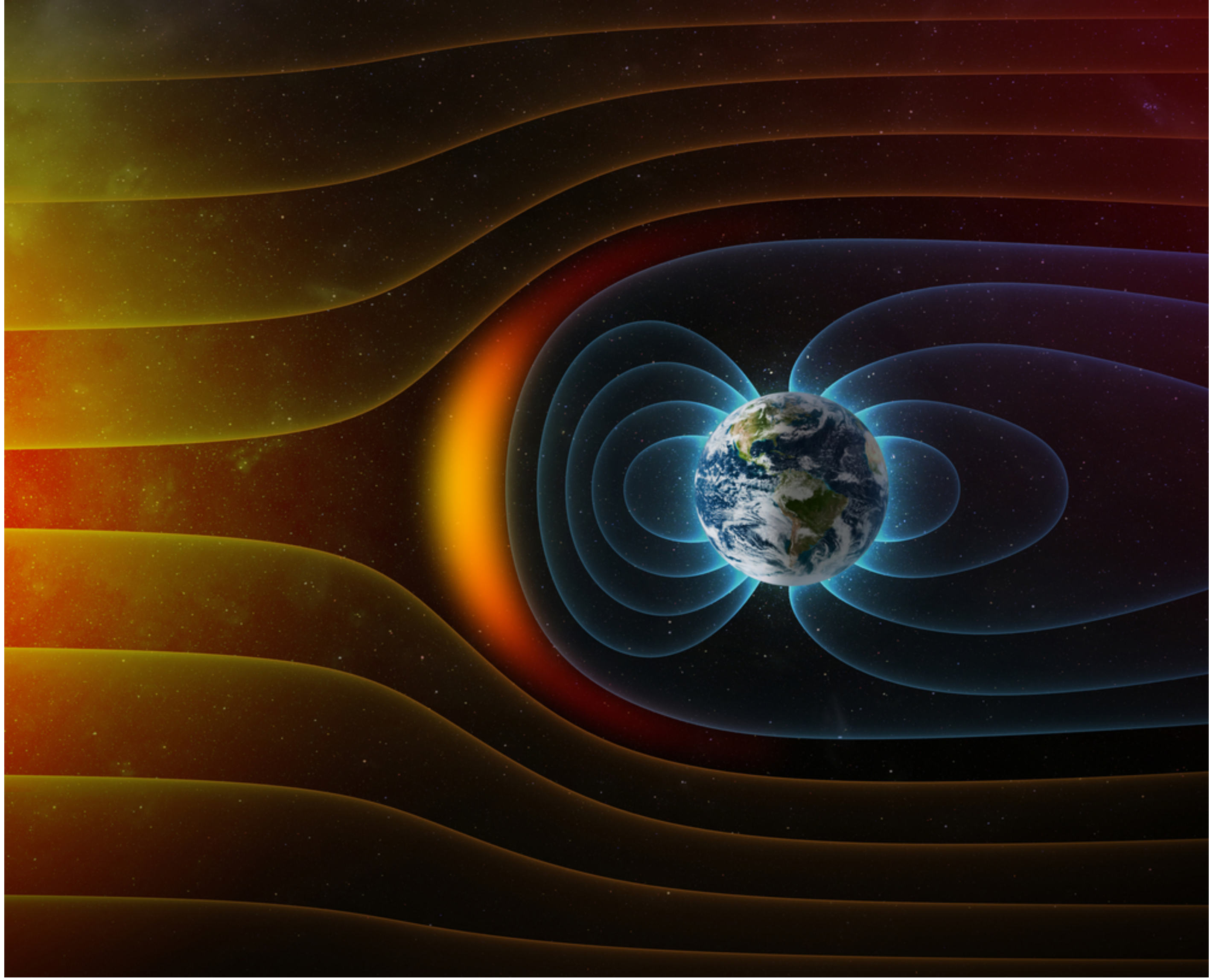
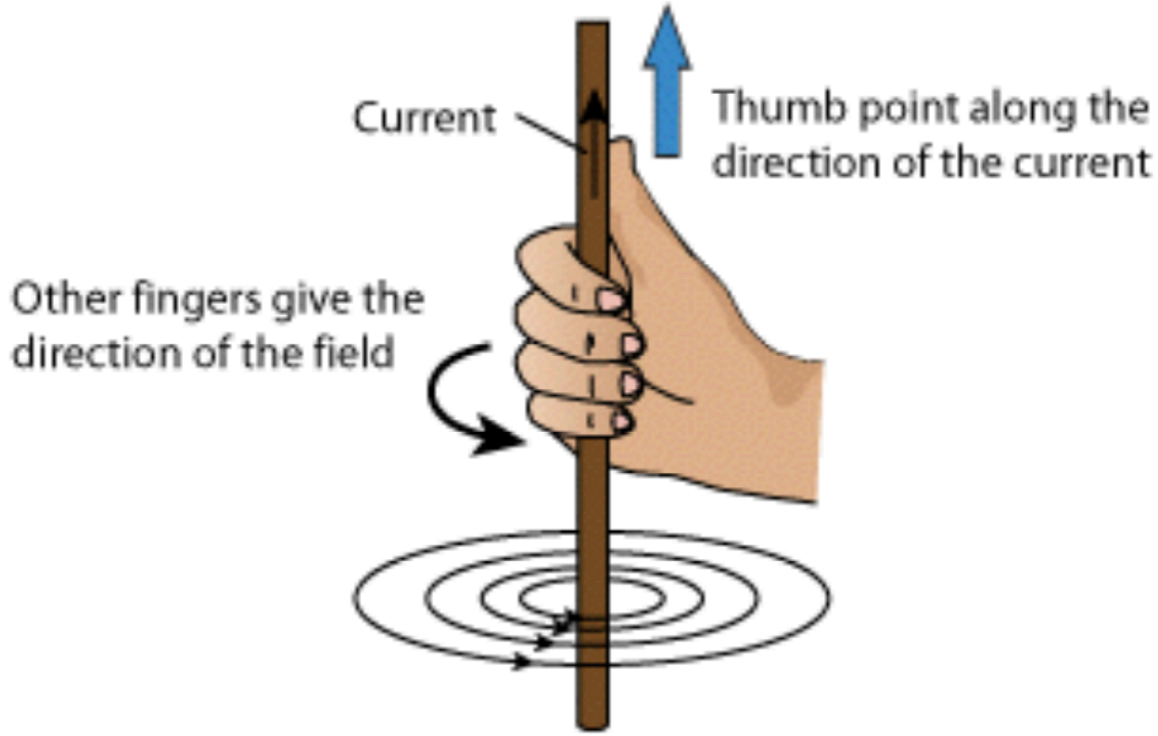
