

Laws of Motion

A Fifth Grade *Commotion*

Discovering Newton's Three Laws

By Cody Beasley

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Introduction

One of the major strands of fifth grade science that is recognized in the North Carolina Essential Standards focuses on force and motion. This unit was designed to aid students in discovering Sir Isaac Newton's three laws of motion and the impact they have on our lives every day. The needs of gifted learners are emphasized throughout the learning experiences present in this unit.

The content of this unit is important for students to learn because it comes directly from the Essential Standards for fifth grade. Fifth graders statewide are tested yearly on their knowledge of the curriculum, of which force and motion are included. Understanding the content covered in this unit allows learners to be cognizant of the relationships between force and motion. This awareness will serve them as they progress through the educational system and out into the real-world as 21st-century learners.

The concepts covered throughout this unit are significant because of their relevance to everything that surrounds us. Forces are constantly at work, even those we cannot visibly see. Hundreds of objects (humans, animals, automobiles, etc.) are in motion within inches of us during a typical day. Gravity is ever-present and we are grateful for that! The main concept, or essential understanding, of the unit is that systems are interdependent. Why concentrate on systems are interdependent? Take a moment to think about the things in our lives that make day-to-day living much easier. Automobiles, cell phones, access to running/clean water that is hot or cold to drink, take a shower, and to have for indoor plumbing, and available heating and air in our homes just to name a few. Even the most basic luxury of all – electricity. With one finger, a switch can be flipped that will provide light to an entire room. Behind all of these conveniences

are countless systems that depend on each other to function together as they are intended to.

The skills required throughout this unit are valuable, especially for gifted learners. In a regular classroom setting the content material may simply be presented to students. This unit requires learners to apply their content knowledge in a real-life, meaningful way. Their performance task is to plan, design, and create a prototype amusement park ride for Carowinds out of basic materials. A marble will then maneuver through the ride to prove that students used their knowledge of the interdependence of systems to build a successful model. Students are asked to observe and analyze, generalize ideas as they collaborate with a team, plan a design for a prototype amusement park ride for Carowinds, organize data, construct their prototype, use trial and error, and create and present a marketing pitch that proves their prototype can pass the test and should win a contract to have their ride built.

This unit provides many opportunities for differentiation, which also benefits gifted learners. The content is fifth grade, but could be used with younger students. Rather than present the material to students, the unit seeks to explore numerous levels of Bloom's Taxonomy during the process dimension of each day. The product dimension of the unit (the amusement park ride) can take any direction based on the unique talents and ideas of the children. The learning environment is student-focused; the teacher acts as a facilitator while students become more in control, invested, and engaged with their own learning.

When developing a plan for this unit I knew I needed a performance task that would appeal to gifted students. I thought about various experiments that could be tested, having students construct mini cars, possibly build rockets to launch, and even paper airplane flying/launching. The idea I chose in the end is based on a project I completed as a senior at Appalachian State University. The premise of this unit is similar to the project I worked on in

college, though expectations and requirements were modified to best suit the age group of students. The performance task is complex and challenging. To construct an amusement park ride from basic materials proves quite difficult once the actual construction begins. It sounds simple, but that is definitely not the case. Adequate critical thinking, planning, observing, and reflection offer tremendous depth to the task. The guidelines are few. This allows for maximum creativity to take place. Students are not shown or told what their design should look like or how it should take form. Assistance can be provided during this aspect of the unit at the discretion of the teacher. Individual student needs may require more input and support from the teacher. The content can be accelerated beyond what is already required. Though not present in this version of the unit, it is easy to see how other subjects can be incorporated. The science content could be quite relatable to mathematics. The inclusion of Carowinds is significant to our state of North Carolina and our state economy if this unit were to be used with fourth graders. Both grade levels could utilize aspects of this unit to develop many types of writing samples (a narrative about the ride or amusement park, an informative piece about the ride, etc.).

Each day of the unit could stretch across multiple days depending on the group of learners and the amount of time available. Each day is also designed to engage gifted learners. Day one utilizes the Creative Problem Solving (CPS) model. The students are given the details of the performance task and are allowed to see the available materials. What follows is their own creativity and innovation. With limited teacher influence they will begin planning their prototype while collaborating with their team members. Critical thinking and ingenuity are vital to success in solving the problem before them. Day two centers on a Socratic Seminar. The seminar encourages deep, thought-provoking conversations, aids in developing communication skills, provides time for observation and reflection, and gives every learner a role. Those who often

“pull back” are asked to “step up” and those who are frequent volunteers are asked to take a back seat during part of the seminar. Day three focuses on questioning. The high-quality of the questions presented ensures that learners are grasping the true meaning of the content and provides validation of student understanding. Day four again focuses heavily on questioning, though more directed to the real-world application of the content knowledge. Also, this is the “final” day of the unit when the performance task is completed and groups present their prototypes and marketing pitch.

One major positive of this unit is it can be used with any population of gifted learners. Socioeconomic status and background are not issues. Would it be beneficial if students have taken a ride on a roller coaster or been to an amusement park? Of course. Is it a necessity? Not at all. There are hundreds of videos on YouTube from around the world of roller coasters with footage taken from the front row of seats. I believe most students in this age range will immediately be engaged when they watch the roller coaster video at the start of day one of this unit. For that matter, most adults would, too. This unit can be modified to fit the needs of various learners, gifted or not, across many achievement levels. Creativity and other unique talents can be put on full display as the students make the prototypes their own. Background knowledge from their own personal experience with roller coasters could prove to be an advantage, but who can accurately predict that when students are given the opportunity to let their inventiveness take over. The key is focusing on the understanding that systems are interdependent. The group that can take this awareness and apply it to their design may have the ultimate edge. Materials are cheap and inexpensive; many can be brought from home. I recommended cardboard paper towel and toilet paper tubes, plastic bottles and jugs, sand paper, tape, scissors, glue, and PVC pipe.

