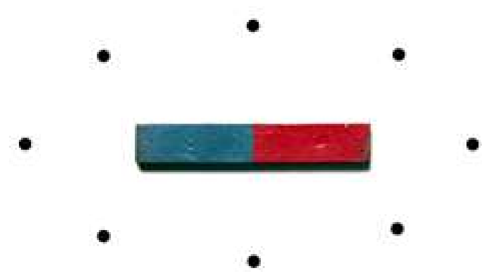
Large Room Meeting I

Major Goals

- □ Represent the $\vec{B}$-field surrounding a magnet.
- □ Determine the direction of the $\vec{B}$-field surrounding a current carrying wire.
- □ Determine the direction of the force exerted by an external $\vec{B}$-field on a current carrying wire.

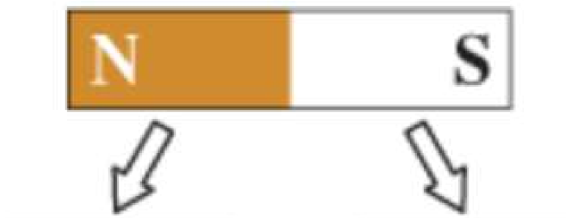
Need to Know
How are magnets different from electrically charged objects?

20.1.2 – Observational Experiment
Observe what happens when we move a small magnet around near a big bar magnet.



Clicker Question #1

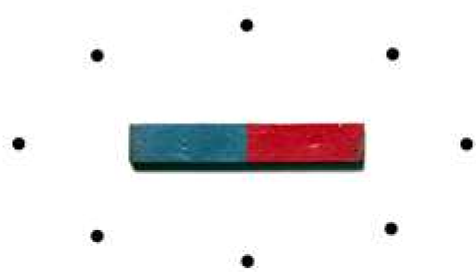
Hypothetical Question
What could happen if we take a bar magnet and cut it perfectly in half?



Explaining the behavior of the compass
Other interactions which occur between two objects without direct contact are gravitational and electric interaction. Could we invent a similar model to explain how magnets interact with one another?

20.1.2 – Observational Experiment

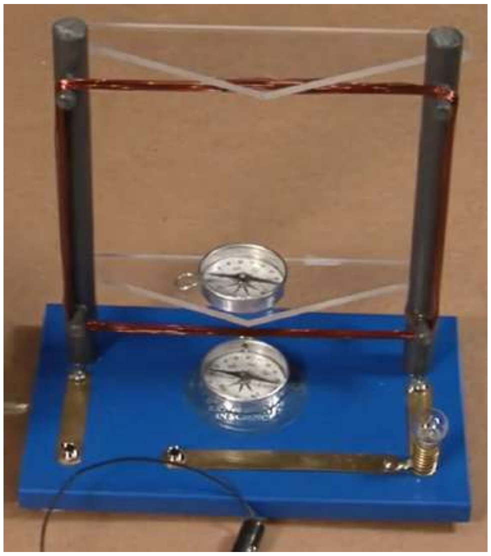
How can we use the direction a compass points to help us visualize this $\vec{B}$-field?



Time for Telling

Read and Interrogate (see "How to Read The Textbook document") PP 617-617 in the textbook.

