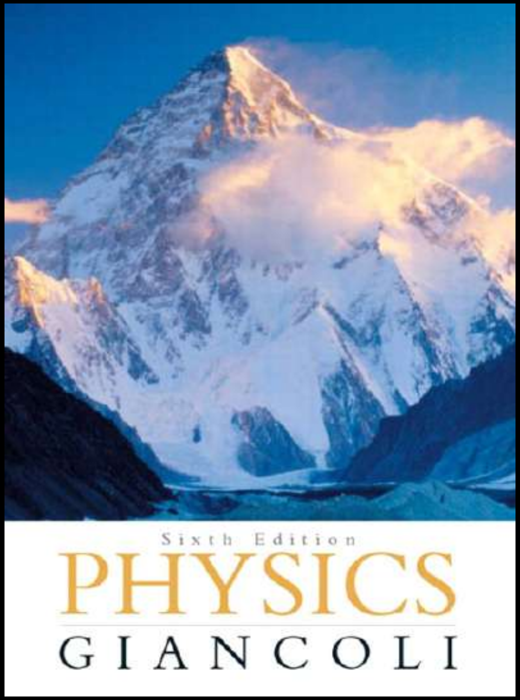


Lecture PowerPoints

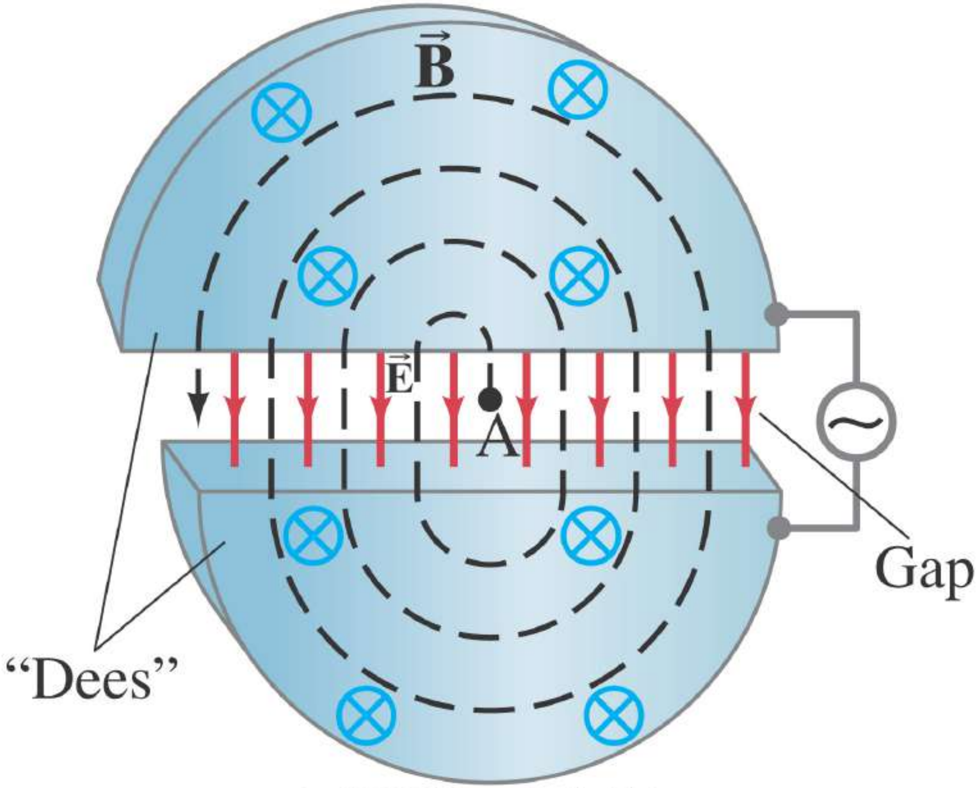
Chapter 20

Physics: Principles with Applications, 6th edition

Giancoli

Chapter 20

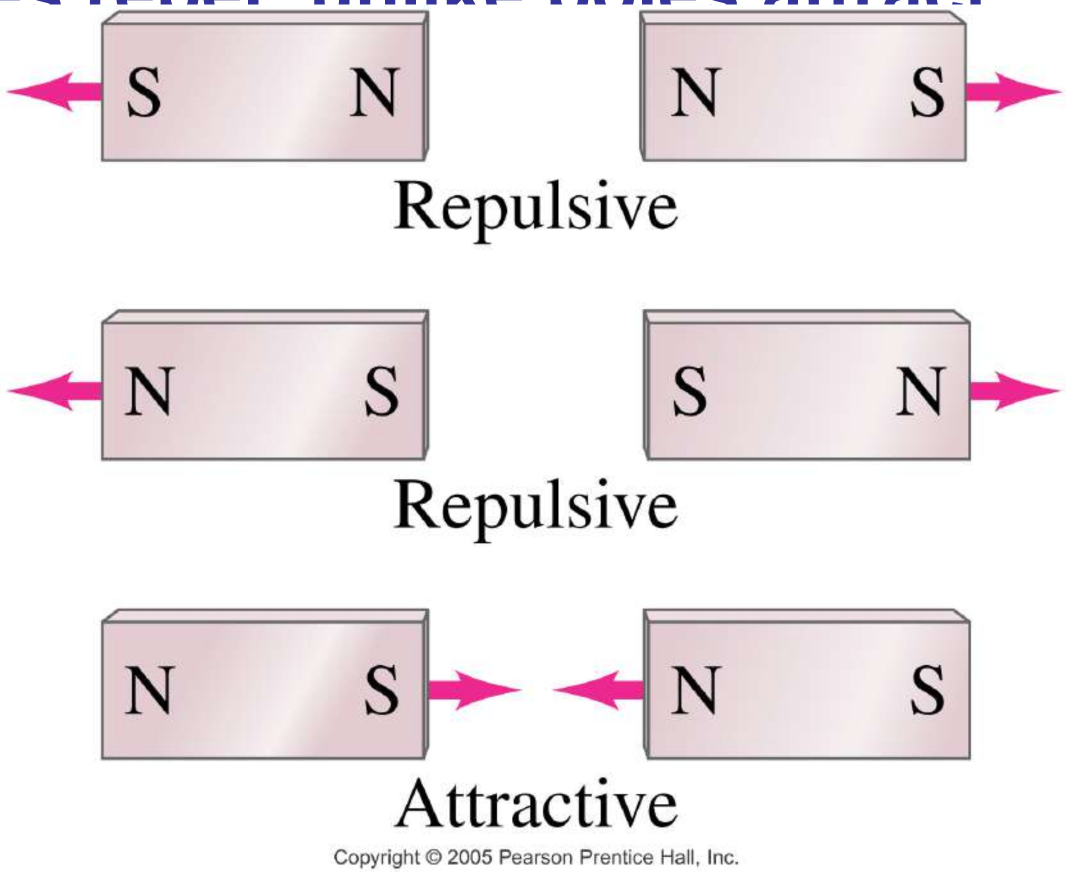
Magnetism



20.1 Magnets and Magnetic Fields

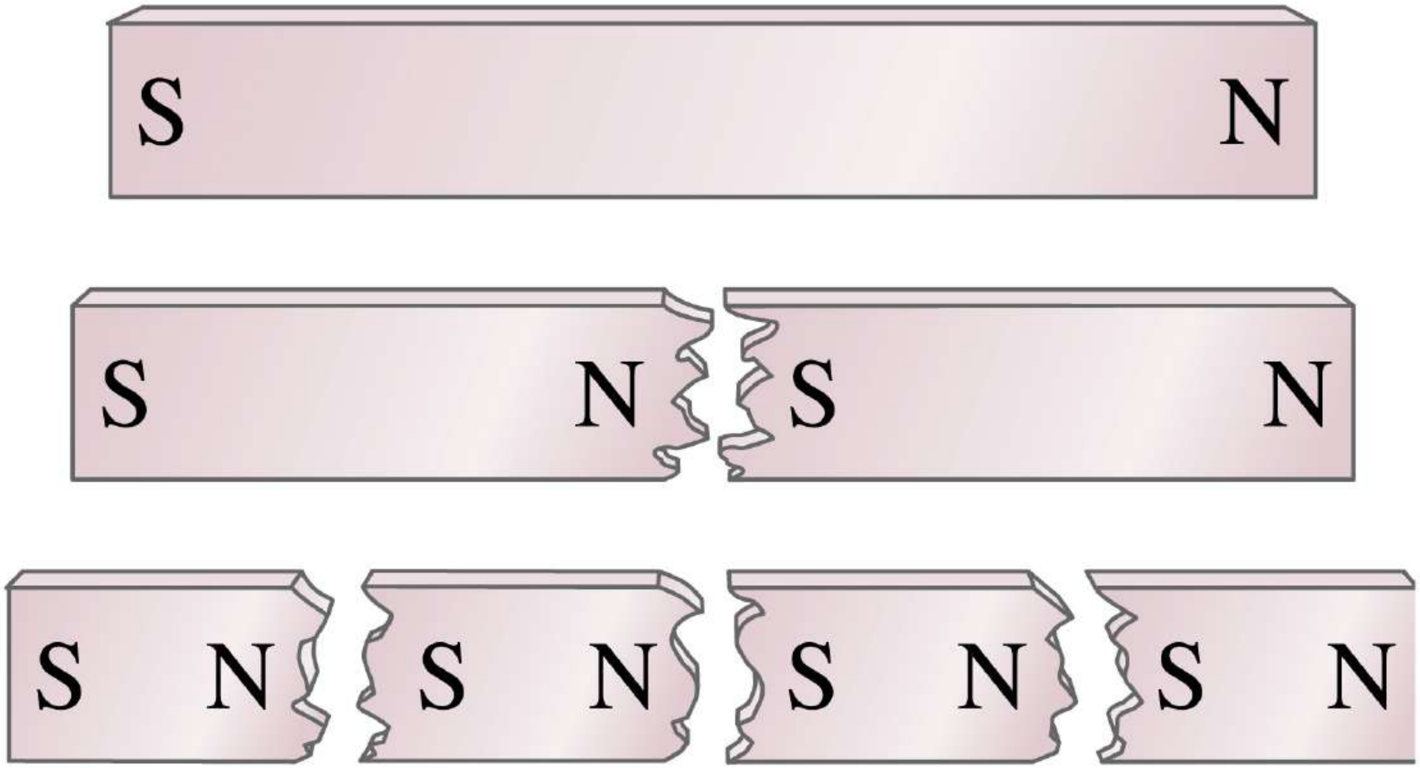
Magnets have two ends – poles – called north and south.

Like poles repel; unlike poles attract.



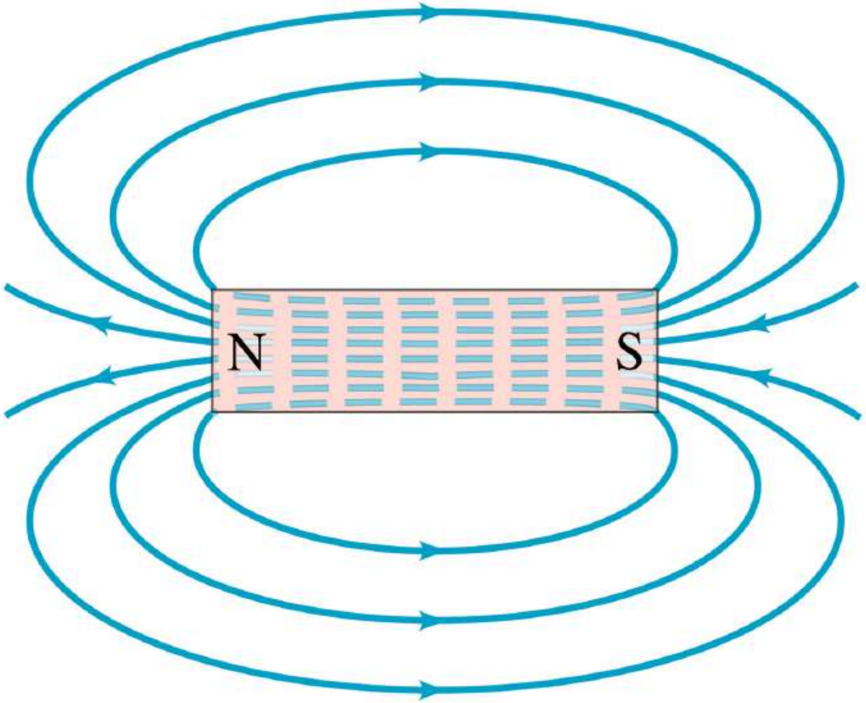
