Chapter 23 Section 4:
Electric Fields

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Reference Book: "Physics for Scientists and Engineers" by R. A. Serway & J. W. Hewett

Similar Book: "Physics for Scientists&Engineers" by

D.C.Giancoli

Section 23.4: The Electric Field
Introduction

The Electric Force is a Field Force.

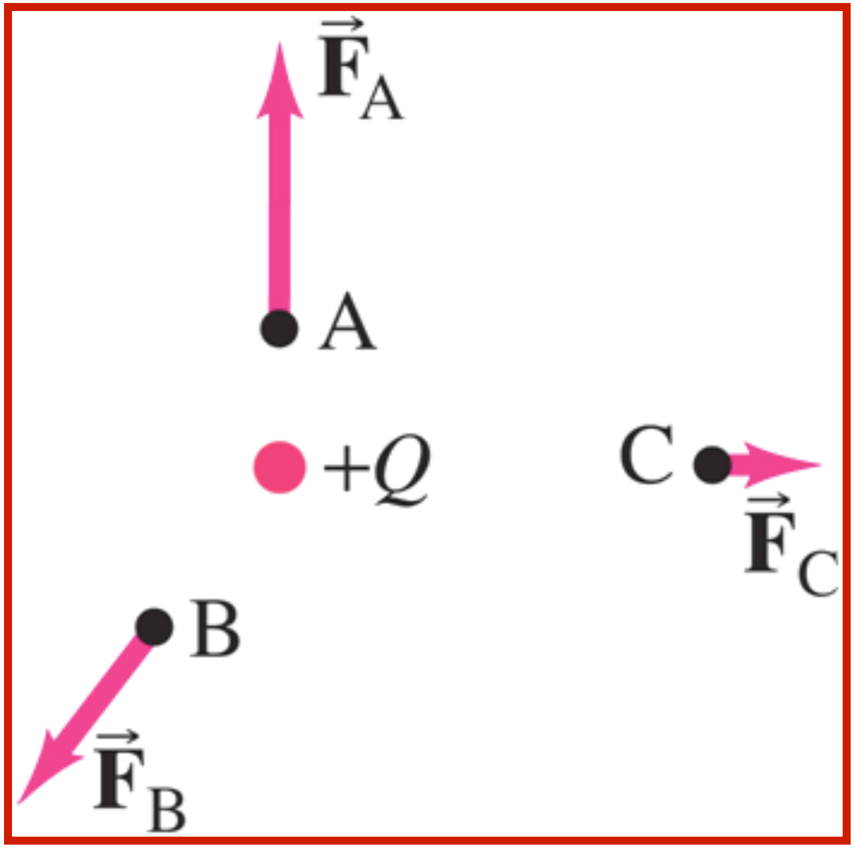
- Field forces can act through all space.
- Their effects are produced even with no physical contact between objects. Faraday developed the concept of a field in terms electric fields.

The Electric Field

- The ***Electric Field*** is **defined** as the force on a small positive charge **q**, (a **"Test Charge"**) divided by the magnitude of the charge:

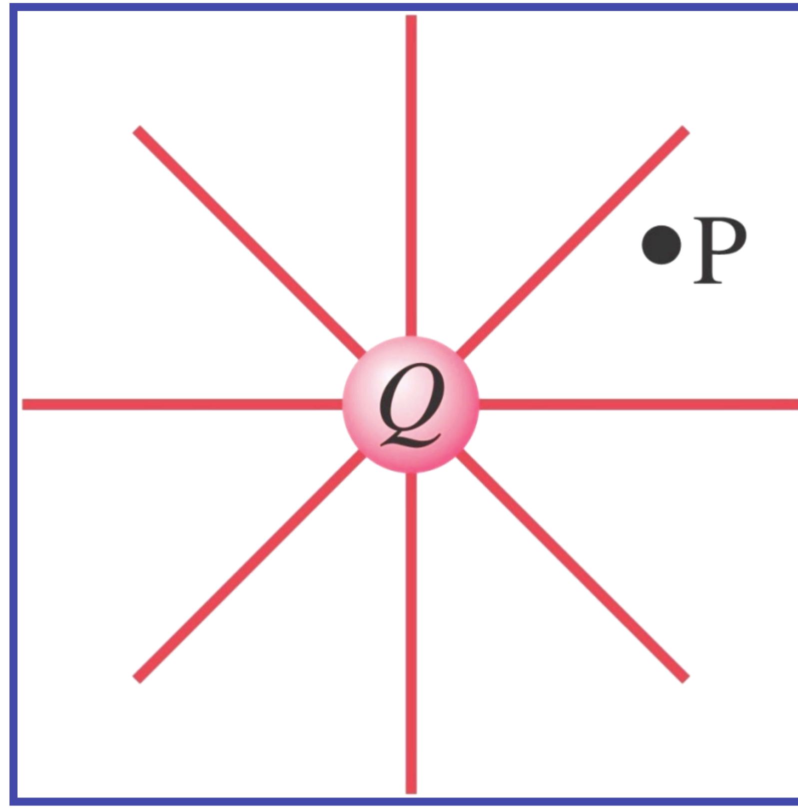
$$\vec{\mathbf{E}} = \frac{\vec{\mathbf{F}}}{q}.$$

- The ***direction*** of the **Electric Field due to a *positive* charge +Q *is radially outward from*** the charge.



