Magnetism and Electromagnetic Induction

Nikoletta Kósa
Department of Biophysics and Radiation Biology
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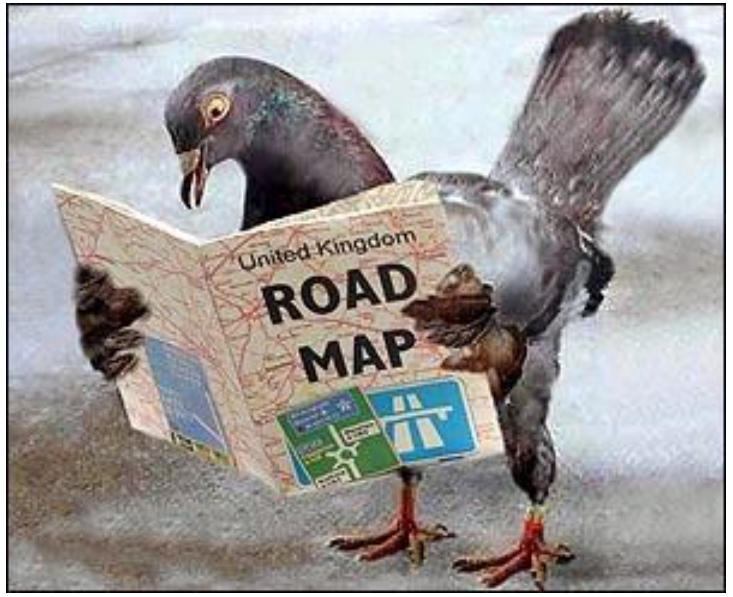
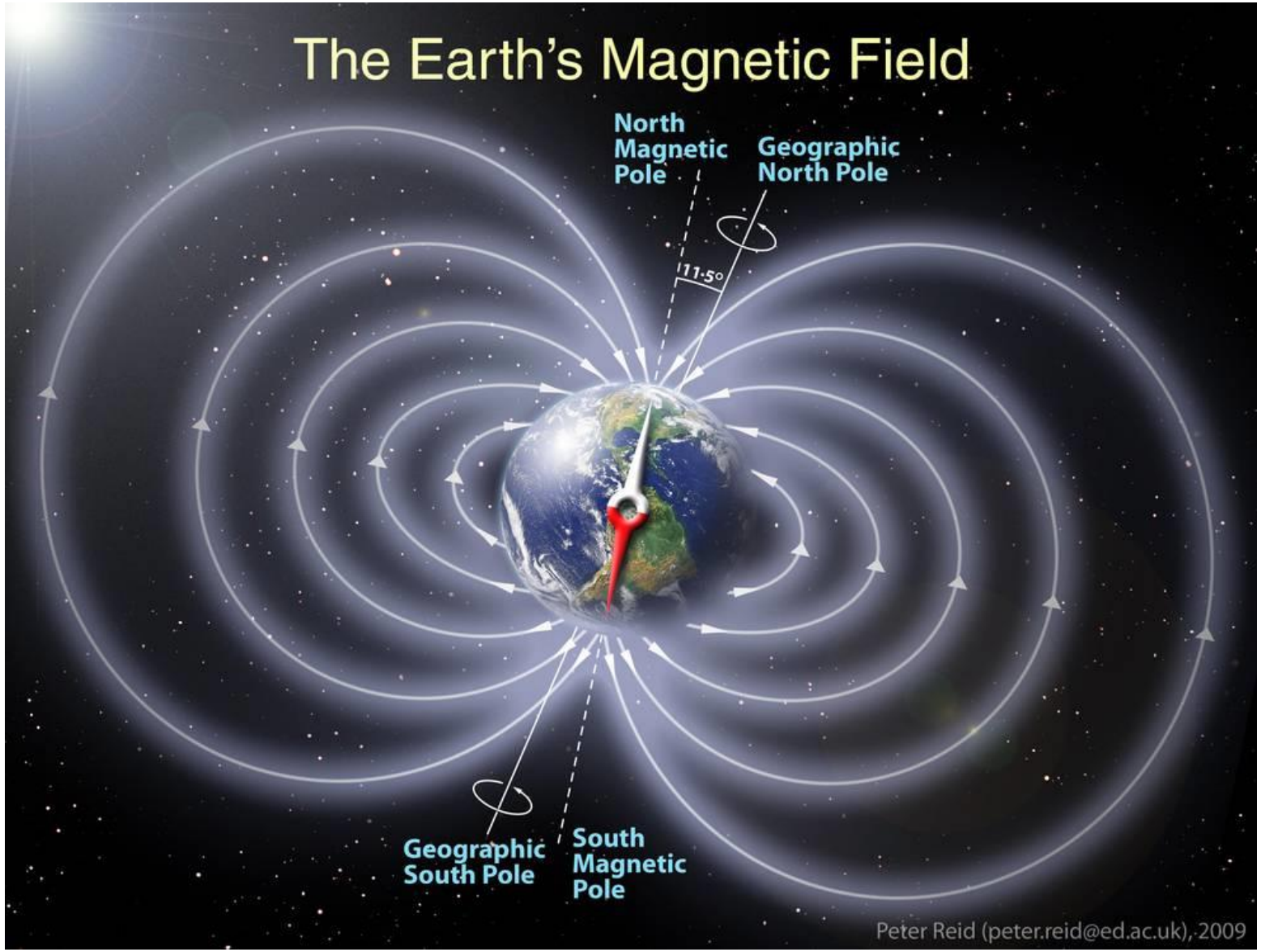
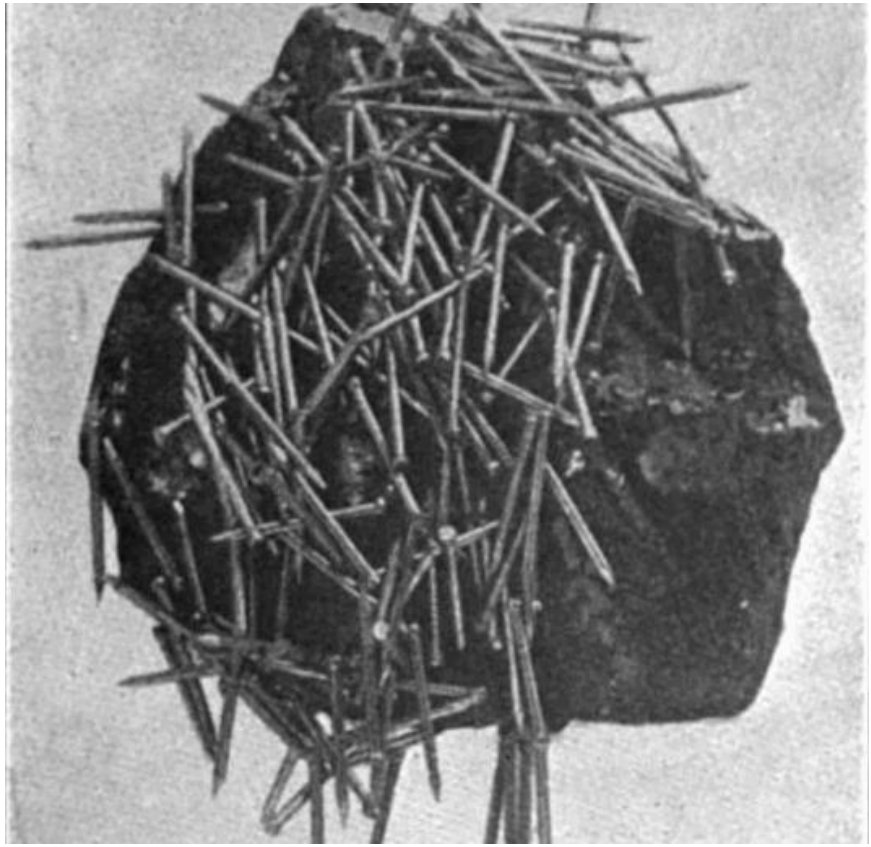