Goals and Outcomes

CONTENT GOAL AND OUTCOMES

GOAL 1: Understand 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. Predict the effect of a given force or a change in mass on the motion of an object.
- D. Know and Identify Newton's three laws of motion.
- E. Recognize that gravity, friction, and change in mass can affect the motion of an object.

(A., B. and C. from: North Carolina Essential Standards for 5th Grade Science)

PROCESS GOAL AND OUTCOMES

GOAL 2: To develop critical thinking skills with application to science.

Students will be able to:

- A. Generalize and communicate their ideas and thoughts collaboratively in a group.
- B. Determine what forces will affect the motion of their ride.
- C. Apply their knowledge of Newton's laws of motion and the impacts of gravity, friction, and change in mass when developing a plan for an "amusement park ride."
- D. Apply their ideas about the impacts of gravity, friction, and change in mass when developing and constructing a functional design for an "amusement park ride."
- E. Hypothesize what forces will affect the motion of their ride and test promising possibilities as well as potential setbacks.
- F. Construct an "amusement park ride" out of recyclable materials that must meet specified criteria by using trial and error.
- G. Listen to the thoughts/ideas of others and think critically about their responses.

CONCEPT GOAL AND OUTCOMES

GOAL 3: To understand that systems are interdependent.

Students will be able to:

- A. Recognize, support, and defend that certain systems are interdependent.
- B. Analyze the interdependence of systems in roller coasters and amusement park rides to develop a prototype with interdependent systems.
- C. Predict the impact of specific systems on their prototype.
- D. Transfer their knowledge about force and motion to the systems present in their design.
- E. Use interdependent systems to construct a functioning prototype.

Assessment Plan

For this unit there are different formative assessments to monitor student understanding and achievement. On day one students should brainstorm in their notebook the ideas they have for their design. They should also record a list of materials they will need while collaborating with their team members. On the second day the students should write down observations, comments, and questions as they read a provided article. They will also participate in a Socratic Seminar and respond to questions, which could be assessed. Learners will respond to the question “How are systems interdependent?” in their notebooks at the end of the first three days. There should be time available to the students every day to work on their prototypes. This is where it will become evident they have an understanding of the content. Finally, the performance task can serve as a summative assessment. A rubric is provided later (with the lesson plans after day one, page 21) that will show what is being looked for at the end of the unit once all prototypes and marketing pitches have been completed. For this unit I had two teams of engineers. The photographs below will show their progress throughout the unit.

Day 1 – Most of this day was spent brainstorming, planning, designing, and gathering materials for the build while collaborating with other team members.

Day 2 – Teams were permitted to use the last part of this day to build.

Day 3 – Teams were permitted to build and fine tune their designs.

Day 4 – Teams had to transport their designs and have them ready to present.



Above you will see “Team One.” Their design looks similar to a water flume ride. The beginning of their design has a steep incline to “help us get up speed.” They have used tubes as support beams and reinforced their design with duct tape “so it’s sturdy.” They added a tunnel because “a lot of rides we know of have tunnels.” The child in the pink shirt is working to reinforce the support beams. The child in the red sweater is attaching sandpaper to “slow down the momentum after that big drop.” The child in the white shirt just placed the roll of duct tape under the end of the ride to “end the momentum of the marble” and is telling the child in the red sweater she might need more sandpaper. It is interesting to note that this team relied heavily on the cardboard tubes for their design.