20.1 Magnets and Magnetic Fields

However, if you cut a magnet in half, you don't get a north pole and a south pole – you get two smaller magnets.



20.1 Magnets and Magnetic Fields

Magnetic fields can be visualized using magnetic field lines, which are always closed loops.



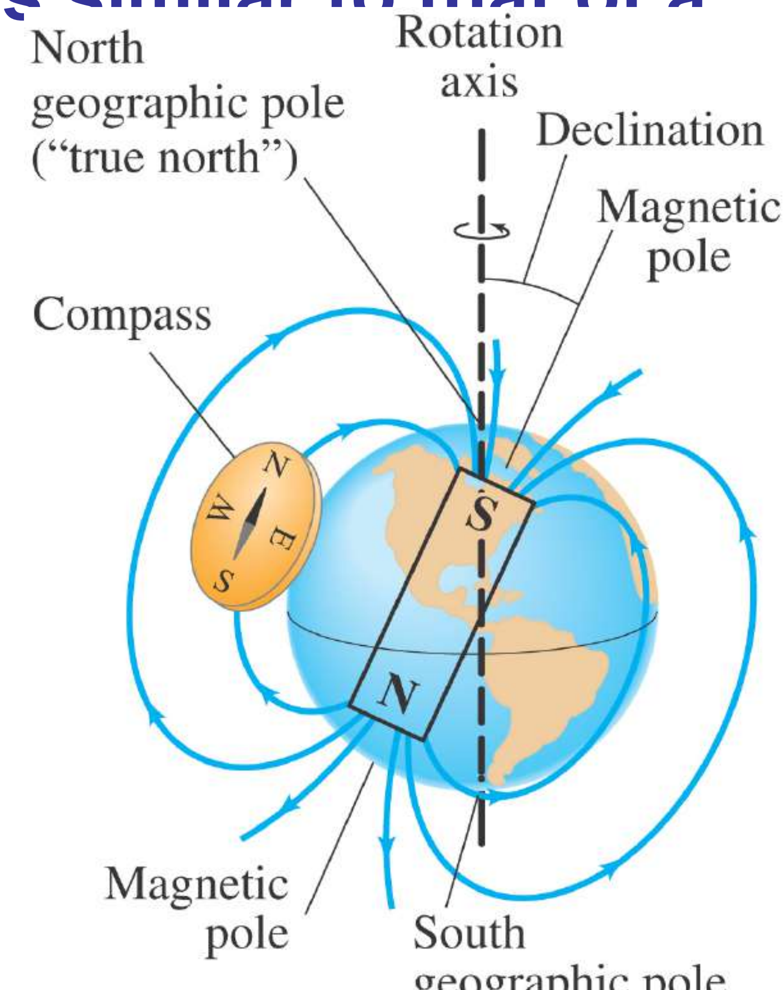
(b)

Notice that the magnetic field goes from North to South.

20.1 Magnets and Magnetic Fields

The Earth's magnetic field is similar to that of a bar magnet.

