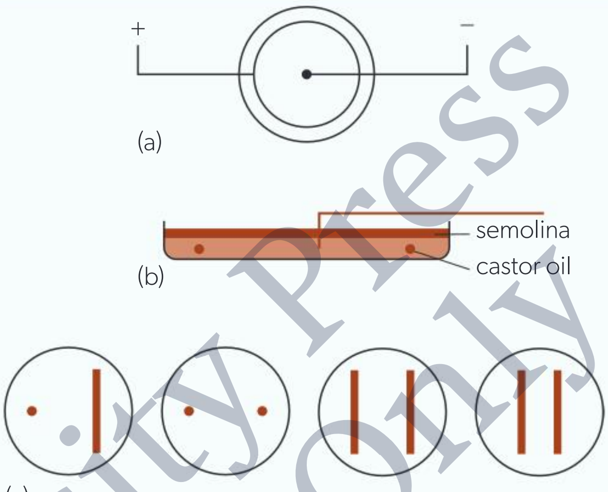
Plotting electric fields

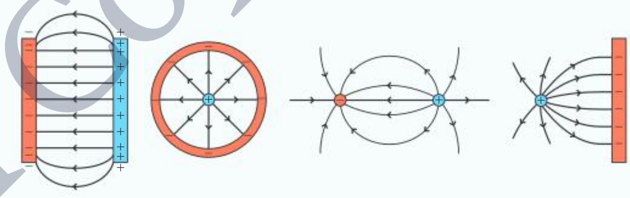
- Tool 1: Recognize and address relevant safety, ethical or environmental issues in an investigation.
- Inquiry 1: Demonstrate creativity in the designing, implementation or presentation of the investigation.
- Inquiry 2: Identify and record relevant qualitative observations.
- Inquiry 2: Interpret qualitative and quantitative data.

Laboratory experiments can be used to make electric fields visible. Patterns of electric field lines can be observed using small particles floating on a liquid. The particles line up in the field that is produced between the wires. The patterns observed resemble those in Figure 11.

- Put some castor oil in a Petri dish and sprinkle some grains of semolina (also known as grits) onto the oil. Alternatives for the semolina include grass seed and hairs cut about 1 mm long from an artist's paint brush.
- Take two copper wires and bend one of them to form a circle just a little smaller than the internal diameter of the Petri dish. Place the end of the other wire in the centre of the Petri dish.
- Connect a 5 kV power supply to the wires. Take care with the power supply!
- Observe the grains slowly lining up in the electric field.
- Sketch the pattern of the grains that is produced.
- Repeat with other wire shapes such as the four examples shown in Figure 10.
- The patterns observed in such experiments will resemble those in Figure 11.



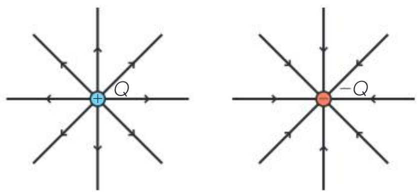
▲ Figure 10 The Petri dish contains a copper point with a copper collar around the edge. A potential difference between the two pieces of copper produces an electric field in the liquid. Small grains show the shape of this field. Other electrode shapes are shown too.



▲ Figure 11 Electric field patterns due to four charge configurations used in the semolina experiment.

The radial field due to a point charge

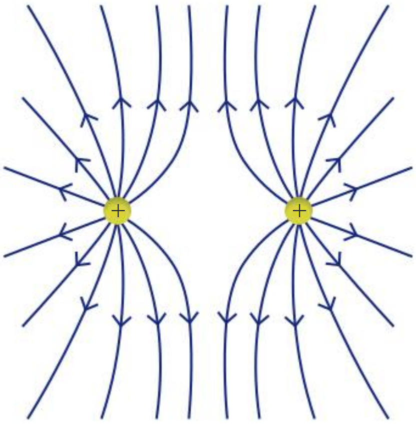
The electric field lines radiate outwards from a positive point charge and inwards towards a negative point. As with the similar pattern in a gravitational field, this is a **radial field**.



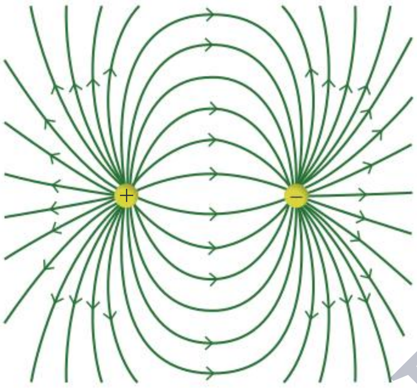
▲ Figure 12 Radial fields for an isolated positive charge and an isolated negative charge.

The field between two point charges

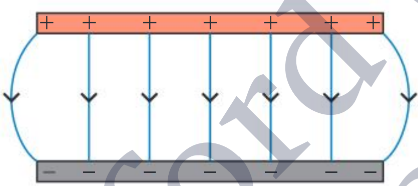
It is not hard to imagine how the two separate fields of Figure 12 combine to give the case where the point charges are close (Figures 13 and 14). There are two cases possible: two like charges and two unlike charges. Although a 2-D view is given, the fields are, of course, in 3-D.



▲ Figure 13 The field around two positive point charges.



▲ Figure 14 The field around a positive point charge and a negative point charge.



▲ Figure 15 View of the field between two parallel plates including the edge effects.

(a) Like charges

There will be a point where the field is zero somewhere between the charges (where the electric forces on a test charge are equal and opposite). When both charges have the same magnitude, this position of zero field strength will be midway between them.

(b) Unlike charges

The electric field lines now link the two unlike charges in the direction that is from positive to negative charge. There is some resemblance to the field of a bar magnet that you meet later in this topic.

The field between two parallel charged plates

An electric field exists in the space between two identical parallel metal plates that are connected to a dc power supply. A positive test charge in the electric field is attracted to the negative plate and repelled by the positive plate. The field pattern is shown in Figure 15.

This electric field:

- is uniform in the region well within the plates
- becomes weaker at the edges. These are known as **edge effects**. This is where the field changes from the strength inside the plates to the value outside the plates (often zero). You should be able to use the properties of the field lines to explain that there cannot be an abrupt change in field strength. At the plate edges, the field lines curve outwards as the field gradually weakens from the large value between the plates to the much weaker field well away from them. For the purposes of this course, you should assume that this curving begins at the edges of the plates (in practice, it begins a little way in from the edge).

Try to predict the way in which the shape of the field lines might change when a small conducting sphere is introduced in the middle of the space between the two plates. (Use your knowledge of charging by induction.)

Sometimes field lines are called **lines of force**. These lines represent the force acting on a positive test charge (by definition) with direction indicated by the arrow on the field line. When the line is curved, the tangent at a point on a line of force gives the direction of the electric force acting on a positive test charge. The relative density of the lines (how close they are) indicates the strength of the force.

ATL Thinking skills

Imagine that you are a small test charge sitting in the middle of two horizontal uniformly and oppositely charged parallel plates. You can see the plates stretching out to the distant horizon, much as if you were standing in a huge flat field, except that there is also a plate overhead. The view would be the same in all horizontal directions and so the electric field must be vertical.

Imagine moving to the side a short distance. Since the plates are uniformly charged, your view would hardly change. As a result, the electric field due to the plates will be the same at this new position—the field must be uniform.

Now imagine that you move to the edge of the plates. If you are centrally between the plates, then any horizontal contribution to the field from the positive plate will be cancelled out by the opposite contribution to the negative plate—this would not be true if you were not positioned at an equal distance from each. Now, though, the plates will only occupy half of your field of view. The electric field strength is half the strength it was at the centre.