Introduction

Formative Assessment Exemplar - Phys.3.3

Introduction:

The following formative assessment exemplar was created by a team of Utah educators to be used as a resource in the classroom. It was reviewed for appropriateness by a Bias and Sensitivity/Special Education team and by state science leaders. While no assessment is perfect, it is intended to be used as a formative tool that enables teachers to obtain evidence of student learning, identify gaps in that learning, and adjust instruction for all three dimensions (i.e., Science and Engineering Practices, Crosscutting Concepts, Disciplinary Core Ideas) included in a specific Science and Engineering Education (SEEd) Standard.

In order to fully assess students' understanding of all three dimensions of a SEEd standard, the assessment is written in a format called a cluster. Each cluster starts with a phenomenon, provides a task statement, necessary supporting information, and a sequenced list of questions using the gather, reason, and communicate model (Moulding et al., 2021) as a way to scaffold student sensemaking. The phenomenon used in an assessment exemplar is an analogous phenomenon (one that should not have been taught during instruction) to assess how well students can transfer and apply their learning in a novel situation. The cluster provides an example of the expected rigor of student learning for all three dimensions of a specific standard. In order to serve this purpose, this assessment is NOT INTENDED TO BE USED AS A LESSON FOR STUDENTS.

Because this assessment exemplar is a resource, teachers can choose to use it however they want for formative assessment purposes. It can be adjusted and formatted to fit a teacher's instructional needs. For example, teachers can choose to delete questions, add questions, edit questions, or break the tasks into smaller segments to be given to students over multiple days.

Of note: All formative assessment clusters were revised based on feedback from educators after being utilized in the classroom. During the revision process, each cluster was specifically checked to make sure the phenomena was authentic to the DCI, supporting information was provided for the phenomena, the SEPs, CCCs, and DCIs were appropriate for the learning progressions, the cluster supported student sensemaking through the Gather, Reason, and Communicate instructional model, and the final communication prompt aligned with the cluster phenomena. As inconsistencies were found, revisions were made to support student sensemaking. If other inconsistencies exist that need to be addressed, please email the current Utah State Science Education Specialists with feedback.

General Format:

Each formative assessment exemplar contains the following components:

1. Teacher Facing Information: This provides teachers with the full cluster as well as additional information including the question types, alignment to three dimensions, and answer key. Additionally, an example of a proficient student answer and a proficiency scale for all three dimensions are included to support the evaluation of the last item of the assessment.
2. Students Facing Assessment: This is what the student may see. It is in a form that can be printed or uploaded to a learning platform. (Exception: Questions including simulations will need technology to utilize during assessment.)

Accommodation Considerations:

Teachers should consider possible common ways to provide accommodations for students with disabilities, English language learners, students with diverse needs or students from different cultural backgrounds. For example, these accommodations may include: Providing academic language supports, presenting sentence stems, or reading aloud to students. All students should be allowed access to a dictionary.

References:

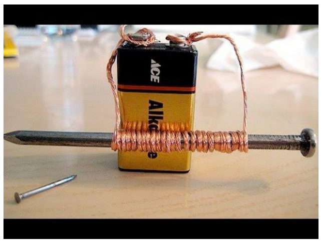
Moulding, B., Huff, K., & Van der Veen, W. (2021). *Engaging Students in Science Investigation Using GRC*. Ogden, UT: ELM Tree Publishing.