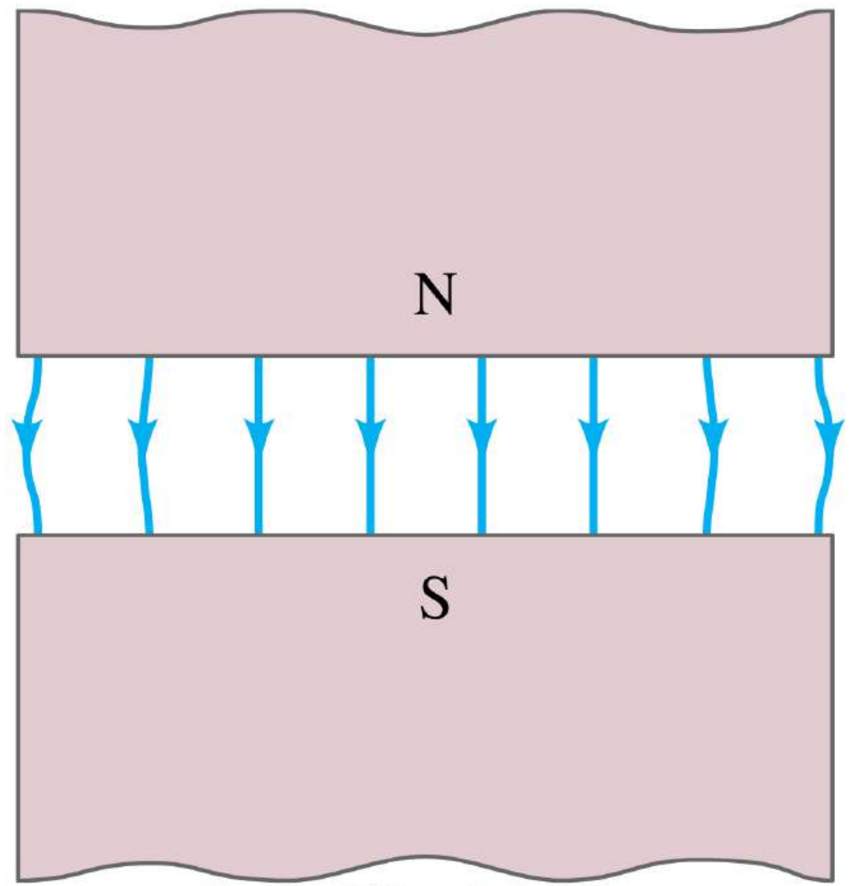
Note that the Earth's "North Pole" is really a south magnetic pole, as the north ends of magnets are attracted to it.



20.1 Magnets and Magnetic Fields

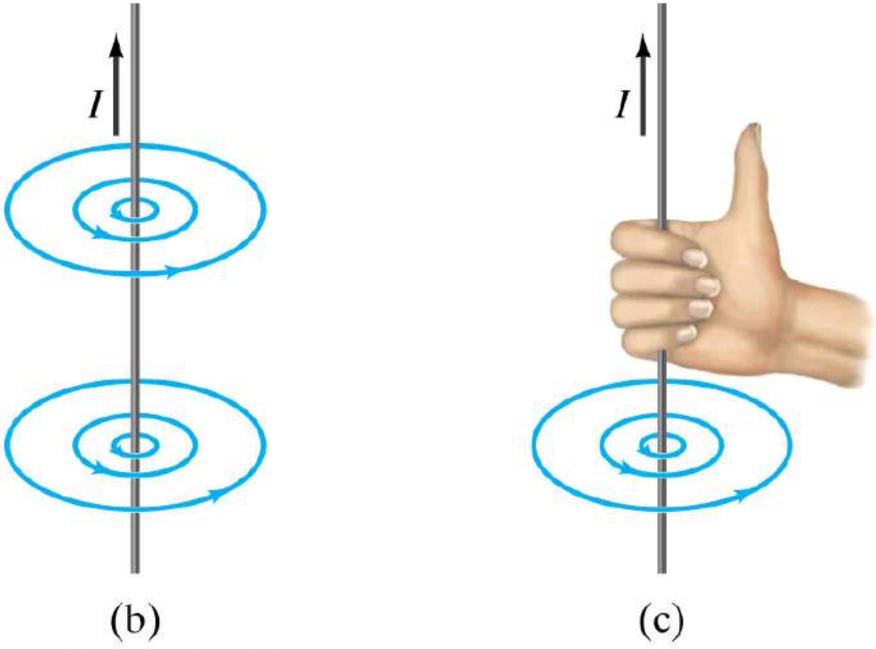
A uniform magnetic field is constant in magnitude and direction.

The field between these two wide poles is nearly uniform.

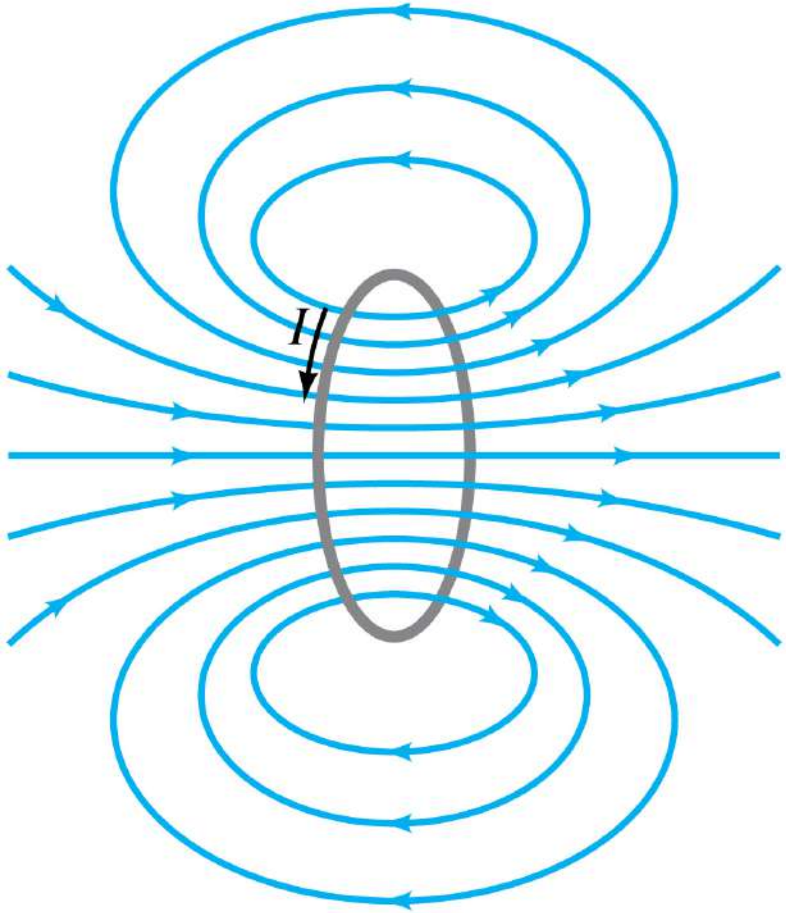


20.2 Electric Currents Produce Magnetic Fields

Experiment shows that an electric current produces a magnetic field. (Right Hand Rule)

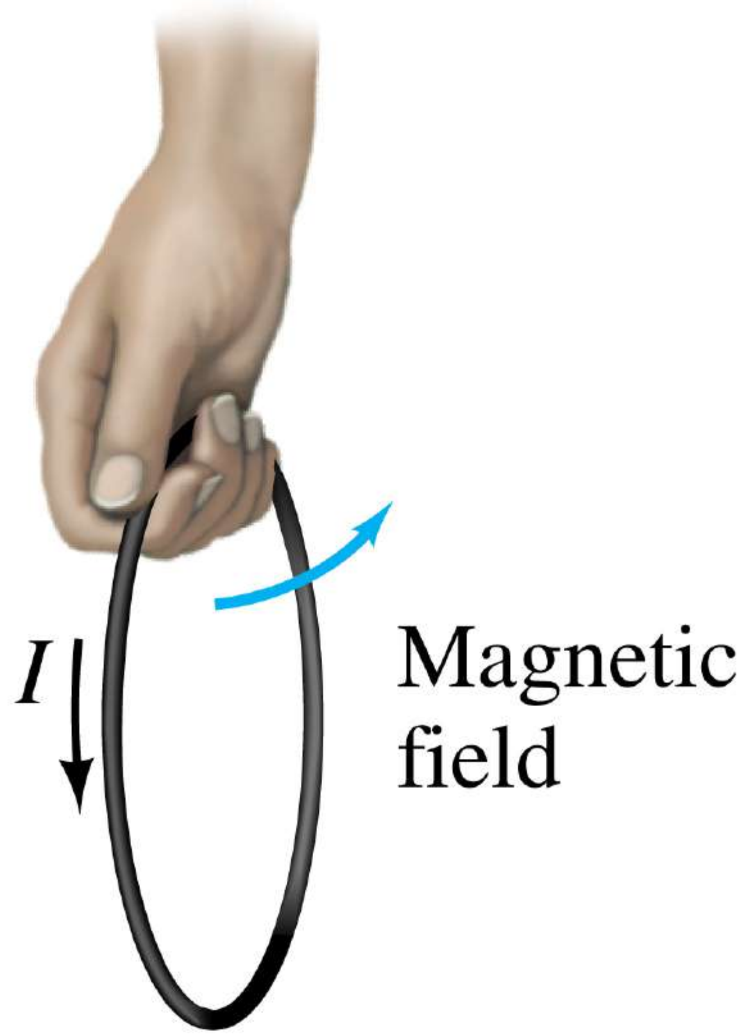


Magnetic field lines due to a circular loop of wire



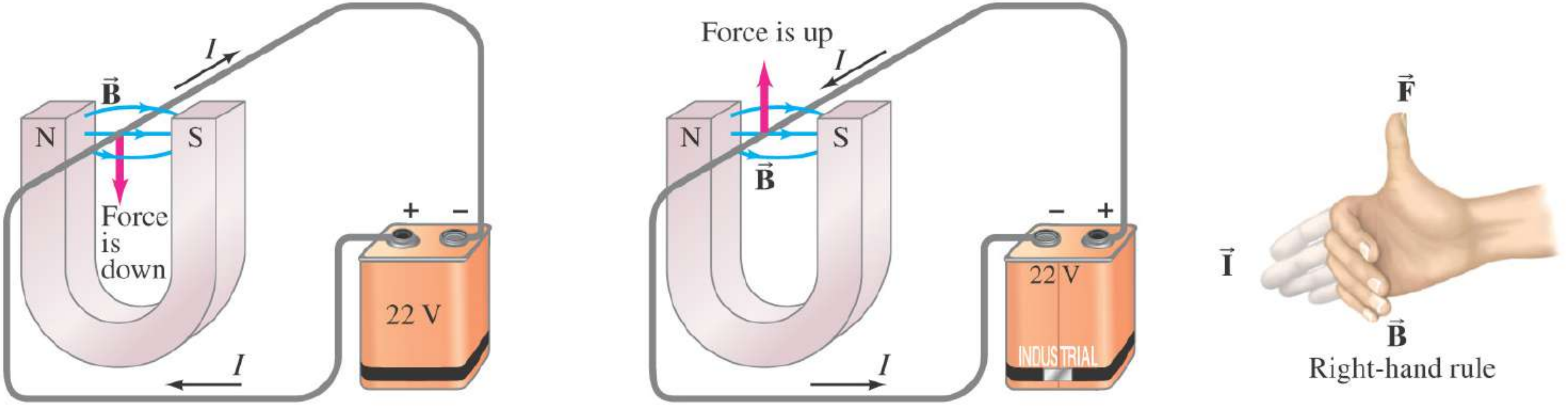
20.2 Electric Currents Produce Magnetic Fields

The direction of the field is given by a right-hand rule.



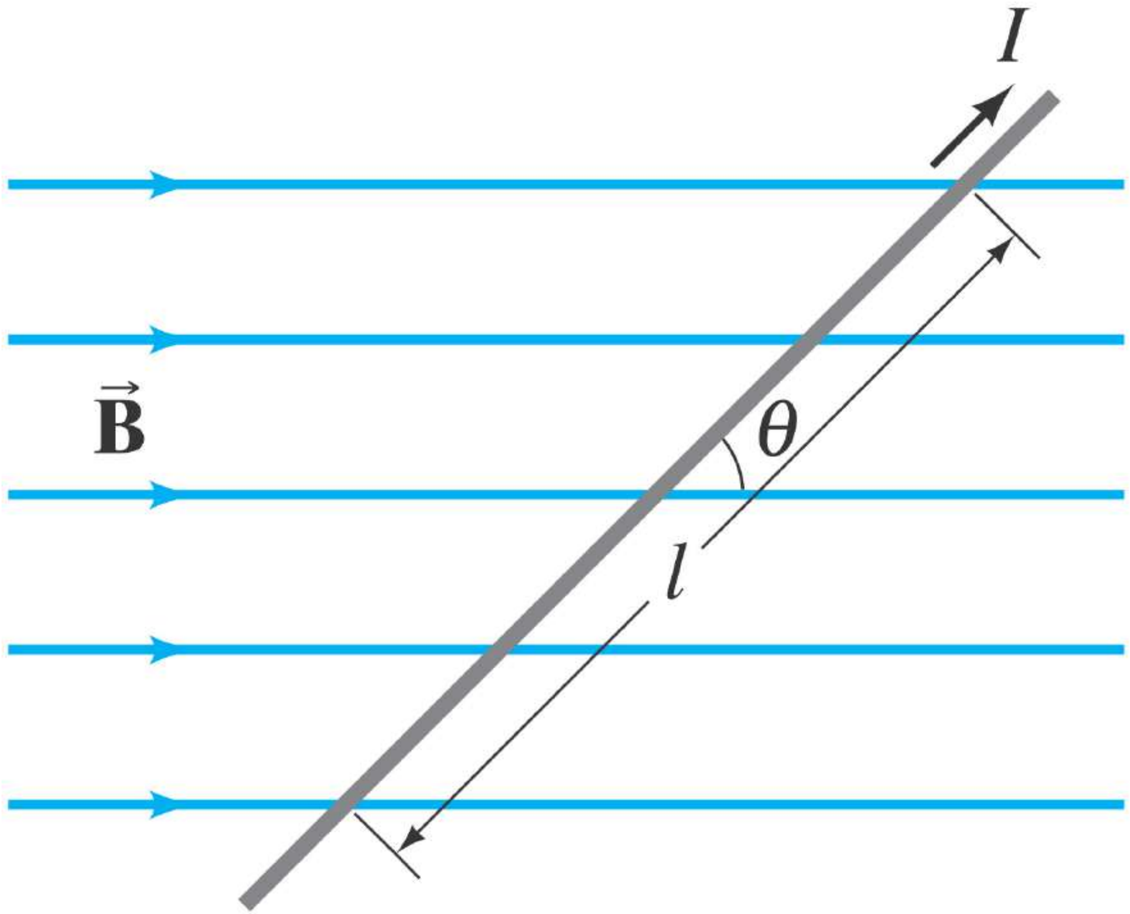
20.3 Force on an Electric Current in a Magnetic Field; Definition of B

A magnet exerts a force on a current-carrying wire. The direction of the force is given by a right-hand rule.



(a) (b) (c)

Current-carrying wire in a magnetic field. The force on the wire is directed into the page.



