This Framework integrates the concept of energy transformation and the mechanisms for using and converting energy in modern applications. The investigation of the electromagnet and fields of force will be central to understanding simple motors and generators as well as other applications, including the Maglev train.

Student Science Performance

8th grade physical science	**Title**
Topic: Interactions of Energy and Matter	May the Forces Be with You: Forms, Fields, and Friction

Georgia Standards of Excellence addressed in this module

S8P2. Obtain, evaluate, and communicate information about the law of conservation of energy to develop arguments that energy can transform from one form to another within a system.

c. Construct an argument to support a claim about the type of energy transformations within a system [e.g., lighting a match (light to heat), turning on a light (electrical to light)].
d. Plan and carry out investigations on the effects of heat transfer on molecular motion as it relates to the collision of atoms (conduction), through space (radiation), or in currents in a liquid or a gas (convection).

S8P5. Obtain, evaluate, and communicate information about gravity, electricity, and magnetism as major forces acting in nature.

a. Construct an argument using evidence to support the claim that fields (i.e., magnetic fields, gravitational fields, and electric fields) exist between objects exerting forces on each other even when the objects are not in contact.
b. Plan and carry out investigations to demonstrate the distribution of charge in conductors and insulators. (*Clarification statement:* Include conduction, induction and friction.
c. Plan and carry out investigations to identify the factors (e.g., distance between objects, magnetic force produced by an electromagnet with varying number of wire turns, varying number or size of dry cells, and varying size of iron core) that affect the strength of electric and magnetic forces. (*Clarification statement:* Including, but not limited to, generators or motors.)

Performance Expectations to guide Instruction

Students will:

- Observe common events that involve energy transformations in a system, identify the type of transformations and develop an argument based on evidence to support a claim about the type of energy transformations that were observed.
  Plan and carry out investigations to determine and explain the effect of heat transfer on molecular motion on conduction, radiation and convection.
- Demonstrate understanding of energy transfer in conduction, radiation, and convection, through application to real world phenomena.
- Use evidence from investigation or supplied data to support the claim that force fields (magnetic, gravitational, and electric) exist between objects exerting forces on each other even when the objects are not in contact.
- Plan and carry out investigations using an electroscope or other device to distinguish between the distribution of charge that results from conduction, induction and friction for conductors and insulators.
- Use an electromagnet, determine the effect of varying the number of wire turns and support your claim with evidence.

- Plan and carry out investigations to identify the factors that affect the strength of electric and magnetic forces in a generator and a motor and other device.

Additional notes on students supports

Misconceptions and Academic Language Notes

1.Students often confuse the meaning of transfer and transform. This distinction is a key point in this module.

2. Research indicates that there is a persistent misconception about the nature of heat transfer, even at the middle grades level. Students may think that an item of clothing provides warmth to the body, because they have been told to wear their warm clothes on a cold day. Address this misconception using the discrepant event of placing thermometers in winter gloves and compare to thermometers laying on the counter.

3. Additionally, students may have difficulty conceptualizing that "cold" indicates a relative condition of lower molecular energy. Heat (thermal energy) is a measure of molecular energy. In a system, energy is transferred throughout the system until the energy is evenly distributed. This condition is called equilibrium.

For example, ice cubes melt when the surrounding warmer air or liquid gives up (transfers) heat to the ice cube.

Suggested Materials for this Framework:

Insulated and uninsulated wire, wire stripper/cutter, batteries, battery tester, battery holders magnets, aluminum foil, electroscopes (purchased or home-made), balloons, Styrofoam, squares of wool, silk, and fur, hard rubber rod or small diameter PVC pipe, glass or plexiglass rod.

Engaging Learners	**Phenomenon: Maglev Train**  Phenomenon rationale: Use this phenomenon to introduce a real-world application of energy transformation created by switching electric and magnetic fields in opposition to the gravitational field. It incorporates major concepts that are to be developed in this framework.

Show one of the many available online videos of a Maglev Train, but if you choose a video that explains how it works, stop the video before the explanation. You will use the explanation as the lessons unfold.

