Electric Fields

Unit: Electricity & Magnetism

NGSS Standards: HS-PS3-2

MA Curriculum Frameworks (2006): N/A

AP Physics 1 Learning Objectives: N/A

Skills:
- drawing electric field lines

Language Objectives:
- Understand and correctly use the term “electric field.”
- Accurately describe and apply the concepts described in this section using appropriate academic language.

Labs, Activities & Demonstrations:
- students holding copper pipe in one hand and zinc-coated steel pipe in other—measure with voltmeter. (Can chain students together.)

Notes:

Electric fields are not part of the AP Physics 1 curriculum, but are part of NGSS.

force field: a region in which an object experiences a force because of some intrinsic property of the object that enables the force to act on it. Force fields are vectors, which means they have both a magnitude and a direction.

electric field: an electrically charged region (force field) that exerts a force on any charged particle within the region.
The simplest electric field is the region around a single charged particle:

Field lines are vectors that show the directions of force on an object. In an electric field, the object is a positively-charged particle. This means that the direction of the electric field is from positive to negative, i.e., field lines go outward in all directions from a positively-charged particle, and inward from all directions toward a negatively-charged particle.

If a positive and a negative charge are near each other, the field lines go from the positive charge toward the negative charge:

(Note that even though this is a two-dimensional drawing, the field itself is three-dimensional. Some field lines come out of the paper from the positive charge and go into the paper toward the negative charge, and some go behind the paper from the positive charge and come back into the paper from behind toward the negative charge.)
In the case of two charged plates (flat surfaces), the field lines would look like the following:

We can measure the strength of an electric field by placing a particle with a positive charge \( q \) in the field, and measuring the force \( \vec{F} \) on the particle.

Coulomb’s Law tells us that the force on the charge is due to the charges from the electric field:

\[
F_e = \frac{kq_1q_2}{d^2}
\]

If the positive and negative charges on the two surfaces that make the electric field are equal, the force is the same everywhere in between the two surfaces. (This is because as the particle gets farther from one surface, it gets closer to the other.) This means that the force on the particle is related only to the charges that make up the electric field and the charge of the particle.

We can therefore describe the electric field \( \vec{E} \) as the force between the electric field and our particle, divided by the charge of our particle:

\[
\vec{E} = \frac{\vec{F}}{q} \quad \text{or} \quad \vec{F} = q\vec{E}
\]