Chapter 22 Magnetism

Outline

22-1 The Magnetic Field

22-2 The Magnetic Force on Moving Charges
22-3 The Motion of Charges Particles in Magnetic Field

22-4 The Magnetic Force Exert on a Current-Carrying Wire

22-5 Loops of Current and Magnetic Torque

22-6 Electric Current, Magnetic Fields, and Ampère's Law

22-7 Electric Loops and Solenoid

22-7 Electric Loops and Solenoid

Current Loop

A Current-carrying wire can produce magnetic field.

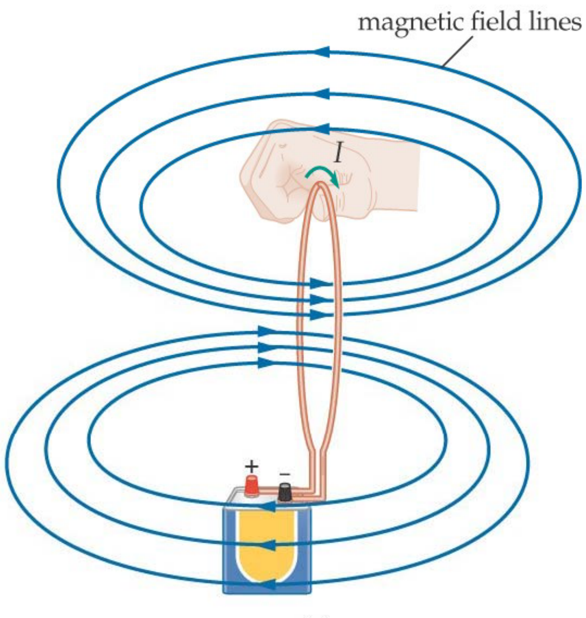


Figure 22-25a
The Magnetic Field of a Current Loop

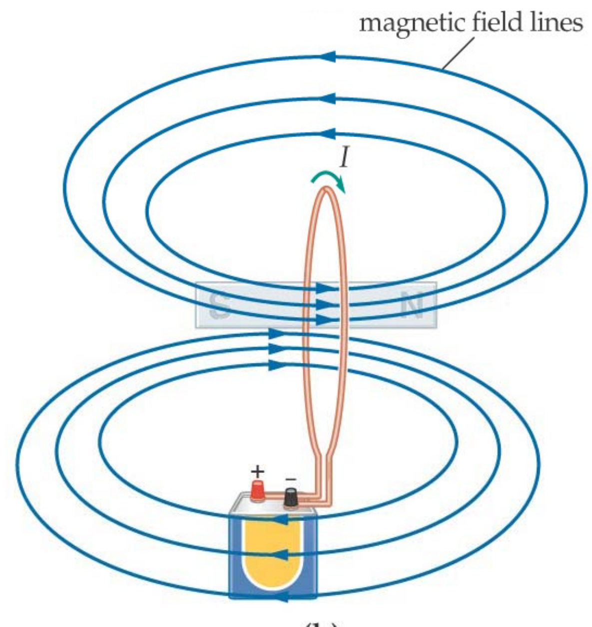
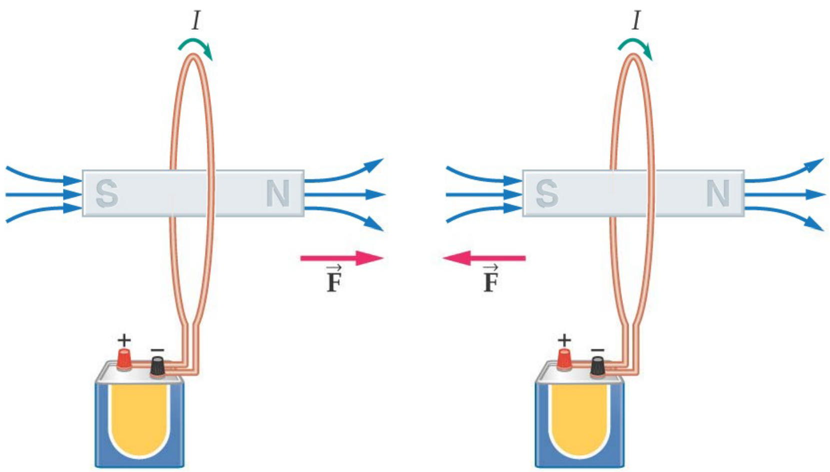


