Electric Field

- How does a charge, q_1, exert a force on another charge, q_2, when the charges don't touch?
- The charge, q_1, sets up an electric field in its surrounding space
- This electric field has both magnitude and direction which determine the magnitude and direction of the force acting on q_2

Electric Field is Dynamic

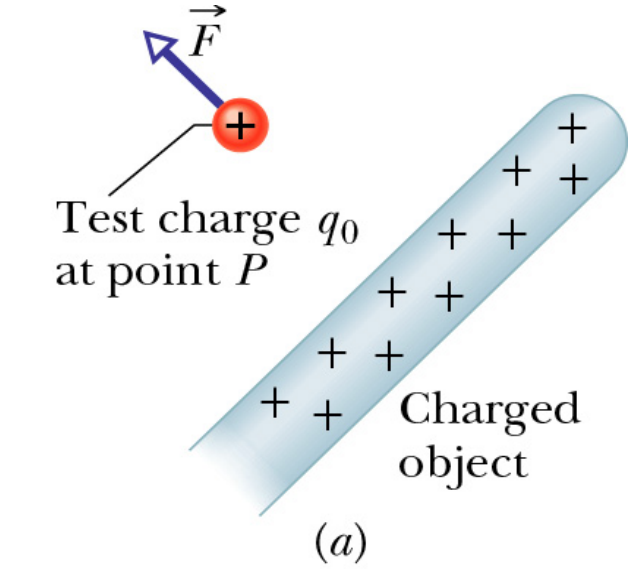
- What happens to the field if q_1 moves?

- Info about q_1 travels outward from it as an electromagnetic wave at speed of light, c

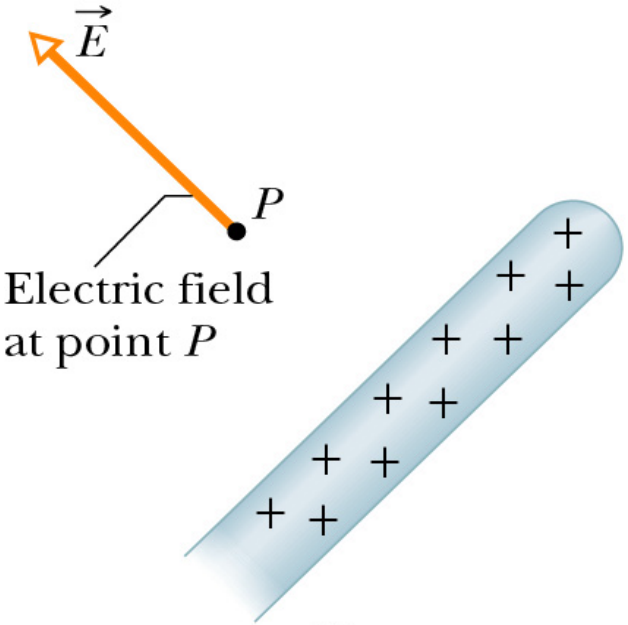
Electric Field is a Vector

- Electric field is a vector field
  - Consists of a distribution of vectors

- Define electric field at a point near the charged object by using a positive test charge, $q_0 \rightarrow 0$ (very small)


$\vec{F}$
Test charge q_0
at point P
Charged
object

(a)


$\vec{E}$
P
Electric field
at point P

(b)

Test Charge

- Test charge - charge which feels forces of other charges but exerts no force on them
  - Mathematical construct
- Electric field exists independently of the test charge

Electric Field

- The magnitude of the electric field, E, is the magnitude of the force per unit test charge (see next slide)
- SI unit for E field is N/C
- Direction of E is the direction of F for the positive test charge

Electric Field of a Point Charge

- Electric field, *E*, is the force per unit positive test charge

$$E = \frac{F}{q_0}$$

- For a point charge

$$F = k\frac{|q_0||q|}{r^2} \qquad \text{so} \qquad E = k\frac{|q|}{r^2}$$

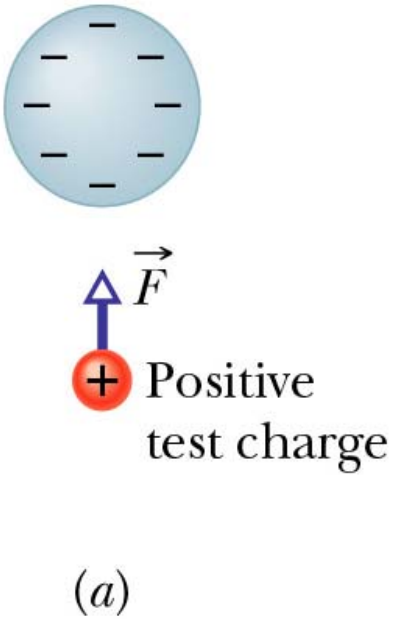
Superposition Principle

- Direction of E = direction of F (for positive charge)
- E points towards a negative point charge and away from a positive point charge
- Superposition of electric fields

