

## Exercises in Statistical Mechanics

Based on course by Doron Cohen, has to be proofed  
*Department of Physics, Ben-Gurion University, Beer-Sheva 84105, Israel*

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 0080]

#### The spreading of a free particle

Given a free classic particle  $H = \frac{p^2}{2m}$ , that has been prepared in time  $t = 0$  in a state represented by the probability function

$$\rho_{t=0}(X, P) \propto \exp\left(-a(X - X_0)^2 - b(p - p_1)^2\right)$$

- (a) Normalize  $\rho_{t=0}(X, P)$ .
- (b) Calculate  $\langle X \rangle$ ,  $\langle P \rangle$ ,  $\sigma_X$ ,  $\sigma_P$ ,  $E$
- (c) Express the random variables  $\hat{X}_t, \hat{P}_t$  with  $\hat{X}_{t=0}, \hat{P}_{t=0}$
- (d) Express  $\rho_t(X, P)$  with  $\rho_{t=0}(X, P)$ . (Hint: ‘variables replacement’).
- (e) Mention two ways to calculate the sizes appeared in paragraph b in time  $t$ . use the simple one to express  $\sigma_x(t), \sigma_p(t)$  with  $\sigma_x(t=0), \sigma_p(t=0)$  (that you’ve calculated in b).