DS4 & DS5:
Charge Distributions and Gauss's Law

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1 Charge Distributions

Calculate the Electric Field due to the following charge distributions:

1. A circular ring of charge of radius R and charge density λ, directly above its centre.
2. An infinite sheet of charge with surface charge density σ.
3. An infinite parallel plate capacitor.

2 The finite-sized proton

1. What is the the Coulomb potential for an idealised proton? Draw it out.
2. Verify that the field corresponding to this potential satisfies the conditions $\nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon_0}$ and $\nabla \times \mathbf{E} = 0$.
3. Let us now assume that the proton has a finite size. Come up with a charge distribution that might make sense.
4. Calculate the Electric Field due to this distribution of charge **over all space**, using your method of choice.
5. Now calculate the potential due to this distribution of charge. Sketch it out.

3 WHERE IS HELL?

A burning (ha-ha) question that faced Physicists including Newton around the time that he postulated his Force of Gravitation was the location of hell. Since the Earth was round, Heaven could not be thought of as simply localised above us. Ideally, Heaven should be a large shell that wrapped around the universe. Of course, even most modern physicists would agree that the simplest extension to this theory would be to place hell at the centre of the Earth.

This led a friend of Newton's, Edmond Halley, to propose the hollow-earth theory. What would be the gravitational force experienced by those condemned to eternal damnation?