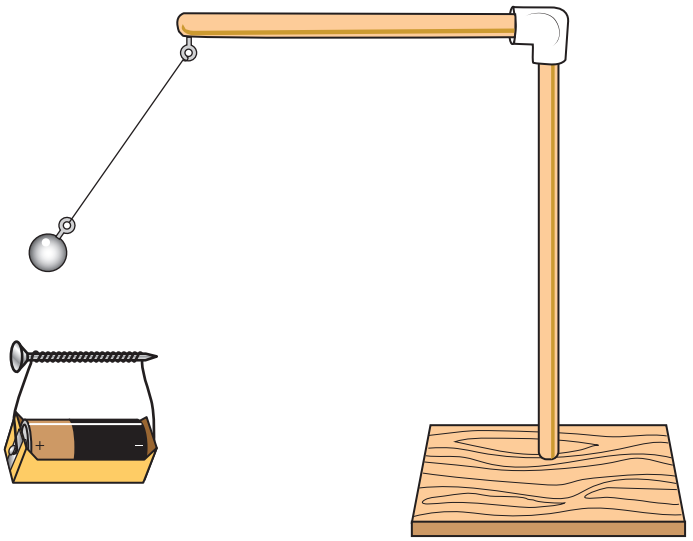
Stimulus 1

A class visiting a science museum sees a pendulum with an electromagnet as shown in Figure 1. The metal ball of the pendulum swings back and forth, but it does not stop or slow down. The ball is made of iron. Back in class, they make a similar setup with their teacher. They discuss the purpose of including the electromagnet in the design. They know that the strength of the electromagnet depends on the number of times the wire is wrapped around the nail.

Figure 1. Pendulum with Electromagnet



The students discuss the fact that electromagnets are commonly used in pendulums. They make an electromagnet using wire, a nail, and a battery. The wire is wrapped around the nail, and the two ends of the wire are connected to the battery, causing an electric current to flow. When the electromagnet is brought close to a pile of metal paper clips on a table, its magnetic force picks up some of the paper clips, as shown in Figure 2. The students repeat the experiment with a battery that has a different voltage and using different distances between the electromagnet and the paper clips. Table 1 shows the number of paper clips picked up with each type of battery and distance.

Figure 2. Electromagnet

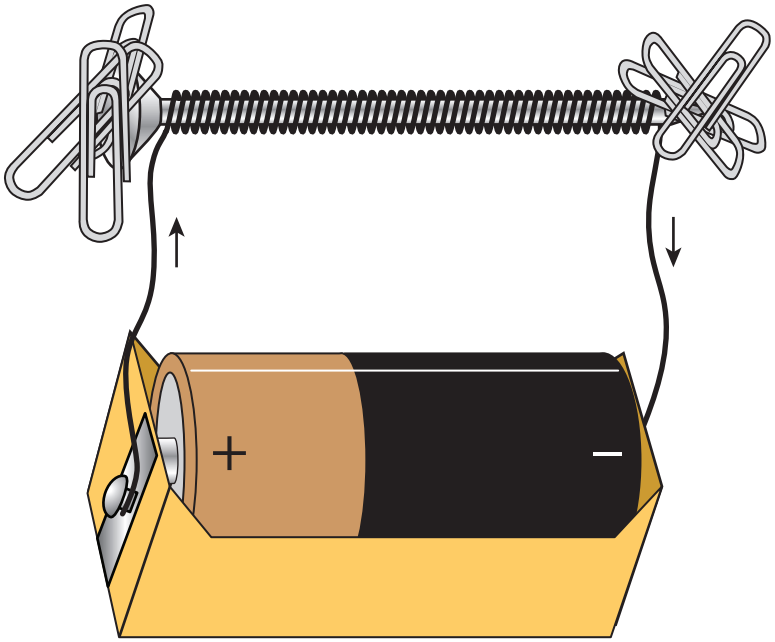


Table 1. Effect of Battery Voltage and Distance on Paper Clips

Battery Voltage (volts)	Distance (centimeters)	Number of Paper Clips Picked Up
1.5	5	13
1.5	10	7
3.0	5	26
3.0	10	14

Item 1

Which design problem is being addressed by including the electromagnet as shown in Figure 1?

- A. the need to make the metal ball swing in a circle when it is near the electromagnet
- B. the need to make the metal ball swing farther in the direction of the electromagnet
- C. the need to increase the weight of the metal ball as it passes near the electromagnet
- D. the need to decrease the speed of the metal ball as it passes over the electromagnet

Item 2

The class wants to measure the speed of the ball by the number of swings per 10 seconds. Which statement correctly explains how they can do this?

- A. They can see how long it takes for the metal ball to swing 10 times.
- B. They can count from 1 to 10 because this should take about 10 seconds.
- C. They can measure 1 second with a stopwatch and multiply the number of swings by 10.
- D. They can measure 10 seconds with a stopwatch and count swings of the metal ball during this time.

Item 3

The motion of the pendulum is affected by where the electromagnet is placed. How should the students perform the experiment, and what information would the students need to gather to determine the best position for the electromagnet?

Circle the correct answers from the lists to complete the sentences.

The students will need to drop the metal ball from the same height and test the effect of the electromagnet at [different locations / the same location] with multiple trials. To compare the patterns of the motion of the pendulum, the students should measure the resulting [string length / swing time].

Rubric	
Score	Description
1	The students will need to drop the metal ball from the same height and test the effect of the electromagnet at **different locations** with multiple trials. To compare the patterns of the motion of the pendulum, the students should measure the resulting **swing time**.
0	The response is incorrect or irrelevant.

