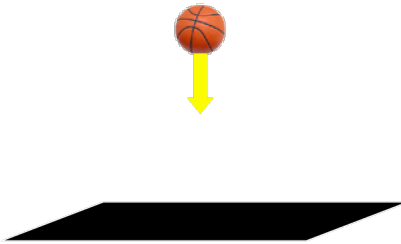


Where does the force come from?



Force on ball – directed downward  
due to gravity  
gravitational field between ball and Earth  
gravitational field  $\Rightarrow$  Force

Similar to the gravitational force...

charged particle/object  $\Rightarrow$  electric field  $\Rightarrow$  electric force

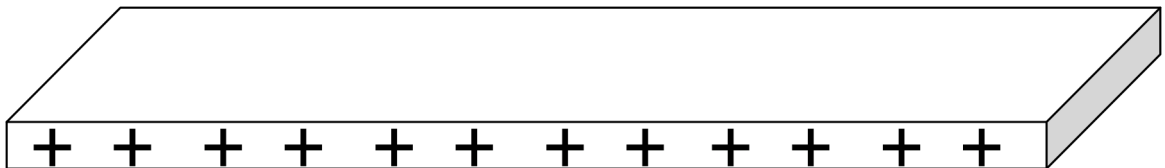


$$\vec{E} \equiv \frac{\vec{F}}{q_0}$$

Electric field produced by Q at the location of  $q_0$   
An E-field exists if a test charge,  $q_0$ , feels a force.

If you know the Electric field ( $\vec{E}$ ) at a specific location, you can find the force on a charge q at that location:  $\vec{F} = q\vec{E}$  - same eqn, just rearranged.

Let's say I have a flat sheet of metal. I've removed a bunch of electrons, leaving a net positive charge on the sheet.



Is there an electric field?

Is there a force?

Need another charged object for there to be a force

→ Interaction pair

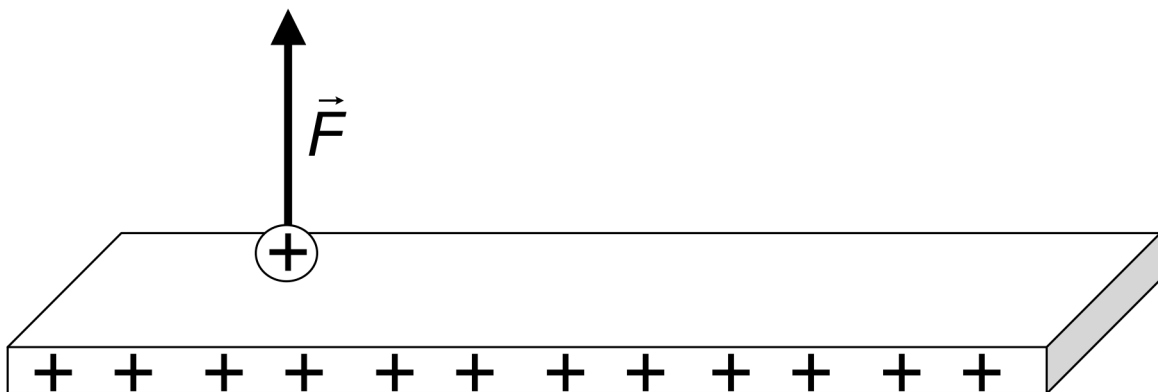
There is a field – let's see if we can “map out” that field. From the definition – an E-field exists if a test charge feels a force...

Bring in a positive test charge – put it near the sheet

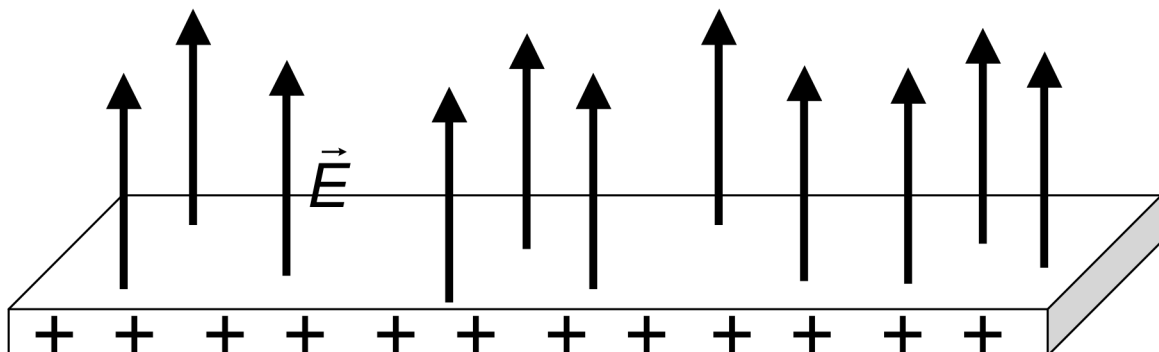
Is there a force on the test charge?