How Animals Sense Magnetism


The Earth's Magnetic Field
North Magnetic Pole
Geographic North Pole
11·5°
Geographic South Pole
South Magnetic Pole
Peter Reid (peter.reid@ed.ac.uk), 2009

Natural magnetism

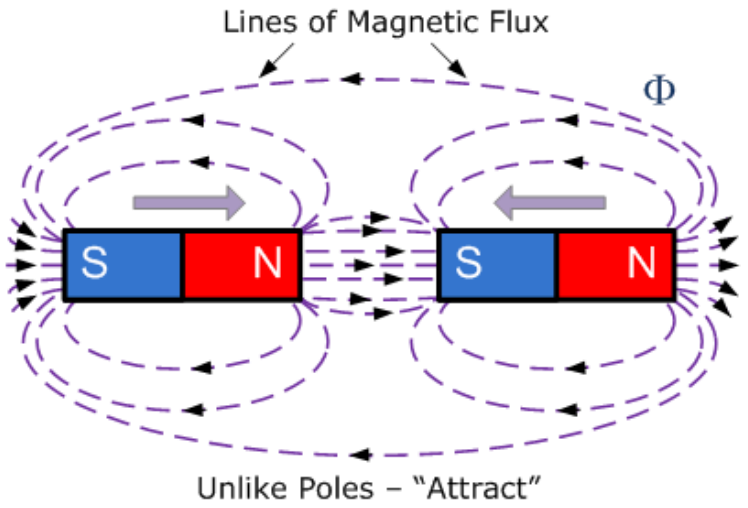


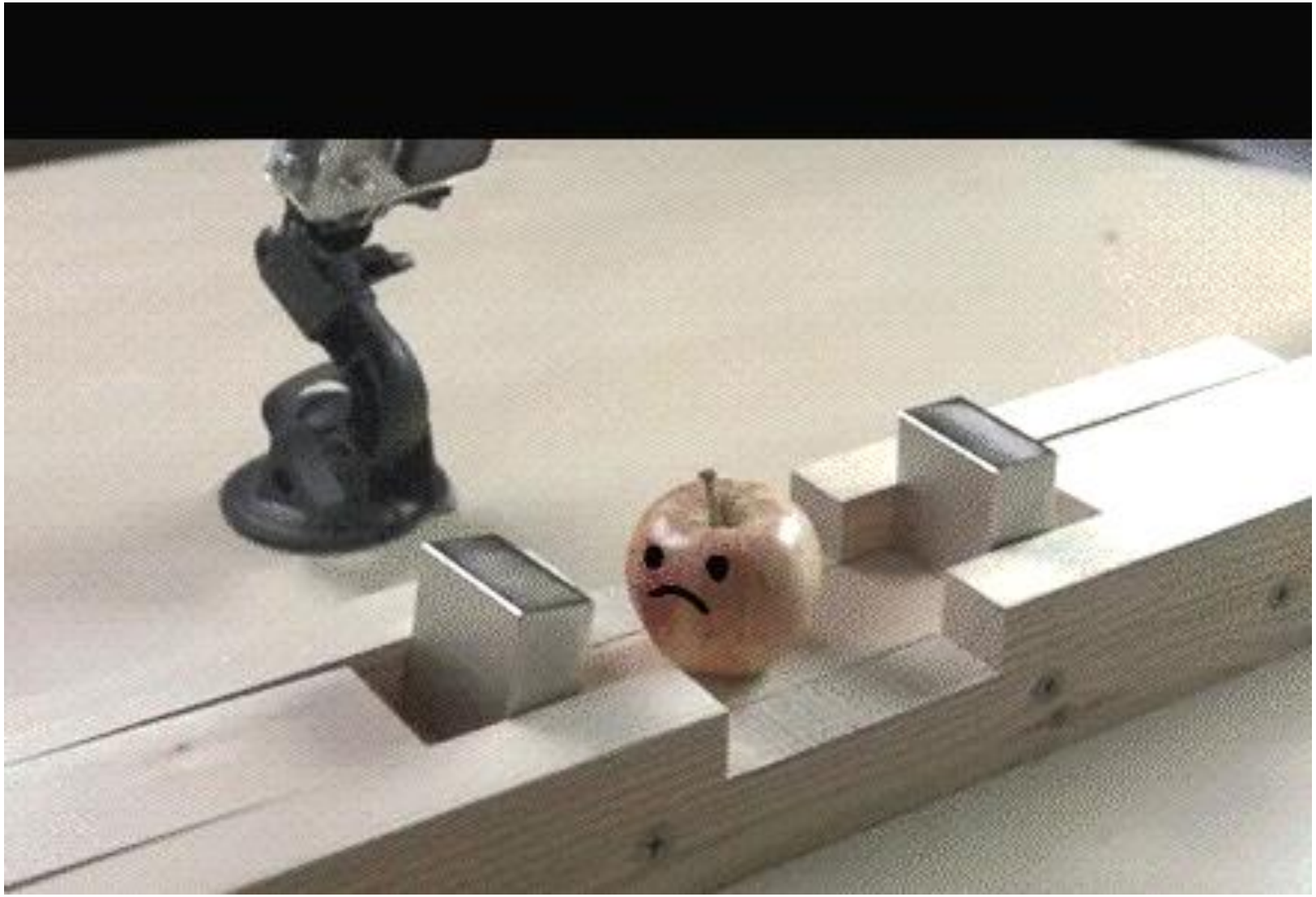
lodeston

magnetit

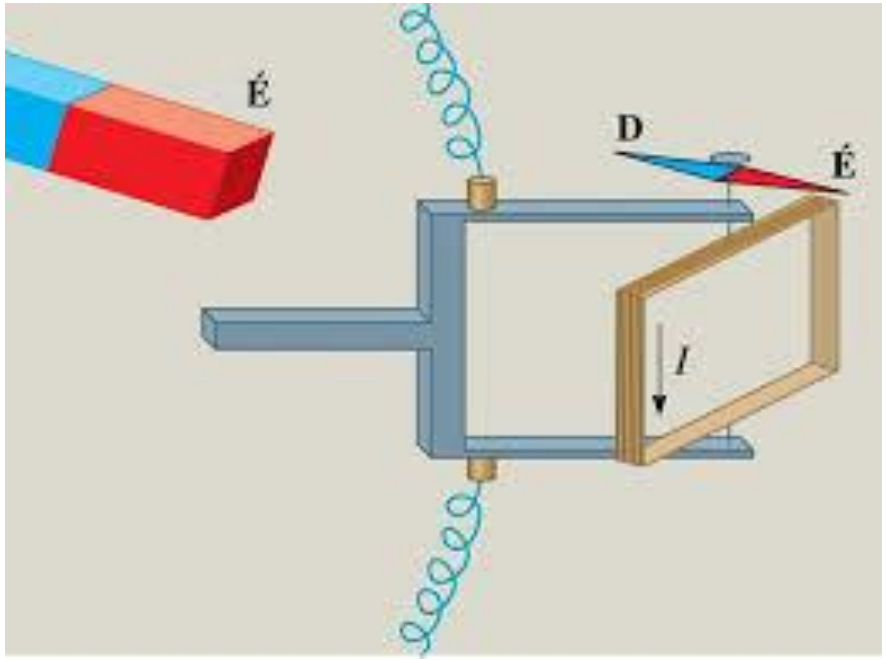
Ancient compass, China, 220 BC

