Physical Science- Introductory Instructional Segment

This is a one-week formative assessment designed to give teachers and students a background to anchor the concepts taught throughout the year in physical science.

Student Science Performance

Grade level: 9-12 Physical Science **Topic:** Introductory Unit	**Title- How do cars or rockets go?**

Performance expectations for GSE:
SPS7. Obtain, evaluate, and communicate information to explain transformations and flow of energy within a system.
a. Construct explanations for energy transformations within a system. (*Clarification statement*: Types of energy to be addressed include chemical, mechanical, electromagnetic, light, sound, thermal, electrical, and nuclear.)

Performance expectations for instruction:

- Understand and use the terms related to the crosscutting concepts.
- Ask questions to anchor and guide instruction related to the core instructional segments in Physical Science.

Materials:
FOR ROCKET (Read suggestions in text to substitute using cars.)

- Day 1- Video clips of cars or rockets (4-5 Be sure to preview.) You will use these same clips again in the Capstone Instructional segment at the end of the year.
- Day 2- Paper (2-3 sheets per group of 3)
- Day 3- Film canisters (1 per group of 3), (both can be purchased cheaply from science supply companies and reused many times), effervescent tablets (½ tablet per group of 3), index cards (2 per group of 3), 10 mL graduated cylinders (1 per group of 3), water
- Day 4- Paper (5-6 sheets per group of 3), drawing materials (colored pencils, etc.)
- Day 5- Effervescent- rockets from Day 3 and additional effervescent tablets (1-2 tablets per group of 3), 10 mL graduated cylinders (1 per group of 3), balance (1 per class, minimum), water

Background for teachers	Phenomenon- The function of a car or rocket. The core idea of physical science is that energy is what drives all of the things that are studied. While high school physical science does not venture into all of the ways that energy governs the universe, energy is involved with the study of atoms, molecules and compounds, chemical reactions, electricity, heat energy, nuclear energy, force and motion, and waves. As a model of all of these interacting topics, this lesson uses the model of a car and/or a rocket as a way to anchor learning for this course. Making connections between these models and the content of the course will allow students to experience a better foundation instead of studying unrelated content (as they would in learning about atoms in one unit and Newton's Laws in another). All of the topics in this course are related and this should be emphasized throughout the course. During this introductory segment, teachers should help students to use terminology that enhances a three-dimensional approach to science instruction. The intersection of the disciplinary core ideas (content) with crosscutting concepts and science and engineering practices is essential, not only to the mastery of the Georgia Standards of Excellence in the Physical Science course, but also to a broader

	science understanding in general. Specifically, a focus on the crosscutting concepts will help to prepare students as they move through the year and experience, rather than just learn about, the principles of Physical Science. Finally, if you are using this unit and the over-arching phenomena for the year, it is helpful to read the sample capstone unit so that you can relate this unit to that one. Importantly you should try and keep the videos of the rocket launches, effervescent rockets, and data sheets for students to use in the capstone unit.
Engaging Learners- Day 1- Patterns	Phenomenon- The function of a car or rocket. Teachers may choose to use one or both of the suggested phenomena. For brevity purposes, we will use the rocket to model this introductory unit, but some references to the function of a car are given when possible. Prepare 5-6 short video segments of rockets launching to view on the first day of class. These video segments should vary enough to show different types of rockets. There are many available videos on YouTube, TeacherTube and other such resources. As always, the teacher should preview the full video segment PRIOR to showing it to students in the classroom. Examples of videos could include- historical videos of some of the first successful rocket launches in the 50s, video of the Apollo missions, video of small hobby rocket launches (or, if possible, the actual launching of a small rocket- following all safety protocols), video of the space shuttle, video of rocket launches from submarines or aircraft, video of SpaceX or recent NASA launches. (Example videos for a car could include videos of different types of cars, or cars throughout time, or even a remote controlled car.) Teacher hint: Prior to watching the videos tell the students that you will be showing them short video clips. The students are to watch the videos, write down their observations and look for PATTERNS. Explain to students that scientists in the real world spend a lot of time looking for and explaining patterns and that in order for them to be successful in Physical Science, they will also need to become experts at looking for patterns as well. **Obtaining-** Show the students the video clips, use your judgement as a teacher about whether or not you discuss after each clip what students noticed or if you want to simply show the clips and then allow students to discuss afterwards. **Communicating**- After watching the videos, place the students into small groups (2-3) and ask them to summarize what patterns they saw in the videos. Students may either record these in writing or draw pictures to help explain what they saw. Similarities of the rocket launches could include fire at ignition, shape of rocket, launch

