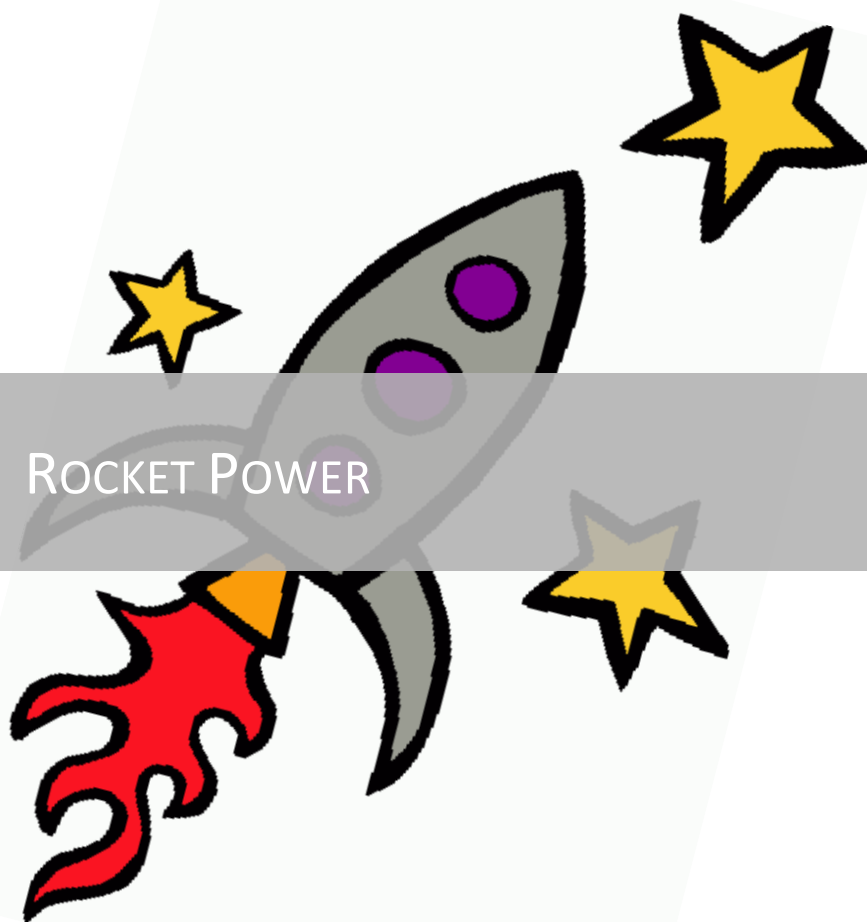


8/4/2016

DURHAM
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ROCKET POWER



5th Grade Force and Motion Unit | J.Champion

Introduction

Rationale

Science has always been my passion. In planning this unit, it was my hope to share my passion of science with my students. I find rocketry fascinating even though I did not know a great deal about the topic prior to creating the unit, which is one reason I wanted to explore rocketry in this unit. I incorporated activities that I would enjoy doing in the regular classroom if I was given the time and resources. It was my goal that through these activities students would be engaged in a deep and meaningful exploration of a science topic that encourages questioning and creativity.

Force and motion was chosen as the content for my rocketry unit because that is a major unit of study in fifth grade science. Rocketry was chosen because typically students are not exposed to this type of information during their force and motion unit, but it connects to many force and motion concepts. In this unit students learned about the history of rockets while also learning about how Newton's Laws of Motion affected the power and movement of rockets.

I have noticed during my time as a fifth grade teacher that the district curriculum guides leave out Newton's Laws of Motion. In my opinion, the ideas explained by Newton's Laws are crucial aspects of force and motion that help explain how forces affect objects. These ideas are essential and need to be address with students. Without Sir Isaac Newton, teachers would not be able to explain pushes, pulls, friction, or gravity. I also think that teachers would not be able to show acceleration or deceleration on a motion graph since Newton's second law of motion is $\text{mass equals force times acceleration}$. This unit touches mainly on Newton's first and third laws,

but the second law can be tied in when the students create rocket powered cars or during the performance task of creating a bottle rocket.

The concept of power is discussed in each lesson. Power is something that can be changed both positively and negatively, especially when creating rockets. Students spent a great deal of time discussing how to add more power to their activities in order to “win” the challenges given by the teacher. When discussing power, however, students may not know the definition of power in its relation to force and motion. It is important for students to make the connection to the other forms of power that exist which was one concept addressed in this unit. For example students can discuss political or economic power as well as power involved in motion of objects which is the primary idea explored throughout the unit.

Differentiation for Gifted Learners

There are many elements of this unit that make this appropriate for gifted learners. Students are highly engaged in the content which allows for the students to conduct independent study on areas of interest relative to the force and motion (science) curriculum. The rationale behind this is that they will be motivated to learn. Since the students are able to study their interests within this curriculum, learning can be accelerated, differentiated to be more complex, and developed to reach a deeper level of understanding all while being made to be challenging for students. The first three lessons of the unit allow for the students to learn the material through hands-on exploration. During these lessons, students use various tools of their choice and skills to work with the force and motion concepts that were discussed in the unit. This allows more kinesthetic learning and also helps keep the students actively engaged in the content. Due to the hands-on nature, students are thinking deeper and at a more complex level which is more

challenging. The learning environment that was set up in the classroom was highly mobile. Since many activities were kinesthetic in nature, I wanted the students to feel that they could change their learning spaces. The students worked at tables, on the floor, in the hallways, or outside to complete their tasks. This allowed me to accommodate the different learning styles of the students and also allowed them more comfort as they were completing their tasks. Students were able to think deeper about their particular learning space and make their own adjustments. The products from each lesson all varied. Students had discussions, completed writing assignments, drew pictures, and created straw rockets, rocket powered cars, and bottle rockets. When creating, the students were able to choose their materials so this allowed them to have ownership of their learning by allowing them to be more creative in their demonstration of knowledge.

Intended Population

This unit was created for a fourth or fifth grade gifted student. Students should have general background knowledge about the topic of force and motion at this age. Previous grade levels touch on force and motion but do not go into detail about Newton's Laws of Motion other than Sir Isaac Newton created the laws and he discussed gravity pulling objects to Earth. In the unit, students will learn about Newton's first and third laws by creating various products. Students will discover that power plays a huge role in these two laws as well. The reading involved with the unit is complex, so it is helpful if the student is gifted in reading although not required to complete the unit successfully. Gifted students should be interested in science and how rockets work. Previous experience in creating rockets is not required as students will learn about the important aspects of rockets as the unit progresses. Students should be willing to learn from any misconceptions they have while creating their products and be open to making necessary modifications. Students should also be open to working in small groups and having the

groupings change based on the specifications given by the teacher. Students should be able to work with a variety of students on the various tasks given. Students should also be able to work independently on the reading and writing tasks. It is helpful for a student to be willing to share their ideas in a group setting comfortably as students will be participating in a Socratic Seminar to wrap up the unit. The students will have to clearly communicate their ideas along with take constructive criticism from their peers.

Goals and Outcomes

Content Goals and Outcomes

Goal 1: To develop an understanding of force, motion and the relationship between them.

Students will be able to...

- A. Explain how factors such as gravity, friction, and change in mass affect the motion of objects.
- B. Infer the motion of objects in terms of how far they travel in a certain amount of time and the direction in which they travel.
- C. Illustrate the motion of an object using a graph to show a change in position over a period of time.
- D. Predict the effect of a given force or a change in mass on the motion of an object.

Process Goals and Outcomes

Goal 2: To develop reasoning skills with application to force and motion.

Students will be able to...

- A. Generate explanations based on evidence from tests of models.
- B. Use background knowledge to make predictions and inferences about shape affecting the flight of rockets.
- C. Draw conclusions about how the power of a rocket is impacted by the design of the rocket.
- D. Design and create based on collected criteria and information.
- E. Synthesize structure based on materials and information provided.
- F. Analyze and articulate the reasons for material and design choices.