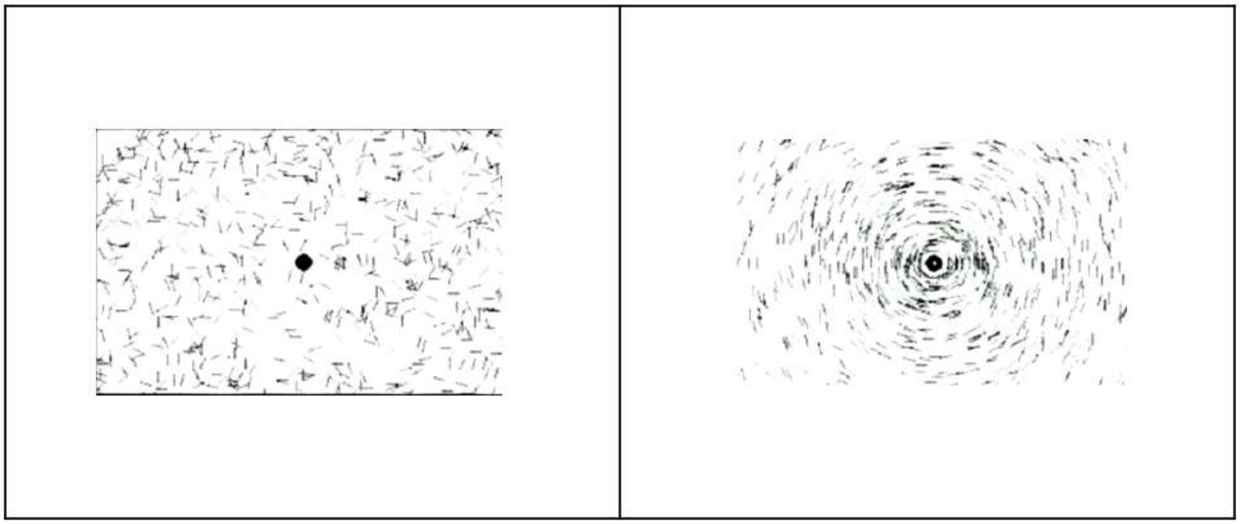
20.2.4 – Observational Experiment
Observe what happens when the setup shown below is connected to a battery.



Time for Telling

Read and Interrogate (see "How to Read The Textbook document") PP 619-620 - before Conceptual Exercise 20.1 in the textbook.

20.2.6 – Observe and Explain
Imagine a wire passing perpendicularly out of a piece of paper with a bunch of iron filings. The pictures below show the iron filings before and after current is run through the wire.

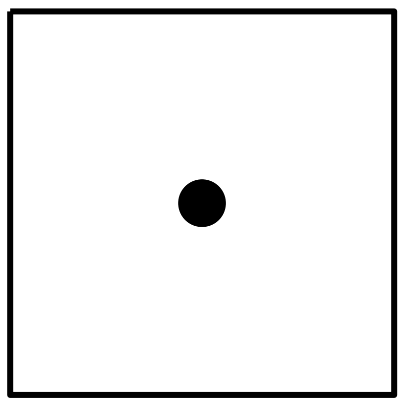


Clicker Question #2

Clicker Question #3

20.2.6 – Observe and Explain

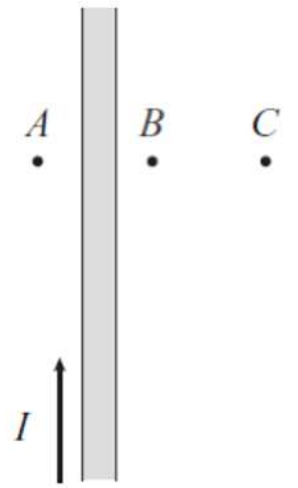
Assume the current is moving out of the page. Sketch 5 $\vec{B}$-field vectors around the wire.



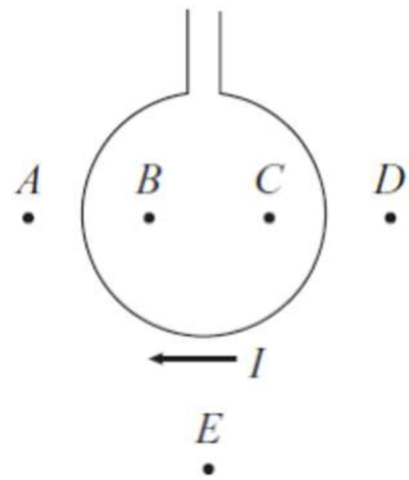
20.2.7 – Represent and Reason

Current flows through each of the following wires in the directions shown. Determine the direction of the $\vec{B}$-field at each of the labeled points. Represent vectors going into the page with a cross ($\otimes$) and vectors coming out of the page with a dot ($\odot$).

