M01T.3—Electron Gas in a Magnetic Field

Problem

Consider a 3D gas of electrons in a large box of size L, under a uniform magnetic field B in the vertical direction. In this problem we will ignore the spin of the electrons.

a)   What are the energy levels and their degeneracies?

b)   Write the grand canonical partition sum, and compute the pressure as a function of the activity $z = e^{\beta \mu}$ and the inverse temperature $\beta = (k_B T)^{-1}$. Assume you are in the low density regime.

c)   Find the magnetization and the magnetic susceptibility χ when $B = 0$, still at low density. Express your answers in terms of β and of the density ρ.

d)   Does the system display ferromagnetism, diamagnetism, or paramagnetism? Explain your answer.