Item 4

The students would like to improve a pendulum with a 50-centimeter string and a total swing time of 4.67 seconds. The students want to replace the metal ball with a magnet to see if the swing time would reach 5 seconds or longer. The electromagnet is placed underneath the pendulum, as shown in Figure 1.

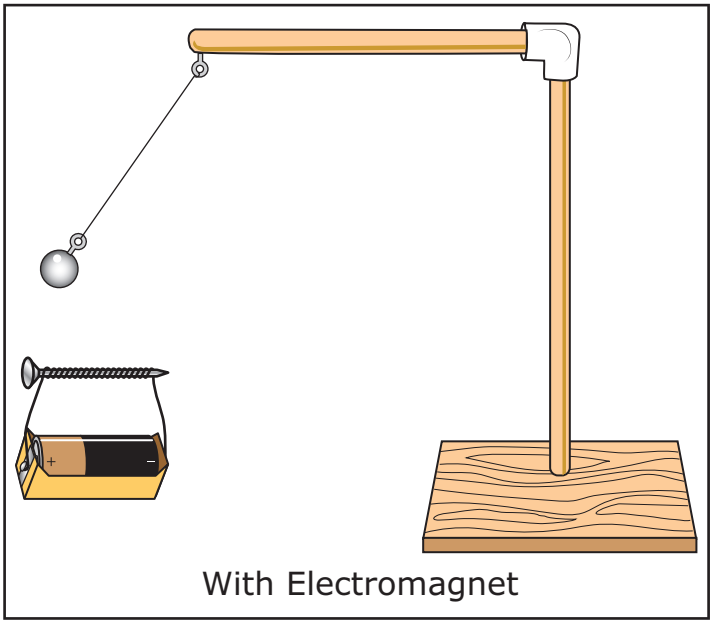
Write the correct answer in each box.

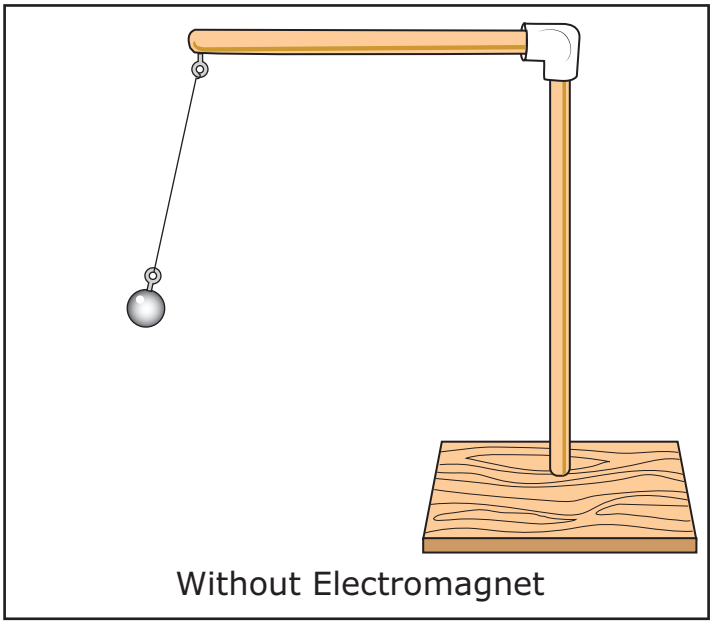
First Blank	Second Blank
A. string length of 50 centimeters	C. number of swings
B. swing time of 5.1 seconds	D. length of the pendulum string

A result that would indicate that the criteria for success was met would be obtaining a [ ]. The strength of the magnetic force between the magnets is limited by the [ ].

Rubric	
Score	Description
2	A result that would indicate that the criteria for success was met would be obtaining a **swing time of 5.1 seconds**. The strength of the magnetic force between the magnets is limited by the **length of the pendulum string**.
0	The response is incorrect or irrelevant.

Figure 3. Pendulum with and without Electromagnet





The students compare the two setups shown in Figure 3. They want to design an investigation to explain the effect of the electromagnet on the metal ball. They look at the data in Table 1.

Circle the correct answers from the lists to complete the sentences.

The students should change the | number of paper clips / voltage of the battery | to see how the strength of the electromagnet affects the motion of the metal ball. They correctly predict that as it increases, the | weight / height | of the metal ball's swing will increase.

Item 6

Students in the class consider the design shown in Figure 1 to decide whether changes could be made that would change the force of attraction between the metal ball and the electromagnet. Evaluate the design to propose ways that the design could be adjusted. Explain your answer.

- Propose **one** change to the design in Figure 1 that would increase the force of attraction between the metal ball and the electromagnet.
- Propose **one** change to the design in Figure 1 that would decrease the force of attraction between the metal ball and the electromagnet.
- Describe what students could measure to evaluate whether there is a change in the force of attraction between the metal ball and the electromagnet.

Analyze the information carefully. Then write your response in the space provided. Support your answer with details.

Scoring Rubric	
Score	**Description**
3	The student answers all 3 parts correctly.
2	The student answers any 2 parts correctly.
1	The student answers any 1 part correctly.
0	The response is blank, incorrect, or irrelevant.
	• In order to increase the force of attraction between the metal ball and the electromagnet, the students could increase the voltage of the battery. As the battery voltage increases, the strength of the electromagnetic force increases. • In order to decrease the force of attraction between the metal ball and the electromagnet, the students could increase the distance between the metal ball and the electromagnet . As the distance between them increases, the strength of the electromagnetic force on the metal ball decreases. • To evaluate whether there is a change in the force of attraction between the metal ball and the electromagnet, the students could measure the length of time the metal ball of the pendulum continues to swing with either different battery voltages or different distances between the electromagnet and the metal ball.