

**U.G. 5th Semester Examination - 2020**

**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**

**(Thermal Physics and Statistical Mechanics)**

**GROUP-A**

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

2×5=10

- What is the change of entropy in a reversible cyclic process?
- Write first law of thermodynamics.
- How does viscosity of gas change with temperature?
- What is internal energy?

[Turn over]

- Define a perfectly black body.
- What is meant by phase space?
- Write Maxwell-Boltzmann distribution law.
- Write any one TdS equation.

**GROUP-B**

2. Answer any **two** questions: 5×2=10
- Describe any one experiment which proves Maxwell's law of distribution of velocities. 5
  - What is enthalpy? Write an expression of  $C_p$  in terms of enthalpy. (No derivation)  
Show that for a reversible isothermal change  $dF = -pdV$ , where F is the free energy of the system. 2+1+2
  - State and deduce Wien's displacement law. 5
  - Draw Carnot's cycle explaining each step. Write Carnot's theorem. 3+2

**GROUP-C**

3. Answer any **two** questions: 10×2=20
- Write Bose-Einstein distribution law and Fermi-Dirac distribution law. Compare the three distribution laws. What is electron gas? 2+2+5+1

- b) Derive Maxwell's law of distribution of velocities. Write law of equipartition of energy (no derivation). What is mean free path?

7+2+1

- c) i) State the second law of thermodynamics (any one statement).

ii) What is entropy?

- iii) Calculate the change of entropy when 5 gm. atoms of solid Hg at melting point (-39° C) is raised to a temperature of 40° C. L = 3 Cals/gm, Atomic weight = 207, S = .0335

2+3+5

- d) Write down 4 Maxwell's relations. Using Maxwell's relation, obtain the expression of (C<sub>p</sub> - C<sub>v</sub>). What is Joule-Thompson effect?

4+4+2

**OPTION-B**

**PHY-G-DSE-T-01**

**(Mechanics)**

**GROUP-A**

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

a) Define axial vector and polar vector.

b) Find the order and degree of the following differential equation.

$$2 \frac{d^2 y}{dx^2} = \left\{ 1 + \left( \frac{dy}{dx} \right)^2 \right\}^{3/2}$$

c) If the position vector of a particle changes from  $\vec{r}_i = 2\hat{i} + 3\hat{j} + 5\hat{k}$  to  $\vec{r}_f = 12\hat{i} + 15\hat{j} + 5\hat{k}$  due to the force  $\vec{F} = 5\hat{i} + 2\hat{j} + 3\hat{k}$ , then calculate the work done by the force.

d) Show that  $\vec{F} = \hat{i} \cos y + \hat{j} x \sin x + \hat{k} \cos z$  is a conservative vector field.

e) Plot displacement vs time for a simple harmonic oscillation and a damped harmonic oscillation.

f) What is meant by angular momentum? What is its unit?

- g) What do you mean by escape velocity from Earth's surface?
- h) What is Poisson's ratio ( $\sigma$ )? Write down the relation between Young's modulus (Y), rigidity modulus ( $\eta$ ) and Poisson's ratio ( $\sigma$ ) for an elastic material.

### GROUP-B

2. Answer any **two** questions : 5×2=10
- a) State the principle of conservation of angular momentum. Is angular momentum a vector quantity? For what value of  $\alpha$ , the two vectors  $\vec{A} = \hat{i} - 3\hat{j} - \hat{k}$  and  $\vec{B} = 2\alpha\hat{i} + \alpha\hat{j} - 4\hat{k}$  are perpendicular to each other? 2+1+2
- b) Write down Kepler's laws for planetary motion. Considering the earth to be a uniform solid sphere, calculate the density of the earth. [Given:  $G = 6.673 \times 10^{-11}$  SI unit; radius of the earth =  $6371 \times 10^3$  m] 2+3
- c) Write down the differential equation of a damped harmonic motion. If the displacement of a particle at any instant  $t$  is given by  $x = a \cos(\omega t) + b \sin(\omega t)$ , show that the motion of the particle is simple harmonic. If  $a=2$ m,

$b=4$ m and  $\omega=4$ rad/s, find the time period, amplitude and initial phase of the particle.

