U.G. 2nd Semester Examination - 2023
PHYSICS
[PROGRAMME]
Course Code : PHY-G-CC-T-02(A-D)

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) What are an isolated and a closed system in thermodynamics?

   b) What are extensive and intensive variables in thermodynamics? Give examples of each.

   c) Show that the work done by a gas when it expands from V_1 to V_2 is given by

   $$W = \int_{V_1}^{V_2} pdV$$

d) Draw p-V indicator diagrams for isochoric, isobaric, isothermal and adiabatic processes.

e) Why adiabatics are steeper than isothermals?

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

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

GROUP-B

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

a) State the principle of equipartition of energy. If the number of degrees of freedom per molecule of a perfect gas is f, show that,

$\gamma = 1 + \dfrac{2}{f}$ Where γ is the ratio of the specific

heats of gas at constant pressure and at constant volume. Calculate the values of γ for monatomic, diatomic and triatomic molecules.

$$1 + 2\tfrac{1}{2} + 1\tfrac{1}{2}$$

b)	Write down the van der Waal's equation for n moles of a real gas. Prove that $\dfrac{RT_C}{P_C V_C} = \dfrac{8}{3}$ for van der Waal's gas. 1+4

c)	What are the differences between reversible and irreversible process? Draw indicator diagram (p-V graph) of Carnot's cycle. A Carnot engine whose low temperature reservoir is at 7°C has an efficiency of 40%. To increase the efficiency to 50% by how many degrees should the temperature of the source be increased? 2+1+2

d)	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 $\gamma = 1.5$. $2\frac{1}{2}+2\frac{1}{2}$

GROUP C

Answer any **two** questions: 10×2=20

3.	i)	Write down the basic assumption of kinetic theory of gases.

	ii)	Derive an expression for the pressure of a gas from the standpoint of kinetic theory.

	iii)	Show that the pressure exerted by a perfect gas is two-thirds of the kinetic energy of the gas molecules per unit volume.

iv) The average kinetic energy of a molecule of hydrogen at 0°C is 5.64×10^{-21} joule and the gas constant R = 8.32 joule mole^{-1}K^{-1}. Calculate Avogadro's Number.   2+4+2+2

4. i) What are mean, rms and most probable velocities of gas molecules?

ii) Find their values from Maxwell's law of distribution of molecular velocities and show that

$$C_{mp} : C_m : C_{rms} = \sqrt{2} : \sqrt{\frac{8}{\pi}} : \sqrt{3}$$

iii) Explain the difference between a perfect gas and a real gas.   3+6+1

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

6. What do you mean by enthalpy function? Show that in throttling process (J-T effect), the enthalpy in the final equilibrium state is equal to the enthalpy in the initial equilibrium state. Find the expression of inversion temperature for van der Waal's gas.

    2+3+5

GROUP–A

1. Answer any **five** questions: $2 \times 5 = 10$

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

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

    $$\vec{E} = A\left[y^2 t\hat{\imath} + (2xy + z^2)t\hat{\jmath} + 2yzt\hat{k}\right]$$

    c) State and explain Gauss law in dielectric medium.

    d) What is Lorentz force? Explain with diagram.

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

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

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

    h) 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).

GROUP-B

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

a) 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

b) 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

c) 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

d) 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

GROUP- C

Answer any **two** questions: 10×2=20

3.   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 $\dfrac{1}{4\pi\varepsilon_0}\dfrac{3Q^2}{5a}$?

          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

4.   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

5.   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. $(1+1+2)+3+3$

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

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

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

PHY-G-CC-T-02C

(Waves & Optics)

GROUP–A

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

   a) State and explain Fourier's theorem.

   b) Determine the ratio of the frequencies in horizontal and vertical direction for the given Lissajous figure:
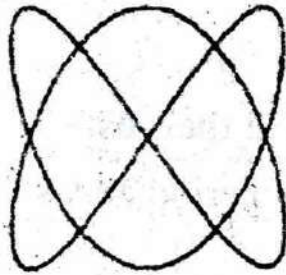
   c) Determine the amplitude, wave velocity, wave length and initial phase angle for the wave $y = 5\sin(30\pi t - 10x)$.

   d) What do you mean by reverberation and reverberation time?

   e) Define wavefront. Give an example of spherical wavefront.

   f) Determine the thickness of a half wave plate and quarter wave plate for light wave of $\lambda = 5000\text{Å}$; given $\mu_0 = 1.65$ and $\mu_c = 1.55$.

g) Distinguish between interference and diffraction.

h) Why two candles do not produce intereference pattern?

GROUP-B

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

a) For a ray of light falling in the interface of two materials of different refractive indices and transmission coefficients, derive the Stokes relations: $t't + r^2 = 1$ and $r = -r'$; the symbols have their usual meanings. What are Fresnel half period zones? Define zone plate. $3+1+1=5$

b) Define intensity and loudness. Using molecular theory give the origin of surface tension. Write down the SI unit of surface tension. $2+2+1=5$

c) 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. $2+3=5$

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

GROUP-C

Answer any **two** questions: $10 \times 2 = 20$

3. a) Derive the expression for the fringes produced in the Young's double slit experiment.

   b) Explain how the wave length of monochromatic light can be determined using Michelson's Interferometer. State and explain Brewster's law. $4+(4+2)=10$

4. What do you mean by positive and negative crystal? State and explain the laws of transverse vibration in a stretched string. Define angle of contact. What do you mean by synclastic and anticlastic surface? Write down the SI unit of viscosity.

   $$2+3+2+2+1=10$$

5. A displacement curve is given by $f(t) = A$ for $0 < t < T/2$ and $f(t) = -A$ for $T/2 < t < T$; where A is a constant. Draw the graph of $f(t)$ and obtain the Fourier series expansion for $f(t)$. Define bel and phon. $6+4=10$

6. 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? $3+5+2$

OPTION–D

PHY-G-CC-T-02D

(Digital Systems & Applications)

GROUP–A

1. Answer any **five** questions: $2 \times 5 = 10$

    a) Express the following decimal number in binary forms: 23.8125.

    b) Use 2's compliment to perform the binary subtraction 11011 – 01101.

    c) Why XOR gate is called inequality detector?

    d) State De-Morgan's theorem.

    e) What is virtual ground in OP-AMP?

    f) Can you calculate 7 in 8085 microprocessor? Explain.

    g) What are volatile and non-volatile memories available in a microprocessor?

    h) Write the full form of ALU in microprocessor.

GROUP–B

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

    a) Draw the schematic diagram and derive expression for the output voltage for a summing amplifier or adder. List the main characteristics of an ideal OP-AMP.

    $(1+2)+2$

b) How many half adder are required to make a full adder? Explain it with a block diagram. Show how an OR and AND gates can be constructed with NAND gates only.   1+2+2

c) What is demultiplexer? Give the circuit diagram of a 1-line to 4-line demultiplexer using basic gates.   1+4

d) 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

GROUP–C

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

a) Explain how the phase difference between two a.c voltages of same frequency can be measured by a CRO using Lissajous figure. What do you mean by deflection sensitivity? Derive an expression for deflection sensitivity of a CRO using electrostatic deflection.

3+2+5

b) What is a counter? Construct a four bit ripple counter. What do you mean by up and down counter? Construct a 4-bit shift resister using D-type flip-flops.   1+4+1+4

c) What do you mean by an 8-bit microprocessor? Draw the block diagram of Intel 8085 microprocessor. With reference to 8085 microprocessor explain the function of the following: Accumulator, ALU, Program counter, Interrupt control and Temporary resistor. 2+3+5

d) 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

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