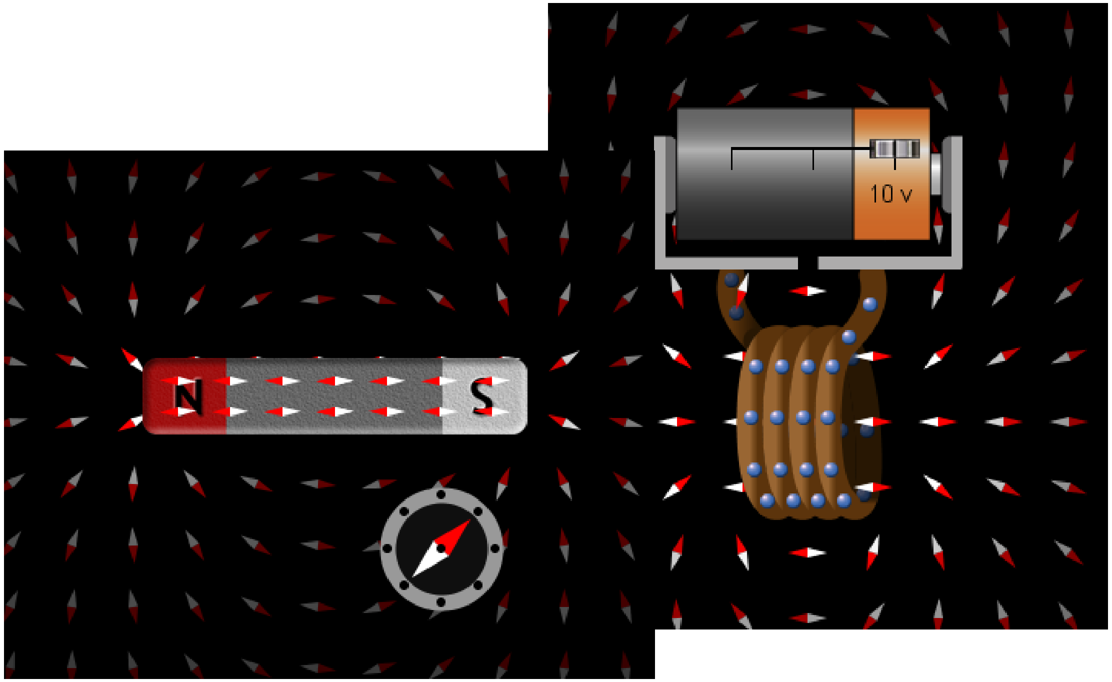
Electromagnets

What is happening?

What is similar and different between the bar magnet and an electro-magnet?

Electromagnets

This magnet and electromagnet will:



A: Attract

B: Repel

C: Neither

What do we know so far?

- Magnetized metals and moving charges (currents) have magnetic fields surrounding them.
- Magnetic fields react with each other.
  - Either attract or repel