Magnetic Field of Magnets
Interaction Between Magnetic Poles





Magnetic Flux Density

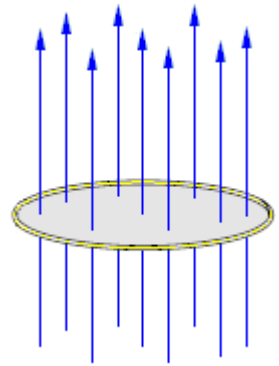


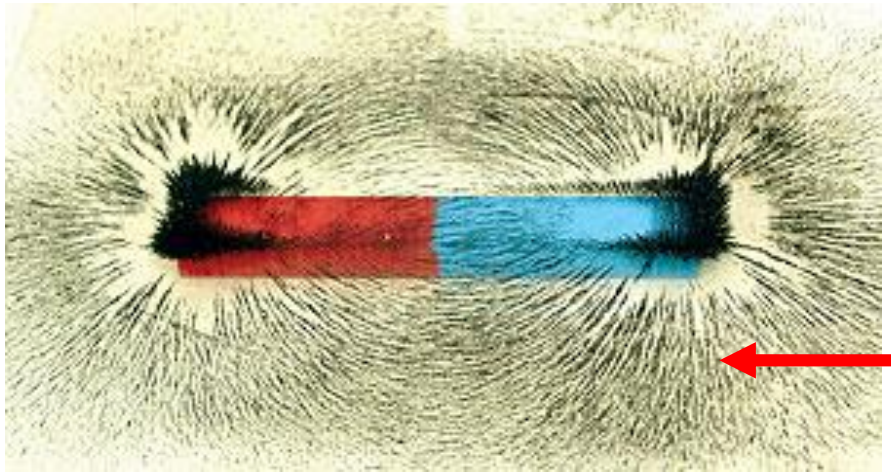
$$M_{MAX} \sim A \times I \times N$$

$$B = \frac{M}{N \times I \times A} \qquad \text{T (Tesla)}$$

Magnetic flux

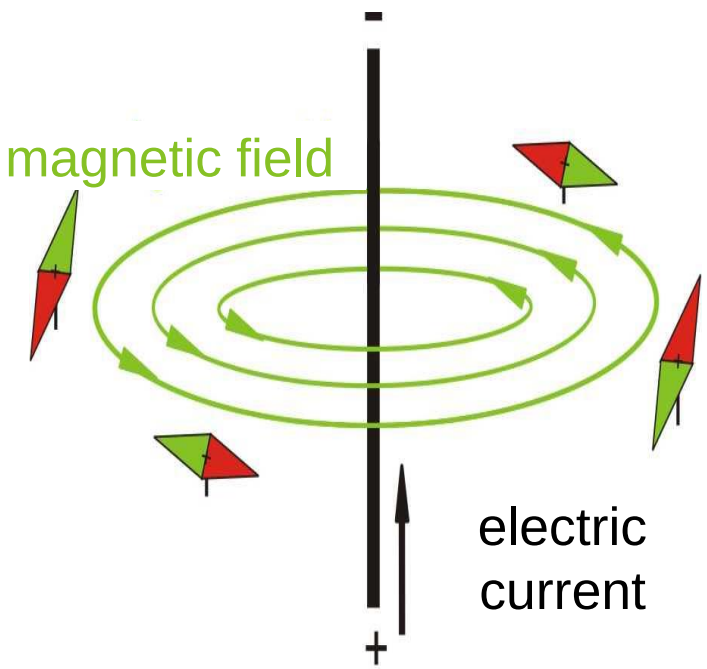
$$\Phi = B \times A \qquad \text{Wb (Weber)}$$

