Seat No. : _____

DM-131

December-2017

M.Sc., Sem.-I

402 : Physics

(Classical Mechanics-I and Statistical Mechanics)

Time : 3 Hours] **[Max. Marks : 70**

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

1. (a) When is Hamilton-Jacobi theory more useful? Discuss the harmonic oscillator problem using Hamilton-Jacobi method. **7**

OR

Discuss how 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) What are the action-angle variables? Explain how they can be used to obtain the frequencies of periodic motion. Hence, determine the frequency of linear harmonic oscillator. **7**

OR

Prove that the Poisson brackets of two constants of motion is itself a constant of motion even when the constants depend upon time explicitly.

2. (a) Define normal co-ordinates. What is meant by stable, unstable and neutral equilibrium? Give example of each. **7**

OR

Obtain Lagrangian equation of motion of vibrating string of length L fixed at both the ends and also discuss how frequencies of different mode of oscillations can be found.

(b) In case of coupled simple pendulum joined by spring with a force constant k and frequencies of oscillations are given by $\omega_1 = \sqrt{\frac{g}{l}}$ and $\omega_2 = \sqrt{\frac{g}{l} + \frac{2k}{m}}$ then find out (1) Eigen vectors, (2) generalized co-ordinates and (3) normal co-ordinates of the system. **7**

OR

What is orthogonality? Show that the Eigen vectors corresponding to the two distinct Eigen frequencies are orthogonal.

3. (a) What is random walk? Considering Brownian motion is random walk problem, discuss Langevin theory of Brownian particles. **7**

OR

For a linear resistive circuit, derive the Nyquist theorem and define the Johnson noise.

(b) State Wiener-Khinchin (W-K) theorem. Using W-K theorem, show that exponentially decaying fast fluctuations come to rest faster than the slowly varying fluctuations. **7**

OR

Define Johnson noise and shot noise. Obtain an equation for RMS shot noise current. State the physical significance of your result.

4. (a) Show that in the second order phase transition the second derivatives of Gibbs functions are discontinuous. **7**

OR

Obtain Clusius-Clayperon equation and show that first order phase transition possess latent heat.

(b) Show that one dimensional Ising chain cannot have spontaneous magnetization. **7**

OR

What do you mean by co-operative phase transition? Explain Curie-Weiss theory of magnetic transition.

5. Answer the following in brief : (Each question carry **one** mark) **14**

(i) Find out unit of $\frac{\partial^2 v}{\partial\theta_i \partial\theta_j}$.

(ii) If force acting per unit length of the string is 2 N/m and mass of the particle is 0.02 kg then find out frequency of oscillations.

(iii) If natural frequency of oscillation of string is 0.2π radian/sec, then find out frequency of only one normal mode of oscillation. If we have two normal modes of oscillations then what will be relation between a_1 and a_2 ?

(iv) Write equation of Hamiltonian principal function S. If $S = \frac{a}{\omega}\cos\omega t$ then what will be unit of $\frac{\partial S}{\partial t}$?

(v) If generating function for the transformation F = a sint + b cost where, a and b are constant and old Hamiltonian $H = \frac{p^2}{2m} + \frac{1}{2} ka^2 \sin^2 \omega t$ then find out the new Hamiltonian.

(vi) If $u = \tan^{-1} x$ and v = tan y then find out Poisson bracket $[u, v]_{x,y}$.

(vii) What do you mean by infinitesimal transformation ?

(viii) State the physical significance of critical exponents.

(ix) Define power spectrum.

(x) State any two applications of auto-correlation function.

(xi) What do you mean by diffusion of Brownian particles ? How is it related to time ?

(xii) Sketch the specific heat versus temperature for 1st order phase transition.

(xiii) Sketch entropy versus temperature for 2nd order phase transition.

(xiv) Define order parameter for β-Brass.
