De Anza College

Electricity and Magnetism
Motion of a Charge in an E-field

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Oct 1, 2015

Last time

- E-field from many charges
- electric fields of charge distribution

Overview

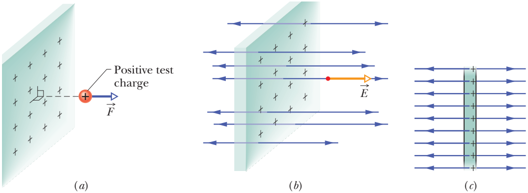
- motion of charges in electric fields

Electric field due to an Infinite Sheet of Charge

Suppose the sheet is in air (or vacuum) and the charge density on the sheet is σ (charge per unit area):

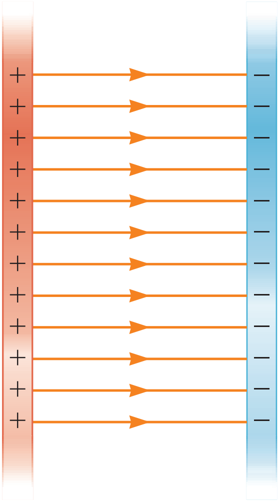
$$E = \frac{\sigma}{2\epsilon_0}$$

It is uniform! It does not matter how far a point P is from the sheet, the field is the same.



Field Lines: Uniform Field

The field from two infinite charged plates is the sum of each field.
$E = \frac{\sigma}{\epsilon_0}$



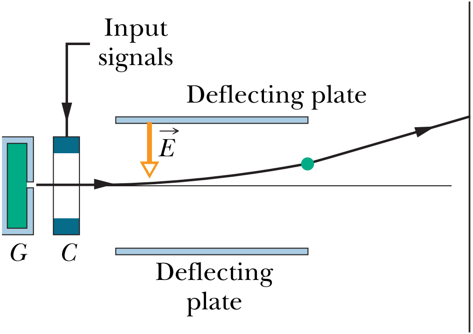
The field in the center of a parallel plate **capacitor** is nearly uniform.

Free charges in an E-field

The force on a charged particle is given by $\mathbf{F} = q\mathbf{E}$.

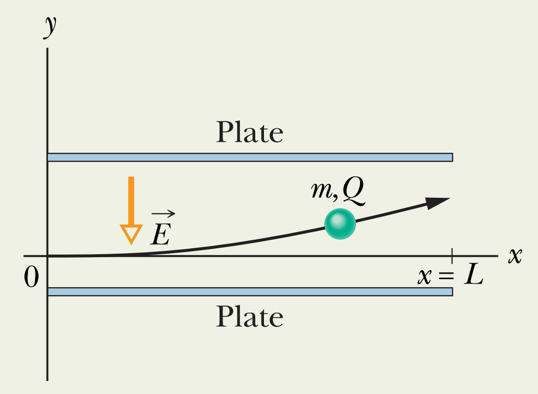
If the charge is free to move, it will accelerate in the direction of the force.

Example: Ink-jet printing



Motion of a Charged Particle in an E-field

If Q is negative:



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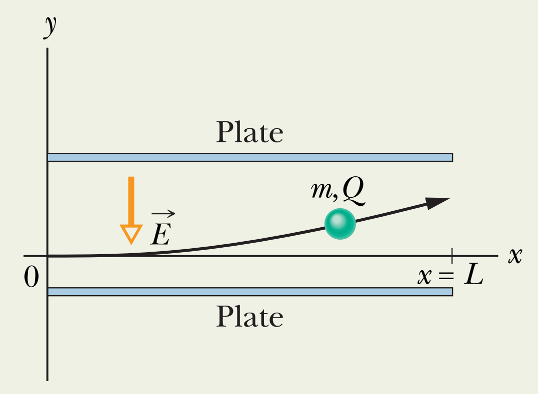
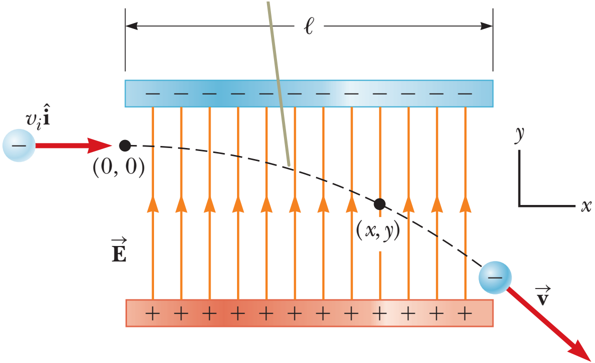


Trajectory is a parabola: similar to projectile motion.