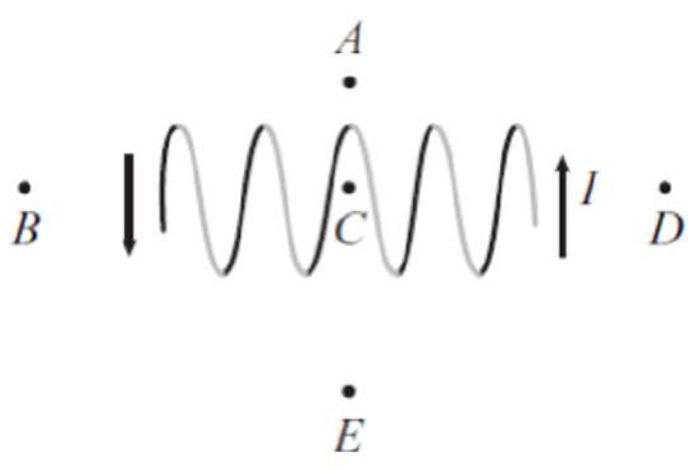
Wire #1:



Wire #2:



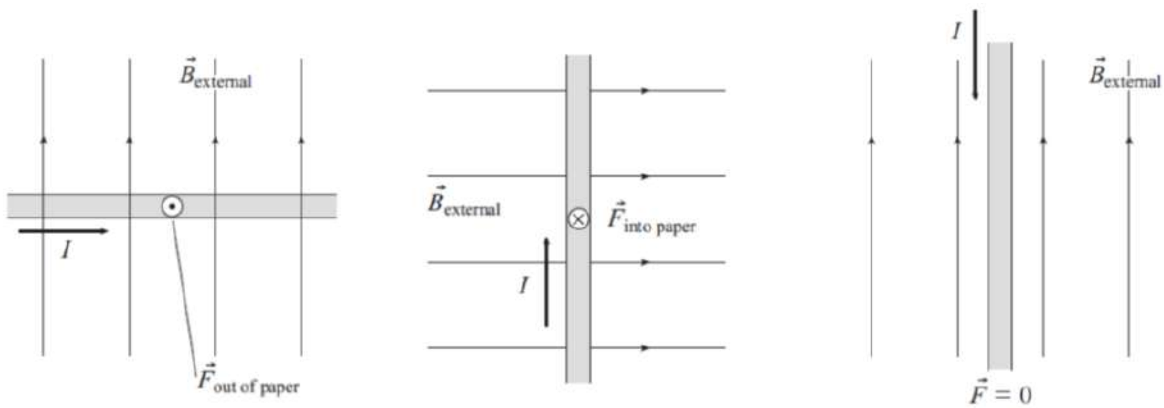
Wire #3:



Read and Interrogate (see "How to Read The Textbook document") PP 620-621 - main idea is in the conceptual Exercise 20.1 in the textbook.

20.3.1 – Find a Pattern

A current-carrying wire is placed between the poles of an electromagnet producing a uniform $\vec{B}_{external}$. The force exerted on the wire by this magnetic field is shown for three orientations of $\vec{B}_{external}$. Invent a rule that relates the directions of the current, the $\vec{B}$-field, and the force.



20.3.2 – Testing Experiment
Test your rule by predicting how the wire will move when current is run through it in each of the orientations shown below:

	Experiment #1	Experiment #2	Experiment #3
			
Prediction:			
Outcome:			

Clicker Question #4

Clicker Question #5

Clicker Question #6

20.3.2 – Testing Experiment

Observe the outcome of the experiments and record them in your handout.