An Electric Field *surrounds every charge*.

- An **Electric Field** exists in the region of space around a charged object.
  - This charged object is the ***Source Charge***.
- When another charged object, the ***Test Charge***, enters this electric field, an electric force acts on it.



The **Electric Field** due to a ***single point charge*** **Q** is:

$$E = \frac{F}{q} = \frac{kqQ/r^2}{q}$$

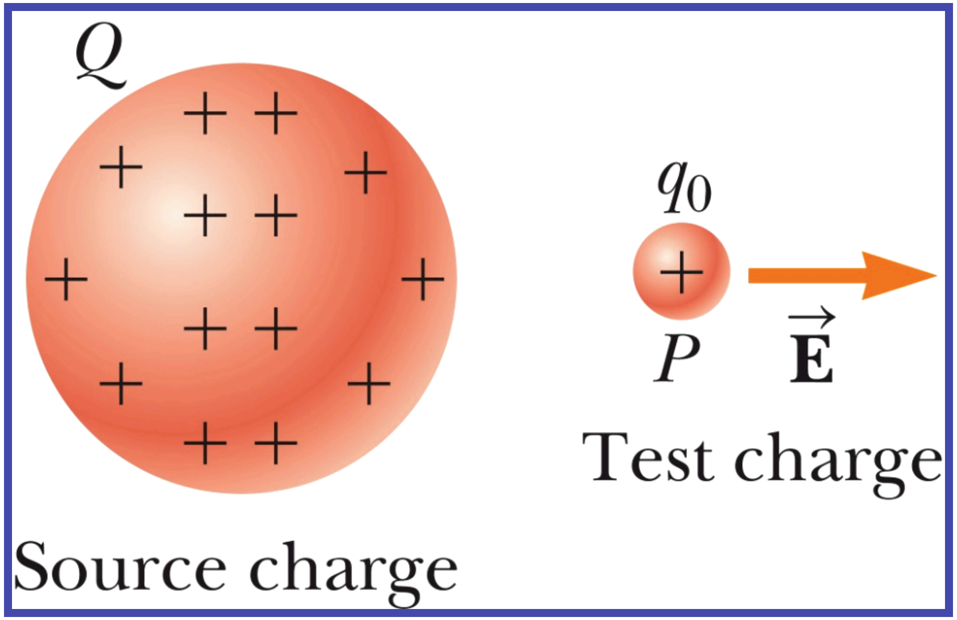
$$E = k\frac{Q}{r^2};$$

In terms of ε_0,the permittivity of free space:

$$E = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}.$$

The direction of E is that of the force on a positive test charge.

- We can also say that an electric field exists at a point if a test charge at that point experiences an electric force.