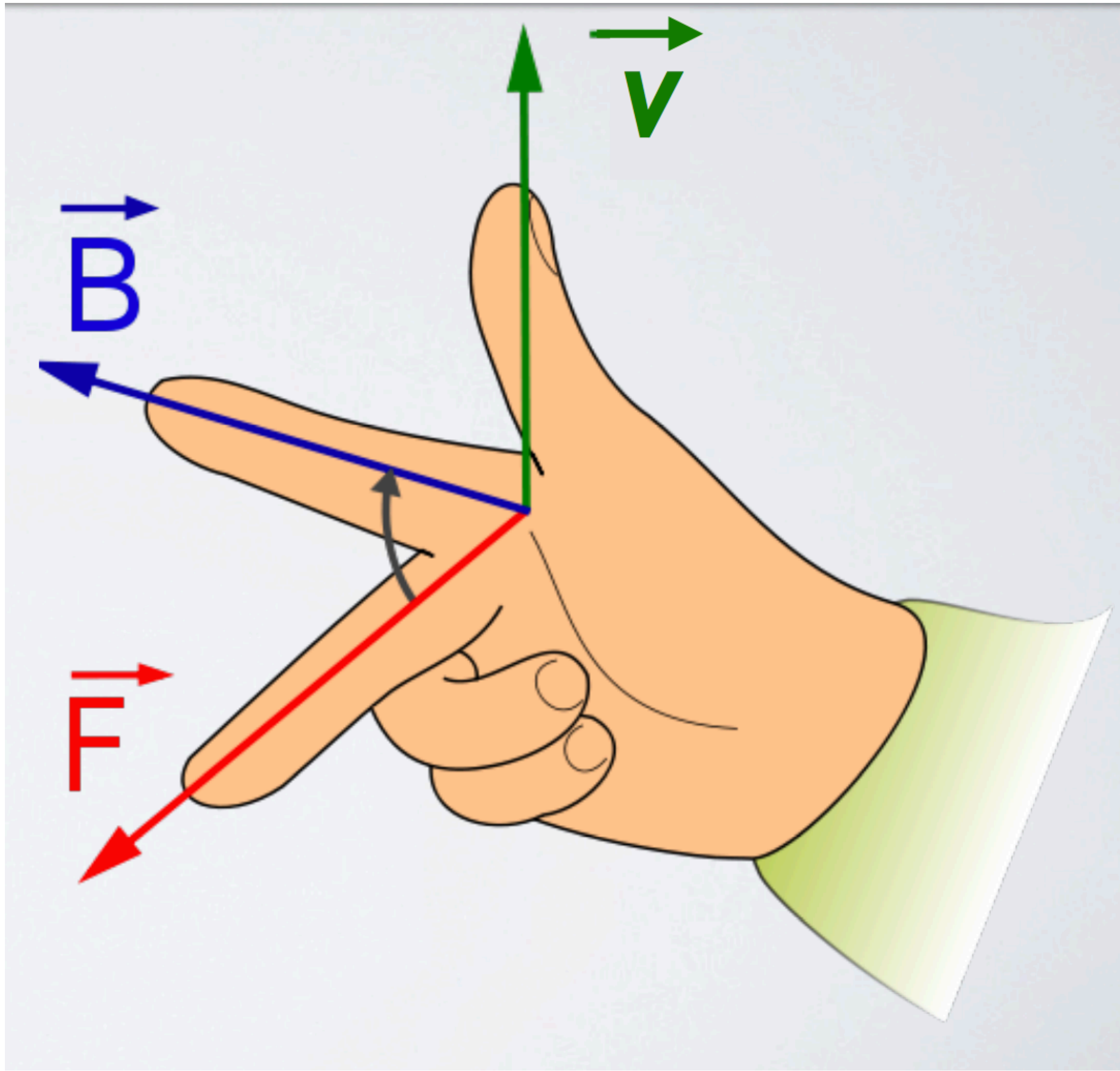
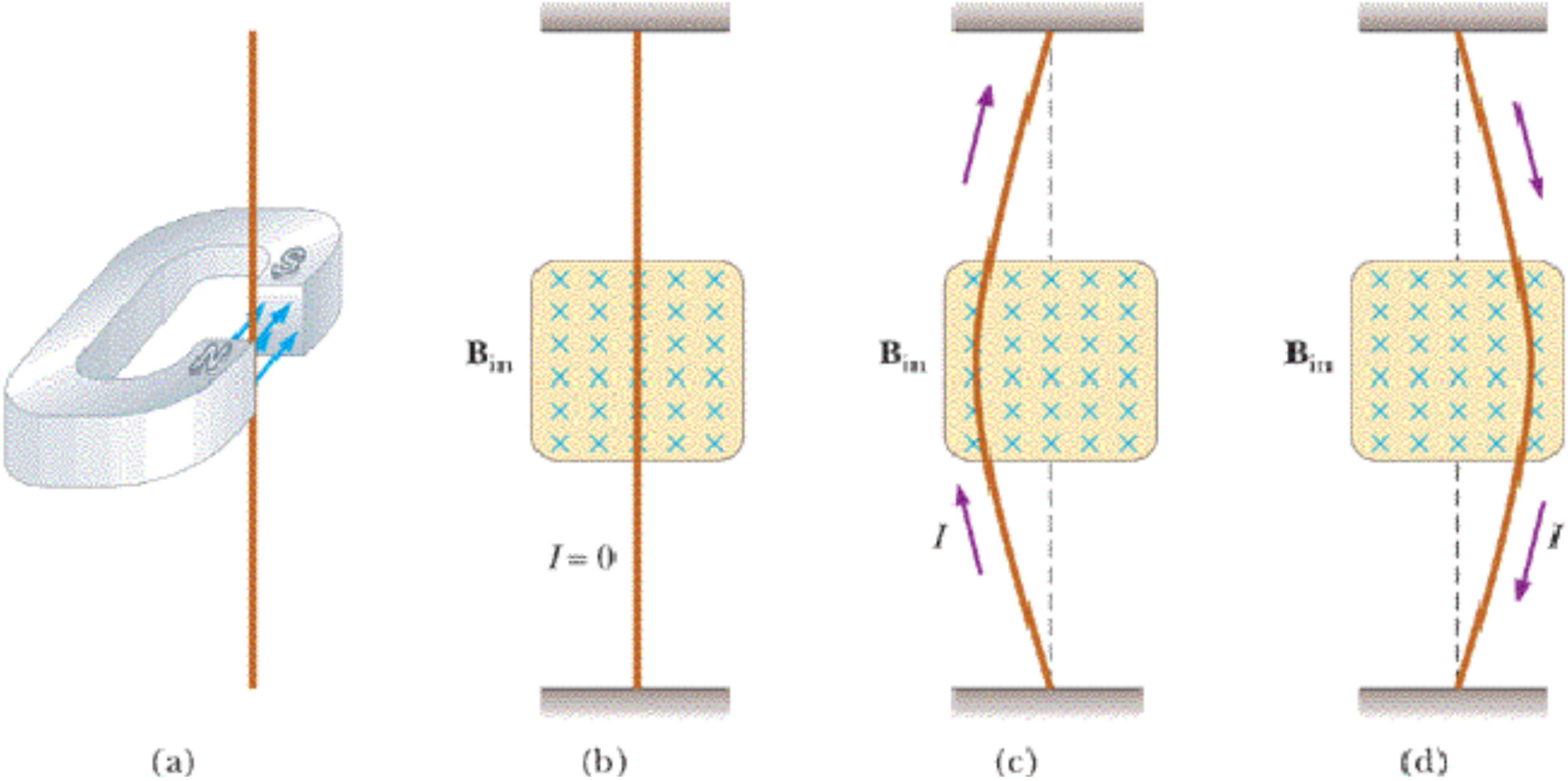


