U.G. 2nd Semester Examination - 2024

PHYSICS

[PROGRAMME]

Course Code : PHY-G-CC-T-02(A-E)

[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-02A

(Thermal Physics)

GROUP–A

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

   a) At what temperature will root mean square velocity of nitrogen molecule be double its value at N.T.P. when pressure remains constant?

   b) Write the Zeroth law of thermodynamics and hence give a concept of temperature.

   c) What is mean free path of gas molecules in a gas? Write down its expression.

d) Define Compressibility and Expansion Co-efficient.

e) Prove for a quasistatic adiabatic process of an ideal gas $TV^{\gamma-1}$ = const.

f) "The existence of internal energy can be inferred from the first law of thermodynamics" —Discuss.

g) Define Boyle's temperature. What would be the nature of the pV– p plot of a real gas at its Boyle's temperature?

h) Explain the terms 'State function' and 'Path function'. Show that the work done by a system is a path function.

GROUP-B

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

a) State the characteristics of Brownian motion. A perfect gas at 27°C is suddenly compressed to 8 times its original pressure. Find its rise in temperature, if $\gamma = 1.5$. $2\frac{1}{2}+2\frac{1}{2}$

b) Deduce an expression for the most probable velocity of the molecules of a gas. Hence show that if the most probable velocity is taken as unit of speed for gas molecules, the probability

that the speed is between c and $c+dc$ is independent of temperature. 2+3

c) Write the principle of increase of Entropy. Calculate the change in entropy for an ideal gas which undergoes an isothermal expansion. 2+3

d) Prove that the difference of molar specific heat $C_p - C_v = \left\{P+\left(\frac{\partial U}{\partial V}\right)_T\right\}\left(\frac{\partial V}{\partial T}\right)_P$. Hence calculate the difference of molar specific heat for an ideal gas. 4+1

GROUP C

Answer any **two** questions: 10×2=20

3. a) Write down the Maxwell's four thermodynamic relation. Starting from the first relation derive the Clapeyron's equation. 2+2

b) Derive the first energy equation and hence show that temperature remaining constant, the internal energy of an ideal gas is independent of volume. 2+2

c) What are the first and second order phase transitions and what is the phase diagram? 2

4. Using thermodynamic potentials derive Maxwell's four relations. $2\frac{1}{2}+2\frac{1}{2}+2\frac{1}{2}+2\frac{1}{2}$

5. a) The equation of state of Vander waal gas is given by $\left(P+\frac{a}{v^2}\right)(v-b)=RT$, where a, b and R are constants. Calculate the quantities: $\left(\frac{\partial P}{\partial v}\right)_T$ *and* $\left(\frac{\partial P}{\partial T}\right)_v$. 2+2

b) Show that the work done by an ideal gas during the quasi-static, isothermal expansion from an initial pressure P_i to a final pressure P_f is given by $W = nRTln(P_f/P_i)$. Calculate the work done when the pressure of 1 mol of an ideal gas is decreased quasi—statically from 20 to 1 atm, the temperature remaining constant at 20° C(R = 8.31 J/mol.deg). 2+1

c) Consider the entropy of a pure substance as a function of T and V, derive the first TdS equation. 3

6. a) Write down the Maxwell's law of velocity distribution of the molecules of a gas mentioning each symbol. Indicate graphically how this distribution changes with the rise of temperature. 2+2

b) Starting from speed distribution law of Maxwell, deduce the momentum distribution law of the molecules of a gas. 2

c) If αt be the probability of a gas molecule making a collision in the time interval dt, where α is a constant, (i) find the probability of a gas molecule experiencing no collision during the interval t, and (ii) calculate the mean time interval between successive collisions. 2+2

OPTION–B

PHY-G-CC-T-02B

(Electricity and Magnetism)

GROUP–A

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

a) Find a vector that is orthogonal to the plane containing the points P=(3, 0, 1), Q=(4, –2,1) and R:(5, 3, –1).

b) Check whether the following represent electrostatic fields or not:

$$\vec{E} = A[y^2 t\hat{i} + (2xy + z^2)t\hat{j} + 2yzt\hat{k}]$$

c) Write the differential form of Gauss's law for dielectric.

d) Show that electric field is always perpendicular to the equipotential surface.

e) What is Lorentz force? Explain with diagram.

f) State and explain Gauss law in dielectric medium.

g) Define polarization vector of a dielectric. What is its physical significance?

h) State and explain Gauss divergence theorem and Stoke's theorem of vectors.

GROUP-B

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

a) What is electric field intensity $(\vec{E})$ and electric potential (φ) at a point P due to a charge +q at a distance r. Find the relation between $\vec{E}$ and φ . Calculate $\vec{\nabla}\times\vec{E}$. 1+2+2

b) Derive the expression of Potential and Electric field due to an electric dipole of dipole moment 'm' at a point at a distance 'r' from on its axial line. 5

c) Write the differences between dia-, para- and ferro magnetic materials. Define dielectric susceptibility of a medium. What is linear dielectric? Give example. 3+1+1

d) Prove that $\vec{\nabla}\times(\phi\vec{V}) = (\vec{\nabla}\phi)\times\vec{V} + \phi(\vec{\nabla}\times\vec{V})$ for a scalar field $\phi(x,y,z)$ and a vector field $\vec{V}(x,y,z)$.

