Workshop Tutorials for Technological and Applied Physics

ER4T: **Electric Potential**

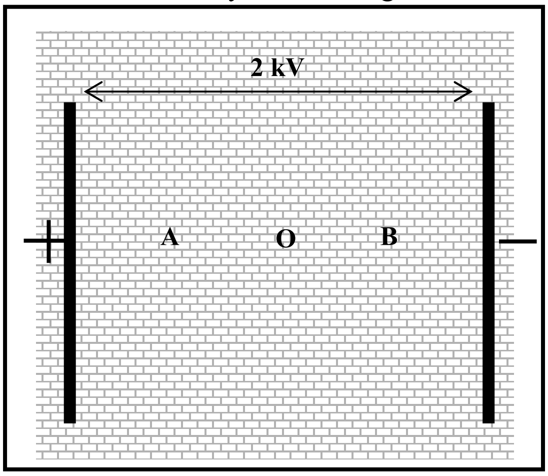
A. Qualitative Questions:

1. When we talk about gravity we usually talk about gravitational potential energy, and not gravitational potential. In electrostatics we do the opposite – we usually talk about electric potential rather than electric potential energy.

a. What is the difference between electric potential and electric potential energy?
b. Why is the electric potential energy of a pair of like charges positive and the electric potential energy of a pair of unlike charges negative?
c. Is the gravitational potential energy of a pair of masses positive or negative?
d. The electric field inside a uniformly charged hollow sphere is zero. Does this necessarily mean that the potential inside the sphere is zero?

2. Many factories use dust precipitators in their chimneys to remove airborne pollutants. In one such precipitator a pair of plates is placed in the square chimney with a potential difference of 2 kV between them. The large electric field causes molecules to be ionized. Free electrons and ions can then attach to dust particles making them charged. Suppose that a dust particle in the chimney has a charge of +1*e*.

a. Draw field lines and lines of equipotential for the arrangement shown.
b. If the dust particle starts from rest at point O, half way between the plates, will it move towards point A or B?
c. Will the system gain or lose electric potential energy? Where does this change in energy come from?
d. Repeat parts **b** and **c** for a particle with a charge of –2*e*. Will the change in electric potential energy be greater, less than or the same for this particle for a given distance traveled?
e. Rank the electric potential at points A, B and O.



B. Activity Questions:

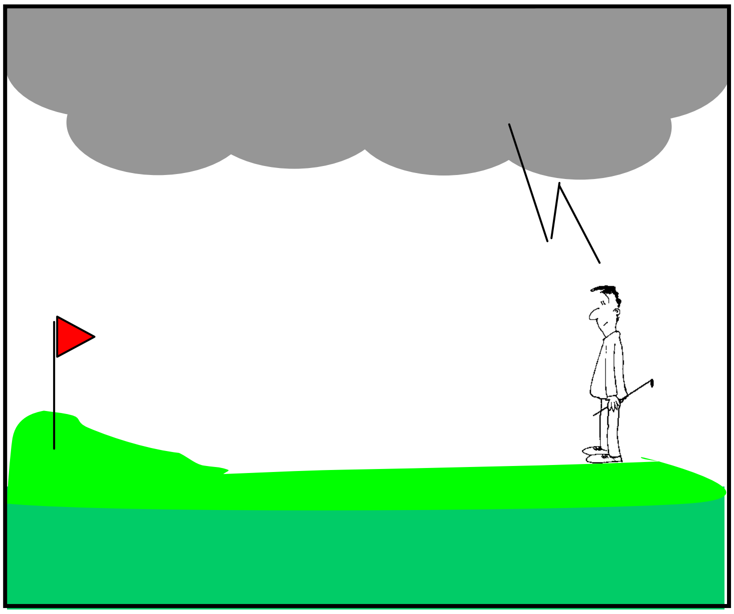
1. Measuring voltages

Use the voltmeter to measure the potential differences across the terminals of the various batteries.
Use the voltmeter to measure the potential difference between two points on the wire.
Now measure the potential difference between one end of the resistor and the other.
Explain why they are different.
Voltmeters are always connected in parallel with the device you are measuring the voltage across.
Why is this the case?

2. Equipotentials

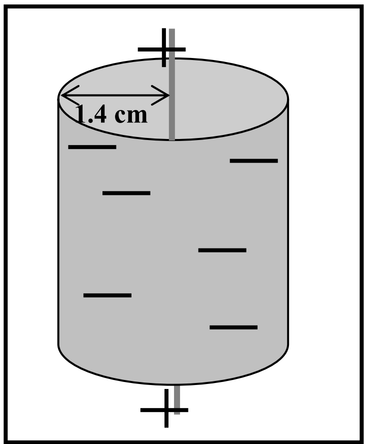
Use the probe to mark out equipotential lines for the arrangements of charges as shown.
What does the density of equipotential lines tell you?

C. Quantitative Questions:



1. Brent and his brother Bert are playing golf on a Sunday afternoon.
It gradually clouds over until there is a thick layer of cloud above them, and they hear the threatening rumble of a thunder storm. Brent tells Bert that the potential difference between the cloud layer 500 m overhead and the ground is probably around a gigavolt (10^9 V), and that he's going back to the club house for a drink. Bert decides to finish the hole that he's on first.

a. Estimate the magnitude of the electric field that Bert is standing in. (Treat the ground and clouds as parallel charged sheets.)
b. Draw a diagram showing field lines and equipotential lines for Bert.
c. Bert is 180 cm tall. If Bert were not there what would be the potential difference between the ground and a point 180 cm above ground?
d. When Bert is standing there what is the potential difference between the hair on his head and his feet?
e. What is the electric potential of his head? Explain your answer.
f. What is the change in electric potential energy of an electron that moves between the cloud and the ground?



2. Geiger counters are used to detect ionizing radiation. The detector part consists of positively charged wire which is mounted inside a negatively charged conducting cylinder, as shown. The charges on the wire and the cylinder are equal, and are opposite, so a strong radial electric field is set up inside the cylinder. The cylinder contains an inert gas at low pressure.
When radiation enters the tube it ionizes some of the gas atoms, and the resulting free electrons are attracted to the positive wire which runs down the middle. On their way to the wire these free electrons ionize more atoms, giving rise to more free electrons, which ionize more atoms, and so on. This is called a cascade effect.
a. The radius of the central wire is 25 μm, the radius of the cylinder is 1.4 cm and the length of the tube is 16 cm. If the electric field at the cylinder's inner wall is 2.9×10^4 N.C^{-1}, what is the total positive charge on the inner wire?
b. Find an expression for the potential difference between the inner wire and the outer cylinder in terms of the linear charge density, λ.
c. Calculate the potential difference between the wire and the cylinder.

Hint: the electric field due to a line of charge with charge density λ is given by $E = \dfrac{\lambda}{2\pi\varepsilon_0 r}$ where r is the radial distance from the line of charge.