What direction is the force on the test charge?

Move the test charge to another location – is there a force? What direction?

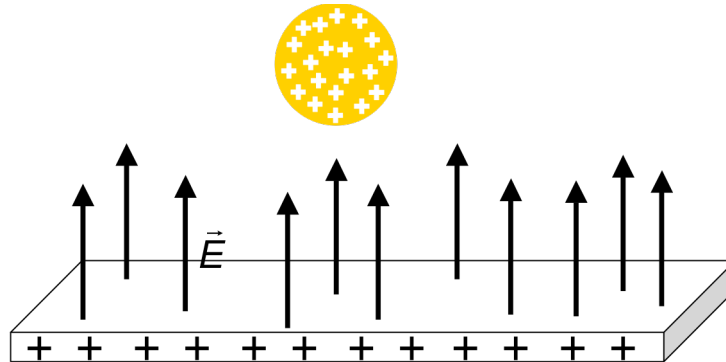


Direction of E-field vector = direction a **positive** test charge would move



Ok, so we have a positively charged flat metal sheet. We now know that there is an E-field emanating from the sheet, directed away from and perpendicular to the sheet.

Let's say now I have a metal sphere, also with a net positive charge on it...



Electric Field lines

$E$  = large when lines are close together (high density)

$E$  = small when lines are far apart (low density)

$E$  = constant when lines are parallel to each other

E-field lines from away from positive charges and toward negative charges

Direction of  $E$  = direction a + test charge would move.

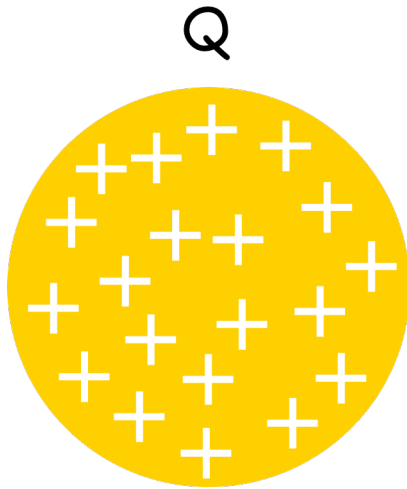
E-field simulations:

point charge: <http://www.falstad.com/vector3de/>

dipole

Explain why electric field lines never cross.

E-field from a point charge (or solid sphere of charge, spherical symmetry)



$$\vec{F} = q_0 \vec{E} \quad \vec{F} = k \frac{q_0 Q}{r^2}$$

Set equations equal.

$$q_0 \vec{E} = k \frac{q_0 Q}{r^2}$$

$$\vec{E} = k \frac{Q}{r^2}$$

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When atoms form ionic bonds one electron is transferred from one atom to the other. This is how sodium and chlorine bind to form sodium chloride (salt). In a salt crystal the sodium is  $\text{Na}^+$  and the chlorine is  $\text{Cl}^-$ , each with a charge of  $\pm 1e$ . They are separated in a salt crystal by 0.28 nm.

Consider only a single pair of ions,  $\text{Na}^+\text{Cl}^-$ , bound together.

- What is the electric field at a point halfway between the two ions?
- Draw a diagram showing the two ions. Draw a straight line between the two ions and extend it out to either side. Will there be any point on the line where the force on another  $\text{Na}^+$  ion will be zero? If so, show on your diagram approximately where this point would be.
- If you had a salt molecule with a calcium ion,  $\text{Ca}^{++}$ , in place of the  $\text{Na}^+$  would there be any point on this line where the second  $\text{Na}^+$  would experience no force? If so, show on your diagram approximately where this point would be.

If there is such a point, what will the field at that point be?

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E-field due to 3 charges - find E at the upper left corner of the configuration:

