar form.

(d) Write Cauchy Riemann equations in polar form.

(e) Define Laplace Transform.

(f) If $L\{f(t)\} = f(s)$, then show that $L\{f(at)\} = \frac{1}{a} f\left(\frac{s}{a}\right)$.

(g) Find the inverse Laplace Transform of $\frac{S}{S^2 + 16}$.

(h) State linearity property of Laplace Transformation.

(i) State convolution theorem of Fourier Transform.

(j) Write the expression for inverse Fourier transform.

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GROUP - C

3. Answer any eight of the following within 75 words each. [2 × 8

(a) Using De Moivre's theorem, solve $x^7 - 1 = 0$

(b) Find the conjugate Harmonic Function whose real part is $(x^2 - y^2)$.

(c) Evaluate $\oint_C \frac{\cos \pi z}{(z-1)} dz$ where C is the circle $|z| = 3$

(d) Find the residues of $f(z) = \frac{z}{z^2 + 1}$ at its poles.

(e) Find Fourier sine transform of $\frac{e^{-ax}}{x}$.

(f) Find Laplace transform of $(e^{2t} + e^{-3t})$.

(g) State Laurent's theorem for complex analytic functions.

(h) What is the result of Laplace transform of Dirac-Delta function.

(i) Discuss about complex conjugate of Fourier Transform.

(j) Find Fourier cosine integral of $f(x) = e^{-ax}$ where a is a positive constant.

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GROUP - D

4. Answer any four questions within 500 words each.

- (a) State and prove Cauchy Residue Theorem. [6]
- (b) State and prove Taylor's theorem for complex analytic function. [6]
- (c) Evaluate $\oint_C \frac{\sin \pi z^2 + \cos \pi z^2}{(z-1)(z-2)} dz$ where C is the circle $|z| = 3$. [6]
- (d) State and prove De Moivre's theorem. [6]
- (e) Find the Fourier transform of Gaussian distribution function $f(x) = Ne^{-ax^2}$, $a > 0$, N and a are constants. [6]
- (f) Using Laplace transform, solve the given differential equation $\frac{d^2y}{dt^2} + 4y = 2\sin(2t + \alpha)$ with $y(0) = 0$, $y'(0) = 0$. [6]
- (g) State and prove convolution theorem for Laplace Transform. [6]

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GROUP - A

1. Fill in the blanks. (all) [1 × 8
- (a) The minimum energy required to remove an electron from the surface of a metal is called _____.
- (b) A hydrogen atom is said to be in its ground state when its orbital electron _____.
- (c) Spin angular momentum of electron is equal to _____.
- (d) If the momentum of a particle is increased to four times, the de-Broglie wavelength will become _____.
- (e) Wavelength of matter waves is independent of _____.
- (f) A positron has the same mass as _____.
- (g) Which is used as moderator in nuclear reaction ? _____
- (h) Nuclear quadrupole moment is _____.

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GROUP - B

2. Answer any eight of the following within two or three sentences each. [1½ × 8

- (a) Explain ionisation potential of an atom.
- (b) What is group velocity ?
- (c) Use uncertainty principle to show that electrons cannot exist inside the nucleus.
- (d) Explain carbon dating.
- (e) What are the assumptions of Liquid drop model ?
- (f) State Stefan's law.
- (g) What are photoelectrons ?
- (h) What is critical potential ?
- (i) What is the physical significance of wave function ?
- (j) Give three properties of nuclear forces.

GROUP - C

3. Answer any eight of the following within 75 words each. [2 × 8

- (a) Why cannot the Compton effect be observed with visible

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light ?

- (b) Why the quantum number $n = 0$ is not allowed as per the Bohr theory ?
- (c) How does Bohr model of an atom explain the stability of the atom ?
- (d) What is wave packet ?
- (e) Show that density of nucleus does not depend upon its mass number.
- (f) What changes will take place in an atomic nucleus in beta emission ?
- (g) What is the function of carbon rods in the nuclear reactors ?
- (h) State the laws of radioactive decay.
- (i) What is the use of semi-empirical mass formula ?
- (j) What is the importance of absorption spectra ?

GROUP - D

4. Answer any four questions within 500 words each.

- (a) Explain the quantum theory of radiation. What is a photon and state its properties. [6

- (b) What is Compton effect ? Derive an expression for change in wavelength of scattered Photon in the Compton effect. [6]
- (c) Draw the energy level diagram of hydrogen atom. Discuss the various series obtained in the spectra of hydrogen atom. [6]
- (d) What is the phase velocity ? Show that it can exceed the velocity of light in vacuum. [6]
Derive a relation between phase and group velocities.
- (e) What is the uncertainty relation in energy and time ? Derive the relation from the uncertainty relation its position and momentum. [6]
- (f) Explain Liquid drop model of nucleus. What are the assumptions made in this model ? [6]
- (g) What is the difference between β^+ , β^- and electron capture ? Discuss the neutrino hypothesis of β -decay. [6]

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GROUP - A

1. Answer all questions and fill in the blanks as required. [1 × 8]
- (a) The value of $\overline{AB} + \overline{A} + AB$ is _____.
- (b) The binary equivalent of decimal number $(38)_{10}$ is _____.
- (c) The ROM is a storage device to store _____ information.
- (d) The logic gate is a digital circuit which can process one or more input signals to produce one output. (True / False / Cannot say)
- (e) A one-bit RAM consists of an RS flip-flop two _____ gates an one _____ gate.
- (f) An integrated circuit is that in which both active and passive components are fabricated on a single semiconductor chip. (True/False/Cannot say)

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- (g) The Two's component of $(101)_2$ is _____.
- (h) The counters are sequential circuits that keep the record of clock pulses sent. (True/False/Cannot say)

GROUP - B

2. Answer any eight of the following within two or three sentences each. [1½ × 8

- (a) State Demorgan's theorem.
- (b) Convert $(0.625)_{10}$ into binary number.
- (c) Why fluorescent screen is used in CRO ?
- (d) Write circuit diagram of XOR gate.
- (e) Show that NAND gate is an universal gate.
- (f) What are demultiplexers ?
- (g) What is decade counter ?
- (h) Evaluate $ABC + A \cdot (B + C)$ and draw the truth table.
- (i) What is peripheral memory ?
- (j) What is linear ICs ?

