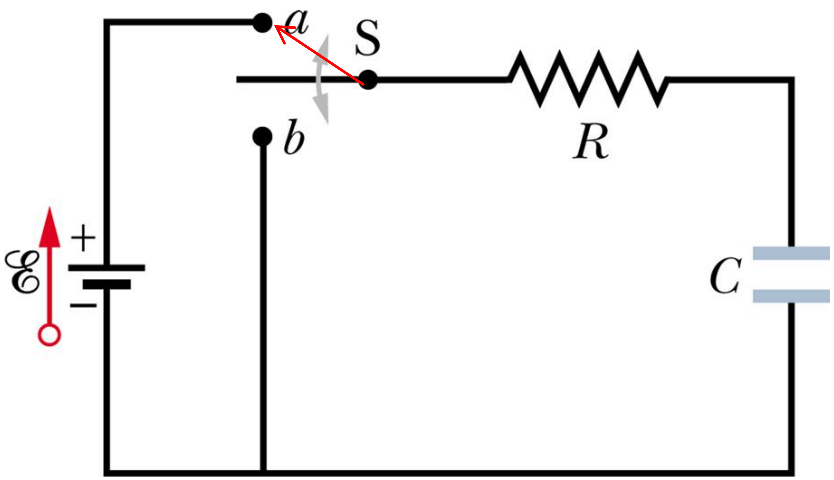
# Copyright statement

- The images and the pictures in this lecture are provided by the CDs accompanied by the books
  1. University Physics, Bauer and Westfall, McGraw-Hill, 2011.
  2. Principles of Physics, Halliday, Resnick, and Walker, Wiley, 8th and 9th Ed.
- The rest is made by me.

# RC circuit




## Charging a capacitor

$$\mathcal{E} - iR - \frac{q}{C} = 0 \qquad i = \frac{dq}{dt}$$

$$R\frac{dq}{dt} + \frac{q}{C} = \mathcal{E}$$

우선 $\mathcal{E} = 0$ 인 경우 (homogeneous eq.)

$q = Ae^{at}$ 라고 놓으면, 위 식은

$$Ra + \frac{1}{C} = 0 \rightarrow a = -\frac{1}{RC}$$

$\mathcal{E} \neq 0$ 일 경우 가장 간단한 해는 $q = C\mathcal{E}$

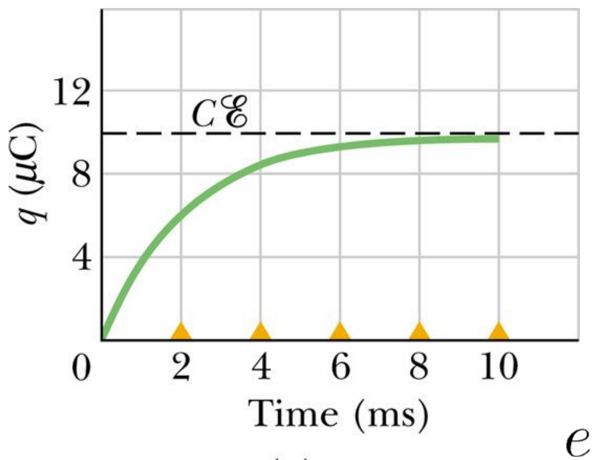
$$q(t) = Ae^{-t/RC} + C\mathcal{E}$$

$t = 0$일 때 $q = 0$므로

$$A = -C\mathcal{E}$$

$$q(t) = C\mathcal{E}(1 - e^{-t/RC})$$

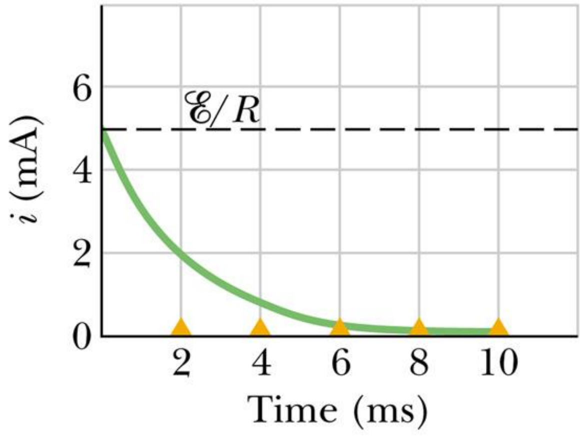
# Time constant




(*a*)

