Seat No. : _____

DB-145

December-2018

M.Sc., Sem.-I

402 : Physics
(Classical Mechanics and Statistical Mechanics)

Time : 2:30 Hours] **[Max. Marks : 70**

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

1. (A) Write the following :

(i) What is gauge transformation ? Explain it by taking example of the Lagrangian function and simple harmonic oscillator. **7**

(ii) Write usefulness of the Hamilton-Jacobi theory. Explain harmonic oscillator by using such theory. **7**

OR

(i) What do you mean by action and angle variables ? Discuss how they are used to obtain the frequencies of periodic motion and calculate the frequency of linear harmonic oscillator.

(ii) Prove that the problem of motion of a body in a central force field is separable in polar co-ordinates but not in cartesian co-ordinates.

(B) Answer the following in brief : (any **four**) **4**

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

(ii) Show that the transformation $P = \sqrt{2qe^{-\alpha}}\sin p$ and $Q = \sqrt{2qe^{\alpha}}\cos p$ is canonical.

(iii) Explain why Lagrangian formulation is more suitable for the transition to quantum field theory.

(iv) Define generating function.

(v) State importance of the Hamiltonian formulation in physics.

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

2. (A) Write the following :

(i) Obtain values of eigen frequencies of oscillations and their related eigen vectors for CO_2 molecule. **7**

(ii) What are normal co-ordinates ? Obtain kinetic energy and potential energy in terms of normal co-ordinates and find out Lagrangian equation of motion. **7**

OR

(i) 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 joined by spring having a force constant k, then find out the (1) eigen vectors, (2) generalised co-ordinates and (3) normal co-ordinates.

(ii) Define orthogonality. Prove that eigen vectors corresponding to the two different eigen frequencies are orthogonal.

(B) Answer the following in brief : (any **four**) **4**

(i) Differentiate stable and unstable equilibrium.

(ii) Give applications of theory of small oscillations in physics.

(iii) What is meant by degeneracy ?

(iv) State physical significance of equation $|V_{jk} - \omega^2 T_{jk}| = 0$.

(v) How many independent modes of vibration of the system having N coupled oscillator with N degrees of freedom ?

(vi) What do you understand by normal modes in relation to coupled oscillator ?

3. (A) Write the following :

(i) What do you mean by time dependence of fluctuations ? Establish a relationship between correlation function and power spectrum of time dependent fluctuations. **7**

(ii) Define Shot noise. Obtain an expression for rms shot noise current. State its applications. **7**

OR

(i) Discuss the Langevin theory of time independent fluctuations.

(ii) Derive Wiener-Khinchin theorem and show that for an exponentially decaying system, the rapid fluctuations rests faster than slowly varying fluctuations.

(B) Answer the following in brief : (any **three**) **3**

(i) State the significance of auto co-rrelation function.

(ii) Give the unit of diffusion coefficient of Brownian particles.

(iii) State any two applications of Johnson noise.

(iv) What is the origin of shot noise ?

(v) Define Brownian motion.

4. (A) Write the following :

(i) Prove that in the second order phase transition the second derivatives of the Gibbs function are discontinuous. **7**

(ii) Explain : (a) Critical indices (b) Order parameter. **7**

OR

(i) Using zeroth order Ising model, show that one dimensional Ising chain can not be ferromagnet.

(ii) Explain statistical equilibrium. Obtain Clausius-Clayperon equation and state its significance.

(B) Answer the following in brief : (any **three**) **3**

(i) "Critical exponents are all independent of each other". (True/False)

(ii) Plot a graph of specific heat versus temperature in first order phase transition.

(iii) Define order parameter for β-Brass.

(iv) Differentiate between first order and second order phase transition.

(v) Define co-operative processes.

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