Electric forces and electric fields

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or google Paul Doherty
Experience Formication
Atomic scale view of two surfaces “touching”
Triboelectric series

Positive (+)
- Air
- Human Hands
- Asbestos
- Rabbit's Fur
- Glass
- Human Hair
- Mica
- Nylon
- Wool
- Lead
- Cat's Fur
- Silk
- Aluminum
- Paper
- Cotton
- Steel
- Wood
- Lucite
- Sealing wax
- Amber
- Polystyrene
- Polyethylene
- Rubber balloon
- Sulphur
- Hard rubber
- Nickel, Copper
- Brass, Silver
- Gold, Platinum
- Sulfur
- Acetate, Rayon
- Polyester
- Celluloid
- Polyurethane
- Polyethylene
- Polypropylene
- Vinyl
- Silicon
- Teflon
- Saran Wrap

Negative (-)

Elektron
A styrofoam plate has been rubbed with wool. Since styrofoam has a greater affinity for electrons than wool, the styrofoam will become negatively charged in the process of charging by friction.

A finger is brought near and touched to the rim of the plate (which has an excess of electrons). Once touched, electrons flow through the finger to ground. It is at this instant that the aluminum plate acquires an overall positive charge.

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As the aluminum plate is lifted away from the styrofoam plate, there is a movement of remaining electrons within the aluminum until the excess of positive charge is uniformly distributed about the aluminum plate.
The charges involved

\[ mg = kq_1q_2/r^2 \]

\[ q_1q_2 = mgr^2/k \]

\[ q_1q_2 = 10^{-4} \times 10 \times 10^{-2}/10^{10} \]

\[ q_1q_2 = 10^{-15} \]

If \( q_1 \) is approximately equal to \( q_2 \) then \( q_1 = 3 \times 10^{-8} \) C about 30 nanocoulombs.

A coulomb is \( 6 \times 10^{18} \) electron charges so this means we transferred about \( 1.8 \times 10^{11} \) electron charges to the PVC rod and the hydra when we rubbed them.
Potential Energy shows up only as differences. You can pick the potential energy at any point to be 0.

For 2 point charges we choose the 0 potential energy to be at infinite distance.
# The Square of Electricity

<table>
<thead>
<tr>
<th>Force</th>
<th>Potential Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td></td>
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<tr>
<td>Field</td>
<td>Potential</td>
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<tr>
<td>Force</td>
<td>Potential Energy</td>
</tr>
<tr>
<td>-------</td>
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</tr>
<tr>
<td>$F = \frac{kQq}{r^2}$ N</td>
<td></td>
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<tr>
<td>$E = \frac{F}{q}$</td>
<td>Electric $k = 9 \times 10^9 \text{ Nm}^2/\text{C}^2$</td>
</tr>
<tr>
<td>Field $E = \frac{kQ}{r^2}$ N/C</td>
<td>Potential</td>
</tr>
</tbody>
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Diagram:

![Diagram of two charges](attachment:image.png)
Electric Field Lines
Field moves charge positive work

$F = qE$

$W = F \cdot d$

$PE_G = mg \cdot y$

$PE_E = qE \cdot y$

External Force must work against the field negative work

$F = qE$
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<td>( F = k \frac{Qq}{r^2} ) N</td>
<td>( F = -\frac{dU}{dr} )</td>
<td>( U = k \frac{Qq}{r} ) J</td>
</tr>
<tr>
<td>( E = \frac{F}{q} ) or ( F = qE )</td>
<td>Electric</td>
<td>( V = \frac{U}{q} ) or ( U = qV )</td>
</tr>
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<td>Field</td>
<td>Potential</td>
<td></td>
</tr>
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<td>( E = k \frac{Q}{r^2} ) N/C or V/m</td>
<td>( E = -\frac{dU}{dr} )</td>
<td>( V = k \frac{Q}{r} ) J/C or V</td>
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The diagram shows a distance \( r \) between two charges \( Q \) and \( q \) with an arrow from \( Q \) to \( q \).
1 electron volt

\[ qV = 1.6 \times 10^{-19} \text{ C} \times 1\text{V} = 1.6 \times 10^{-19} \text{ J} \]
Ionization energy for hydrogen
Ground State  13.6 eV
$10 \text{ C} \quad 10^8 \text{ V}$

$U = qV = 10^9 \text{ J}$
Artificial Lightning strikes a car and arcs to the ground through the air next to a tire.
Boston Museum of Science
Van der Graaf generator

http://www.youtube.com/watch?v=LLPKxk7ym7g