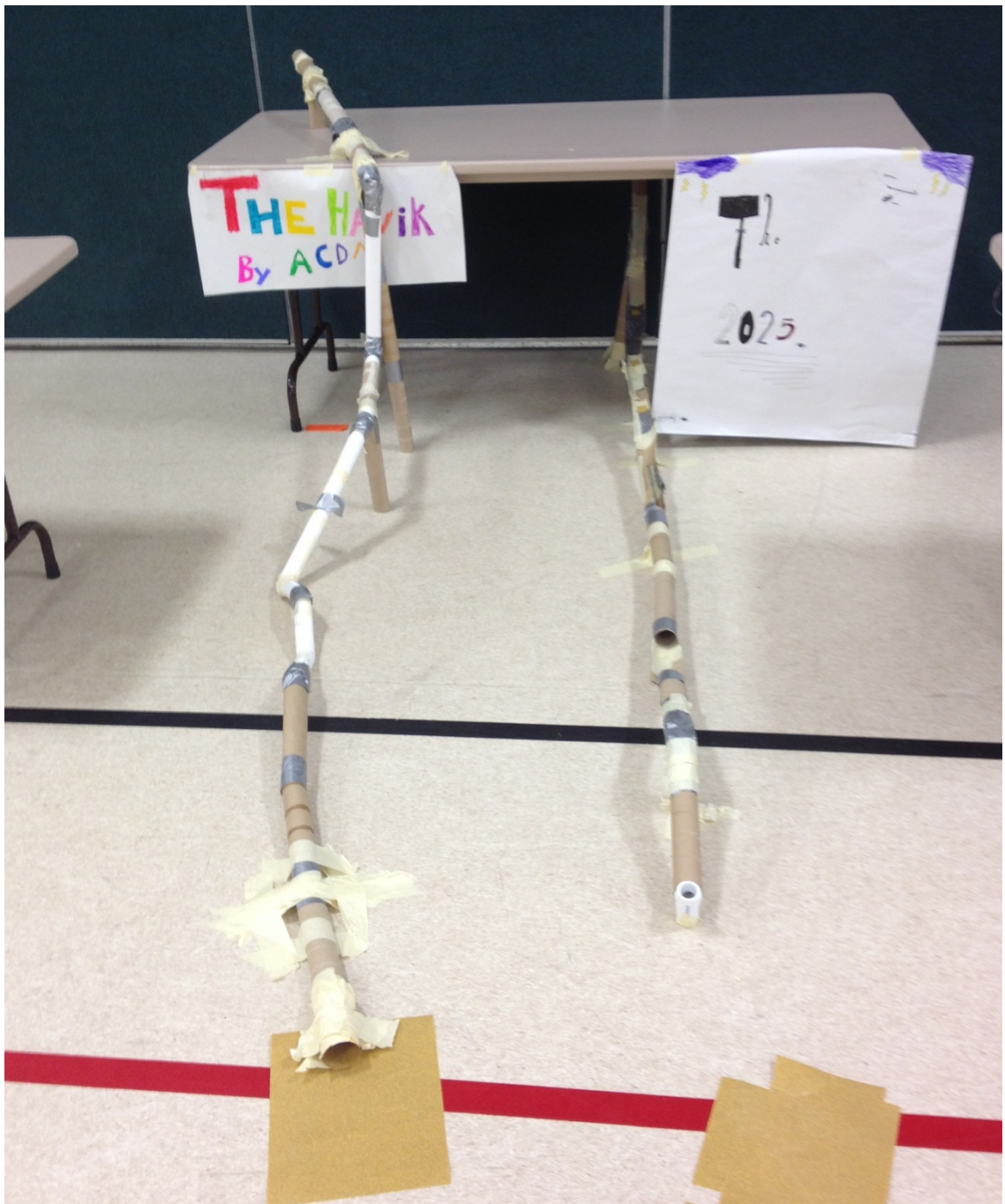
Above you will see “Team Two.” Initially they used a chair to support their design because “we want all the twists and turns of a real roller coaster.” In the picture on the left, the child in the blue shirt is using the stopwatch on her phone to test the time the marble stays in motion. The child in red is holding the first major change in direction of their design in place. The child in purple is watching for the marble to complete the journey. The team immediately realized the chair was an issue as a support system. They quickly constructed major support systems out of the cardboard tubes, which you can see in the picture on the right. If you look closely, two members of Team One have walked over to observe the design of their classmates. Team One was fascinated at how different their design was in comparison. Note two things, the number of changes in direction of the design in the picture on the right and that Team Two relied heavily on the PVC pipe for the portion of their design that the marble would pass through, but used cardboard tubes as a main system of support.



Above you will see the teams on the last day. On the left, Team One has extended the length of their design. They have put systems in place that allow the marble to remain in motion for a longer duration. However, they chose to tape their design down to the floor. My assistant is telling the team that this must be moved carefully. On the right, Team Two has encountered issues with their design. As you may notice, the support systems in place cannot bear the weight of the PVC pipe. With only minutes before the time came to transport they had to decide what the best course of action would be. In the background you will notice the plastic bottles and jugs that also failed to support the weight of the PVC pipe.

Below you will see the final products. On the left, Team Two with “The Havik.” Their final design was much different from their initial prototypes during the first couple of days. On the right, Team One with “The 2025 – The Ride of the Future.” Their final design was quite consistent with their prototypes throughout the first couple of days. The students truly discovered the impact of force and motion, the importance of Newton’s three laws, and how interdependent the systems of their prototypes had to be to prove successful.

Team Havik was confident throughout the unit that they would have the most creative and successful design. Team 2025 was excited about their design, but spent parts of each day watching Team Havik. One team member even said, “I wish I was on their team. Theirs is cool!” However, when the time came to present the prototypes Team Havik could not get their marble to travel beyond the first major drop (a 90° angle). Team 2025 had no issues as their marble successfully traveled the entire length of their design and gently came to rest at the end.



Lesson Plans

TEACHER NAME		Lesson #
Cody Beasley		1
MODEL	CONTENT AREA	GRADE LEVEL
Creative Problem Solving (CPS)	Science	Grade 5
CONCEPTUAL LENS		LESSON TOPIC
Interdependence		Newton's Laws of Motion
LEARNING OBJECTIVES(from State/Local Curriculum)		
North Carolina Essential Standards for Science: 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.1.4 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)
Systems are interdependent		How are systems interdependent?
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?)
- Students will know Newton's three laws of motion: - An object at rest tends to stay at rest and an object in motion will remain in motion with the same direction and speed. - The acceleration of an object is determined by how much force is applied. - For every action there is an equal and an opposite reaction. - Students will know that gravity, friction, and change in mass can affect the motion of an object.		Students will be able to... - Develop a list of what allows a roller coaster to operate. - Generalize and communicate their ideas and thoughts collaboratively in a group. - Recognize, support, and defend that certain systems are interdependent. - Apply their ideas about the impacts of gravity, friction, and change in mass when developing and constructing a functional design for an "amusement park ride." - Hypothesize what forces will affect the motion of their ride and test promising possibilities as well as potential setbacks. - Construct an "amusement park ride" out of recyclable materials that must meet specified criteria by using trial and error.

