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Sardar Patel University
Vallabh Vidyanagar
M Sc (Physics)- I Semester Examination
PS01CPHY02 Classical and Statistical Mechanics
Day and Date: Thursday, 7th April 2016

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

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

1. For the Lagrangian, $L = a\dot{x}^2 + b\frac{y}{x} + c\,x\,y + dy^2\,\dot{x}\,\dot{z} - k\sqrt{x^2 + y^2}$ identify the cyclic co-ordinate (a, b, c, d and k are constants).
   (a) x (b) y (c) z (d) k

2. In the case of Harmonic oscillator problem the Hamilton Jacobi equation for the Hamilton's principal function, S by setting the momentum co-ordinate p equal to
   (a) $\frac{\partial S}{\partial t}$ (b) $\frac{\partial^2 S}{\partial t \partial q}$ (c) S (d) $\frac{\partial S}{\partial q}$

3. In a system of two degrees of freedom, the transformation $Q_1 = q_1$, $P_1 = p_1$ and $Q_2 = p_2$, $P_2 = -q_2$ is generated by the function
   (a) $F = q_1 P_1 + q_2 Q_2$ (b) $F = q_1 P_1 + q_2 P_2$
   (c) $F = q_1 Q_1 + p_2 P_1$ (d) $F = p_1 P_2 + q_2 Q_1$

4. Phase transitions which are connected with entropy discontinuity are the case of
   (a) Second order phase transition (b) First order phase transition
   (c) Third order phase transition (d) No phase transition

5. A finite volume (V) and temperature (T), number of ideal bosons in the excited states are given by the proportionality relation
   (a) $N_{exc}^{max} \propto VT^{3/2}$ (b) $N_{exc}^{max} \propto VT^{2}$
   (c) $N_{exc}^{max} \propto V^2T^3$ (d) $N_{exc}^{max} \propto VT^{-2}$

6. If $\hat{\rho}$ is the density operator, the expectation value of an operator $\hat{f}$ can be obtained as
   (a) $\hat{f}\,Tr(\hat{\rho})$ (b) $\hat{\rho}Tr(\hat{f})$ (c) $\frac{Tr(\hat{f})}{Tr(\hat{\rho})}$ (d) $Tr(\hat{\rho}\hat{f})$

7. Towards the BEC state fugacity of the system approaches to
   (a) zero (b) infinity
   (c) one (d) negative

8. Sun like stars in their old age become a
   (a) neutron star (b) white dwarf star
   (c) a black hole (d) a strange star

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

1. Explain how the conservation theorem and symmetry are related in Lagrangian mechanics?
2. What are canonical transformations? Explain with an example.
3. How the equilibrium of a mechanical system is defined? What are the different types of equilibrium?
4. What are the characteristics of a chaotic motion?
5. What are normal co-ordinates?
6. Explain with a suitable example the advantage of cluster integrals.
7. Discuss the various degrees of freedom for a system of diatomic molecules. How the Partition function for such a system can formally be written?
8. Define fugacity of an ideal gas and describe its limiting values for a system of noninteracting bosons?
9. What are critical exponents? Why are they important?

III A. Discuss the Lagrangian formulation of relativistic mechanics. (6)

B. Based on the Hamilton-Jacobi theory solve the Harmonic oscillator problem. (6)

OR

B. Discuss the infinitesimal transformations and deduce the conservation theorems in the Poisson bracket formulation. (6)

IV A. Discuss the techniques for obtaining the resonant frequencies and normal modes of oscillations by considering a system of linear triatomic molecule. (6)

B. Discuss in detail small oscillations of particles on a string. (6)

OR

B. What are nonlinear oscillations? Give illustrative examples. How are they studied? (6)

V A. Derive density matrix and derive the density matrix operator in the case of an electron in an external magnetic field **B.** Also compute the expectation value of σ_z for this case. (6)

B. Discus the thermodynamic [properties of an ideal Bose gas at finite temperature. (6)

OR

B. Discuss the behaviour of ideal Fermi gas at very low temperature. Show that the gas exert huge pressure even at zero temperature. (6)

VI A. Discuss in detail Landau's theory of second order phase transition. (6)

B. Determine the second virial coefficient for an imperfect classical gas under the interaction potential of the form

$U(r) = \infty$ for $r < r_0$ and $U(r) = -a/r^6$ for $r > r_0$. (6)

OR

B. Discuss the theory of Ising model in one dimension. (6)