***Teacher Note**: Pre-assess student knowledge and activate this framework by showing a Maglev video and then facilitating discussion that allows students to discuss personal experiences with various means of transportation. Ask probing questions to encourage responses that consider how **energy is transformed** (S8P2c) by various means of transportation. Most may not have heard of a train that hovers above the track and moves forward due to electromagnetic energy, so as the discussion progresses, explain the meaning of the name, Maglev, and ask them to think about how this train transforms energy. Explain that in this framework they will be obtaining, evaluating and communicating information to explain this phenomenon. At this point, also ask them to consider (begin preliminary evaluation) the pros and cons of the different forms of transportation. The big ideas to begin developing or reinforcing in this discussion are (1) energy is transformed from one form to another in order to move from one point to another and (2) energy is conserved.*

Example video: World's Fastest Train (initially show the first 1:12 of the video.)

As a formative assessment to be sure students have a basic idea about the Maglev train and to integrate language arts, students could be challenged to write a diamante poem (6-7 lines that form a diamond shape) using the following pattern: The following example is a 7-line version but can be adapted to five or six lines and the instructions can be varied to fit the topic. Have students brainstorm words that describe or relate to the Maglev train before beginning to compose their poems.

Line 1: A one syllable synonym for the object
Line 2: A two syllable adjective that describes the object
Line 3: Three syllables that provide details
Line 4: Four syllables that further describe the object
Line 5: Three syllables that describe how it moves
Line 6: Two syllables that describe the object
Line 7: The name of the object.

Sample Diamante Poem:

Ride
Rapid
Magnetic-
Electric fields
Flip, float, fly
Maglev
Train

Engage and Explore	Based on pre-assessment, the following content can be incorporated as needed to review and clarify this content. (***GSE Alignment note***: *Heat is introduced in the 3rd grade; light and sound content is found in the 4th grade and again in the 8th grade; electricity and magnetism are covered in the 5th and again in the 8th grade.)* Content Review: The following information is included to be used as needed. Students watch video of family/friends on a camping trip when the generator goes out. However, if this material is used, be careful to help students distinguish between transfers and transformations. Four Forms of Energy *Teacher note: This video lasts 10 minutes. Show portions as needed to introduce or review* *the different aspects of energy transfer as students learn about them: You will need to address the proper use of the terms transfer and transform.*

0 - :33	*The generator stops working at the campsite.*
:34-1:14	*Introduction to Energy Transfer*
1:15-1:56	*Mechanical Energy*
1:54-3:23	*Chemical Energy*
3:24-5:05	*Heat Energy*
5:06-5:59	*Light Energy*
6:00-6:41	*Photosynthesis*
6:42-7:15	*Solar Energy*
7:16-8:30	*Electrical Energy*
8:31-10:00	*Sound Energy*

Evaluate / Communicate

Students determine if they agree with the actors about the causes/reasons for the generator

Teacher Hint: Provide students a framework for organizing their thoughts. Click

Handout 1 Sample Organizer.

Obtain, evaluate and communicate:

Students observe demonstrations of energy transformations or rotate through stations to explore and collect data about the energy transformations. Students then create a data table or other graphic representation to explain their results. The table below provides examples for this.

Example	***Observations***	***Initial form of Energy***	***Transformed to ______energy***
Light a match	*Colored substance on match head turns black and heat is felt; light is seen*	*Chemical*	*Light and heat*
Turn on electric fan	*When the switch is flipped, the fan turns.*	*Electrical*	*Mechanical*
Photosynthesis occurs	*Based on text, simulation, or other information provided at station*	*Light*	*Chemical*
Sun	*Based on text, simulation, or other information provided at station*	*Nuclear*	*Light, heat, other EMR*

Obtain Information about Conduction, Convection, Radiation (S8P2d)

Implement demonstrations and explorations.

	Example Teacher Demonstrations and student explorations to Activate Student Engagement: Heat a metal container of water using a Bunsen burner. Initially the flame produces radiation which heats the tin can. The tin can then transfers heat to the water through conduction. The hot water then rises to the top by convection. Example Conduction Exploration: ● The handle of a metal spoon whose bowl is placed in a cup of ice water will feel cold. ● The handle of a metal spoon whose bowl is placed in a cup of hot water will feel warm. For example, Radiation Exploration: ● A small amount of water in a sealed bag placed in direct sunlight will expand as the water molecules gain enough energy to evaporate and change to water vapor. Example convection explorations: ● Pour 100 mL of water into a graduated cylinder. Have students use a dropper to add 10 drops of heated water colored with red food coloring. Then have them add 10 drops of cold water colored with blue food coloring. Watch the convection currents as they move to balance the temperature of the water. ● Freeze water colored with food coloring. Drop the colored ice cubes into a glass of room temperature water to see the convection currents move. **S8P2d** Performance Task(s): Students will investigate the effects of heat transfer on molecular motion as it relates to conduction, radiation and convection and demonstrate their understanding of energy transfer through application to real world phenomena. See S8P2d Performance Task Instructions for details on how to organize differentiated performance tasks to meet this performance expectation. **(S8P2b)** Demonstrate a series of phenomena* that illustrate induction, conduction and friction, using conductors and insulators. Have students record their observations. Do not explain the reasons for the behavior of the materials yet. *Examples of phenomena to demonstrate: ● Rub inflated balloons on your hair and then put them on the wall, where they will "stick".

