Intro to Electrical Terminology 1

An electrical charge, q_2, experiences an electrical force when it enters the electrical field, E, surrounding another electrical charge, q_1.

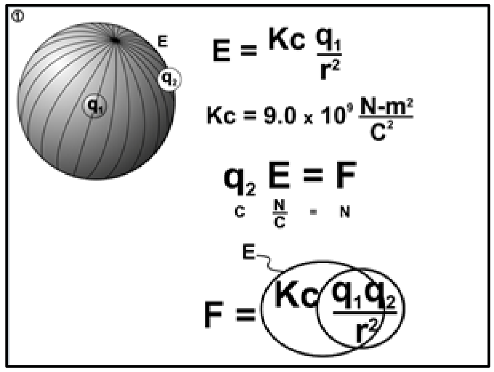
An electrical charge is measured in coulombs and the electrical field is measured in newtons per coulomb.

The strength of the electric field, E, at a distance, r, around q_1 is coulomb's constant, is $\frac{9.0 \text{ x } 10^9 \text{ N}-\text{m}^2}{C^2}$, times the coulombs in q_1 divided by r^2 in meters squared, E = $\frac{\text{Kc } q_1}{r^2}$.

When an electrical charge enters an electrical field, the newtons of force that develop between the two electrical charges is q_2 x E. Coulombs times newtons per coulomb equals newtons of force.

The force experienced between q_1 and q_2 depends on three things: the charge on q_1, the charge on q_2, and the distance between them.

The permittivity of the medium surrounding q_1 is taken into account in coulomb's constant, Kc. In a vacuum, coulomb's constant is $\frac{9.0 \text{ x } 10^9 \text{ N}-\text{m}^2}{C^2}$.



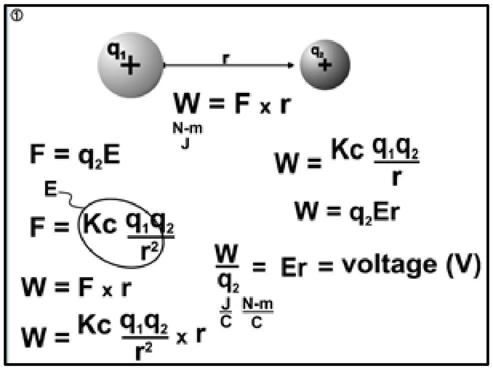
Intro to Electrical Terminology 2

If q_1 were negative and q_2 positive, and they overlapped each other exactly, it would take a force to separate them a distance, r. The force you exert to separate them times the distance, r, is force times distance, or work energy with units of newton-meters, or joules.

Force is q_2 times E, or $\frac{\text{Kc } q_1 q_2}{r^2}$. Work is force times distance, or $\frac{\text{Kc } q_1 q_2}{r^2}$ x r. This reduces to $\frac{\text{Kc } q_1 q_2}{r}$. This is the same energy needed to push a positive electrical charge, q_2, from an infinite distance to within r meters of another positive charge, q_1.

Since work is q_2 times Er, work divided by q_2 is Er, which, in English, says that work per unit of electrical charge is voltage in units of joules per coulomb, or newton-meters per coulomb.

Regrouping newton-meters per coulomb, voltage is also newtons per coulomb times distance, the units for E x r.



Intro to Electrical Terminology 3

electrical charge	electrical field	electrical force	electrical work	electrical voltage
C	$\frac{N}{C}$, $\frac{V}{m}$	N	N-m, J	$\frac{N\text{-}m}{C}$, $\frac{J}{C}$
q_1	$\frac{Kq_1}{r^2}$	$\frac{Kq_1q_2}{r^2}$	$\frac{Kq_1q_2}{r}$	$\frac{Kq_1}{r}$
	E	q_2E	q_2Er	Er
	$\frac{V}{r}$		q_2V	

Here is a chart relating electrical charge, electrical field, electrical force, electrical work, and electrical voltage.