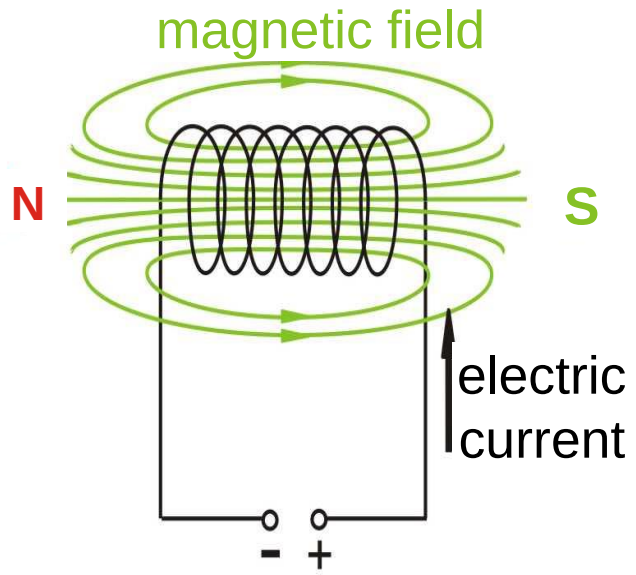




Magnetic field lines

The Magnetic Effect of Electric Current



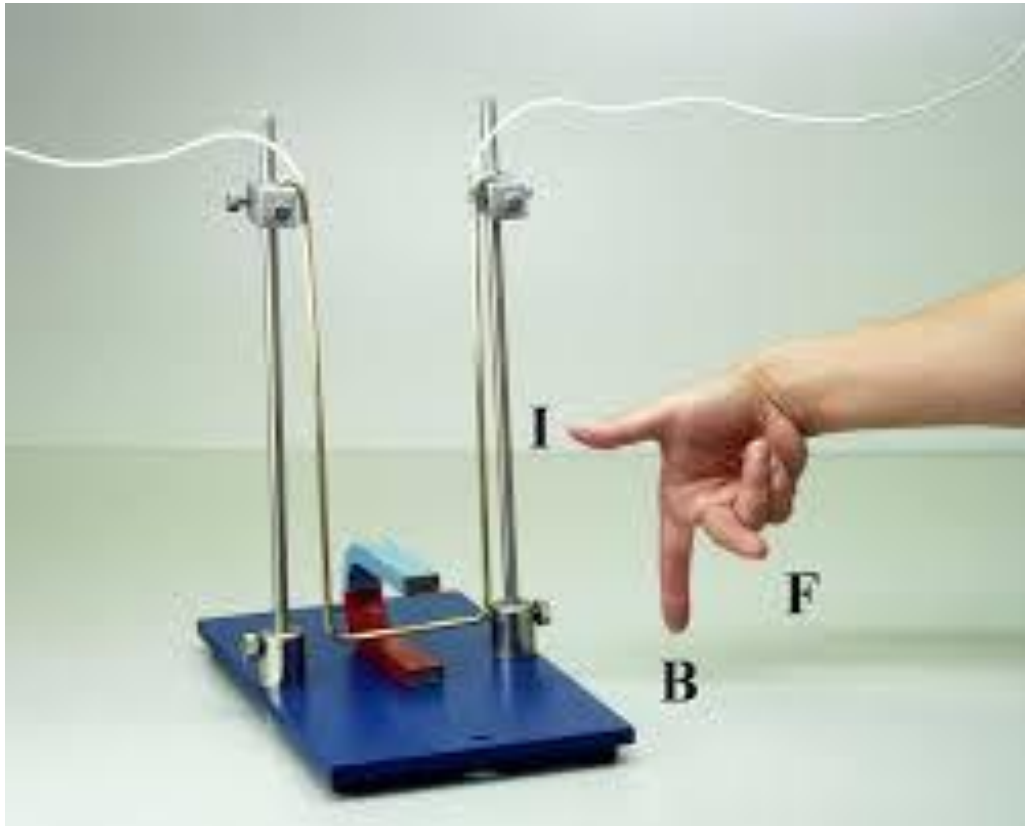


$$B = \frac{\mu_0}{2\pi} \times \frac{I}{r}$$

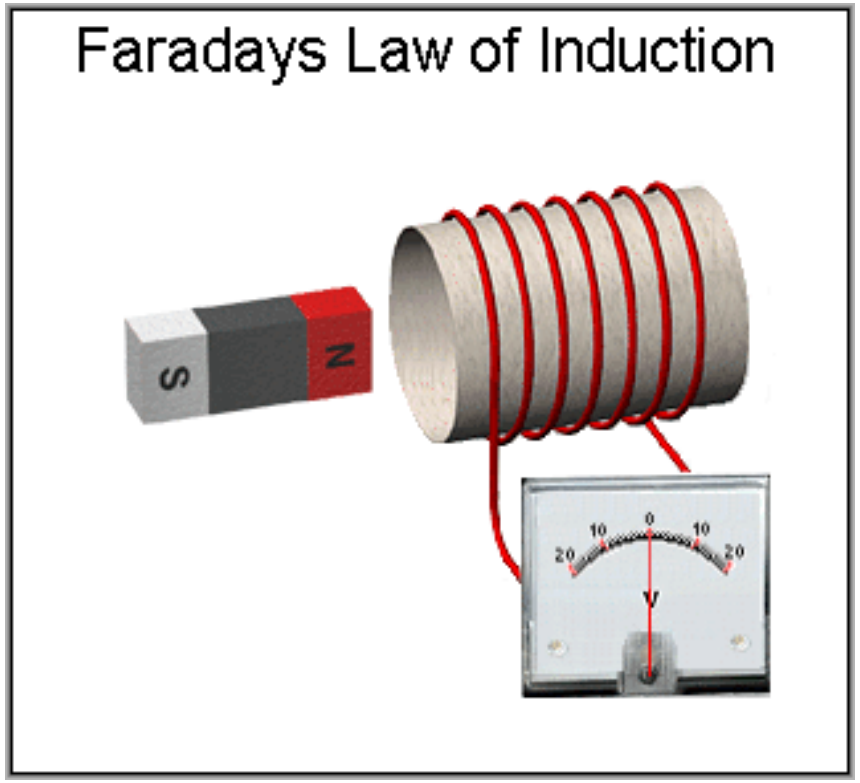
$$B = \mu_0 \times \frac{I \times N}{l}$$

- Ferromagnets
- Paramagnets
- Diamagnets

Lorentz Force



Electromagetic Induction
(motional)