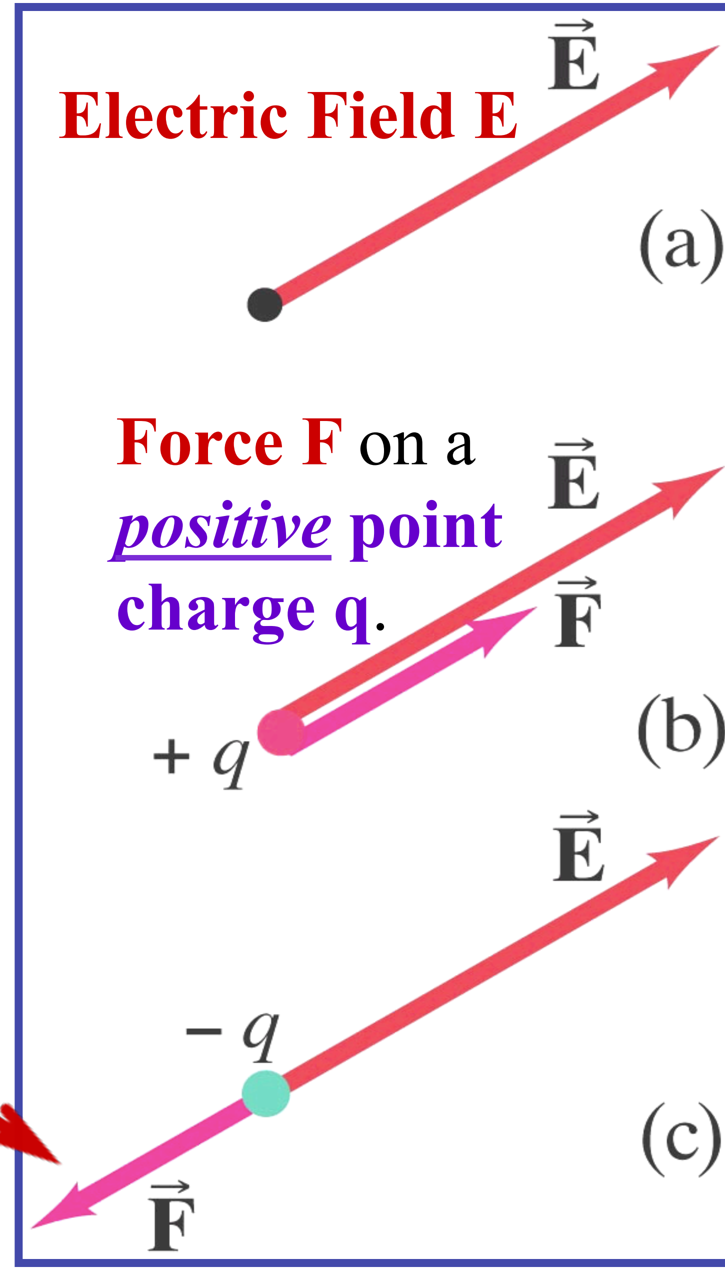
- The **SI** units of **E** are **N/C** (or **V/m**).

- The **Force on a *positive* point charge q** in an electric field **E**:

$$\vec{\mathbf{F}} = q\vec{\mathbf{E}}.$$

- This is valid for a point charge only. If **q** is negative, the **Force F** & the **Electric Field E** point in the opposite direction than when **q** is positive.

Force F on a ***negative*** **point charge -q**.



Electric Field, Vector Form

Remember that **Coulomb's Law**, between the source and test charges can be expressed as

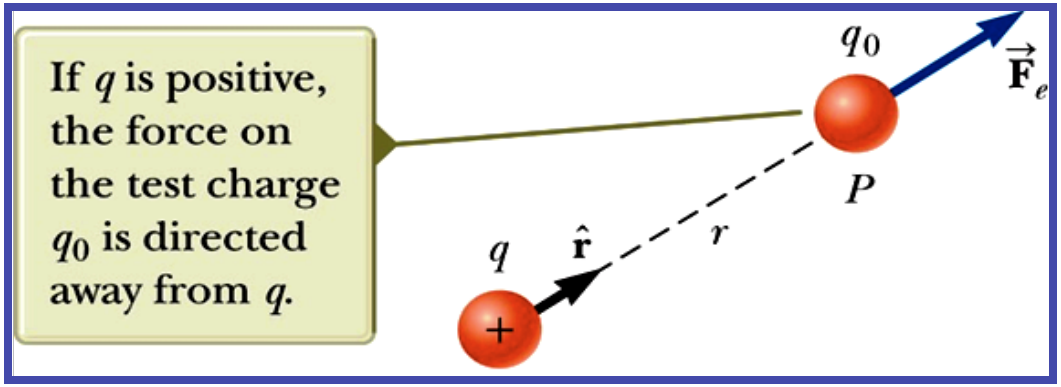
$$\vec{\mathbf{F}}_e = k_e \frac{q q_o}{r^2} \hat{\mathbf{r}}$$

Then, **the electric field will be**

$$\vec{\mathbf{E}} = \frac{\vec{\mathbf{F}}_e}{q_o} = k_e \frac{q}{r^2} \hat{\mathbf{r}}$$

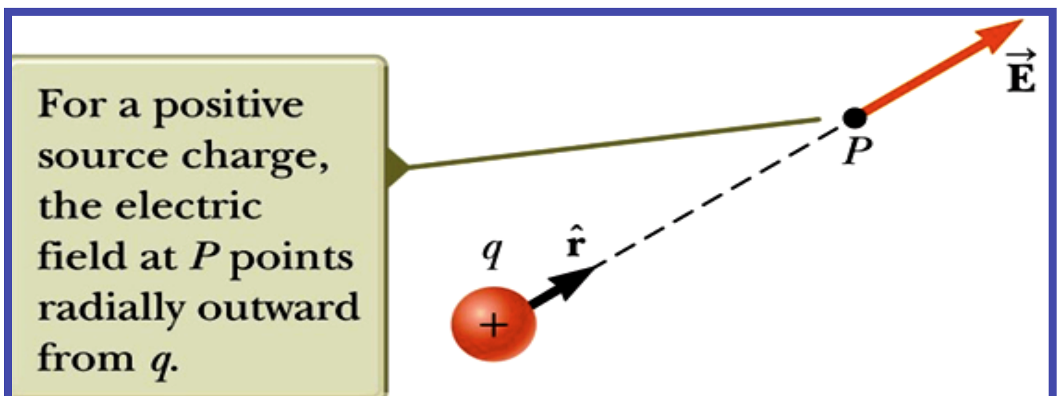
More On Electric Field Direction

- If a ***Charge q is Positive***, the **Force is *Directed Away from* q**.



