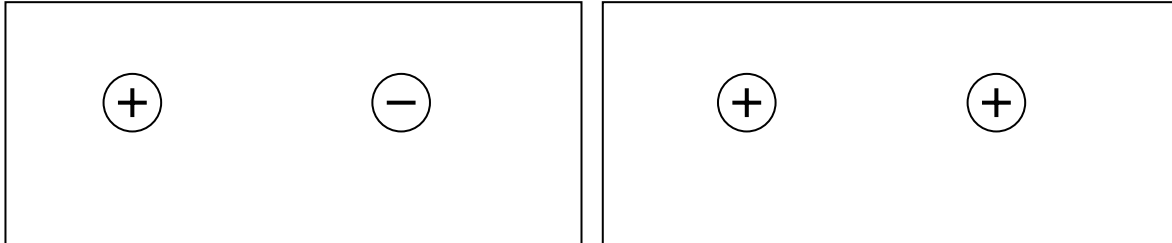# Workshop Tutorials for Technological and Applied Physics
ER2T: **Electric Fields**

A. Qualitative Questions:

1. A useful way of representing fields is by drawing field lines.
a. Draw electric field lines for the charges shown below. Note that the charges have equal magnitude.


b. Draw gravitational field lines for the earth and moon, shown below.

Hint: what do we use to define the field at a given point in space?

c. Gravitational and electric fields have some similarities and some differences. Use your diagram above to help explain these similarities and differences.

2. In the figure below the + signs represent a very wide and long sheet of charge (an infinite sheet).
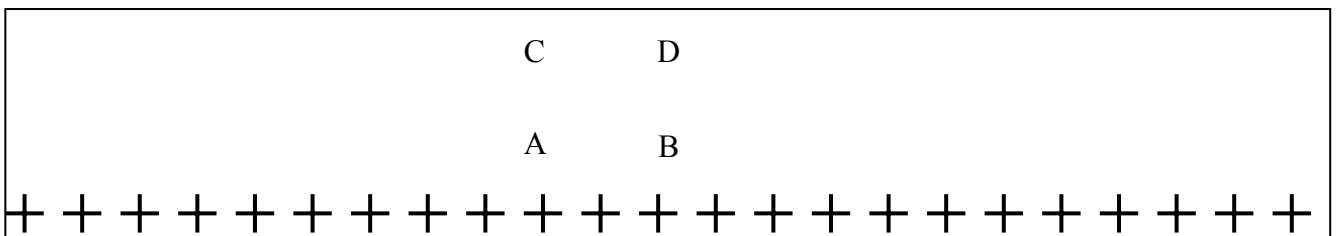
a. Draw vectors to show the direction of the electric field at the points A, B, C and D.
Two students are trying to decide where the field is strongest. Brent says that because C and D are further from the charges, the field must be weaker at these points than at A and B. Rebecca says that the field will be the same at C and D as it is at A and B because of the way the field lines are drawn.
b. Draw the field lines and decide who you agree with. Explain why the other student is wrong.

B. Activity Questions:

1. van de Graaff generator and wig
Place the "wig" on the generator. What do you observe?
Explain your observations. Draw field lines for the dome of the generator.
What happens when a person, insulated from the ground, touches the generator?

2. Ball in a capacitor
Explain what is happening to the ping pong ball.
Why is it behaving in this manner?
How would it behave of you removed the aluminium foil?
Draw the field lines for the capacitor plates.

3. Confused bubbles

Bubbles blown towards a van de Graaff generator behave in different ways.

Are the bubbles initially neutral?

