U.G. 5th Semester Examination - 2021

PHYSICS

[PROGRAMME]

Discipline Specific Elective (DSE)

Course Code : PHY-G-DSE-T-01

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-DSE-T-01

(Mechanics)

GROUP–A

1. Answer any **five** of the following questions:

    $2 \times 5 = 10$

    a) What is meant by solenoidal vector?

    b) What do you mean by exact differential equation? Give an example.

    c) If the position vector of a particle changes from $\vec{r} = 3\hat{i} + 4\hat{J} + 5\hat{k}$ to $\vec{r}_f = 12\hat{I} + 17\hat{J} - 5\hat{k}$ due

to the force $\vec{F} = 6\hat{i} - 2\hat{J} - 4\hat{k}$, then calculate the work done by the force.

d) Define conservative force field. Is frictional force conservative?

e) At what points on the path of a simple harmonic motion are the velocity and acceleration are maximum? At what points are they minimum?

f) State the principle of conservation of angular momentum.

g) What are the differences between gravitational potential and electrostatic potential?

h) How does elasticity of a material depend on temperature?

GROUP-B

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

    a) Calculate $\vec{\nabla}\left(\dfrac{1}{r}\right)$. If a scalar function is given by

    $\phi(x, y, z) = 2xz^4 - x^2 y + y^2 x$, then calculate grad(ϕ) at $(2, -2, -1)$. $2+3$

    b) Determine the limiting values of Poisson's ratio (σ). A 0.5 m long and 1 mm diameter wire is twisted by 45° by applying 0.43 N-m torque at one end. Calculate the rigidity modulus of the material of wire. $2+3$

c) What are the characteristics of a geo-stationary satellite? Show that the minimum velocity required to project an object out of the gravitational field of a planet is $v = R\sqrt{\dfrac{8\pi G\rho}{3}}$ where R: radius of the planet, ρ : average density of the planet and G : gravitational constant. 2+3

d) Write short notes on time dilation and length contraction. $2\frac{1}{2} + 2\frac{1}{2}$

GROUP-C

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

3. a) What is meant by pseudo force? Give example.

b) Prove that gravitational force field is conservative.

c) A particle of mass m moves on a straight line with velocity given by $v = a\sqrt{x}$ where, *a* is a constant and x is the distance travelled. Find the total work done due to the displacement from *x*=0 to *x*=d. 3+4+3

4. a) Obtain the differential equation of a damped harmonic oscillation and solve the equation for oscillatory solution.

b) The equation of a simple harmonic motion is given by $3\dfrac{d^2x}{dt^2} + 12x = 0$ determine the amplitude and frequency of motion.

c) What are Lissajous figures? (2+3)+3+2

5. a) Define Young's modulus, Poisson's ratio and rigidity modulus.

b) Show that a shear is equivalent to an equal elongation and compression at right angles to each other.

c) Calculate the work done in stretching a uniform metal wire of area of cross-section $10^{-6}\,\text{m}^2$ and length 1.5 m through $4 \times 10^{-3}\,\text{m}$. Given $Y = 2 \times 10^{11}\,\text{Nm}^{-2}$. 3+4+3

6. a) State Kepler's laws of planetary motion. Deduce law of gravitation from Kepler's law.

b) What is escape velocity? Find an expression for it.

c) The escape velocity of a body on the surface of the earth is 11.2 km/s. A body is thrown vertically upward from the surface of the earth with a velocity three times the escape velocity. What will be the velocity of the body at a distance far away from the earth? (2+3)+3+2

OPTION-B

PHY-G-DSE-T-01

(Electricity and Magnetism)

GROUP–A

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

   a) If the magnitude of a vector $\vec{A}$ is constant then show that $\vec{A}.\dfrac{d\vec{A}}{dt}=0$

   b) Determine the electric field due to the potential $\phi(r)=\left(\dfrac{A}{r}\right)e^{-\lambda r}$.

   c) State the Gausses law for dielectrics.

   d) Apply Gausses theorem to show that no electric field exists inside a charged conducting sphere.

   e) Distinguish between polar dielectrics and non-polar dielectrics.

   f) State Ampere's circuital law.

   g) Define Poynting vector.

   h) Write down the expression for electromagnetic energy density.

GROUP-B

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

   a) Calculate $\vec{\nabla}\left(\dfrac{1}{r}\right)$ where $r\neq0$. Verify Gauss

theorem for the vector field $\vec{R}=x\hat{i}+y\hat{j}+z\hat{k}$ over a surface enclosing the volume of a sphere of radius a with center at origin. $2+3$

   b) Deduce Laplace's equation from Gauss law. Find out the electrostatic potential and field at a point inside and outside a uniformly charged solid sphere. $2+3$

   c) What is meant by magnetic vector potential? Verify that the vector potential $\vec{A}$ due to a uniform magnetic induction $\vec{B}$ is given by $\vec{A}=-\dfrac{1}{2}(\vec{r}\times\vec{B})$. $2+3$

   d) Show that the Maxwell equations $\vec{\nabla}\times\vec{E}=-\dfrac{\partial\vec{B}}{\partial t}$ and $\vec{\nabla}.\vec{B}=0$ are compatible. Establish the continuity equation relating the charge density and the current density. $2+3$