20.3 Force on an Electric Current in a Magnetic Field; Definition of B

The force on the wire depends on the current, the length of the wire, the magnetic field, and its orientation.

$$F = IlB \sin\theta$$

(on formula sheet)

If the direction of I is perpendicular to B, then $\theta = 90^\circ$ and $\sin\theta = 1$. If I is parallel to B, then $\theta = 0^\circ$ and $\sin\theta = 0$. This equation defines the magnetic field B.

20.3 Force on an Electric Current in a Magnetic Field; Definition of B

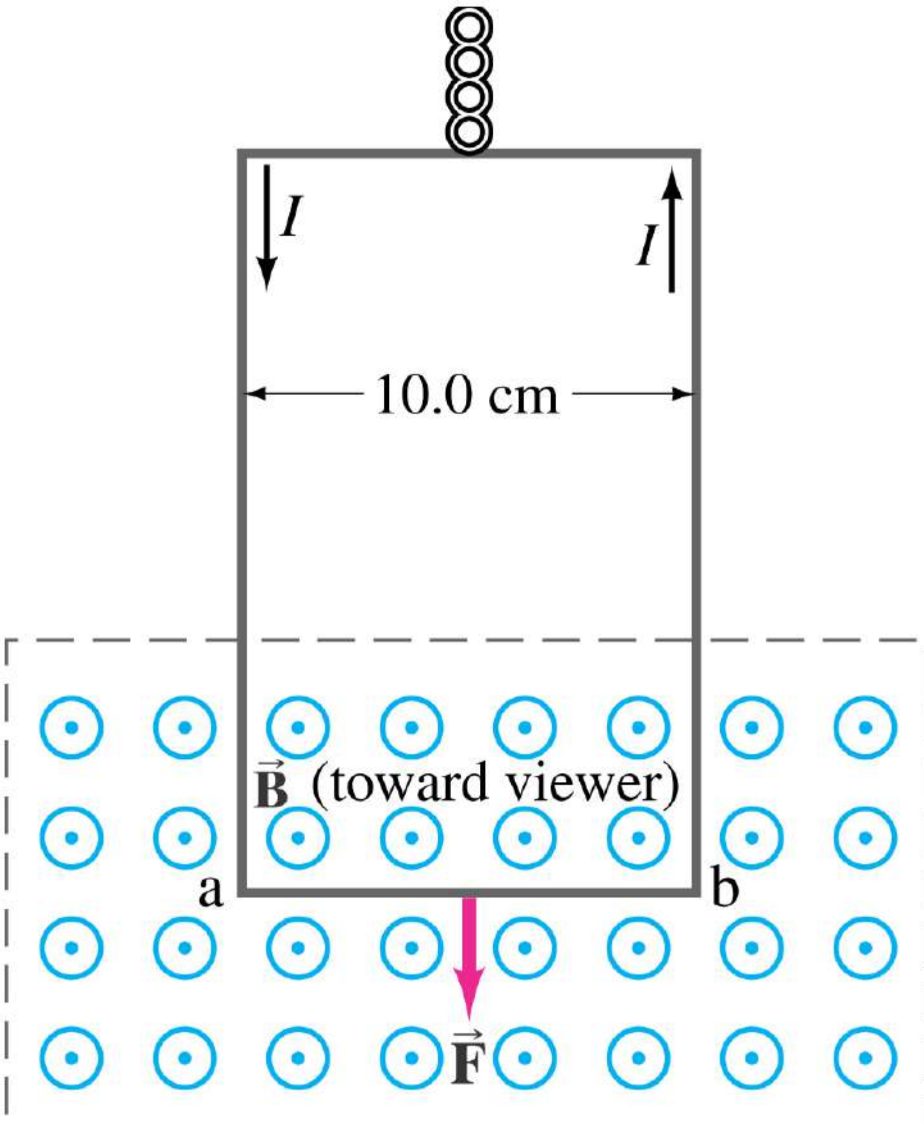
Unit of B: the tesla, T.

1 T = 1 N/A·m.

Another unit sometimes used: the gauss (G).

1 G = 10^{-4} T.

Measuring a magnetic field B



What is the magnetic field if the force is 0.0348 N and the current is 0.245 A? What about the magnetic forces on the two vertical sections of the wire that are in the magnetic field?

20.4 Force on Electric Charge Moving in a Magnetic Field

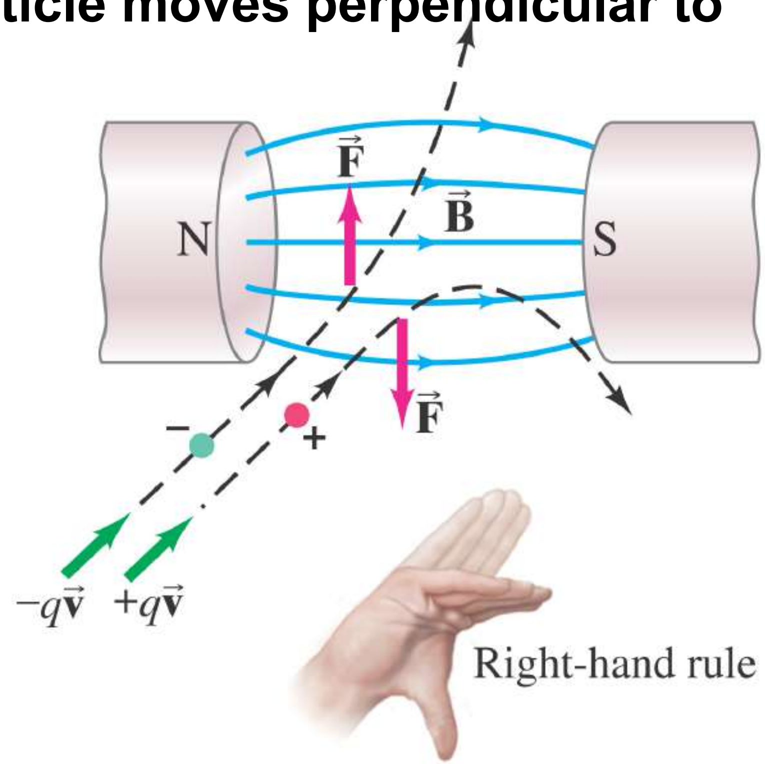
The force on a moving charge is related to the force on a current:

$$F = qvB\sin\theta$$

(on formula sheet)