	• Suspend two inflated balloons by string from the ceiling. Use a charged rod to move up and down in the space between the two balloons. • Place an empty aluminum soda cans on a smooth counter. Using a charged rod, cause the can to roll first one direction and then back. • Bring a charged rod near a trickling stream of water from a lab faucet. (The stream will be diverted.) • Use small pieces of Styrofoam wrapped in aluminum foil to move around with a charged rod. • Create a whirligig by cutting a disk from a Styrofoam plate. Mark this disk with alternating colored sections. Suspend it with a string over another Styrofoam plate which you have charged by rubbing it with silk or nylon fabric. • If available, demonstrate a Van de Graaff generator. After the demonstrations, have students compile their observations with partners and discuss patterns that they observed. They should list these patterns and share with the class. At this point, provide content to clarify and unify the discussion using charge diagrams for charging by friction, conduction and induction to help students develop explanations based on these patterns. Develop the use of correct academic language for these terms using Frayer models and graphic organizers. The video at Electrostatic Induction (first couple of minutes only) or similar video can provide visuals to support this discussion and explanation. Students will experience these charging effects by constructing a simple electroscope or by using a standard lab electroscope and exploring the results of bringing charged objects near the electroscope post and touching the electroscope post. Provide instructions on the how to make and use a simple electroscope (or on how to use standard lab electroscopes if available). Numerous sites provide instructions for constructing a simple electroscope. For example: How to Make an Electroscope Students will observe the effects of conduction and induction and the role of friction as they carry out guided inquiry using the electroscopes. Depending on the available materials for charging the electroscope, it will be necessary to guide the students as to

	which materials become positively and negatively charged. (For example, a rubber rod rubbed with fur becomes negatively charged, and the fur becomes positively charged. See the S8P5.b Reference Triboelectric Series for guidance.) Students will draw their conception of the distribution of charge for each step in the inquiry and provide explanation for their drawing. **S8P5** Discrepant event: Prior to class, construct a basic battery-wire coil train. See multiple sites for instructions on creating this "speeding train. There are many websites and videos that discuss the construction and the science behind this electromagnetic train. One example is found here. Using the model that you have made, show students the "train" and the "track". Prior to the demonstration have students record their prediction about what will happen once the battery train is placed within the wire coil. Demonstrate. (Run the battery train more than once.) As an interactive demonstration have the class suggest one variable to change and then demonstrate the effect of changing that variable and collect data to model the process of manipulating one variable for the class. This will scaffold the following exploration.
Explaining	For students to investigate the reasons for these results, they should continue into the explaining stage by building a simple electromagnet and evaluate the effect of changing the number of coils, size of iron core, and number of dry cells used. Give students instructions and materials to facilitate this guided inquiry. Different groups could manipulate different variables and collect data. Then the class could compile class data to identify patterns. Students will analyze the data, explaining the effect of the manipulating the variable on the strength of the electromagnet. Example resource: How to make an electromagnet and change the strength of the magnet

Elaborating	Challenge students to plan and design an electromagnet that will move a paper clip a specific distance, pick up a specific number of paper clips, etc. *Teacher note: Students should change only one factor at a time for useful data.* For more information and ideas about how electromagnets are used in electronic devices like speakers and motors, use Exploratorium Science Snacks. Once students have investigated electromagnets, they should apply their understanding of electric and magnetic fields to the construction of electric generators and motors.
Evaluation	Investigation Resources: Exploratorium How to Build a Generator Lesson on Building an Electric Generator Finalizing the Model: After these explorations and investigations, bring students back to the discussion of the Maglev Train and the Simple Fast Train. Their culminating task will be to return to their Simple Fast Train and engineer the fastest train possible with the materials provided to them. The task is to build, demonstrate and explain the mechanism for their train working and the adjustments they made to make it go faster considering gravitational, electrical and magnetic fields. The students' explanations should provide evidence-based explanations for their results, using a Claims, Evidence, Reason Format (CER) or other format that provides for argument from evidence. Provide students with organizers as needed. If students are not yet proficient with CER, scaffold this approach with them. One such organizer is Field Evidence Gathering. This organizer could be employed as a formative assessment prior to the culminating task. As a closing assessment, remind students of the original discussion about forms of transportation. Ask students to consider the pros and cons of Maglev trains and the role of magnetic and electrical fields in creating these trains. If not already provided during the unit, concise text on these trains and or further videos may be provided at this time and students should connect their experiences in this unit to the benefits and issues surrounding these trains. This assessment may be done orally, in writing, or as a poster display.