Motion of a Charged Particle in an E-field

(a) What is the acceleration of an electron in the field of strength E?



(b) The charge leaves the field at the point (ℓ, y_f). What is y_f in terms of ℓ, v_i, E, e, and m_e?

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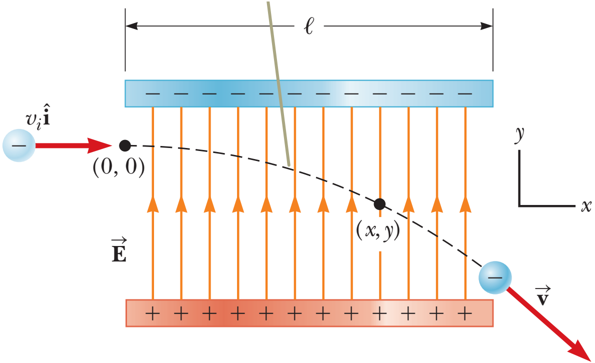
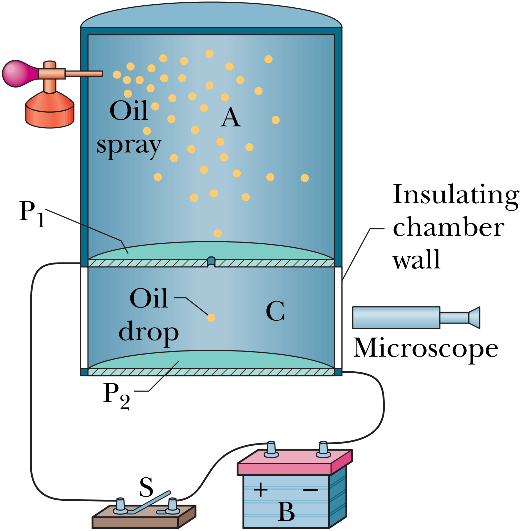


(b) The charge leaves the field at the point (ℓ, y_f). What is y_f in terms of ℓ, v_i, E, e, and m_e?

$$y_f = -\frac{eE\ell^2}{2m_e v_i^2}$$

Millikan's Oil Drop Experiment: Measuring e



Sparking: Electrical Breakdown

Electric fields can cause forces on charges.

If the field is very strong, it begins to accelerate free electrons which strike atoms, knocking away more electrons forming ions. This starts a cascade, forming a spark.

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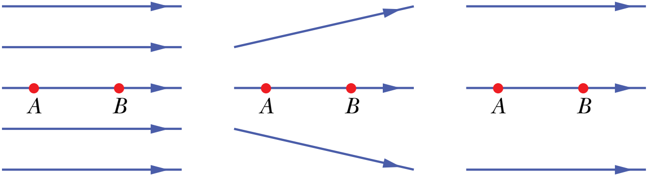
The air along the spark becomes a **plamsa** of free charges and can conduct electricity.

Sparks look like bright streaks because the air molecules becomes so hot. Accelerating charges radiate, so lightning can also cause radio interference.

Question

Page 597, #1

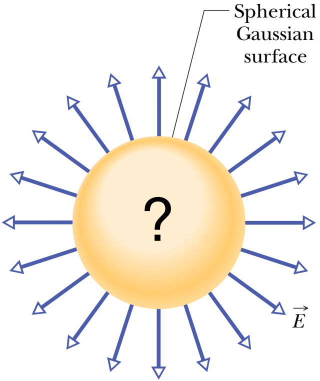
1 Figure 22-20 shows three arrangements of electric field lines. In each arrangement, a proton is released from rest at point A and is then accelerated through point B by the electric field. Points A and B have equal separations in the three arrangements. Rank the arrangements according to the linear momentum of the proton at point B, greatest first.



(a) (b) (c)

For next time: Gauss's Law basic idea

Gauss's law relates the electric field across a closed surface (*eg.* a sphere) to the amount of net charge enclosed by the surface.



Can we quantify the "electric field across a boundary"?

Summary

- motion of charges in E-fields

Homework Halliday, Resnick, Walker:

- Read up through Chapter 23.
- Ch 22, onward from page 597. Problems: 39, 43