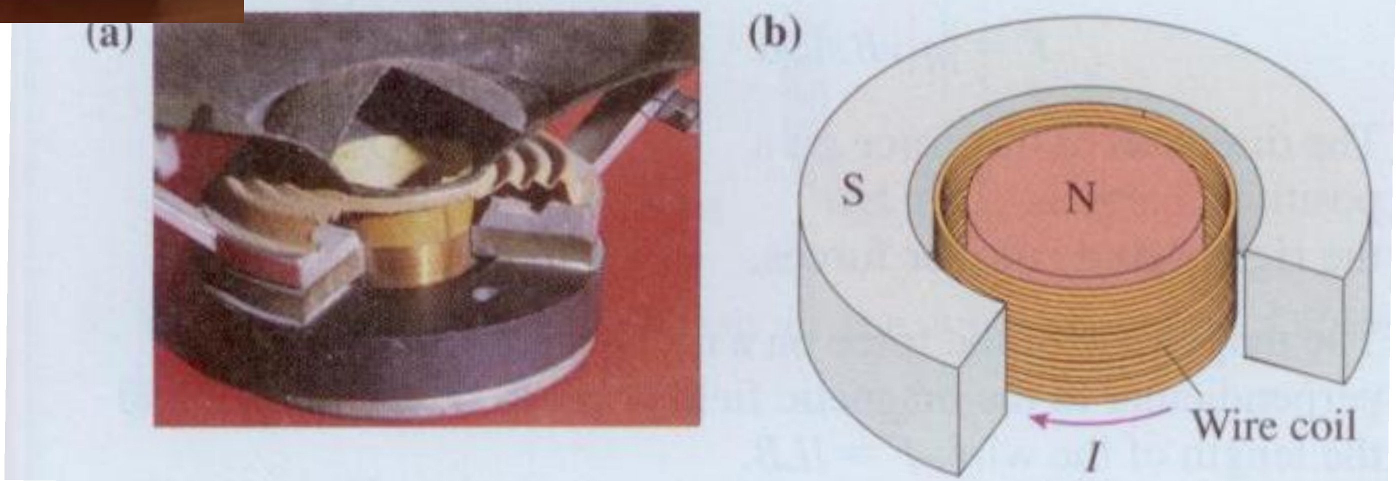
Applications

- Speakers/Microphones

Applications

- Speakers

24.61 The arrangement of the coil and magnet poles
dspeaker.



Applications

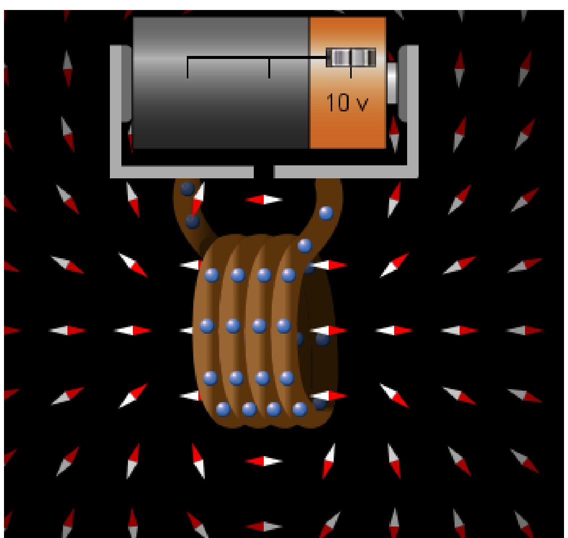
- Speakers
- Credit card strips
- Magnetic media: hard disks, floppy disks, cassette tapes, VHS tapes, 8 tracks (0, 1)
- Medical (artificial heart, kidney dialysis or flow meter)
- Old TVs/Monitors
- Transformers – lab next week
- Stud finder (older type – new ones measure dielectric constant of the wall.)

