d) Find the Laplace transform of $\cos^2 t$.

GROUP–C

3. Answer any **two** questions: 10×2=20

a) Determine the poles of the following function. Find the order of each pole.

$$\frac{z-3}{(z-2)(z+1)^2}$$

Evaluate the following complex integral

$\oint_C \frac{z-1}{(z-2)(z+1)^2}$ where c is the circle $|z-i|=2$.

5+5

b) Find the Fourier sine and cosine transform of $ae^{-\alpha x}+be^{-\beta x}$. 5+5

c) Show that the real and imaginary parts of the function w = log z satisfy the Cauchy-Riemann equations when z is not zero. Find its derivative.

Find an analytic function $f(z)=u(r,\theta)+iv(r,\theta)$ such that $V(r,\theta)=r^2\cos^2\theta-r\cos\theta+2$.

5+5

d) Prove $L(t^n)=\frac{n!}{s^{n+1}}$. Find the Laplace transforms of the following: $t\sin 2t$. 5+5

U.G. 3rd Semester Examination - 2024

PHYSICS

[PROGRAMME]

Course Code : PHY-G-CC-T-03-(A-D)

[CBCS]

Full Marks : 40 Time : $2\frac{1}{2}$ Hours

The figures in the right-hand margin indicate marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer all the questions from Selected Option.

OPTION-A

PHY-G-CC-T-03

(Elements of Modern Physics)

GROUP–A

1. Answer any **five** questions: 2×5=10

a) Write the position momentum uncertainty principle.

b) Show that $[\hat{x},\hat{p}_x]=ih/2\pi$.

c) Can pair production take place in vacuum ? Explain your answer.

d) What is the physical significance of normalizing a wave function?

e) What is the relation between phase velocity and group velocity?

f) Define half life of a radioactive nucleotide.

g) What are the differences between nuclear fission and fusion?

h) What is neutrino? What are the basic differences between a neutrino and an antineutrino ?

GROUP–B

2. Answer any **two** questions: 5×2=10

a) What is the stopping potential in photoelectric effect? Is stopping potential dependent on frequency of incident electrons? The maximum kinetic energy of photoelectron is 1.3eV when ultraviolet light of wavelength 350 nm is directed at a potassium surface. Find the work function of potassium. 2+1+2

b) What is the Compton wavelength? Explain the presence of the unmodified line in Compton scattering. Will there be any Compton shift for light in the visible range? 1+2+2

c) What do you mean by inverse beta decay ? How can the continuous nature of the beta-ray spectrum be explained theoretically? Does parity remain conserved in case of beta decay? 1+3+1

d) Define the binding energy of a nucleus. How does the binding energy per nucleon vary with the mass number ? Give examples of isotope and isotone. 2+2+1

GROUP–C

3. Answer any **two** questions: 10×2=20

a) i) The nuclei are approximately spherical and have an average radius r given by $r = R_0 A^{1/3}$ where A is the mass number and R_0 is a constant equal to 1.2×10^{15}m. If the mass of proton and neutron be approximately equal to 1.6×10^{-27} kg then show that the nuclear density is greater than the density of water by a factor 10^{14}.

ii) Show from the semi-empirical mass formula, that $A = 2Z$ for light nuclei .

iii) A nucleus with A = 235 splits into two nuclei whose mass no. are in the ratio 2:1. Find the radii of the new nuclei. ($R_0 = 1.4$ *fm*) 4+4+2

b) Give a short description of construction and working principle of RUBY laser. Derive relations between Einstein's A and B coefficients. What is optical pumping in laser action? 4+4+2

c) i) Find the eigenfunctions and eigenvalues for the operator $x+\frac{d}{dx}$.

ii) Normalize $\Psi_1(x)=A_1e^{-\alpha x^2}$ and $\Psi_1(x)=A_2xe^{-\alpha x^2}$ over the interval $-\infty \le x \le \infty$. 5+(2+3)

d) i) A particle is confined to move in one dimensional box with perfectly rigid walls at x = 0 and at x = a. Find the normalized wave functions and energy eigenvalues.