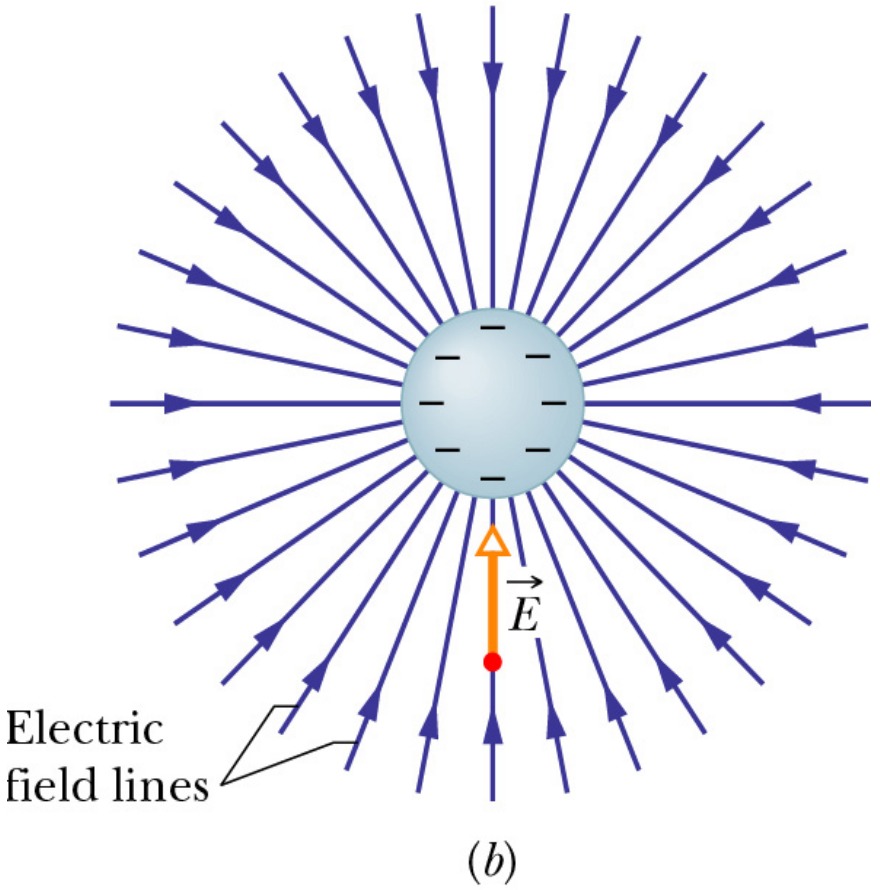
$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \ldots + \vec{E}_n$$

Electric Field Lines

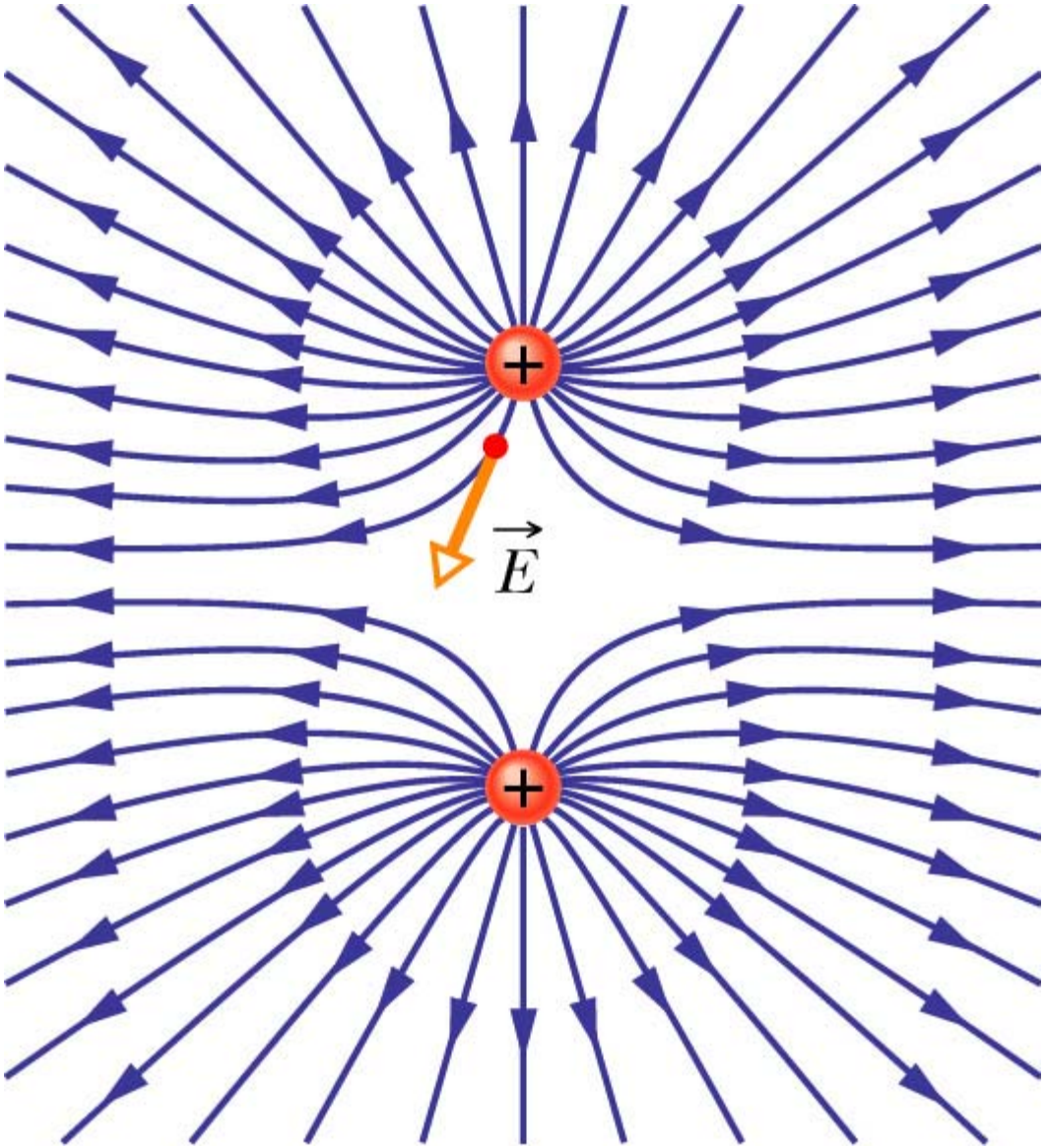
- Use electric field lines to visualize E field
- Field lines point away from positive charges and towards negative charges
- At any point, the tangent to the field line is the direction of the E field at that point
- Density of field lines is proportional to the magnitude of the E field