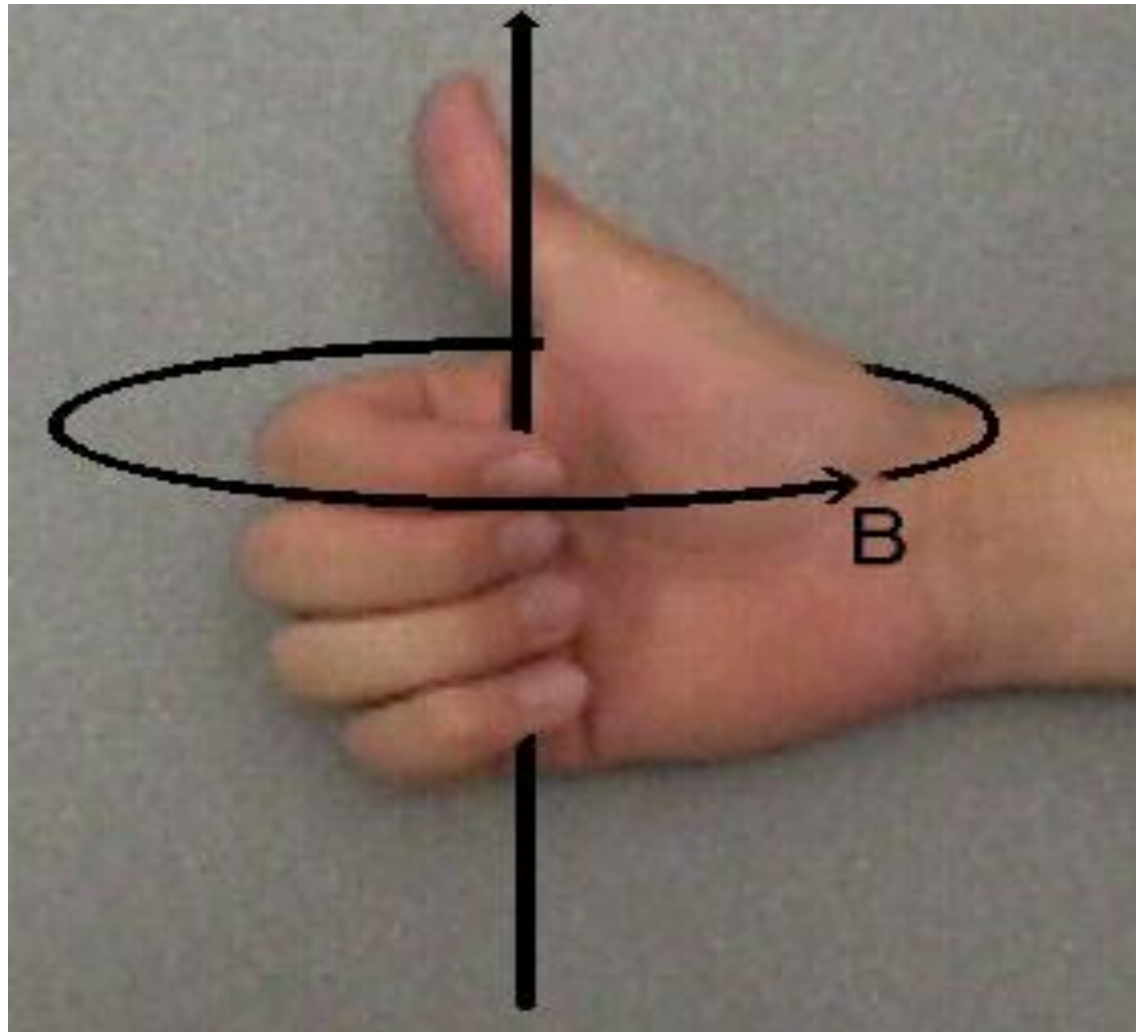
Direction of Magnetic field from moving charge/current

RIGHT hand

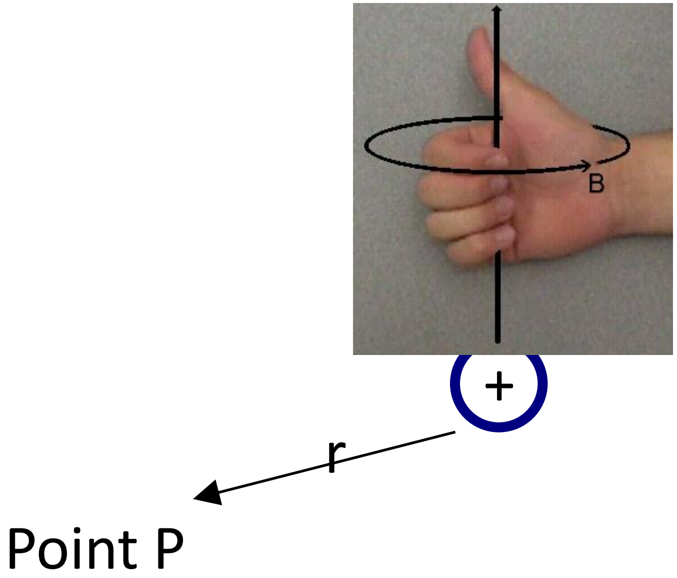
Thumb direction of **+** charge flow

Fingers wrap in direction of B-field



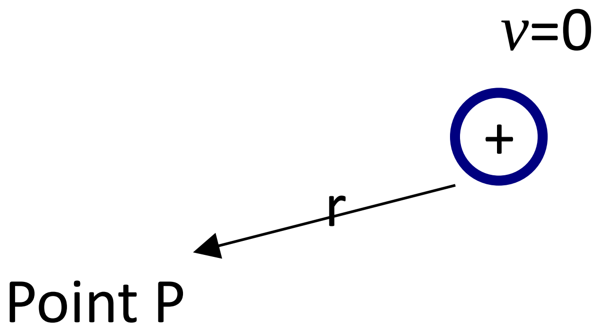


What is the direction of the B-field created by the moving proton, at the point P indicated?