Now take $\vec{V}$ to be a non-zero constant vector field $\vec{C}$ and use Stoke's theorem to prove that

$$\oint_C \phi d\vec{r} = \iint_S d\vec{S}\times\vec{\nabla}\phi$$

2+3

GROUP- C

Answer any **two** questions: 10×2=20

3. a) State and explain Faraday's laws of electromagnetic induction.

   b) Starting from the expression of magnetic vector potential $\vec{A} = \frac{\mu_0 I}{4\pi}\int \frac{\vec{dl}}{r}$, obtain the expression $\vec{B} = \frac{\mu_0 I}{4\pi}\int \frac{\vec{dl}\times\vec{r}}{r^2}$, where $\vec{B} = \vec{\nabla}\times\vec{A}$.

   c) Calculate self inductance L of a circular coil of radius 'a' having 'n' turns. 3+4+3

4. a) Write down the relation between B, H and M. What is ferromagnetism? Draw magnetization curves for soft iron and steel on the same graph as each is taken through a complete cycle of magnetic field.

   b) Show that the hysteresis loss per unit volume per cycle of magnetization is equal to the area enclosed by the B-H loop.

   c) Derive an expression of magnetic force on a current carrying wire. (1+1+2)+3+3

5. a) State and explain equation of continuity of current. What is Displacement current?

   b) Consider a long straight wire XY carrying current I(t). Calculate the flux through a rectangular wire ABCD in the plane of the wire

XY. Calculate induced e.m.f around ABCD and comment about the direction of induced current in ABCD.

   c) What is a parallel plate capacitor? Find an expression for its capacitance. 2+(2+1+1)+4

6. a) Calculate the electric field inside and outside of a uniformly charged solid sphere.

   b) Show that the electrostatic self energy of a uniformly charged sphere is $\frac{1}{4\pi\varepsilon_0}\frac{3Q^2}{5a}$? Where '$a$' is the radius of the sphere, Q is the charge on the sphere.

   c) Define magnetic vector potential and scalar potential. 4+4+2

OPTION–C

PHY-G-CC-T-02C

(Waves & Optics)

GROUP–A

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

   a) Why two candles do not produce intereference pattern?

   b) The wavelength of a light 589nm incident on a grating with 104 lines/mm. How many orders would be visible?

   c) Explain the formation of Newtons ring with diagram.

   d) Draw the resultant patterns due to superposition of two rectangular simple harmonic motion with same frequencies.

   e) At what temperature would the speed of sound in air be double its value at 0°C.

   f) An orange light with wavelength 600nm has a coherence length of approx. 20cm. Calculate the line width in terms of wavelength.

   g) Distinguish between interference and diffraction.

   h) The primary focal length of a zone plate is 20cm for light of wavelength 500nm. Calculate the radius of the central zone on the zone plate.

GROUP-B

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

   a) Show that the radius of the n^{th} zone of Fresnels Half period zone depends on 'n' but the area of the n^{th} zone is independent of 'n'. 5

   b) Explain the nature of Lissajous figure obtained due to superposition of the waves $x = 5\sin\omega t$ *and* $y = 5\cos\omega t$.

   Show that the number of beats produced per second is the dilference between the frequencies of the sources. 2+3=5

   c) Calculate the fringe width produced on a film when a parallel beam of monochromatic light incident normally on the film. 5

   d) Write a short note on Nicol prism. 1+4=5

GROUP-C

Answer any **two** questions: 10×2=20

3. Write down the characteristics of a good auditorium. Considering necessary assumptions derive Sabine's formula of optimum reverberation. What is the

difference between Fresnel and Fraunhofer diffraction? 3+5+2

4. a) What is Fresnel diffraction? Discuss the properties of Fresnel diffraction of a cylindrical wave front at a narrow obstacle (cylindrical wire).

   b) What is Holography? Briefly explain the theory of Holography. 1+4+1+4

5. a) Consider a constant tension of stretched string is 'T'. The length of the string is 'L' and mass per unit length is 'm'. Calculate the velocity of transverse vibration of the string.

   b) For a plucked string, show that the amplitude of the s-th harmonic is proportional to $1/s^2$. 3+7

6. a) Write down the conditions for observable interference pattern.

   b) Explain the effect of introducing a thin glass plate in the path of one of the interfering beams in bi-prism experiment. Also show that the velocity of light is maximum in vacuum. 2+8

OPTION–D

PHY-G-CC-T-02D

(Digital Systems & Applications)

GROUP–A

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

   a) Write the full form of ALU in microprocessor.

   b) What do you mean by positive logic and negative logic?

   c) What do you mean by bit, nibble and byte?

   d) Write down the two De Morgan's theorem.

   e) Which gates are called universal logic gates and why?

   f) Convert binary 110.001 to a decimal number.

   g) What is the difference between analog and digital circuits?