Experiment #1	Experiment #2	Experiment #3

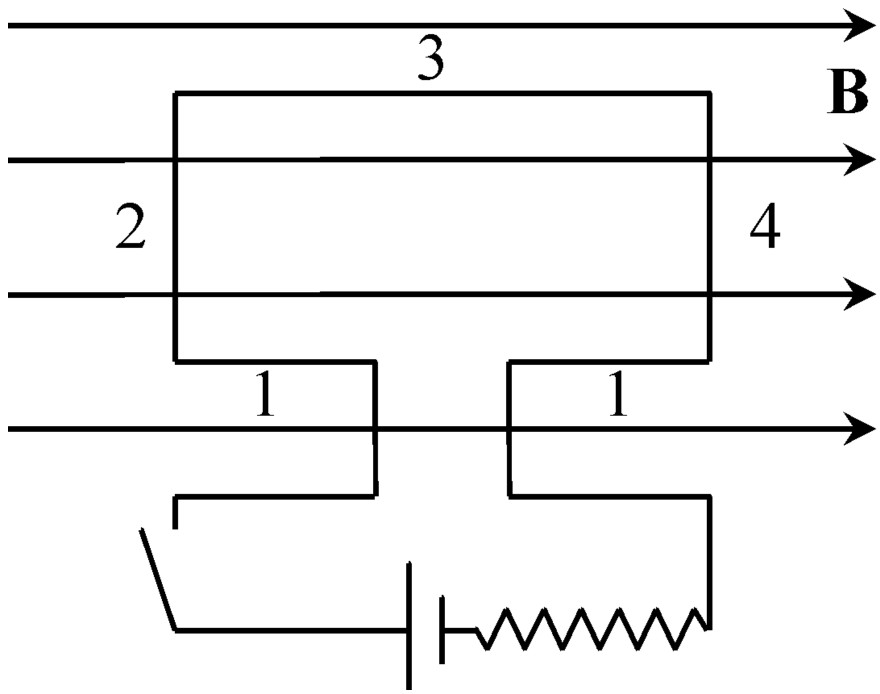
Time for Telling

Read and Interrogate (see "How to Read The Textbook document") PP 621-626 - before "The direct current electric motor" section in the textbook. Pay special attention to Testing Experiment Table 20.3 - make sure you can repeat the reasoning leading to the prediction.

20.3.5 – Represent and Reason

A current-carrying wire shaped into a rectangular loop is placed in an external $\vec{B}$-field as shown

below. Determine the direction of the force the magnetic field exerts on each side of the wire loop.



Read and Interrogate (see "How to Read The Textbook document") PP 627-628 - stop before Section 20.4 in the textbook.

Clicker Question #7

Clicker Question #8

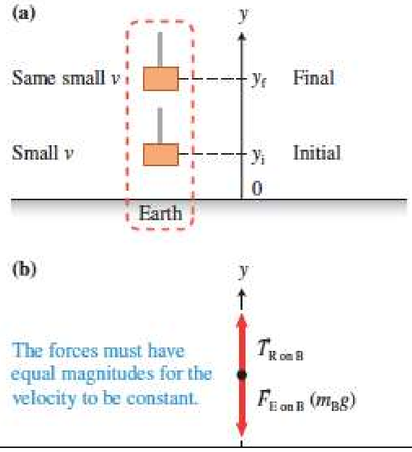
Small Room Meeting

Major Goals

- □ Use the interrogation method to read the textbook.
- □ Apply the right-hand rule for the $\vec{B}$-field to determine the direction of the $\vec{B}$-field produced by a current carrying wire.

Read Chapter 20.1-20.3: Use the "interrogation method" described in the handout "How to Read the Textbook" on Canvas, also pasted below.

FIGURE 7.3 Lifting a box at a negligible constant speed.



Imagine that a rope lifts a heavy box upward at a constant negligible velocity (Figure 7.3a). The rope is attached to a motor above, which is not shown in the figure. First, we choose only the box as the system and apply Newton's second law to find the magnitude of the force that the rope exerts on the box. Since the box moves up at constant velocity, the upward tension force $\vec{T}_{\text{R on B}}$ exerted by the rope on the box is equal in magnitude to the downward gravitational force $\vec{F}_{\text{E on B}}$ exerted by Earth on the box (see the force diagram in Figure 7.3b), $m_{\text{B}}g$, we find that the magnitude of the tension force for this process is $T_{\text{R on B}} = m_{\text{B}}g$.