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 does a roller coaster work? - What do you see? - What is happening? - How does the roller coaster move on the track? - What causes the roller coaster to move?	- How might you build a roller coaster that mimics the one in the video using the materials provided to you? - What are systems? - What is interdependence? - What impact does gravity play in affecting the motion of an object like a roller coaster? - How is motion dependent on gravity? - How would friction affect the motion of an object? - What impact would changing the mass of an object play in affecting its motion? - How will you use the materials provided to design and construct an amusement park ride? - Which systems are present in your design? - Which systems are dependent on one another? - What materials are dependent on one another? - Why are the materials dependent on one another?	- What is your opinion on which forces affect motion the most? - How would you prove which forces affect motion? - What are the parts of your model? (list them, please) - How could you determine what would work better for your model? - How do you plan to prove the various systems of your model are interdependent? - What other materials could help you achieve the motion you want for your ride? - Why did you choose to use _____ on your model? - What might have been better choices? - What data did you use to improve the systems within your model? - How did your knowledge of forces of motion influence the design of your product? - How would your design be different if you did not have this knowledge? - What are the outcomes that you did not anticipate? - What flaws/issues did you encounter? - How did you solve those flaws/issues? - What is the function of _____ in your model? - What is the relationship between the different parts of your model and what you think about interdependence? - What systems are present in your design? - How are systems interdependent?

DIFFERENTIATION <i>(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.</i>		
Content	Process	Product
Students will be tasked with understanding one of the more difficult standards in the 5 th grade science curriculum and prove their understanding by working collaboratively in groups to design and build an "amusement park ride."	Students must think critically about systems and their interdependence. They will be asked to use their critical thinking during the design and building processes.	The end result of this lesson is having students work in collaborative groups to design a model for an amusement park ride and then construct their design using provided materials. This targets gifted learners because of the performance task that coincides with their learning experiences.
		Learning Environment
		Student- focused. Teacher begins by presenting a problem, then acts as facilitator and allows students to freely discuss their thoughts and ideas with their team of peers. Ample space will be provided during the design and construction of the amusement park rides.

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.*

As an ice breaker, each student will have a blank piece of white paper. For about 10 minutes they will draw their favorite feature of a roller coaster they have ridden or would like to ride. We will introduce ourselves, share our illustrations, and tell why we chose those illustrations.

When students enter the classroom I will have the following video playing on the board:

<https://www.youtube.com/watch?v=a5GZ1QOYdpk>

This is a video of the new Fury 325 at Carowinds. It is the tallest Giga Coaster in the world.

After the students have had the opportunity to watch the video a couple of times, I will divide them into small teams.

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.*

Once teams are set, I will post the Pre-Lesson Questions on the board. The teams will brainstorm their answers and record them in their journals as they discuss the possible answers. Next, students are told they have about five minutes to walk to a designated area and view materials that have been placed there (cardboard paper towel and toilet paper tubes, cardboard boxes, tape, glue, scissors, sand paper, plastic bottles and jugs, etc.). They can look at these items and touch these items, but cannot take any of them.

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.*

After all teams have had a chance to observe the materials, I will present to them my performance task. It reads as follows:

Carowinds, the "Thrill Capital of the Southeast," has announced the closing of the iconic wooden roller coaster, Thunder Road. After 39 years of operation the park has decided the time has come to retire the ride to make room for future growth and attractions. Because you are learning about the science that allows for such things as roller coasters to be gravity defying, you have been selected to develop the next great attraction at Carowinds.

You are competing for the rights to a contract. Your task is to collaborate with your team members to design and construct a 3-Dimensional model of your proposed attraction with the materials provided, along with a clever marketing pitch. You must choose a company name for your team, as well as a name for your final product. On your ride, a glass marble must remain in continuous motion - from start to finish - through the design for a period of time longer than 10 seconds, yet less than 30 seconds. The design must include a minimum of three turns (or as we will call it, an observable change in the direction traveled by the marble). The marble must be at rest at the starting point and at the ending point. The release of the marble will need to be controlled, which means no force other than gravity can be applied to move or stop the marble during its journey through the design. Upon completion of the design, the marble will remain at rest within the structure of the design, not rolling across the floor - safety first! After completing your model, you will present your attraction to the Carowinds Construction Committee. During your presentation you will reveal your company name and your ride name, point out a minimum of three turns, and describe to the committee how the systems present in your design are interdependent. A successful design and proposal may land you the distinction of being able to ride YOUR attraction at Carowinds one day! Be creative with your design and presentation to the committee members.

Students will spend the next 15-20 minutes discussing with their team members how they might build a roller coaster that mimics the one in the video with the materials provided. This time must be used for planning and making an initial materials list – no collecting of materials or building. During-Lesson Questions will be posed during this time. Students are told that the next part of the lesson will be the design and construction of a model of a new amusement park ride for Carowinds that will be presented to the Carowinds Construction Committee.

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*

Students will be given two important items, a sheet of instructions and construction hats that will be purchased by the teacher (probably from Party City). The instructions on the sheets are as follows: They are competing for a contract and have been asked to design and construct a prototype amusement park ride. They must choose a company name for their team, as well as a name for their final product. On their ride, a glass marble must remain in continuous motion - from start to finish - through their design for a period of time longer than 10 seconds, yet less than 30 seconds. The design must include a minimum of three turns (or as we will call it, an observable change in the direction traveled by the marble).