Concept Goals and Outcomes

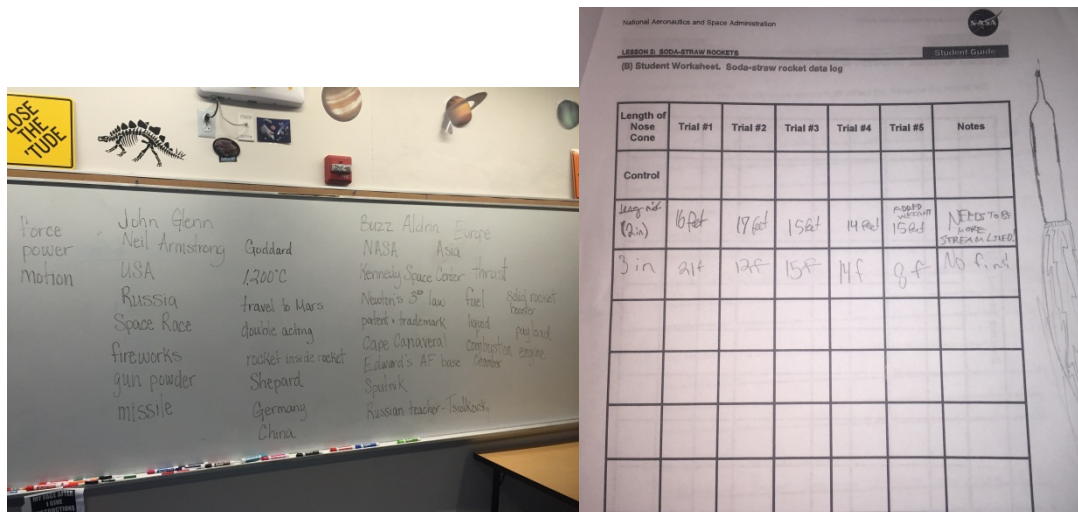
Goal 3: To understand the concept of power.

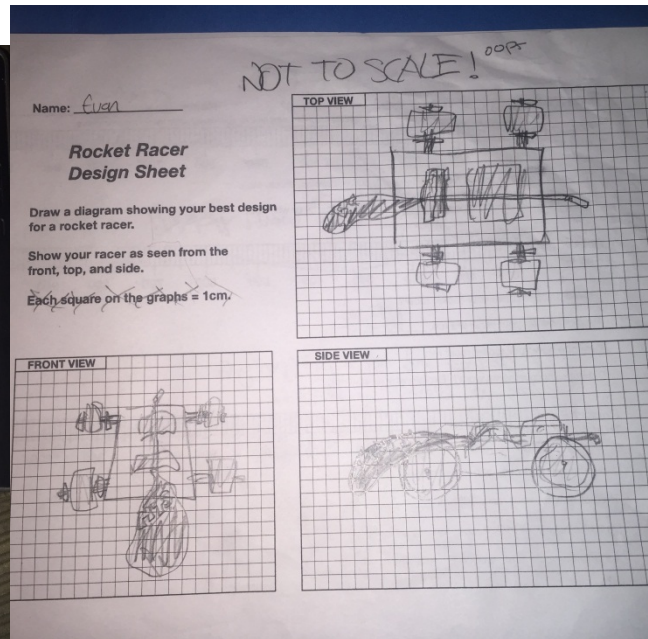
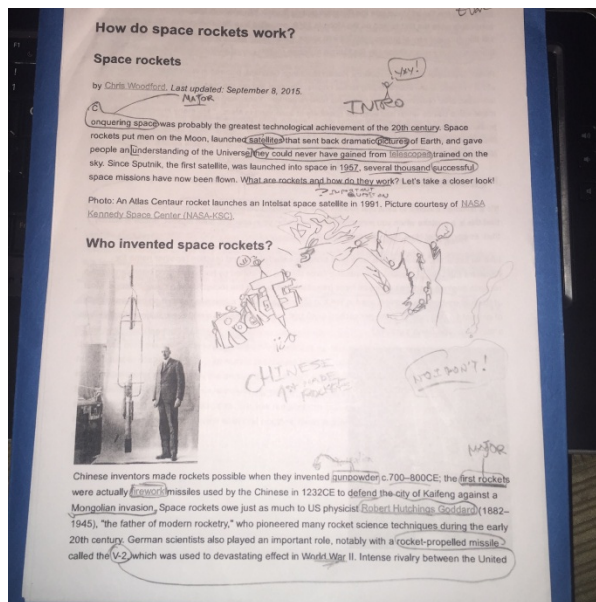
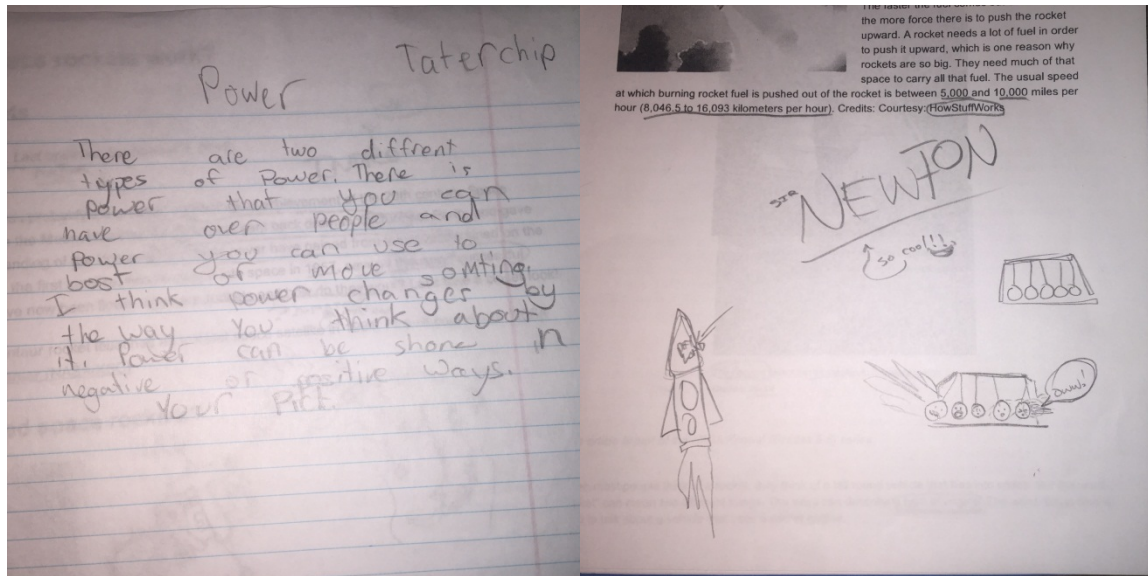
Students will be able to...

- A. Know there are multiple definitions of power
- B. Discuss how power can be manipulated.
- C. Discuss how power is affected by design.
- D. Recognize how force, motion, and power are interrelated (Motion is the result of an applied force, a force is caused by a power source so you need power that results in a force that leads to a motion)
- E. Discuss how the availability of materials and access to manufacturing resources may limit and challenge power.

Assessment Plan

Students will show their knowledge of Newton's Laws of Motion and power through both formative and summative assessments. The formative assessments are discussions, writing assignments, question stems, and self-evaluations. During the lessons, the teacher is moving throughout the classroom questioning students and checking their understanding. Since students are keeping notes in their science notebooks, the teacher can check for understanding and clear up misconceptions prior to the end of the lesson. At the end of the lesson, students are given the opportunity to self-evaluate their products and can use additional time to modify their products to meet given criteria. Students will also participate in discussions. During this time, the teacher can note which students need additional support and which students need acceleration.





For the summative assessment, the students will be creating bottle rockets. Bottle rockets will store power inside as students will be using water and air pressure to build up the power. Rockets will be launched at 60 psi (pounds per square inch) and the power will be transferred as the rocket goes into the air. Students will show their unit understanding by using aerodynamics, various nose cone shapes, thrust, balance, etc.



Performance Task

NASA has hired a team of rocket scientists to create a new rocket design that will stay aloft after the entire power source has been consumed. As a part of this team, you will be designing a rocket prototype. Using what you have learned and discovered about how power can be changed, you will design a bottle rocket. It will be your task to use your understanding of nose designs and other design factors (aerodynamics, thrust, etc.) to create a rocket that will stay aloft for thirty seconds or more. First you must sketch your rocket and identify the plan for building it to accomplish the task. Then you will write a brief (one) paragraph response to explain why you believe your rocket design will create the most powerful rocket that will stay aloft for thirty seconds or more and how power is changed through the launching of your rocket. Finally you will build your rocket and test it to compare your design to other rockets to see which design resulted in the most powerful rocket. NASA will choose the most successful bottle rocket design to be used to design their next rocket.

