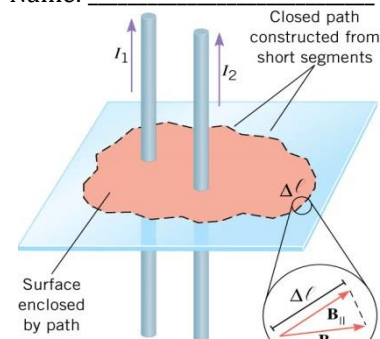


Ampere's Law

$$\sum \vec{B} \cdot \Delta \vec{\ell} = \mu_0 I$$

$$\sum B_{\parallel} \Delta \ell = \mu_0 I$$

- Where B = the magnetic field (B_{\parallel} is the B -field _____ to ℓ), $\Delta \ell$ = a portion of the _____ surround the current, μ_0 = _____ of free space = $4\pi \times 10^{-7}$ Tm/A, I = current _____ by path



Long Straight Wire

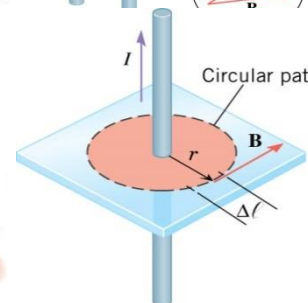
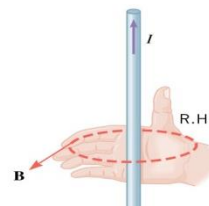
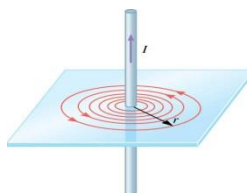
- To make it simpler, let's use a _____ for our path around _____ wire.

$$\sum \vec{B} \cdot \Delta \vec{\ell} = \mu_0 I$$

$$B(2\pi r) = \mu_0 I$$

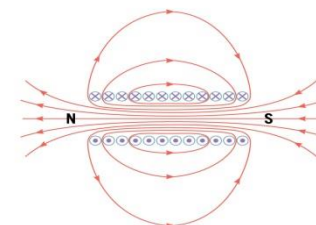
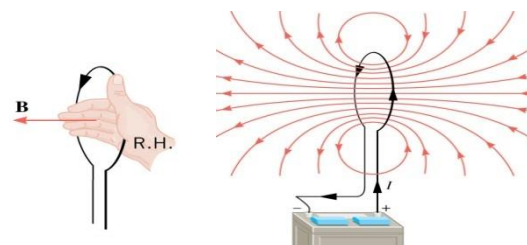
$$B = \frac{\mu_0 I}{2\pi r}$$

- Right Hand Rule
 - Grab the wire with _____ hand
 - Thumb points in direction of _____
 - Fingers curl in direction of _____ field



Loop

- Right Hand Rule
- At _____ of loop
- $B = N \frac{\mu_0 I}{2R}$
 - N = number of loops



Solenoid

- $B = \mu_0 n I$
 - n = loops/m

A long straight current-carrying wire runs from north to south.

A compass needle is placed above the wire points with its N-pole toward the east. In what direction is the current flowing?

If a compass is put underneath the wire, in which direction will the needle point?

A single straight wire produces a B-field. Another wire is parallel and carries an identical current. If the two currents are in the same direction, how would the magnetic field be affected? What if the currents are in the opposite direction?

Suppose a piece of coaxial cable is made with a solid wire at the center. A metal cylinder has a common center with the wire and its radius is 1 mm. A 2 A current flows up the center wire and a 1.5 A current flows down the cylinder.

Find the B-field at 4 mm from the center.

Find the B-field at 0.5 mm from the center.

What current should be in the cylinder to have no B-field outside of the cylinder?

Two wires are 0.2 m apart and 2 m long and both carry 2 A of current. What is the force on the wires?

