Electricity and Magnetism - Lecture 7 Notes

Joshua Clement

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Electric Field Due to a Parallel Plate Capacitor

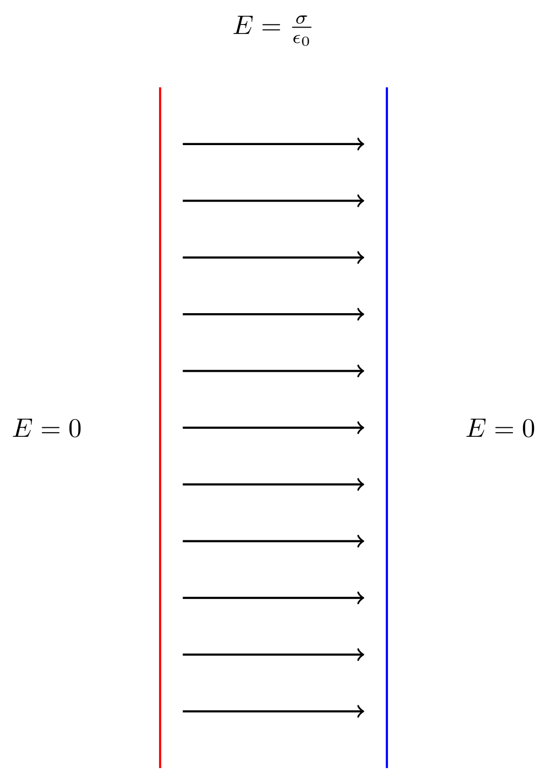

Figure 1: Electric field between two infinite parallel plates. Fields inside add up, while fields outside cancel.

- **Two Oppositely Charged Plates**: Create a nearly uniform electric field between them.

- **Field Between Plates**:
$$E = \frac{\sigma}{\epsilon_0}$$
where σ is the surface charge density and ϵ_0 is the permittivity of free space.

- **Fringe Field**: Charges on the outer edges of plates create a non-uniform field at the edges.

Electric Field of a Uniformly Charged Shell (Recap)

- **Outside the Shell** ($r > R$): The electric field behaves as if all charge is concentrated at the center.
$$E = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}$$

- **Inside the Shell** ($r < R$): The electric field is zero due to complete cancellation.
$$E = 0$$

Electric Field of a Uniformly Charged Sphere

- **Outside the Sphere** ($r > R$): The electric field is similar to that of a point charge.
$$E = \frac{1}{4\pi\epsilon_0}\frac{Q}{|r|^2}\hat{r}$$

- **Inside the Sphere** ($r < R$): The electric field increases linearly with distance from the center.
$$E = \frac{1}{4\pi\epsilon_0}\frac{Q|r|}{R^3}\hat{r}$$
where R is the radius of the sphere and r is the distance from the center.

Two Infinite Planes with Opposite Charges

- **Superposition Principle**:
  - Two infinite planes with surface charge densities σ and $-\sigma$.
  - **Field Between the Planes**:
  $$E = \frac{\sigma}{\epsilon_0}$$
  - **Field Outside the Planes**: The fields cancel, resulting in $E = 0$.

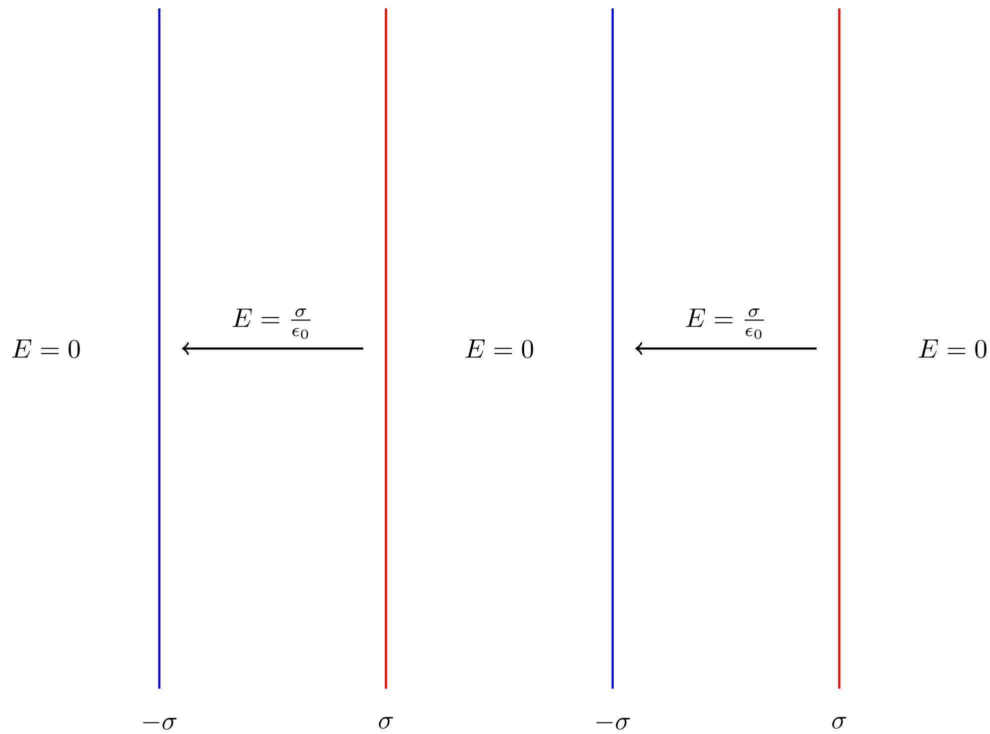

Figure 2: Electric field between two sets of parallel plates with opposite surface charge densities. Fields are zero outside the plates, while between the plates the field is $E = \frac{\sigma}{\epsilon_0}$.

Spherical Shell vs. Solid Sphere

- **Spherical Shell**:
  - **Outside** ($r > R$): Field behaves as if all charge is at the center.
  - **Inside** ($r < R$): Field is zero.
- **Solid Sphere**:
  - **Outside** ($r > R$): Field similar to a point charge.
  - **Inside** ($r < R$): Field increases linearly with distance from the center.

Building a Solid Sphere from Spherical Shells

- **Concept**: A solid sphere can be thought of as a series of concentric spherical shells.

- **Electric Field Calculation**:
  - Use symmetry to determine that the field outside is the sum of all individual shell fields.
  - Inside a uniformly charged conducting sphere, $E = 0$ in equilibrium as charges move to the surface.