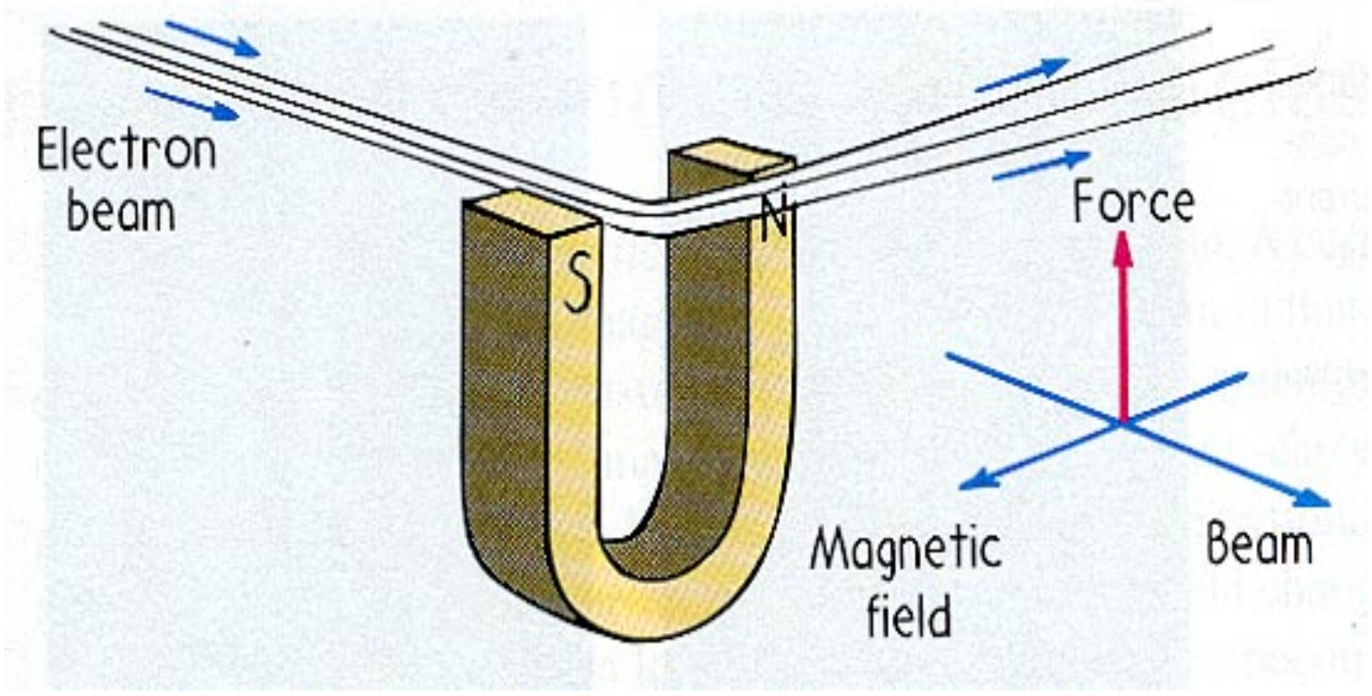


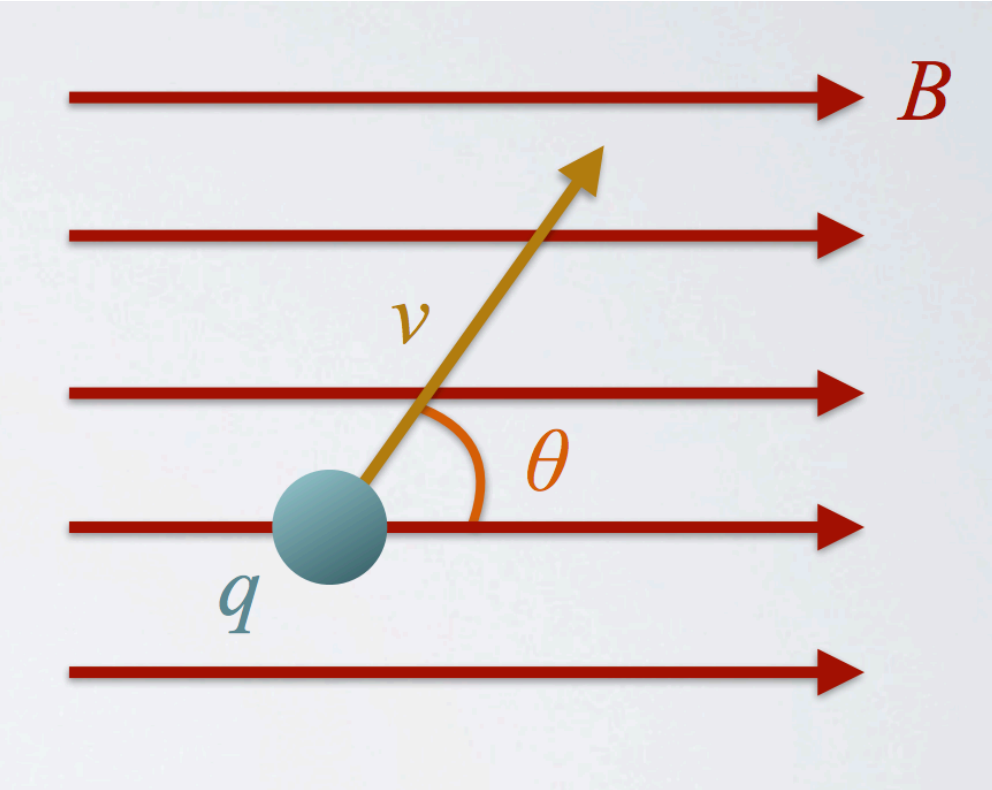
Right Hand Grip Rule



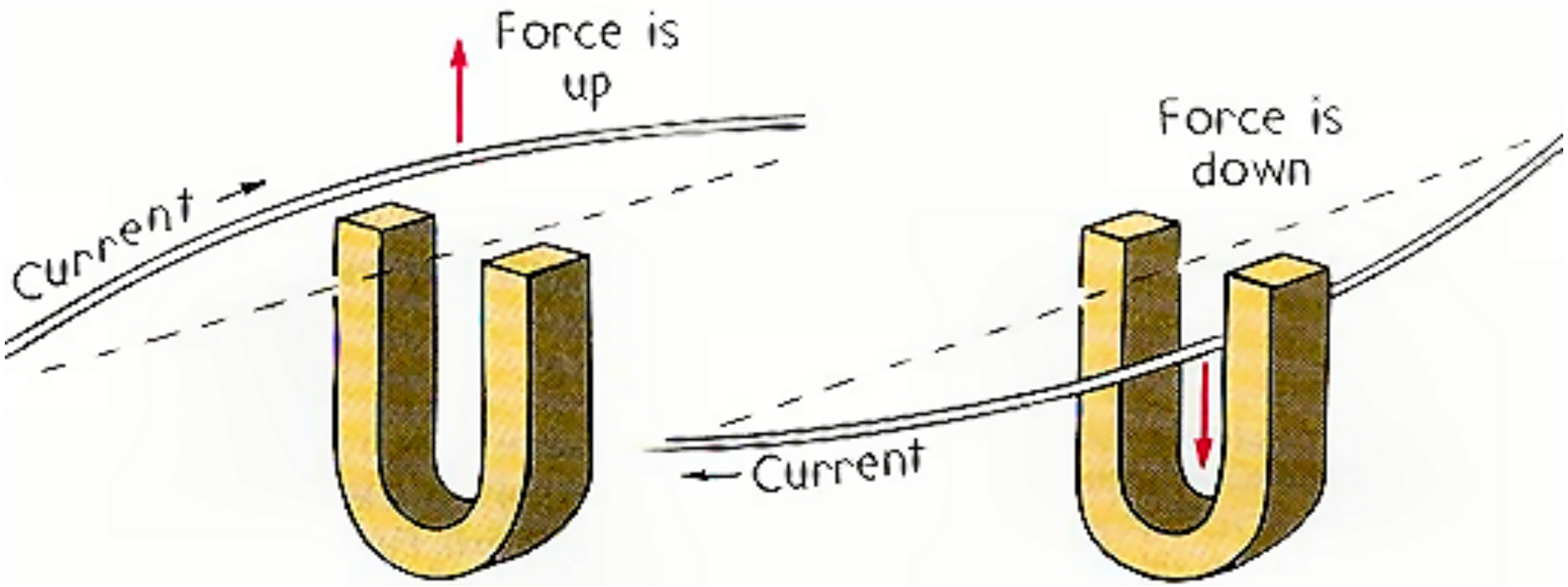


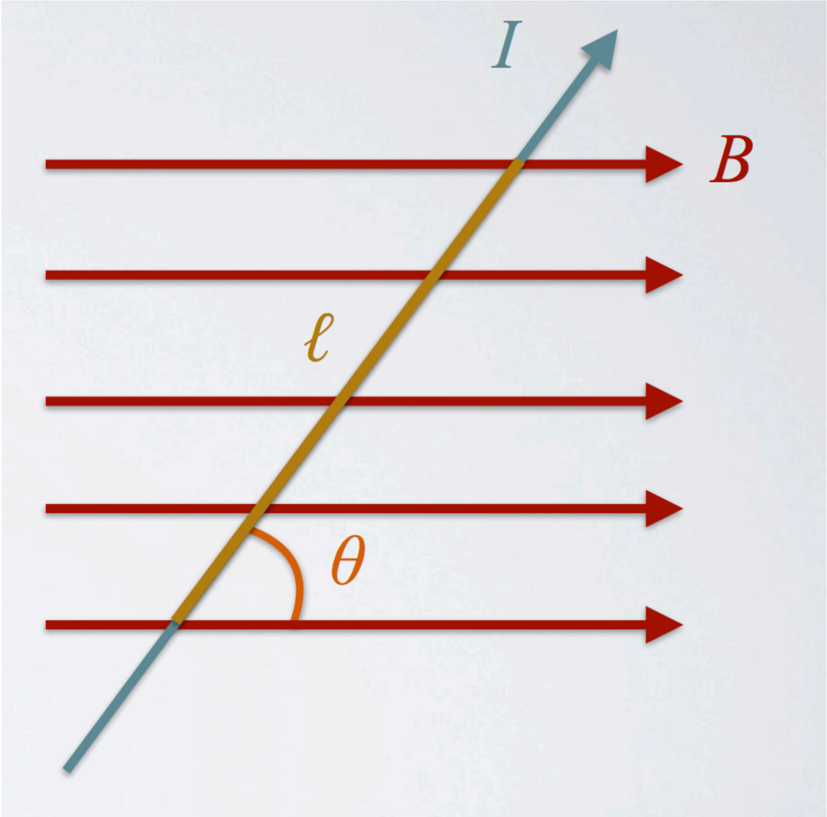
S
N
B_{in}
$I = 0$
B_{in}
I
B_{in}
I
(a)
(b)
(c)
(d)


Electron
beam
S
N
Force
Magnetic
field
Beam


B
v
θ
q

Magnetic Forces on Current Carrying Wires





An proton travels at 2.0×10^7 m/s in a plane perpendicular to a 0.010-T magnetic field. Describe its path. (q_p = 1.6×10-19 C, $m_p = 1.67\times10^{-27}$ kg)

$F = qvB = mv^2/r$

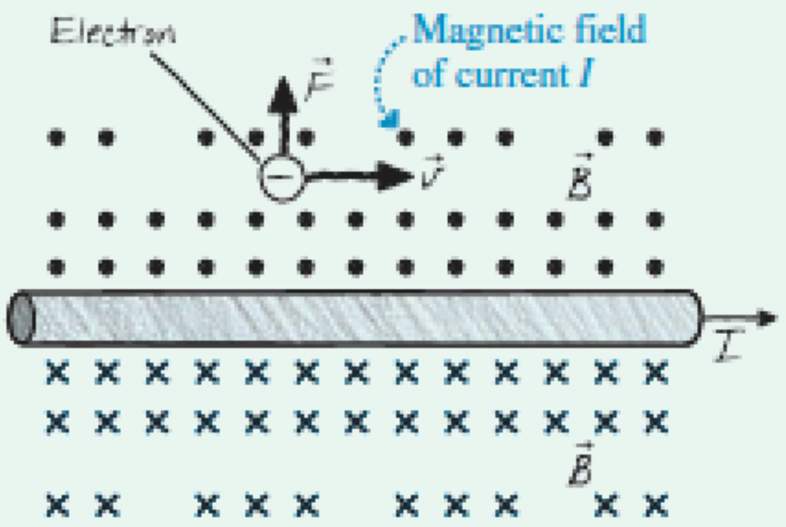
- Answer: circle with radius r = 20.9 m

A long wire carries a 10 A current from left to right. An electron 1.0 cm above the wire is traveling to the right at a speed of 1.0×10^7 m/s. What are the magnitude and the direction of the magnetic force on the electron?

MODEL The magnetic field is that of a long, straight wire.

VISUALIZE **FIGURE 32.38** shows the current and an electron moving to the right. The right-hand rule tells us that the wire's magnetic field above the wire is out of the page, so the electron is moving perpendicular to the field.

FIGURE 32.38 An electron moving parallel to a current-carrying wire.