- Force of one wire on another _____ wire
 - $\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi r}$
 - Attractive if same I 's in _____ direction, repulsive if _____

Homework

1. Suppose two long straight wires run perpendicular to one another without touching. Does one exert a net force on the other? If so, what is its direction? Does one exert a net torque on the other? If so, what is its direction? Justify your responses by using the right hand rules.
2. Use the right hand rules to show that the force between the two loops in Figure 1 is attractive if the currents are in the same direction and repulsive if they are in opposite directions. Is this consistent with like poles of the loops repelling and unlike poles of the loops attracting? Draw sketches to justify your answers.

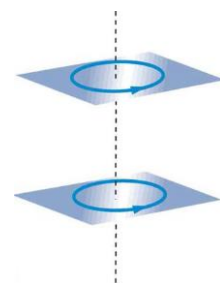


Figure 1

3. (a) The hot and neutral wires supplying DC power to a light-rail commuter train carry 800 A and are separated by 75.0 cm. What is the magnitude and direction of the force between 50.0 m of these wires? (b) Discuss the practical consequences of this force, if any. (OpenStax 22.50) **8.53 N, repulsive**
4. The force per meter between the two wires of a jumper cable being used to start a stalled car is 0.225 N/m. (a) What is the current in the wires, given they are separated by 2.00 cm? (b) Is the force attractive or repulsive? (OpenStax 22.51) **150 A, repulsive**

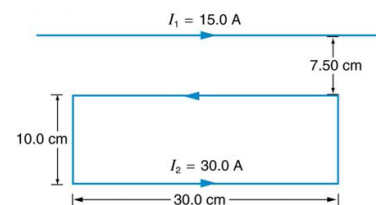


Figure 2

5. A 2.50-m segment of wire supplying current to the motor of a submerged submarine carries 1000 A and feels a 4.00-N repulsive force from a parallel wire 5.00 cm away. What is the direction and magnitude of the current in the other wire? (OpenStax 22.52) **400 A, opposite**
6. The wire carrying 400 A to the motor of a commuter train feels an attractive force of 4.00×10^{-3} N/m due to a parallel wire carrying 5.00 A to a headlight. (a) How far apart are the wires? (b) Are the currents in the same direction? (OpenStax 22.53) **0.100 m, Yes**

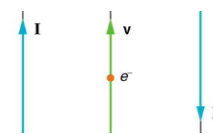


Figure 3

7. Figure 2 shows a long straight wire near a rectangular current loop. What is the direction and magnitude of the total force on the loop? (OpenStax 22.55) **2.06×10^{-4} N, repulsive**
8. Indicate whether the magnetic field created in each of the three situations shown in Figure 4 is into or out of the page on the left and right of the current. (OpenStax 22.58) **out, into; into, out; into, out**

9. What are the directions of the fields in the center of the loop and coils shown in Figure 4? (OpenStax 22.59) **out, right, left**

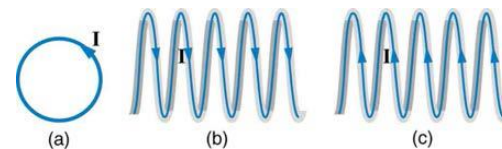


Figure 4

10. What are the directions of the currents in the loop and coils shown in Figure 5? (OpenStax 22.60) **CW, CW as seen from left, CW as seen from right**

11. Inside a motor, 30.0 A passes through a 250-turn circular loop that is 10.0 cm in radius. What is the magnetic field strength created at its center? (OpenStax 22.62) **4.71×10^{-2} T**

12. How strong is the magnetic field inside a solenoid with 10,000 turns per meter that carries 20.0 A? (OpenStax 22.64) **0.251 T**

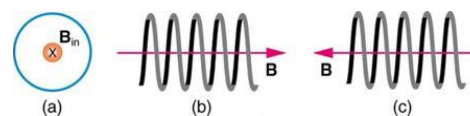


Figure 5

13. How far from the starter cable of a car, carrying 150 A, must you be to experience a field less than the Earth's (5.00×10^{-5} T)? Assume a long straight wire carries the current. (OpenStax 22.66) **0.600 m**

14. Calculate the size of the magnetic field 20 m below a high voltage power line. The line carries 450 MW at a voltage of 300,000 V. (OpenStax 22.72) **1.5×10^{-5} T**