Name: ______________________ Date: __________ **Skill and Practice**

17B Magnetic Fields and Forces

Read:

The movement of charge in space creates some very interesting and useful phenomena. When current passes through a wire, it creates a magnetic field around the wire. Magnetic field, like current, has a direction. This skill sheet gives you practice calculating the strength or force of a magnetic field near a wire and at the center of a coil of wire when current is being conducted.

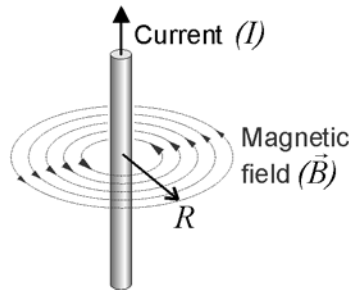
Magnetic field near a wire

The direction of the magnetic field around a wire can be found by pointing the thumb of your right hand in the direction of the current. The direction that your fingers curl is equivalent to the direction of the magnetic field.

The strength of the magnetic field decreases as the distance (R) from the wire increases and it is given by:

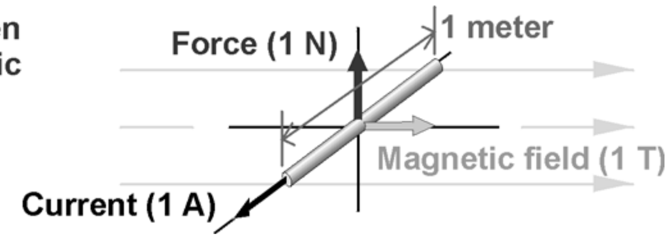
Magnetic field near a wire

$$\underbrace{\vec{B}}_{\text{Magnetic field (T)}} = 2\times 10^{-7}\,\frac{\overset{\text{Current (A)}}{I}}{\underset{\text{Radius (m)}}{R}}$$



Magnetic field is a vector and, as such, has magnitude and direction. The unit of the magnetic field is the tesla (T). Another common unit is the gauss. The relationship between the tesla and the gauss is: $1 \text{ tesla} = 10{,}000 \text{ gauss}$. Earth's magnetic field is about 0.5 gauss.

Relation between units of magnetic field



Magnetic field at the center of a coil

When you take a wire and wrap it around a cylinder and you look at a cross-section of the wire, the total current (I_{Total}) is equal to the current (I) in the wire multiplied by the number of turns (N).

$$I_{total} = NI$$

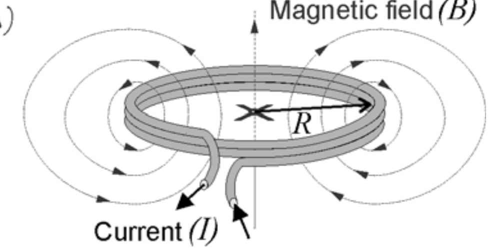
Skill and Practice

The magnetic field at the center of the coil is given by:

Magnetic field at the center of a coil

$$\vec{B} = 2\pi \times 10^{-7} \frac{NI}{R}$$

Magnetic field (T) — Turns (#) — Current (A) — Radius of coil (m)



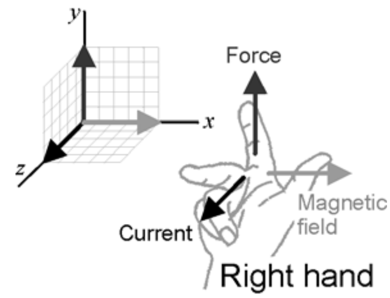
When a current carrying wire is placed in a magnetic field, it experiences a force. This magnetic force is perpendicular to both the direction of the magnetic field and the direction of the current.

The direction of the force can be found by applying the following version of the right-hand rule.

Point fingers in the direction of the current, wrap fingers in the direction of the magnetic field, and the thumb points in the direction of the force.

The equations can be used to find the strength of a magnetic field around a wire and through a loop. When I is given in amperes and R in meters, the magnetic field is in tesla.

The right-hand rule
(for force, current, and field)



Practice:

1. A straight wire is carrying a current of 10 amperes. What is the magnitude of the magnetic field at a distance of 0.5 meters from the wire? Express your answer in tesla and gauss.

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2. At what distance is the magnetic field due to the current in the wire of problem 1 equal to Earth's magnetic field?

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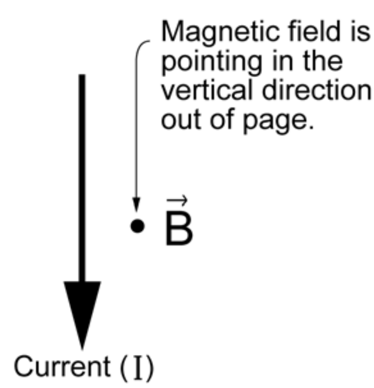
3. On the diagram at right, draw an arrow to indicate the direction of the force acting on the current-carrying wire.
   The dot in the graphic represents the magnetic field vector ($\vec{B}$) pointing vertically out of the page. (HINT: Use the right-hand rule in Part 2.)



4. Two parallel straight wires carry a current *I* in the same direction. The wires are separated by a distance *r*. What is the direction of the force from each wire? Are the wires attracting or repelling each other?

5. Referring to problem 4 above, if the distance between these wires doubles from *R* to 2*R*, by what factor has the force of the magnetic field changed? Write the equation that helps you answer this question.

6. A current of 10 amps flows in a coil made from 200 turns of thin wire. The diameter of the coil is 1.5 centimeters. Calculate the strength of the magnetic field (in tesla) at the center of the coil.

7. The strength of the magnetic field at the center of a coil of thin wire is 1000 gauss. A current of 2 amps flows in the coil and it has a diameter of 1 centimeter. How many turns of wire are in the coil?