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GROUP - C

3. Answer any eight of the following within 75 words each. [2 × 8]
- (a) Prove that $(A + B) \cdot (A + C) = A + B \cdot C$.
 - (b) Find the time for which the monostable IC-555 timer is ON if $R = 1.4 \text{ K}\Omega$ and $C = 0.1 \text{ mF}$.
 - (c) Write the logic symbol and truth table for NOT gate.
 - (d) What are active components ? Write one example of active component.
 - (e) Using 1's complement method, subtract 01101 from 11011.
 - (f) Write the applications of astable and monostable multivibrators.
 - (g) How does a decoder function ? Explain.
 - (h) Explain a 4 bit binary Adder.
 - (i) What is Memory interfacing ?
 - (j) Compare the twisted Ring counter with standard Ring counter.

GROUP - D

4. Answer any four questions within 500 words each.
- (a) With neat circuit, explain the working of a CRO. [6]

P.T.O.

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- (b) What do you mean by scale of integration ? Explain SSI, MSI, LSI and VLSI. [2 + 4]
- (c) What are shift registers ? With neat circuit, explain the operation of serial-in-serial-out shift registers. [2 + 4]
- (d) What is memory ? Explain different types of memory with suitable diagram. [2 + 4]
- (e) What is multiplexer ? Draw a logic block diagram of a 4 to 1 multiplexer. [1 + 5]
- (f) What is NOR gate ? Write its truth table. How OR, AND and NOT gate can be obtained using NOR gate ? [1+2+1+1+1]
- (g) Draw the block diagram of an IC-555 timer and describe the functions of all the pins of IC-555 timer. [6]

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GROUP - A

1. Fill in the blanks. (all) [1 × 8
- (a) The volume of a nucleus in an atom is proportional to the _____.
- (b) Rainbows are formed by _____.
- (c) When $u \ll c$, then the Lorentz transformation reduces to the _____.
- (d) Newton's rings are _____.
- (e) If the numerical value of the kinetic energy of the electron of H-atom be k , then the total energy E of the electron is _____.
- (f) The velocity of photoelectrons depends on the _____ of the incidenting photon.

[2]

(g) If a particle is moving with kinetic energy K , then the de Broglie wavelength (λ) associated with it is related with K as _____.

(h) The wave function $\psi(\vec{r}, t)$ is said to be normalized if

$$\int_{\text{all space}} |\psi(\vec{r}, t)|^2 d\tau = \underline{\hspace{2cm}}$$

GROUP - B

2. Answer any eight of the following within two or three sentences each. [1½ × 8

(a) Write down the expression for velocity of electromagnetic wave in terms of μ_0 and ϵ_0 .

(b) What do you mean by coherent sources ?

(c) A particle of rest mass m_0 moves with speed $\frac{c}{\sqrt{2}}$. What will be its relativistic mass ?

(d) If the plane of polariser and analyser are perpendicular, then what will be intensity of the emergent light ?

(e) The refractive index for water is 1.33. Calculate the polarising angle for water.

(f) The decay chain of the nucleus ${}_{92}\text{U}^{238}$ involves eight α -decays and six β -decays. What will be the final Nucleus ?

(g) What is the consequence of Michelson Morley Experiment.

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- (h) What is the physical interpretation of the wave function ?
- (i) What is Bohr's correspondence principle ?
- (j) What do you mean by probability density ?

GROUP - C

3. Answer any eight of the following within 75 words each. [2 × 8

- (a) What is chromatic aberration ?
- (b) In Young's double slit experiment, $d = 1 \text{ mm}$, $D = 4 \text{ m}$ and $\lambda = 600 \text{ nm}$. Find $\beta =$ Fringle width.
- (c) How fast would a rocket have to go relative to an observer for its length to be contracted to 99% of its original length ?
- (d) Write down the basic postulates of the special theory of relativity.
- (e) Establish a relation between average life and half life of a radioactive nuclei.
- (f) What is the basic difference between Nuclear fusion and fission ?
- (g) State Ehrenfest's theorem.
- (h) What is expectation value of an observable ?

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- (i) Write down the limitations of Bohr's theory.
- (j) Write down the formula for Planck's quantum theory of radiation.

GROUP - D

4. Answer any four questions within 500 words each.

- (a) Describe Young's experiment for demonstration of interference of light. Find an expression for fringe width in case of Young's double slit experiment. [6]
- (b) Explain how Newton's rings are formed and describe the method for determination of wavelength of light using Newton's rings. [6]
- (c) Discuss about Compton Effect. [6]
- (d) Discuss about Frank Hertz Experiment. [6]
- (e) Derive Time independent Schrodinger's wave equation. [6]
- (f) Derive expression for Equation of Continuity. [6]
- (g) Show that acceleration is invariant in case of Galilean transformation. [6]