Identify some patterns of behaviour. Why would bubbles be attracted or repelled by the generator?
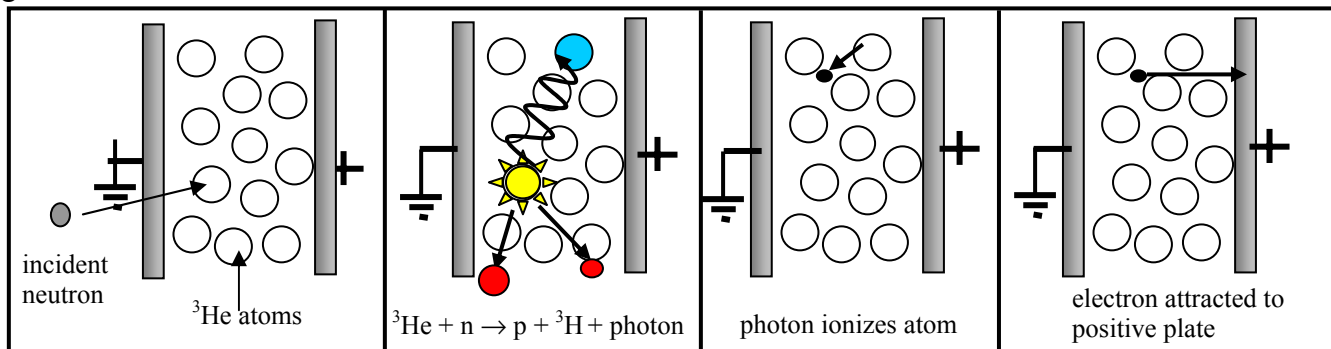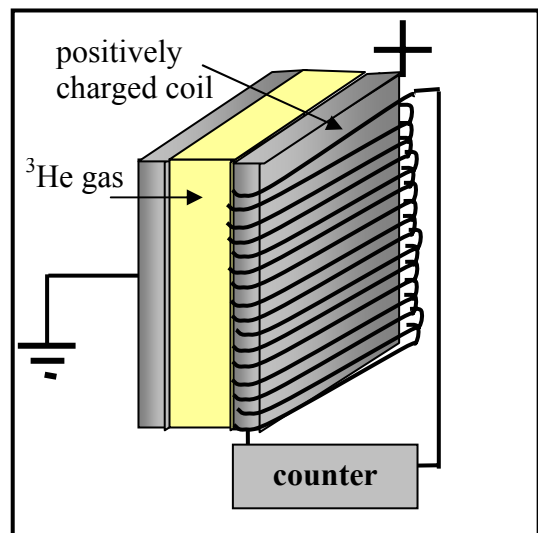
C. Quantitative Questions:

1. A photocopier works by putting positive charge onto the paper at the places where the image will appear. The toner particles are given a negative charge so that they will be attracted to these points. A wire, called the corona wire, is used to put the positive charge onto the paper. This wire typically has a radius of around 50 μm and charged to a potential of around +7kV, giving the wire a linear charge density of 40 nC.m⁻¹.

a. Assuming the corona wire is uniformly charged, draw a diagram showing the wire and the field it produces.

b. How does the field strength vary with the distance from the wire? How does this compare to the way field varies with distance from a point charge? What about a sheet of charge?

c. Write down an expression for the field at some distance r from the wire.

d. What is the electric field at a distance of 0.1 mm from the wire, approximately the distance from the wire to the paper?

2. Electric fields are used in many devices, such as photocopiers, printers and radiation detectors. Neutron detectors also use electric fields to count incident neutron radiation.

A neutron detector consists of a positively charged plate and a neutral plate (earthed) with a space in between filled with ^{3}He. The plates are actually made by wrapping wire around a square plate, and the plates are typically 10 cm × 10 cm and spaced 5 mm apart. Neutrons don't have a charge, so the electric field doesn't affect them. However when a neutron collides with a ^{3}He atom, it breaks apart into a tritium (^{3}H) a proton and a photon. This photon can then ionize another atom, causing an electron to be ejected. This electron is then accelerated by the electric field to a plate, where it causes a small current. You can even tell where on the wire the electron hit by looking at the time gap between the current pulse reaching the two ends of the wire. This process is shown below. The proton is also accelerated towards the earthed plate, but being much heavier it takes a lot longer to get there.

incident neutron

^{3}He atoms

^{3}He + n → p + ^{3}H + photon

photon ionizes atom

electron attracted to positive plate

Consider an electron which has been emitted from an atom midway between the plates, 8 cm above the bottom of the detector. The electron is initially at rest. Assuming it does not interact with any other atoms as it falls, how big an electric field is necessary to ensure that it reaches the positive plate before "falling out" of the detector?

(Hint: you will need to use $\Delta x = v_o t + \frac{1}{2} at^2$.)

data: $m_e = 9.11 \times 10^{-31}$ kg, $e = 1.6 \times 10^{-19}$ C.