GROUP-C

Answer any **two** questions: $10\times2=20$

3. a) What is meant by electric dipole? Define electric dipole moment and polarization vector.

   b) Determine the potential energy of a dipole in an external electric field.

   c) A metal sphere of radius a is surrounded out

to a radius *b* by a linear dielectric material. Determine the capacitance. 3+3+4

4. a) What is Lorentz force?

 b) Starting from Biot-Savart law, show that $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$.

 c) Find the force between two straight, infinite, parallel wires carrying currents I_1 and I_2 separated by a distance *d* and placed in air. 2+5+3

5. a) State the laws of electromagnetic induction.

 b) Calculate the self-inductance of a uniformly wound solenoid.

 c) Show that the equivalent inductance of two coils of self-inductances L_1 and L_2 connected in parallel is given by $L_{eq} = \dfrac{L_1 L_2 - M^2}{L_1 + L_2 \pm 2M}$

 d) Determine the e.m.f. developed between the terminals of a straight conductor of length *l* moving with a constant velocity at right angles to a uniform magnetic field $\vec{B}$. 2+3+3+2

6. a) Derive the wave equations for the electric and magnetic fields in vacuum from the Maxwell's equations.

 b) What are polarized waves?

c) The magnetic intensity in a region of free space is given by $\vec{H} = H_0 \cos\left(\omega t - \dfrac{\omega}{c} z\right)\hat{y}$. Determine the displacement current density if there is no free charge. (2+2)+3+3

OPTION-C

PHY-G-DSE-T-01

(Waves and optics)

GROUP–A

1. Answer any **five** of the following questions:

 $2 \times 5 = 10$

 a) What is meant by plane polarized wave?

 b) Define decibel.

 c) What are beats?

 d) Describe a zone plate.

 e) Define the terms wave velocity, wavelength and frequency.

 f) What are the properties of a wavefront?

 g) Draw the resulting pattern for two rectangular Simple Harmonic Motion of frequency ratio 1:2 and phase difference $\dfrac{\pi}{2}$.

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

a) Calculate the excess pressure inside a spherical bubble. 5

b) Show that two harmonic oscillations, at right angles to each other, of equal amplitudes and frequencies, but with phases differing by $\frac{\pi}{2}$ are equivalent to a uniform circular motion, the radius of the circle being equal to the amplitude of either oscillation. 5

c) Discuss the procedure for determining the state of polarization of a light beam. 5

d) What are the differences between Fresnel and Fraunhofer class of diffraction? What are half period zones in the context of Fresnel diffraction? $2\frac{1}{2}+2\frac{1}{2}$

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

a) i) Derive the differential equation of motion for the transverse vibrations of a uniform flexible stretched string. 5

ii) Obtain an expression for the frequencies of the normal modes of the string which is rigidly fixed at its ends. 5

b) i) State Fourier's theorem. Use it to analyse a square wave. 2+4

ii) Describe musical notes and musical scale. 4

c) i) Describe the working of a Fresnel biprism and obtain an expression for the fringe separation. 5

ii) What are Newton's rings? How can the wavelength of light be measured with Newton's rings? 2+3

d) i) What is meant by group velocity and phase velocity? Deduce a relation between them. 2+3

ii) Write down the three dimensional wave equation in cartesian coordinate system. What are spherical waves? 2+3

OPTION-D

PHY-G-DSE-T-01

(Thermal Physics and Statistical Mechanics)

GROUP–A

1. Answer any **five** of the following questions:

2×5=10

a) Write any one statement of 2nd law of thermodynamics.

b) Name one boson and one fermion.

c) Write short note about Gibbs free energy.

d) What is the change of entropy in a reversible cyclic process?

e) Write Clausius-Clapeyron equation.

f) What is Joule-Thomson effect?

g) Can you attain absolue zero of temperature? Discuss briefly.

h) Ideal gas obeys which statistics?

GROUP-B

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

a) What is Zeroth law of thermodynamics? Discuss about the concept of temperature.

$3+2$

b) What is entropy? 100gm of water slowly heated from 27^0C to 87^0C. Calculate the change of entropy in this process. Sp. heat of water=$4200J\,kg^{-1}K^{-1}$. $2+3$

c) Deduce Stefan-Boltzmann law and Wiens displacement law from Planck's law. 5

d) What is the work done by a ideal gas in a isothermal process? Compare the slopes of isothermal and adiabatic curves. $2+3$

GROUP-C

Answer any **two** questions: $10\times2=20$

3. a) Write Bose-Einstein distribution law and Maxwell-Boltzmann distribution law. Discuss any two properties of electron gas. What is phase space? Write a short note about photon gas. $2+2+2+2+2=10$

b) Write any experimental verification of Maxwell's law of distribution of velocity. Write law of equipartition of energy. Write short notes about viscosity of gas and diffusion of gas. $4+2+2+2$

c) Write down 4 Maxwell's relation. Write an expression for $\dfrac{C_p}{C_v}$ by using Maxwell's relation. Write TdS equations. $4+2+4$

d) Draw the Carnot's cycle for a Carnot Engine. What are the four stages of operation? Calculate the work done in each stage. Hence calculate the efficiency of a Carnot engine $2+2+4+2$

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