

Week 4 Worksheet

Electrostatics

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Exercise 1. Using Dirac delta functions in the appropriate coordinates if necessary, express the following charge distributions as three-dimensional charge densities $\rho(\mathbf{r})$.

- In spherical coordinates, a charge Q uniformly distributed over a spherical shell of radius R .
- In cylindrical coordinates, a charge λ per unit length uniformly distributed over a cylindrical surface of radius b .
- In cylindrical coordinates, a charge Q spread uniformly over a flat circular disc of negligible thickness and radius R .

Exercise 2. Two infinite parallel plates carry equal and opposite uniform charge densities $\pm\sigma$. Put the positively charged plate in the (x, y) -plane and the negatively charged one at $z = 1$ above it. Find the electric field in each of three regions: $z < 0$, $0 < z < 1$, and $z > 1$.

Exercise 3.

- The potential at a point \mathbf{r} is defined as

$$V(\mathbf{r}) = - \int_{\mathcal{O}}^{\mathbf{r}} \mathbf{E} \cdot d\ell,$$

where \mathcal{O} is some reference point. Explain why this is well-defined (i.e. unambiguous, up to the choice of \mathcal{O}).

Hint: Use Stokes' theorem.

- An infinite plate carries a uniform charge density σ . Find the potential everywhere.

Hints: Recall that the electric field is $E = \sigma/2\epsilon_0$. Where would you put your reference point \mathcal{O} ?