$$U = N \times \frac{\Delta\Phi}{\Delta t}$$

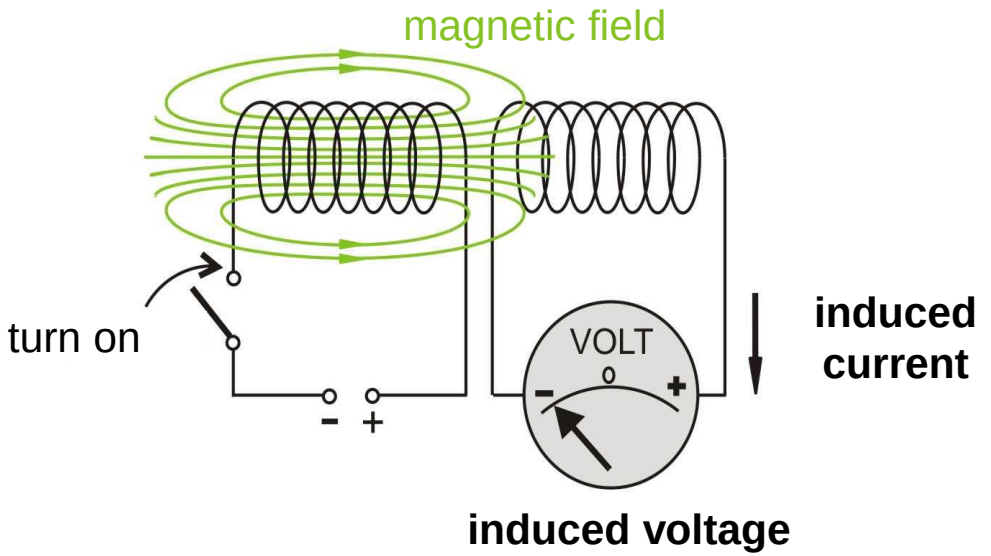
Neumann's Law

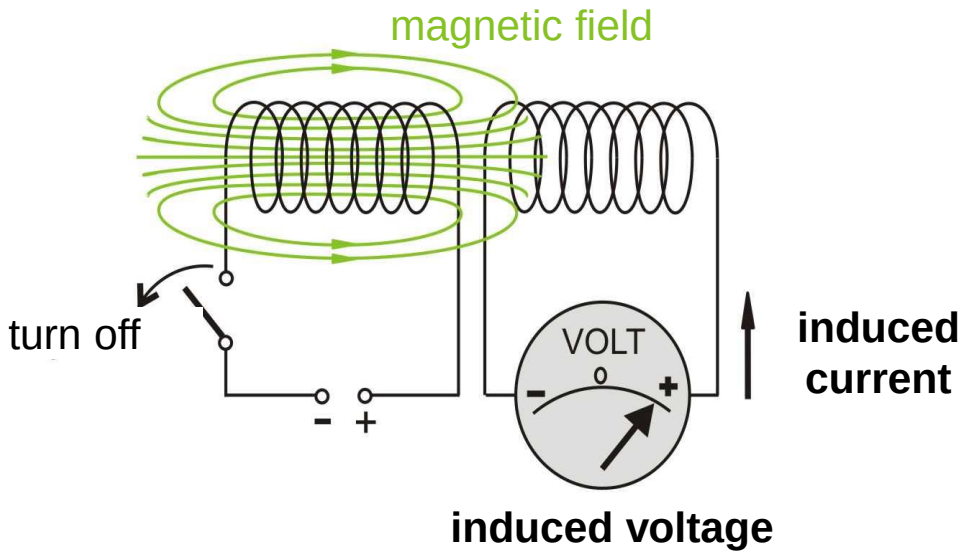
$$U = B \times l \times v$$