1+2+2

- d) Write down the two postulates of special theory of relativity. When can a motion be called relativistic? What is Lorentz transformation? 2+1+2

### GROUP-C

3. Answer any **two** questions: 10×2=20
- a) For any three vectors  $\vec{A}, \vec{B}$  and  $\vec{C}$  prove that  $\vec{A} \times (\vec{B} \times \vec{C}) = \vec{B}(\vec{A} \cdot \vec{C}) - \vec{C}(\vec{A} \cdot \vec{B})$ .
- b) If  $|\vec{a} + \vec{b}| = |\vec{a} - \vec{b}|$  then find the angle between  $\vec{a}$  and  $\vec{b}$ .
- c) Solve the following differential equation.
- $$\frac{d^2y}{dx^2} + 4\frac{dy}{dx} + 13y = 0. \quad 4+3+3$$
4. a) What is central force? Give two examples.
- b) Show that the angular momentum of a particle moving under a central force is constant.
- c) Prove that the potential energy and the kinetic energy of an artificial satellite revolving around the earth is equal.

- d) “An object is weightless in an artificial satellite”– Explain. (2+1)+2+3+2
5. a) Write down Hooke’s law.  
 b) Deduce an expression for work done per unit volume on an elastic body experiencing volume strain.  
 c) What is the difference between angle of twist and angle of shear?  
 d) Show that shear is equivalent to an extension and an equal compression in two perpendicular directions. 1+4+2+3
6. a) Define inertial and non-inertial frames of reference? Give examples of both the frames of reference.  
 b) What is meant by length contraction and time dilation in connection with relativity?  
 c) Two photons are moving towards each other in free space. Calculate the relative speed of any photon with respect to the other. (2+1)+4+3

**OPTION-C**  
**PHY-G-DSE-T-01**  
**(Electricity and Magnetism)**

**GROUP–A**

1. Answer any **five** of the following questions:  
 2×5=10
- a) For any two vectors  $\vec{A}$  and  $\vec{B}$  prove that  $\vec{A} \cdot (\vec{A} \times \vec{B}) = 0$ .
- b) What are the Poisson’s equation and Laplace’s equation in electrostatics? Explain.
- c) Why the electrostatic field is said to be conservative?
- d) The capacitance of an isolated sphere is  $50 \times 10^{-5}$  F. What is the radius of the sphere?
- e) State Biot-Savart law regarding intensity of magnetic field due to a small current carrying conductor.
- f) What will be the magnetic force on a charged particle moving along magnetic lines of force? Explain.
- g) What are retentivity and co-ercivity of a magnetic material?
- h) Write down Maxwell’s equations in free space.

**GROUP-B**

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

a) Calculate  $\nabla \cdot \left( \frac{\mathbf{r}}{r} \right)$  where  $r \neq 0$ . Apply divergence

theorem to calculate the surface integration

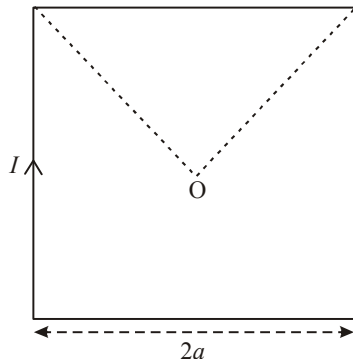
$$\oint_S x \, dy \, dz + y \, dz \, dx + z \, dx \, dy \quad \text{where } S$$

represents a surface of a sphere

$$(x^2 + y^2 + z^2 = a^2). \quad \text{2+3}$$

b) State Gauss's theorem of electrostatics. What are the advantages of Gauss' theorem over the Coulomb's equation? Define electric flux and electric flux density. 2+1+2

c) Define Magnetic field  $\mathbf{B}$ . What is its unit? A current  $I$  flows through a square loop of sides  $2a$  as shown in the figure. Calculate the expression for magnetic field  $\mathbf{B}$  at the centre of the loop. 2+3



d) What are displacement current and Poynting vector? Obtain the electromagnetic wave equation in free space from the Maxwell's equations. 2+3

**GROUP-C**

Answer any **two** questions: 10×2=20

3. a) Electric current is not a vector quantity. Explain.

b) What is the difference between electric potential and potential energy?