Teacher Facing Info

Teacher Facing Information

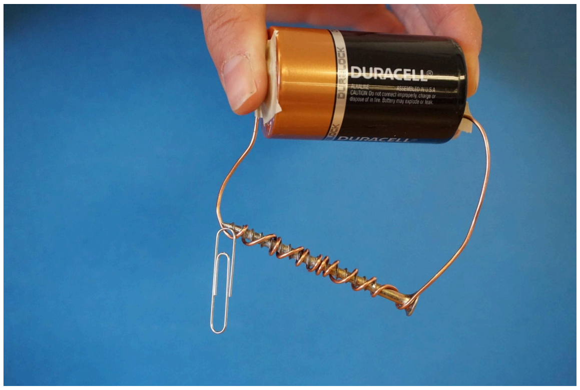
Standard: Phys.3.3

Assessment Format: Printable or Online Format (Does not require students to have online access)

Phenomenon	
 Students in a science classroom were tasked with creating an **electromagnet**. An electromagnet uses electrical energy to create a magnetic field. To create an electromagnet within the classroom, a line of copper wire is first twisted in loops around a linear piece of metal that contains some iron. These two characteristics are important. When the metal is linear, it helps positive and negative poles form on its ends, like a magnet. Iron also is a metal that is easily magnetized while some metals are not. Each end of the copper wire is attached to the ends of a battery that provides an electrical source. Each student investigated changes that were made to the electromagnet and determined their effects on the strength of the magnet when picking up paper clips. Students changed the size of the battery and the distance the electromagnet was held from objects.	Proficient Student Explanation of Phenomenon: Electrons flow from one end of the battery to the other end of the battery, through the coil. This causes the coil to be “electrified.” A field of electrical force is created due to the coiling of the wire. This is different from a common electrical circuit as it behaves like a magnet instead of having a linear flow of electrons. These electrical “magnetic” fields follow paths that can be detected, modeled, and diagrammed. The strength of these fields change depending on the relative positions of objects within the field. Some areas of the field are strong and some are weak. The electromagnet will attract an object depending upon the relative placements of the object and the magnet.
Cluster Task Statement	
In the questions below, you will analyze and interpret data to determine how the distance between objects or the properties of objects affect the nature of the electric field or force between them.	

Supporting Information

First, students tested how the distance they placed the electromagnet away from the paperclips affected how many paper clips were attracted to it. This was done by placing paperclips on a table and holding the electromagnet above at different distances.



Then the students tested whether or not the size of the battery had an effect on the number of paperclips the electromagnet could attract. Students used a *9V battery,* and a *AA battery*.

During the investigation, data was collected and then summarized in **Table-1** below:

Table-1
Electromagnets and Attraction

Distance of Separation	Battery Size	Number of Paper Clips Attracted
0 cm	9V	11
5 cm	9V	6
10 cm	9V	4
0 cm	AA	2
5 cm	AA	1
10 cm	AA	0

Cluster Questions

Gather: Cluster Question #1 Question Type: multiple select Addresses: DCI: **PS3.D** SEP: **Analyze and interpret data** CCC: **Cause and effect** Answer:	Item: Which **two** variables below directly affected the number of paperclips the electromagnet could attract? A. The shape of the battery B. The size of the battery C. The angle the nail is held in reference to the paperclips D. The size of the nail E. The distance the electromagnet was placed away from the paperclips

B and E

Gather:
Cluster Question #2
Question Type: Long Answer
Addresses:
DCI: **PS3.C**
SEP: **Planning or Carrying Out Investigations**
CCC: **Cause and effect**
Answer:
Answer below is just an example

Balloons and Confetti	
Distance balloon held	**Number of confetti**
0 cm	12
5 cm	4
10 cm	1
15 cm	0

Item:
Conduct the investigation below to determine if the electromagnetic phenomenon may apply to other items.

Rub a balloon on your hair or shirt for at least 1 minute, then bring it near a pile of small bits of paper. Conduct 4 trials, rubbing for the same amount of time for each trial. Use the following distances: 0 cm, 5 cm, 10 cm, and 15 cm. Record results in the table below:

Balloons and Confetti	
Distance balloon held	**Number of confetti**

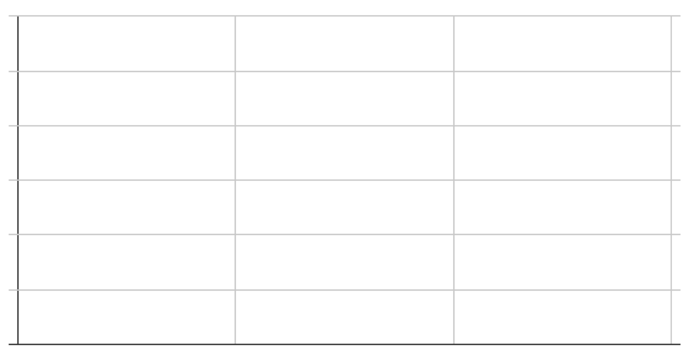
Gather:
Cluster Question #3
Question Type: Graphing
Addresses:
DCI: **PS3.C**
SEP: **Developing or Using Models**
CCC: **Cause and effect**

Answer:
Students generate a graph with the correct x and y axes, labels, and scales.

Distance should be on the x axis and number of pieces of paper should be on the y.

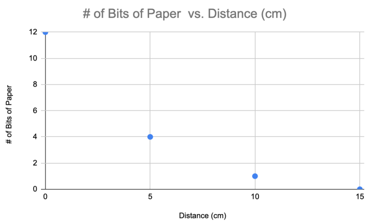
Graph should show decreasing

Item
Create a graph showing the relationship between how many pieces of paper were attracted and the distance the balloon was held from the paper. Be sure to use proper graphing techniques.



<table>
<tr><td>strength as distance increases.

Example below is from the data shown in the answer to 2


</td><td></td></tr>
<tr><td>Reason:
Cluster Question #4
Question Type: short answer
Addresses:
DCI: PS3.C
SEP: Analyze and interpret data
CCC: Cause and effect

Answer:
Distance is related to electric force in that the farther one object is from the other, the less force there is. Examples include: the farther the electromagnet, the fewer paperclips, the farther the balloon, the fewer confetti pieces. [students need to cite numeric data from the previous questions, but can present different numerical references which are correct]</td><td>Item:
Based on the data graphed in Question 3, write a claim that describes how the magnitude of electromagnetic force between two charged objects is related to the distance they are held apart.

Include evidence and cite data both from the electromagnet experiment and your balloon experiment from question 2. (electricity and magnetism are part of the same fundamental force, electromagnetism).</td></tr>
<tr><td>Reason:
Cluster Question #5
Question Type: Short answer
Addresses:
_____ DCI PS3.C
_____ SEP
_____ CCC Cause and effect
Answer:
The student can:</td><td>Item:
A student used the following to create an electromagnet: Two D batteries, a nail, and a wire. The student held the electromagnet a distance of 8 cm from a pile of paperclips. The electromagnet attracted 15 paperclips under these conditions.

Identify which conditions, materials, or parameters should be changed in the investigation above that would reduce the total number of paperclips the electromagnet could attract.</td></tr>
</table>

1- use one less battery 2- move farther from the paperclips	
Communicate: Cluster Question #6 Question Type: Short answer Addresses: DCI: **PS3.C** SEP: **Analyze and interpret data** CCC: **Cause and effect** Answer: Since distance is at the bottom of the formula, this follows the inverse square law. This means that as distance is increased, the force is reduced by $1/d^2$. The experiments show that as an electromagnet or charged balloon is moved farther from other objects, the force [ability to pick up items/objects] decreases. Evidenced by less objects attracted with increasing distance in my data.	Item: The formula for electrical force between any two charges (or a balloon and confetti) is: $$\boldsymbol{Electrical\ Force} = \frac{\boldsymbol{k_c q_1 q_2}}{\boldsymbol{d^2}}$$ $\boldsymbol{k_c}$ *represents Coulomb's constant of* $8.99 * 10^9\ Nm^2C^{-2}$ $\boldsymbol{q_1}$ *and* $\boldsymbol{q_2}$ *represent the charges of each item in Coulombs* $\boldsymbol{d}$ *represents the distance between each object in meters* Write an explanation that describes how the steps taken and data recorded during the investigations could be used to validate or support this equation as a mathematical model.