SEP, CCC, DCI	**Science Essentials**
Science and Engineering Practices	• Ask questions and define problems (for example, designing a speeding train • Develop and use models (for example diagrams of electrical charge) • Plan and carry out investigations for example: energy transformations, increasing effectiveness of electromagnetic devices) • Analyze and interpret data from investigations (for example: data from investigating transformations, charging, electromagnetic devices) • Construct explanations and design solutions (for example: design of speeding train) • Obtain, evaluate, and communicate information throughout this framework.
Crosscutting Concepts	• Patterns • Cause and effect: Mechanism and explanation • Scale, proportion, and quantity • Systems and system models • Energy and matter: Flows, cycles, and conservation • Structure and function • Stability and change
Disciplinary Core Ideas	This framework brings together elements of the following DCIs. • PS1: Matter and its interactions • PS2: Motion and stability: Forces and interactions • PS3: Energy PS4: Waves and their applications in technologies for information transfer

<u>Additional Supports for struggling learners:</u>

The following supports are suggestions for this lesson and are not the only options to support students in the classroom. These supports target students that struggle with science material, this lesson or a previous lesson. These are generalized supports and do not take the place of IEP accommodations as required by each student's Individualized Education Program.

General supports for the following categories:

Reading:	Writing:	Math:
1. Provide reading support by reading aloud or doing partner reads 2. Have the teacher model what they are thinking when reading the text 3. Annotate the text with students so that they may refer to it as they work through the lab	1. The teacher can provide a sentence starter for the students. 2. The teacher can give students an audience to write to (i.e. Write a letter to your sibling explaining this topic). 3. The teacher can provide constructive feedback during the writing process to help students understand the expectations.	1. Provide calculators as needed. 2. Provide graph paper as needed.

Supports for this specific lesson if needed:

Performance expectations for instruction:

1. The teacher should provide information to students in various formats to reach as many students as possible.
2. The students should be given adequate time to complete each part of the lesson.
3. The students should be allowed to express their knowledge in various formats.
4. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material.

Engage:

1. The teacher may need to show the video more than once to help struggling students identify the most important pieces.
2. Wait time may need to be increased when asking struggling students questions to allow them to process the question and formulate a response.
3. The teacher can also warn students in advance that they are going to be asked a question about a specific topic to cut down on the students' anxiety of waiting to see if they will be called on.
4. The poem may prove very difficult for struggling students to construct. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. This can be in writing, drawing or designing a play.

Exploring:

1. The teacher may need to provide support for the vocabulary in this unit as students move through the lesson. This can be done by have students use academic language to describe scenarios or solutions, using card sorts and the teacher being sure to use academic language when they are discussing the topic.
2. The teacher may need to show the video more than once to allow students to identify the most important parts.
3. The teacher has specific parts of the video that they would like to students to focus on. The teacher may need to provide a list of topics to the students that should be listened for as the video plays. The teacher may need to show the video more than once and/or stop the video at the critical points to allow students to process the information.
4. The teacher should give the students an organizer for students to record their data and thoughts on as they move through the stations.
5. The teacher should make sure that students are able to visit all stations and spend adequate time to make observations at each station.
6. The teacher should complete the demo and then ask students to try and explain what is occurring with the Bunsen burner, can and water. Provide enough wait time for students to process the information that they know and what they are seeing in the demo before accepting a hypothesis from any student.
7. As the students prepare to move through the different lab activities the teacher should be explicit about any safety measures that should be taken during this lab.
8. The teacher may need to repeat directions multiple times for struggling students.
9. The teacher may need to show demos more than once for students to be able to see the most important parts of the demo. Another approach that the teacher could take is to discuss what is occurring in the demo with students and have them record observations on a data sheet to refer to later.
10. The teacher is guided to give students Frayer models or graphic organizers by this lesson. These are a great tool to use for struggling students. The teacher may consider filling in pieces of the Frayer model or graphic organizer for students and then having the student complete it. This allows students to not be overwhelmed by staring at a blank page.
11. Students may need to see the videos more than once to be able to determine which topics are most important.
12. Struggling students may need to have directions repeated more than once to help them accomplish a task.
13. Struggling students may need more time to complete the design portion of the electroscope activity.
14. Struggling students should have a place to record observations, predictions and their thoughts. This will assist them in keeping up with the activity as it moves forward.