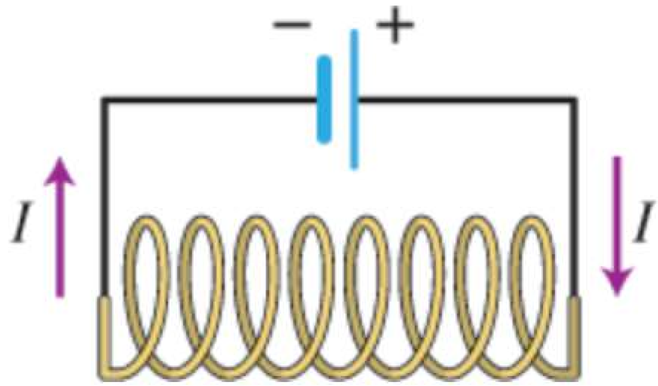
To derive an expression for gravitational potential energy, we must change the boundaries of the system to include the box and Earth (if Earth is not included in the system, the system does not have gravitational potential energy). The origin of a vertical y-axis is the ground directly below the box with the positive direction upward. The initial state of the system is the box at position y_i moving upward at a negligible speed $v_i \approx 0$. The final state is the box at position y_f moving upward at the same negligible speed $v_f \approx 0$. According to work-energy Eq. (7.3),

$$E_i + W = E_f$$

You read the first sentence: *Imagine that a rope lifts a heavy box upward at a constant negligible velocity (figure 7.3a).* You tell yourself: "Aha, if they say constant negligible velocity, it means that kinetic energy does not change and it actually does not matter, this is what negligible means. Why would they do it at constant velocity? Maybe they want to simplify the process. Now, where is this figure 7.3a – oh, it is on the left. I see the box, and they labeled everything nicely. Oh, and I see the system boundary, I bet they will say later that the box and Earth are the system. And the axis points up, maybe I will need it later, I will remember that for now." After this silent conversation with yourself you proceed to the next sentence: *The rope is attached to a motor above, which is not shown in the figure.* You tell yourself: Well, if they do not show the motor, it will be external to the system, I bet it will do work on the system!" You continue reading: *First we choose only the box as a system and apply Newton's second law to find the magnitude of the force that the rope exerts on the box. Since the box moves up at constant velocity, the upward tension force* $\vec{T}_{\text{R on B}}$ *exerted by the rope on the box is equal in magnitude to the downward gravitational force* $\vec{F}_{\text{E on B}}$ *exerted by Earth on the box (see the force diagram in Figure 7.3 b), mg, we find that the magnitude of the tension force in this process is* $T_{\text{R on B}} = mg$. You tell yourself: "Hmm, they did not choose the system I thought they would. But the force diagram makes sense. If Earth was in that system, we would not put the force it exerts on the box on the diagram and we would not be able to figure out what the force that the cable exerts is. But why do we need this force if we are trying to figure out the mathematical relation for gravitational potential energy? I guess I do not understand it yet, let me read on."

The above example shows you how experts think when they are reading texts like this. This kind of thinking is almost intuitive as they engage in it every day. So, for you to learn from the textbook (a skill vital in any job you will hold later), you need to learn to do this when you are reading the textbook.

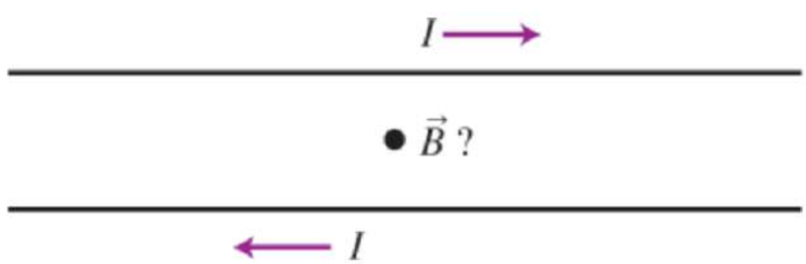
Question #1 (Conceptual Exercise 20.1)
Draw the magnetic field lines of a solenoid connected to a battery. (A solenoid is a wire with a large number of loops in a cylindrical shape. For simplicity in this exercise we will use a solenoid with eight loops.)



Question #2 (Conceptual Exercise 20.1 Try it Yourself)

Use the right-hand rule for the B-field and the superposition principle to predict the direction of

the magnetic field exactly in the middle between two straight wires. The two wires are oriented horizontally in the plane of the page, with currents as shown below.