ii) An electron is trapped in a one dimensional region of length 1.0×10^{-10}m. How much energy must be supplied to excite the electron from ground state to first excited state.

iii) Show that eigenvalues of a Hermitian operator are real. 5+3+2

OPTION-B

PHY-G-CC-T-03

(Analog Systems and Applications)

GROUP–A

1. Answer any **five** questions: 2×5=10

a) Derive relation between α and β of a transistor.

b) What do you mean by drift velocity of charge carriers? Write down its Sl unit.

c) State and explain Barkhausen criterion of oscillation.

d) Draw the energy band diagrams of a metal, conductor and semiconductor.

e) Explain Zener breakdown and avalanche breakdown.

f) With the help of a neat diagram show the frequency response of an R–C coupled amplifier. What do you mean by bandwidth?

g) In the light of band theory distinguish metal, conductor and semiconductor.

h) Explain the term virtual ground of an OP–AMP.

GROUP–B

2. Answer any **two** questions: 5×2=10

a) Explain the terms load line and Q point of a transistor? Define class A and Class B amplifiers. $1\frac{1}{2}+1\frac{1}{2}+2=5$

b) What do you mean by the hybrid parameters of a transistor? Why are they called so? Explain the terms h_{oe} and h_{fe} in a transistor. Define decibel gain. 1+1+2+1=5

c) Write down the full form of LED. Draw the V-I curve of a forward biased LED. Write down two advantages of LED. What is a solar cell? 1+1+2+1=5

d) With the help of a neat diagram explain the working principle of a full wave bridge rectifier. Write down its two disadvantages. 3+2=5

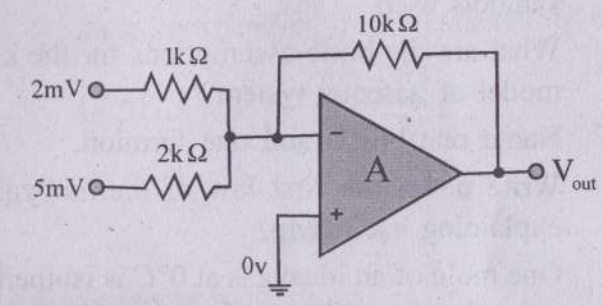
GROUP–C

3. Answer any **two** questions: 10×2=20

a) What do you mean by intrinsic and extrinsic semiconductors? Draw energy band diagrams of a p-type and n-type semiconductor. Using the schematic diagram explain the effect in potential barrier height due to forward and reverse biasing in a p-n junction diode. Explain the working principle of a zener diode as voltage regulator. 2+2+3+3=10

b) With the help of necessary circuit diagram explain the working principle of a RC coupled amplifier. Write a short note on the D/A converter. 5+5=10

c) What do you mean by inverting and non inverting OP-AMP? Derive the expression for current gain in an inverting OP-AMP. Explain briefly the working principle of an OP-AMP as adder. For the circuit given below determine the value of V_{out} 2+3+3+2=10



d) Explain the terms CMRR and virtual ground. Establish the relation $\frac{D_p}{\mu_p}=\frac{kT}{e}$; The symbols have their usual meanings. Write down the principle of multi-stage amplifiers. Write down two origins of noises in an amplifier. 2+4+2+2=10

OPTION-C

PHY-G-CC-T-03

(Thermal Physics and Statistical Mechanics)

GROUP-A

1. Answer any **five** questions: $2\times5=10$

a) What is an isenthalpic process, discuss with an example?

b) Represent a Carnot cycle on i) p–v diagram, ii) S–T diagram.

c) What is black body radiation?

d) Write down the Maxwell Boltzmann molecular velocity distribution law explaining all the symbols used.

e) What are the basic assumptions for the kinetic model of gaseous system?

f) Name one boson and one fermion.

g) Write down the first law of thermodynamics explaining each term.

h) One mole of an ideal gas at $0°C$ is isothermally expanded from 1 litre to 2 litre. Find the work done?