$$V_C = \frac{q}{C} = \mathcal{E}(1 - e^{-t/RC})$$

$$e^{-1} \sim 0.37$$



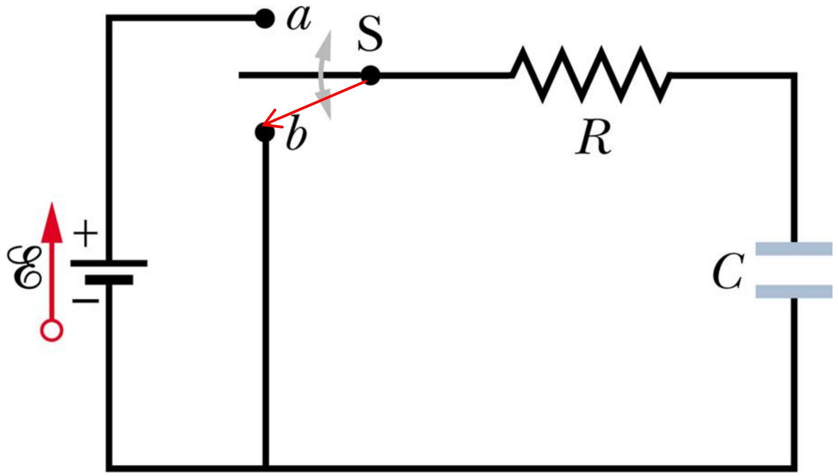

(*b*)

