U.G. 5th Semester Examination-2024

PHYSICS

[PROGRAMME]

Discipline Specific Elective (DSE)

Course Code : PHY-G-DSE-T-01(A-G)

[New Syllabus]

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.

Symbols have their usual meaning.

Answer all the questions from Selected Option.

OPTION-A

PHY-G-DSE-T-01

(Electricity and Magnetism)

GROUP-A

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

a) Find the angle between the vectors $\vec{A}=(-\hat{i}+\hat{j})$ and $\vec{B}=\hat{i}-\hat{j}$.

b) State and explain Gauss's divergence theorem.

c) Check whether the vector $\vec{E}=x\hat{i}+y\hat{j}+z\hat{k}$ represents a conservative field or not.

d) What do you mean by equipotential surface?

e) Explain why two electric lines of forces do not intersect each other?

f) Define paramagnetic, diamagnetic, and ferromagnetic materials.

g) Define the Poynting's vector. Write down its physical significance.

h) Explain the importance of dielectric material in capacitors.

GROUP–B

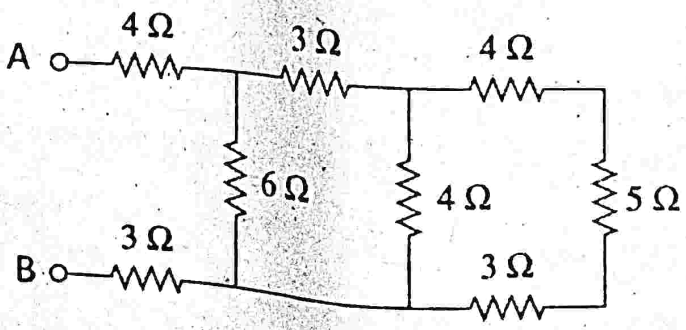
Answer any **two** questions: $5\times2=10$

2. a) Write down Gauss's theorem of electrostatics. Derive Coulomb's law from it. 2+3

b) Derive the expression of the torque experienced by a magnetic dipole kept perpendicular to an electric field $\vec{B}$. Write down the physical significance of $\vec{\nabla}.\vec{B}=0$. 4+1

c) Write Biot-Savart's law. Apply this law to find the magnetic field at a perpendicular distance r from above the Centre of a circular loop carrying current I. 2+3

d) What do you mean by source field and sink field? Find out the equivalent resistance value between points A and B in the figure below:



2+3

GROUP–C

$10 \times 2 = 20$

Answer any **two** questions:

3. a) State and prove Lenz's law. Define eddy current. Why are transformer cores laminated? What is motional e.m.f.? Define self-inductance and mutual inductance. 2+2+2+2+2

b) Write down four Maxwell's equations, explaining each term. Write down the equation of continuity. Write down the expression for the velocity of light in free space (c) in terms of μ_0 and $\in_0$. With the help of suitable diagram explain the electromagnetic nature of light. 4+1+1+1+3

c) What do you mean by hysteresis and hysteresis loss? What kind of materials will you suggest for the electromagnet and permanent magnet? State and explain Ampere's circuital law. Write a short note on Poynting's theorem. 1+1+1+1+2+4

d) Define magnetic susceptibility and permeability. Find the relationship between B and H. Define Bohr magneton and find out its value. State and prove Lenz's law. Derive the value of $\vec{\nabla} r^5$. 2+2+2+2+2

OPTION-B

PHY-G-DSE-T-01

(Computational Physics Skills)

GROUP-A

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

a) Define an algorithm and give one example of its use in computational physics.

b) What is a flowchart, and list two key advantages of using it?

c) What is the significance of the RETURN statement in FORTRAN?

d) State any two differences between algorithms and flowcharts.

e) Name two Linux commands used for managing files and directories.

f) Write the formula for converting Cartesian coordinates to spherical polar coordinates.

g) Mention any two types of control statements in FORTRAN.

h) What is the purpose of the DIMENSION statement in FORTRAN?

GROUP-B

2. Answer any **two** of the following questions: $5\times2=10$

a) Write the properties of a well-defined algorithm. Draw a flowchart to calculate the roots of a quadratic equation.

b) Explain the basic structure of a DO-WHILE loop in FORTRAN with an example.

c) Differentiate between internal and external Linux commands. Write Linux commands for creating and deleting directories.

d) Describe how control statements (selection, repetition, and jumping) work in FORTRAN, with one example each.

GROUP-C

3. Answer any **two** of the following questions: $10\times2=20$

a) Develop an algorithm and flowchart to calculate the sum and product of a finite series. Explain the process of using Linux commands to compile and execute a FORTRAN program.

b) Write a FORTRAN program to calculate the sine of an angle using its Taylor series expansion. Explain the arithmetic, relational, and logical operators used in FORTRAN.

c) Describe the steps to write and run a FORTRAN program on a Linux system. Develop an algorithm to plot the trajectory of a projectile thrown at an angle with the horizontal.

d) Explain the usage and examples of FORTRAN functions and subroutines, including the CALL and RETURN statements.