Lenz's Law

$$U = -B \times l \times v$$

Induced Electric Field





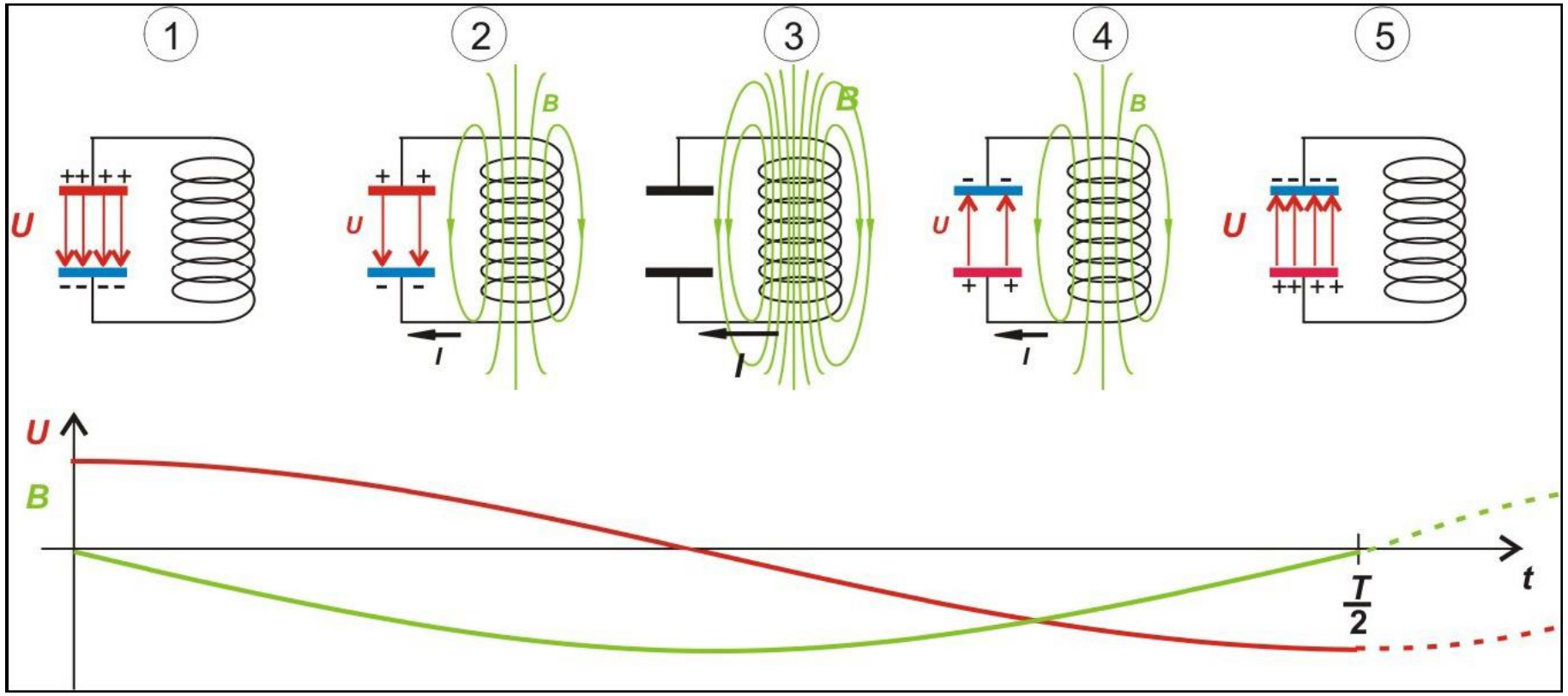
$$U = L \times \frac{\Delta I}{\Delta t}$$

