



James Clerk Maxwell



Michael Faraday

## Electromagnetism

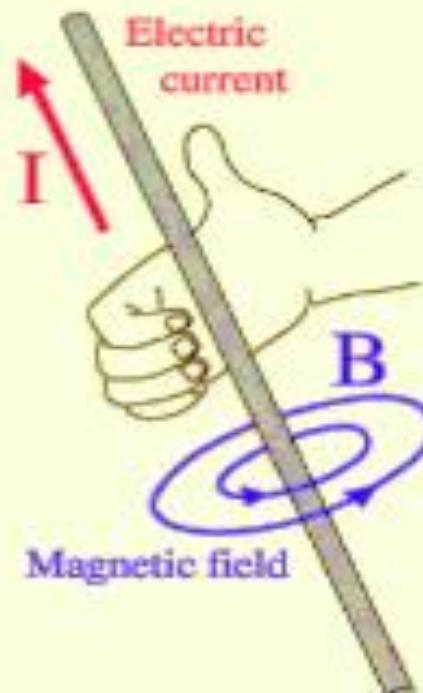
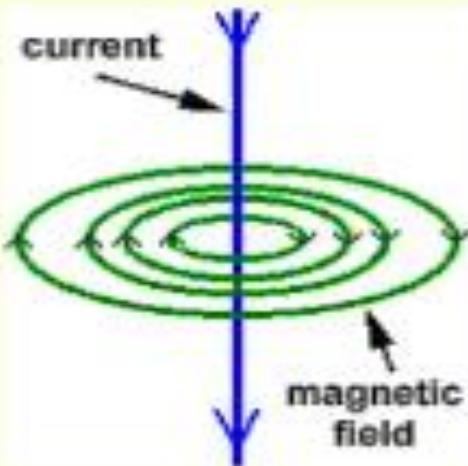
Electromagnetic Induction  
Electromagnetic Waves

# Electromagnetism

- Electricity and magnetism are different facets of *electromagnetism*
  - a moving electric charge produces magnetic fields
  - changing magnetic fields move electric charges
- This connection first elucidated by Faraday, Maxwell
- Einstein saw electricity and magnetism as frame-dependent facets of *unified electromagnetic force*

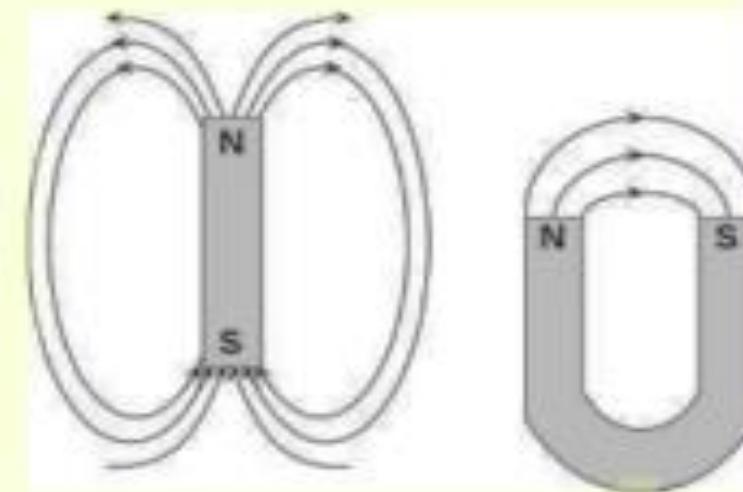
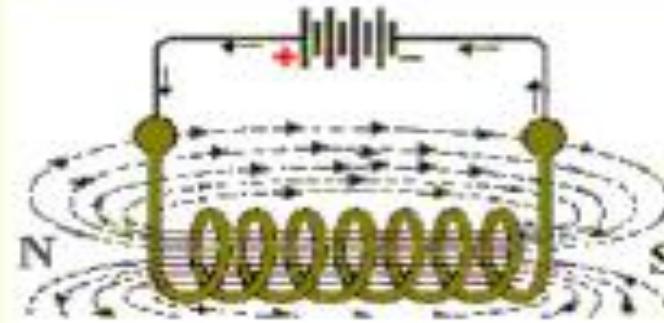
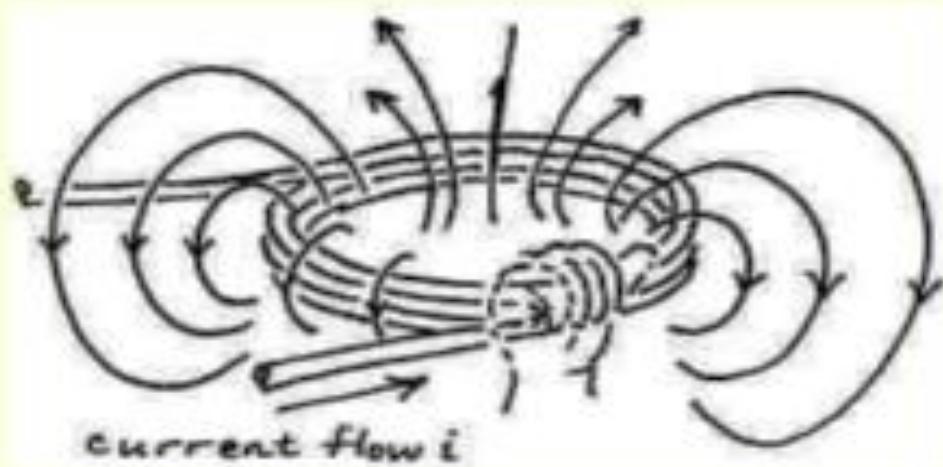
# Magnetic fields from electricity

