'समानो मन्त्रः समितिः समानी'

UNIVERSITY OF NORTH BENGAL

B.Sc. Honours 3rd Semester Examination, 2023

GE2-P1-PHYSICS

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.

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) 'Electric current is not a vector quantity' — Why? 1

(b) Write down the order and degree of the differential equation: 1

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

(c) What do you mean by the inertial frame of reference? 1

(d) Two artificial satellites of different masses are revolving round the earth at the same altitude. Which one will be moving faster? 1

(e) Define radius of gyration. 1

(f) State the condition under which a motion can be called simple harmonic. 1

(g) Following Stirling's formula calculate the value of 10!. 1

(h) What is the value of Poisson's ratio for a perfectly elastic body? 1

GROUP-B

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

2. (a) For what value of 'λ', the set of vectors $3\hat{i}-2\hat{j}+\hat{k}$, $\hat{i}+\hat{j}-2\hat{k}$ and $3\hat{i}-4\hat{j}+\lambda\hat{k}$ are coplanar? 3+2

(b) If $\vec{A}=\vec{A}(t)$ is a time(t)-dependent vector having constant magnitude, show that $\vec{A}$ and $d\vec{A}/dt$ are perpendicular to each other.

3. (a) What do you mean by central force? Prove that, the angular momentum of a particle under a central force is conserved. (1+2)+(1+1)

   (b) Under what condition a force is termed as 'conservative'? Give an example of a conservative force.

4. (a) Define centre of mass of a body. Can the geometrical centre and the centre of mass of a body coincide? If yes, give an example. (1+1+1)+(1+1)

   (b) What is a centrifugal force? Why it is called a fictitious force?

5. Define the modulus of rigidity of an elastic material. Show that the torsional rigidity of a cylindrical wire of length l and radius R is $\pi\eta R^4/2l$, η being the modulus of rigidity of the material of the wire. 1+4

6. (a) Write down the postulates of Einstein's special theory of relativity. 2+3

   (b) Two space-ships A and B are moving opposite to each other. An observer, at rest on the earth measures the speed of A to be $0.75c$ away from the earth and that of B to be $0.85c$ towards the earth where c is the speed of light in vacuum. Find out the velocity of B with respect to A.

GROUP-C

Answer any *two* questions from the following $10\times2 = 20$

7. (a) What is a geo-stationary satellite? Write down few applications of GPS system. 1+2

   (b) Calculate the minimum velocity and the period of revolution of an artificial satellite at a certain height from the surface of the earth. 2+2

   (c) What do you mean by the term 'escape velocity'? Explain the absence of any atmosphere on the moon. 1+2

8. (a) Establish the differential equation of a simple harmonic motion and hence find out its solution. 3+3

   (b) Prove that $x(t) = 3\sin t + 4\cos t$ represents a solution of the equation of simple harmonic motion. What is the amplitude of this motion? 3+1

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

   (b) Define Young's modulus, Bulk modulus and Shear modulus of a homogeneous elastic body and hence establish the interrelation among them. 3+4

10. (a) Define an axial vector and a polar-vector. Give an example of each. 2+2

    (b) If the distance between the sun and the earth is reduced to half of their present distance, how many days will be there in one year? 3

    (c) Explain the phenomenon of time-dilation in STR. What do you mean by 'proper time interval'? 2+1

GE-3B

THERMAL PHYSICS AND STATISTICAL MECHANICS

GROUP-A

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

   (a) What is extensive variable? Give an example.

   (b) What is a perfect blackbody?

   (c) State the third law of thermodynamics.

   (d) What do you mean by 'mean free path' of a gas particle?

   (e) Define the Fermi energy of a system of spin-$\frac{1}{2}$ particles.

   (f) Write a short note on a closed system.

   (g) Write down the statement of the Stefan-Boltzmann law.

   (h) State the equipartition law of gas.

GROUP-B

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

2. (a) A system of ideal gas undergoes an adiabatic process. Obtain the expression of work done during the process. 2+3

   (b) Show that, for an ideal gas $C_P - C_V = R$.

3. (a) Define the root mean square (rms) velocity of the molecules of a gas. 1+4

   (b) Using the Kinetic theory of gases, show that the pressure of a gas $P = \rho c^2/3$, where ρ is the density of the gas, and c is the r.m.s. velocity of the gas particles.

4. Derive the Maxwell law of velocity distribution for the molecules of a gas at temperature T, and pressure P. 5

5. What is Gibb's paradox? How can it be resolved? 3+2

6. (a) Show that for an ideal gas thermal conductivity $K = \eta C_v$, where the symbols carry their usual meanings. 3+2

   (b) C_P for O_2 gas is 7.05 cal mol^{-1} k^{-1}. If the temperature of 64 gm of O_2 gas is increased from 300 K to 350 K, find out the increase in its enthalpy.

GROUP-C

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

7. (a) Give the derivation of Planck's law of blackbody radiation. How can we arrive at the Rayleigh-Jeans distribution law from Planck's law? 5+2

   (b) From Kirchhoff's law show that a good radiator is also a good absorber. 3

8. (a) What do you mean by thermodynamic potential? 3

   (b) Prove the thermodynamic relations: 4+3

   (i) $\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$ and

   (ii) $\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$

   Where the symbols carry their usual meanings.

9. (a) What is heat engine? Briefly describe the working principle of a heat engine. 5

   (b) Show that the thermal efficiency of a Carnot engine operating between a source at temperature T_1 and a sink at temperature T_2, is $\eta = 1 - \frac{T_2}{T_1}$. 5

10. (a) Using the Fermi-Dirac statistics derive the F-D distribution function. 5

    (b) State and derive Liouville's theorem in thermodynamics. 1+2

    (c) Obtain the relation between entropy and thermodynamic probability for an ensemble of your choices. 2

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