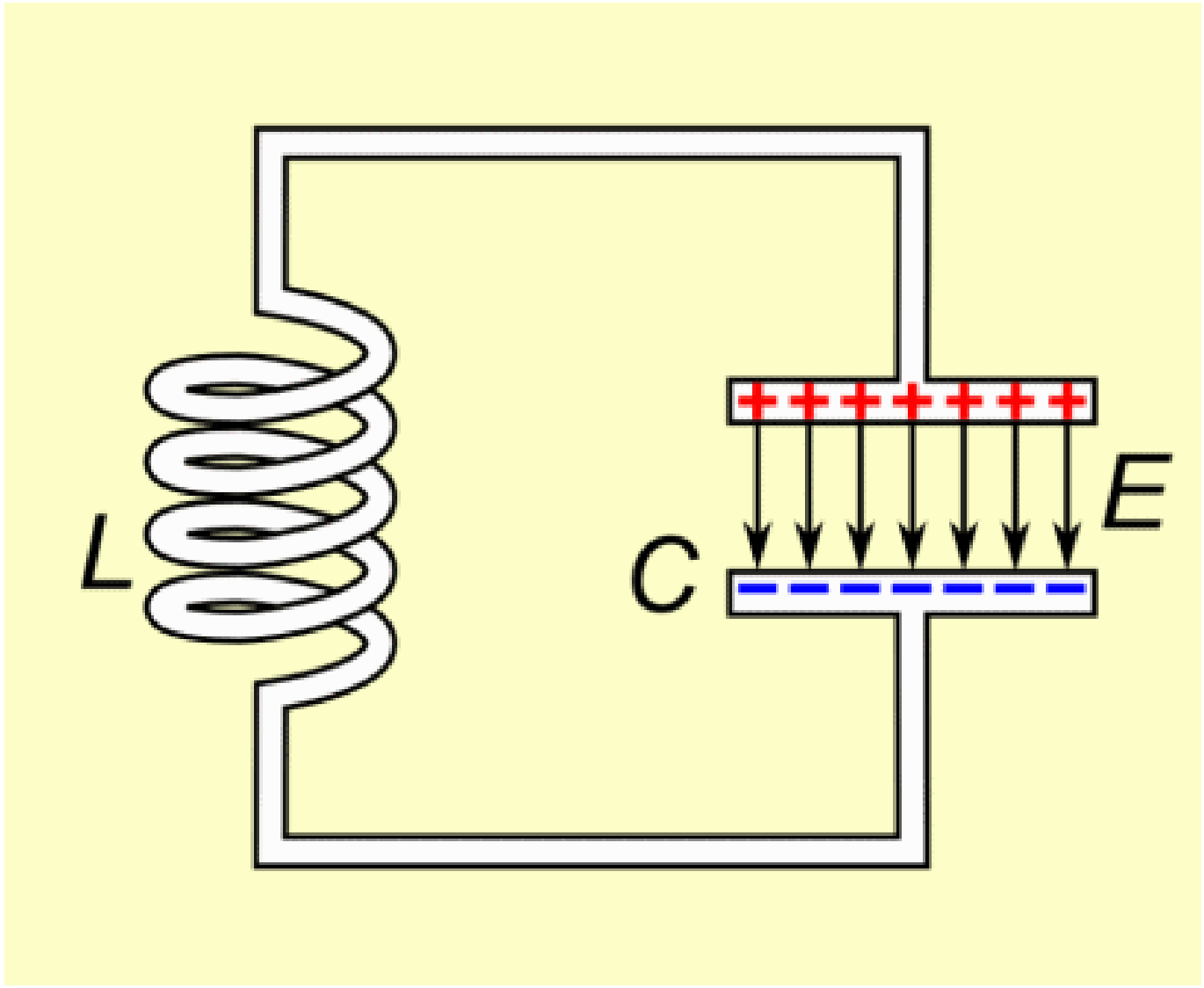
$$L = U \times \frac{\Delta t}{\Delta I}$$

H (Henry)

$$W = \frac{1}{2} \times L \times I^2$$

LC-Circuit




L
C
E

Problems:

1. Which quantity characterizes the strength of a magnet?

magnetic moment

2. Compare the electric and magnetic interactions. Which statement is correct?
   A: Like electric charges attract but like magnetic poles repel.
   B: While electric charges may exert attractive or repulsive force, magnets may exert only attractive.
   C: Electric charges can be isolated from each other but magnetic poles cannot.
   D: Magnetic poles can be isolated from each other but electric charges cannot.

3. Which quantity characterizes the strength of a magnetic field (sometimes called magnetic field by itself)?

magnetic flux density (*B*)

4. What is the SI unit of magnetic flux density (*B*)?
   A: tesla (T) **B**: volt (V) **C**: ampere (A) **D**: Siemens (S)

5. A magnet is placed in an external magnetic field. By what factor would the strength of the interaction between them increase if both the magnet's moment and the magnetic flux density of the external field is doubled?
   A: 1 **B**: 2 **C**: 4 **D**: 8

6. How can a nearly homogeneous magnetic field be created?
   a conductor coil with current flowing through it

7. What is the phenomenon "electromagnetic induction"?
   A:. Creating a magnetic field with a coil.
   B: The magnetization of a body.
   C: Creating an electric field with a changing magnetic field.
   D: The orientation of compasses using an external magnetic field.

8. Consider the second Figure in the paragraph about "electromagnetic induction". In which case is there no electric current induced in the second coil?
   A: There is constant current flowing in the first coil while the second coil is moved toward the first.
   B: There is constant current flowing in the first coil while it is moved toward the second coil.
   C: Both coils are motionless, and an increasing current is flowing in the first.
   D: Both coils are motionless, and a constant current is flowing in the first.

9. What is the name of the phenomenon when a voltage is induced in a coil because of the changing current flowing through it? Self-induction

10. What are the components of an ideal resonant circuit? coil and capacitor (without ohmic resistor)

Thank you!