PHYS 330: Final Project Proposal

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April 9, 2022

For my final project I propose to attempt problem 4.32 in the text, which has to do with Earnshaw's theorem. The problem statement is as follows:

Problem 4.32 ! Earnshaw's theorem (Prob. 3.2) says that you cannot trap a charged particle in an electrostatic field. Question: Could you trap a neutral (but polarizable) atom in an electrostatic field?

The statement of Earnshaw's theorem is that a collection of point charges cannot be maintained in a stable stationary equilibrium configuration solely by the electrostatic interaction of the charges (Wikipedia). In order to show the result that an atom acting as a dipole under the influence of an external electric field is not subject to a force that allows for stable equilibrium points. Showing the result will be done as follows. Following the recommendation of the text, I would need to show that the force acting on the particle is $\mathbf{F} = \frac{1}{2}\alpha\nabla(E^2)$. Since force is defined to be the gradient of potential energy, in this case the potential is proportional to E^2. Thus, if one can show that E^2 has no local minima or maxima, then one can show that there are no stable equilibrium points for the particle to be in. I also hope to explain more in depth Earnshaw's theorem, including how it applies to all inverse square law forces such as the gravitational force. I also hope to explain how Earnshaw's theorem applies to permitting stable configurations in magnetic fields. I plan to present the results in powerpoint format.