STORYLINE: 3.3.4: Non-contact Forces

Strand 3.3: FORCE AFFECTS MOTION
Forces act on objects and have both a strength and a direction. An object at rest typically has multiple forces acting on it, but they are balanced, resulting in a zero net force on the object. Forces that are unbalanced can cause changes in an object's speed or direction of motion. The patterns of an object's motion in various situations can be observed, measured, and used to predict future motion. Forces are exerted when objects come in contact with each other; however, some forces can act on objects that are not in contact. The gravitational force of Earth, acting on an object near Earth's surface, pulls that object toward the planet's center. Electric and magnetic forces between a pair of objects can act at a distance. The strength of these non-contact forces depends on the properties of the objects and the distance between the objects.

Standard(s) 3.3.4: Ask questions to **plan and carry out an investigation** to determine cause and effect relationships of electric or magnetic interactions
between two objects not in contact with each other. Emphasize how static electricity and magnets can cause objects to move without touching. Examples could include the force an electrically charged balloon has on hair, how magnet orientation affects the direction of a force, or how distance between objects affects the strength of a force. Electrical charges and magnetic fields will be taught in Grades 6 through 8. (PS2.B)

Phenomena Statement(s):
Static electricity can cause objects to move without touching.
Magnets can cause objects to move without touching.

Expected Student Explanation: Students should be able to explain that objects do not need to come in contact with each other in order to have a cause and effect relationship. Students should be able to give an example of non-contact forces that involve magnetism and static electricity. They should also be able to **ask questions** that will help them to identify factors that might affect the size of the force. And finally, students should be able to **plan an investigation** to demonstrate the cause and effect relationship between non-contact forces.

Science & Engineering Practices (SEP)	Crosscutting Concepts (CCC)	Disciplinary Core Ideas (DCI)
Asking Questions and Defining Problems in grades 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. ● Ask questions that can be investigated based on patterns such as cause and effect relationships. **Planning and Carrying Out Investigations** to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. ● Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.	Cause and Effect relationships are routinely identified, tested, and used to explain change.	**PS2.B: Types of Interactions** Electric, and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.

Storyline Narrative	Documents for Storyline

Students explore phenomena that have to do with electricity and magnetism. They tie into the knowledge they gained previously in the bundle about non-contact forces, and use that knowledge to make observations about cause and effect relationships, as well as to **formulate questions** regarding electric and magnetic interactions. Students **plan and conduct investigations** to learn about what factors can affect the sizes and directions of forces in both magnetic and electric interactions. This piece of the bundle wraps up with students formulating **questions** about electric and magnetic interactions form the real word and identifying the cause and effect relationships they see.	Review and/or print out the following documents for this storyline. To edit the following documents you must open, then make your own copy. Links: ● Storyboard Slides - episode instructions are in the slide notes ● Student Journal - or use composition notebook ● Supply List - complete list of supplies needed for each episode ● Teacher prep to begin two weeks prior to starting storyline

STORYLINE: Episodes Matrix				
Episode	**Phenomenon**	**Episode Descriptions & Student Performance Prompts** **Note:** This is where you add a short description of what occurs during the episode, includes the CCCs and SEPs.	**Conceptual Understandings**	
			What We Figured Out: what will the students discover	**Next Questions or Steps:** what they will investigate next
Episode 1 **Engage** Time: 30 minutes	A balloon attracts hair to to it without the two having to touch. Slime moves to a magnet, then up the magnet without the two having to touch first.	**Gather-** 1. Students make observations and **obtain information** by watching observing the phenomena in two videos: ● https://safeYouTube.net/w/4YZz ● https://safeYouTube.net/w/PYZz *Teaching Suggestions: There are two phenomena: one for electricity, and one for magnetism. In the second phenomenon, which is a time-lapse video, the slime is made to include iron filings, and that the objects with which it interacts are magnets.* 2. Students **develop questions** about the phenomena and investigate the causes of what they observed. *Teaching Suggestion: Help students connect the phenomena to their prior knowledge forces, especially to contact and non-contact forces.*	Objects do not have to be touching in order to cause some sort of reaction with another object.	Students will explore what non-contact forces look like in more situations.