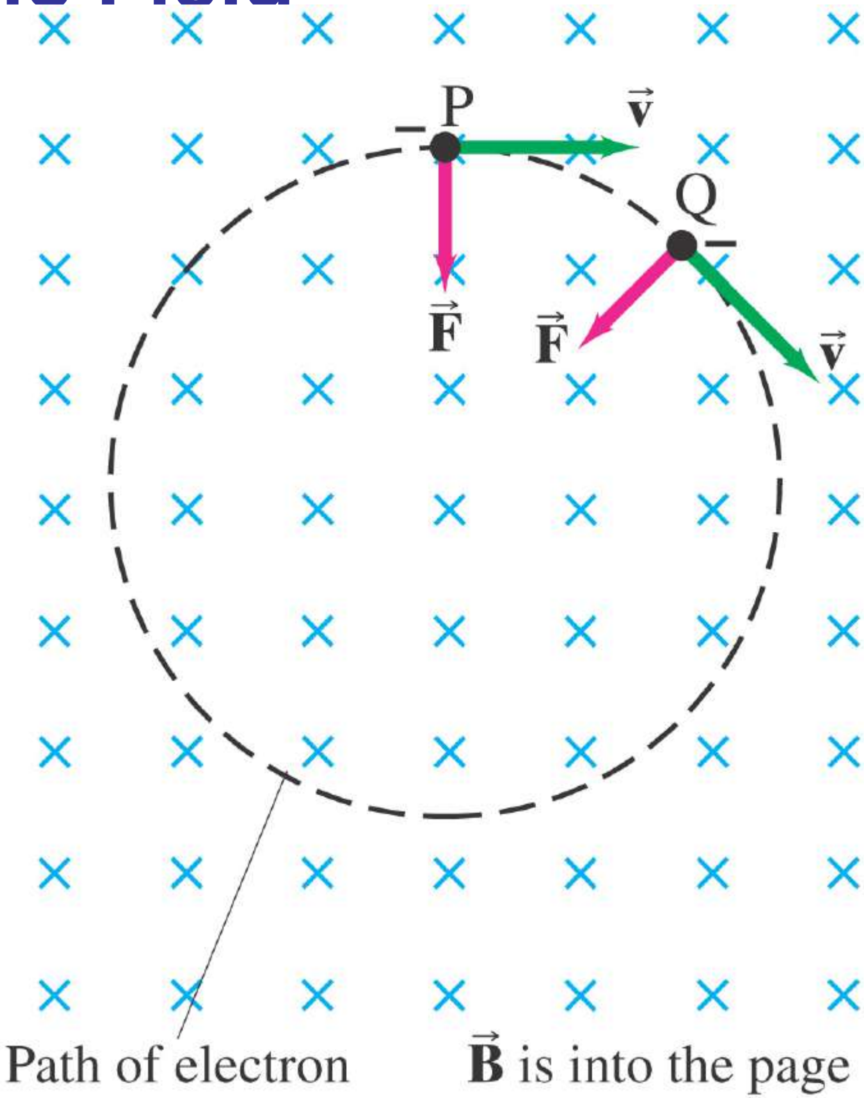
The force is greatest when the particle moves perpendicular to B (θ = 90°)

Once again, the direction is given by a right-hand rule. The rule is for positive particles. Notice the difference between positive and negative particles.



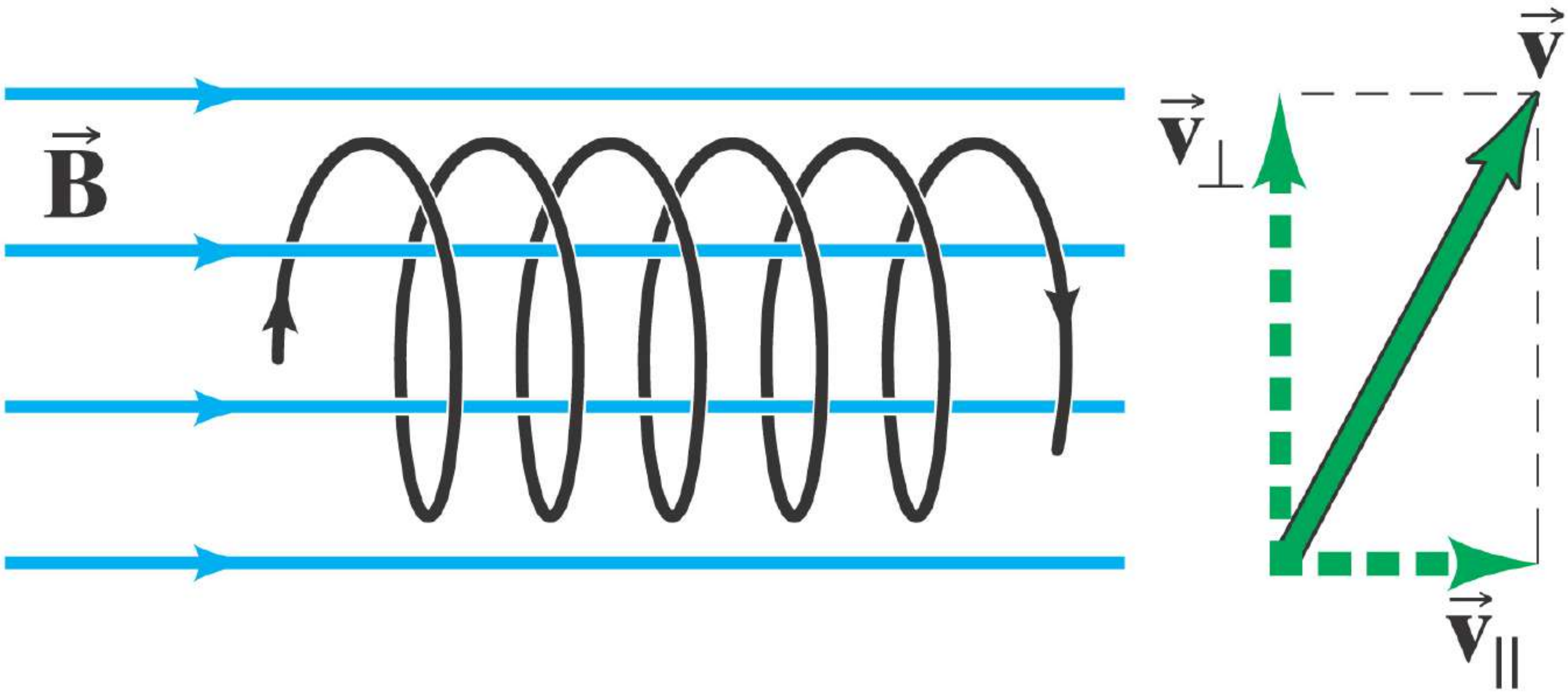
20.4 Force on Electric Charge Moving in a Magnetic Field

If a charged particle (in this case an electron) is moving perpendicular to a uniform magnetic field, its path will be a circle.

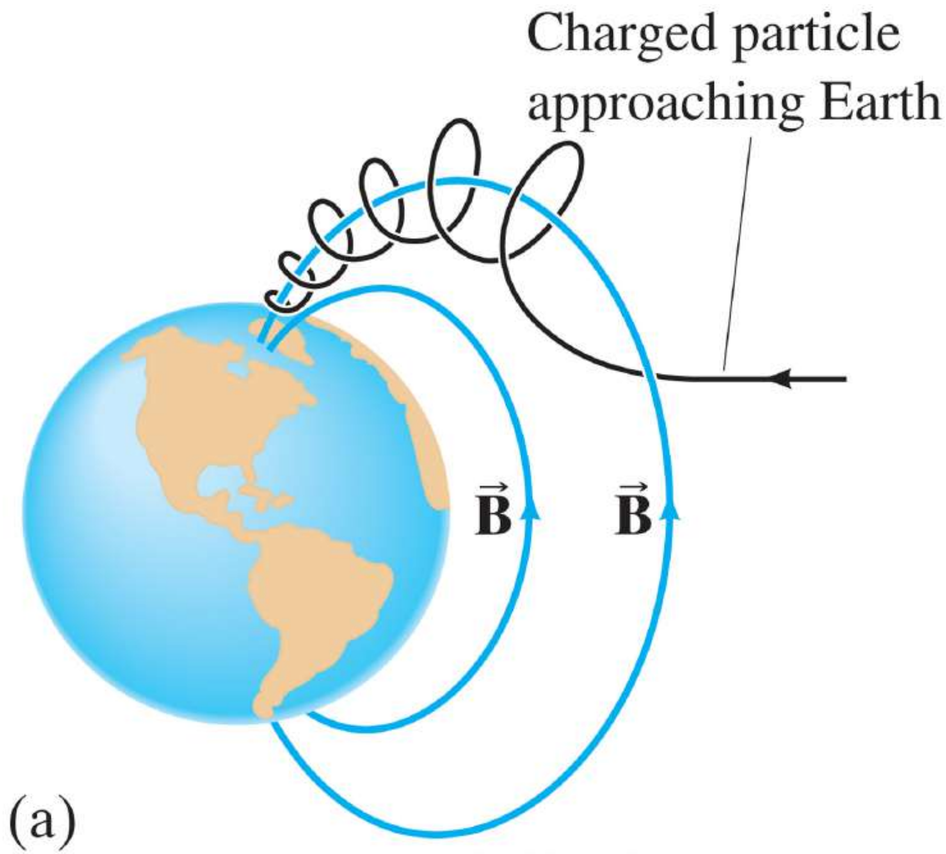


What is the path of a charged particle if its velocity is *not* perpendicular to the magnetic field?