SOLVE The electron charge is negative, thus the direction of the force is opposite the direction of $\vec{v} \times \vec{B}$. The right-hand rule shows that $\vec{v} \times \vec{B}$ points down, toward the wire, so $\vec{F}$ points up, away from the wire. The magnitude of the force is $|q|vB = evB$. The field is that of a long, straight wire:

$$B = \frac{\mu_0 I}{2\pi d} = 2.0 \times 10^{-4}\ \text{T}$$

Thus the magnitude of the force on the electron is

$$F = evB = (1.60 \times 10^{-19}\ \text{C})(1.0 \times 10^7\ \text{m/s})(2.0 \times 10^{-4}\ \text{T})$$
$$= 3.2 \times 10^{-16}\ \text{N}$$

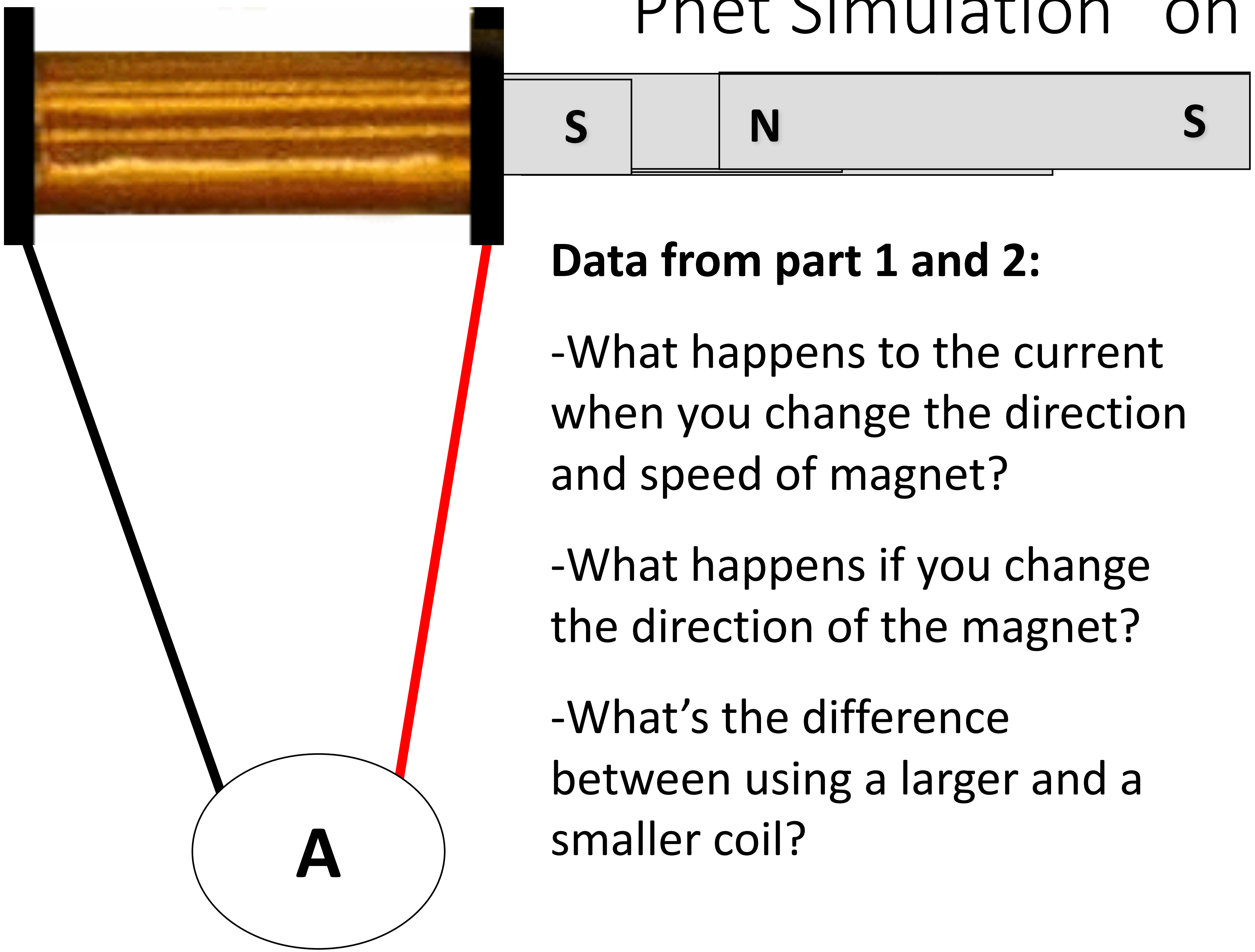
The force on the electron is $\vec{F} = (3.2 \times 10^{-16}\ \text{N, up})$.

ASSESS This force will cause the electron to curve away from the wire.

1: Solenoids

2: Look up "Faraday's Law Phet Simulation" on Google

3: Copper tube



Data from part 1 and 2:

-What happens to the current when you change the direction and speed of magnet?

-What happens if you change the direction of the magnet?

-What's the difference between using a larger and a smaller coil?

Conclusion part 1 and 2:
What is necessary to generate a current in some copper coils?

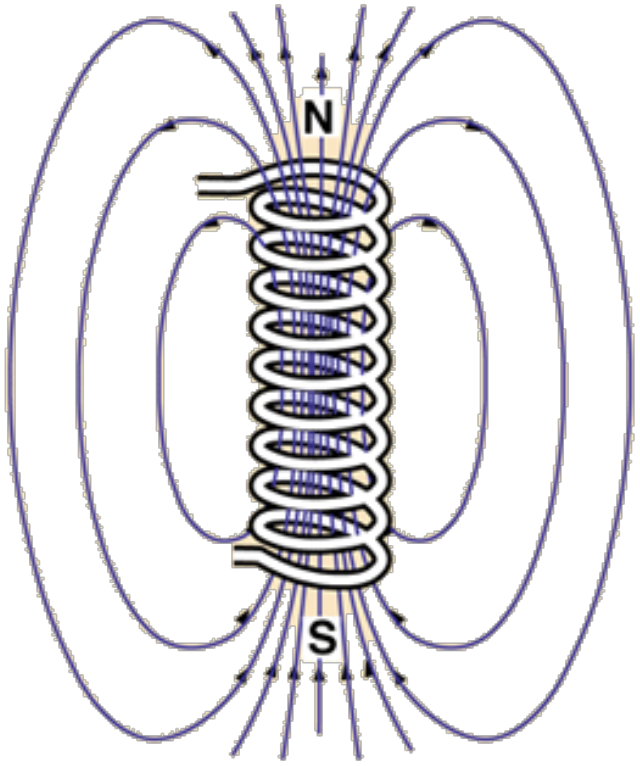
Conclusion part 3:
What's causing the magnets to slow down?

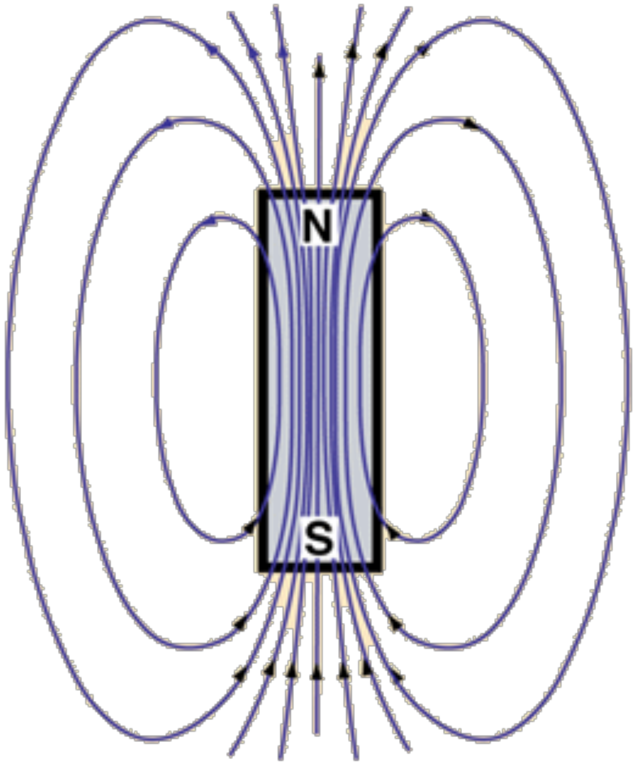
What causes the can to explode and the quarter to shrink?

https://www.youtube.com/watch?v=AXOa66-k9MA

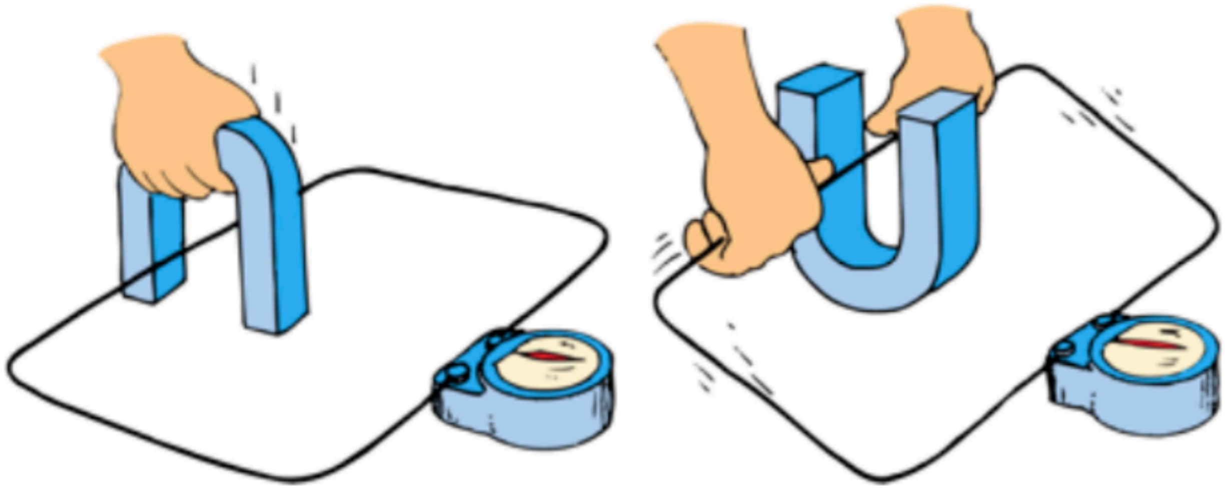
Right hand rule to find Magnetic Field in a solenoid or electromagnet