Voltage = Er says that the voltage between two capacitor plates is the electrical field times the distance between the plates. Separating the two plates further by increasing r increases the voltage without affecting the electrical field. Since the voltage of a capacitor is the electrical field, E, times the distance, r, between the two plates, the electrical field can be defined as voltage per meter.

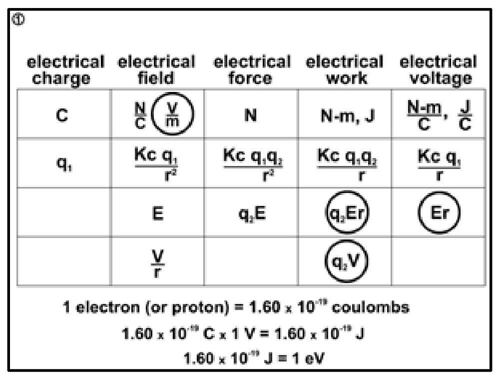
Voltage has no direction; it's just a value given by the formula, E times r.

The work needed to move an electron from a positive capacitor plate to the negative capacitor plate is qEr, or qV.

1 electron has an electrical charge of 1.60×10^{-19} coulombs.

Moving an electron up a voltage gradient of 1 volt requires q x V, or 1.60×10^{-19} joules.

1.60×10^{-19} joules is 1 electron volt.



electrical charge	electrical field	electrical force	electrical work	electrical voltage
C	$\frac{N}{C}$ ($\frac{V}{m}$)	N	N-m, J	$\frac{N\text{-}m}{C}$, $\frac{J}{C}$
q_1	$\frac{Kc\,q_1}{r^2}$	$\frac{Kc\,q_1q_2}{r^2}$	$\frac{Kc\,q_1q_2}{r}$	$\frac{Kc\,q_1}{r}$
	E	q_2E	(q_2Er)	(Er)
	$\frac{V}{r}$		(q_2V)	

1 electron (or proton) = 1.60×10^{-19} coulombs
1.60×10^{-19} C x 1 V = 1.60×10^{-19} J
1.60×10^{-19} J = 1 eV

1) Which match is incorrect?

	Units
(A) electrical charge	coulombs
(B) electrical field	newtons/coulomb
(C) electrical force	newtons-meters/coulomb
(D) electrical work	newton-meters
(E) electrical voltage	joules/coulomb

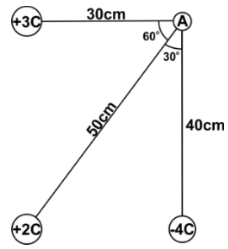
2. Which match is incorrect?

	Equals
(A) electrical field, E	$\frac{Kq_1}{r^2}$
(B) electrical field, E	$\frac{V}{r}$
(C) electrical force	$\frac{Kq_1q_2}{r}$
(D) electrical work	q_2V
(E) electrical voltage	Er

3. Lightning rods protect buildings by __________.

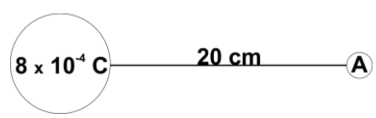
(A) being insulated from the building and directing the lightning bolt away from the building.
(B) being attached to the building and reducing the electrical charge on the building.
(C) attracting lightning bolts to the rod instead of the building.
(D) removing electrical charges in the air gravitating toward the building.
(E) creating a negatively charged field adjacent to the building.
lightning rod, the charges quickly begin to repel each other out into the air.

4. at point A? The electrical constant is What is the voltage $\frac{(9 \text{ x } 10^9 \text{ N}-\text{m}^2)}{C^2}$.