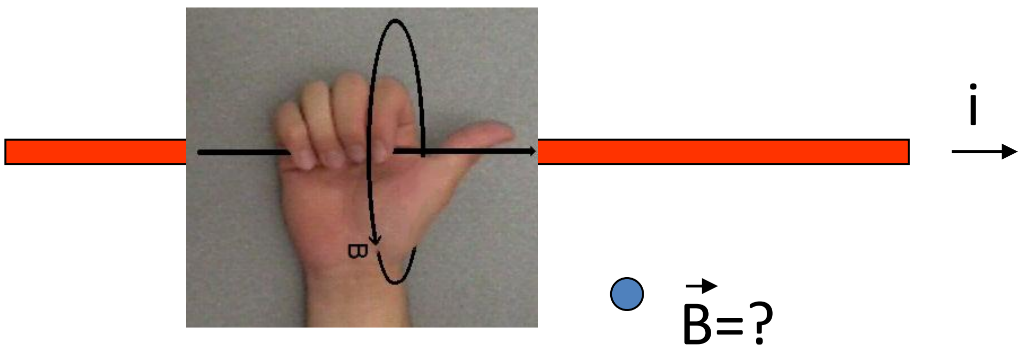
A) Up and Left
B) Down and Left
C) Out of Page
D) Into Page
E) None of these

What is the direction of the B-field created by the stationary proton, at the point P indicated?



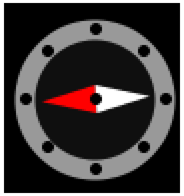
A) Up and Left
B) Down and Left
C) Out of Page
D) Into Page
E) None of these

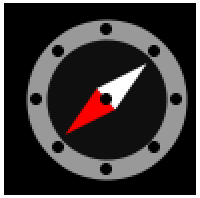
A *<u>long</u>* wire has a current. What is the direction of the B-field created by the wire, just below the wire?

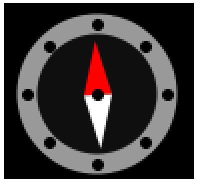


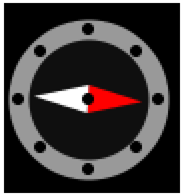
A) ⊙ Into the page
B) ⊗ Out of the page
C) →
D)↓
E) other

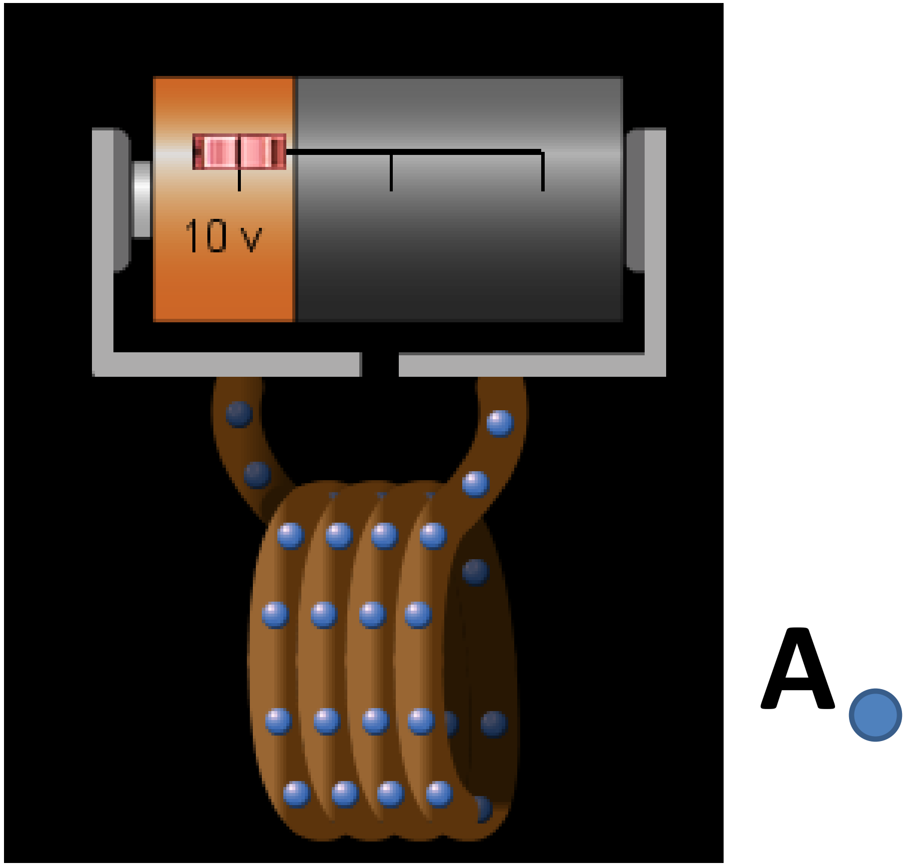
Which compass shows the correct direction of the magnetic field at point A?