Proficiency Scale

Proficient Student Explanation:
Since distance is in the bottom of the formula (denominator), this follows the inverse square law. This means that as distance is increased, the force is reduced by $1/d^2$. The experiments show that as an electromagnet or charged balloon is moved farther from other objects, the force [ability to pick up items/objects] decreases. Evidenced by less objects attracted with increasing distance in my data.

Level 1 Emerging	Level 2 Partially Proficient	Level 3 Proficient	Level 4 Extending
SEP: Does not meet the minimum standard to receive a 2.	**SEP:** Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.	**SEP:** Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and	**SEP:** Extends beyond proficient in any way.

	Distinguish between causal and correlational relationships in data. Analyze and interpret data to provide evidence for phenomena. Analyze and interpret data to determine similarities and differences in findings. Analyze data to define an optimal operational range for a proposed object, tool, process, or system that best meets criteria for success.	reliable scientific claims. Evaluate the impact of new data on a working explanation and/or model of a proposed process or system. Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.	
CCC: Does not meet the minimum standard to receive a 2.	**CCC:** Cause and effect relationships may be used to predict phenomena in natural or designed systems.	**CCC:** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. Changes in systems may have various causes that may not have equal effects.	**CCC:** Extends beyond proficient in any way.
DCI: Does not meet the minimum standard to receive a 2.	**DCI:** When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. Forces between two objects at a distance	**DCI:** When two objects interacting through a field change relative position, the energy stored in the field is changed.	**DCI:** Extends beyond proficient in any way.

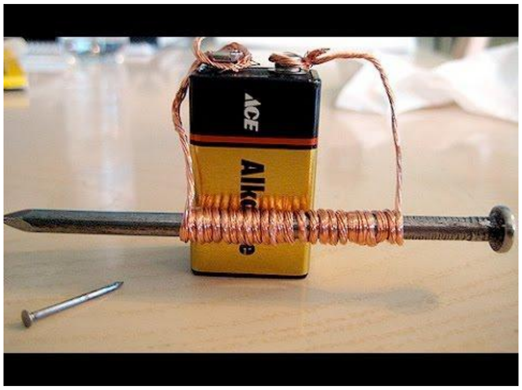
	are explained by force fields (gravitational, electric, or magnetic) between them.		

(Student Facing Format on following page)

Student Assessment

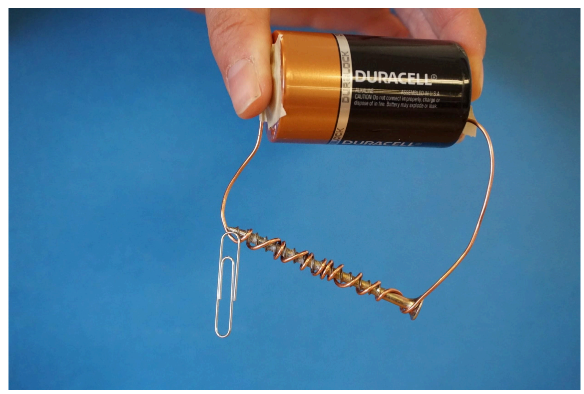
Name: ____ Date: ________

Stimulus



Students in a science classroom were tasked with creating an **electromagnet**. An electromagnet uses electrical energy to create a magnetic field. To create an electromagnet within the classroom, a line of copper wire is first twisted in loops around a linear piece of metal that contains some iron. These two characteristics are important. When the metal is linear, it helps positive and negative poles form on its ends, like a magnet. Iron also is a metal that is easily magnetized while some metals are not. Each end of the copper wire is attached to the ends of a battery that provides an electrical source. Each student investigated changes that were made to the electromagnet and determined their effects on the strength of the magnet when picking up paper clips. Students changed the size of the battery and the distance the electromagnet was held from objects.

First, students tested how the distance they placed the electromagnet away from the paperclips affected how many paper clips were attracted to it. This was done by placing paperclips on a table and holding the electromagnet above at different distances. Then the students tested whether or not the size of the battery had an effect on the number of paperclips the electromagnet could attract. Students used a *9V battery*, and a *AA battery*.