Criterion	**Perfect (2)**	**Needs some work (1)**	**Needs a lot of work (0)**
Clarity	The solution is clear, expressed in words and symbols, takes no effort to comprehend.	The words are lacking but the symbolic part is clear. Takes some effort to comprehend.	Takes a lot of effort to comprehend. There is only math, mostly numbers, not general equations and there are no words explaining the thought process.

Large Room Meeting II

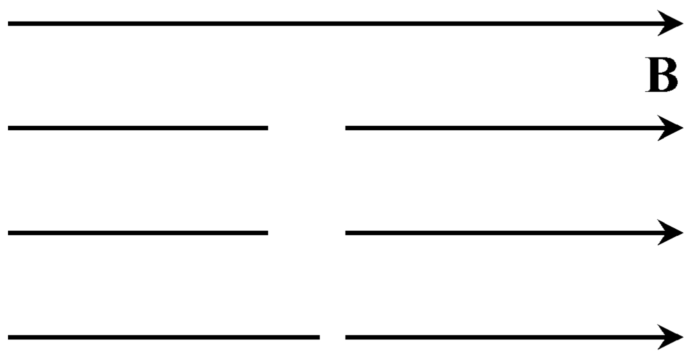
Major Goals

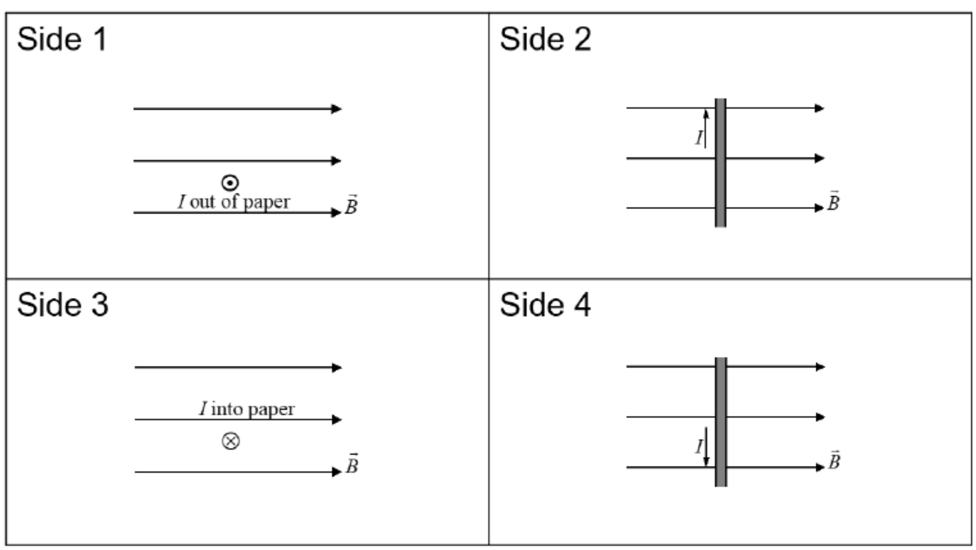
- □ Define

20.3.6 – Represent and Reason

A current-carrying wire shaped into a rectangular loop is placed in an external $\vec{B}$-field as shown

below. The loop is positioned so that it is perpendicular to the screen. Determine the direction of the force the magnetic field exerts on each side of the wire loop.



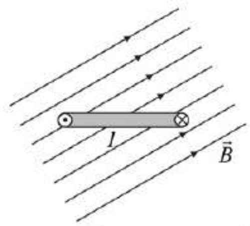


Clicker Question #1

Clicker Question #2
20.3.7 – Represent and Reason

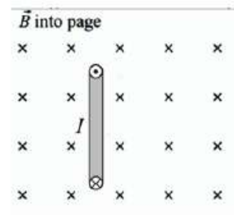
Does the magnetic field exert a nonzero torque on the current loop in each case pictured below? If so, and if the loop is initially at rest, which way would the magnetic torque cause the loop to start turning?

a)