$$i = \frac{dq}{dt} = \frac{\mathcal{E}}{R} e^{-t/RC}$$

Time constant $\tau = RC$

$$[\tau] = [\mathrm{V/A \cdot C/V}] = T$$

# Discharging a capacitor

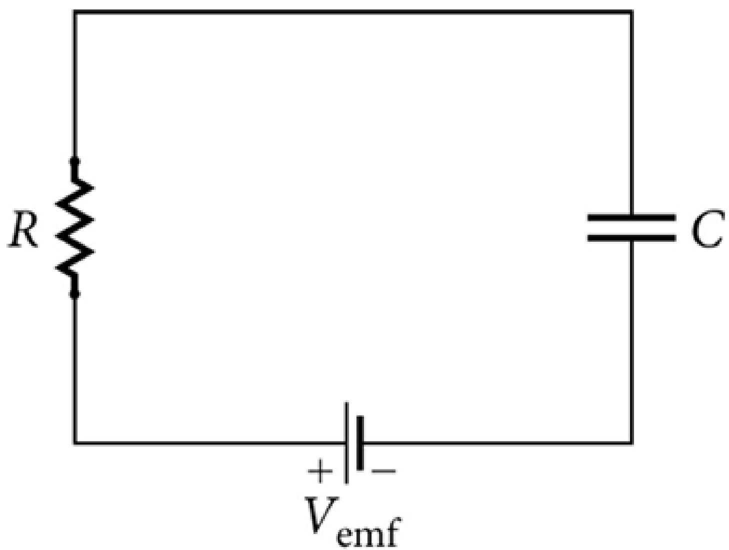



$$R\frac{dq}{dt} + \frac{q}{C} = 0$$

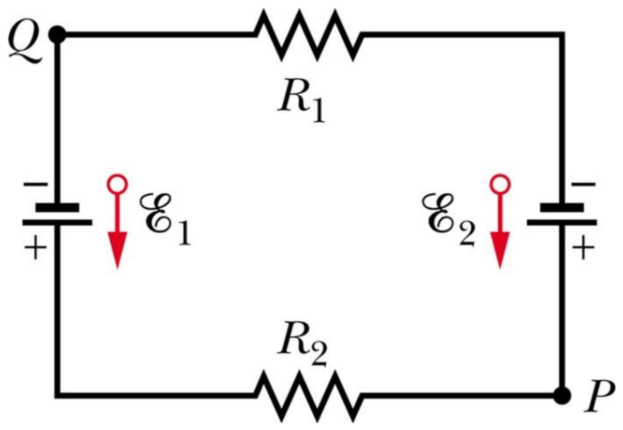
$$q = q_0 e^{-t/RC} = C\mathcal{E} e^{-t/RC}$$

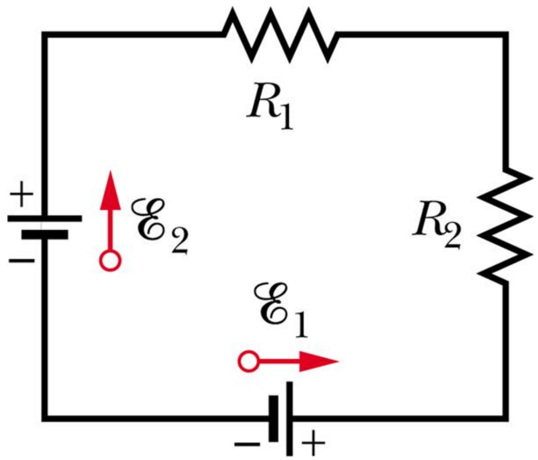
$$i = \frac{dq}{dt} = -\frac{q_0}{RC} e^{-t/RC} = -\frac{\mathcal{E}}{R} e^{-t/RC}$$

# Solved problem 26.4
# rate of energy storage in a capacitor



# Problem 1



# Chapter 27 Magnetism

# General arguments about magnetism

1) Electric field는 electric charge에 의해서 만들어 진다. Magnetic charge는 존재하지 않는다. 그렇다면 무엇이 magnetic field를 만드는가?

2) 전자석의 경우처럼 전류가 자기장을 만들기도 하지만 영구 자석도 자기장을 만들어 준다. 그 차이는 무엇인가?

