Electric Permittivity

Unit: Electric Force, Field & Potential

NGSS Standards/MA Curriculum Frameworks (2016): HS-PS2-4

AP® Physics 2 Learning Objectives/Essential Knowledge (2024): 10.1.A, 10.1.A.2, , 10.1.A.3, 10.1.A.3.i, 10.1.A.3.ii, 10.1.A.4, 10.1.B, 10.1.B.1, 10.1.B.2, 10.1.B.3

Mastery Objective(s): (Students will be able to…)

- Solve problems using Coulomb's Law
- Quantitatively predict the effects on the electrostatic force when one of the variables (amount of electric charge or distance) in Coulomb's Law is changed.

Success Criteria:

- Variables are correctly identified and substituted correctly into the correct part of the correct equation.
- Algebra is correct and rounding to appropriate number of significant figures is reasonable.

Language Objectives:

- Explain how force and distance both affect the amount of force between two charged objects.

Tier 2 Vocabulary: charge

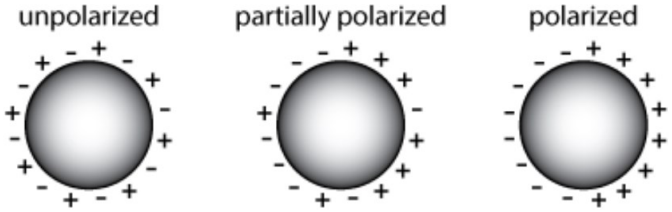
Notes:

force field: a region in which objects experience a force that is proportional to the amount that the object has of the property that the field acts upon.

electric field: a force field that acts upon objects with a nonzero electrical charge.

For example, in physics 1, you learned about the gravitational force field, which acts upon objects with mass. In the *Electric Fields* topic, starting on page 171, you will learn more about electric fields, which act upon objects with charge.

polarized: an object or region that has opposite values of some property at each end. An object is electrically polarized if one end is charged more positively or less negatively than the other.



electric permittivity: the degree to which a material or medium is polarized in the presence of an electric field.

permittivity of free space (ε_o): the degree to which empty space (a vacuum) can support an electric field. The permittivity of free space is defined in terms of two constants: the magnetic permeability of a vacuum (μ_o; see *Magnetism*, starting on page 282) and the speed of light (c).)

$$\varepsilon_o = \frac{1}{\mu_o c^2} = 8.85 \times 10^{-12} \frac{\text{F}}{\text{m}}$$

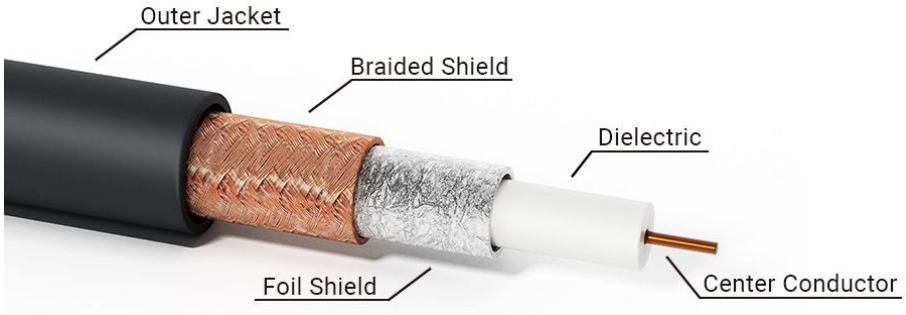
relative permittivity (dielectric constant) (κ^* or ε_r): the ratio of the electric permittivity of a substance to the electric permittivity of empty space.

A vacuum (empty space) has a relative permittivity of 1.

Relative permittivity is most often used to determine the ability of an insulating material to prevent electric charges from moving through itself. The lower the relative permittivity, the better the insulator.

Substance	κ	**Substance**	κ
vacuum	1	rubber	~7
air	1.0006	ethanol @ 25 °C	24.3
paper	1.4	methanol @ 25 °C	32.7
polyethylene	2.25	water @ 25 °C	78.4
silicon dioxide	3.9	calcium copper titanate	>250 000

Polyethylene is often used as a dielectric (insulator) between the center conductor and the outside shield in coaxial cables.



* Note that κ is the Greek letter "kappa," not the Roman letter "k".