GROUP-B

2. Answer any **two** questions. $5\times2=10$

a) A Carnot engine operates between T_1 and T_2 with gas as working substance whose equation of state is given by $P(V-b)=RT$. Work out expression for heat absorbed and the work done in each part of the cycle and show that the efficiency $\eta=1-T_2/T_1$ 2+2+1

b) What do you mean by phase space? Write Bose-Einstein distribution law and Fermi- Dirac distribution law explaining each term. $2+1\frac{1}{2}+1\frac{1}{2}$

c) Define mean free path of gas molecules. Show that the probability of gas molecule traveling a distance x without collision, is $e^{x/\lambda}$, where λ is the mean free path of the gas molecule. 1+4

d) Discuss the concept of quasistatic process in thermodynamics. During a quasistatic adiabatic expansion of an ideal gas, the pressure at any moment is given by the equation $PV\gamma=K$, where γ and K are constants. Show that the work done in expanding from a state (Pi, Vi) to a state (Pf, Vf) is $W=-\dfrac{P_iV_i-P_fV_f}{\gamma-1}$ 2+3

GROUP-C

3. Answer any **two** questions. $10\times2=20$

a) What is Joule- Thomson effect? Show that the Joule- Thomson coefficient μ can be derived as $\mu=\left(\dfrac{\partial T}{\partial P}\right)H=\dfrac{1}{C_P}\left[T\left(\dfrac{\partial V}{\partial T}\right)_P-V\right]$. Hence show that ideal gas does not show any Joule-Thomson effect. What do you mean by inversion temperature? Write short note on Clausius-Clapeyron equation. $2+3+1+1\frac{1}{2}+2\frac{1}{2}$

b) What is the principle of increase of entropy? Calculate the change of entropy for an ideal gas which undergoes an isothermal expansion. What do you mean by Gibb's free energy? Show that for an infinitesimal reversible process $dG=SdT+VdP$ (symbols have their usual meaning). Also show that in case of a reversible isothermal and isobaric process Gibb's free energy remains constant. 2+3+1+3+1

c) Write down four Maxwell's relations. Write down the first and second TdS equations. Hence prove the relation $C_P - C_V = T\left(\frac{\partial P}{\partial T}\right)V\left(\frac{\partial V}{\partial T}\right)P$. 4+3+3

d) Derive Planck's radiation law in case of black body radiation. In what conditions that Planck's law reduces to Wein's law and Rayleigh- Jeans law? Calculate the total rate of radiation of energy of a thin circular disc of radius 10 cm, heated at 500°C. 5+2+3

OPTION-D

PHY-G-CC-T-03

(Mathematical Physics-III)

GROUP–A

1. Answer any **five** questions: 2×5=10

a) Define isolated singularity of a complex function.

b) Evaluate the integral $\int_C |z|dz$ where C is the straight line from $z = -i$ to $z = i$.

c) Determine whether $(1/z)$ is analytic or not.

d) Find the residue of tan z at its pole.

e) Prove that $z = \pm i$ are branch points of $\left(z^2+1\right)^{\frac{1}{3}}$.

f) Prove $L(1) = 1/s$.

g) Write down the Convolution Theorem on Fourier Transform.

h) State Residue theorem.

GROUP–B

2. Answer any **two** questions: 5×2=10

a) Verify, Cauchy theorem by integrating e^{tz} along the boundary of the triangle with the vertices at the points $1 + i$, $-1 + i$ and $-1 - i$.

b) Find the Fourier cosine transform of

$$f(x) = e^{-2x} + 4e^{-3x}.$$

c) Show that the function $e^x(\cos y + i \sin y)$ is an analytic function. Find its derivative.