7.6 Electric Field Strength

videos

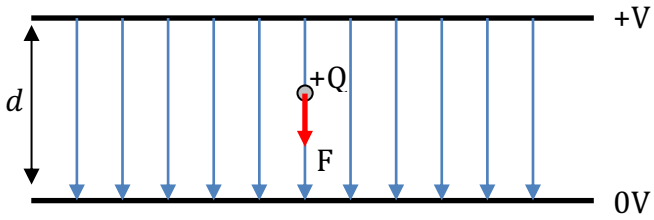
An electric field is a region of space where a charged object will experience an electrostatic force. The electric field strength (E) is the size of the force (F) felt by a unit charge:

$$E = \frac{F}{Q}$$

(1) From this equation, what is the unit for electric field strength E?

Uniform electric field

We can create a uniform electric field by applying a potential difference across two parallel conducting plates separated by a distance d. In the diagram, below, field lines are drawn to show the electric field.



Field lines show two things. The arrows show the direction a force will act on a positive charge placed at any position. The spacing of the field lines tells us about the relative strength of the field. The closer the lines are together, the stronger the field.

If we moved a charge *+Q* from *0V* to *+V*, we would need to do work on the charge because the force F would be acting downwards.

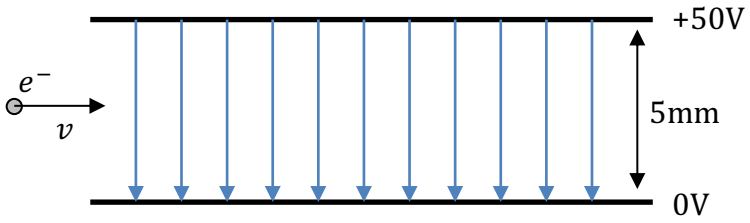
(2) Write an expression for work done (using Q, E, d) in moving the charge from 0V to +V. (Hint: work done W=Fd)

(3) The work done in moving a charge Q from 0 to +V is also given by $W = QV$*. Substitute for W in your first expression and simplify to get an expression for the electric field strength E for parallel plates.*

(4) A potential difference of +100V is applied across two parallel plates with a separation of 1.0cm. What is the electric field strength in the gap?

(5) What is the force on a $1.5 \times 10^{-6} C$ *charge placed in the gap?*

Consider the following situation:



(6) An electron e^- is fired, with velocity v, into a gap between two charged plates, 5mm apart. Sketch the path the electron will take in the electric field. Explain your answer.

(7) The electron has a charge of $-1.6 \times 10^{-19} C$. What force will it experience?

(8) The electron has a rest mass of $9.11 \times 10^{-31} kg$. What acceleration will it experience?

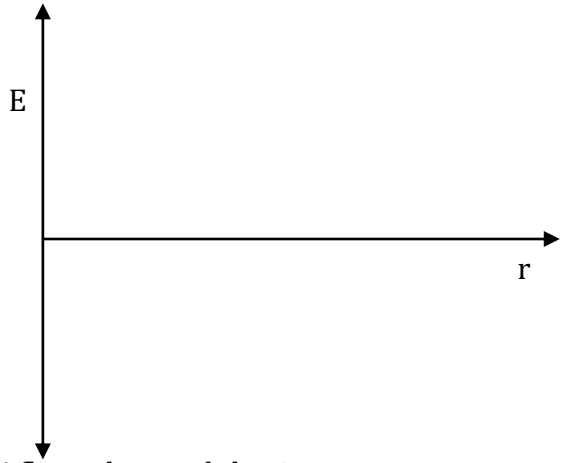
Radial electric field

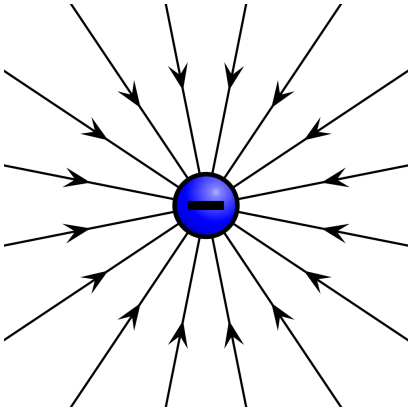
A point charge Q will produce a radial electric field strength given by the expression:

$$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$$

where ε_0= permittivity of free space, r = radial distance from charge Q.

(9) Sketch a graph to show how the electric field strength varies with distance r from a point positive charge. On the same graph do the same for a point negative charge.





The diagram, left, shows field lines around a negative point charge.

(10) Why do the arrows point inwards?

(11) How can you tell from the field lines that the strength of the electric field increases as you move inwards?

The force experience by a charge q is given by $F=qE$

(12) Show that the force experienced by a charge q in a radial electric field is given by the expression:

$$F = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}$$

where Q is the point charge producing the radial field.