Rubric

	<i>4</i>	<i>3</i>	<i>2</i>	<i>1</i>
<i>Skill</i>	Student thoroughly considers the forces that would affect the rocket. Sketch of the rocket is useful and includes measurements.	Student adequately considers the forces that would affect the rocket. Sketch of the rocket is useful.	Student considers some of the forces that would affect the rocket. Sketch of the rocket is rough.	Student minimally considers the forces that would affect the rocket. Sketch of the rocket is not made.
<i>Understanding</i>	Student follows all safety procedure, and work shows evidence of having thoroughly tested and modified the rocket.	Student follows most of the safety procedures, and work shows evidence of having adequately tested and modified the rocket.	Student follows some of the safety procedures, and work shows evidence of having tested or modified the rocket.	Student did not follow many of the safety procedures, and work shows little evidence of having tested or modified the rocket.
<i>Content / Knowledge</i>	Rocket write up is thorough and well organized. Student communicates all appropriate features of the rocket.	Rocket write up is adequate. Student communicates most of the appropriate features of the rocket.	Rocket write up is appropriate but is hard to follow. Student communicates some of the features of the rocket.	Rocket write up is incomplete and hard to follow. Student communicates a few features of the rocket.
<i>Product</i>	Student creates a bottle rocket that stays aloft for 30 seconds or more.	Student creates a rocket that stays aloft for 20-29 seconds.	Student creates a rocket that stays aloft for 10-19 seconds.	Student creates a rocket that stays aloft for 10 seconds or less.

TEACHER NAME			Lesson #
Julia Champion			1
MODEL	CONTENT AREA	GRADE LEVEL	
Taba Concept Development	Science	5	
CONCEPTUAL LENS		LESSON TOPIC	
Power		Force and Motion (Rockets)	
LEARNING OBJECTIVES (from State/Local Curriculum)			
5.P.1 Understand force, motion and the relationship between them. 5.P.1.1 Explain how factors such as gravity, friction, and change in mass affect the motion of objects. 5.P.1.2 Infer the motion of objects in terms of how far they travel in a certain amount of time and the direction in which they travel. 5.P.1.3 Illustrate the motion of an object using a graph to show a change in position over a period of time. 5.P.1.4 Predict the effect of a given force or a change in mass on the motion of an object.			
THE ESSENTIAL UNDERSTANDING (What is the overarching idea students will understand as a result of this lesson?)		THE ESSENTIAL QUESTION (What question will be asked to lead students to “uncover” the Essential Understanding)	
Power can be changed.		How can power be changed?	
CONTENT KNOWLEDGE (What factual information will students learn in this lesson?)		PROCESS SKILLS (What will students be able to do as a result of this lesson?)	
- There are relationships between force and motion. - Power has many definitions.		- Work collaboratively in a group to organize information. - Discuss similarities and differences in power.	
GUIDING QUESTIONS What questions will be asked to support instruction? Include both “lesson plan level” questions as well as questions designed to guide students to the essential understanding			
Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:	
- What is power? - What are some examples of power? - Where does power come from? - How is power affected by humans? - How does one obtain power?	- What aspects of power do you see? - Which of these aspects belong together? Why? - How can you label the groups you have formed? - Why did you group the items that way? - What are the differences and similarities between the aspects of power? - How would some of these belong in more than one group? - How can we put these same items in different groups?	- How do humans affect power? - How can power be changed? - Can power be negative? - Where does power occur? - How are changes in power seen? - How is power used in rocketry?	
DIFFERENTIATION (Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.)			
Content	Process	Product	Learning Environment

Readings used in the lesson use advanced vocabulary.	Students engage in in-depth critical thinking as they must analyze the concept of power in great depth through grouping and regrouping ideas.		- Classroom - Small groups (groups can work at desks or in other areas around the classroom)
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PLANNED LEARNING EXPERIENCES

(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)

Engage and Connect - This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.

To begin the lesson, students will watch a video from youtube.com titled What is Power? (<https://www.youtube.com/watch?v=1MeEd8Nl9a4>). This video was filmed in New York City as part of a people on the street series. The individuals in the video were asked "what is power?" and they gave their definition of power. This video provides knowledge on the various definitions and thoughts about the term power.

Explore - In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.

Listing

- Students will read the articles: What is a Rocket?, How do Rocket Engines Work?, and Space Rockets (stopping at A typical space rocket: the Atlas Centaur). As the students read, they will be expected to make notes of people, places, things, ideas that show power. (15 minutes)
- Students will share lists while teacher makes a comprehensive list on the board. Listed items need to be detailed and the students should come up with at least 20 items. (5 minutes)

Articles

- <http://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-a-rocket-58.html>
- <http://discoverykids.com/articles/how-do-rocket-engines-work/>
- <http://www.explainthatstuff.com/spacerockets.html>

Explain - Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.

Grouping and Labeling

- Students will create smaller word lists based on similarities (with their assigned groups of no more than 4 students). The small groups will work together in order to decide which items in the comprehensive list belong together. Students will write their words on small cards and sort them into groups based on the following rules: at least three different groups, at least three items in each, cannot use any word more than once. Students will need to make sure that items are grouped together based on similarities as they relate to power. (time will vary depending on groups)
- The teacher will move throughout the classroom checking in with the student groups. The teacher will guide the students as necessary with questions but will allow the students to determine their own conclusions. As the groups finish, the teacher will instruct students to label the newly defined groups. Students will explain their reasons to the teacher. The teacher will ask students to describe the similarities and differences among groups as they relate to power (time will vary depending on groups).

Elaborate — Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways

Regrouping, Renaming

- Students will be challenged to regroup the items. The new groups must be new categories. Rules for regrouping include: items can be used again, categories must be new, and each category needs at least four items. The teacher will remind students that categories must be based on some aspect of power (time will vary depending on groups)
- Teacher will ask groups to share their categories regardless of if they grouped items once or twice (2 minutes)

Evaluate: This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.

- Teacher will wrap up the lesson by asking the class to explain the relationship between power, force, and motion. What generalizations and conclusions can be made about how power can be changed? Students will be expected to write a paragraph explaining what they have learned about power and the relationship between force and motion.
- Students will submit their writing at the end of class. (15 minutes)
- Students will be assessed throughout the lesson during small group and full class discussions. At the end of the lesson, students will provide details of what they have learned in a paragraph (no less than 4-5 sentences) that will be submitted to the teacher.

TEACHER NAME		Lesson #
Julia Champion		2
MODEL	CONTENT AREA	GRADE LEVEL
Questioning	Science	5
CONCEPTUAL LENS		LESSON TOPIC
Power		Force and Motion (rockets)
LEARNING OBJECTIVES <i>(from State/Local Curriculum)</i>		
5.P.1 Understand force, motion and the relationship between them. 5.P.1.1 Explain how factors such as gravity, friction, and change in mass affect the motion of objects. 5.P.1.2 Infer the motion of objects in terms of how far they travel in a certain amount of time and the direction in which they travel. 5.P.1.3 Illustrate the motion of an object using a graph to show a change in position over a period of time. 5.P.1.4 Predict the effect of a given force or a change in mass on the motion of an object.		
THE ESSENTIAL UNDERSTANDING <i>(What is the overarching idea students will understand as a result of this lesson?)</i>		THE ESSENTIAL QUESTION <i>(What question will be asked to lead students to "uncover" the Essential Understanding)</i>
Power can be changed.		How can power be changed?
CONTENT KNOWLEDGE <i>(What factual information will students learn in this lesson?)</i>		PROCESS SKILLS <i>(What will students be able to do as a result of this lesson?)</i>
- There are relationships between force and motion. - Nose shape effects aerodynamics. - Mass effects power		- generate explanations based on evidence from tests of models - use background knowledge to make predictions and inferences about nose cone shape effecting the flight of the rocket - draw conclusions about how the power of a rocket is impacted by the design of the rocket