The marble must be at rest at the starting point and at the ending point. The release of the marble will need to be controlled, which means no force other than gravity can be applied to move or stop the marble during its journey through the design. Upon completion of the design, the marble will remain at rest within the structure of the design, not rolling across the floor - safety first! Groups are to collect data – their different designs and model ideas, materials used, and test data throughout as attempts are made with the marbles. While recording their data, students should observe and note the various systems they develop and the interdependence of the different parts of their model. Students are now allowed to go collect the materials they deem useful and begin constructing and testing their design - keeping in mind that their focus is systems are interdependent.

Any remaining During-Lesson Questions will be asked during this time as the teacher meets individually with each group.

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

To assess this lesson, students will present their prototype to the Carowinds Construction Committee for the right to earn the contract to have their design made into the newest attraction at the park. Each group will have an opportunity to present their design and share what they have learned from the experience.

The Post Lesson Questions will be asked to the whole group at this time as we hold a class discussion about our designs. Finally, each student will be asked to respond to the following question in their notebook: How are systems interdependent?

Performance Task below

Carowinds, the “Thrill Capital of the Southeast,” has announced the closing of the iconic wooden roller coaster, Thunder Road. After 39 years of operation the park has decided the time has come to retire the ride to make room for future growth and attractions. Because you are learning about the science that allows for such things as roller coasters to be gravity defying, you have been selected to develop the next great attraction at Carowinds.

You are competing for the rights to a contract. Your task is to collaborate with your team members to design and construct a 3-Dimensional model of your proposed attraction with the materials provided, along with a clever marketing pitch. You must choose a company name for your team, as well as a name for your final product. On your ride, a glass marble must remain in continuous motion - from start to finish - through the design for a period of time longer than 10 seconds, yet less than 30 seconds. The design must include a minimum of three turns (or as we will call it, an observable change in the direction traveled by the marble). The marble must be at rest at the starting point and at the ending point. The release of the marble will need to be controlled, which means no force other than gravity can be applied to move or stop the marble during its journey through the design. Upon completion of the design, the marble will remain

at rest within the structure of the design, not rolling across the floor - safety first! After completing your model, you will present your attraction to the Carowinds Construction Committee. During your presentation you will reveal your company name and your ride name, point out a minimum of three turns, and describe to the committee how the systems present in your design are interdependent. A successful design and proposal may land you the distinction of being able to ride YOUR attraction at Carowinds one day! Be creative with your design and presentation to the committee members.

G.R.A.S.P.S.

- **GOAL:**

Pages 18 and 19.

- **ROLE:**

The students are the Carowinds attraction designers. They will collaborate with their team members to design and create a 3-D model, develop a marketing pitch, then present their model and pitch to the construction committee.

- **AUDIENCE:**

The Carowinds Construction Committee.

- **SITUATION:**

Pages 18 and 19.

- **PRODUCT:**

The students will create a 3-D model, marketing pitch, and a presentation of the model/pitch that will be presented to the committee for the opportunity to have their ride be the next new attraction at Carowinds.

- **STANDARDS and CRITERIA [INDICATORS]:**

Rubric of expectations for success on page 21.

Student shows evidence of misunderstandings.		Student essentially understands the standards.	
0 – Unsatisfactory: Limited Achievement	1 – Satisfactory: Partial Achievement	2 – Proficient: Significant Achievement	3 – Exceptional: Full Achievement
The task is attempted and some effort made. The overall goals are not observable and further work is needed. Misunderstandings are evident and student may not understand the ideas.	Part of the task is accomplished. Only parts of the goals are observable. Some additional work is needed and some misunderstandings may be present.	Tasks and goals are observable and may need minimal feedback. Very little, if any, work is needed. Student shows adequate understanding and can communicate ideas with minimal assistance.	All tasks and goals are easily observable. May have minor errors that do not impact the task or require additional work. Student can clearly communicate the important ideas.

Criteria Looked At	Achievement (see above)	Teacher Feedback
Plan of Model		
Aesthetics/Design of Model		
Plan of Marketing Pitch		
Proposal Presentation		
Demonstration of Teamwork		

TEACHER NAME		Lesson #
Cody Beasley		2
MODEL	CONTENT AREA	GRADE LEVEL
Socratic Seminar	Science	Grade 5
CONCEPTUAL LENS		LESSON TOPIC
Interdependence		Newton's Laws of Motion
LEARNING OBJECTIVES(from State/Local Curriculum)		
North Carolina Essential Standards for Science: 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.1.4 Predict the effect of a given force or a change in mass on the motion of an object. ELA Common Core Standards: RI.5.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. SL.5.1.A - Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion. SL.5.1.B - Follow agreed-upon rules for discussions and carry out assigned roles. SL.5.1.C - Pose and respond to specific questions by making comments that contribute to the discussion and elaborate on the remarks of others.		
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>
<i>Systems are interdependent</i>		<i>How are systems interdependent?</i>
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>
- Students will know basic details about Sir Isaac Newton and his accomplishments. - Students will know Newton's three laws of motion: - An object at rest tends to stay at rest and an object in motion will remain in motion with the same direction and speed. - The acceleration of an object is determined by how much force is applied. - For every action there is an equal and an opposite reaction. - Students will know that gravity, friction, and change in mass can affect the motion of an object.		Students will be able to... - Generalize and communicate their ideas and thoughts collaboratively in a group. - Listen to the thoughts/ideas of others and think critically about their responses. - Discuss the content they have read. - Craft questions and maintain an inquiry based dialogue with their peers that deeply examines ideas and concepts. - Organize their data.

