Physics 102.

Lecture 16. Monday. Oct. 18. 2004

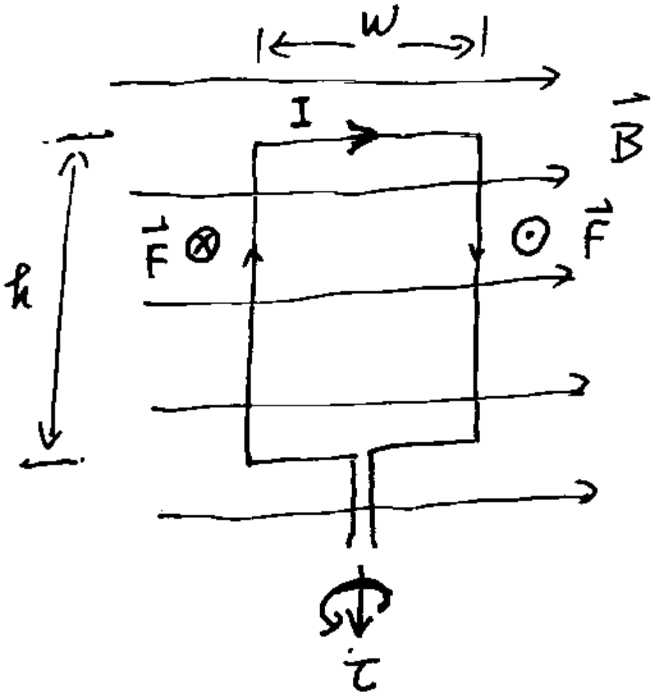
- Magnetic Torque acting on a Loop of current.

① when a uniform $\vec{B}$ field is parallel to the Loop.

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

$\tau = IAB$

$A = hw$ — area of Loop.



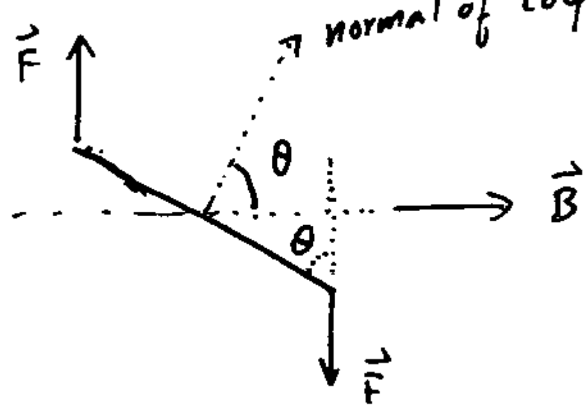
Then, the Loop starts to turn.

② when the field $\vec{B}$ is not parallel to the plane of the loop.

$\tau = 2F \cdot \frac{W}{2} \cdot \sin\theta$

$= 2ILB \frac{W}{2} \cdot \sin\theta$

$= IAB \cdot \sin\theta$



③ General:

$\tau = NIAB \cdot \sin\theta$.

(NIA — Magnetic moment)

A — doesn't have to be rectangle.

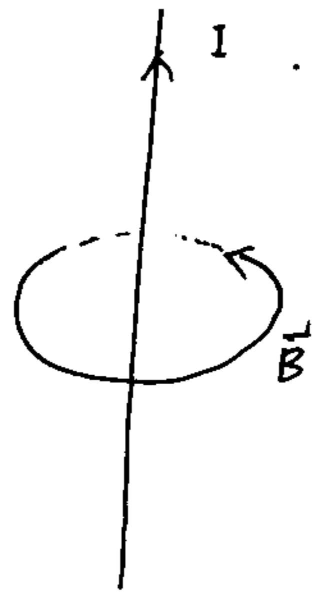
N — # of Turns.

- Magnetic field due to a current carrying long wire.

  (Ampere's Law).

  electric current can produce magnetic field.

- A long straight wire with a current I.



Direction of $\vec{B}$: RHR.

Ampere's Law.

$$\sum_{C} B_{\parallel} \Delta L = \mu_0 I .$$

C — A closed path.

I — enclosed current.

μ_0 — permeability of free space.

$\mu_0 = 4\pi \times 10^{-7}\ T \cdot m/A$.

* (Ampere's law in a better Math from:

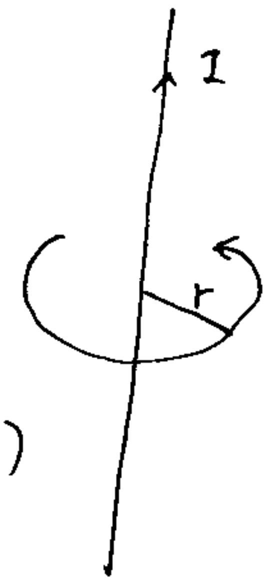
$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I .$$

)

- Application of Ampere's law:

for a long straight wire

choose C as a circle centred at the wire. with a radius r.



by symmetry, $B = B_{\parallel}$ = same on C.

↑ along the path. (tangential direction)

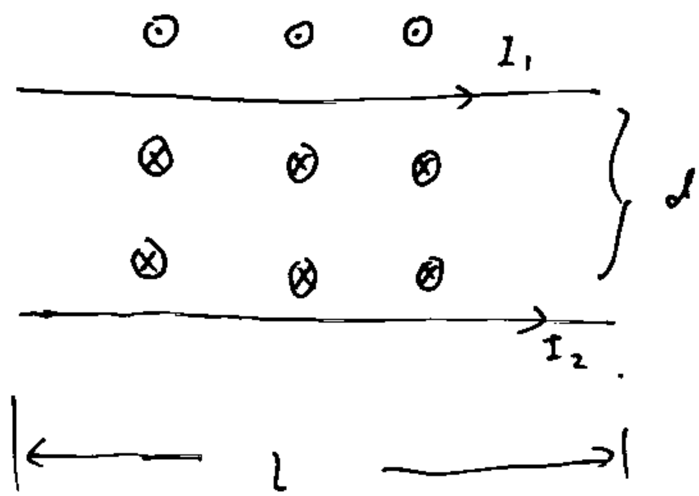
$\therefore \quad \Sigma B_{\parallel} \cdot \Delta L = B \cdot \Sigma \Delta L = B \cdot 2\pi r$

Ampere's law: $\quad \Sigma B_{\parallel} \cdot \Delta L = \mu_0 I$.

$\therefore \quad B \cdot 2\pi r = \mu_0 I$.

$$\boxed{B = \frac{\mu_0 I}{2\pi r}}$$ — Magnetic field of a long straight wire.

e.g. Force between 2 current-carrying wires.



Current I_1 produces a $\vec{B}$ field at where I_2 is:

$$B_1 = \frac{\mu_0 I_1}{2\pi d}.$$

which exerts a force on current I_2:

$$F_2 = I_2 L \cdot B_1 = \frac{\mu_0 I_1 I_2}{2\pi d} L.$$

Also, I_2 produces a field B_2 that exerts a force F_1 on I_1:

$$F_1 = F_2 = \frac{\mu_0 I_1 I_2}{2\pi d} L. \quad \text{(action and reaction)}.$$

* Ampere is defined as:

when $F = 2 \times 10^{-7}$ N.

$L = 1$ m.

$d = 1$ m.

$I_1 = I_2$.

Then $I = I_1 = I_2 = 1$ Ampere.