GUIDING QUESTIONS			
What questions will be asked to support instruction?			
Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding			
Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:	
- How do we know we can get where we want to go? - How is power helpful in people getting where we want to go? - What is engineering? - How do engineers solve problems? - What is a design used for? - What are the criteria and constraints for a successful solution to a problem or task? - What is needed to create motion? - How is power manipulated by engineers? - Would different amounts of power be needed to overcome the changes in the nose cone design? Explain. - Would the rocket exert a different amount of power based on the shape of the nose cone? Explain.	- What do different rockets and launches have in common? - What are the differences in the nose cones of the different rockets? - What would happen if a different cone was used when making a rocket? - What would happen if the cone of a rocket was shorter or longer? - What if there was no cone on the rocket? - What would happen to the distance the rocket traveled if the nose cone was altered? - How would the nose cone shape or lack of a nose cone affect the rocket's power? - How does the design shape of the rocket impact the rocket's power? - How does the length of the nose cone impact the power of the rocket? How did you use this information to help you determine which rocket design was the best?	- What is the reason that a longer cone will have a longer or shorter distance? - What happened to the distance traveled when there was a longer nose cone? - What happened to the distance traveled when there was a shorter nose cone? - What were some problems during the investigation that might have changed the distance traveled? - Was the hypothesis supported? If yes, what evidence is there to support the hypothesis? If no, why do you think the hypothesis wasn't supported? - What are three additional variables that might change the distance traveled? Why might these variables change the distance traveled of the rocket? - What is a design used for? What are the criteria and constraints for a successful solution to a problem or task? - How can we explain and predict interactions between objects? - How can we predict an object's continued motion, changes in motion, or stability? - How is an object's shape and mass a factor in how powerful the object is? - How did you measure the power of your rocket to determine the success of the design? - How would the nose cone shape or lack of a nose cone affect the rocket's power? - How was power changed during flight?	
DIFFERENTIATION			
(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.			
Content	Process	Product	Learning Environment
Students can do additional research on rockets using the NASA website. Research will be based around exploration of how NASA designs different rockets to explore more deeply the ways designs impact the power and function of a rocket. Students can compare the different information and use this to determine what designs they think	- Students will engage in critical thinking skills as they design and modify straw rockets. - Students will explore the topic of force and motion through hands on investigation. - The questions planned for this lesson require high level thinking.		Collaborative pairs (groups can work at desks or in other areas around the classroom)

impact power the most..			
PLANNED LEARNING EXPERIENCES <i>(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)</i> Engage and Connect - This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students. Research common rocket features (20 mins) A. Blast off! Getting off Earth and going toward a solar system destination is exciting. How do we know we can get where we want to go? How is power helpful in people getting where we want to go? Engineering design is important to helping us reach our goals. For this engagement, you will be modeling steps in the inquiry process for your students, from observation and questioning to testing and acquiring results, as well as engineering design. B. Show images of rockets. For initial engagement, you can also begin with "Mars in a Minute: How do we launch to Mars?" as a cartoon teaser for more in-depth content. Research video and images of rockets that NASA sends into space. http://www.nasa.gov/centers/kennedy/launchingrockets/archives/elv_archiveindex.html). Ask students what they may notice about the rockets and the launches. Do they have something in common? C. Guide the students to look directly at the nose cone of the rocket. Are there any differences? What would happen if a different cone were used? What might happen if the cone was shorter, longer, or if the rocket didn't have one at all? A. What do the students predict would happen to the distance a rocket will travel if changes were made to the cone? Would different amounts of power be needed to overcome the changes in the nose cone design? Would the rocket exert a different amount of power based on the shape of the nose cone? B. Let's investigate those questions! Have students fill out their hypothesis on Soda Straw Rocket Analysis (Question 1). For making a connection to NASA's Mars Rover "Curiosity," teacher can show students additional video and slideshow resources at: http://mars.jpl.nasa.gov/participate/marsforeducators/soi/ Explore - In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas. Design and implement rocket investigation (30 mins) A. Give students the Soda-Straw Templates and direct them to write their names on the fins of the rockets. Review the directions on how to construct their rocket. Have students work in pairs to construct the rocket tubes. One student can hold the tube tight on the pencil and the other student can apply the tape to the paper tube. Students build the rocket on the pencil. Tell them not to remove it from the pencil until you are ready to distribute the straws. B. Students can be organized into groups of 4 so that each of the students within the group can build a rocket with a different length of nose cone. C. Students should select a control for this investigation. Discuss that the purpose of a control is to have something to which you can compare the results. This control should be similar to what you are testing, but something that will be unaffected by the things you are changing. For this investigation, construct one control rocket that has almost no nose cone at all. To do this, just tape the end of the paper tube closed. D. Students will launch each rocket, one at a time, and record the distance it traveled (in centimeters) on the Data Log. Ensure students realize that the distance traveled is how they are determining the power of the design of the rocket. E. Students may wish to write in any observations they want to remember as they perform their investigations (this can include things such as direction). F. Students should do five trials of the investigation and record the results on their Data Log. G. Students will then graph their data on the Data Analysis Sheet in order to draw a conclusion as to which nose cone length produced the best rocket. How does the length of the nose cone impact the power of the rocket? How did you use this information to help you determine which rocket design was the best?			

Explain - Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.

Drawing conclusions from data and evidence (10 mins)

- Students will write a conclusion for their results. The conclusion should discuss the nose cone lengths used and what they saw happen in their investigation. Student conclusions will indicate how the power of a rocket changed with various nose lengths to make connections between the design of a rocket and the power of the rocket. Students will compare their results to draw conclusions about how power is impacted by the design of a rocket such as through questions like: How did changing the design of the nose of a rocket change the power of the rocket? How did the different designs compare? What impacted the power the most in regards to the nose design? You may even push the students a little further by asking them to explain why this is the result that they discovered. What is the reason that a longer cone will have a longer or shorter distance? Were different amounts of power needed to overcome the changes in the nose cone? Did the rocket exert a different amount of power based on the shape of the nose cone? How do you know this?

Elaborate —Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways

Consider other possible variables (10 mins)

- Give students the opportunity to evaluate other possible variables that could affect the flight pattern and the power of a rocket. They may come up with examples such as: angle of launch, number of fins, length of the tube, weighted with paper clips, power needed to put rocket in motion etc. This exercise helps to build your students collaboration and participation in a full inquiry model. If time permits, give them the opportunity to explore some of these different variables and report results out to the class.

Evaluate: This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.

Reflect on findings from rocket testing (20 mins)

- Ask students to complete the Soda Straw Rocket Analysis Worksheets so that they can draw conclusions based on evidence from their tests . How was power changed in the activity? How do you know this? What caused this change?

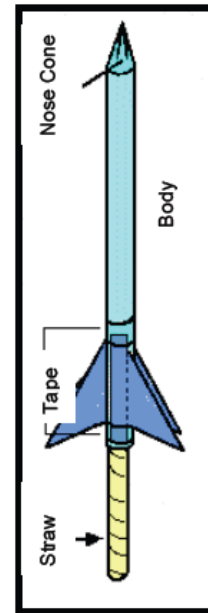


LESSON 5: SODA-STRAW ROCKETS

Student Guide

(A) Student Worksheet. Soda-straw rocket template (1 of 2)

