

## Exercises in Statistical Mechanics

Based on course by Doron Cohen, has to be proofed  
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This exercises pool is intended for a graduate course in “statistical mechanics”. Some of the problems are original, while other were assembled from various undocumented sources. In particular some problems originate from exams that were written by B. Horovitz (BGU), S. Fishman (Technion), and D. Cohen (BGU).

### ===== [Exercise 2050]

#### Pressure by a particle in a spring-box system

A spring that has an elastic constant  $K$  and natural length  $L$  is connected between a wall at  $x = 0$  and a piston at  $x = X$ . Consequently the force that acts of the piston is  $F_0 = -K(X - L)$ . A classical particle of mass  $m$  is attached to the middle point of the spring. The system is at equilibrium, the temperature is  $T$ .

- (1) Write the Hamiltonian (be careful).
- (2) Write an expression for the partition function  $Z(\beta, X)$ . The answer is an expression that may contain a definite integral.
- (3) Write an expression for the force  $F$  on the piston. The answer is an expression that may contain a definite integral.
- (4) Find a leading order (non-zero) expression for  $F - F_0$  in the limit of high temperature.
- (5) Find a leading order (non-zero) expression for  $F - F_0$  in the limit of low temperature.

Your answers should not involve exotic functions, and should be expressed using  $(X, L, K, m, T)$ .

