



‘সমানো মন্ত্র: সমিতি: সমানী’

UNIVERSITY OF NORTH BENGAL

B.Sc. Honours 1st Semester Examination, 2024

GE1-P1-PHYSICS

Time Allotted: 2 Hours

Full Marks: 40

The figures in the margin indicate full marks.

The question paper contains GE-1A and GE-1B. Candidates are required to answer any *one* from the *two* courses and they should mention it clearly on the Answer Book.

GE-1A

MECHANICS

GROUP-A

Answer any *five* questions from the following:

1×5 = 5

- (a) Find the order and degree of the given differential equation:

$$\left(\frac{d^2y}{dx^2}\right)^{2/3} + \frac{d^2y}{dx^2} - \frac{dy}{dx} = 0$$

- (b) If  $\phi(x, y, z) = 3x^2yz$ , find  $\vec{\nabla}\phi$  at the point  $(1, 1, -1)$ .

- (c) What do you mean by conservative force?

- (d) State the principle of conservation of linear momentum.

- (e) What are Geosynchronous orbits?

- (f) What do you mean by rigidity modulus of a material?

- (g) If  $\vec{A} = 3\hat{i} + 2\hat{j} - \hat{k}$  and  $\vec{B} = 5\hat{i} + \hat{j} + 3\hat{k}$ , find  $\vec{A} \times \vec{B}$ .

- (h) Show that the value of Poisson's ratio lies between  $-1$  and  $0.5$ .

GROUP-B

Answer any *three* questions from the following

5×3 = 15

- (a) Find the value of ' $p$ ' such that the following vectors are co-planar:

3

$$\vec{A} = 3\hat{i} + 2\hat{j} + \hat{k}, \quad \vec{B} = 3\hat{i} + 4\hat{j} + 5\hat{k}, \quad \vec{C} = \hat{i} + \hat{j} - p\hat{k}$$

- (b) Find the cosine of the angle between the vectors  $\vec{A} = \frac{3}{2}\hat{i} + 3\hat{j} - \frac{1}{4}\hat{k}$  and

2

$$\vec{B} = \hat{i} - \hat{j} + \frac{1}{2}\hat{k}.$$

4. (a) Prove that the work done by the particle in a force field is equal to the change in its kinetic energy. 3  
 (b) Describe any two applications of global positioning system. 2
5. (a) State Hooke's law in elasticity. 1  
 (b) Draw the stress-strain diagram. 1  
 (c) Prove that  $Y = 3k(1 - 2\sigma)$  for a homogeneous medium, where the symbols have their usual meanings. 3
6. (a) Write down the three Kepler's laws of planetary motion.  $2\frac{1}{2}$   
 (b) Show that the areal velocity is constant for a particle moving in a central force field.  $2\frac{1}{2}$

### GROUP-C

Answer any two questions from the following

10×2 = 20

7. (a) Obtain expressions for potential energy and kinetic energy of a simple harmonic motion. Show that the total energy of simple harmonic oscillator is constant. 2+2+1  
 (b) Establish the differential equation of a damped simple harmonic oscillator. Solve the equation in the under damped condition. Graphically represent the under damped motion.  $1\frac{1}{2} + 2\frac{1}{2} + 1$
8. (a) Solve the following differential equation: 3  

$$y^2 dx + (xy + x^2) dy = 0$$
  
 (b) Find an expression for the velocity of an artificial satellite moving in a circular orbit around the earth. 3  
 (c) Show that the angular momentum of a particle moving in a central force field is constant. 2  
 (d) Solve the equation  $\frac{dy}{dx} = \cot x \sin y$ . 2
9. (a) Show that the twisting couple per unit twist on a right angled cylinder of length  $l$  and radius  $r$  is  $C = \frac{\pi\eta r^4}{2l}$ , where  $\eta$  = coefficient of rigidity of the material of the cylinder. 4  
 (b) Two cylindrical shafts have the same length and mass and are made of the same material. One is solid while other is hollow having an external radius twice the internal radius. What is the ratio of their torsional rigidities? 3  
 (c) Define Young's modulus in elasticity. Calculate the percentage increase in length of a wire of diameter 0.4 mm, stretched by a load of 5 kg. (Given Young's modulus of elasticity of the material of the wire is  $12.5 \times 10^{10} \text{ N/m}^2$ ). 3
10. (a) State Einstein's postulates of special theory of relativity. 2  
 (b) Discuss the phenomena 'length contraction' and 'time dilation' in special theory of relativity. 3+3  
 (c) Calculate the percentage change in length of a rod moving with a velocity  $0.8c$  in the direction of its length. 2