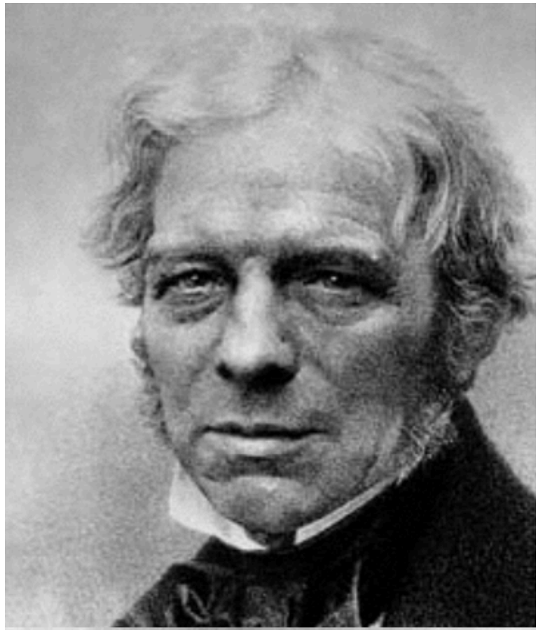
1. Point your thumb in the direction of the current
2. The magnetic field points in the direction the rest of your fingers curve toward (upward)
3. Because the field lines leave the top end of solenoid, the top end is the **N**orth pole and the bottom end is the **S**outh pole

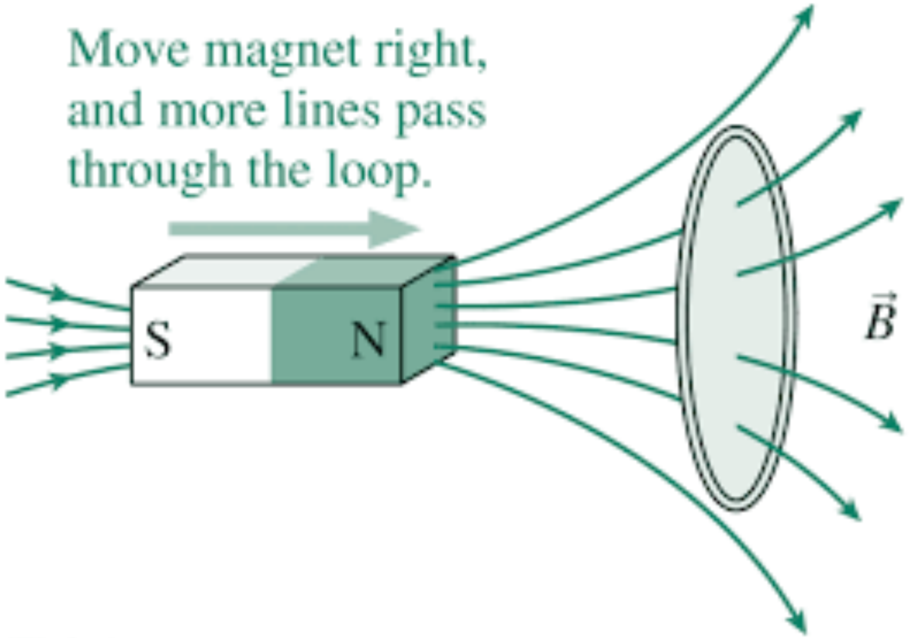




Michael Faraday from England (top) and James Henry from the USA (bottom) simultaneously discovered in 1831 that a changing magnetic field induces a current in a coil of wire



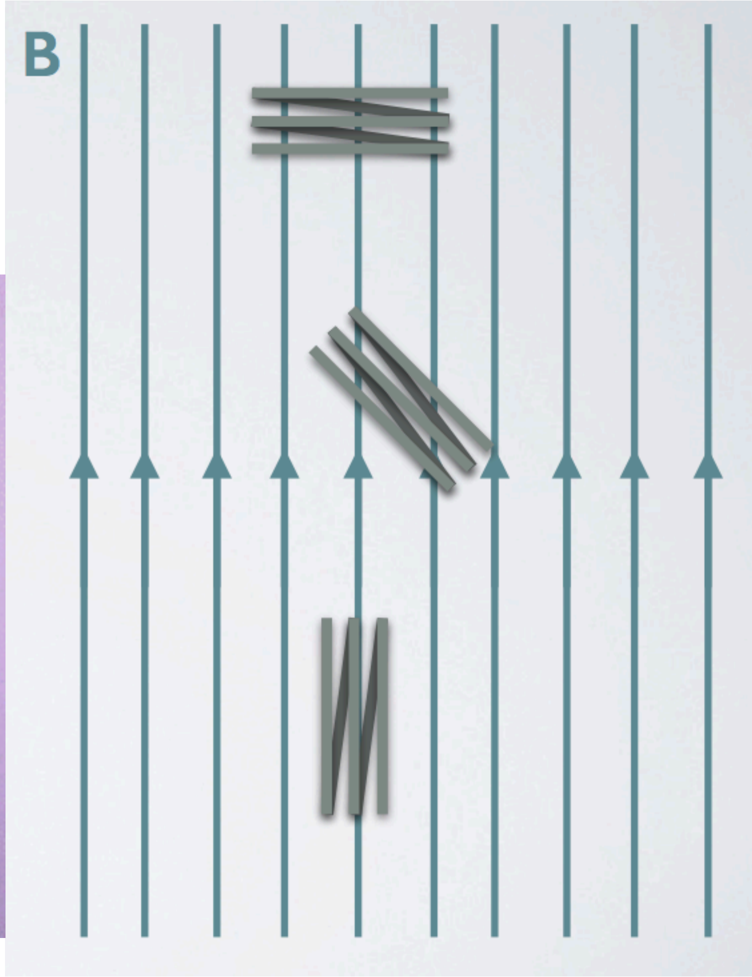




Magnetic field

$$\text{Magnetic flux} = \Phi = B\,A$$

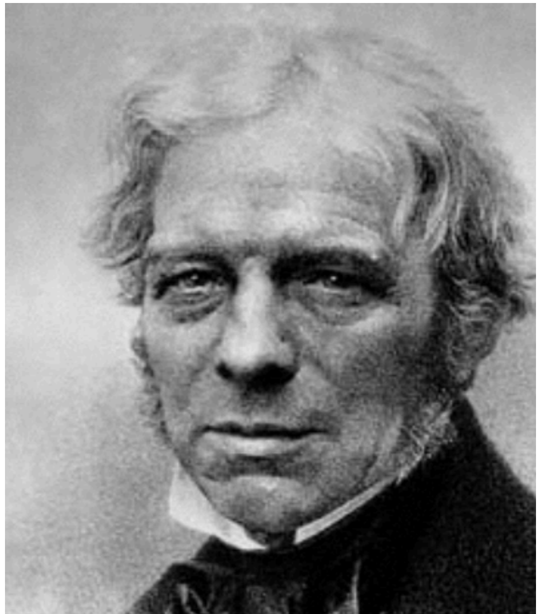
Area perpendicular to magnetic field B

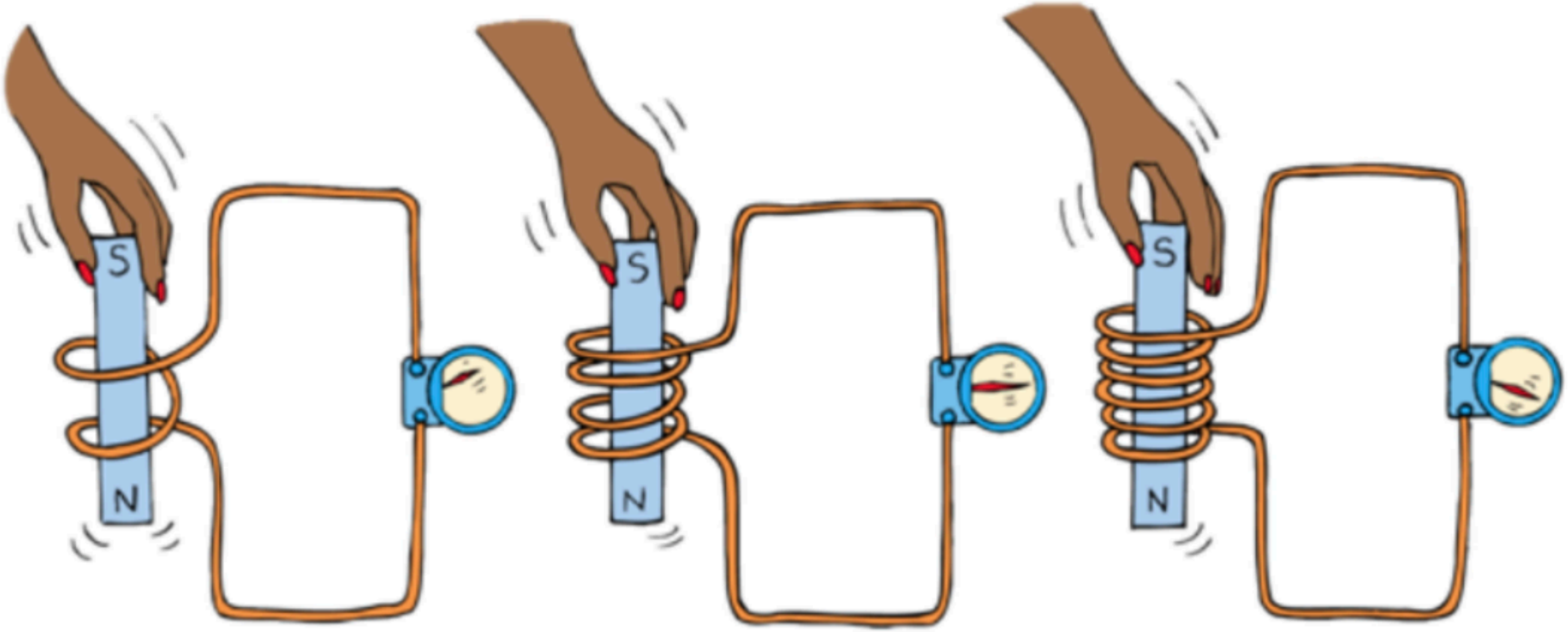


Units of flux = Webers (Wb)