		Reason- 3. Students **construct an explanation** supported by evidence from the phenomena about whether objects have to be touching in order to interact and why or why not. *Teaching Suggestions for Classroom Discussion: What could cause objects to interact without having to touch?* **Communicate-** 4. Students **communicate** explanations about whether objects have to be touching to interact. *Teaching Suggestions for Classroom Discussion: Have you seen other examples of this in your life?*		
Episode 2 **Explore** Time: 45-60 minutes		**Gather-** 1. Students **obtain information** by observing three demonstrations about non-contact forces: a) A balloon rubbed on hair, causes movement of the hair without touching. b) A charged balloon picks up small scraps of paper without touching them. c) A magnet picks up paper clips without touching them. *Teaching Suggestions: Students should be making the connection that static electricity and magnetism are non-contact forces.* 2. Students **develop questions** to investigate the cause of the objects' interactions. *Teaching Suggestions: Examples of student questions could include: Why does rubbing the balloon on someone's hair make it stand up? Would the hair still stand up if you didn't rub first?*	Non-contact forces can be observed in situations using static and magnetic electricity.	Students will explore factors that further influence non contact interactions by **planning and carrying out investigations**

		Would this work if you rubbed the balloon on something else first? *Teaching Suggestions for Classroom Discussion: How were these demonstrations similar? Were the causes and effects you observed in each demonstration similar? How?* **Reason-** 3. Students **construct an explanation using a model** for the cause of objects' ability to interact without touching. **Communicate-** 4. Students **communicate** their explanations and how they relate to the cause and effect relationships they observed during the demonstrations. *Teaching Suggestions for Classroom Discussion:* ● *How were the types of interactions you observed similar or different (for example, magnetic vs. electric forces)?* ● *How could the concept of non-contact forces be applied to real-life situations?*		
Episode 3 **Explore** Time: 45-60 minutes (this episode could be split among multiple sessions)		**Gather-** 1. Students **obtain information** from the teacher about the meaning of key vocabulary terms (properties, orientation, magnetic poles) *Teaching Suggestions:* ● *Show students a soda can (or photo of one) and ask them to list its properties. Explain that properties of an object are its characteristics, or things we can observe with the five senses. Some guiding questions could include: Is the can big or small? What is it made of? What does it look like?* ● *Show students a compass (or picture of one) and ask them what is the orientation of the needle. Explain that orientation means the direction in which something is facing and that it is a property that affects forces.*	The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.	Next, the teacher will guide the students through an explicit explanation of the phenomenon they have been observing.

		● *Place two ring magnets on a pencil so that they repel. Then switch one so the magnets attract. Ask students to record what they notice about how the orientation of the magnets affects the way they interact with each other. Explain that every magnet has a north and south pole. Like poles repel, while opposite poles attract. Every magnet has a north and south pole--whether or not they are labeled, and regardless of the magnet's shape.* **Reason-** 2. Students **plan and conduct an investigation** using different types of magnets and objects to reason about the ways orientation, size, and distance can affect the direction and strength of magnetic forces. *Teaching Suggestions: Allow students to see the available materials before they begin planning their investigations.Split students into groups or pairs. Each group should have a few different kinds of magnets and objects (both magnetic and non-magnetic--make sure all groups have some paper clips). Students should include examples of experiments that test one variable at a time for each of the following: size (or number) of magnets/objects, distance, and orientation of magnets.* 3. Students **analyze and interpret data** about **their investigations.** *Teaching Suggestions for Classroom Discussion:* ● *Which objects did the magnets attract? Which objects were not attracted by the magnets? Why do you think that happened?* ● *Did the size of the magnet you used make a difference?* ● *If you used two magnets, how did their orientations affect the force?* ● *Did it matter how close you held your magnet to your objects?*		