The parallel component of v experiences no force, so it remains constant. The perpendicular component of v results in circular motion. Together this produces a spiral motion.

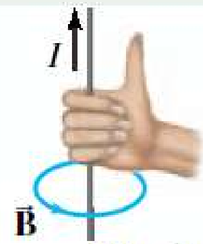
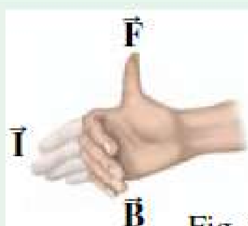
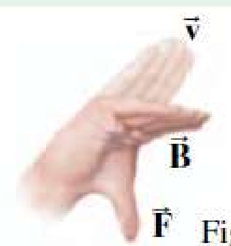


Charged ions approach the Earth from the sun (solar wind) and are drawn toward the poles. This causes the Northern lights.



20.4 Force on Electric Charge Moving in a Magnetic Field

TABLE 20–1 Summary of Right-hand Rules (= RHR)

Physical Situation	Example	How to Orient Right Hand	Result
1. Magnetic field produced by current (RHR-1)	 Fig. 20–8c	Wrap fingers around wire with thumb pointing in direction of current I	Fingers point in direction of $\vec{\mathbf{B}}$
2. Force on electric current I due to magnetic field (RHR-2)	 Fig. 20–11c	Fingers point straight along current I, then bent along magnetic field $\vec{\mathbf{B}}$	Thumb points in direction of force
3. Force on electric charge $+q$ due to magnetic field (RHR-3)	 Fig. 20–14	Fingers point along particle's velocity $\vec{\mathbf{v}}$, then along $\vec{\mathbf{B}}$	Thumb points in direction of force

20.5 Magnetic Field Due to a Long Straight Wire

The field is inversely proportional to the distance from the wire:

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

(on formula sheet)

The constant μ_0 is called the permeability of free space (or Vacuum permeability), and has the value:

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

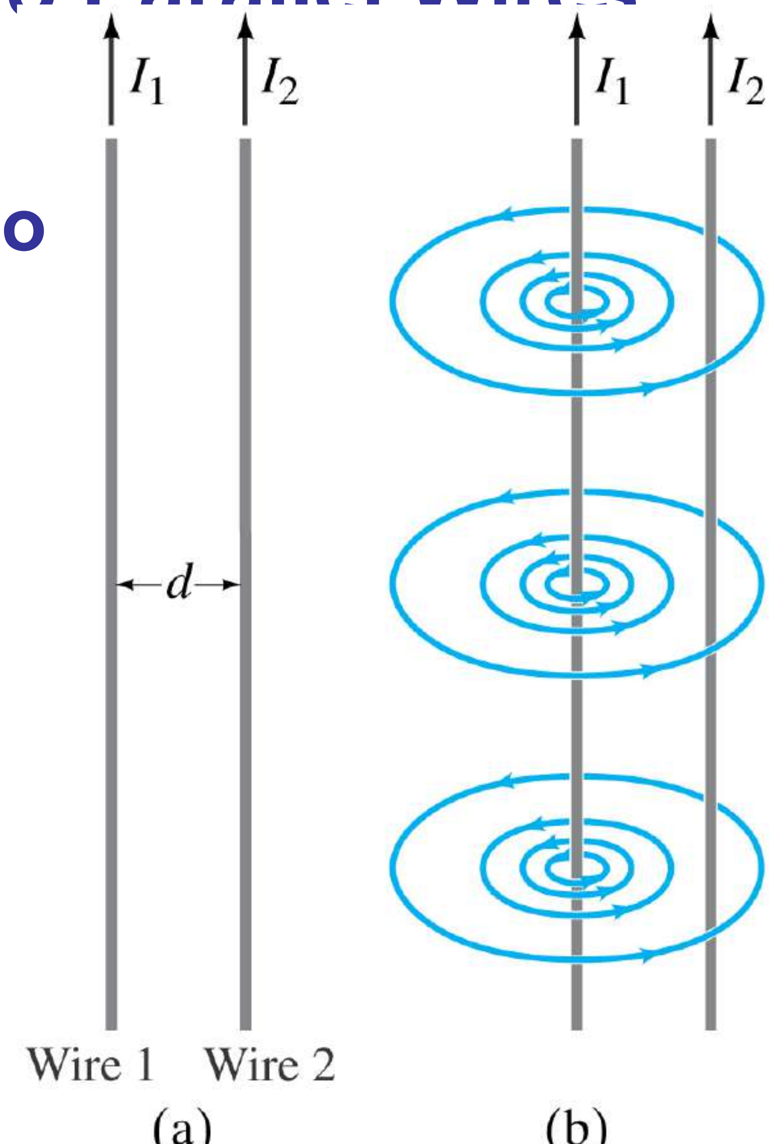
20.6 Force between Two Parallel Wires

The magnetic field produced at the position of wire 2 due to the current in wire 1 is:

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

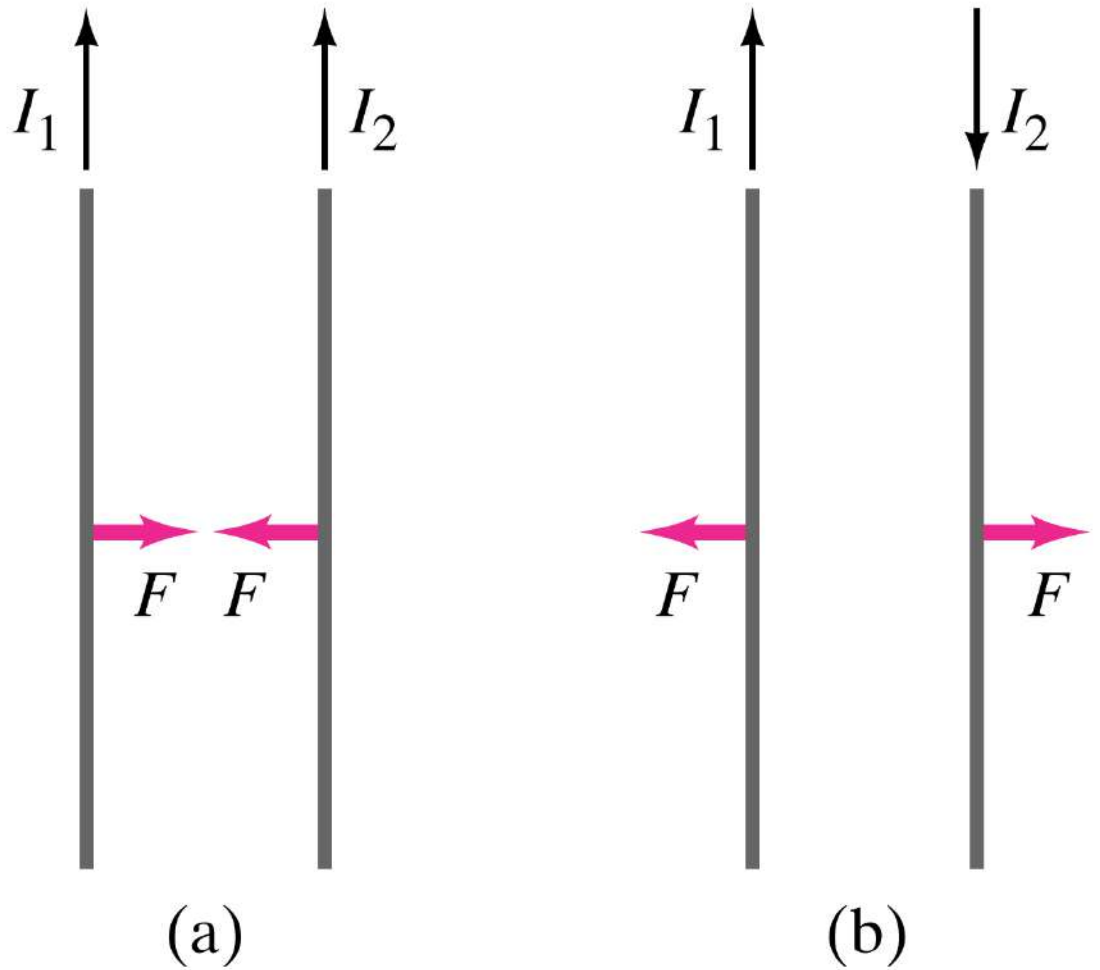
The force this field exerts on a length l_2 of wire 2 is:

$$F_2 = \frac{\mu_0}{2\pi} \frac{I_1 I_2}{d} l_2 \quad \textbf{(20-6)}$$



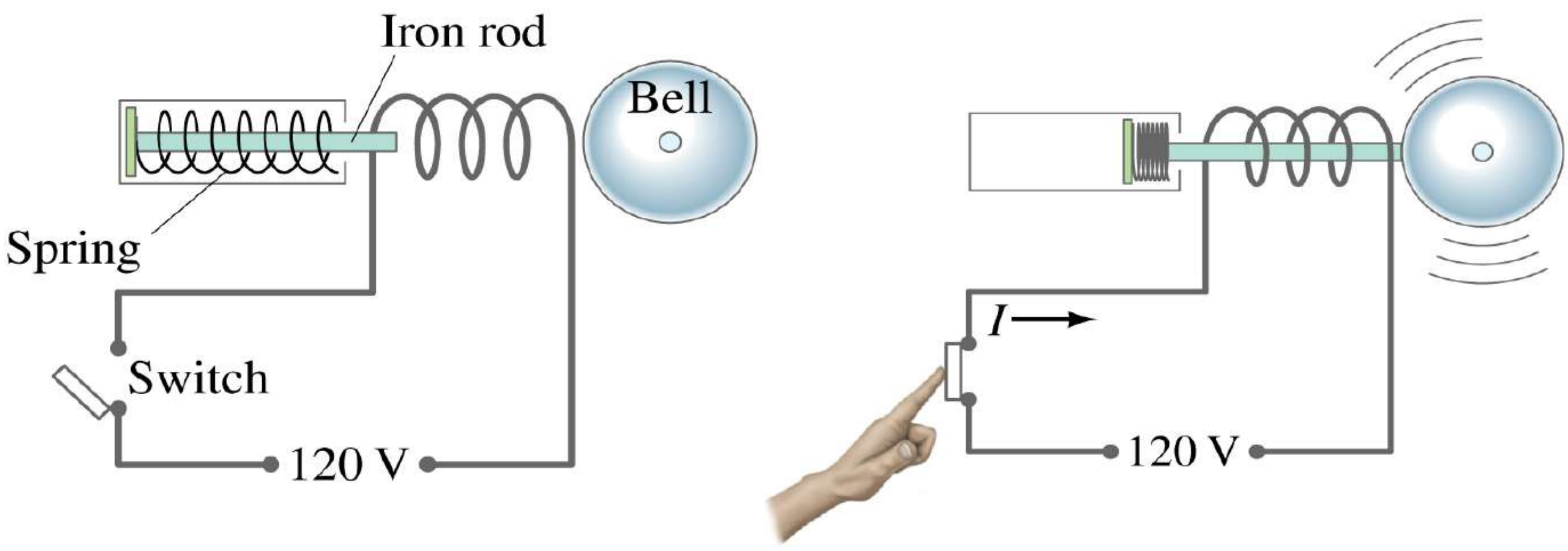
20.6 Force between Two Parallel Wires

Parallel currents attract; antiparallel currents repel.



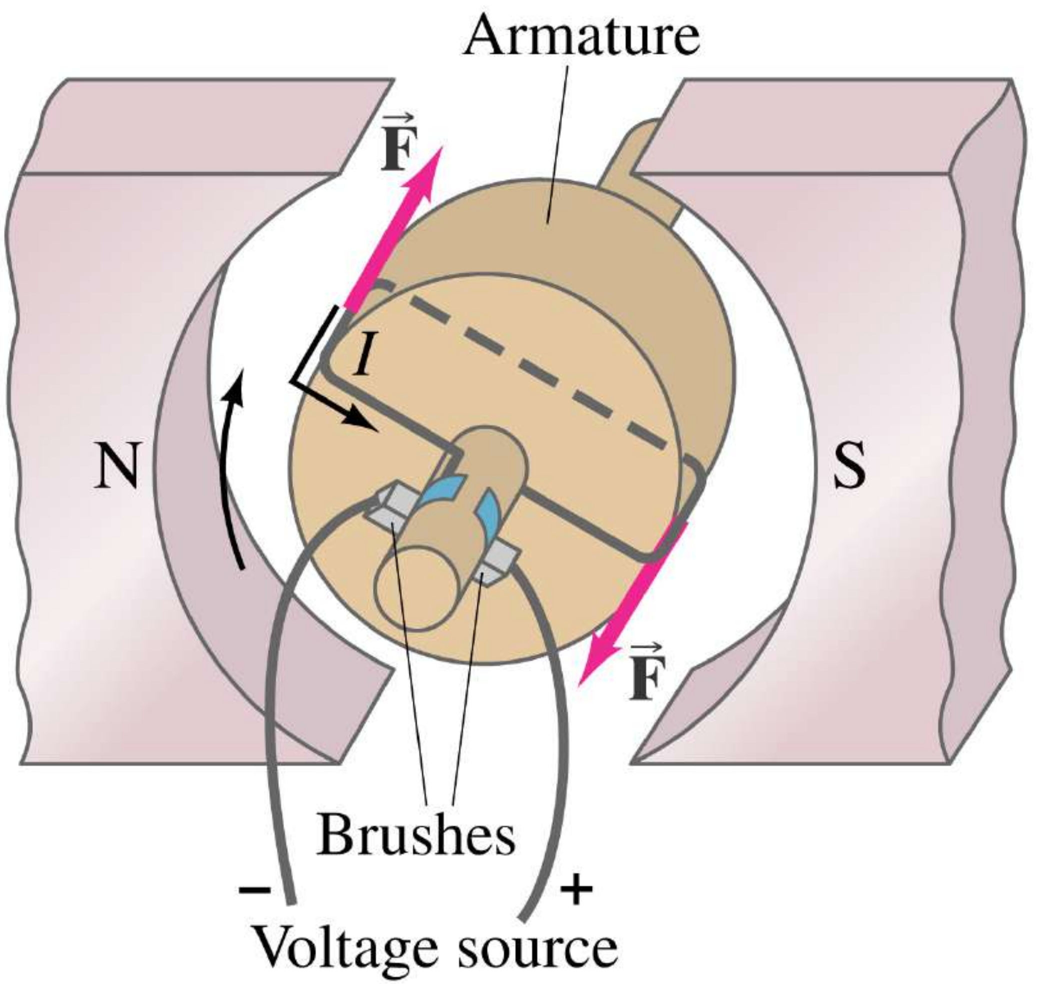
20.7 Solenoids and Electromagnets

If a piece of iron is inserted in the solenoid, the magnetic field greatly increases. Such electromagnets have many practical applications.



20.10 Applications: Motors & Loudspeakers

An electric motor takes advantage of the torque on a current loop, to change electrical energy to mechanical energy.



20.10 Applications: Motors & Loudspeakers

Loudspeakers use the principle that a magnet exerts a force on a current-carrying wire to convert electrical signals into mechanical vibrations, producing sound.