Physical Science Capstone Instructional Segment

This is a two-week summative designed to give students an opportunity to review and re-examine the concepts covered in this course.

Student Science Performance

Grade level: 9-12 Physical Science

Topic: Capstone Unit

Title - Rockets and Physical Science (or Cars and Physical Science)

Performance expectations for GSE:

All from year- but illuminate the following-

Structure and Function of Matter

- **SPS1. Obtain, evaluate, and communicate information from the Periodic Table to explain the relative properties of elements based on patterns of atomic structure.**
- **SPS2. Obtain, evaluate, and communicate information to explain how atoms bond to form stable compounds.**

  Stability and Change in Reactions
- **SPS3. Obtain, evaluate, and communicate information to support the Law of Conservation of Matter.**
- **SPS5. Obtain, evaluate, and communicate information to compare and contrast the phases of matter as they relate to atomic and molecular motion.**
- **SPS6. Obtain, evaluate, and communicate information to explain the properties of solutions.**

  Energy and Matter
- **SPS4. Obtain, evaluate, and communicate information to explain the changes in nuclear structure as a result of fission, fusion and radioactive decay.**
- **SPS7. Obtain, evaluate, and communicate information to explain transformations and flow of energy within a system.**
- **SPS10. Obtain, evaluate, and communicate information to explain the properties of and relationships between electricity and magnetism.**

  Cause and Effect in Force and Motion
- **SPS8. Obtain, evaluate, and communicate information to explain the relationships among force, mass, and motion.**

  Patterns in Waves
- **SPS9. Obtain, evaluate, and communicate information to explain the properties of waves.**

Performance expectations for instruction:

- Students will have an opportunity to communicate their understanding of the "big ideas" of physical science. This will allow students to return to each of the concepts, review the information prior to the EOC and ensure correct understanding.

Materials (amounts and items will be based the directions teachers take):

- Safety equipment such as eye protection
- Effervescent tablets (3-4 tablets per group)
- Graduated cylinders (1-2 per group)
- pH Paper (1-2 per group)
- Timers
- Temperature sensor or thermometer (1 per group)
- Beakers or cups (2-3 per group)
- Hot plates (1 per class, min.; 1 per group, max.)
- Balances (1 per class, min.; 1 per group, max.)
- Baggies (1-2 per group)
- Water

Background for teachers	This is a capstone unit for the year. While it may serve as a review for the year's content, the more important outcome for this unit is for the **students to demonstrate their learning** in real and concrete ways that tie together all of the learning for the year. Teachers can design activities and opportunities for students to demonstrate understanding. The amount of time and depth of these activities are determined by the teacher, but these activities should allow students to think deeply about the physical science standards and confirm what they have learned this year, as well as give teachers another opportunity to check for the correct understanding of these concepts. The examples given below are for a rocket, but if teachers have chosen to use the car as an overarching phenomena, they can use hints in the information below.
Structure and Function of Matter	**Phenomenon-** A rocket uses chemicals in its structure to function. Tell students they are going to look into the materials and compounds that are used to make a rocket. Students can use internet and other resources to research this. NASA Resource: Rocket Parts *Teacher note*: Rockets are largely made of titanium and aluminum, however there are many other chemicals used in the rocket system. For instance, copper wire is used in electrical systems. Decide to go as deep as you would like. The overarching topics to address are elements and bonding. **Obtaining-** Students will return to their notes, journals and other materials from the structure and function of matter unit. Students will look at the properties of the elements that are used in the rockets. Students should research these elements for their atomic structure, conductivity, strength, ions, etc. from the original unit. It is possible that the element cards that they made in the original unit on the Periodic Table could be used, or they can make new ones. **Evaluating-** Lead the class in a discussion of the unique properties of the elements that are used in rockets. Have students ask questions about these elements and why they are used in a rocket. Be sure to lead the discussion on why these particular elements have the properties and the structure that are needed for this function (rockets). In the discussion remember to review location on the periodic table and what that means, subatomic particles, valence electrons, ions, atomic number, atomic mass, etc. To extend this lesson you will also want to cover the types of bonds these metals are likely to form, and the names of these using IUPAC. **Communicating-** Students will develop a product that allows them to demonstrate their understanding that the structure and properties of the elements are necessary for a rocket to function. Examples of products include a children's book, brochure, short essay, song, poster, a video, etc.

