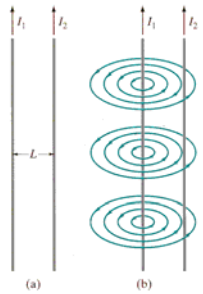
3 – Magnetism

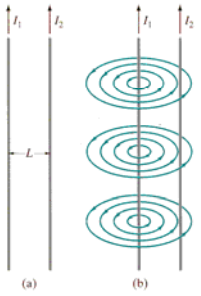
Force on Two Wires



- A wire carrying current produces a magnetic field and feels force when placed in a magnetic field.
- So TWO current carrying wires would exert a Force on each other!
- Consider 2 long 2 wires separated by distance L.
- Currents I1 and I2 each producing B1 & B2 at location of second conductor.

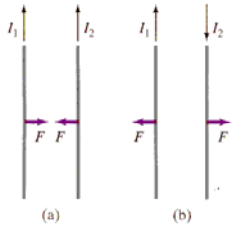
Force on Two Wires

- $B_1 = \frac{\mu_0 I_1}{2\pi r}$
- Force on I2
- $\frac{F}{\ell} = I_2 B_1$
- Force on I2 due ONLY to the field from I1, does not exert a force on itself.
- Substituting:
- $\frac{F}{\ell} = \frac{\mu_0 I_1 I_2}{2\pi L}$



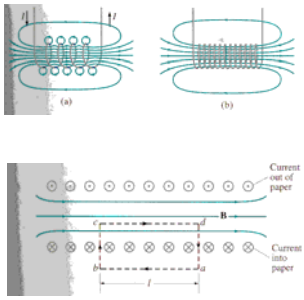
2Wire Right Hand Rule

- By using the right hand rule, you can see that:
  - If the currents are in the same direction, then the forces attract.
  - If the currents are in the opposite direction, then the forces repel.
  - Do NOT mix in left hand!

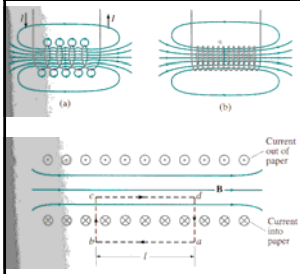


Ampere's Law

- Is there a general relationship between the current of a wire of whatever shape and the magnetic field around it?
- **solenoid** – long coil of wire with many loops
- $\sum B_{parallel} \Delta\ell = \mu_0 I$



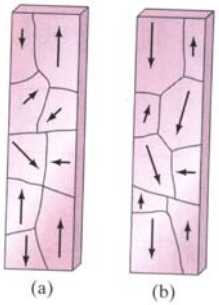
Ampere's Law



- $B\ell = \mu_0 NI$
- Let n=N/ℓ be the number of loops per unit length
- $B = \mu_0 nI$
- B depends on the number of loops per unit length, n & current, I
- Field does NOT depend on position within the solenoid, so B is uniform!

FERROMAGNETISM

- **domains**–microscopic magnetic regions that atoms are grouped within
- Atoms are magnetically polarized parallel to a crystal axis. Not all pieces of iron behave as magnets since the domains may NOT be in line. Can be aligned in response to strong magnetic fields and become a permanent magnet,
- **Curie point**–when a ferromagnetic material is heated above some certain critical value, it becomes more random with its domains and cannot retain its magnetism.
- Dropping a magnet or striking it may also randomize the domains.

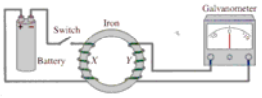


Electromagnets and Solenoids

- Place a piece of iron inside a solenoid and magnetic field increases because the domains of iron are aligned by the magnetic field produced by the current.
- Reverse current and you reverse N & S
- soft iron—loses magnetism
- hard iron--holds magnetism

Induction

- An electric current produces a magnetic field, B.
- A magnetic field exerts a F on an electric current OR moving charge.
- Is it possible that a magnetic field can produce an electric current? You betcha!
- 10 years after Oersted, American Joseph Henry and Brit Michael Faraday independently found that was possible.
- Faraday published first!



Induced EMF

- Faraday's Device
- Coil X is connected to a battery and then wrapped around soft iron core to intensify the magnetic field in hopes that a current develops [is induced] in the Y coil
- Coil Y was attached to a galvanometer with detects faint electric currents [more sensitive than an ammeter]

Induced EMF

- However, he did notice the needle was deflecting at the moment he threw the switch and again when he opened the switch....
- A ***CHANGING*** Magnetic Field, B, produces and electromotive force, while a steady B does not!

Induced EMF