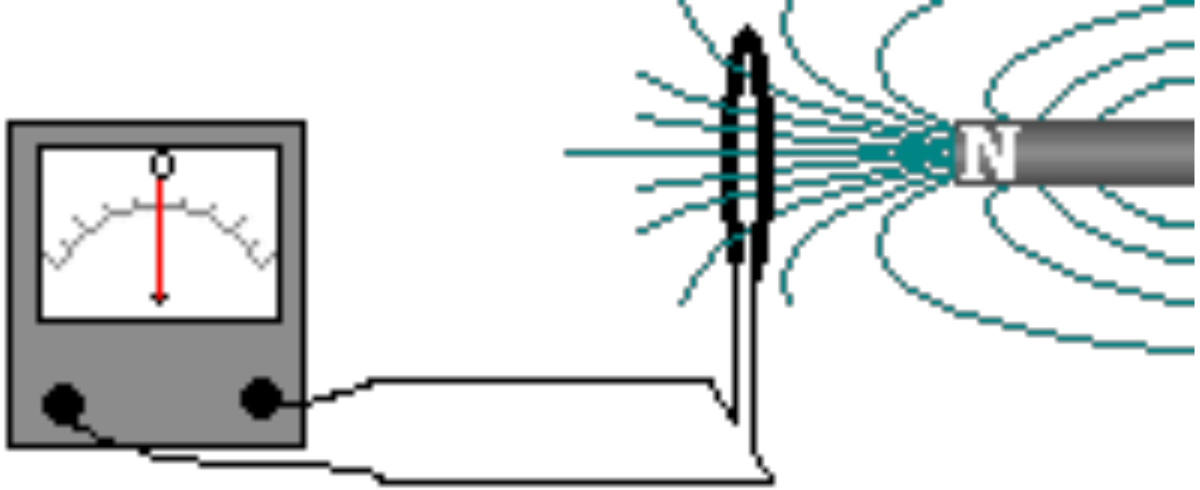
The voltage induced in a coil is proportional to the number of coils times the rate at which the magnetic flux changes inside the coils

Faraday's Law of Induction

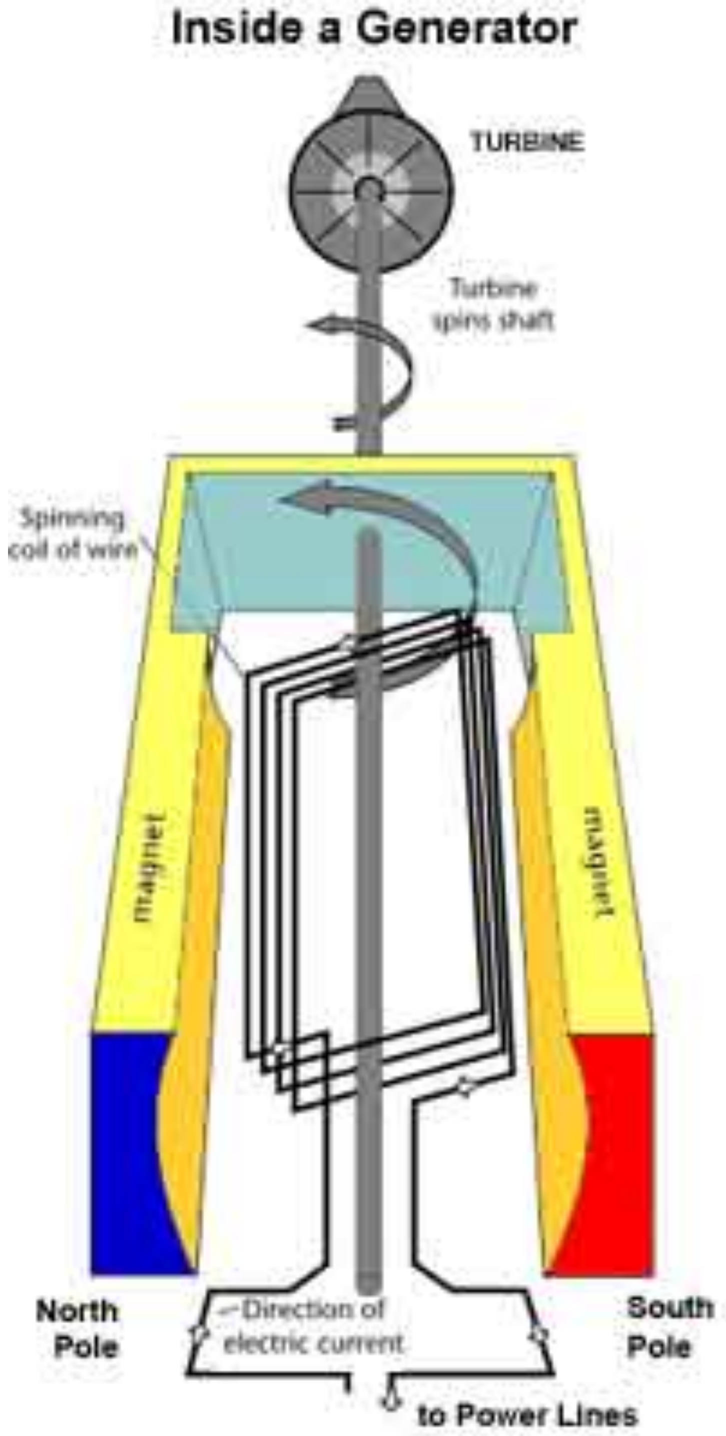


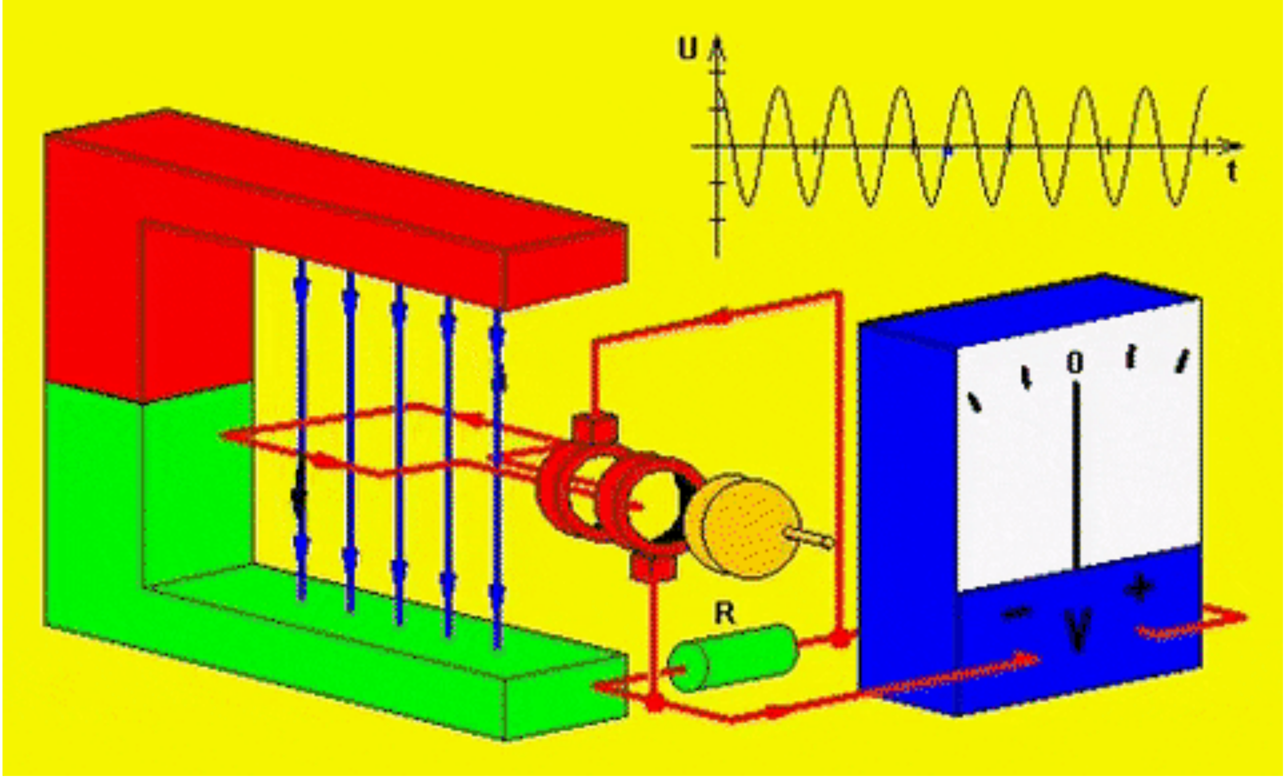


More coils and faster change in flux (faster movement of the magnet or wire) = more voltage generated = more current generated



