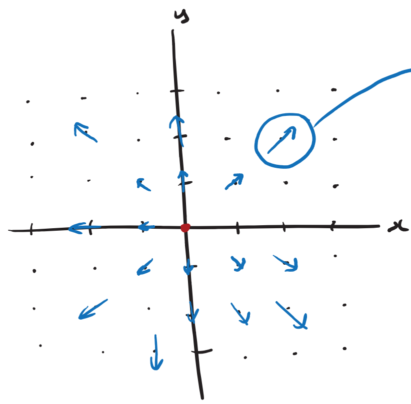
3.1 Introduction

→ focus on a new point of view: **FIELDS!**

What is a vector field?

↳ in vector calculus and physics, we assign a vector to each point in a subset of space



Each field vector is an arrow with:

- ↳ magnitude / length
- ↳ direction

Very useful in observing certain phenomena:

- → moving fluid throughout space
- → magnetic, electric or gravitational force observations

We will be using vector fields to describe electric fields

3.2 Electric Field Definition

Electric Field (E-Field): surrounds an electric charge and exerts a force on other charges in the field, attracting or repelling them

How do we measure this?

↳ let's look at a point charge Q in space

We define the $\vec{E}$-field due to Q at point P as the force per positive unit test charge (assuming q is very small or $q \to 0$).

$$\vec{E}(\vec{r}) = \lim_{q\to 0} \frac{\vec{F}_{Qq}}{q} = \lim_{q \to 0} \frac{kQq}{qr^2}\hat{r}$$

ELECTRIC FIELD

$$\boxed{\vec{E}(\vec{r}) = \frac{\vec{F}_Q}{q} = \frac{Q}{4\pi\varepsilon_0 r^2}\hat{r} \left[\frac{N}{C}\right]}$$

$$k = \frac{1}{4\pi\varepsilon_0}$$

What if there are multiple point charges?

↳ the $\vec{E}$-field at any point is the superposition of $\vec{E}$-fields due to individual charges at that point

$$\boxed{\vec{E}_{TOT} = \sum_{n=1}^{n=N} \vec{E}_n = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \dots + \vec{E}_N}$$

3.3 So What Changed?

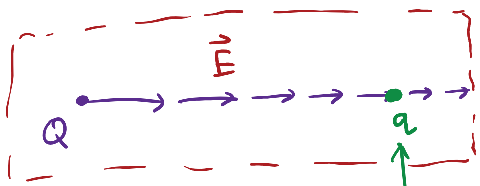
Coulomb's Law

$$\vec{F} = \frac{kQq}{r^2}\hat{r}$$

Electric Field

$$\vec{E} = \frac{\vec{F}}{q}\hat{r} = \frac{kQ}{r^2}\hat{r}$$

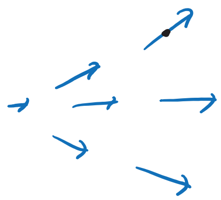
↳ the E-field is the source of electrostatic force



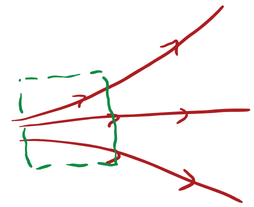
q experiences an interaction from the E-field generated by Q

3.4 Electric Field Visualization

There are 2 different ways of visualizing $\vec{E}$-fields:



SET OF VECTOR ARROWS

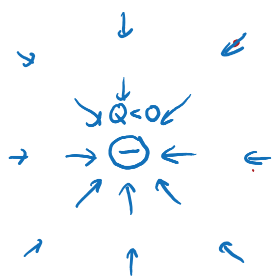


ELECTRIC FIELD LINES
→ TANGENT LINES TO VECTORS

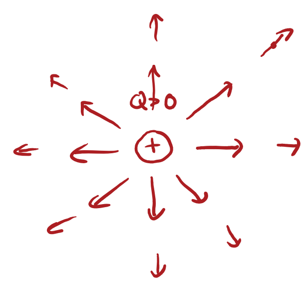
Good for:
- → magnitude and direction of $\vec{E}$-field at specific points in space

Good for:
- → observing "flow"
- → density of lines is proportional to the strength of the E-field

How do we know which direction the vector points in?
↳ We look at our point charge Q (+ve or −ve) and bring in a positive test charge!



Test charge +q will experience an attractive force



Test charge +q will experience a repulsive force

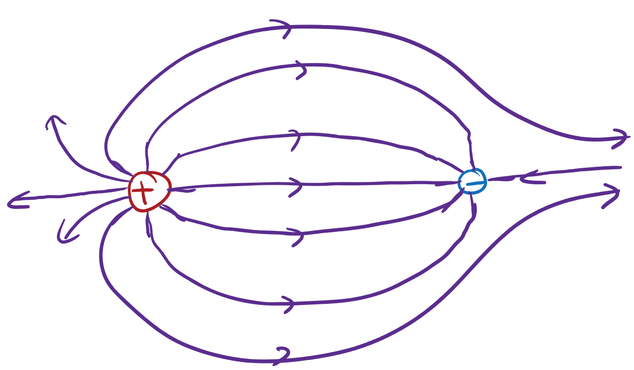
Note:

$\vec{E} \propto Q$

$\vec{E} \propto \frac{1}{r^2}$

Examples:

#1: Draw electric field lines for these charges.



#2: Draw electric field lines for these charges.

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