OPTION-C

PHY-G-DSE-T-01

(Thermal Physics Statistical Mechanics)

GROUP-A

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

a) Calculate the change of entropy when an ideal gas undergoes an isothermal expansion or compression?

b) What do you mean by degrees of freedom of a dynamical system?

c) What is irreversible process? Give an example.

d) State Carnot's theorem.

e) What do you mean by transport phenomena of ideal gasses?

f) γ for diatomic and polyatomic gases is 1.4 and 1.33 respectively. Find the degrees of freedom of the gas molecules?

g) What do you mean by phase space of a single particle?

h) What is meant by phase transition? Write down Clausius Clapeyron equation's equation and explain the symbols.

GROUP-B

2. Answer any **two** of the following questions: $5\times2=10$

a) One mole of an ideal gas is expanding adiabatically from (p_1, V_1) to (p_2, V_2). What is the change of internal energy? Combining first and second law of thermodynamics deduce the following relation between specific heats for any substance:

$$C_p - C_v = \left[p + \left(\frac{\partial U}{\partial V}\right)_T\right]\left(\frac{\partial V}{\partial T}\right)_p$$ 2+3

b) Draw the temperature- entropy diagram of Carnot cycle and derive the efficiency of Carnot cycle from it. 2+3

c) What are degrees of freedom? Show for an ideal gas $\frac{C_p}{C_v} = 1 + \frac{2}{f}$, f is the number of degrees of freedom per molecule of a perfect gas. What is the average translational kinetic energy of 1 mole of gas at $30°C$? 1+2+2

d) Define emissive power and absorbative power of a body? What is Newton's law of cooling? Show that Newton's Law of cooling follows from Stefan-Boltzmann Law? 1+2+2

GROUP-C

3. Answer any **two** of the following questions: $10\times2=20$

a) What is Joule- Thomson coefficient? Show that for one mole of van der Waals' gas the Joule-Thomson coefficient $\mu=\frac{1}{C_p}\left(\frac{2a}{RT}-b\right)$. What is inversion curve? Show heating and colling region inside that curve? Distinguish between cooling happened in Joule-Thompson expansion and adiabatic expansion? $1+4+1+1+3$

b) Show that for one mole of van der Waals' gas

$$dQ=C_V dT+\frac{RT}{(V-b)}dV.$$

Show that for Gibb's free energy G entropy

$$S=-\left(\frac{\partial G}{\partial T}\right)_p.$$

Two bodies of equal mass m and heat capacity C respectively are at absolute temperature T_1 and T_2. Calculate the change of entropy when they are kept in thermal contact. $5+2+3$

c) Write down the Maxwell's speed distribution of the gas molecules? Show it graphically for two different temperatures T_1 and T_2 ($T_1 > T_2$). Find rms speed of gas molecules? Discuss about viscosity of gasses and diffusion of gasses.

2+2+3+3

d) Derive the Planck's distribution formula for black body radiation? A body is at room temperature ($T = 20°C$). At what wavelength does it emit the maximum thermal radiation? What statistics does the photon gas obey? Show that for photon gas the density of states is proportional to E^2, when it is enclosed in a three-dimensional box. How does density of states change with the energy E in case of two- and one-dimensional cases? 4+2+1+3

OPTION-D

PHY-G-DSE-T-01

(Wave and Optics)

GROUP-A

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

   i) "Coefficient of viscosity of glycerine is 8.4 poise"-Explain.

   ii) Is light energy destroyed in the region of destructive interference? Why are coherent sources necessary for interference experiments?

   iii) Calculate the fringe-width of interference pattern produced in Young's double slit experiment, with the slits $10^{-3}m$ on a screen $1m$ apart. Wavelength of light is 5893Å.

   iv) What is the difference between Fresnel class and Fraunhofer class of Diffraction?

   v) Explain the phenomenon of interference of light.

   vi) What is the distance covered by a particle executing Simple Harmonic Motion of amplitude A in one time period?

vii) Water is flowing with a speed of $50 cm/s$ through a pipe of diameter $3mm$. Calculate Reynold's number. Is the flow streamline? Given, $\eta = 1$ centipoise.

viii) How are the Simple Harmonic Motion and circular motions related?

