

Seat No. : \_\_\_\_\_

# FB-138

February-2025

M.Sc., Sem.-I

402 : Physics

## (Classical Mechanics-I and Statistical Mechanics) (Old and New Course)

Time : 2:30 Hours]

[Max. Marks : 70

- Instructions :** (1) Attempt **all** questions.  
(2) Symbols used have their usual meanings.

1. (A) State and explain the Hamilton-Jacobi equation for Hamilton's principle function. 7  
(B) Outline how action-angle variables can be used to obtain frequencies of a periodic system. 7

**OR**

1. (A) Distinguish between point transformation and canonical transformation. 7  
(B) Define Poisson bracket and state its important properties. 7
2. (A) Sketch the normal modes of vibration of CO<sub>2</sub> molecule in the increasing order of frequency. 7  
(B) What are normal coordinates ? Obtain kinetic energy and potential energy in terms of normal coordinates and find out Lagrangian equation of motion. 7

**OR**

2. (A) What do you mean by stable and unstable equilibriums ? Establish the Lagrangian and find the Lagrange's equations of motion for small oscillations of a system in the neighborhood of stable equilibrium. 7  
(B) If frequencies of oscillations are  $\omega_1 = \sqrt{\frac{g}{l}}$  and  $\omega_2 = \sqrt{\frac{g}{l} + \frac{2k}{m}}$  for coupled simple pendulum linked by spring having a force constant k, obtain the (1) eigen vectors, (2) generalized coordinates and (3) normal coordinates. 7

3. (A) Define Brownian motion. Show that the diffusion of Brownian particles is related to its root means square displacement by – 7

$$D = \frac{\langle x^2(t) \rangle}{2t}$$

(B) Define Johnson noise. State and prove the Nyquist theorem. State its applications. 7

**OR**

3. (A) Define Shot noise. Obtain an expression of RMS shot noise current and state its importance. 7

(B) State the limitation of Einstein theory of Brownian motion and discuss the Langevin theory to prove that Brownian motion is irreversible. 7

4. (A) Write an explanatory note on (i) Critical indices (ii) Order parameter. 7

(B) Giving suitable example, define second order phase transition. Show that in the second order phase transition, the second derivatives of the Gibbs function is discontinuous. 7

**OR**

4. (A) With the help of Curie-Weiss theory of magnetic transition, explain the co-operative phenomenon and thereby deduce an equation for spontaneous magnetization. 7

(B) Show that in first order phase transition, the latent heat is non-zero. 7

5. Answer in brief any **Seven** questions from the following : (Each question is of **two mark**) 14

(i) Validate  $[A, B] = -[B, A]$ .

(ii) Show that  $[v, q_k] = -\frac{\partial v}{\partial p_k}$ .

(iii) What is the Poisson bracket of two canonical variables,  $q_j$  and  $p_j$ ?

(iv) What is the condition for a system to undergo small oscillations ?

(v) What mathematical method is used to find the natural frequencies of a system in small oscillations ?

(vi) What is the physical interpretation of the normal modes in small oscillations ?

(vii) Draw molar volume and specific heat versus temperature graph in second order phase transition.

(viii) Define order parameter in case of  $\beta$ -Brass.

(ix) State any two applications of Weiner-Kinchin theorem.

(x) What proves the universality of phase transitions ?

(xi) What do you mean by white noise ? Give one example.

(xii) Define auto-correlation function in context of time varying fluctuations.