c) Prove that  $\nabla \times (\Phi \mathbf{A}) = \Phi (\nabla \times \mathbf{A}) + (\nabla \Phi) \times \mathbf{A}$  where,  $\Phi$  is a scalar function.

d) If the vector  $\mathbf{A} = \hat{i}(x+3y) + \hat{j}(y-2z) + \hat{k}(x+bz)$  is solenoidal, calculate the value of  $b$ . 1+2+4+3

4. a) A point charge  $Q$  is located at a distance  $z$  above the centre of a circular surface of radius  $R$ . Calculate the electric flux through the surface.

b) What is an electric dipole? Obtain an expression for the torque on an electric dipole placed in a uniform electric field.

- c) Two capacitors of capacitance  $0.1 \mu\text{F}$  and  $0.01 \mu\text{F}$  are connected in series and 20 Volts potential difference is applied to the combination. If the two capacitors are now connected in parallel, how much energy will be wasted?  $3+(1+3)+3$
5. a) Briefly describe Ampere's circuital law. Apply it to calculate the magnetic field inside a long solenoid.
- b) Compare between dia, para and ferromagnetic materials.
- c) What is hysteresis?  $(2+3)+3+2$
6. a) Define coefficient of self and mutual induction. Calculate the energy stored in the magnetic field in a coil carrying current.
- b) Write down the expression for total energy in an electromagnetic wave. How do you conclude that electromagnetic waves are transverse in nature?  $(3+3)+(1+3)$

**OPTION-D**  
**PHY-G-DSE-T-01**  
**(Wave and Optics)**  
**GROUP-A**

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

$2 \times 5 = 10$

যে-কোনো পাঁচটি প্রশ্নের উত্তর দাও :

- a) What is the relation between path difference and phase difference?  
পথ পার্থক্য এবং দশা পার্থক্যের মধ্যে সম্পর্ক কি?
- b) State Huygen's principle.  
হাইগেনের নীতি উল্লেখ কর।
- c) What is Sabine's formula for reverberation time?  
প্রতিধ্বনি সময় সংক্রান্ত স্যাবিনের সূত্রটি কি?
- d) What is diffraction grating and grating constant?  
অপবর্তন গ্রেটিং ও গ্রেটিং ধ্রুবক কি?
- e) Define group velocity and phase velocity.  
দলীয় গতি এবং দশা গতির সংজ্ঞা দাও।

- f) Find the wavelength and frequency of a travelling wave given by

$$y(x, t) = 0.01 \sin(4\pi t - 0.02\pi x) \text{ with } t \text{ in seconds and } x \text{ in meters.}$$

একটি চলতরঙ্গের সমীকরণ

$y(x, t) = 0.01 \sin(4\pi t - 0.02\pi x)$  হলে, তরঙ্গটির তরঙ্গ দৈর্ঘ্য ও কম্পাঙ্ক নির্ণয় কর, যেখানে  $t$  সেকেন্ডে এবং  $x$  মিটারে দেওয়া আছে।

- g) Explain whether energy is conserved in interference of light.

আলোর ব্যতিচারে শক্তি সংরক্ষিত থাকে কিনা ব্যাখ্যা কর।

- h) What is Fresnel diffraction?

ফ্রেনেল অপবর্তন কাকে বোঝায়?

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

যে-কোনো দুটি প্রশ্নের উত্তর দাও :

- a) State the superposition principle of wave motion. Is this principle valid for,

তরঙ্গগতির উপরিপাত সূত্রটি লেখ। এই সূত্রটি কি.....

- i) Sound waves of all frequencies and intensities?

সকল কম্পাঙ্ক এবং প্রাবল্যের শব্দ তরঙ্গের ক্ষেত্রে প্রযোজ্য?

- ii) Light waves of all frequencies and intensities?

সকল কম্পাঙ্ক এবং প্রাবল্যের আলোক তরঙ্গের ক্ষেত্রে প্রযোজ্য?  $2 + 1\frac{1}{2} + 1\frac{1}{2}$

- b) Solve the equation of motion of a damped forced simple harmonic oscillator and derive the condition for velocity resonance.

