PHYS 111
1ST semester 1439-1440

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Lecture 3

23.6 Electric Field Lines

- The *electric field lines are* first introduced by Faraday, *and they* are related to the electric field in a region of space in the following manner:
  - The electric field vector **E** is tangent to the electric field line at each point. The line has a direction that is the same as that of the electric field vector.
  - The field lines are close together where the electric field is strong and far apart where the field is weak.

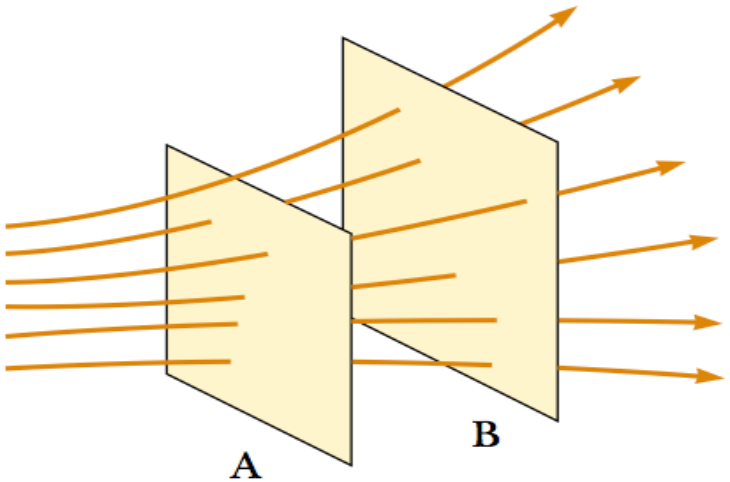
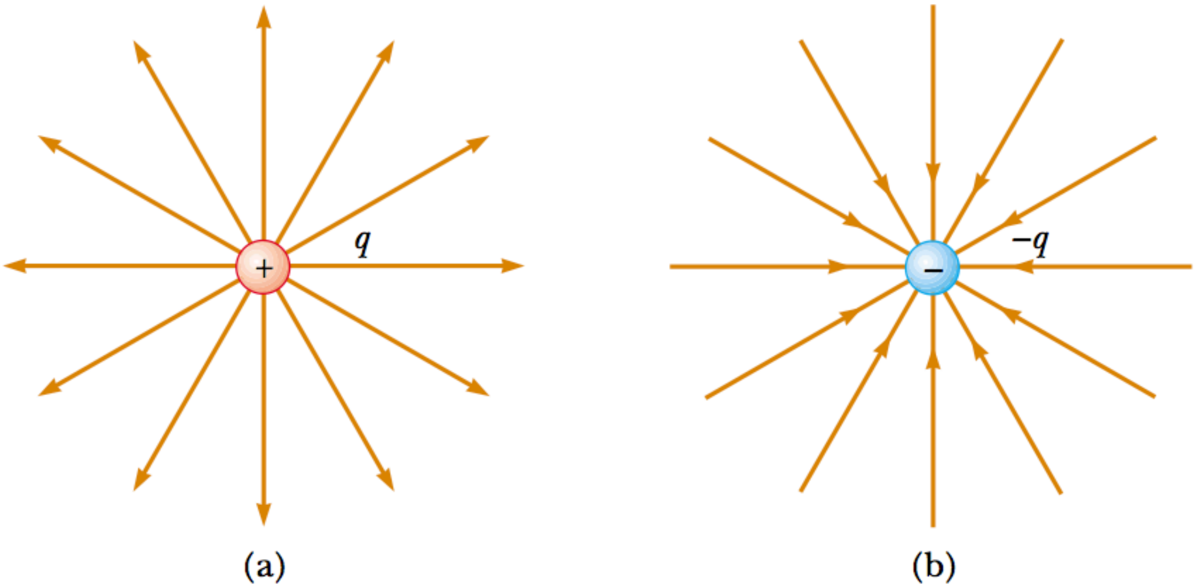


Figure 23.20 Electric field lines penetrating two surfaces. The magnitude of the field is greater on surface A than on surface B.

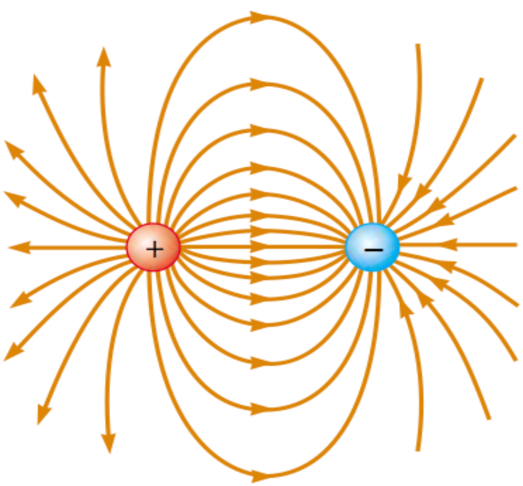
23.6 Electric Field Lines

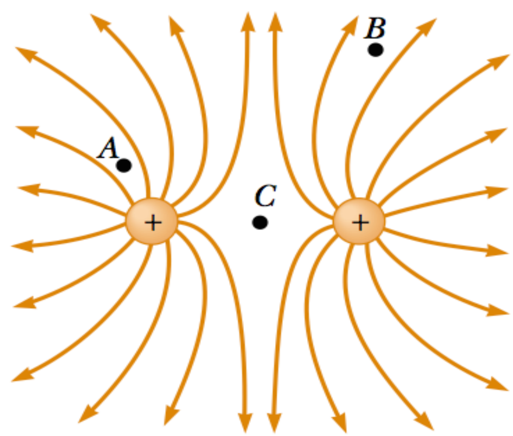
- The electric field due to a single positive or negative point charge is two-dimensional drawing shows only the field lines that lie in the plane containing the point charge.