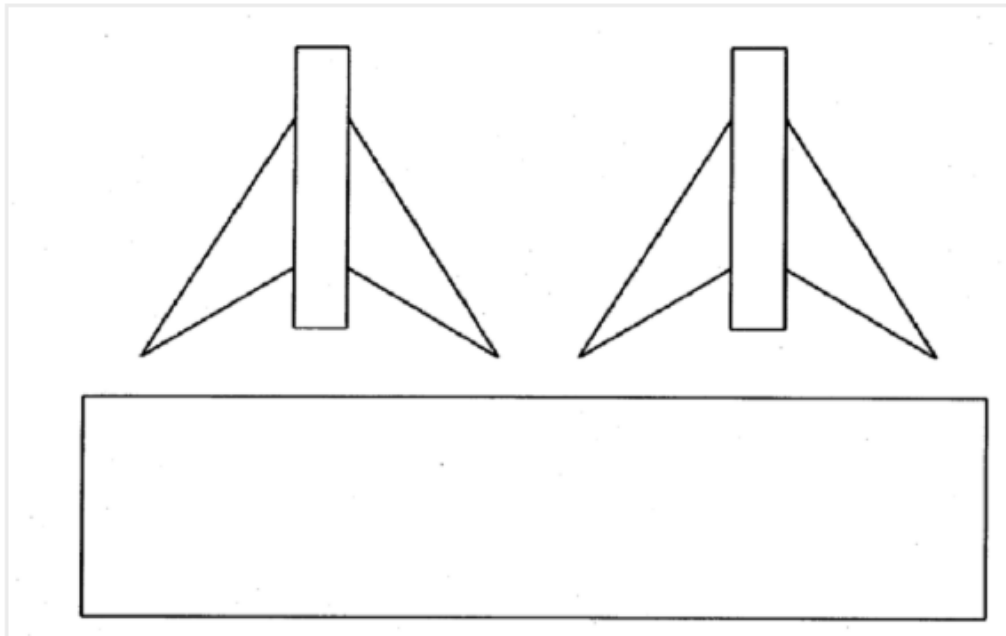
1. Carefully cut out the rectangle. It will be the body tube of the rocket. Wrap the rectangle around a #2 pencil, lengthwise, and tape the rectangle so that it forms a tube.
2. Carefully cut out the two fin units and align the rectangle between the two fins with the end of your body tube. Tape it to the body tube. Tape the tube about $\frac{1}{4}$ " above the end of the tube. That helps to prevent the taping of the fin to the pencil. Do the same thing for the other fin unit, but tape it on the other side of the pencil, so you have a "fin sandwich."
3. Bend one fin on each fin unit 90 degrees so that each fin is at a right angle to its neighbor. When you look along the back of the rocket (near the pencil eraser), the fins should form a "+" mark.
4. At the sharpened end of your pencil, twist the top of the body tube into a nose cone. Measure your nose cone from the base to its tip and record the length on your (B) Data Log and on the rocket itself.
5. Remove the pencil and replace it with a soda straw. Blow into the straw to launch your rocket. Remember launch safety! Never point your rocket at a person. Your goal is to get to your target destination! Record the distance it travels on your (B) Data Log.





(A) Student Worksheet. Soda-straw rocket template (2 of 2)

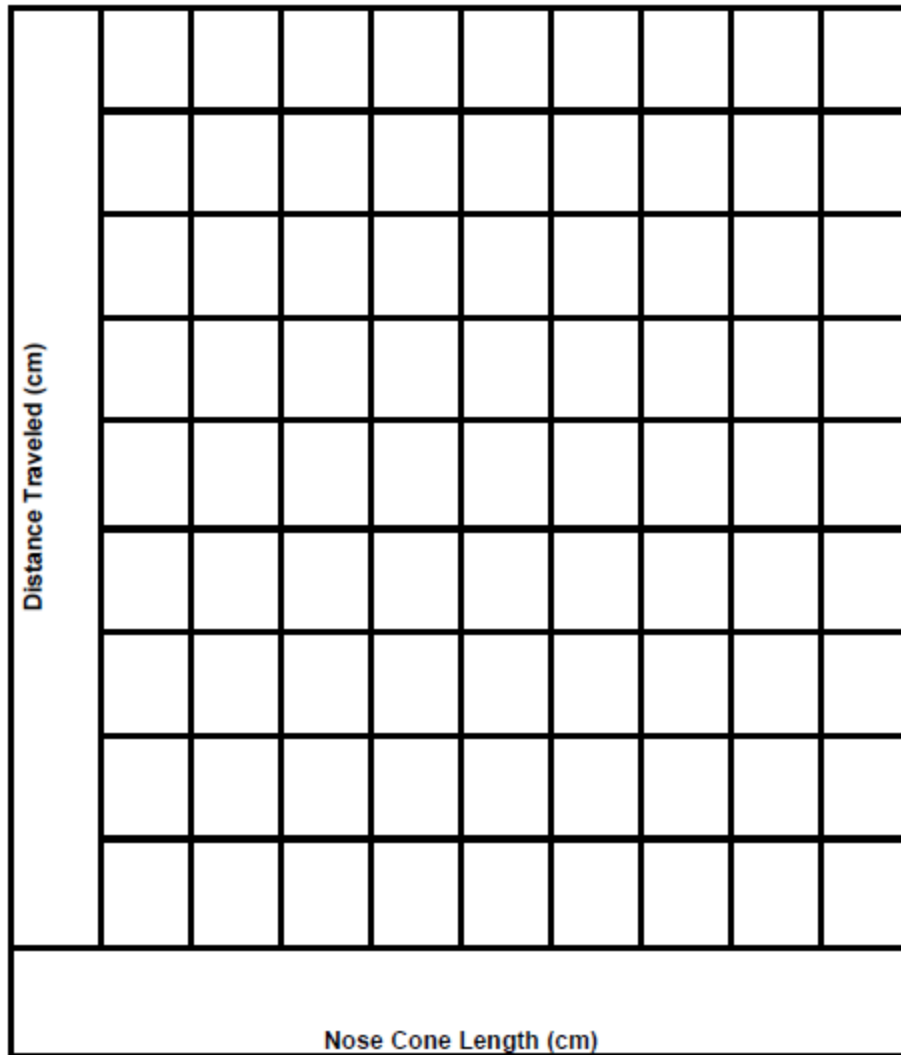
Soda Straw Rocket Template – Cut these three pieces out carefully.



(B) Student Worksheet. Soda-straw rocket data log

Length of Nose Cone	Trial #1	Trial #2	Trial #3	Trial #4	Trial #5	Notes
Control						
Distance Traveled (in cm)						

(C) Student Worksheet. Soda-straw data analysis graph



**(D) Student Worksheet. Soda-straw Rocket Analysis (1 of 2)****Your Research Question:**

How will changes to the rockets' nose cone length affect the distance the rocket will travel?

1. Your Prediction (Your Hypothesis):

2. Your Conclusion:

A. What Nose Cone Lengths did your team use? _____. _____.

B. What happened to the Distance Traveled when you had a longer Nose Cone?

C. What happened to the Distance Traveled when you had a shorter Nose Cone?

D. Why do you think these results happened?

**(D) Student Worksheet. Soda-straw Rocket Analysis (2 of 2)**

- E. Did you have any problems during the investigation that might have changed the Distance Traveled?

- F. Was your prediction supported? _____

- G. If yes, what evidence do you have your prediction was supported? If no, why do you think it wasn't supported?

- H. Other than nose cone length, give 3 examples of variables that might be changing the Distance Traveled.

1. _____
2. _____
3. _____

- I. Pick one of the examples and give a hypothesis (a suggested explanation that predicts a particular outcome, based on a model or theory) as to why this variable might change the Distance Traveled of the rocket.

TEACHER NAME		Lesson #
Julia Champion		3
MODEL	CONTENT AREA	GRADE LEVEL
Creative Problem Solving	Science	5
CONCEPTUAL LENS		LESSON TOPIC
Power		Rockets (force and motion)
LEARNING OBJECTIVES (from State/Local Curriculum)		
5.P.1 Understand force, motion and the relationship between them. •5.P.1.1 Explain how factors such as gravity, friction, and change in mass affect the motion of objects. •5.P.1.2 Infer the motion of objects in terms of how far they travel in a certain amount of time and the direction in which they travel. •5.P.1.3 Illustrate the motion of an object using a graph to show a change in position over a period of time. •5.P.1.4 Predict the effect of a given force or a change in mass on the motion of an object.		
THE ESSENTIAL UNDERSTANDING (What is the overarching idea students will understand as a result of this lesson?)		THE ESSENTIAL QUESTION (What question will be asked to lead students to “uncover” the Essential Understanding)
Power can be changed.		How can power be changed?
CONTENT KNOWLEDGE (What factual information will students learn in this lesson?)		PROCESS SKILLS (What will students be able to do as a result of this lesson?)
- Recognize how force, motion, and power are interrelated (Motion is the result of an applied force, a force is caused by a power source so you need power that results in a force that leads to a motion) - The availability of materials and access to manufacturing resources may limit and challenge power.		- design and create based on collected criteria and information - synthesize structure based on materials and information provided - collaborate in design teams - analyze and articulate the reasons for material and design choices - generate explanations of Newton’s third law of motion based on evidence from designs and models of rocket powered racing cars