# What is magnetic field?

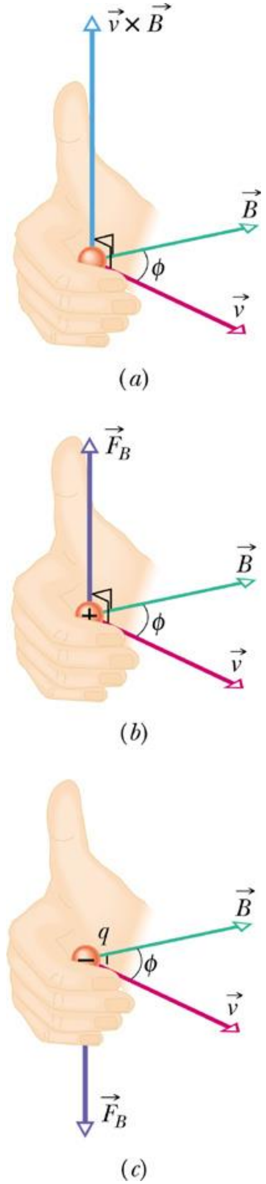
Electric field

$$\vec{E} = \frac{\vec{F}_E}{q}$$

Magnetic field

$$B = \frac{F_B}{|q|v}$$

# Magnetic force



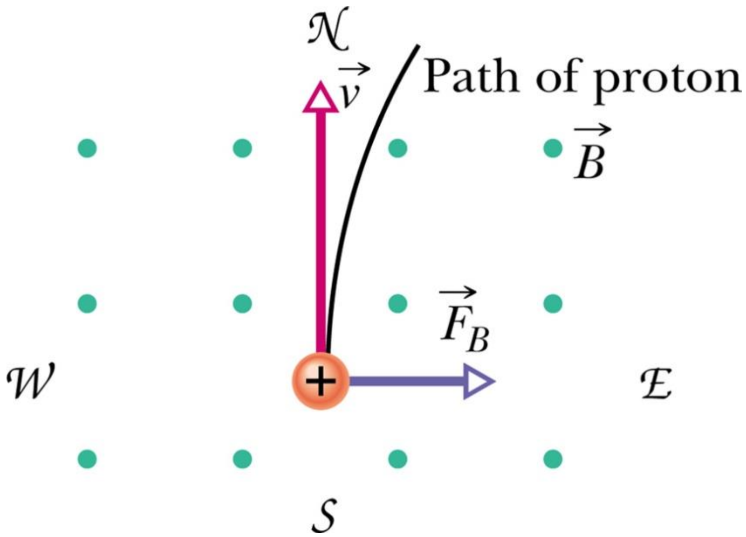

$$\vec{F}_B = q\vec{v} \times \vec{B}$$

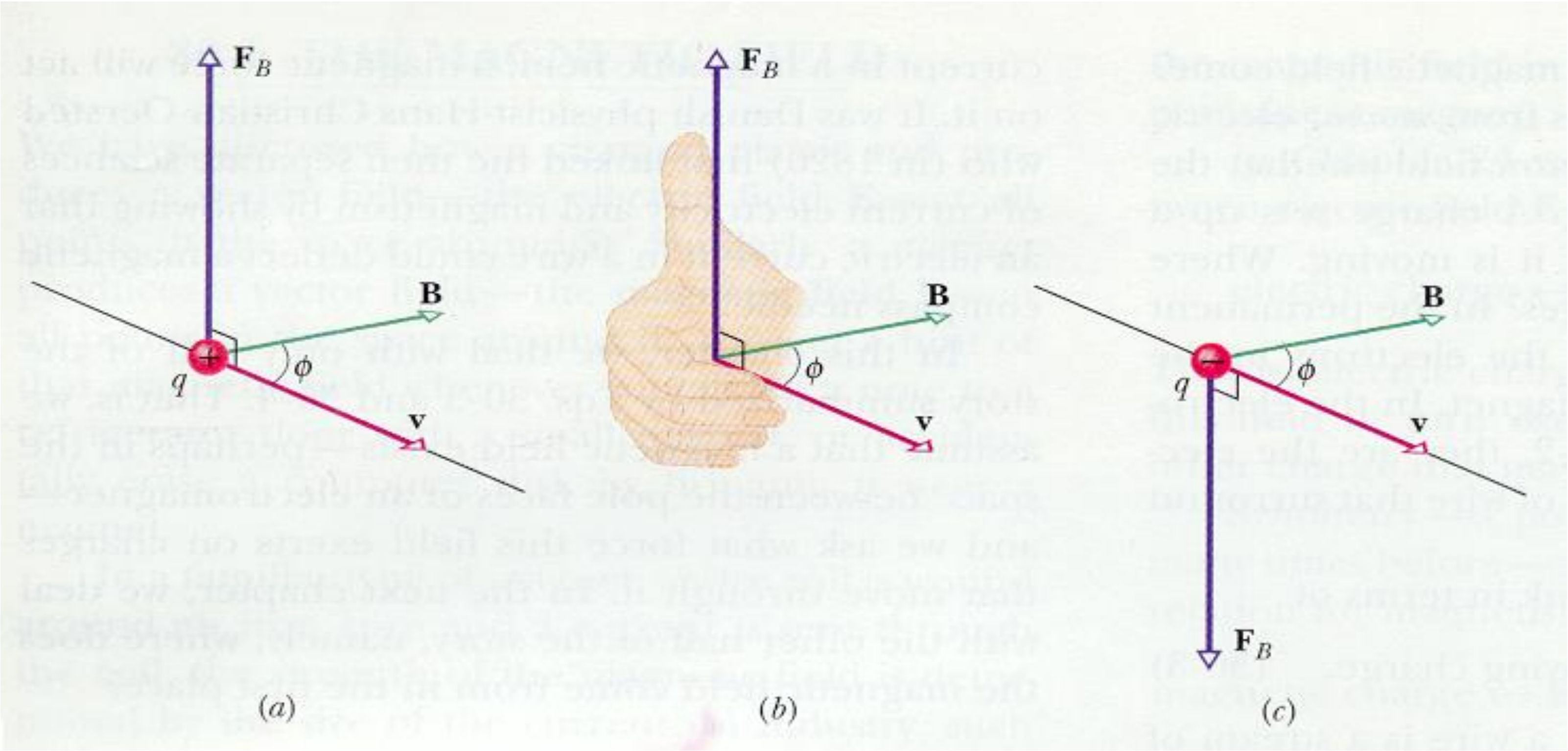
$$F_B = |q|vB\sin\phi$$

SI unit $$1\ \mathrm{T} = 1\ \frac{\mathrm{N}}{\mathrm{C} \cdot \mathrm{m/s}} = 1\ \frac{\mathrm{N}}{\mathrm{A} \cdot \mathrm{m}}$$