A. 

B. 

C. 

D. 



Magnetic field produced by a current

$$|\boldsymbol{B}| = \frac{\mu_o I}{2\pi r}$$

μ_o = 1.26 x 10^{-6} Tm/A

I is current

r is distance from current

Force acting on a wire in a magnetic field

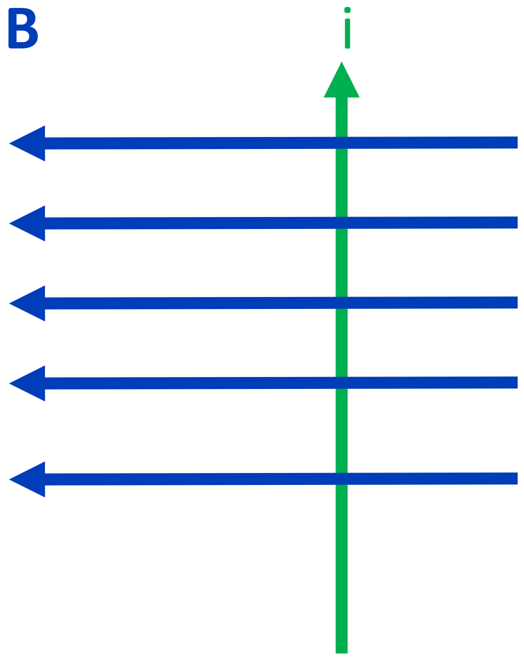
$$F = ILB\sin\theta$$

I : current

L : length of the wire

B : magnitude of the magnetic field

θ : the angle between the field and **I**

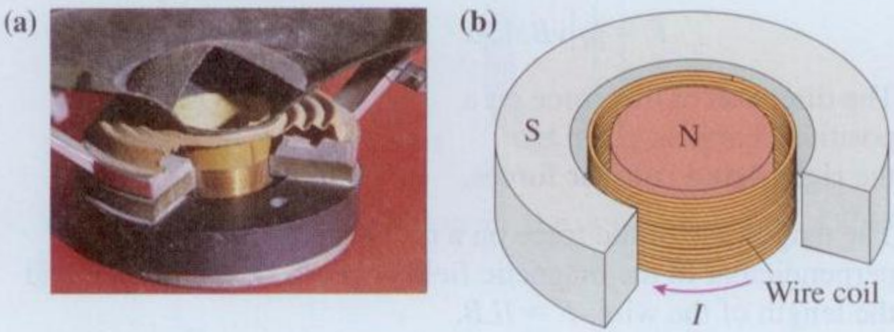


Applications

INTEGRATED EXAMPLE 24.15 **Making music with magnetism**

A loudspeaker creates sound by pushing air back and forth with a paper cone that is driven by a magnetic force on a wire coil at the base of the cone. **FIGURE 24.61** shows the details. The bottom of the cone is wrapped with several turns of fine wire. This coil of wire sits in the gap between the poles of a circular magnet, the black disk in the photo. The magnetic field exerts a force on a current in the wire, pushing the cone and thus pushing the air.