GUIDING QUESTIONS			
What questions will be asked to support instruction?			
Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding			
Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:	
- What are the differences you see between the cars that you see on the poster and the cars you see on the street? - Why do you think the cars are different? - What is a prototype? - Why would a prototype be created? - Who creates a prototype? - What technology or knowledge might be needed to create a prototype? - How can power be manipulated in a prototype? - How is power important when designing prototypes? - What types of power can be used to power cars?	- Why did your group decide on these items for your car design? - How do the items you chose to design your car resemble the items on the prototypes we viewed earlier in the lesson? - What innovations will you use as you work on designing and building your car? - What other items might you select? - What needs do you intend to meet by using the items you selected for your car? - What problems have you encountered as you are designing and building your car? - How will your car be powered?	- What challenges did you encounter when building your car? - How did you overcome the challenges of building? - How would you change the design of your car to make it better such as to make it more powerful? - If you could have access to materials other than the ones provided, what would you have requested? - What designs did you see from other teams that you thought worked well? Why do you think these designed worked well? - How would using the power of rocket engines be a good or bad idea for automobiles? - How would using rocket engines to power cars affect the product? The consumer? The environment? - How are the wheels on a rocket racer similar to and different from wheels on a regular automobile? - How did you manipulate the power needed to move your rocket powered car?	
DIFFERENTIATION			
(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.			
Content	Process	Product	Learning Environment
	Students will be using creative problem solving as an instructional model. This model encourages both divergent and convergent thinking and nurtures leadership, teamwork, creativity, and persistence.	Student products will vary based on the creativity and innovation visible in their car design. The open-endedness of the product makes it well-suited for gifted learners.	Students will work in collaborative groups. Lesson will be student led.

PLANNED LEARNING EXPERIENCES

(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)

Engage and Connect - This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.

Show students pictures of various "rocket" powered cars. Then show students Liberty High School's Balloon powered race car challenge video. <https://www.youtube.com/watch?v=nBJLmpe7j40> . Students should note how the students are working together to build the cars and the various designs and materials used to create and power the cars. Discuss how students are using materials to create a way to power the cars to move (power of energy).

Explore - In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.

Students are to create their own rocket powered car using the available materials. The "rocket" will be a balloon. The balloon will be the power source. Students are being challenged to design a rocket powered car that goes further than other rocket races. It is important to make sure students have a clear understanding of the challenge and the goal. Review the Rocket Racer Data Sheet and make sure students know how to fill out the graphs and what data they should collect.

Students are allowed to view the items, but will not be allowed to touch or discuss them during viewing. Each group will get to view the materials for 2 minutes. (Materials include: Styrofoam trays, balloons, wooden dowels, tape, wooden skewers, gum drops, straws, shoeboxes, scissors, construction paper, paper clips, glue, pencils, markers, cds, spools, ruler, sandpaper, meter stick, toothpicks etc.) Then groups will be allowed to discuss the materials and come up with a design of the car they will build as a team. The groups will have 20 minutes to sketch their designs.

Prior to going to the materials table, students are to have a design completed and a materials list prepared. One student from each group will be allowed to collect materials. The teacher will lay out the racer course.

Students develop a work plan for putting their idea into action (prior to construction) – assigning responsibilities to each team member to ensure completion of the task. Students are given 30 minutes to build their rocket powered racer (time to be adjusted if necessary). One student, the materials manager, is allowed to go to the materials table for supplies.

After 30 minutes of building time, assess if any additional time is needed to complete the task. When time is called students remain with their teams. Teacher may provide additional time if needed.

Explain - Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.

When student racers are ready, have one or two students at a time inflate their balloons and pinch off the end of the straw to keep the air inside. Have them place their racers just behind the starting line and release the straws. Regardless of how much curving a racer does, the measured distance is how far along the straight line of the race course the car reached.

Post distance records to motivate students to modify their racers to set new records.

After each racer runs three times, have students complete their data sheets and sketch their final design on the design sheets. Be sure to encourage students to think of designs that would maximize the power of the balloon because that is the source of the energy of the rocket racer. On the data sheet students will reflect on how power changed and was utilized in their designs by responding to the following questions: How did the amount of power used affect the distance your rocket racer traveled? How did the design of the rocket racer change the power it demonstrated? How could you change the design of the racer to increase the power and change the distance it travels when powered by the balloon?

Would it be a good idea for automobiles to be powered by rocket engines?

If there was only one rocket powered automobile on the road, it would work fine. However, imagine rush hour traffic loaded with rocket cars. Each would blow exhaust gas at the vehicles to the rear.

How are the wheels on a rocket racer similar to and different from wheels on a regular automobile?

Rocket racer wheels reduce friction with the ground. They turn when the air coming from the balloon exerts a thrust. Wheels for an automobile also permit the car to roll across the ground, but the thrust of an automobile depends upon friction. The engine turns the wheels, and friction with the rubber and the pavement transmits the action force so that the car rolls forward.

Elaborate —Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways

Hold Rocket Racer drag races. Lay out a 3-meter-long course. The fastest car is the one that crosses the finish line first. Calculate racer average speed by timing start to finish with a stopwatch (e.g., four seconds to go three meters = 0.75 m/second or 2.7 km/h).

Have students try multiple balloons for additional thrust. How will students design cars that are balanced with the extra load? How does the addition of balloons change the amount of power being exerted?

Have students control the thrust of their balloons by inflating them to the same diameter each time. How can students ensure that the balloon is always the same? Students will have to use a string to keep the diameter measurements the same each time. Use this to encourage students to think about how the diameter of the balloon impacts the power produced when the racer is released. Ideally students will understand that when the same amount of thrust is exerted by ensuring the balloons are the same size and filled with the same amount of air that they can better compare the different designs. It should also help students realize that the balloon is the direct power source that is causing the racer to move. When the balloon is filled with air, there is potential energy stored in the balloon and when the balloon is released, the energy is changed to kinetic energy that powers the racer and causes the movement. Guide student understanding through questions such as: Does inflating the balloon to the same diameter each time change the power exerted on the car? How do you think the balloon is changing each time you inflate the balloon? How can using the same diameter for each balloon help us understand the power of each racer?

Using the same materials, what other devices can be created that demonstrate the action-reaction principle of Newton's third law of motion?

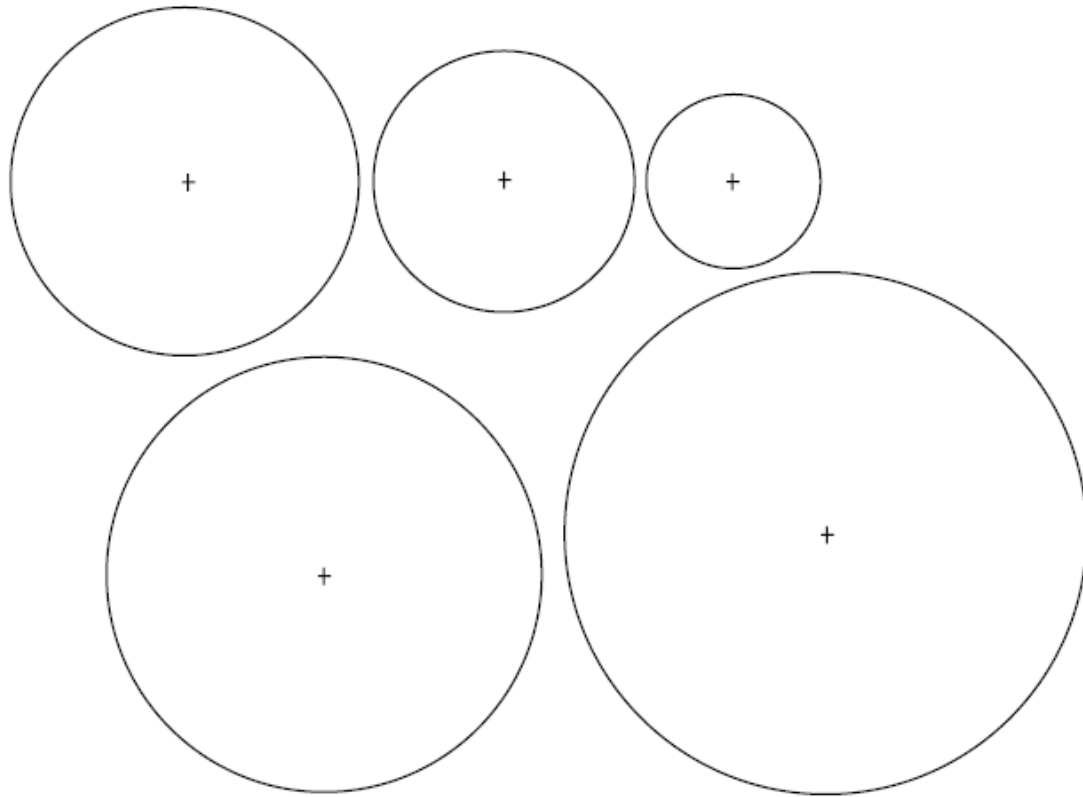
Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

Review student Rocket Racer Data Sheets and Design Sheets.