একটি অবমন্দিত প্রণোদিত সরল সুসমঞ্জস দোলকের গতিয় সমীকরণ সমাধান কর এবং বেগ অণুনাদের শর্তটি বাহির কর।  $2\frac{1}{2} + 2\frac{1}{2}$

- c) Explain how would you obtain a beam of plane polarized light by reflection.

প্রতিফলনের দ্বারা কিভাবে সমতল সমবর্তিত আলোক সৃষ্টি করবে তা ব্যাখ্যা কর। 5

- d) Derive an expression for the intensity due to Fraunhofer diffraction by a double slit when monochromatic light is incident normally on it.

একটি ডাবল স্লিট ফ্রনহফার বিবর্তন চিত্রে আলোর তীব্রতা ব্যঞ্জক প্রতিষ্ঠা কর, যখন একবর্ণী আলো স্লিটের উপর লম্বভাবে আপতিত। 5

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

যে-কোনো দুটি প্রশ্নের উত্তর দাও :

a) i) A particle is simultaneously under two simple harmonic motions at right angles to each other, represented by  $x = a \sin \omega t$ ,  $y = b \sin(\omega t + \delta)$ .

একটি কণা একই সময়ে দুইটি পারস্পরিক ভাবে লম্ব সরল সুসমঞ্জস্য গতির অধীনে থাকে, যথা  $x = a \sin \omega t$ ,  $y = b \sin(\omega t + \delta)$ ।

I) Show that the resultant motion is represented by

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{2xy}{ab} \cos \delta = \sin^2 \delta.$$

দেখাও উহাদের লব্ধ গতি হবে

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{2xy}{ab} \cos \delta = \sin^2 \delta.$$

II) What will be the locus of the particle when  $\delta = \frac{\pi}{2}$  and  $a = b$ ?

যদি  $a = b$  এবং  $\delta = \frac{\pi}{2}$  হয়, তাহলে, গতি পথ কি প্রকার হবে?  $4+1$

ii) What are beats? Explain the formation of beats.

স্বরকম্প কি? স্বরকম্প কিভাবে তৈরী হয় ব্যাখ্যা কর।  $2+3$

b) i) Define coefficient of viscosity. Mentioning the assumptions, derive Poiseuille's equation for streamline flow of a liquid through a narrow tube.

সান্দ্রতা গুণাঙ্কের সংজ্ঞা দাও। অনুমানগুলির বর্ণনাসহ একটি সরু নলের মধ্য দিয়া তরলের ধারারেখ প্রবাহ সংক্রান্ত Poiseuille সূত্রটি নির্ণয় কর।  $2+4$

ii) Calculate the excess pressure inside a spherical bubble.

একটি গোলীয় বুদবুদের অভ্যন্তরস্থ অতিরিক্ত চাপের পরিমাণ নির্ণয় কর।  $4$

c) i) Explain the formation of interference pattern produced by a thin transparent film of uniform thickness. What do you mean by Haidinger fringes?

সুযম পাতলা স্বচ্ছ সরের ক্ষেত্রে ব্যতিচার পটি গঠনের বিষয়টি ব্যাখ্যা কর। হাইডিনজার পটি বলতে কী বোঝায়?  $5+2$

ii) Under what conditions do we obtain circular fringes with a Michelson's interferometer? What are Fizeau fringes?



একটি মাইকেলসনের ব্যাতিচার মাপা যন্ত্রে কোন্ অবস্থায় বৃত্তীয় ফ্রিঞ্জ দেখা যায়? ফিজু পটি কি?

2+1

- d) i) Set up the differential equation for transverse vibration of a string of length  $L$  under tension  $T$ .

$L$  দৈর্ঘ্যের একটি নমনীয় তার  $T$  টানে রাখা থাকলে, উহার তির্যক কম্পনের অবকল সমীকরণটি প্রতিষ্ঠা কর।

5

- ii) Write down the mathematical expressions for a progressive and stationary wave. Explain why your expressions imply a progressive and a stationary wave respectively.

একটি প্রগামি এবং একটি স্থির তরঙ্গের গাণিতিক ব্যঞ্জক লেখ। ব্যঞ্জকগুলি কেন একটি প্রগামি ও একটি স্থির তরঙ্গ বোঝায় ব্যাখ্যা কর।

4+1

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