GROUP-B

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

i) Show that the intensity distribution for the diffraction in a single slit is given by $I = I_0 \frac{\sin^2\beta}{\beta^2}$. 5

ii) Find the temperature at which the speed of sound in air becomes 1.5 times its value at 0^0C. What is the absolute intensity of a 60dB sound if the standard intensity is $10^{-12} W/m^2$? 2+3

iii) State and prove Brewster's law. For maximum polarization of light by reflection from a plane dielectric, what is the angle between reflected and refracted rays? 2+3

iv) Derive Poiseuille's formula for the steady flow of an incompressible viscous liquid through a horizontal capillary of uniform cross section. 5

GROUP-C

$10 \times 2 = 20$

3. Answer any **two** questions:

i) a) What is an anti-reflection coating? Discuss the theory behind it. 1+3

b) Two coherent sources of the same frequency have intensity I_0 and $2I_0$. What is the ratio of maximum intensity to minimum intensity in their interference pattern? What do you mean by fringes of equal width and fringes of equal inclination? 3+3

ii) a) What is angle of contact? How do cohesion and adhesion affect its value? Two drops of a liquid, each of radius r, coalesce to form a large drop. Derive an expression for the rise in temperature. 1+2+2

b) Deduce an expression for the excess pressure inside a soap bubble in terms of surface tension of the soap solution and the radius of the bubble. 5

iii) a) Prove that the fundamental frequency of transverse vibration of a stretched string of length l and mass m per unit length under tension T is given by $\nu = \frac{1}{2l}\sqrt{T/m}$. 5

b) What are Lissajous figures? Find the Lissajous figures formed by the suspension of two simple harmonic vibration at right angles when their periods are in the ratio 2 : 1 and there is a phase difference 0 or $\frac{\pi}{2}$. 1+4

iv) a) Define group velocity and phase velocity. A wave group is formed by the superposition of two waves of equal amplitude but of slightly different frequencies and wavelengths. Show that if c_g be the group velocity and c be the phase velocity, then, $c_g = c - \lambda \frac{dc}{d\lambda}$. 2+3

b) What is the sharpness of resonance? What are the effects of damping on sharpness of resonance? Distinguish between amplitude resonance and velocity resonance. 1+2+2

OPTION-E

PHY-G-DSE-T-01

(Digital, Analog Circuits and Instrumentation)

GROUP-A

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

a) Write the differences between P-type and N-type semiconductor.

b) Define avalanche breakdown.

c) What is meant by biasing of a transistor? Why is it necessary?

d) Calculate the ripple factor (γ) for a full wave rectifier.

e) Draw the circuit diagram of a non-inverting amplifier using OPAMP and indicate its gain.

f) What is meant by CMRR in the context of OPAMP? What should be the value of CMRR for an ideal OPAMP?

g) Subtract the binary number $(101110)_2$ from $(1101011)_2$.

h) What are the universal Gates and why are they called so?

GROUP-B

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

a) Draw and explain the I-V characteristics of a Zener Diode. Explain how Zener breakdown occurs in such diodes? 3+2

b) Find the relation between open loop gain and closed loop gain of a feedback amplifier. Write down the Barkhausen criteria for feedback amplifier to function as an oscillator. 3+2

c) Draw the block diagram of CRO. Explain how the frequency of an AC signal can be measured by CRO. 2+3

d) Simplify the truth table using K-map:

A	B	C	D
0	0	0	1
0	0	1	X
0	1	0	1
0	1	1	X
1	0	0	0
1	0	1	X
1	1	0	1
1	1	1	0

5

GROUP-C

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

3. a) What is load line and Q point in transistor characteristics?

   b) Define hybrid parameters for transistor.

   c) Explain the voltage divider bias circuit for CE amplifier.

   d) Define Class A and Class B power amplifier.

$2+2+4+2$

4. a) Explain the principle of operation of an OPAMP as a differential amplifier with a clear circuit diagram.

   b) Write down the basic characteristics of an ideal OPAMP.

   c) What do you mean by negative feedback?

$5+3+2$

5. a) What is the basic difference between Analog and Digital circuits?

   b) Draw circuits to show the construction of AND, OR and NOT gates using any one universal gate.

   c) Write down the truth table for the XOR gate.

$2+(2+2+2)+2$

6. a) Draw the pin diagram of IC 555. What is the purpose for using this IC?

b) The current gain of a transistor in CE mode is 120. Calculate the emitter current if the collector current is 50 mA.

c) Explain how a capacitor filter helps to regulate voltage? Explain how a Zener diode can further enhance voltage regulation? 2+3+(2+3)

OPTION-F

PHY-G-DSE-T-01

(Elements of Modern Physics)

GROUP-A

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

   a) Show that the dimension of Planck's constant is Equal to the dimension of angular momentum.

   b) Calculate the de Broglie wavelength of 1 keV electron.

   c) What is Compton effect? Is it possible to observe Compton effect with visible light? Explain.

   d) In quantum mechanics, what is wave packet? Can it be normalised?

   e) Normalize the wave function $\psi(x) = Ne^{-x/2}$.

   f) What is metastable state?

   g) What is meant by mean life and half-life of a radioactive substance?

   h) Explain why electrons cannot reside inside the nucleus.

