How Things Move: A 3rd Grade Unit of Study on Forces & Motion

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This curriculum unit is recommended for:
Third Grade Science

Keywords: third grade, science, physics, forces, motion, friction

Teaching Standards: See Appendix 1 for teaching standards addressed in this unit.

Synopsis: This curriculum unit is designed for elementary students to build a basic understanding of Newton's Three Laws of Motion. The unit spans ten days and includes eight mini-lessons that teach physical science-specific vocabulary terms, five hands-on lessons, one personalized learning pathway and an assessment piece. The unit is specifically designed with a young child's desire and motivation to learn through movement and physical activity. It incorporates sports such as running, basketball and soccer into the science curriculum. Through the activities, students will apply what they have learned about forces, friction, mass and speed. The integration of reading, writing, and diagramming in a science notebook is the backbone of each lesson. The personalized learning approach is integrated as students work independently on their pathway. This pathway includes reading, writing, explorations and technology as choices for students to make connections to the learning they have done in class.

I plan to teach this unit during the coming year: 23 students in 3rd grade during the 2016-2017 school year.

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Introduction

Grand Oak Elementary is a K-5 school located in Huntersville, North Carolina and serves as a home school to students in surrounding neighborhoods. It is a part of the North Learning Community in Charlotte-Mecklenburg Schools (CMS). The student population is approximately 600 students. Of those students, approximately 84% are white. In the 2015-2016 school year, 93% of the students were at or above grade level on the 5th grade Science EOG.

As a third grade teacher, I have a homeroom of 23 students. Our students rotate to other teachers for Math and ELA blocks but return to homeroom for science instruction. Our schedule allows for 45-60 minutes of science instruction per day for the first half of the year. The second half of the year is dedicated to social studies instruction.

This school year, I am lucky to have a tray of 10 iPads and 17 Chromebooks in my classroom for student use. We also have a Bring Your Own Technology (BYOT) policy that allows students to bring their own devices to school for classroom use.

Grand Oak is one of the Personalized Learning schools in CMS. Personalized Learning is an educational philosophy that seeks to develop the whole child and empower them to take ownership of their learning in order to be successful and productive 21st century citizens in a world that is changing faster than we can prepare them for it. The Personalized Learning philosophy focuses on: Whole Child, Student Ownership, Mastery Learning and Paces, Playlists and Pathways (which I will discuss more in detail through strategies).

Rationale

Science Standards & Testing

In NC and across the country, science instruction in K-4 classrooms is often put on the back burner to Math and Literacy instruction. By the time students reach 5th grade, their background knowledge in Science is lacking yet they are expected to take and pass a NC Science EOG at the end of the school year and then go on to required higher level science classes in middle school. Building a strong foundation beginning in Kindergarten is important to student success.

The NC Essential Standards use scaffolding to build knowledge in students. Physical science is most evident across grade levels and it one of the most important sets of standards in 5th grade.

Expectations of Learning in Physical Science, by grade level:

- Kindergarten students are expected to understand position of objects in relation to one another and how motion changes the position of objects.
- First grade students are expected to be able to explain how forces (pushes and pulls) change the motion of an object. They begin to explore how forces like air and magnetism can move objects without touching them and to make predictions on how forces will affect an object.
- Second grade force and motion standards are focused on sound. Students explore how vibrations create sound and how our ears hear sound.
- Third grade standards circle back to first grade objectives and build on them. They are explored more deeply below.
- Fourth grade students apply force and motion knowledge to magnetism and electricity.
- In fifth grade, students dive deeply into the knowledge they gained in 3rd grade science. They are expected to understand the relationship between forces (such as gravity, friction) and how things like inertia and mass affect the motion of objects. They must be able to analyze graphs and data to infer the motion of an object.

The fifth grade curriculum is very deep and based heavily on students having a foundation, particularly from 1st & 3rd grades. This is why I have chosen to focus my unit on the 3rd grade force and motion concepts.