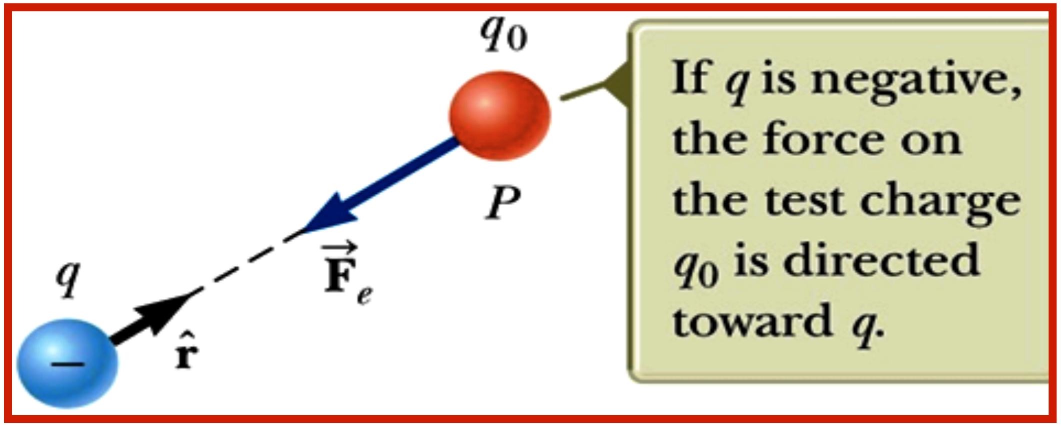
(Fig. a)

- The ***Electric Field* Direction is *Also Away from*** a ***Positive Source Charge***.



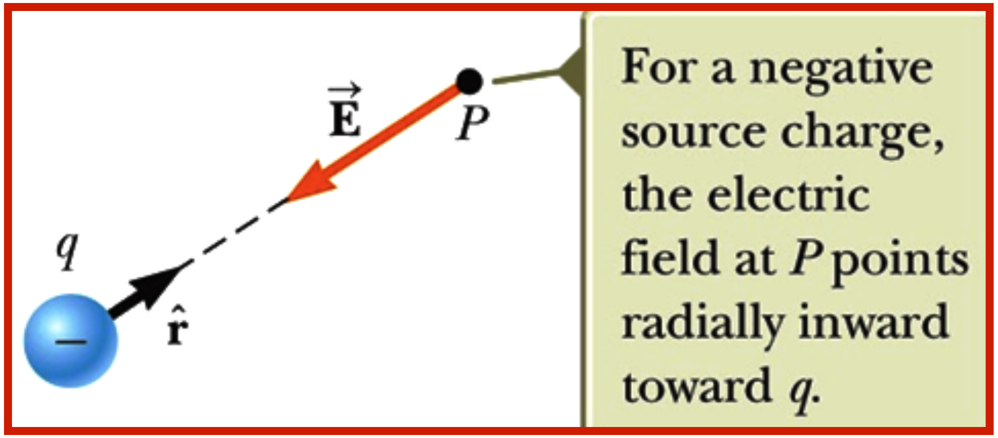
(Fig. b)

- If a ***Charge q is Negative***, the **Force is *Directed Towards* q**.



(Fig. c)

- The ***Electric Field* Direction is *Also Towards*** a ***Negative Source Charge***.



(Fig. b)

Electric Fields from Multiple Charges

- At any point **P**, the total electric field **E** due to a group of source charges $\mathbf{q_i}$ equals

  The Vector Sum of the electric fields of all of the charges:

$$\vec{\mathbf{E}} = k_e \sum_i \frac{q_i}{r_i^2} \hat{\mathbf{r}}_i$$

Problem Solving in Electrostatics:

Electric Forces & Electric Fields

1. **Sketch *a Diagram*** showing all charges, with signs, & electric fields & forces with directions.

3. **Calculate *Forces*** using **Coulomb's Law.**

4. **Add Forces *Vectorially*** to get the result.

5. **Check *Your Answer!***