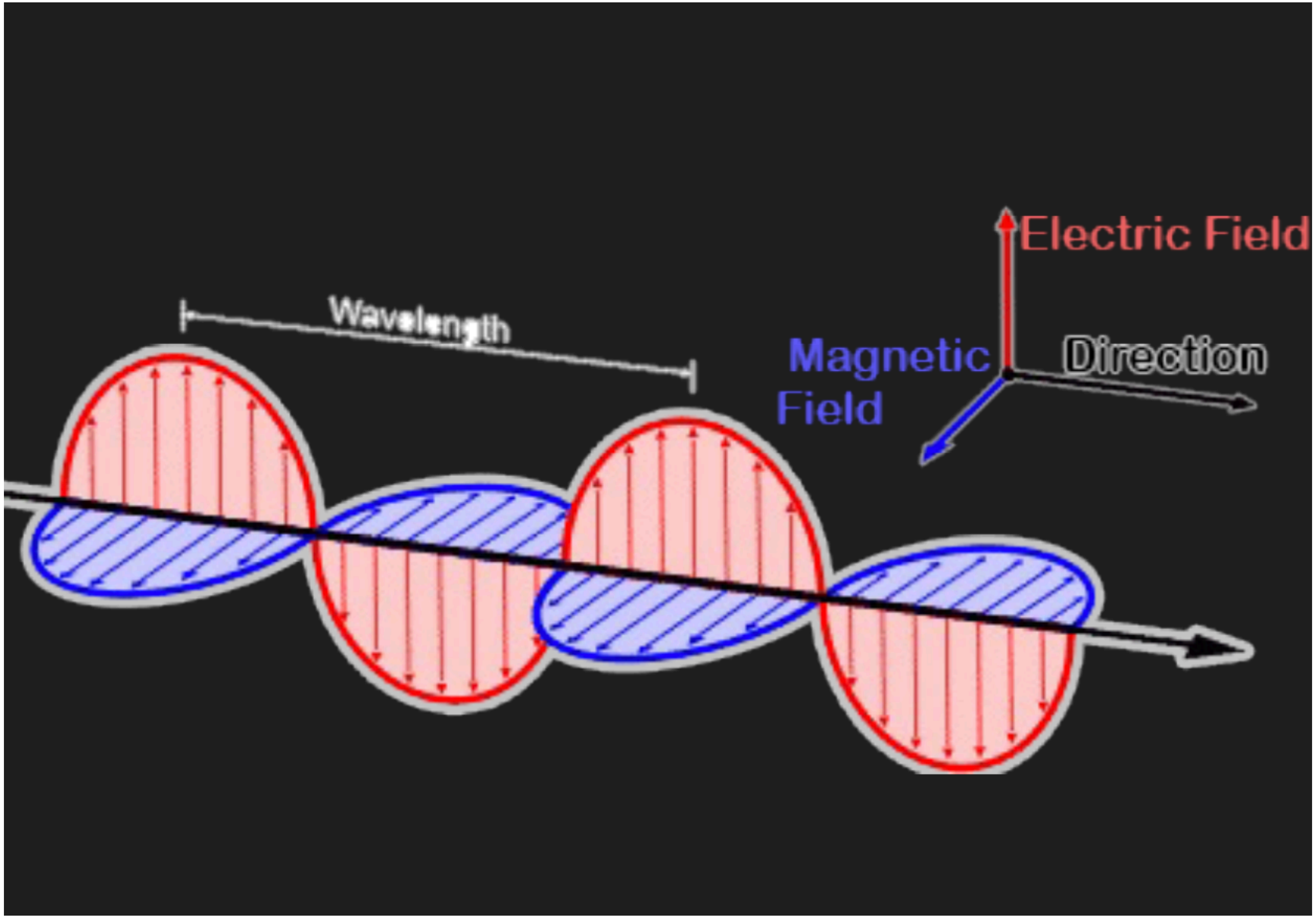
- An ammeter is connected in a circuit of a conducting loop
- When a bar magnet is moved closer to, or farther from, the loop, an electromotive force (emf) or voltage is induced the loop
- The ammeter indicates currents in different directions depending on the relative motion of magnet and loop
- When the magnet stops moving, the current returns to zero as indicated by the ammeter





As the loop rotates, the magnitude and direction of the voltage (and current) change

- One complete voltage cycle is produced for every full rotation of the loop. The voltage induced by the generator alternates and produces an alternating current (AC)



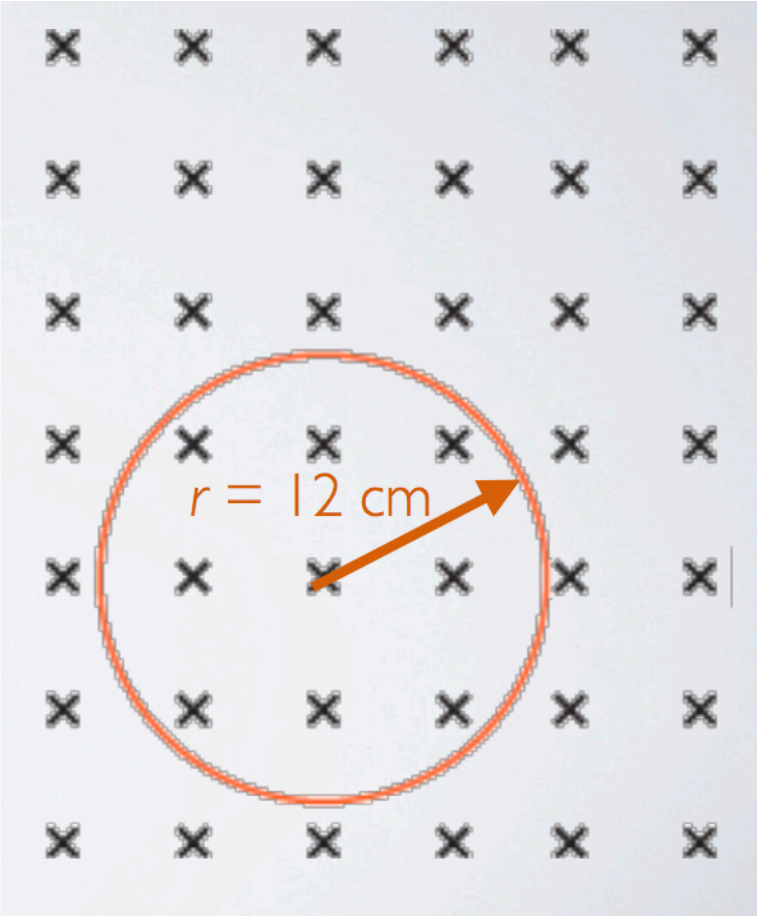
Electromagnetic Waves

Changing magnetic field induces electric field, which induces an magnetic field!

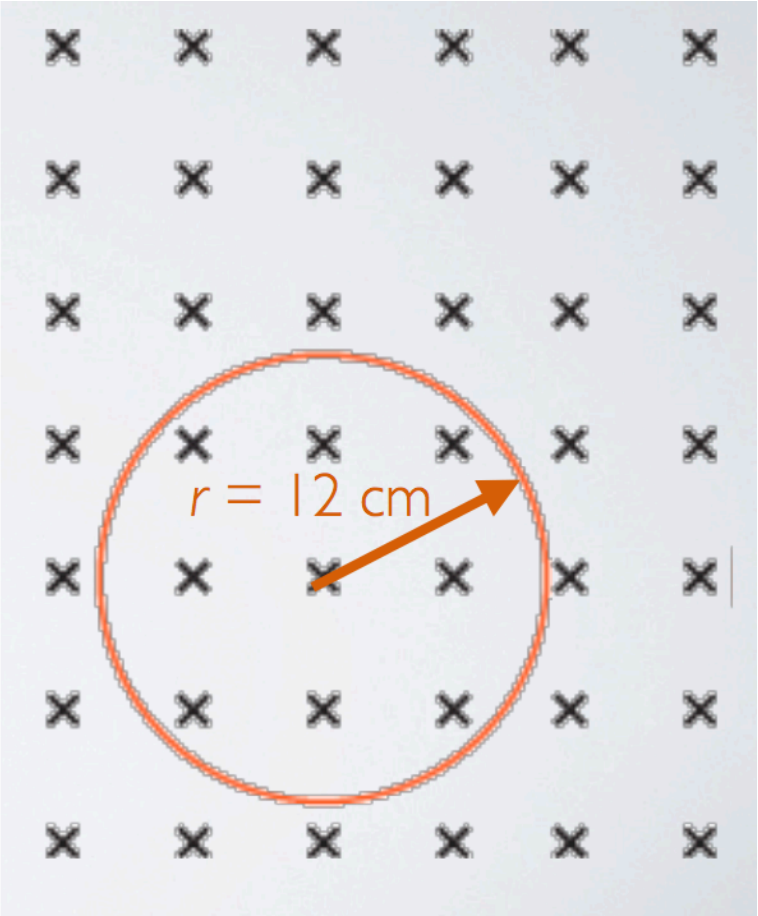
A circular, 100-loop coil of wire has a radius of 12 cm. it is exposed to a magnetic field pointed into the board which grows at a steady rate of 0.33 T/s.

In what direction is the induced magnetic field according to Lenz’s Law?

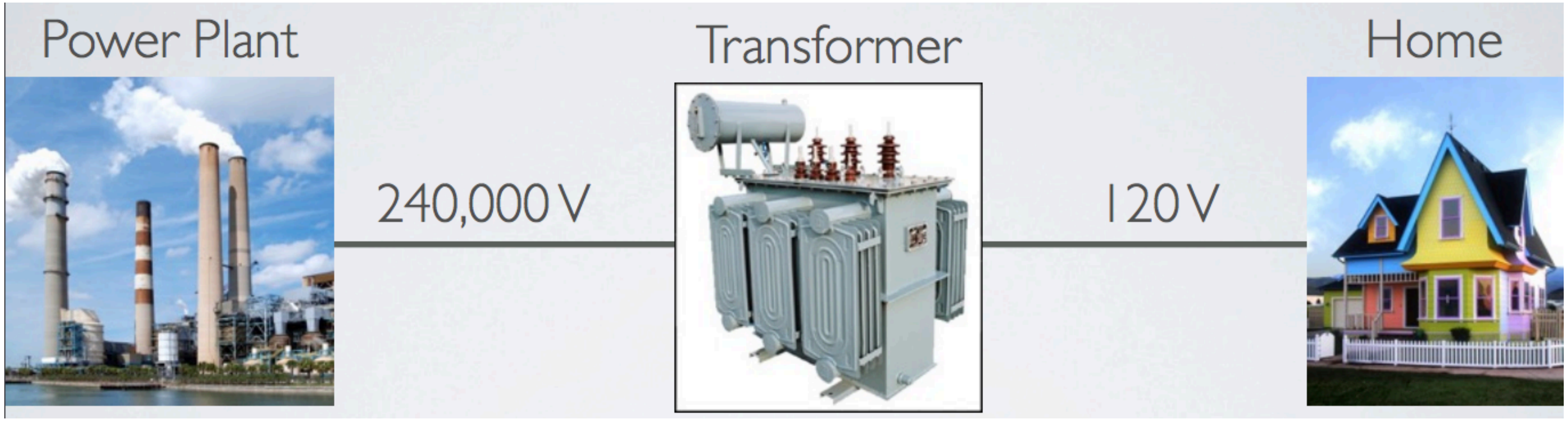
In what direction will current flow?