23.6 Electric Field Lines

- The rules for drawing electric field lines are as follows:
  - The lines must begin on a positive charge and terminate on a negative charge.
  - The number of lines drawn leaving a positive charge or approaching a negative charge is proportional to the magnitude of the charge.
  - No two field lines can cross.





Because the charges are of equal magnitude, the number of lines that begin at the positive charge must equal the number that terminate at the negative charge.

Quick Quiz 23.8

Which of the following statements about electric field lines associated with electric charges is false?

(a) Electric field lines can be either straight or curved.

(b) Electric field lines can form closed loops.

(c) Electric field lines begin on positive charges and end on negative charges.

(d) Electric field lines can never intersect with one another.

23.7 Motion of Charged Particles in a Uniform Electric Field

- When a particle of charge *q* and mass *m* is placed in an electric field **E**, the electric force exerted on the charge is *q* **E**
- The net force causes the particle to accelerate according to Newton's second law.

$$\mathbf{F}_e = q\mathbf{E} = m\mathbf{a}$$

- The acceleration of the particle is

$$\mathbf{a} = \frac{q\mathbf{E}}{m}$$

  - If **E** is **uniform** (that is, constant in magnitude and direction), then the **acceleration** is **constant**.
  - If the particle has a **positive** charge, its acceleration is in the direction of the electric field. If the particle has a **negative** charge, its acceleration is in the direction opposite the electric field.

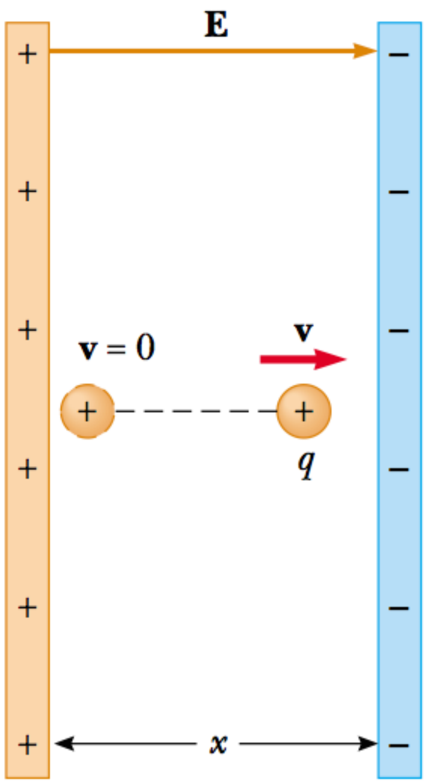
Example 23.10 **An Accelerating Positive Charge**

- A positive point charge *q* of mass *m* is released from rest in a uniform electric field **E** directed along the *x* axis, as shown in Figure 23.25. Describe its motion.

$$x_f = x_i + v_i t + \frac{1}{2}at^2$$

$$v_f = v_i + at$$

$$v_f^2 = v_i^2 + 2a(x_f - x_i)$$

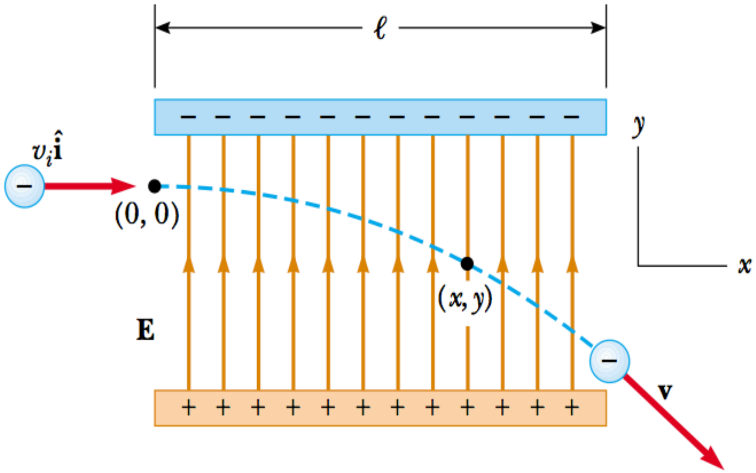


23.7 Motion of Charged Particles in a Uniform Electric Field

- The electric field in the region between two oppositely charged flat metallic plates is approximately **uniform**.
- Suppose an electron of charge -*e* is projected horizontally into this field from the origin with an initial velocity $v_i \hat{\mathbf{i}}$ at time t=0.
- Because the electric field **E** is in the positive *y* direction, the acceleration of the electron is in the negative *y* direction.

$$\mathbf{a} = -\frac{eE}{m_e}\hat{\mathbf{j}}$$

- Because the acceleration is constant, we can apply the equations of kinematics in two dimensions with $v_{xi}=v_i$ and $v_{yi}=0$.



23.7 Motion of Charged Particles in a Uniform Electric Field

- After the electron has been in the electric field for a time interval, the components of its velocity at time *t* are

$$v_x = v_i = \text{constant}$$

$$v_y = a_y t = -\frac{eE}{m_e} t$$

- Its position coordinates at time *t* are

$$x_f = v_i t$$

$$y_f = \frac{1}{2} a_y t^2 = -\frac{1}{2} \frac{eE}{m_e} t^2$$

Example 23.11 **An Accelerated Electron**

- An electron enters the region of a uniform electric field as shown in Figure 23.26, with v_i=3.00X10^{6}m/s and E=200 N/C. The horizontal length of the plates is l=0.100 m.

(A) Find the acceleration of the electron while it is in the electric field.

(B) If the electron enters the field at time t=0, find the time at which it leaves the field.

(C) If the vertical position of the electron as it enters the field is y_i =0, what is its vertical position when it leaves the field?