Have students write an explanation of Newton's third law of motion (for every action, there is an equal and opposite reaction from lesson plan 2) using their rocket racers as examples. Before student respond, have a discussion about Newton's third law of motion to directly connect the law to their racers. It is important for students to understand that when they release the energy in the balloon, there is an equal reaction produced that exerts that amount of energy to move the racer. Provide additional background information to students about how a force is a push or a pull that acts upon an object and as a result of its interaction with another object. So forces result from interactions. Some of these are from contact (ex: friction) while others are the result of at a distance interactions (ex: gravity). According to Newton when two objects interact they exert forces on one another which are called action and reaction forces. This means that there is pair of forces acting on the two interacting objects and these always come in pairs. This is Newton's Third Law of Motion: for every action, there is an equal and opposite reaction. An example of this law would be the motion of a car on the way to SPARK camp. The car has wheels that spin and as the wheels spin, they grip the road and push the road backwards. While this is happening the road is equally pushing the wheels of the car forward. So the size of the force on the road equals the size of the force on the wheels of the car and the direction of the force on the road (backwards) is opposite of the direction of the force on the wheels (forwards). Keeping this in mind, how does your rocket racer relate to Newton's Third Law of Motion? If all forces act in pairs, what would happen if the rocket racer had more power? What would happen if the rocket racer had less power?

Wheel Patterns

Cut out the desired wheel size. Trace the wheel outline on the Styrofoam. Punch the pencil point through the cross to mark the center.



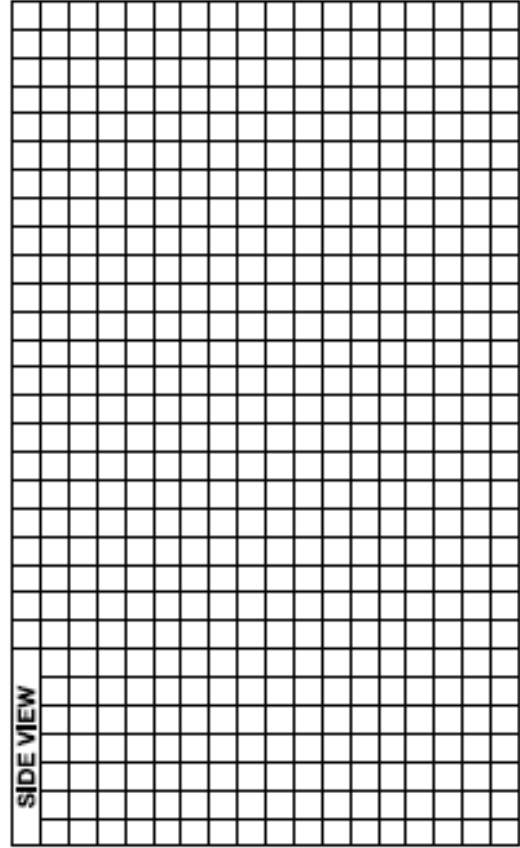
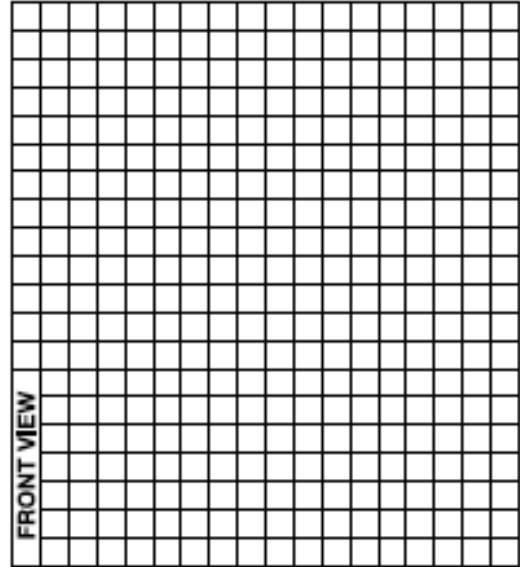
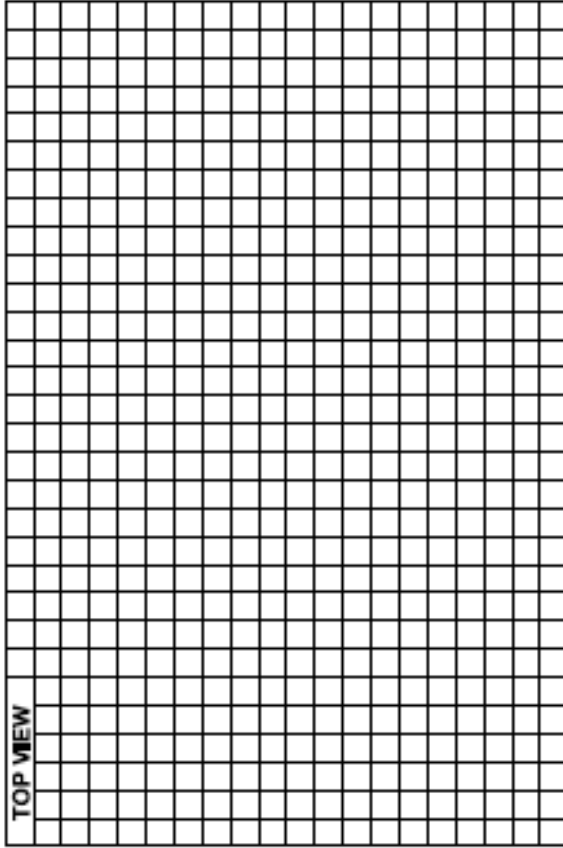
Name: _____

Rocket Racer Design Sheet

Draw a diagram showing your best design for a rocket racer.

Show your racer as seen from the front, top, and side.

Each square on the graphs = 1 cm.



TEACHER NAME		Lesson #
Julia Champion		4
MODEL	CONTENT AREA	GRADE LEVEL
Socratic Seminar	Science	5
CONCEPTUAL LENS		LESSON TOPIC
Power		Laws of Motion (force and motion)
LEARNING OBJECTIVES (from State/Local Curriculum)		
5.P.1 Understand force, motion and the relationship between them. 5.P.1.1 Explain how factors such as gravity, friction, and change in mass affect the motion of objects. 5.P.1.2 Infer the motion of objects in terms of how far they travel in a certain amount of time and the direction in which they travel. 5.P.1.3 Illustrate the motion of an object using a graph to show a change in position over a period of time. 5.P.1.4 Predict the effect of a given force or a change in mass on the motion of an object. - RI.5.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. - RI.5.3 Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text. - RI.5.8 Explain how an author uses reasons and evidence to support particular points in a text, identifying which reasons and evidence support which point(s).		
THE ESSENTIAL UNDERSTANDING (What is the overarching idea students will understand as a result of this lesson?)		THE ESSENTIAL QUESTION (What question will be asked to lead students to “uncover” the Essential Understanding)
Power can be changed.		How can power be changed?
CONTENT KNOWLEDGE (What factual information will students learn in this lesson?)		PROCESS SKILLS (What will students be able to do as a result of this lesson?)
- There are relationships between force, motion, and power. - Newton’s laws of motion - The limitations of Newton’s laws of motion - The difference between law and theory - The significant differences between scientific theories and “common theories”		- Close read and formulate questions from a text - Discuss ideas openly based on text, background knowledge - Listen and respond to peers in an open dialogue - Explain the relationship between force, motion, and power - Explain Newton’s Laws of Motion