GROUP–B

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

   a) Show how an S-R flip-flop can be converted into a J-K flip flop. What do you mean by edge triggering in a flip flop? 3+2

   b) What do the letters R and S stand for in the term "RS flip-flop"? Explain the operation of the master-slave flip-flop. 1+4

c) What is a multiplexer? Explain with the help of truth table and logic circuit how a 4-to-1 multiplexer works. 1+4

d) What are minterms? How many fundamental products are there for n variables? Let us suppose that a three-valuable truth table has a high output for these input conditions: 000, 010, 100 and 110. What is the sum-of-products circuit? 1+1+3

GROUP–C

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

a) A shift register has eight flip-flops. What is the largest binary number that can be stored in it? Name the four basic types of shift registers and draw a block diagram for each. Derive an expression for deflection sensitivity of a CRT using electrostatic deflection. 1+4+5

b) Prove that $A(\overline{A}+C)(\overline{A}B+C)(\overline{A}BC+\overline{C})=0$. Write down a summary of the Karnaugh-map method for simplifying Boolean equations. Subtract 16 from 83 by using 2's complement representation. 3+3+4

c) Using Karnaugh Map simplify the logic function:

$$+BC+A+ABC$$

Using NAND only generate the function: B+A. What is a decoder? Explain with logic circuit how BCD digits can be decoded as decimal digit. 4+2+4

d) Draw the logic diagram, truth table and waveforms for a two-flip-flop ripple counter. Draw the circuit diagram of an astable multivibrator using IC 555 timer and explain its working principle. Convert the binary number 1011110001.1001101 into its hexadecimal equivalent. 3+5+2

OPTION–E

PHY-G-CC-T-02E

(Mathematical Physics-II)

GROUP–A

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

   a) Define gamma function $\Gamma(n)$. Evaluate $\Gamma(-5/2)$ using $\Gamma(1/2) = \sqrt{\pi}$.

   b) Define ordinary point and singular point.

   c) What do you mean by even and odd function symmetry?

   d) Distinguish between Random error and Systematic error.

   e) Show that $erf(\infty) = 1$.

   f) Write down the Laplace's equation for spherical polar coordinate.

   g) State under what conditions, a function $f(x)$ can be Fourier expanded in convergent series.

   h) What are the Dirichlet conditions in Fourier series?

GROUP–B

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

   a) Show that $\Gamma(n+1) = n!$ and hence show $\Gamma(5/2) = (3/4)\sqrt{\pi}$. 5

   b) Expand the function $f(x)=\begin{cases}0, & -\pi \le x < 0 \\ A & 0 \le x < \pi\end{cases}$ in a Fourier series. 5

   c) Examine the singular point for the following Bessel's equation $x^2\frac{d^2y}{dx^2}+x\frac{dy}{dx}+\left(x^2-m^2\right)y=0$ and also show the nature of singularity. 5

   d) Solve the following boundary value problem $\frac{\partial u}{\partial x}=4\frac{\partial u}{\partial y}$ given $u(0, y) = 8\, e^{-3y}$, by the method of separation of variables. 5

GROUP–C

Answer any **two** from the following questions: 10×2=20

3. a) Define Bessel's function of first kind of order n denoted by J_n and prove the recurrence formulae $xJ_n' = nJ_n - x\,J_{n+1}$. 2+3

b) Show that $g(x, t) = (1-2xt+t^2)^{-1/2}$ is the generating function of Legendre polynomials $P_n(x)$ and hence prove the recurrence relation $n\ P_n(x) = (2n-1)x\ P_{n-1}(x) - (n-1)\ P_{n-2}(x)$.

2+3

4. a) Show that $\beta(m, n) = \dfrac{\Gamma(m)\Gamma(n)}{\Gamma(m+n)}$. 4

b) Find the Fourier series for the following function $f(x) = \begin{cases} -k, & -\pi < x < 0 \\ k & 0 < x < \pi \end{cases}$.

Hence show that $\dfrac{\pi}{4} = 1-1/3+1/5-1/7+1/9-\ldots$

4+2

5. a) State whether the following partial differential equation $\dfrac{\partial^2 u}{\partial x^2} + \dfrac{\partial^2 u}{\partial y^2} = 0$ is elliptic or parabolic.

Find a solution to the following differential equation $\dfrac{\partial^2 \psi}{\partial x^2} + \dfrac{\partial^2 \psi}{\partial y^2} = 0$ inside an annulus bounded by the circles $x^2 + y^2 = r_1^2$ and $x^2 + y^2 = r_2^2$ that satisfies the conditions $\psi = \psi_2$ *at* $r = r_2$ and $\left(\dfrac{\partial \psi}{\partial r}\right) = \dfrac{k}{r_1}$ at $r = r_1$. 2+4

b) Write down the expression for *erf(x)* and *erf(–x)* and show that *erf(x)* + *erf(–x)* = 0.

2+2

6. Solve any **two** from the following integral: 5×2=10

a) $\int_0^{\pi/2} \left(\tan^3\theta + \tan^5\theta\right) e^{-\tan^2\theta}\, d\theta$

b) $\int_0^{\infty} 3^{-4z^2}\, dz$

c) $\int_0^1 \dfrac{dx}{\sqrt{1-x^n}}$