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 was happening in the first video you watched? - How would you explain what you witnessed take place? - How does the absence of dialogue impact your perspective? - What most stood out to you in the second video? - How would you "define" Newton based on what Dr. Tyson said about him?	- What contributed to Newton developing his three laws of motion? - How was Newton viewed during his lifetime and what caused him to be viewed this way? - What is interdependence? - How does interdependence play a role in Newton's three laws of motion? - Thinking like Newton, what impact does gravity play in affecting the motion of an object? - How would friction affect the motion of an object? - What impact would changing the mass of an object play in affecting its motion?	- What was one "big idea" you discovered through participation in this seminar? - What concepts did you explore as a result of this seminar? - What generalizations can you make about Newton's impact in history? - How did this seminar experience help you deepen your knowledge about systems and interdependence? - How are systems interdependent? - What challenges did you encounter during this seminar? - How did your role in the seminar (inner vs. outer) impact your feelings about the seminar? - How did your thinking grow or change as a result of this seminar? - What unanswered questions do you still have?	
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 must think critically while reading, interpreting information and thinking, listening, questioning, and communicating during the seminar.		Student- focused. Teacher acts as facilitator and allows students to work in a variety of environments – independently, small group, and seminar.

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.*

When students enter the classroom they will be given an index card with the following questions: "What is happening in the first video?" and "What are your thoughts while watching the videos?"

I will play the following videos on the board: <https://www.youtube.com/watch?v=jwPc0kK9VHU>
<https://www.youtube.com/watch?v=danYFxGnFxQ>

The first video is a brief animation of "what happened" to Newton as he discovered gravity. The second video is the brilliant Neil deGrasse Tyson explaining why he believes Newton is the greatest physicist in history.

After the students have had the opportunity to watch the videos, we will share orally what they have written on their index cards. After each student has had the opportunity to share, I will ask the Pre-Lesson Questions as a whole class discussion.

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 will be provided with a copy of the article Isaac Newton: Who He Was, Why Google Apples Are Falling by Kate Ravilious from <http://news.nationalgeographic.com/news/2010/01/100104-isaac-newton-google-doodle-logo-apple/> Each student will be asked to read the article silently. Once all students have finished, I will model a close reading of the article.

Next, students will be divided into smaller groups. Each group will have read the first article. Each student will be given a second article, Did Newton Really Have An Apple Fall On His Head, Inspiring Him To Come Up With His Theory On Gravity? by Emily Upton from <http://www.todayifoundout.com/index.php/2013/10/origin-apple-falling-newtons-head-story/> Students will be instructed to read this article quietly and independently, employing the close reading strategies that were just modeled. As all group members are finishing the article, the students should review the notes and questions they have written during the close reading. Each student should craft five questions as a result of the close reading. The questions should require higher levels of thinking. These will be used, along with the notes from the close reading, during the Socratic Seminar.

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.*

After all the groups have had a chance to craft their questions, the During Lesson Questions are asked at this time. Students will respond orally to the questions based on their learning and understanding so far.

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*

Students will be divided into two groups. The guidelines for the Socratic Seminar will be explained. One group will begin as the inner circle of the Socratic Seminar. The other group will begin as the outer circle of the Seminar. The inner circle members begin the dialogue while the outer circle members take notes about the dialogue taking place, craft questions they have about the dialogue, and observe one participant of the inner circle. The leader, one student designated by the teacher, will begin the Seminar with one provocative question. Inner circle students will respond in a courteous way during the Seminar.

If the leader does not have an opening question, options could include:

1. What is the significance of Sir Isaac Newton today?
2. What type of insight did the readings provide?

Students will dialogue for 10 minutes and then the inner and outer circles will change places. The new outer circle members will now be taking notes, crafting further questions, and observing their partner in the inner circle.

Once the Seminar process has been completed a second time, all groups will be asked the Post Lesson Questions as a whole group.

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

To assess this lesson, students will be asked to respond to the following questions on a new index card:

1. If Newton were alive today, what item would you choose to show him that proves his laws still hold true?
2. What one question would you ask Newton if given the chance?
3. How do Newton's laws prove that systems are interdependent?

Any remaining time is to be spent on continuing the design and construction of the amusement park ride.

TEACHER NAME		Lesson #
Cody Beasley		3
MODEL	CONTENT AREA	GRADE LEVEL
Questioning	Science	Grade 5
CONCEPTUAL LENS		LESSON TOPIC
Interdependence		Newton's Laws of Motion
LEARNING OBJECTIVES(from State/Local Curriculum)		
North Carolina Essential Standards for Science: 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.1.4 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)
Systems are interdependent		How are systems interdependent?
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?)
- Students will know Newton's three laws of motion: 1. An object at rest tends to stay at rest and an object in motion will remain in motion with the same direction and speed. 2. The acceleration of an object is determined by how much force is applied. 3. For every action there is an equal and an opposite reaction. - Students will understand that gravity, friction, and change in mass can affect the motion of an object.		Students will be able to... - Identify Newton's three laws of motion. - Classify Newton's three laws of motion. - Apply their knowledge of Newton's laws of motion and the impacts of gravity, friction, and change in mass when developing a plan for an "amusement park ride." - Determine what forces will affect the motion of their ride. - Construct an "amusement park ride" out of recyclable materials that must meet specified criteria.