$$1\ \mathrm{T} = 10^4\ \mathrm{gauss}$$

# Example



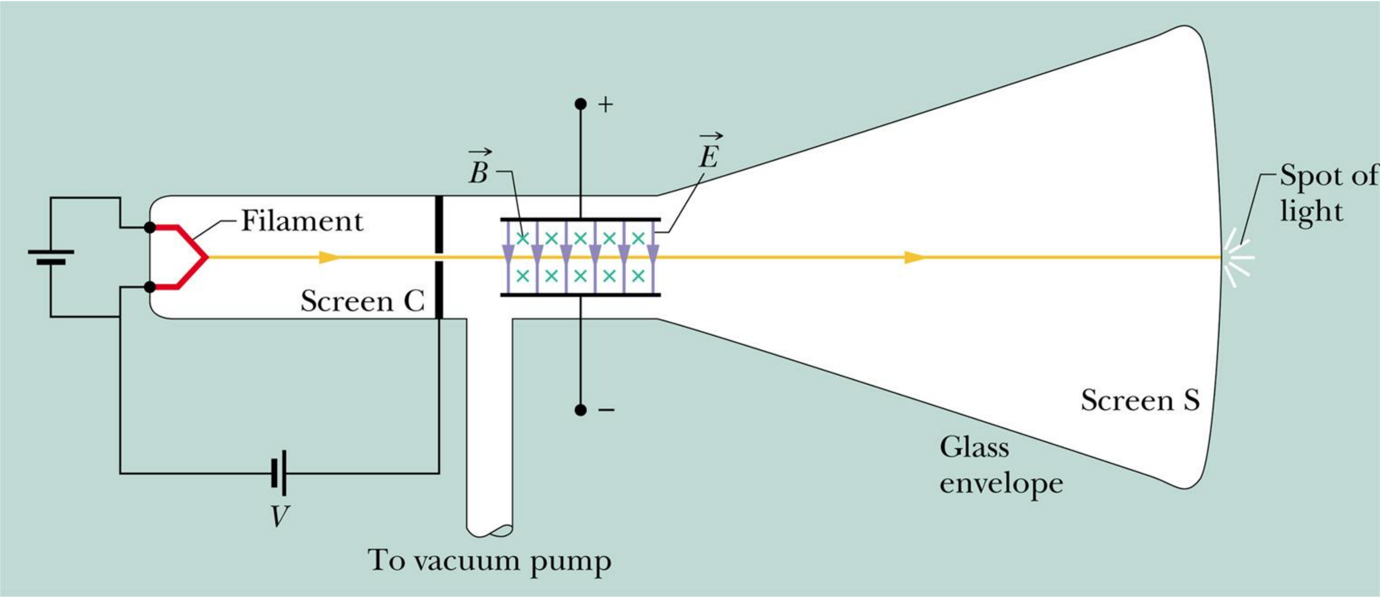



$$\mathbf{F}_B = q\mathbf{v} \times \mathbf{B}$$

# Typical magnitudes of magnetic fields

| | |
|---|---|
| 중성자별 표면 : | $10^{8}\,\mathrm{T}$ |
| 전자석: | $1.5\,\mathrm{T}$ |
| 막대자석: | $10^{-2}\,\mathrm{T}$ |
| 지구 표면: | $10^{-4}\,\mathrm{T}$ |
| 행성간 공간: | $10^{-10}\,\mathrm{T}$ |
| 뇌 자기장: | $10^{-14}\,\mathrm{T}$ |