- A static distribution of charges produces an electric field
- Charges in *motion* (an electrical current) produce a magnetic field
  - electric current is an example of charges (electrons) in motion



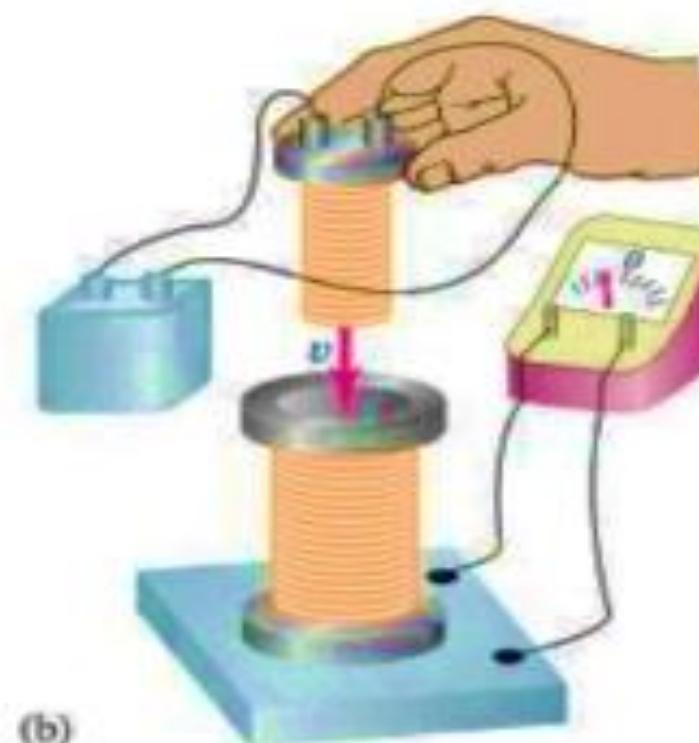
# Electromagnets

- Arranging wire in a coil and running a current through produces a magnetic field that looks a lot like a bar magnet
  - called an electromagnet
  - putting a real magnet inside, can shove the magnet back and forth depending on current direction: called a solenoid



# Induced Current

- The next part of the story is that a *changing* magnetic field produces an electric current in a loop surrounding the field
  - called electromagnetic induction, or Faraday's Law



(a)

(b)

(c)

# The Electromagnetic Connection

- A *changing* magnetic field produces an electric field, and a changing electric field produces a magnetic field.
- Electric and Magnetic fields can produce forces on charges
- An *accelerating* charge produces electromagnetic waves (radiation)
- Both electric and magnetic fields can transport energy
  - Electric field energy used in electrical circuits, e.g., released in lightning
  - Magnetic field carries energy through transformer, for example