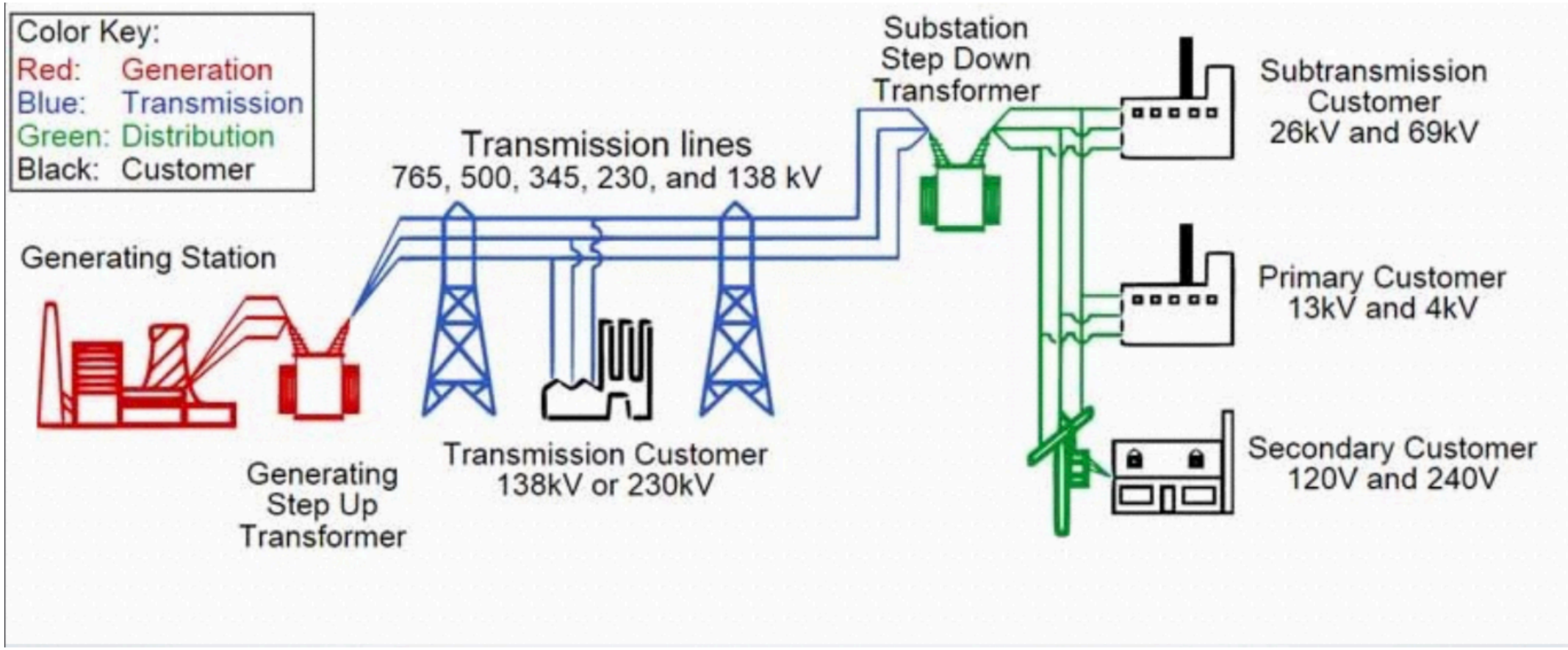
A circular, 100-loop coil of wire has a radius of 12 cm. it is exposed to a perpendicular magnetic field which grows at a steady rate of 0.33 T/s. What is the induced voltage, and in what direction will current flow?



Transformers



Transformers: device for increasing or decreasing an AC voltage



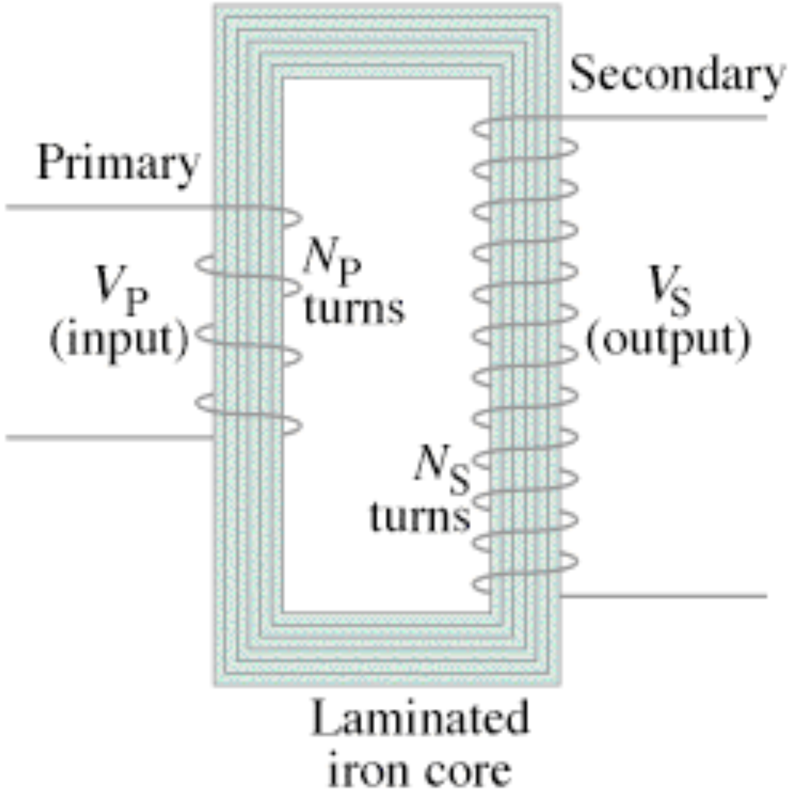
A transformer consists of two coils of wire known as the primary and secondary coils

If the secondary coil has more loops than the primary, the secondary voltage will be greater than the primary

- Called a step-up transformer

If the secondary coil has less loops than the primary, the secondary voltage will be less than the primary

- Called a step-down transformer

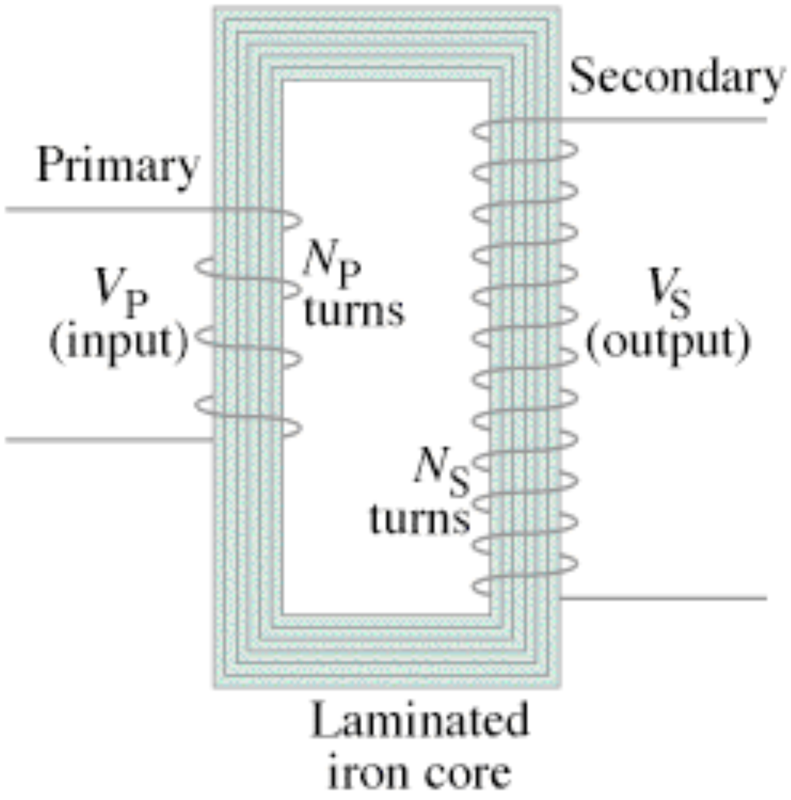


$$\frac{\textbf{Primary Voltage}}{\textbf{\# of } 1^o \textbf{ turns}} = \frac{\textbf{Secondary Voltage}}{\textbf{\# of } 2^o \textbf{ turns}}$$

Energy <u>must</u> be conserved!

Because power is the rate of change of energy, the power in must be the same as power out.

We learned from electricity that
P = IV



(Power IN) = (Power OUT)

$$\text{(Voltage x Current)}_{primary} = \text{(Voltage x Current)}_{secondary}$$

An electron is shot through two oppositely charged parallel plates at a velocity of 4.5×10^6 m/s. The plates are separated by a distance of 4 cm and have a potential difference of 10,000 V applied to them.

a) What is the electric field between the plates? (*Ans = 2.5×10^5 N/C)*

b) If the electron passes through the plates undeflected, what is the magnitude and direction of the magnetic field? *(Ans = 0.06 T into the page)*