Explaining:

1. The teacher should use intentional grouping to match students into working groups. Best practice is to use data to group students.
2. Struggling students may need the teacher to repeat directions more than once.
3. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. This can be in writing, drawing or designing a play.

Elaborating:

1. The teacher should use intentional grouping to match students into working groups. Best practice is to use data to group students.
2. The teacher should be walking around and asking questions during the design process to help students evaluate their work.
3. Struggling students may need the teacher to show videos more than once to be able to identify the most important topics.

Evaluating:

1. The students may need additional time to formulate their design of the fastest train possible.
2. Students should be allowed to express their knowledge in various ways. This could include writing their argument, drawing a cartoon, designing a play or making a power point.
3. Struggling students benefit from explicit explanations of what is expected. Graphic organizers, rubrics and other organizers to help students see the big picture of the requirements for this design project should be provided.

Return to Instructional Segment

Sample Organizer

<table>
<tr><th colspan="4">What might cause the generator to stop working?</th></tr>
<tr><td>Initial Claim:
(Do you agree with the boys?)</td><td colspan="3">The generator stopped working due to
____
____.</td></tr>
<tr><td>Initial Reasoning</td><td colspan="3">1.____
2.____
3.____</td></tr>
<tr><td>Revised Claim after Investigation</td><td colspan="3"></td></tr>
<tr><td rowspan="4">Supporting Evidence from Investigation</td><td>1.</td><td rowspan="4">Connected Reasoning</td><td>1.</td></tr>
<tr><td>2.</td><td>2.</td></tr>
<tr><td>3.</td><td>3.</td></tr>
<tr><td>4.</td><td>4.</td></tr>
</table>

Return to Instructional Segment

Performance Tasks for S8P2d: Differentiated Investigations and Applications for Conduction, Convection and Radiation

Coding: Bloom's Taxonomy= BT; Rigor and Relevance = RR. **points = sum of BT +RR. Level 1 total = 5 or 6. Level 2= 6, 7, or 8. Level 3 = 9, 10, or 11.** See page 2 for detailed explanation and instructions for using this chart.			
BT+RR	**Analytical**	**Creative**	**Practical**
Level 1 **Max points: 5 or 6**	Make a Venn Diagram to compare and contrast conduction, convection, and radiation. BT= 4 + RR=1 Total points =5	Create a presentation that explains the relationship of conduction, convection, and radiation to weather events. BT= 2 + RR=4 Total points=6	Find examples of heat transfer by conduction, convection, and radiation and create a report that explains the importance of each transfer to our daily lives. BT= 2+ RR=4 Total points=6
Level 2 **Max points: 6 - 8**	Create a concept map that shows the relationship of conduction, convection, and radiation to heat transfer. BT=5 or 6+ RR=1 Total points=6 or 7	Create an ad for a newly designed cooking stove. The ad must show how the stove cooks food using conduction, radiation, and convection. BT=3+ RR=4 Total points=6	Construct a solar cooker and document the way it uses conduction, convection, and radiation BT= 3+ RR=4 Total points=6
Level 3 **Max points: 9-11** **Total: 9 -11**	Construct an apparatus to test the effect of collisions of particles on the heat in the system. BT= 5+ RR=5 Total points=6	You are a chocolate chip cookie, just out of the oven. Write an essay that explains how you owe your condition to conduction, convection, and radiation. BT= 6 + RR=4 Total points= 106	Design, construct and test a container that minimizes energy transfer by conduction, convection, and radiation. Also provide a labeled drawing of the device and explain how the device minimizes collision of atoms, transfer through space, and reduces movement of fluids. BT= 5+ RR=4 Total points= 10

If one project from each level is successfully completed, the minimum points totals 20. Maximum points would total 25.

This performance task choice board is designed to engage students in creative, practical and analytical learning experiences and performance tasks. It also considers readiness level. There are several ways to implement this choice board and differentiate instruction. These are explained below.