	location, rocket's materials, etc. Remind students that the goal of the activity is not to be able to explain how the launch took place, but rather to explain the patterns that they saw despite the differences in the types of rockets, date of launch or any other variables. **Evaluating-** Lead a discussion as a class about the patterns they noticed. You may want to record their answers on a class chart. You may find that many high school students are not used to being asked to make this type of observation. Encourage students that they will get better with practice. If no student suggests that the rockets were made of similar materials (metals or at least some metallic parts in the case of hobby rockets), offer this pattern. Explain to students that in the first instructional segment of the year, they will explore different properties of elements and this may help to explain why these materials were chosen.
Exploring- Day 2- Structure and Function	On the second day of class refer to the class chart of patterns. One of the patterns that students likely noticed was that most rockets have a similar shape. Tell students that this shape is the overall STRUCTURE of the rocket and that this STRUCTURE relates to the FUNCTION of the rocket. (If you are using cars- students also likely noticed that they have similar shape.) Tell students that they are going to explore how the STRUCTURE affects FUNCTION in today's activity. Students will engage in a paper airplane building activity to see what structure cause better function. (Students can explore the shapes that work best for distance, speed and agility (ability to go follow a projected path). Students have likely had some experiences with making paper airplanes, and while this activity is fun and engaging the real challenge for the students is to identify that changes in structure can change the function. (If you are using cars- you could have small toy cars with different shapes and carry out similar experiments.) Divide the students into small groups and give the students paper and the challenge to build three paper airplanes, one that will go the furthest, one that will go a set length the fastest, and one that will have the best agility (land in a recycling bin a certain distance from where it was launched). Prior to starting class you can mark off a 10M distance either in your classroom or outside where students can test their designs. Explain to students that while traditional rockets don't "fly" (as in using the Bernoulli principle to stay airborne) many rockets deliver vehicles that do so as in the case of the space shuttle. However, the goal of this activity is to explore how structure affects function. Because the goal of the activity is to understand structure and function, it is recommended to only allow students to use one kind of paper and not introduce variables other than changing the shape (structure) of the airplane.

	Obtaining- Students will attempt to design and produce three paper airplanes: one to meet each of the following goals- travel the furthest, move the fastest, and have the greatest agility (can land in a designated spot). Allow students to design and test multiple samples until they feel they are ready to compete. **Evaluating**- After students have completed and tested their airplanes, encourage students to look for similarities in the structure of the airplanes that went the fastest, had the most agility and that went the farthest. In some cases, similar structures may work well in order to achieve more than one of the stated goals. **Communicating**- Students should communicate through written or other means how the structure of the paper airplanes they or their classmates created related to the airplane's function.
Exploring- Day 3- Cause and Effect	Remind students again of the patterns that students observed on the first day. Students should have noticed that all of the rockets required thrust (though students may not have used this specific term, which is fine), in order to lift off the ground. In today's activity students will look for cause and effect while launching a small model rocket. (If you are using cars, you could give students block building systems to produce and test different variables (such as mass, size, etc.) as causes for the effects of the motion of the car.) Students will make small rockets using film canisters, effervescent tablets and index cards. A sample lesson plan is available here- Rockets Activity. The focus of the activity is on the cause (chemical reaction between the effervescent tablets and water) and effect (launch of rocket). If teachers would like to also discuss the chemical reaction (which is one of the areas of focus for this year), they may take the opportunity to do this. Students can also be formatively evaluated on their understanding of force and motion by listening to how they describe the motion of the rocket in the activity. (Be sure that students save their rockets for the following day's activities.) **Obtaining**- Students will produce their effervescent-rockets as described in the directions. Ask students to make careful observations of what occurs. **Communicating**- Students explain their observations of their effervescent-rockets focusing on getting as specific as possible on the cause of the rocket leaving the ground. Ultimately students should link the production of a gas from the chemical reaction to the separation of the canister and lid as a source of thrust for the rocket. You may also want to emphasize that while Cause and Effect may seem like a simple concept for many scientists, proving a cause can be quite