## GE-1B

## THERMAL PHYSICS AND STATISTICAL MECHANICS

## GROUP-A

1. Answer any *five* questions from the following: 1×5 = 5
- State Zeroth law of thermodynamics.
  - What do you mean by isolated system? Give one example.
  - Can a Carnot engine work as a heat pump? Explain.
  - State Wien's displacement law.
  - Define Fermi temperature.
  - At what temperature will the r.m.s. velocity of a gas be half of its value at 0° C ?
  - What do you mean by 'quasistatic' process?
  - Find the total energy of a diatomic gas molecule at a temperature 300 K. Given, value of Boltzmann constant  $k_B = 1.38 \times 10^{-23} \text{ J/K}$ .

## GROUP-B

Answer any *three* questions from the following

5×3 = 15

- Distinguish between 'reversible' and 'irreversible' processes. 2
  - Find an expression for work done in an adiabatic process. 3
- Compare the Fermi-Dirac and Bose-Einstein statistical distribution laws. 3
  - Describe the properties of bosons. 2
- What do you mean by a transport phenomena? 1
  - On the basis of kinetic theory of gas derive an expression for the coefficient of viscosity of a gas. 4
- Deduce Wien's displacement law from Planck's law of radiation. 3
  - What do you mean by ultra-violet catastrophe? Explain using Rayleigh-Jeans law. 2
- Write down the four Maxwell's thermodynamic relations. 2
  - Using Maxwell's thermodynamic relations prove that 3

$$C_P - C_V = -T \left( \frac{\partial P}{\partial V} \right)_T \left( \frac{\partial V}{\partial T} \right)_P^2$$

where the symbols have their usual meaning.

## GROUP-C

Answer any *two* questions from the following

10×2 = 20

- Write down the expression of Maxwell-Boltzmann distribution law of molecular velocities. Using the above law define distribution function and plot its graph. Why does the distribution curve become flatter with rise in temperature? Explain. 1+2+2

- (b) State and explain the survival equation in relation to mean free path of gas molecules. 2
- (c) Calculate the molecular diameter of nitrogen molecules if the number density of the gas is  $2.7 \times 10^{25} \text{ m}^{-3}$  and the mean free path of the gas molecules is  $8 \times 10^{-8} \text{ m}$ . 3
8. (a) State and explain Carnot's theorem. 4
- (b) Calculate the change in entropy when 200 gm water is heated from  $25^\circ \text{ C}$  to  $75^\circ \text{ C}$ . 2
- (c) Show that for a Carnot engine  $\frac{Q_1}{T_1} = \frac{Q_2}{T_2}$ . 2
- (d) Represent the Carnot cycle in 1+1
- (i) P-V diagram (ii) T-S diagram.
9. (a) Write down the assumptions of Maxwell-Boltzmann statistics. 1+2
- Find the no. of possible arrangements of 4 particles in 2 states assuming the particles obey Maxwell-Boltzmann statistics.
- (b) Using Maxwell's thermodynamic relations prove that 3
- $$TdS = C_p dT - T \left( \frac{\partial V}{\partial T} \right)_P dP$$
- (c) What do you mean by Gibbs' free energy? Why is it called thermodynamic potential?  $1 \frac{1}{2} + 1 \frac{1}{2}$
- (d) 2 moles of an ideal gas at  $30^\circ \text{ C}$  expands isothermally so that its volume doubles. Calculate the work done. 1
- 10.(a) Show that mean free path of the molecules of a gas is  $\frac{1}{\sqrt{2} \pi n \sigma^2}$ , where  $n$  is the 4
- no. of molecules per unit volume,  $\sigma$  = diameter of each gas molecule.
- (b) What do you mean by internal energy of a system? Using 1<sup>st</sup> law of thermodynamics find the change in internal energy for the following processes: 1+1+1+1
- (i) Isochoric process
- (ii) Isothermal process
- (iii) Adiabatic process.
- (c) Draw the black-body radiation curve and describe its nature. 2

—x—