# Electric Field of a Straight Wire

Gauss' law allows to easily determine the electric field of simple symmetrical charge distributions. As a one-dimensional example we consider a long, straight wire with a uniform charge distribution.

**Prerequisites:** You know how to calculate the electric flux through a surface.

### Goals

- You can apply Gauss' law to determine the electric field of a simple charge distribution.
- You realise that generally the force between charged objects cannot be calculated using Coulomb's law.

**Time:** 30 minutes

### Problem

Two long, straight wires are placed at a short distance, one parallel to the other. They carry opposite charges of equal magnitude.

Find the magnitude of the force acting on the wires.

### Instructions:

1. Consider only one wire to start with. What does the electric field in the space surrounding the wire look like (direction)? Suppose that the wire has infinite length.
2. As an appropriate Gaussian surface we choose a cylinder with radius $r$ and length $L$, centred at the wire. Derive a formal expression for the electric flux through this surface.

   Explain how the magnitude of the electric field changes when the distance to the wire is doubled.
3. Using Gauss' law, find a formal expression for the magnitude of the electric field at distance $r$ from the wire. Express your result in terms of the *linear charge density* $\lambda$, i.e. the amount of charge per unit length.
4. Determine the force acting on the second wire from its charge and the magnitude of the first wire's electric field at the position of the second one.
5. As an example consider two wires with length 1.5 m at a distance of 2.5 cm, carrying the charges + 10 nC and − 10 nC, respectively. Calculate the magnitude of the electric field in the middle between the wires and the magnitude of the mutually attractive forces.