Model: Fields and Forces

Act 9.1.2 FNT from DLM10 (no activity sheet) 20 minutes

Learning Goals:

- Understand what is meant, in physics, when we call a physical quantity a "field"
- Recognize the difference between scalar fields and vectors fields

Act 9.1.3 Electric Field Model for Electrical Forces 75 minutes

Learning Goals:

- Understand how to determine the direction of the electric field due to a set of charges from the electric fields of the individual charges (this is the first part of our electric field model)
- Be able to find the forces on a set of charged particles due to the electric field that they see.

Act 9.1.4 Electric Field Lines 40 minutes

Learning Goals:

- Understand the connection between electric field lines and electric field vectors
- Understand that a very large conducting charged plate produces a uniform electric field.

Our electric field model consists of only three ideas:

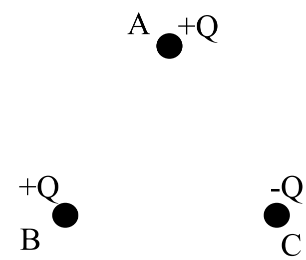
i) Point charge *Q* produces an electric field with magnitude $E_Q = \frac{kQ}{r^2}$ and direction away from Q if Q is positive and toward Q if Q is negative. In the equation, r is the distance from the charge.

ii) The **total electric field** at a point is the vector sum of the electric fields at that point due to all the charges producing the field.

iii) Charge *q* placed in electric field, E_{total}, **feels force** $F_{on\ q} = qE_{total}$.

and you can figure out everything about electrostatics using these three ideas.

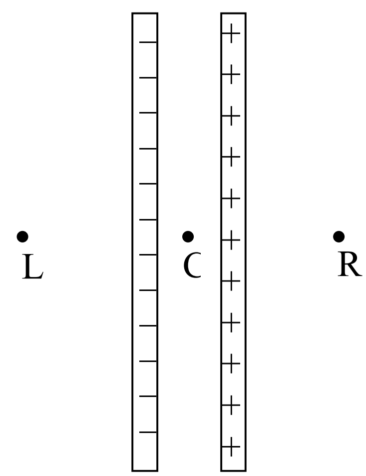
1. (Solidification) Consider the diagram of charges below. A charge of +Q is located at position A, +Q at position B, and -Q at position C. All charges are the same distance, r, apart.



a) Redraw the diagram including
  i. the net E-field vector that the particle at position C feels,
  ii. the E-field vector at position A due to the charge at position C
  iii. the E-field vector at position B due to the charge at position C
  iv. the force on the charge at position C

b) Imagine now that the charge at position C is removed and a new charge of +2Q is put in its place at position C. Redraw the pictures showing any changes to the previously drawn vectors.

2. (Application) You know what the electric field looks like to the left or right of a very large thin conducting plate that is positively charged. Now consider two such plates parallel to each other and **equally but oppositely** charged. Since they are equally charged, the magnitudes of the electric fields will be the same.



a) Sketch an electric field vector for each plate for position L. What will E_{total} be at position L? Similarly, what will E_{total} be at position R?

b) Sketch an electric field vector for each plate for position C. What will E_{total} be at position C?

3. (Solidification) **Analogy between electric field and gravitational field.** We have a field model (due to Newton) for gravitational forces that is exactly analogous to our electric field model:

i) A mass M produces a gravitational field with magnitude $g_M = \frac{GM}{r^2}$ and direction toward M.

ii) A mass, m, placed in the gravitational field g_M feels a force $F_{on\ m} = mg_M$.

Look up the mass of the earth (in kg), the gravitational constant, G, and the radius of the earth, r, and use them to calculate g at the earth's surface (i.e. sea level). Then find g at the location of the International Space Station, in orbit about 350km above Earth.