		Communicate- 4. Students **communicate** the conclusions they drew from their **investigations.** *Teaching Suggestions for Classroom Discussion:* *What did other groups do differently than you did? Were their conclusions the same or different from yours? How else could you demonstrate that different factors can affect the strength and direction of magnetic forces?*		
Episode 4 **Explain** Time:30-45 minutes		**Gather-** 1. Students **obtain information** from the teacher and other reliable sources about key vocabulary. 2. Students draw and label **models** of examples related to the key terms. *Teaching Suggestions:* ● *Make sure students understand the terms non-contact force, magnetic force, and static electricity.* ● *Potential resources:* *https://safeshare.tv/x/ss5ef3b44c438eb* *-This video about static electricity shows several examples. You could opt to show only a few or to show all of them:https://safeshare.tv/x/ss5ea0a9a65c5d1* **Reason-** 3. Students **construct an explanation** using a **model** to demonstrate the difference between a contact force and a non-contact force. *Teaching Suggestion: Students' models could include drawings of contact forces such as someone kicking a ball, pushing a stroller, etc. Non-contact forces could include magnets, static electricity, etc.* **Communicate-**	In this lesson the teacher explicitly provides explanations and definitions of non-contact forces	Students will encounter a new situation where students will apply their knowledge on factors that effect non contact forces by **planning and conducting an investigation**

		4. Students use their **model** to clearly communicate your **explanation** describing how a contact and a non-contact force are different. *Teaching Suggestion: Ask students to justify how their potential investigations demonstrate non-contact forces.*		
Episode 5 **Elaborate** Time: 45-60minutes		**Gather-** 1. Students **obtain information** and make observations by participating in a demonstration using static electricity (non-contact force). *Teaching Suggestions:* ● *Distribute a balloon and a soda can to each group* ● *Instruct students to charge their balloons with static electricity by rubbing them on their hair* ● *Line two teams up at the start line. Have students push or pull their cans to the finish line using their balloons. If they touch the balloon to the can, they are disqualified.* **Reason-** 2. Students **design a solution** using non-contact forces based on their observations during the demonstration. *Teaching Suggestions: Students plan different ways to adjust their can to see if they can make it faster (using only non-contact forces). Some possible ways to do this would be to charge their balloons with different materials or cut down their cans (help them if they are cutting to avoid sharp edges).* 3. Students test their **solutions** in a second round of the original demonstration. 4. Students **construction an explanation** using evidence from the demonstration about how the solution they	Students will recognize that the materials and methods of charging the balloons can have an effect on the size of the non-contact force.	Students will practice answering and evaluating questions that help them to better understand non-contact forces

		designed affected the second run-through of the demonstration. *Teaching Suggestions for Classroom Discussion:* ● *Did the distance you held the balloon affect your soda can in the race? How?* ● *How did you change your can for the second race? How did that affect the outcome?* **Communicate-** 5. Students **communicate** their **explanations** and conclusion and the cause and effect relationships they observed. *Teaching Suggestions for Classroom Discussion:* ● *What cause and effect relationships did you observe?* ● *What factors did you observe that affect the force(s) between two objects? Give an example and explain what happened in your example.* ● *What did other groups do differently or the same as you? What did they notice?*		
Episode 6 **Evaluate** Time: 60 minutes		**Gather-** 1. Students **obtain information** from reliable sources and **ask questions** to determine the cause and effect relationship in the non-contact electric or magnetic interaction they observe. *Teaching Suggestions: Video sources:* ● *https://safeshare.tv/x/ss5ea0aefe42462* ● *https://safeshare.tv/x/kuCY9aEsoqo* ● *https://safeshare.tv/x/ss5ea0b16017fe1* ● *https://safeshare.tv/x/_85m4ycCuzU* **Reason-** 2. Students **engage in argument from evidence** about which **questions** are most useful in determining the cause and effect relationships of the forces they observed.	Specific questions help us to better understand non-contact forces.	How can we **ask questions** to **plan and carry out investigations** to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other?

		Teaching Suggestions: ● *Split students into groups and have them read each other's questions. Each group should choose one question that they think best helps determine the cause and effect relationship of the forces observed. Have the group post the question they chose in a designated spot in the classroom.* ● *Give each student a sticker. Have students place their stickers on the question that they think will best help to understand the cause and effect relationship of the forces and interactions shown in the clip.* ● *Discuss the question the group picked overall as a class. Why was this a good question? How can it help us understand the cause and effect relationships?* **Communicate-** 3. Students **communicate** a summary about what they learned about magnetic and electric non-contact interactions and cause and effect relationships.		
Summative Assessment		Use a **model** to **construct an explanation** for why it is possible to pick up scraps of paper with a balloon without touching them after the balloon has been rubbed on your head.		