(*a*)



(*b*)

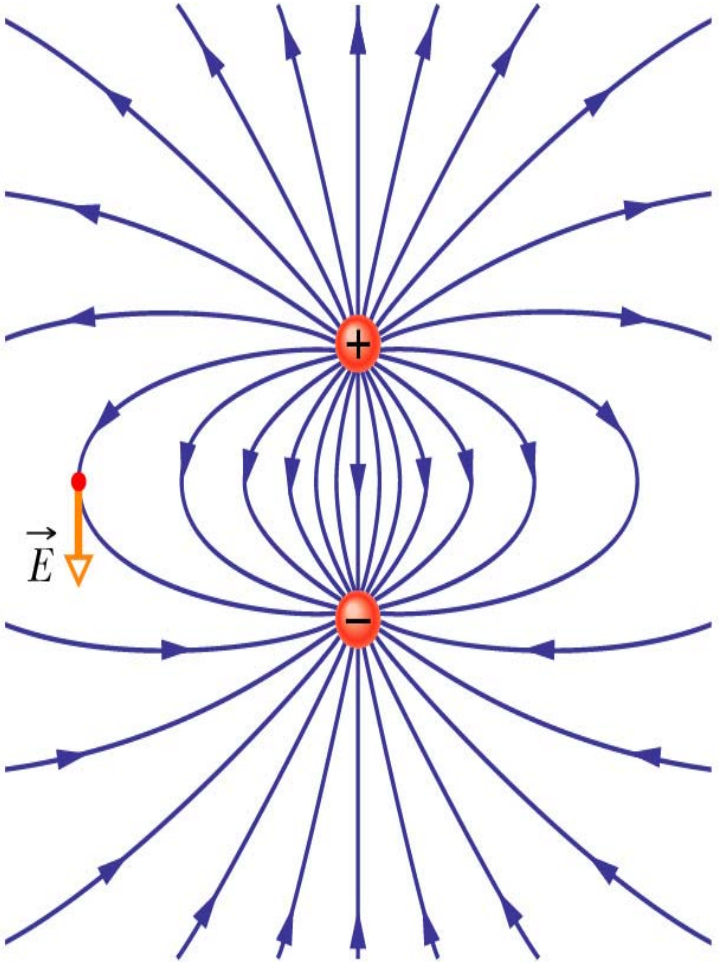

+
+
$\vec{E}$

Rules for Electric Field Lines

- Close to a point charge are radial in direction
- Do not intersect in a charge-free region
- Do not begin or end in a charge-free region

Electric Field of a Dipole

- Electric field lines:
  - Point away from positive and towards negative
  - Tangent to the field line is the direction of the E field at that point
  - density of lines is proportional to magnitude of the charge



Charge in an Electric Field

- If a charge q is placed in an electric field, then there is a force given by:

$$\vec{F} = q\,\vec{E}$$