	difficult due to the complexity of the systems they study. This will lead into tomorrow's activity on the need for models in scientific study.
Exploring- Day 4- Systems and System Models	Using the data from yesterday's activities, students will engage in a discussion of how models are used to explore scientific concepts and will make a 2D model of their system. **Obtaining-** Begin the class by asking the question- Have you ever made a model? It is likely that students have made a model of a cell, the solar system or something else in a previous science class. Discuss with students about why they made the model and how the model they is similar or different from the real thing. You may want to have some pictures of models available from online resources for students to also discuss. After the class has sufficiently discussed the models, talk about how the effervescent rockets they used yesterday are models for the rockets that they viewed on the first day. Tell students that they are going to draw a model of their effervescent rocket system. Discuss with students what a "system" is and discuss some "systems" that they are familiar with. Students may talk about body systems, ecosystems, or other such concepts that they have been introduced to in the past. (If you are using cars, students can sketch a 2D model of the car they made yesterday with the building blocks.) According to the Framework for K12 Science Education, high school students will make models of systems that incorporate inputs and outputs as well as mathematical representations of what is happening within the system. In the case of the effervescent rocket, all of the parts (index card, tape, effervescent tablet, water, etc.) are part of the system studied. Encourage students to work in small groups and to make a 2D model (labeled drawing or written explanation) of how all of the parts of the system work together for the rocket to launch. Explain to students that throughout the study of Physical Science they are introduced to a number of models and asked to make their own, as many of the things they will study from atoms to waves are not easily observable. It is important for them to recognize the limitations of the models they will use this year as well as to understand that while we often study parts of physical science as a closed system, in reality, there are many interactions that are difficult to include in any model. After the class discussion of models and systems, allow students to work on their 2D models of their effervescent rockets in small groups (2-3 students). Encourage students to think beyond the obvious and observable items in their model to include any invisible inputs or outputs that may affect the operation of the effervescent rocket. After sufficient time, allow the students to share these with the class. Try and encourage students who work quickly to include more difficult things in their model such as energy and also the limitations of their models. For groups who need more assistance, encourage them to at least think through the different parts of the effervescent rocket and how they interact.

	Communicating- Students will share their 2D models of the effervescent rocket system. **Evaluating**- Class discussion of this activity should focus on the development of a model of a system, and how scientists also do this to explain their theories and hypotheses as well as connecting this to some of the physical science concepts they will work on this year. *Teacher note: Students will use these models again during the Capstone Instructional Segment at the end of the year. Have a place to store them.*
Exploring- Day 5- Scale, Proportion, and Quantity	In this culminating activity, students will use proportion and quantity to explore the effect of adding more or less of the effervescent tablets and water to the effervescent rockets. (If you are using cars instead of rockets as your model phenomena, you could do a similar activity using the height and length of a ramp vs. the distance the car travels as an activity.) Begin the lesson by talking about scale. Discuss with students why an understanding of scale is important when you are studying something. Also talk about the upcoming topics for the year and how they will build from very small, atoms and subatomic particles, to large, interactions objects with force and motion. Tell students that during the year, keeping scale in mind is very important. Following this, students will use their effervescent rockets to attempt to find the correct proportion of effervescent tablet and water to maximize the height of the rocket launch. In order to measure the height of the rocket launch, it is recommended that the rockets are launched near a wall or other object so that the height can be measured. (One suggestion is to have students measure the distance between bricks on a wall and use this as a measurement, or students can connect meter sticks and place them along a wall. The typical maximum height of a rocket launch is approximately 5-6 meters.) Give students their effervescent rockets and the data log. Students will have a number of variables they can use to test a formula to have the highest rocket launch. For data collection and analysis it is suggested that you use Google Sheets or Microsoft Excel so that all of the student data is collected and analyzed. Students can change the amount of liquid fuel (water) and solid fuel (effervescent tablets). *Teacher hint: Color the water so that it is easier for students to see when measuring in the graduated cylinders.* An extension of this activity is to experiment with crushing or breaking the tablet to see if there is an effect on the height of the rocket. **Obtaining**- Student groups will decide how much water and effervescent tablet they would like to use to maximize the height of

	their rocket. To ensure reliability of data, students will repeat their experiment three times and share the average with the class. **Evaluating**- Graph the data of the proportion (g/mL) of fuel to the height of the flight for the class data. If possible, allow the data from multiple classes show on the graph and/or allow student groups to have multiple trials. Students are asked to draw conclusions from the results about what proportion of fuel is the best to maximize the height of the rocket. Lead a discussion with the class what proportion means and why this had an effect on the height of the rocket. Also, students can graph the amount of liquid fuel vs. height and the amount of solid fuel vs. height in order to discuss the difference in quantity (amount) vs. proportion (which takes into account both the liquid and the solid fuel). **Communicating**- As a culminating activity for the week, students can write two paragraphs describing what they learned this week using the terms below. Students who cannot properly use these terms in their reflection of learning will need remediation as the use of these terms will be important throughout the year. ● Patterns ● Energy ● Models ● Systems ● Proportion ● Quantity ● Cause ● Effect ● Structure ● Function
Explaining, Elaborating, Evaluating	Because this unit is a formative assessment unit, no explanations, elaborations or evaluations are given other than what is suggested in each daily activity. These will come later during the units throughout the year.
SEP, CCC, DCI	**Science Essentials**
Science and Engineering Practices	● Asking questions ● Planning and carrying out Investigations ● Developing and using models
Crosscutting Concepts	● Patterns ● Cause and Effect ● Structure and Function ● Systems and System Models ● Scale, Proportion and Quantity
Disciplinary Core Ideas	NA- this is a formative assessment segment