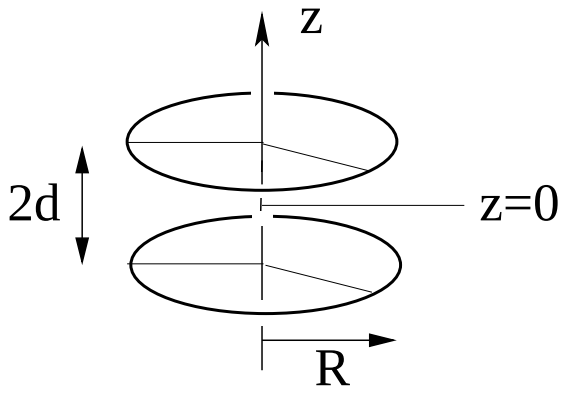
PY 452: Quantum Physics II Problem Set 3

Due date: Friday, September 24, by 5:00pm

Reading: We'll finish discussing quantum statistical mechanics in the first few minutes of Tuesday's lecture and then move to the major topic of perturbation theory. Please read chapter 6, sections 1 & 2 in the text. We will like finish non-degenerate perturbation theory and start with degenerate perturbation theory sometime on Thursday.

1. A spatially-uniform magnetic field is created by a solenoid, but this requires use of lots of wire. The Helmholtz coil is a device to obtain a relatively spatially-uniform magnetic field that uses much less wire. This coil consists of two separate wire loops arranged as in the figure with the same current I in each loop. If the loop radius R and the separation between the loops $2d$ are judiciously chosen, the magnetic field on the z-axis varies extremely slowly with z. Find the ratio of d/R such that the magnetic field along the z-axis can be written as $B = B(z{=}0) + az^4$. For a single coil at $z = 0$, the magnetic field at a point z on the z-axis is $B(z) = A[R^2 + z^2]^{-3/2}$.



(see next page)

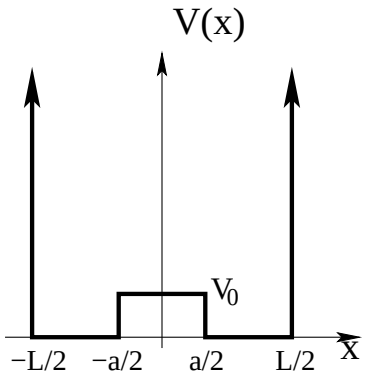
2. Consider a particle in an infinite square-well potential with a small bump at the bottom as illustrated below to the left:

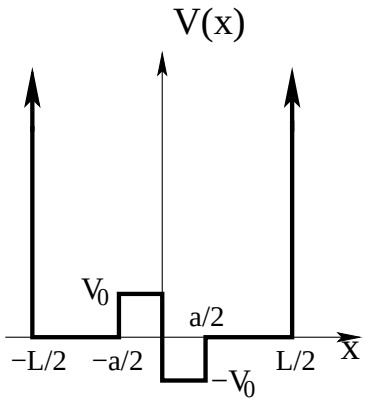
   (a) Calculate the first-order corrections to the eigenenergies of the unperturbed system.

   (b) Calculate the first-order corrections to the lowest three states eigenfunctions.

   (c) What dimensionless ratio must be small compared to 1 for the first-order perturbation theory to be valid?

   (d) Repeat parts (a) and (b) for the potential sketched on the right.





3. Text 6.3.

4. Text 6.5.