'समानो मन्त्रः समितिः समानी'

UNIVERSITY OF NORTH BENGAL

B.Sc. Honours 3rd Semester Examination, 2021

GE2-P1-PHYSICS

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
All symbols are of usual significance.

The question paper contains GE-3A and GE-3B.
The candidates are required to answer any *one* from *two* courses.
Candidates should mention it clearly on the Answer Book.

GE-3A

MECHANICS

GROUP-A

1. Answer any ***five*** questions from the following: 1×5 = 5

   (a) What is axial vector? Give an example. 1

   (b) When the resultant sum of two vectors is zero? 1

   (c) What do you mean by impulse of a force? 1

   (d) Give two examples of conservative force. 1

   (e) What is the radius of gyration? 1

   (f) What is the condition of a simple harmonic motion? 1

   (g) Find the dimension of gravitational constant. 1

   (h) State Kepler's third law of planetary motion. 1

GROUP-B

Answer any *three* questions from the following 5×3 = 15

2. Define gravitational potential energy and find its expression for a system of masses. 1+4

3. (a) Prove that, the areal velocity of a particle under central force is constant. 3

   (b) Show that, the angular momentum of a particle under central force is constant. 2

4. (a) Define the following terms related to differential equation: 2

   (i) Ordinary (ii) homogeneous

   (b) Solve the differential equation 3

$$\frac{dy}{dx} + \frac{y}{x} = x^3 - 3$$

5. (a) Show that Poisson's ratio of an elastic material lies between $-\frac{1}{2}$ and $+\frac{1}{2}$. 2

   (b) Prove that for a homogeneous medium 3

   $$Y = 3K(1-2\sigma)$$

   where the symbols have their usual meanings.

6. (a) Given $\vec{A} = \hat{i} + 2\hat{j} + 3\hat{k}$ and $\vec{B} = 2\hat{i} - \hat{j} + 2\hat{k}$. Find out the unit vector perpendicular to both $\vec{A}$ and $\vec{B}$. 2

   (b) Prove that, 3

   $$\frac{d}{dt}(\phi\vec{A}) = \phi\frac{d\vec{A}}{dt} + \frac{d\phi}{dt}\vec{A},$$

   where ϕ is a differentiable scalar function and $\vec{A}$ is a differentiable vector.

GROUP-C

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

7. (a) Establish the differential equation for a simple harmonic motion and find out it's solution. 2+4

   (b) Derive the expression of potential energy for a simple harmonic motion and show that total energy for SHM is constant. 2+2

8. (a) How fast would rocket have to go relative to an observer for its length to be contracted to 98% of its length at rest? 2

   (b) Establish the relativistic equation between the total energy and the momentum of a moving body. 4

   (c) Starting from the relation of variation of mass with velocity establish the equivalence relation of mass and energy. 4

9. (a) Define the bulk modulus and the compressibility. 1+1

   (b) What is the difference between angle of twist and angle of shear? 2

   (c) Calculate the work done in twisting a wire. 3

   (d) Draw and explain stress-strain diagram in connection with the elastic behaviour of a wire. 3

10. (a) Establish the relation between the torque and the angular momentum. 2

    (b) If earth suddenly contracts to half of its present radius. What would be the length of a day? 2

    (c) A circular disc of mass *m* and radius *r* is set rolling on a table. If ω be the angular velocity. Show that total energy of the disc is given by $E = \frac{3}{4}m\omega^2 r^2$. 3

    (d) A sphere of mass 50 g and radius 2 cm rolls with a velocity 5 cm/s. Find out the linear and rotational kinetic energy of the sphere. 3

GE-3B

THERMAL PHYSICS AND STATISTICAL MECHANICS

GROUP-A

1. Answer any ***five*** questions from the following: 1×5 = 5

   (a) What is the unit of Entropy in S.I. system? 1

   (b) What is the physical significance of the enthalpy? 1

   (c) Write down the expressions of the r.m.s velocity and the most probable velocity of ideal gas particles? 1

   (d) If in a three dimensional space electron density is increased eight times, then how much the Fermi energy is increased? 1

   (e) What is the rotational degree of freedom for a diatomic gas molecule? 1

   (f) What is the value of the chemical potential of a photon gas? 1

   (g) What is the spin of a photon? 1

   (h) What is a throttling process? 1

GROUP-B

Answer any *three* questions from the following 5×3 = 15

2. (a) Show that for an ideal gas $C_P - C_V = R$. 3

   (b) Find out the expression of work done in an adiabatic process for an ideal gas. 2

3. (a) Define the Helmholtz free energy and the Gibbs free energy. 3

   (b) Establish the Clausius-Clapeyron equation from the Maxwell's relations. 2

4. (a) What is the mean free path? 1

   (b) Find out the expression of average velocity of an ideal gas molecule. 4

5. Establish the relation $PV = \frac{2}{3}E$ for an electron gas at $T = 0\text{K}$. 5

6. Deduce Wien's displacement law from Planck's law. 5

GROUP-C

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

7. (a) What is a heat engine? 2

   (b) Describe, in brief, its working principle. 2

   (c) Show that the thermal efficiency of a Carnot's engine operating between a source at temperature T_1 and a sink at temperature T_2 is $\eta = 1 - \frac{T_2}{T_1}$. 6

8. (a) State the Maxwell's Velocity distribution law and draw Velocity distribution curve. 2+1

   (b) Make a comparative discussion on r.m.s average and most probable velocities of an ideal gas molecules. 3

   (c) Prove that $\gamma = 1 + \frac{2}{f}$ for a mechanical system. (where $\gamma = C_P / C_V$). 4

9. (a) Define a perfect black body, give one example. 1+1

   (b) Use Kirchhoff's law to show that a perfect emitter is also a perfect absorber. 2

   (c) Draw the energy distribution diagram of a perfect black body at two different temperatures. 2

   (d) Suppose the temperature of a body is decreased from 40ºC to 30ºC in 10 minutes. Let the temperature of the surrounding be 15ºC. What will be the temperature of the body after 5 minutes more? 4

10. (a) Define phase space. 1

    (b) Explain the concept of microstates with example. 2

    (c) Define the Fermi temperature. If the Fermi velocity of a conduction electron is 7×10^5 m/s , then find out the Fermi temperature. 1+2

    (d) In a two-dimensional electron gas, show that the number of electron per unit area is 4

$$n = \frac{4\pi m k_B T}{h^2} \ln(1 + e^{E_F / k_B T})$$

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