# Chapter 23

1

## ELECTRIC FIELDS



1

# Lecture 04

2

## Motion Of Charged Particle In A Uniform Electric Field



2

# Motion of a Charged Particle in a Uniform Electric Field

3

When a charged particle of mass $(m)$ and charge $(q)$ is placed in an electric field $(E)$, it experiences an electrical force.
If this is the only force on the particle, it must be the net force.
The net force will cause the particle to accelerate according to newton's second law.

- $\sum \vec{F} = m\vec{a}$
- $\vec{F}_e = m\vec{a}$
- $q\vec{E} = m\vec{a}$

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



3

# Motion of Particles, cont

4

- If the field is uniform, then the acceleration is constant.
- The particle under constant acceleration model can be applied to the motion of the particle.
  - If the particle has a **positive** charge, its acceleration is in the direction of the field.
  - If the particle has a **negative** charge, its acceleration is in the direction opposite the electric field.

$$v_f = v_i + at$$

$$\Delta x = v_i t + \frac{1}{2}at^2$$

$$\Delta x = v_f t - \frac{1}{2}at^2$$

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$\Delta x = \frac{1}{2}(v_i + v_f)t$$



4

# Motion along the Field-1

Friday, 29 January, 2021 20:02

Lecturer: Mustafa Al-Zyout, Philadelphia University, Jordan.

- [x] R. A. Serway and J. W. Jewett, Jr., *Physics for Scientists and Engineers*, 9th Ed., CENGAGE Learning, 2014.
- [ ] J. Walker, D. Halliday and R. Resnick, *Fundamentals of Physics*, 10th ed., WILEY,2014.
- [ ] H. D. Young and R. A. Freedman, *University Physics with Modern Physics*, 14th ed., PEARSON, 2016.
- [ ] H. A. Radi and J. O. Rasmussen, *Principles of Physics For Scientists and Engineers*, 1st ed., SPRINGER, 2013.

A proton is projected in the positive x direction into a region of a uniform electric field $\vec{E} = -6 \times 10^5 \ N/C\, ,\hat{\imath}$ at $t = 0$. The proton travels $7\ cm$ as it comes to rest. Determine:

- the acceleration of the proton,
- its initial speed, and
- the time interval over which the proton comes to rest.

Solution:

the acceleration:

$$a = \frac{\mathrm{q}E}{m} = \frac{1 \cdot 6 \times 10^{-19} \times 6 \times 10^5}{1 \cdot 67 \times 10^{-27}} = 5 \cdot 76 \times 10^{13}\, m/s^2$$

So: $\vec{a} = -5.76 \times 10^{13}\, m/s^2\, ,\hat{\imath}$

its initial speed

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$0 = v_i^2 + 2(-5 \cdot 76 \times 10^{13})(0.07)$$

$$v_i = 2 \cdot 84 \times 10^6\, m/S$$

So: $\vec{v}_i = 2.84 \times 10^6\, m/s\, ,\hat{\imath}$

the time interval

$$v_f = v_i + at$$

$$0 = 2 \cdot 84 \times 10^6 - 5 \cdot 76 \times 10^{13} \times t$$

$$t = 4 \cdot 93 \times 10^{-8} s$$

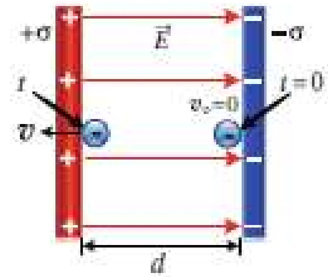
# Motion along the Field-2

Friday, 29 January, 2021 20:02


- [ ] R. A. Serway and J. W. Jewett, Jr., *Physics for Scientists and Engineers*, 9th Ed., CENGAGE Learning, 2014.
- [ ] J. Walker, D. Halliday and R. Resnick, *Fundamentals of Physics*, 10th ed., WILEY,2014.
- [ ] H. D. Young and R. A. Freedman, *University Physics with Modern Physics*, 14th ed., PEARSON, 2016.
- [x] H. A. Radi and J. O. Rasmussen, *Principles of Physics For Scientists and Engineers*, 1st ed., SPRINGER, 2013.


The figure shows two oppositely charged parallel plates that are separated by a distance $d = 1.5\ cm$. Each plate has a charge per unit area of magnitude $\sigma = 4\ \mu C/m^2$. An electron is released from rest at $t = 0$ from the negative plate.

- Calculate the electric field between the two plates.
- Find the resultant force exerted on the electron?
- Find the acceleration of the electron.
- How long does it take the electron to strike the positive plate?
- What is the speed and kinetic energy of the electron just before striking the positive plate?




Solution:

the electric field is:

$$E_{net} = E_+ + E_- = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0} = \frac{\sigma}{\varepsilon_0}$$

$$E_{net} = \frac{4 \times 10^{-6}}{8.85 \times 10^{-12}} = 4.52 \times 10^5\ N/C$$

$$\vec{E}_{net} = 4.52 \times 10^5\ N/C\ \ , \hat{\imath}$$

the resultant force is:

$$\vec{F} = q\vec{E} = -1 \cdot 6 \times 10^{-19} \times 4 \cdot 52 \times 10^5 = -7.23 \times 10^{-14} N\ , \hat{\imath}$$

the acceleration is:

$$\vec{a} = \frac{\vec{F}}{m} = \frac{-7 \cdot 23 \times 10^{-14}}{9.11 \times 10^{-31}} = -7 \cdot 95 \times 10^{16}\ m/s^2\ , \hat{\imath}$$

The time it take to strike the positive plate is:

$$\Delta x = v_i t + \frac{1}{2} a t^2$$

$$-0.015 = 0 - \frac{1}{2} \times 7 \cdot 9 \times 10^{16} \times t^2$$

$$t = 6.14 \times 10^{-10} s$$

The final speed is:

$$v_f = v_i + at = 0 - 7 \cdot 9 \times 10^{16} \times 6.14 \times 10^{-10} = -4 \cdot 88 \times 10^{7}\, m/s$$

$$\vec{v}_f = -4 \cdot 88 \times 10^{7}\, m/s \;\; , \hat{\imath}$$

The final kinetic energy is:

$$K_f = \frac{1}{2} m v_f^2 = \frac{1}{2} \times 9.11 \times 10^{-31} \times (4 \cdot 88 \times 10^{7})^2 = 1.08 \times 10^{-15} J$$