GUIDING QUESTIONS			
What questions will be asked to support instruction?			
Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding			
Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:	
• What effect do forces have on the motion of an object? • What is the result when a greater force (more power) than the initial is applied? • How does the mass of an object affect force, speed, and motion? • What are Newton's Laws of motion? • How do these laws relate to power? • How is power affected by the laws of motion?	• The text is titled laws of Motion. What could be another title for the text? Why would this be a good title? • What do you make of the (blue) underlined text? (Why is it underlined, and does the underlined text make sense?) As a form of categorization, what alterations or changes might you propose to the underlined text? • What possibly overlooked key ideas regarding laws of motion are represented here? Why do those ideas matter in our study of physical science? • In the middle of the diagram the following law can be found: "An unbalanced force acting on an object changes its speed or direction of motion, or both." Does the organization of the text suggest that law is most important? Is it? Explain. • What link between the laws do you find most interesting? Most important? Most confusing? Explain. • Why are the Laws of Motion important to know to better our understanding of power?	• How does the text help you better understand the laws of motion within the physical world? • What metaphors or similes can you create between this text and something else we have studied in Science? • How do these laws relate to power? • How is power affected by the laws of motion? • Would Newton's laws of motion be considered a balance of power? Why or why not? • How does knowledge of Newton's laws help you manipulate power?	
DIFFERENTIATION			
(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.			
Content	Process	Product	Learning Environment
	Students will learn through open dialogue with one another.		Learning will be student led (teacher will act as facilitator)

PLANNED LEARNING EXPERIENCES

(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)

Engage and Connect - This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.

Have a piece of material large enough to cover a small table or student desk and hang down a bit all around. Teacher will set the table with clean dishes (can be paper and plastic). Without saying a word, teacher will walk up to the table and gather the cloth in hands, and then pull the table cloth out from under the dishes without rattling a single one. Is it magic? No, it's science. Teacher will then ask the students what they observed. "An object at rest will remain at rest unless acted on by an outside force."

Students brainstorm up to 10 facts/occurrences they think are related to the Laws of Motion. Have students share in small groups and then whole group. The teacher may decide to let students voice their opinion about the accuracy of what is being shared, and the teacher is encouraged to record what is being articulated, but should refrain from making corrections at this time. In order to denote uncertainties in the class list that students might want to revisit later, use a question mark to signify the need to return to the idea at the conclusion of the lesson.

Explore - In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.

Distribute the text (Laws of Motion) and ask participants to anticipate and predict what they expect this reading to be like and what information they will learn. Students should be given a couple of minutes of quiet time and are encouraged to add any labels or notes as they see fit. The facilitator will want to have students number the 2 concept boxes in the same manner for quick reference, ideally by way of document camera modeling. Then systematically read the text aloud whole group. How is it organized? How is it similar and different to other texts they know?

(Post directions.) Have participants mark words and phrases of interest as well as puzzlement. Participants should also consider independently how the text is organized and why might it be organized as it is. Have participants write down these initial thoughts on the organizational structure of the text. From this point, ask student to paraphrase two Laws of Motion. Lastly, students should attempt to jot down an explanation for at least two relationships they can highlight from the map between concepts.

Explain - Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.

Pre-Seminar Process:

- 1) Define and state purpose for Socratic seminar.
- 2) Describe the responsibilities of facilitator and participants.
- 3) Students don't need to raise their hands to talk.
- 4) Students should focus on the main speaker and wait their turn.
- 5) Students should respond to each other, using each other's names.
- 6) Students should express agreement or disagreement in a courteous, thoughtful manner.

Seminar Questions:

Opening question: What is power and how can it be changed?

Questions and discussions should be student led after the opening question is posed. Below are additional questions that can be asked if the discussion has reached a lull.

Other questions that may be asked:

The text is titled Laws of Motion. What could be another title for the text?

What do you make of the (blue) underlined text? (Why is it underlined, and does the underlined text make sense?) As a form of categorization, what alterations or changes might you propose to the underlined text?

What key ideas possibly overlooked regarding laws of motion are represented here? Why do those ideas matter in our study of physical science?

In the middle of the diagram the following law can be found: "An unbalanced force acting on an object changes its speed or direction of motion, or both." Does the organization of the text suggest that law is most important? Is it? Explain.

What link between the laws do you find most interesting? Most important? Most confusing? Explain.

Elaborate —Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways

How does the text help you better understand the laws of motion within the physical world?

What metaphors or similes can you create between this text and something else we have studied in Science?

After studying the Laws of Motion text, write a short essay in which you explain something that happens in our physical world and link it to key ideas from the Laws of Motion text. Be sure that students connect these Laws of Motion to the idea of power by making connections to how knowledge of the Laws of Motion can be used to manipulate/change power.

Evaluate: This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.

Have participants do a written self-assessment of their personal participation goal.

Do a group assessment of the social and intellectual goals of seminar.

The rest of the lesson will finish up with the performance task of constructing a bottle rocket.

Unit Resources

- 1) EGFI – For Teachers » Activity: Balloon-powered Car. (2010, April 26). Retrieved

August 01, 2016, from <http://teachers.egfi-k12.org/activity-ballon-powered-car/>

This website provides teachers with additional information on how to create a rocket powered car.

- 2) EGFI – For Teachers » Activity: Straw-Rocket Aeronautics. (2012, June 19). Retrieved

August 01, 2016, from <http://teachers.egfi-k12.org/straw-rocket-aeronautics/>

This website provides teachers with additional information on how to create the soda straw rocket.

- 3) Gamequarium: Forces and Motion Games. (n.d.). Retrieved August 01, 2016, from

<http://www.gamequarium.com/forcesandmotion.html>

This website has various force and motion games that the students can play either with a partner or complete individually.

- 4) Hesterberg, T. (2012, August 19). How To Make - Tim Hesterberg. Retrieved August 01,

2016, from <http://www.timhesterberg.net/water-bottle-rockets/how-to>

This website provides step by step instruction on how to create a bottle rocket.

This would be useful is students are struggling with their rockets.

- 5) Make straw rockets - Kidspot. (2015). Retrieved August 01, 2016, from

<http://www.kidspot.com.au/things-to-do/activities/make-straw-rockets>

This website could be useful for both teachers and students. This is an additional way of creating a soda straw rocket and has a YouTube how to link provided.

- 6) Physics and Motion. (n.d.). Retrieved August 01, 2016, from

<http://interactivesites.weebly.com/physics-and-motion.html>

This website has links to force and motion games that the students can play with a partner or alone. Some of the games review how friction effects an object.

- 7) Rocket-powered car. (2016). Retrieved August 01, 2016, from

<http://www.herts.ac.uk/rocketry/rocket-powered-car>

This is a link to an article about college students and staff building a rocket powered car. The students could relate this to creating their own rocket powered cars.

- 8) StudyJams. (2016). Retrieved August 01, 2016, from

<http://studyjams.scholastic.com/studyjams/jams/science/index.htm>

Study Jams provides videos and quizzes about force and motion topics for students. These can be used whole group, partner, or individual.

- 9) Water Powered Soda Bottle Rocket | Make:. (2016). Retrieved August 01, 2016, from

<http://makezine.com/projects/make-05/soda-bottle-rocket/>

This website provides instructions on how to build a bottle rocket and the launcher. There is a YouTube video on the site that would provide a good visual for both student and teacher.

- 10) Wild, F. (2016, August 01). For Educators. Retrieved August 01, 2016, from

<https://www.nasa.gov/audience/foreducators/index.html>

This website gives teachers additional research and activities on force and motion. The teacher can search activities, articles, and videos by grade level.

11) Wild, F. (2016, July 27). For Students. Retrieved August 01, 2016, from

<https://www.nasa.gov/audience/forstudents/index.html>

This website is similar to the teacher website created by NASA. This one is for students and gives information about the NASA program along with current opportunities for students to be involved in.