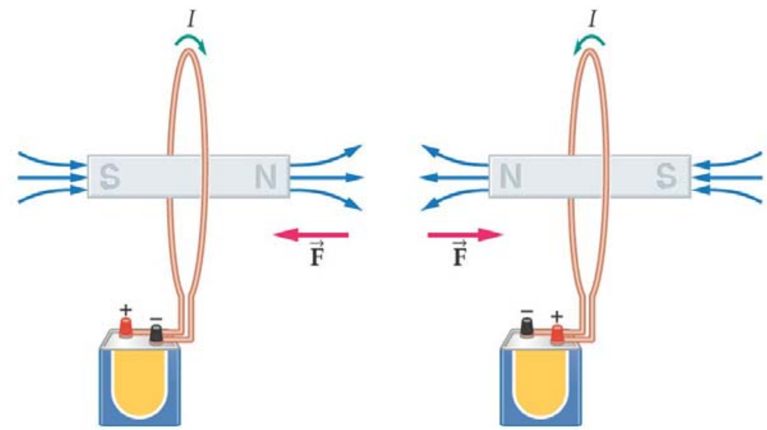
Figure 22-25b
The Magnetic Field of a Current Loop

Figure 22-26a Magnetic Forces Between Current Loops



(a)

Figure 22-26b Magnetic Forces Between Current Loops



(b)

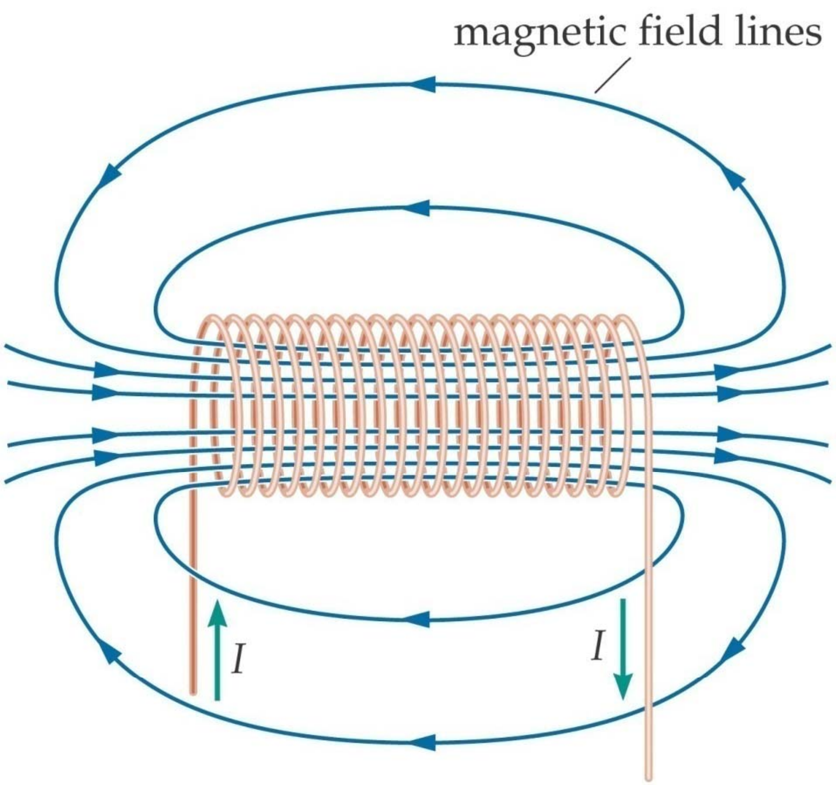
The magnetic field produced by *a circular loop of N turns*, radius R, and current varies at different locations. At the loop center, it can be expressed as

$$B = \frac{N\mu_0 I}{2R} \qquad (22-11)$$

Solenoid

A Solenoid is an electric device in which a long wire wound into a succession of closely spaced loops with the geometry of a helix.

A solenoid carrying a current can produce an intense, nearly uniform magnetic field inside the loops, as shown in the figure.



Outside the loop, the magnetic field is so week compared with that the inside, so it is zero for the outside (idealization case).

Figure 22-27
The Solenoid

Deriving magnetic field

Applying the Ampère's Law to the loop (shown in the figure), we have

$$\sum B_{\|}\Delta L = \sum_{side1} B_{\|}\Delta L + \sum_{side2} B_{\|}\Delta L + \sum_{side3} B_{\|}\Delta L + \sum_{side4} B_{\|}\Delta L$$
$$= BL + 0 + 0 + 0 = BL$$