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 motion? • What does motion look like? • How do we, as living individuals, demonstrate motion? • What are systems? • How might certain systems affect the motion of an object? • What types of systems can affect the motion of an object?	• What is Newton's first law of motion? • How do systems in Newton's first law of motion exhibit interdependence? • What is Newton's second law of motion? • How do systems in Newton's second law of motion exhibit interdependence? • What is Newton's third law of motion? • How do systems in Newton's third law of motion exhibit interdependence? • What impact does gravity play in affecting the motion of an object? • How is motion dependent on gravity? • How does friction affect the motion of an object? • What impact would changing the mass of an object play in affecting its motion? • How have you used the materials provided to design and construct an amusement park ride? • What is the function of _____ in your model? • What is the interdependence between the different systems present in your model?	• What is your opinion on which systems affect motion the most? • How would you prove which systems affect motion? • Can you list all of the systems present in your model? • How could you determine what would work better for your model? • What other materials could help you achieve the motion you want for your ride? • Why did you choose to use _____ on your model? • What might have been other (better) choices? • What data did you use to improve the design of your model? • How did your knowledge of forces of motion and systems influence the design of your product? • How did your knowledge of interdependence influence the design of your product? • How would your design have been different if you did not have this knowledge? • What are the outcomes that you did not anticipate? • What flaws did you encounter with your design? • How did you solve those flaws/issues?

DIFFERENTIATION <i>(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.</i>		
Content	Process	Product
	Students must think critically about motion and how forces affect motion. They will be asked to use their critical thinking during the design and building processes and prove their understanding of how systems are interdependent by working collaboratively in groups to design and build an "amusement park ride."	The end result of this lesson is having students work in collaborative groups to design a model for an amusement park ride and then construct their design using provided materials. This targets gifted learners because of the performance task that coincides with their learning experiences.
		Student- focused. Teacher begins by presenting content, then acts as facilitator and allows students to freely discuss their thoughts, feelings, and ideas. Ample space will be provided during the design and construction of the amusement park rides.

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.*

When students enter the classroom I will be jogging around until I bump into random objects such as desks, chairs, and walls. I will continue doing this until all students are in the room. If they ask what I am doing, all I will say is, "It is motion!"

I'll begin by asking the students to tell me what they observed as they walked into the room. I will record their observations in my notebook. Students will be asked to write down, in their own words, what motion is in their notebooks. The Pre-Lesson Questions will be asked at this time.

Next, they will watch part of an episode of Bill Nye the Science Guy entitled *Motion* from <https://www.youtube.com/watch?v=06zCLTSaPmc> The portion they will watch will focus on Newton's three laws of motion (roughly from the 8 minute until the 18 minute mark).

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.*

We will discuss the Pre-Lesson Questions as a whole group during this time. Since the students have had a couple of days to tinker with their design and plans, this should provide further insight and reflection of what they have learned and how they have applied their knowledge and skills.

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.*

The first nine During Lesson Questions are asked at this time. Students are told that the next part of the lesson will be the continued construction of their amusement park ride model.

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*

The remaining During Lesson Questions will be asked during this time as the teacher rotates to meets individually with each group. I will serve as a facilitator and consultant during this time. A majority of this day will be spent on this phase as the students should now be equipped with the knowledge they need and will have planned their design and likely begun construction of their model

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

To assess this lesson, the Post Lesson Questions will be asked to the whole group at this time as we hold a brief class discussion about our designs. Finally, each group will be asked to respond orally to the following questions: What systems seem to be the most critical to your design? How are systems interdependent?

TEACHER NAME		Lesson #
Cody Beasley		4
MODEL	CONTENT AREA	GRADE LEVEL
-	Science	Grade 5
CONCEPTUAL LENS		LESSON TOPIC
Interdependence		Newton's Laws of Motion
LEARNING OBJECTIVES(from State/Local Curriculum)		
North Carolina Essential Standards for Science: 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.1.4 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)
Systems are interdependent		How are systems interdependent?
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?)
- Students will know Newton's three laws of motion: 1. An object at rest tends to stay at rest and an object in motion will remain in motion with the same direction and speed. 2. The acceleration of an object is determined by how much force is applied. 3. For every action there is an equal and an opposite reaction. - Students will understand that gravity, friction, and change in mass can affect the motion of an object.		Students will be able to... - Identify Newton's three laws of motion and how they impact amusement park rides. - Apply their knowledge of Newton's laws of motion and the impacts of gravity, friction, and change in mass when completing their model of an "amusement park ride." - Determine what forces have affected the motion of their ride and make appropriate adjustments. - Complete construction of an "amusement park ride" out of recyclable materials that must meet specified criteria.

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:
Before experiment: - What will happen if I hold the tennis ball on top of the basketball and drop them at the same time? - What do you think will happen if I hold the basketball on top of the tennis ball instead? After experiment: - What did you observe taking place? - What forces of motion were at work during the experiment outside? - What was the action and reaction during the experiment? - What systems were interdependent? - What affected the motion of the tennis ball? - What caused the acceleration of the tennis ball?	Whole group: - How can one person move the 14-ton Kugel Ball? - How can enough force be applied to move the Kugel Ball on its base? - What system does the Kugel Ball depend on for movement? - What system is the unbalanced force on the Golden Zephyr? - What do the rocket vehicles want to do instead of going around in circles? Why do they want to do this? - How do the canoe and riverboat paddles prove any of Newton's laws? - How do the Astroblaster bumper cars exhibit Newton's third law? - What is the action and reaction of the cars? - What systems are interdependent in the bumper cars? - What systems are interdependent on California Screamin'? - How does the design of California Screamin' compare to your design? How does it differ? Individual: - Are there any flaws present in your current design? - What about your design has worked well? - How have you used the materials provided to design and construct an amusement park ride?	- What is the name of your attraction? - Tell me about your model. - What issues did you encounter when designing your model? - What about your ride will people be excited about? - What makes your proposed attraction the <i>best</i> candidate for Carowinds? - Why do you feel your team deserves the contract from the Carowinds Construction Committee? - Describe how Newton's Laws are present in your design. - How does your model show that systems are interdependent?

