# IPhO-2014-Astana-Problem 1.

Part A. A small puck of mass m is carefully placed onto the inner surface of a thin hollow cylinder of mass M and of radius R. Initially, the cylinder rests on a horizontal plane and the puck is located at a height R above the plane as shown in the figure on the left. Find the contact force F between the puck and the cylinder at the moment when the puck passes the lowest point of its trajectory. Assume that there is no friction between the puck and the inner surface of the cylinder, and that the cylinder moves on the plane without slipping. The free fall acceleration is g.
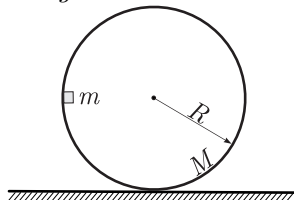
Part B. A bubble of radius $r = 5.00\,\text{cm}$ is a soap film of thickness $h = 10.0\,\mu\text{m}$ containing a diatomic ideal gas. It is placed in vacuum. The soap film has surface tension $\sigma = 4.00 \times 10^{-2}\,\text{N/m}$ and density $\rho = 1.10\,\text{g/cm}^3$.

a) Find a formula for the molar heat capacity of the gas in the bubble, for a process in which the gas is heated so slowly that the bubble remains in mechanical equilibrium. Evaluate your answer.

b) Find a formula for the frequency ω of small radial oscillations of the bubble and evaluate it under the assumption that the heat capacity of the soap film is much greater than the heat capacity of the gas in the bubble. Assume that the interior of the bubble reaches thermal equilibrium much faster than the period of oscillations; also, the total mass of the gas is much smaller than the mass of the soap film. Neglect the possibility of soap film's evaporation.

Part C. Initially: switch S in the circuit below is open; the capacitor of capacitance $2C$ carries electric charge q_0; the capacitor of capacitance C is uncharged; and there are no electric currents in either the coil of inductance L or the coil of inductance $2L$. The capacitor starts to discharge and at the moment when the current in the coils reaches its maximum value, the switch S is instantly closed. Find the maximum current $I_{\max}$ through the switch S thereafter.