	Teacher hint for Car: Like rockets, cars are built of materials that are light but strong to maximize gas mileage and minimize damage to people in the event of a crash.
Stability and Change in Reactions	**Phenomena-** Chemical reactions power rockets. **Obtaining-** Pass out the effervescent -rockets that were used the beginning of the year. If your students keep a science journal, have them return to their data they collected on their rockets. Ask students to ask questions about how this chemical reaction takes place. Remind students of the topics that were covered in this unit- solutions and solvents, acids and bases, solid, liquid and gases, conservation of mass, etc. Challenge the students to use this simple reaction between effervescent tablets (active ingredient- Sodium Bicarbonate) and water to demonstrate their understanding of these topics. Students will need to plan and carry out investigations to explore each of these topics. *Teacher Hints:* *Solvents and Solutions- Students can return to their lesson from the introductory unit on which size of effervescent tablets would allow the rocket to go the highest as it relates to solubility based on surface area. They can also plan and carry out an investigation on the effect of agitation and temperature on the reaction. They can identify the solvent, solute and solution from this reaction.* Acids and Bases- Sodium Bicarbonate can be tested to determine if it is acidic, basic or neutral. Students can use the chemical formula of sodium bicarbonate to relate this to the concentration of OH- and/or H+. Solids, Liquids and Gases- In this reaction you have a solid fuel (effervescent tablets), liquid fuel (water) and the generation of gas- CO2. Students need to relate these in the reaction for how the molecular structure of these three phases relates to their ability to launch the effervescent -rocket. Students can make models (drawings or writings) about how the particles in these compounds move and act in each state. Conservation of mass: Students design an experiment to show the conservation of mass in this reaction. Students will realize quickly that a gas is produced, so any measurements must be done in a closed system (baggie). **Evaluating-** Students will use the reaction of Sodium Bicarbonate and water to design and carry out investigations to demonstrate their understanding of the topics from this unit. **Communicating-** Students will develop a product that demonstrates their understanding of all of the topics in this unit. Examples of products include a children's book, brochure, short essay, song, poster, a video, etc. *Teacher hints --Car notes: Like rockets, chemical reactions power the motion of a car. The model of the effervescent tablet can also demonstrate this reaction.*

	(Just as we are not using hydrogen and oxygen reacting for rockets for safety reasons, we would also not use gasoline in a car's combustion reaction in classroom labs.)
Energy and Matter	**Phenomena-** Rockets are powered in a number of ways. All of these require transformations and transfers of energy to allow the rocket to operate. **Obtaining**- Show the videos that you used at the beginning of the year of the rocket launches. Have the students ask questions about the energy that they see. Use these questions to guide students through the mini-lessons on this topic. Review the terms *transfer*, *transformation* and *systems*. Ask students to make a model of the system of the rocket labeling or diagramming as many inputs, outputs, transformations as possible. Encourage students to think deeply about the "invisible transformations" they can show in the rocket system. **Evaluating-** Students will spend time thinking, researching and discussing all of the types of energy that are transferred and transformed in the rocket system. It is helpful to have a list of all of the energy types you have studied this year (the word bank example is from the station lab sample lesson from the Energy and Matter unit). Students will identify all of the types of energy except nuclear. To assist students with nuclear, you may want to introduce the theoretical Nuclear Thermal rocket that was designed by NASA, but never flown. Information on this can be found at Nuclear thermal rocket. One possibility is to give a group this example to use. TYPES OF ENERGY- WORD BANK Kinetic- Potential Chemical • Electrical • Electromagnetic • Mechanical • Nuclear • Radiant (Light) • Sound • Thermal (Heat) **Communicating**- Students will make posters with energy transfer models. (Allow students to choose how to best share this information. Some may draw rockets while others may use energy transfer diagrams. The focus is on the conceptual understanding of the core idea.) Students can share these with the class through presentations, poster walks, or other methods. Encourage constructive criticism and corrections to ensure all students have the correct understanding of the concept. *Extension*- As an extension of this unit, ask students to describe the type of heat transfer taking place, talk about the circuits that are present in rockets, and discuss the role of fission in the conceptual thermal rocket. This will allow teachers to extend this activity to evaluate understanding of all of the energy and matter core ideas. *Teacher hint: Car notes: Like rockets, cars have many transformations and transfers of energy used in their operations. Like the theoretical nuclear rocket- there was also a theoretical model car- Nucleon.*