(A) $\frac{8.2 \text{ x } 10^9 \text{ J}}{C}$
(B) $\frac{3.6 \text{ x } 10^{10} \text{ J}}{C}$
(C) $\frac{4.8 \text{ x } 10^{10} \text{ J}}{C}$
(D) $\frac{6.4 \text{ x } 10^{10} \text{ J}}{C}$
(E) $\frac{8.2 \text{ x } 10^{10} \text{ J}}{C}$

5. What is the electrical field strength at point A 20 cm away from an electrical charge of 8 x 10^{-4} coulombs? The electrical constant is $\frac{(9 \text{ x } 10^9 \text{ N}-\text{m}^2/\text{C}^2)}{C^2}$.

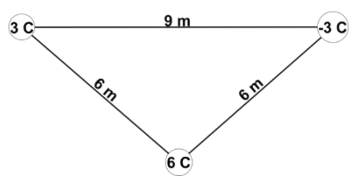


(A) $\frac{3.6 \text{ x } 10^7 \text{ N}}{C}$
(B) $\frac{7.2 \text{ x } 10^7 \text{ N}}{C}$
(C) $\frac{1.8 \text{ x } 10^8 \text{ N}}{C}$
(D) $\frac{7.2 \text{ x } 10^8 \text{ N}}{C}$
(E) $\frac{1.8 \text{ x } 10^9 \text{ N}}{C}$

6. What is the magnitude and direction of the force exerted by a 2×10^{-5} C electrical charge and a -3×10^{-7} C electrical charge when placed 10 m apart? The electrical constant is $\frac{9 \times 10^9 \text{ N-m}^2}{C^2}$.

(A) 5.4×10^{-5} N
(B) -5.4×10^{-5} N
(C) 5.4×10^{4} N
(D) -5.4×10^{-4} N
(E) 5.4×10^{-6} N

7. What happens if we introduce a third electrical charge?



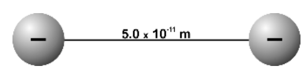
Here is a positive 3 coulomb electrical charge and a negative 3 coulomb electrical charge sitting 9 meters apart. A 6 coulomb sits 6 meters from each of the 3 coulomb charges. What is the magnitude and direction of the electrical force being exerted on the 6 coulomb electrical charge? The electrical constant is 9×10^9 N-m^2/C^2.

(A) 5.1×10^{8} N directed horizontally to the right.
(B) 4.3×10^{8} N directed horizontally below the horizontal
(C) 1.5×10^{9} N directed 30° above the horizontal
(D) 3.0×10^{9} N directed horizontally to the right
(E) 4.4×10^{9} N directed horizontally to the right

8. How fast does an electron travel when released from the negative side of a 100.0 voltage gradient? The charge on an electron is 1.60×10^{-19} coulombs.

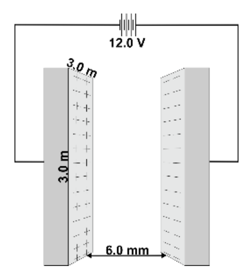
(A) 4.4×10^{5} m/sec
(B) 5.3×10^{6} m/sec
(C) 5.9×10^{6} m/sec
(D) 6.7×10^{6} m/sec
(E) 6.2×10^{7} m/sec

9. What is the potential energy of two electrons sitting 5.0×10^{-11} meters apart? The electrical constant is $\frac{(9 \times 10^9 \text{ N-m}^2/\text{C}^2)}{\text{C}^2}$. The charge on an electron is 1.60×10^{-19} coulombs.



(A) 4.6×10^{-18} joules, 28.8 eV
(B) 5.7×10^{-18} joules, 32.4 eV
(C) 6.3×10^{-19} joules, 18.5 eV
(D) 5.1×10^{-19} joules, 25.5 eV
(E) 7.0×10^{-18} joules, 22.8 eV

10. Two parallel plates, each 3 meters square, are placed 6 mm apart and attached to a 12 V battery. What is the strength of the electrical field between the two plates?



(A) 2000 volts per meter
(B) 1500 newton meters per coulomb
(C) 2500 volts per meter
(D) 1250 newton meters per coulomb
(E) 2750 newton meters per coulomb