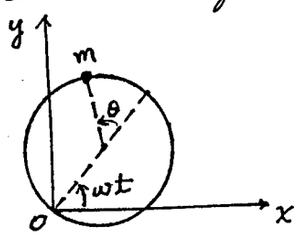
(1) A disk of mass m and radius R rotates with an angular velocity ω_0 about a horizontal axis. If it is placed on a horizontal plane, the coefficient of friction being μ, how far the disk travel before it is engaged in a pure rolling motion? 15%

(2) Three point masses, rigidly connected together, are situated as follows: m at $(1, 1, 0)$
$2m$ at $(1, -1, 0)$
$3m$ at $(-1, 1, 0)$ 15%

(a) Find the set of principal axes $(\hat{i}', \hat{j}', \hat{k}')$ and the moments of inertia about these axes.

(b) Find the angular momentum when the system has an angular velocity $\omega = \frac{\omega_0}{\sqrt{2}}(\hat{j}' + \hat{k}')$.

(3) A bead of mass m slides on a smooth circular wire of radius b which rotates in a horizontal plane about one of its points, O, with a constant velocity ω as shown in the figure. Find the Lagrangian, the equation of motion, and the Hamiltonian. 20%



(4) (a) Prove that the partition function of an Einstein crystal is $Z = \frac{e^{-h\nu/2k_BT}}{1 - e^{-h\nu/k_BT}}$, where h is the Planck's constant, ν the vibration frequency, and k_B the Boltzmann's constant. 20%

(b) If the crystal consists of N_a lattice points, calculate (b) the Helmholtz function F, (c) the pressure P, and (d) the entropy S. (f) Express the zero-point energy in terms of Θ_E.

(5) How can you distinguish the first-order from the second-order phase transition? 10%

025

(6) The pressure on 300g of copper is increased reversibly and isothermally from zero to 300 atm at 100 K (Take the density $\rho = 8.93 \times 10^3\ kg/m^3$, volume expansivity $\beta = 31.5 \times 10^{-6}\ K^{-1}$, isothermal compressibility $K = 7.21 \times 10^{-21}\ Pa^{-1}$, and heat capacity $C_p = 0.254\ kJ/kg \cdot K$ to be constant.) 20%

(a) How much heat is transferred during the compression ?

(b) How much work is done during the compression ?

(c) Determine the change of the internal energy.

(d) What would have been the rise of temperature if the copper had been subjected to a reversible adiabatic compression ?