	- What is the function of _____ in your model? - What is the interdependence between the different systems present in your model?		
DIFFERENTIATION <i>(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.</i>			
Content	Process	Product	Learning Environment
Students will be tasked with understanding one of the more difficult standards in the 5 th grade science curriculum.		The end result of this lesson is having students present their design/model for an amusement park ride and use their marketing pitch to prove they should earn the rights to the building contract.	Student- focused. Teacher begins by presenting content, then acts as facilitator and allows students to freely discuss their thoughts, feelings, and ideas. Ample space will be provided during the design and construction of the amusement park rides.

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.*

When students enter the room I will begin dribbling a basketball. After a few seconds I will stop and hold the basketball in one hand and a tennis ball in the other. The 'before experiment' Pre-Lesson Questions are asked.

Next, the students will go outside (weather permitting) for a brief experiment (if weather does not permit, there are videos online showing this experiment). Students are to observe what they see taking place. I'll hold the basketball in one hand and the tennis ball on top of it with my other hand. Both will be dropped at the same time. As the basketball bounces off of the pavement it will impact the downward motion of the tennis ball. This will skyrocket the tennis ball quite a good distance into the air and is why this experiment should take place outdoors. We head back inside and the 'after experiment' Pre-Lesson Questions will be asked.

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.*

Because this is the last day, my intent with this lesson is to remain flexible. If groups need more time to complete their designs, the explore and explain portions of the lesson can be abbreviated accordingly. Students will watch the video The Science of Disney Imagineering: Newton's 3 Laws of Motion. This video shows where imagination meets engineering and how science brings those ideas to life at Disney theme parks. The beginning of the video gives a recap of the science already explored throughout the week. Depending on time, there are segments of the video that are not essential and can be fast forwarded through.

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.*

After the first few minutes of the video are complete, the rest of the video shows various Disney rides and attractions with wonderful explanations and demonstrations from the Imagineers who created them. The 'whole group' During Lesson Questions are asked during this time as I pause the video at certain points where rich discussions can take place. The purpose is to tie-in the science content covered, the reasoning behind having the students create a model, and to prove that there are real-life implications and opportunities. After the video is finished the students will continue completion of their designs.

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*

The 'individual' During Lesson Questions will be asked during this time as I rotate to meet individually with each group. I will serve as a facilitator and consultant during this time.

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

To assess this lesson (and the week), students will make their marketing pitch and present their final products to the Carowinds Construction Committee representatives (my partner and myself). The Post Lesson Questions will be asked to the groups at this time as they present their designs and share what they have learned during our week together. ☺

Unit Resources

Daniel, L., Hackett, J., Moyer, R., & Vasquez, J. (2006). Newton's Laws of Motion. In *Science* (North Carolina [ed.]. ed., pp. F2-F41). New York, New York: Macmillan/McGraw-Hill School Pub.

- This is the 5th grade science book used in the county I teach and other surrounding counties. Unit F deals with Newton's three laws of motion and would be beneficial to those teaching this unit.

Ravilious, K. (2010, January 7). Isaac Newton: Who He Was, Why Google Apples Are Falling. Retrieved June 2015, from <http://news.nationalgeographic.com/news/2010/01/100104-isaac-newton-google-doodle-logo-apple/>

- The above link will take you to the article I used to model close reading. This article details the more well-known events of Newton's life and career. (Used on Day 2)

The Science of Disney Imagineering: Newton's 3 Law of Motion [Motion picture on DVD]. (2009). United States: Distributed by Disney Educational Productions.

- This DVD is used on Day 4. Various rides around Disney theme parks are showcased with the science behind each ride explained. Specific focus is placed on Newton's three laws of motion and how they make each ride special and unique.

Upton, E. (2013, October 22). Did Newton Really Have an Apple Fall on His Head, Inspiring Him to Come Up with His Theory on Gravity? Retrieved June 2015, from <http://www.todayifoundout.com/index.php/2013/10/origin-apple-falling-newtons-head-story/>

- The above link will take you to the other article I had the students use during the Socratic Seminar. This article goes more in depth with the story behind the famous apple falling on Newton's head. It also includes interesting bonus facts. (Used on Day 2).

<https://www.youtube.com/watch?v=a5GZ1QOYdpk>

- The link above will take you to a 2:44 video of the brand new Fury 325 at Carowinds. This is a wonderful introduction to the design aspect of a roller coaster as the video gives viewers a front seat look at the systems used to make the Fury 325 function. (Used on Day 1)

<https://www.youtube.com/watch?v=jwPc0kK9VHU>

- The link above will take you to a 2:29 video called "Best Idea Ever!" This wordless video is a brief animation of "what happened" to Sir Isaac Newton as he discovered gravity. (Used on Day 2)

<https://www.youtube.com/watch?v=danYFxGnFxQ>

- The link above will take you to a 1:57 video called “Neil deGrasse Tyson: My Man, Sir Isaac Newton.” In this video is the brilliant Neil deGrasse Tyson explaining why he believes Newton is the greatest physicist in history. (Used on Day 2)

<https://www.youtube.com/watch?v=06zCLTSaPmc>

- This link will take you to an episode of Bill Nye the Science Guy called “Motion.” Generally, students go crazy for Bill Nye videos and, as usual, this one packs in the science content and interesting real-world applications. This episode in the Bill Nye series is also available on Netflix. (Used on Day 3)