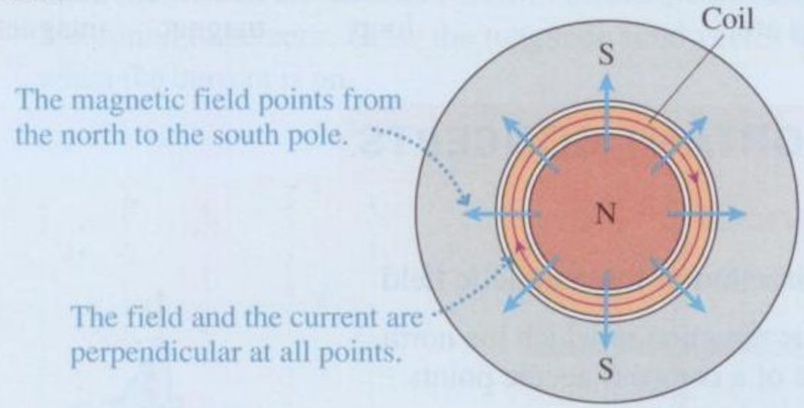
FIGURE 24.61 The arrangement of the coil and magnet poles in a loudspeaker.



There is a 0.18 T field in the gap between the poles. The coil of wire that sits in this gap has a diameter of 5.0 cm, contains 20 turns of wire, and has a resistance of 8.0 Ω. The speaker is connected to an amplifier whose instantaneous output voltage of 6.0 V creates a clockwise current in the coil as seen from above. What is the magnetic force on the coil at this instant?

PREPARE The current in the coil experiences a force due to the magnetic field between the poles. Let's start with a sketch of the

FIGURE 24.62 The magnetic field in the gap and the current in the coil.



SOLVE The current in the wire is produced by the amplifier. The current is related to the potential difference and the resistance of the wire by Ohm's law:

$$I = \frac{\Delta V}{R} = \frac{6.0\ \text{V}}{8.0\ \Omega} = 0.75\ \text{A}$$

Because the current is perpendicular to the field, we can use Equation 24.10 to determine the force on this current. We know the field and the current, but we need to know the length of the wire in the field region. The coil has diameter 5.0 cm and thus circumference $\pi(0.050\ \text{m})$. The coil has 20 turns, so the total length of the wire in the field is

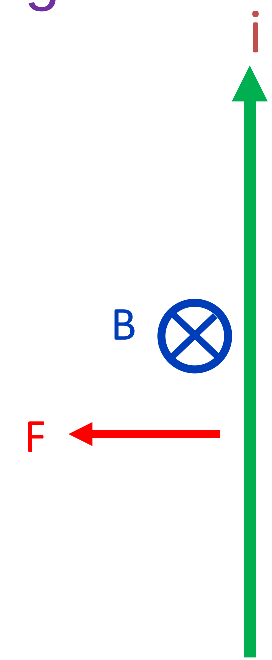
$$L = 20\pi(0.050\ \text{m}) = 3.1\ \text{m}$$

The magnitude of the force is then given by Equation 24.10 as

$$F = ILB = (0.75\ \text{A})(3.1\ \text{m})(0.18\ \text{T}) = 0.42\ \text{N}$$

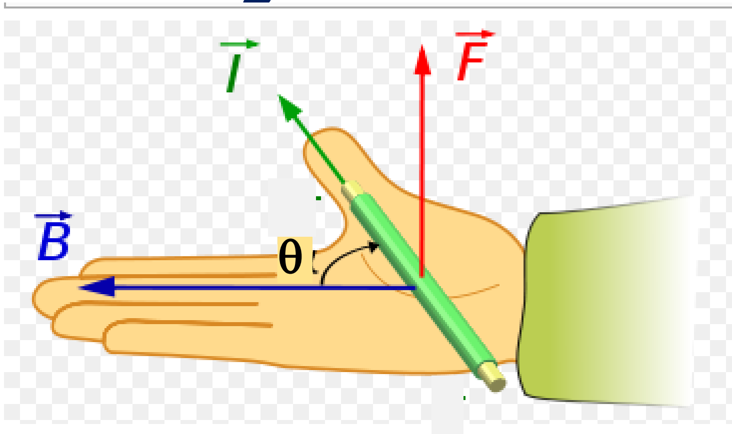
What is the direction of the Force acting on the **Green** wire?