Cause and Effect in Force and Motion	**Phenomena-** Rockets use force (thrust) to generate upward motion. *Teacher Hint- While videos of rocket launches are for this activity (or Alka-Rockets), a much more impactful opportunity is to use a small model rocket or a 2-liter bottle rocket (There are many available designs online). This activity requires students to make connections between many of the concepts relating to force and motion (speed, acceleration, velocity, force, gravitational force and Newton's Laws). Students will likely find it very challenging, so scaffolding students by modeling the calculations and calling attention to how these concepts and calculations relate to each other are helpful. Be sure to follow all safety protocols- safety glasses, etc.* **Obtaining-** Allow students to watch a rocket launch (see teacher hint above). Using protractors, timers, and motion detectors (if available), students should produce data tables with speed, acceleration and velocity of the rocket. (If motion detectors are not available, calculate velocity, but only discuss acceleration). Online simulations of rocket launches with speed, acceleration and velocity are available, and could be used in lieu of students conducting hands-on tests, but this is a less-desired teaching method. The outcome of the obtaining stage should be velocity and acceleration table listing the time, distance traveled, velocity and acceleration of the rocket's' flight. **Evaluating-** Students will use their data table to produce a report on the interactions of velocity, speed, acceleration, gravity, and Newton's three Laws in the rocket system. Students relate the motion of the rocket to each of the concepts taught earlier in the year. Students will use the data they collected from the rocket launch (or simulation) and use it as evidence of the concepts of force and motion in the rocket system. Students should show calculations of velocity, acceleration, gravitational force (they will need the mass of the rocket) for the movement of the rocket during flight. Emphasize the interaction between speed, velocity, force, and acceleration during the evaluating phase. **Communicating-** A graphic organizer allowing student to describe the interactions of force and motion in a rocket is one way for students to demonstrate their understanding. Students could also make posters, presentations or other products so that they can share their understandings with the class. The focus on this activity is on ensuring that students do not have an isolated view of this concept. Students must understand that Newton's Laws, gravitational and other forces, and motion are interrelated. Students should relate the motion of the rocket to acceleration (including calculations), velocity (including calculations), force (including calculations), speed, gravitational force, balanced and unbalanced forces, and Newton's Three Laws. *Teacher note: There are nearly unlimited extensions for this activity. Depending on time and other factors, students could engage in STEM activities on building rockets with the greatest velocity, acceleration, force, distance, height, etc. Students would account for mass, force, etc. in their designs and asked to relate the success or failure of their designs to concepts such as gravitational force*

	and Newton's laws. Extending this unit further can allow students to connect the motion of their rockets' structure (elements and compounds) to the chemicals that fuel them, the chemical reactions that provide them energy, and the transformations and transfers of energy in the system. Engagement in more in-depth activities will give students an enhanced opportunity to demonstrate their understanding of what was learned throughout the course. *Teacher hints: Car notes- Students can use model cars and measurements of the car's motion as they move down a ramp (because that will also allow an obvious interaction with gravity) will work well as a replacement for this activity.*
Patterns in Waves	**Phenomena-** Rockets make waves as they move. *Teacher hint: Students can use their recollections of the rocket launch from the Force and Motion activity as it relates to waves (light, sound, mechanical, and electromagnetic). However redoing the launch and allowing students to specifically think about waves as they are watching it will likely result in better student outcomes.* **Obtaining**- Students will observe and/or participate in a rocket launch. As students watch the launch ask them to notice any types of waves they observe. Remind them of all of the types of waves you studied this year- electromagnetic, mechanical, sound, and light. Also remind them of the properties of waves you studied- amplitude, frequency, and wavelength and ask them to think about how this relates to any of the waves they observe. Students will make a data table listing each of the types of waves, how they were seen in the rocket launch, and the properties that the waves may have. Teacher hint- Encourage students to watch how the grass and other materials surrounding the rocket move in response to the launch as an example that mechanical waves are generated (as well as sound waves). Light is the best example of electromagnetic waves. If you are using a rocket with a combustion reaction, the colors produced can lead to a discussion of wavelengths and the visible spectrum. Students can also think about how real rockets use radio waves to communicate to earth from long distances. **Evaluating**- Students will review their notes, research, data tables, etc. and work in groups to evaluate the claim that rockets make waves. Students should produce a claims-evidence-reasoning chart for each type of wave (see sample below or make copies of Claims, Evidence, Reasoning Handout) with their groups. Focus on extending the students discussion beyond just a simple discussion of waves into a deeper understanding of the properties of waves.

<table>
<tr><td></td><td>
<table>
<tr><td colspan="4">Rockets produce waves as they launch and move.</td></tr>
<tr><td>Initial claim:</td><td colspan="3">The rocket produced waves of the following types:
_____
_____
_____</td></tr>
<tr><td>Initial reasoning:</td><td colspan="3">1.
_____
2.
_____
3.
_____</td></tr>
<tr><td rowspan="4">Supporting Evidence from investigation and research</td><td>1.</td><td rowspan="4">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>

Communicating- Students will share their claims-evidence-reasoning charts with the class. Teachers should use their best judgement when choosing groups to share and should encourage other groups to change their charts to reflect correct understanding. Students can pose questions about the types and properties of waves during the presentations and allow their peers and teacher to correct or ensure proper understanding of these concepts.

Teacher hint: Car hint: Like rockets, cars cause waves as they move. Videos of the Doppler Effect with cars are found online, and some types of race cars produce visible fire from tailpipes (evidence of heat and light).</td></tr>
<tr><td>SEP, CCC, DCI</td><td>Science Essentials</td></tr>
<tr><td>Science and Engineering Practices</td><td>● Asking questions
● Planning and carrying out investigations
● Developing and using models</td></tr>
<tr><td>Crosscutting Concepts</td><td>● Patterns
● Cause and Effect
● Energy and Matter
● Structure and Function
● Systems and System Models
● Scale, Proportion and Quantity</td></tr>
<tr><td>Disciplinary Core Ideas</td><td>ALL FROM YEAR</td></tr>
</table>