# Crossed fields: discovery of electron

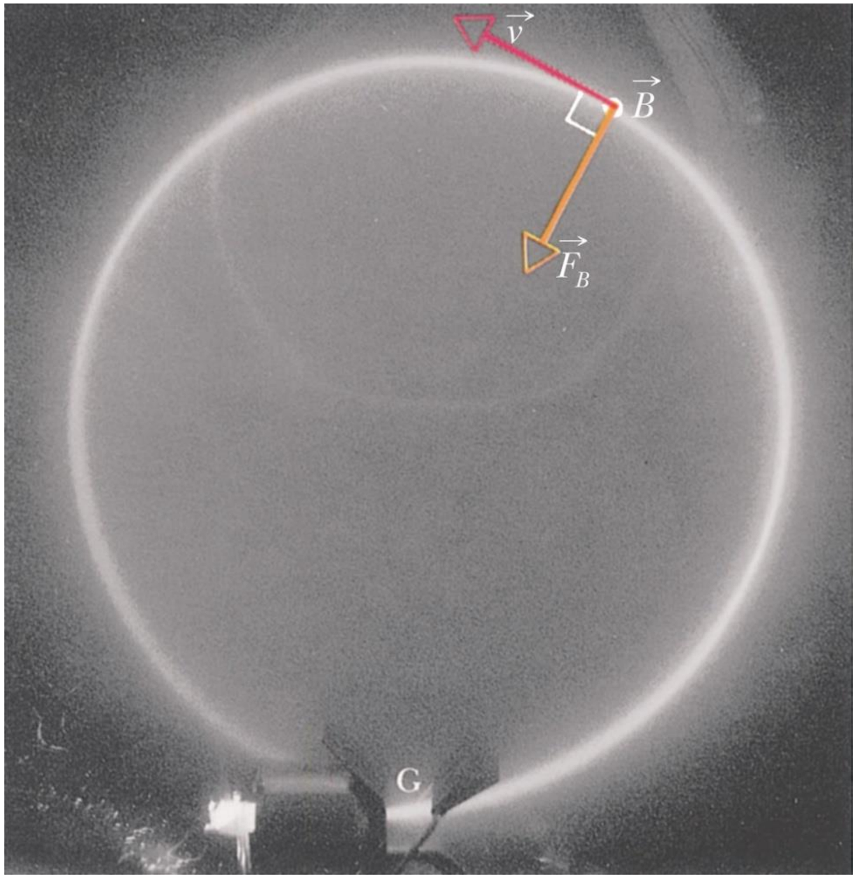


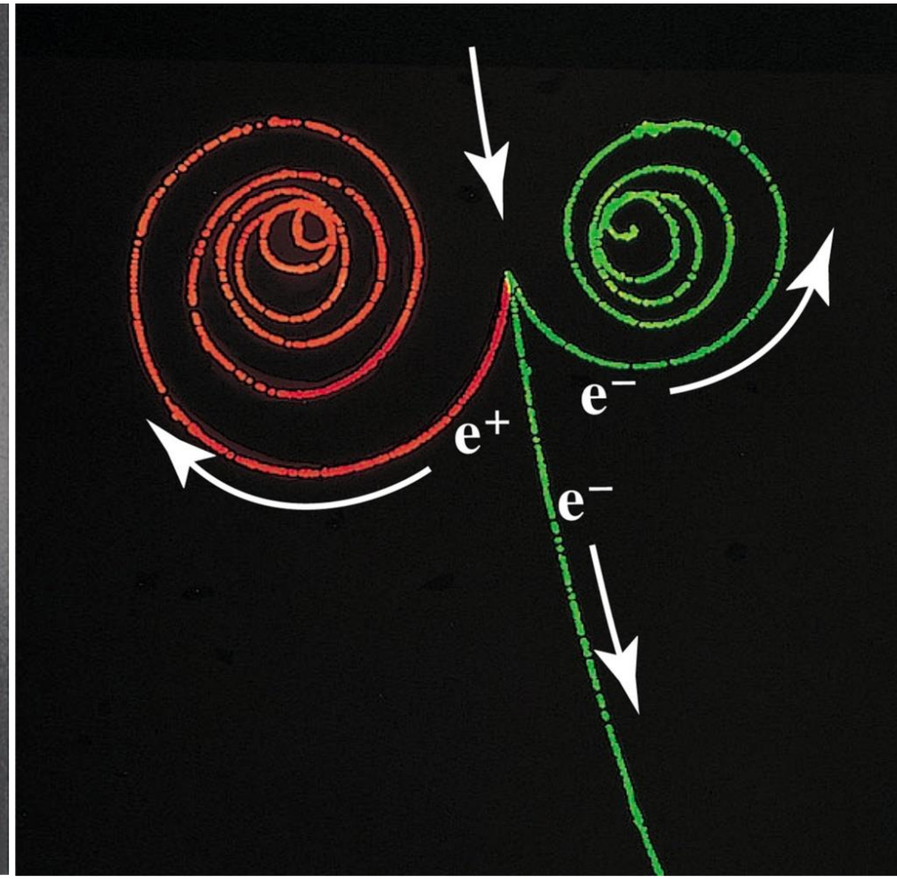

$$y = \frac{1}{2}at^2 = \frac{1}{2}\frac{eE}{m}\left(\frac{L}{v}\right)^2$$

$$\frac{e}{m} = \frac{2yE}{B^2L^2}$$

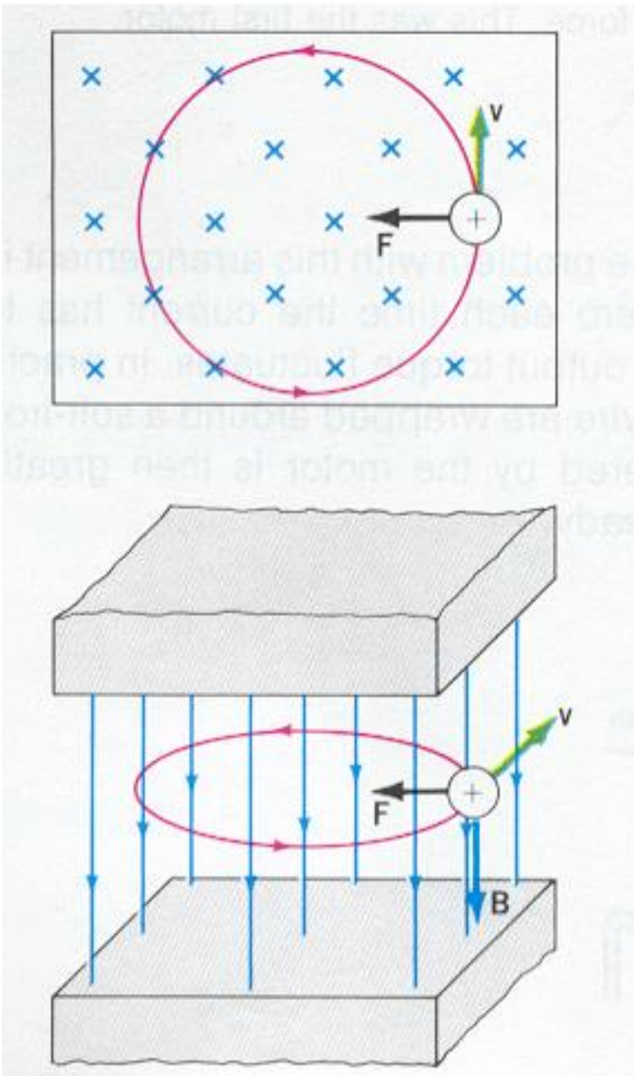
$$eE = evB \rightarrow v = \frac{E}{B}$$

