

Exercises in Statistical Mechanics

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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 3555]

Fermions in magnetic field - Landau

Consider N spinless electrons that have mass m and charge e in a 2D box that has an area A at zero temperature. A perpendicular magnetic field B is applied. The purpose of this question is to find the magnetization of the system.

- (1) What are the threshold value B_n for which there are exactly n filled Landau levels.
- (2) Find the energy $E(B)$ and the magnetization $M(B)$ for strong field $B > B_1$. Give an optional semiclassical derivation to the result assuming that each electron is doing a cyclotron motion with minimal one-particle energy.
- (3) Find the energy $E(B)$ and the magnetization $M(B)$ for $B_{n+1} < B < B_n$. In particular find $E(B_n)$ and explain why they are all equal to $E(0)$. Write what is the value of the magnetization at the endpoints of each interval.
- (4) Give a semiclassical derivation to the drops of $M(B)$ at the threshold values B_n , using the Hall formula for the current along the Edge.

Keywords: Landau levels; Landau magnetism; The de Haas van Alphen (dHvA) oscillations; The quantum Hall effect.