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Sardar Patel University
Vallabh Vidyanagar
M Sc (Physics)- I Semester Examination
PS01CPHY02 Classical and Statistical Mechanics
Day and Date: Thursday, 23 April 2015

Time: 10:30 am to 1:30 pm **Max marks: 70**

I Choose the best possible answer from the given choices. (8x1=8)

1. Identify the type of constraints for the case of a particle placed on the surface of a sphere.
   (a) Holonomic (b) Rheonomous
   (c) Nonholonomic (d) Scleronomous

2. If the virtual work of the applied forces vanishes then the system is said to be
   (a) in equilibrium (b) in continuous motion
   (c) not in equilibrium (d) chaotic

3. Under the canonical transformation, the Poisson brackets
   (a) will not be invariant (b) will be invariant
   (c) reduces to zero (d) becomes commutation brackets divided by $\hbar$

4. The vanishing of a Lyapunov exponent indicates the existence of
   (a) Chaotic attractor (b) A stable fixed point for the trajectories to converge
   (c) A periodic motion (d) An unstable equilibrium.

5. The action integral of a particle of mass, m executing simple harmonic motion under the influence of Hooke's law with a force constant, k with total energy E is given by
   (a) $2\pi E\sqrt{\frac{m}{k}}$ (b) $2\pi E\sqrt{\frac{k}{m}}$
   (c) $2\pi\sqrt{\frac{E\,m}{k}}$ (d) $2\pi\sqrt{\frac{mk}{E}}$

6. A pure state is represented by
   (a) $Tr(\hat{\rho}) = 0$ (b) $Tr(\hat{\rho}) = 1$
   (c) $\hat{\rho} = \hat{\rho}^2$ (d) $\hat{\rho} = \hat{\rho}^\dagger$

7. As a system of bosons undergo BEC state, its fugacity approaches to
   (a) One (b)Infinity
   (c) Zero (d) one half

8. The stability of neutron stars are understood as its gravitational pressure balances with the
   (a) Centrifugal force (b) Electron degeneracy pressure
   (c) Neutron degeneracy pressure (d) Hyper nuclear forces

II Attempt any seven of the following short answer questions. (7x2=14)

1. What are constraints? How are they classified?.
2. Set up a Lagrangian of a coupled two mass points.
3. Explain de Alembert's principle and derive the Euler- Lagrange's equation.
4. What is logistic equation? Illustrate with an example.
5. Obtain the partition function corresponds to the translational motion of a system.
6. Define density operator? How a pure state is defined in terms of the density operator?
7. Show the behaviour of the specific heat in the case of a second order phase transition.
8. Illustrate the diagrammatic representation of a typical Cluster integral.
9. Explain the Boltzmann H-Theorem.

III A. Consider the motion of a relativistic particle under a constant force, write the corresponding Lagrangian for it and if the particle starts at rest from the origin, the solution results a hyperbolic motion. (6)

B. A Hamiltonian of one degree of freedom has he form

$H = \frac{p^2}{2a} - bqpe^{-at} + \frac{b}{2}q^2e^{-at}(a+be^{-at}) + k\frac{q^2}{2}$ where a, b, k are constants. Find the Lagrangian corresponding to this Hamiltonian. Deduce the Lagrangian for the case which is not explicitly depends on time, t.. (6)

OR

B. Show that the transformation, $Q = \log(\frac{1}{q}\sin p)$, $P = q\cot p$ is canonical. (6)

IV A. In the case of a linear triatomic molecule, the motion in the y and z directions are governed by the potentials $V_y = \frac{k}{2}(y_2 - y_1)^2 + \frac{k}{2}(y_3 - y_2)^2$ and $V_z = \frac{k}{2}(z_2 - z_1)^2 + \frac{k}{2}(z_3 - z_2)^2$. Find the eigen frequencies for small vibrations in three dimensions and describe the normal modes. (6)

B. Discuss the equations of Canonical transformation. Describe properties of the four basic Canonical Transformations. (6)

OR

B. What are cyclic co-ordinates? Discuss its importance with respect to the symmetry and the corresponding conservation laws? (6)

V A. Derive density matrix and the partition function for a system of free particles in co-ordinate space. (6)

B. Discus the thermodynamic properties of an ideal Bose gas at very low temperatures. (6)

OR

B. Discuss the thermodynamic properties of an ideal Fermi gas at 0^0K. And show that it has a huge energy density even at 0^0K. (6)

VI A. What are critical exponents? Deduce the various scaling relations among them. (6)

B. Discuss the Mayer's cluster expansion. Obtain an expression for the second virial coefficient. (6)

OR

B. Discuss in detail Landau's theory of second order Phase transition. (6)

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