# Charged particle in a circular motion



# Charged particle in a circular motion




$$|q|vB = \frac{mv^2}{r}$$

$$r = \frac{mv}{|q|B}$$ Radius of the circle

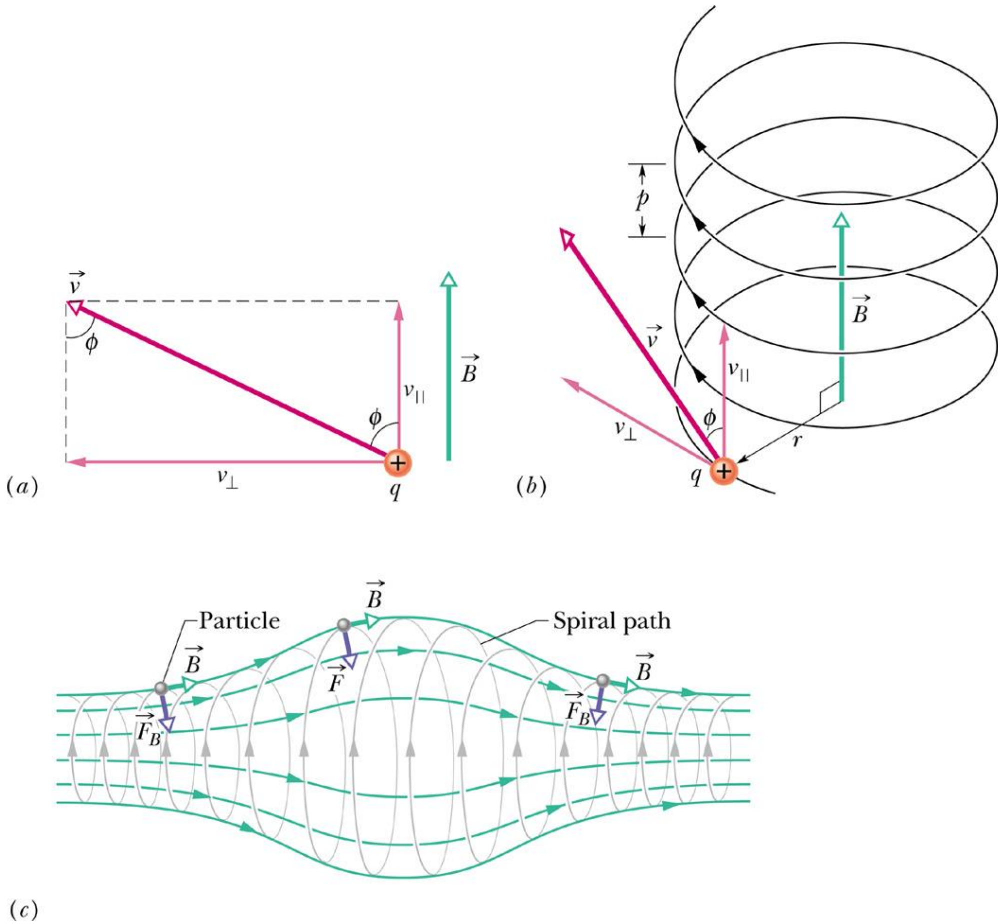
period:

$$T = \frac{2\pi r}{v} = \frac{2\pi}{v}\frac{mv}{|q|B} = \frac{2\pi m}{|q|B}$$

frequency: $$f = \frac{1}{T} = \frac{|q|B}{2\pi m}$$

angular frequency: $$\omega = 2\pi f = \frac{|q|B}{m}$$

# Spiral motion




$$v_{||} = v \cos \phi$$ Straight motion

$$v_{\perp} = v \sin \phi$$ Circular motion