The current enclosed by the rectangular circuit is NI, where N is the number of the loops. So we have

$$BL = \mu_0 NI$$

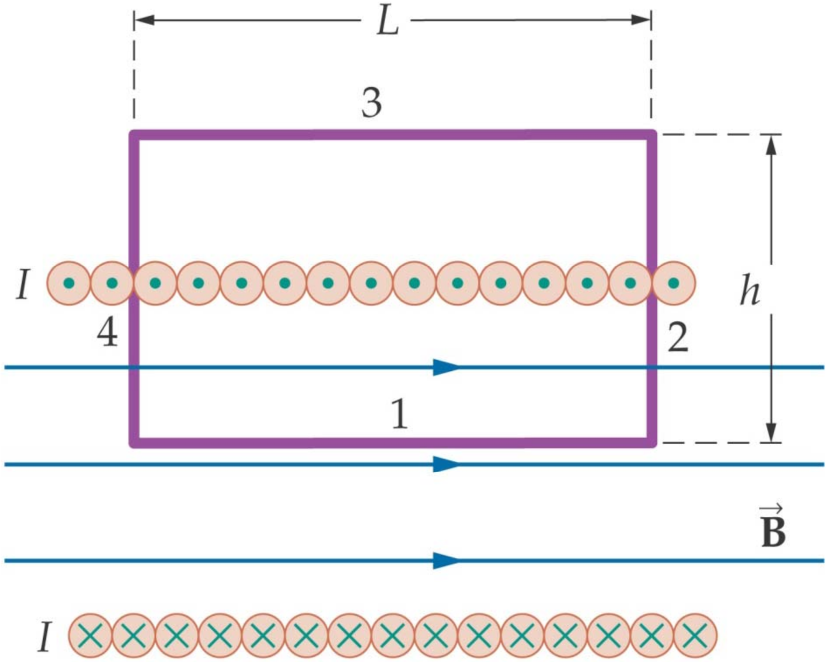


Figure 22-28
Ampère's Law and the Magnetic Field in a Solenoid

Magnetic Field of a Solenoid

$$B = \mu_0 (\frac{N}{L}) I = \mu_0 n I \qquad (22-12)$$

SI unit: Tesla, T

Where loop density n = N / L, is the number of loops per meter length .

CONCEPTUAL CHECKPOINT 22–6

If you want to increase the strength of the magnetic field inside a solenoid, is it better to **(a)** double the number of loops, keeping the length the same, or **(b)** double the length, keeping the number of loops the same?

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Reasoning and Discussion

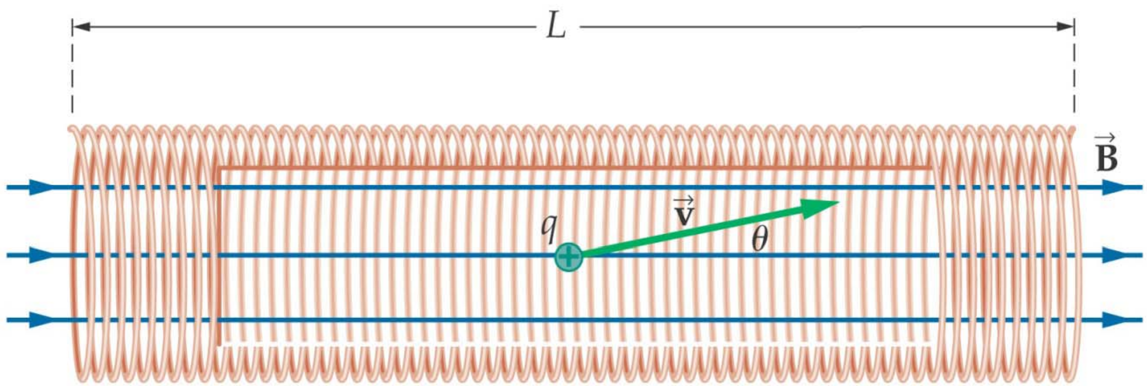
Referring to the expression $B = \mu_0(N/L)I$ we see that doubling the number of loops $(N \rightarrow 2N)$ while keeping the length the same $(L \rightarrow L)$ results in a doubled magnetic field $(B \rightarrow 2B)$. On the other hand, doubling the length $(L \rightarrow 2L)$ while keeping the number of loops the same $(N \rightarrow N)$ reduces the magnetic field by a factor of 2 $(\mathrm{B} \rightarrow \mathrm{B}/2)$. Hence, to increase the field one should pack more loops into the same length.

Answer:

(a) Double the number of loops with the same length.

Example 22-7 Through the Core of a Solenoid

A solenoid is 20.0 cm long, has 200 loops, and carries a current of 3.25 A. Find the magnitude of the force exerted on a 15.0 uC charged particle moving at 1050 m/s through the interior of the solenoid at angle of 11.5° to the solenoid axis.



Example 22-7
Through the Core of a Solenoid

Summary

(Uniform) Magnetic Field of a Solenoid

$$B = \mu_0 (\frac{N}{L}) I = \mu_0 n I \qquad (22-12)$$

SI unit: Tesla, T