All performance tasks on the board should be assessed with the same rubric with emphasis on the common learning target.

Design of the choice board:

- The columns correspond to Sternberg's three intelligence categories: analytical, creative, and practical.
- The rows correspond to increasing rigor of the tasks and take into consideration Bloom's taxonomy and Webb's Depth of Knowledge.
- See the chart below for explanation of the numbers on the choice board

Use of the choice board:

Explain the choice board to the students and provide the rubric for assessing the performance tasks prior to beginning the instruction on ___

1. Full Implementation:

- Students pick one task from each column (the three intelligences) and each of these must be at a different level of relevance/rigor.
- Student have some autonomy in choosing tasks, while ensuring that everyone is graded uniformly.
- For example: If a student enjoys practical tasks, but tends to struggle with analytical tasks, the student might pick the most rigorous practical task and the least rigorous analytical task, choosing the middle level of rigor for the creative task.
- If you choose to substitute a different task, be careful to insert it into the plan at the same level of readiness and rigor and for the same intelligence as the task that is removed. Otherwise, the validity of the choice board is compromised.

2. Selective Implementation when time does not allow for students to complete three separate projects:

- The teacher can choose one horizontal level and students choose one project to complete.
- If the middle level is chosen, then the teacher may differentiate further by allowing struggling students to choose from the first rigor level, and advanced students might choose from the highest rigor level.

- Another method of using this choice board is to pick one task, usually from the highest rigor level for all students to complete as an anchor task. Then students choose one individual task as described in bullet 2.

By the numbers:

For a given task, the readiness/interest level is assigned based on considering both Bloom's Taxonomy and Webb's Depth Knowledge. The assigned numbers on the choice board are a guide to be sure that students are selecting a variety of tasks that are challenging and engaging them in creative, analytical and practical applications of the learning.				
Bloom's Taxonomy		Rigor and Relevance		
Remember	1	Possess knowledge in one discipline	1	
Understand	2	Apply knowledge in one discipline	2	
Apply	3	Apply knowledge across disciplines	3	
Analyze	4	Apply knowledge to predictable real-world situation	4	
Evaluate	5	Apply knowledge to unpredictable real-world situations	5	
Create	6			

[Return to Instructional Segment]

The Triboelectric Series

Use this chart for reference as students work on the performance task:

- Plan and carry out investigations using an electroscope or other device to distinguish between the distribution of charge that results from conduction, induction and friction for conductors and insulators
- Overview: Materials toward the top of this series tend to lose electrons and become more positive. Materials at the bottom tend to gain electrons and become more negative. If a material such as glass is rubbed with rabbit fur, the glass will become more negative and the fur becomes more positive. However, if the glass is rubbed with silk the glass rod becomes more positive and the silk becomes more negative. (Results may vary, but the further apart two materials are on the list, the more dependable the charging will be.)

	Most positive
Air	+++++
Human Hands, Skin	
Rabbit Fur	
Glass	
Human Hair	
Nylon	
Wool	
Lead	
Cat Fur	++
Silk	
Aluminum	
Paper	+
Cotton	
Steel	-
Wood	
Lucite	
Rubber Balloon	--
Hard Rubber	
Mylar	
Copper	
Silver	---
Acetate, Rayon	
Polyester	
Cellophane Tape	
Polyvinylidene chloride (Saran)	
Polypropylene	
Polyvinylchloride (Vinyl)	
Kel-F (PCTFE)	
Silicon	
Teflon	-----
Silicone Rubber	
	Most Negative (-)

Return to Instructional Segment

Evidence for Effects of Electrical, Magnetic and Gravitational Fields of Force

Your task is to build, demonstrate and explain how your train works and how your adjustments made it go faster considering gravitational, electrical and magnetic fields. Use the data you collect and the research and reading you have done to develop an evidence-based explanation.

From your experience with building a speeding train, and from you reading and research, what evidence is there that forces can impact objects even when the objects are not in contact?

How does the data you collected provide evidence that magnetic and electric fields interact and can be used to move objects within the Earth's gravitational field?

Use this chart to organize your information before writing your Claims, Evidence, and Reason explanation.

	Magnetic	Electric	Gravitational
How do you know this force exists?			
What is the effect of the force on the train?			
What evidence is there of a force even when there is no contact with an object?			
How did manipulating these fields affect your train?			
How does understanding the interaction of these forces allow Engineers to design efficient trains?			

Return to Instructional Segment