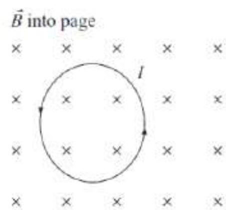
*This is a loop coming perpendicularly out of the page

b)

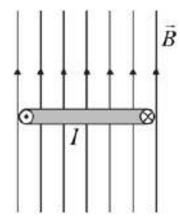


*This is a loop coming perpendicularly out of the page

c)

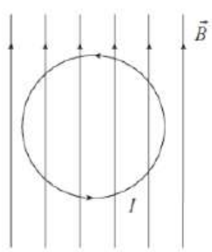


d)



*This is a loop coming perpendicularly out of the page

e)



Clicker Question #3

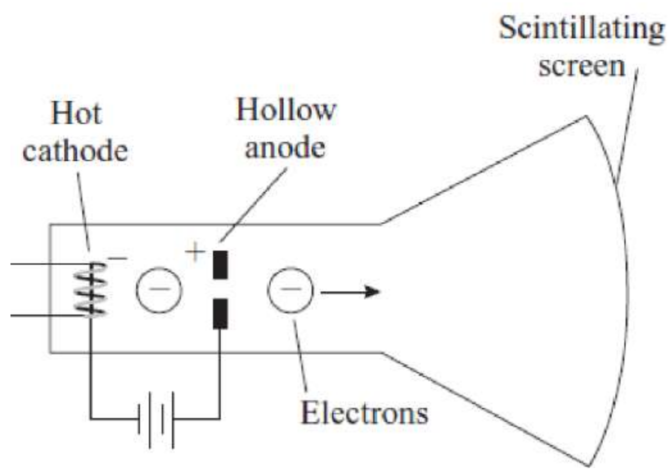
20.3.9 – Represent and Reason

Two wires are parallel to each other. Wire 1 has electric current going into the page and wire 2 has electric current coming out of the page. We want to know how these two wires interact with one another.

Clicker Question #4

20.4.1 – Observational Experiment

A cathode-ray tube (CRT) is part of a traditional television set or of an oscilloscope. Watch what happens when we bring a magnet near the CRT.



Describe what you observed in the video.

Come up with an explanation for your observations.

Invent a rule which describes the direction the of the force an external $\vec{B}$-field exerts on a moving

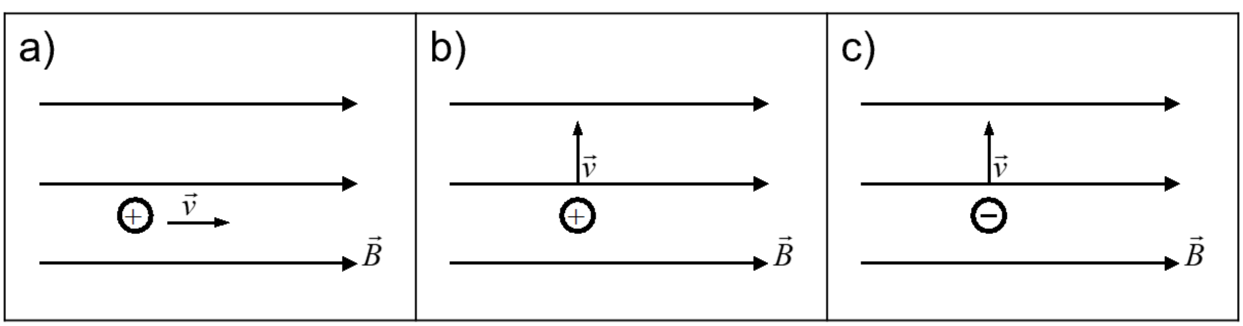
electron relative to the direction of its velocity $\vec{v}$.