$$F = ILB\sin\theta$$



A) Up
B) Right
C) Left
D) Into the Page
E) Out of the Page

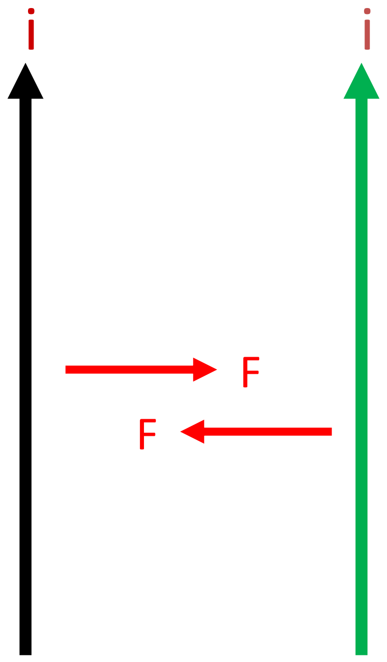
Either visualize tiny magnets or use Force right hand rule



What is the direction of the Force acting on the **Black** wire?

$$F = ILB\sin\theta$$

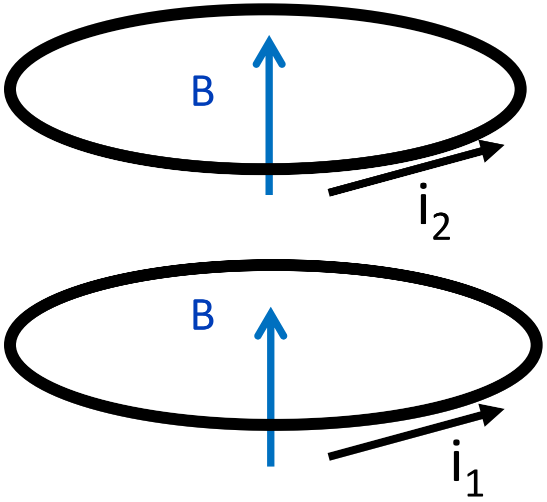
A) Up
B) Right
C) Left
D) Into the Page
E) Out of the Page



Crushed by currents The forces between currents are quite small for ordinary currents, even the large currents in the jumper cables of the previous example. But for a current of tens of thousands of amps, it's a different story. This lightning rod is hollow. When struck by lightning, it carried an enormous current for a very short time. The currents in all parts of the rod were parallel, so they attracted each other. The tremendous size of the currents led to attractive forces strong enough to crush the rod.

Two loops of wire have current going around in the same direction.
The force between the loops is:

A: Attractive
B: Repulsive
C: Net force is zero.