GROUP-B

2. Answer any **two** of the following questions: $5\times2=10$

   a) Define phase velocity and group velocity and deduce the relation between them. 2+3

b) State and explain Heisenberg uncertainty principle. If $\psi(x,t)$ is a schrodinger wave function then prove that $\psi^*(x,t)\psi(x,t)$ must necessarily be real and positive. 2+3

c) Show that the shift in wavelength of a X-ray photon due to scattering by a free electorn is given by

$$\Delta\lambda = \frac{h}{m_0 C}(1-\cos\phi)$$

where the symbols have their usual meanings. 5

d) Write down the semi empirical mass formula. Give explanation of the various terms used in the formula 2+3

GROUP-C

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

3. a) Describe Davison-Germar experiment. What is its significance?

b) Derive the expression for the total energy of an electron in the n^{th} Bohr orbit and show that

$$E_n \propto \frac{1}{n^2}$$ (2+3)+5

4. a) Write down the time dependent Schrodinger wave equation for one dimension.

b) Solve the time independent Schrodinger wave equation for a particle enclosed in a one-dimensional rigid box of side 'L' and obtain its eigenvalues.

c) Calculate the expectation values of $\langle x \rangle$ and $\langle p_x \rangle$ for the ground state. 2+4+(2+2)

5. a) Explain orthogonality of wave function.

b) Find the eigenfunction of the operator $\frac{d}{dx}$, for the eigenvalue K.

c) Prove that the eigenvalues of a Hermitian operator are real.

d) Check whether the operator $\hat{x}\hat{p}_x$ is Hermitian or not. 2+2+3+3

6. a) Define the terms - isobar, isotone, and mirror nuclei.

b) The half-life of a radioactive element is 3.8 days. Calculate after how many days will only $\frac{1}{10}$ th of the radioactive element sample remain behind?

c) Distinguish between nuclear fission and nuclear fusion.

d) Explain the energy release mechanism in Nuclear fission and fusion. 2+3+2+3

OPTION-G

PHY-G-DSE-T-01

(Mechanics)

GROUP-A

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

a) Find the angle between the face diagonals of cube of side 1 using vector algebra.

b) Show that $(3x^2+y\cos x)dx+(\sin x-4y^3)dy=0$ is an exact differential equation.

c) Write down the Galilean transformation equations.

d) A stationary body if mass 3 kg explodes into three equal pieces. Two of the pieces fly off at right angle each other, one with 2j m/s and the other with 3j m/s. Find the velocity of the 3rd piece.

e) A particle at rest is acted on by a force $F=i\pi\sin 2\pi t$ newton. Calculate the linear momentum of the particle after $t = 0.5$ *secs.*

f) Why astronauts feel weightlessness in an artificial satellite?

g) Show that the Poission's ratio lies between -1 and $\frac{1}{2}$.

h) State the two postulates of special theory of relativity.

GROUP-B

2. Answer any **two** of the following questions: $5\times2=10$

a) Prove that total energy of simple harmonic motion is constant. A particle executes simple harmonic motion of period 12 second and amplitude 8 m. Find the time it takes to travel 3 m from the positive extremity of its oscillations. 3+2

b) Solve the equation $\frac{dy}{dx}=\frac{y^2+xy}{x^2}$. 5

c) Find the expression relativistic addition of velocity. The proper life time of a particle is $2.5*10^{-8}$ s. Calculate the mean life time of that particle moving with velocity $2.4*10^{10}$ cm/s. 3+2

d) Show that angular momentum is conserved under central force field. Write the statements of Kepler's law. 2+3

GROUP-C

3. Answer any **two** of the following questions: $10\times2=20$

a) If $\vec{A}=5u^2i+uj-u^3k$ and $\vec{B}=\sin ui-\cos uj$, find $\frac{d}{du}(\vec{A}.\vec{B})$ and $\frac{d}{du}(\vec{A}*\vec{B})$. If $\vec{A}+\vec{B}+\vec{C}=0$, prove that $\vec{A}*\vec{B}=\vec{B}*\vec{C}=\vec{C}*\vec{A}$. Write the geometrical interpretation of vector cross product. 5+3+2

b) Find the relation between Y, K, n and σ. Find the expression of Torsional rigidity of a cylinder. 6+4

c) Write and prove work- energy principle and prove. A particle of mass m moves with its velocity $v=a\sqrt{x}$. Find the total work done by the forces during a displacement from $x = 0$ to $x = d$. In free space rocket is moving without any external force. Show that the speed of rocket an any time t is independent of time. 2+3+5

d) Find the kinetic energy and angular momentum of a system of particles. What is inertial and non-inertial frame? 4+4+2