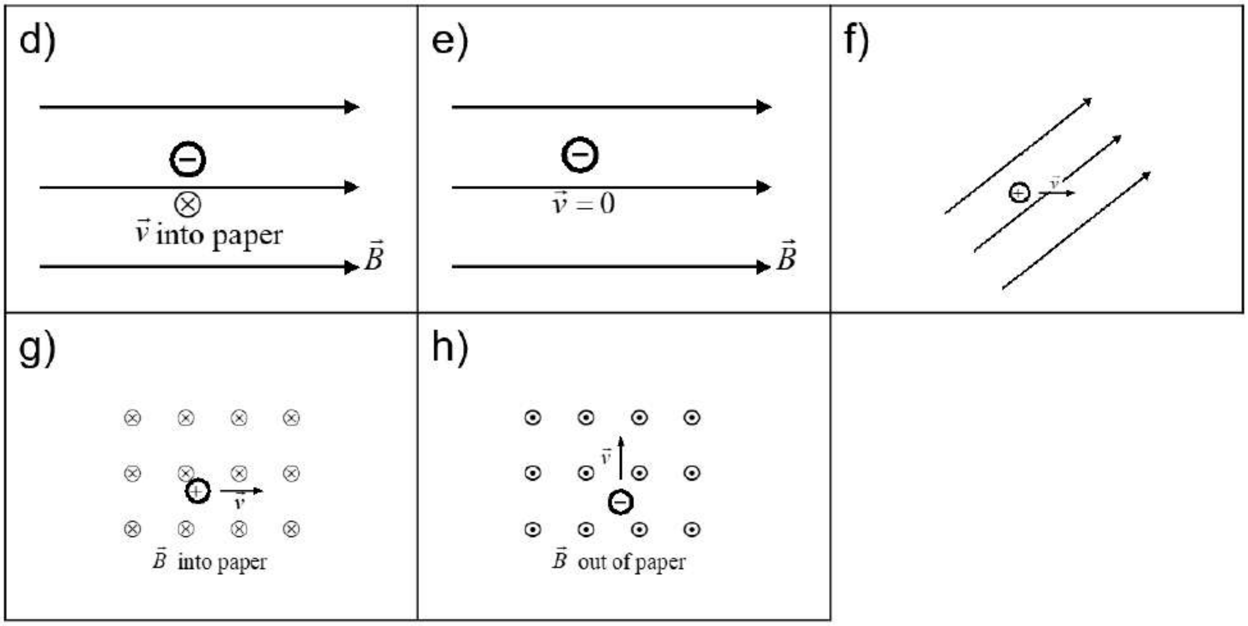
Your friend says that the beam of electrons is deflected by the magnet because the electrons are charged particles and the magnet is made of iron. How can you convince your friend that she is mistaken?

Time for Telling

Read and Interrogate (see "How to Read The Textbook document") PP 628-630 - make sure you follow the steps in derivation on page 629 in the textbook.

20.4.2 – Represent and Reason
For each situation below, decide whether a nonzero magnetic force is exerted on the moving electric charge (test object). If the force is not zero, draw direction of the magnetic force on the figures that follow.





Time for Telling

Read and Interrogate (see "How to Read The Textbook document") PP 630-631.

Magnetic Field Created a Straight Wire

We've seen the shape of the $\vec{B}$-field created by a straight current-carrying wire, but what about its magnitude?

There are two things we can vary: the current through the wire and our distance from the wire. The following data were obtained by varying each. Identify patterns from these data.

I (A)	1.0	2.0	3.0	1.0	1.0	1.0
r (m)	0.2	0.2	0.2	0.4	0.8	0.1
B (μT)	1.00	2.00	3.00	0.50	0.25	2.00

Clicker Question #5

Clicker Question #6

Time for Telling

Read and Interrogate (see "How to Read The Textbook document") PP 632-634 in the textbook.

20.6.2 – Apply what You've Learned
Your group wonders if you could support your clothesline by running an electric current through it while it resides in the $0.5 \times 10^{-4} T$ magnetic field due to Earth. We'll assume that you are in Costa Rica near the equator, where the field is parallel to Earth's surface. The line is to be 10 m long. You estimate that, with the clothes attached, its mass is 2.0 kg. What direction should you orient the line and what electric current is needed to support the line? Finally, does this seem like a promising way to support a clothesline? Explain.

Read and Interrogate (see "How to Read The Textbook document") Section 20.6 in the textbook, make sure you can solve all example problems in it on your own.