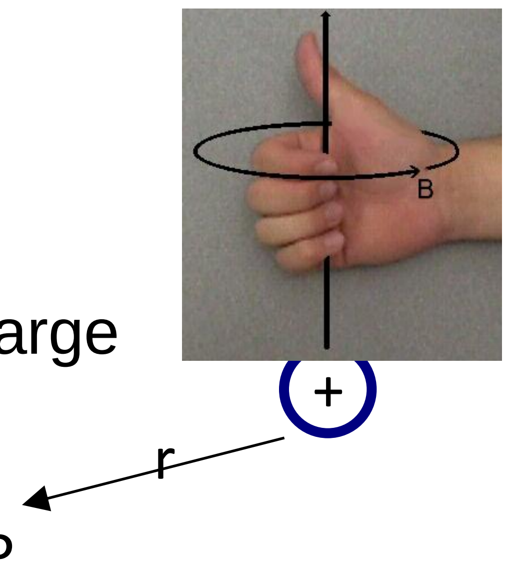


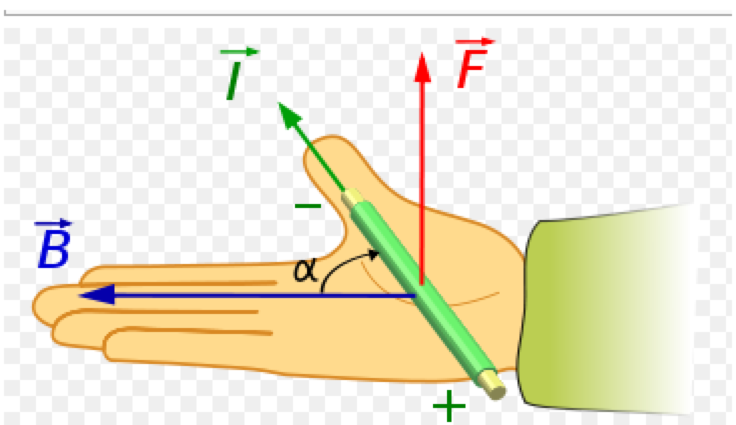
Moving charge creates a magnetic field
So….
Put it in another magnetic field and it will feel a **force**.
Either attracted or repelled

$$F = qvB\sin\theta$$

q : charge that is moving
v : speed of the charge
B: *external* magnetic field
θ : angle between field and velocity of charge

Field created





experiences no magnetic force, and so continues in a straight line. A more general situation in which a charged particle's velocity $\vec{v}$ is neither parallel to nor perpendicular to the field $\vec{B}$ is shown in FIGURE 24.32. The net result is a circular motion due to the perpendicular component of the velocity coupled with a constant velocity parallel to the field: The charged particle spirals around the magnetic field lines in a helical trajectory.

High-energy particles stream out from the sun in the solar wind. Some of the charged particles of the solar wind become trapped in the earth's magnetic field. As FIGURE 24.33 shows, the particles spiral in helical trajectories along the earth's magnetic field lines. Some of these particles enter the atmosphere near the north and south poles, ionizing gas and creating the ghostly glow of the **aurora**.

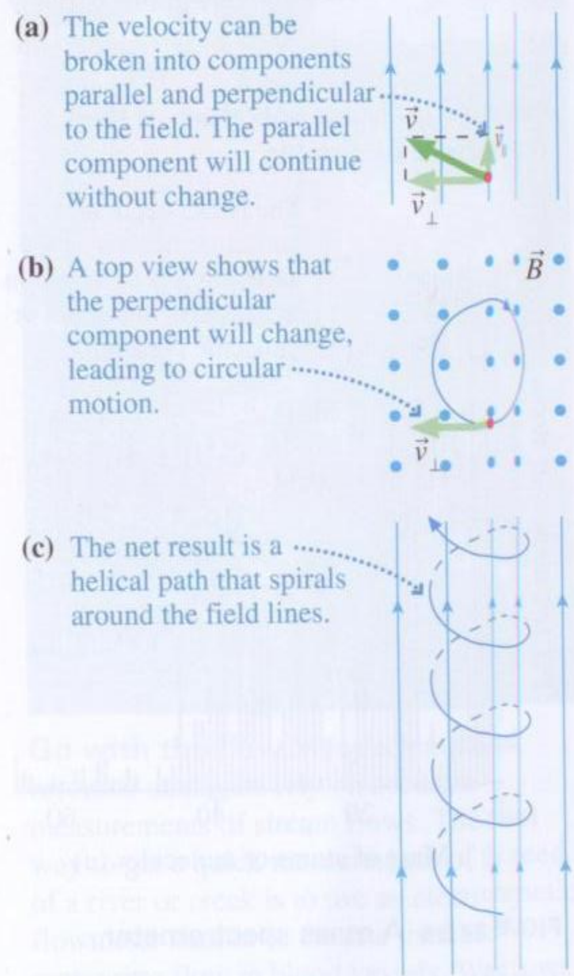


FIGURE 24.33 Charged particles in the earth's magnetic field create the aurora.