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Your Task

In the questions below, you will analyze and interpret data to determine how the distance between objects or the properties of objects affect the nature of the electric field or force between them.

Question 1

Which **two** variables below directly affected the number of paperclips the electromagnet could attract?

A. The shape of the battery
B. The size of the battery
C. The angle the nail is held in reference to the paperclips
D. The size of the nail
E. The distance the electromagnet was placed away from the paperclips

Question 2

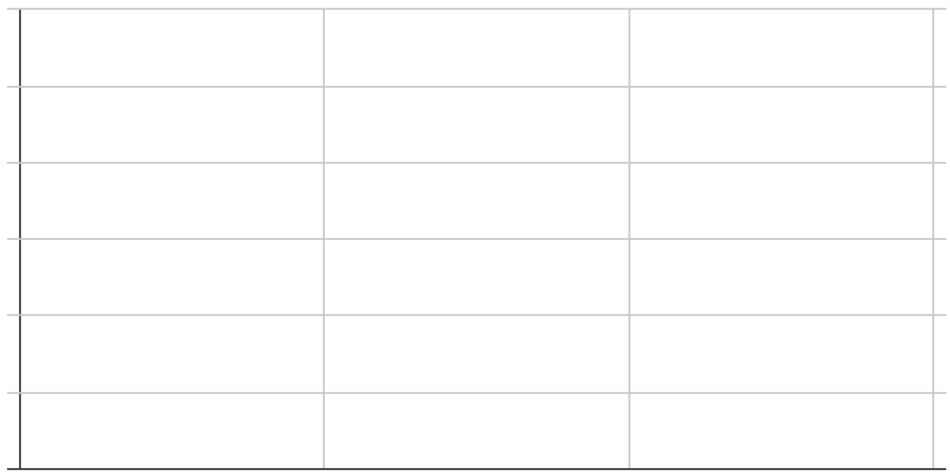
Conduct the investigation below to determine if the electromagnetic phenomenon may apply to other items.

Rub a balloon on your hair or shirt for at least 1 minute, then bring it near a pile of small bits of paper. Conduct 4 trials, rubbing for the same amount of time for each trial. Use the following distances: 0 cm, 5 cm, 10 cm, and 15 cm. Record results in the table below:

Balloons and Confetti	
Distance balloon held	**Number of confetti**

Question 3

Create a graph showing the relationship between how many pieces of paper were attracted and the distance the balloon was held from the paper. Be sure to use proper graphing techniques.



Question 4

Based on the data graphed in Question 3, write a claim that describes how the magnitude of electromagnetic force between two charged objects is related to the distance they are held apart.

Include evidence and cite data both from the electromagnet experiment and your balloon experiment from question 2. (electricity and magnetism are part of the same fundamental force, electromagnetism).

Question 5

A student used the following to create an electromagnet: Two D batteries, a nail, and a wire. The student held the electromagnet a distance of 8 cm from a pile of paperclips. The electromagnet attracted 15 paperclips under these conditions.

Identify which conditions, materials, or parameters should be changed in the investigation above that would reduce the total number of paperclips the electromagnet could attract.

Question 6

The formula for electrical force between any two charges (or a balloon and confetti) is:

$$\textbf{\textit{Electrical Force}} = \frac{\boldsymbol{k_c q_1 q_2}}{\boldsymbol{d^2}}$$

$$\boldsymbol{k_c} \textit{ represents Coulomb'sconstant of } 8.99 * 10^9\ Nm^2C^{-2}$$
$$\boldsymbol{q_1} \textit{ and } \boldsymbol{q_2} \textit{ represent the charges of each item in Coulombs}$$
$$\boldsymbol{d} \textit{ represents the distance between each object in meters}$$

Write an explanation that describes how the steps taken and data recorded during the investigations could be used to validate or support this equation as a mathematical model.