Beyond Standards & Testing

Teaching science in schools goes beyond testing and standards. There is a huge focus on preparing students for a jobs and skill sets that don’t even exist right now. This focus, called 21st Century Learning, builds student competency in areas such as collaboration, digital literacy, critical thinking, and problem-solving that advocates believe schools need to teach to help students thrive in today's world. “These skills not only help students prepare for the rapidly changing technology and media-infused workplace, but are also key for participatory citizenship." (Price et al., 2011) Scientific literacy is key to participatory citizenship – mastery of standards, as well as a mastery of 21st Century Skills creates a population of students who scientifically literate.

Why Hands-On Science?

We know why we need to teach science in schools but how we teach science is important too. My students are mostly 8 or 9 years old. They are young and active, and are being asked to sit still in a classroom for 7 hours a day. Students who are engaged in hands-on learning that creates connections between their hands and minds tend to be more engaged and more successful than their peers. A study from the University of Chicago described in an article by Kontra et al. focuses on getting students to physically experience some of the concepts they are learning shows how this changes the way students process the information. "When physical experience is closely tied to the to-be-learned content, subsequent activation of sensory and motor systems can effectively support students' reasoning" (Kontra et al., 2015). Students who physically experience their learning score higher on tests and retain more information.

The other benefit to hands-on science is that students are able to apply what they learned to the real-world. "Examining and manipulating objects may make this abstract knowledge more concrete and clearer." (Ruby, 2001) Ruby also asserts that hands-on science helps children pass through the stages of developmental learning. Students start in a very concrete way of thinking, but through science, they are able to think more abstractly. Hands-on science offers concrete illustrations of abstract ideas at a time when the mind needs concrete representations for understanding. (Ruby, 2011)

Paces, Playlists, and Pathways

As it is a cornerstone of Personalized Learning, I will be including the use of a virtual learning pathway in my science unit. Pathways are technology tools that allow students to choose a path of learning through the use of virtual activities, websites, videos, and physical products that support their mastery of a concept.

> "Findings suggest that 'hands-on' science using virtual materials, which can also be more efficient (i.e, take less times and resources to develop and use), could be an effective alternative to the use of physical materials." (Triona & Klahr, 2007)

Pathways give students a choice of activities that appeal to their learning modalities, which they can work through at a pace that suits them.

Objectives

North Carolina and Charlotte-Mecklenburg Schools use the North Carolina Essential Standards in Science to guide assessment and curriculum planning. I follow these standards closely and help support classroom teachers in their teaching of objectives. In my classroom, I like to pick a few objectives that are more difficult for students from each unit of study and plan several very hands-on and interactive lessons. Unfortunately, I do not have the ability to do this with all objectives because of time constraints.

While North Carolina has not yet adopted the Next Generation Science Standards, I still use these standards as a guide in my classroom because I believe they are the future of science education in our country. These standards give a guideline for what students should know of science content, but also provide a framework for science practices, cross-curricular connections and vertical alignment from Kindergarten through 12th grade.

North Carolina Science Objectives

3.P.1 Understand motion and factors that affect motion.

3.P.1.1 Infer changes in speed or direction resulting from forces acting on an object.

3.P.1.2 Compare the relative speeds (faster or slower) of objects that travel the same distance in different amounts of time.

3.P.1.3 Explain the effect of earth's gravity on the motion of any object on or near the earth.

Next Generation Science Standards

3-PS2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

During this unit I plan to address the following scientific processes and concepts:

- Questioning how things move and how their movements can change
- Observing how mass, speed and force all affect how an object moves
- Predicting the motion of objects based on a given variable
- Measuring, collecting and recording data
- Communicating findings and learning with peers
- Making connections to real-life events (particularly sports/physical activity)

Scientific Content: Overview for Teachers

Vocabulary

- acceleration – change in speed or velocity.
- balanced force – two forces with equal strength acting an on object at the same time. When balanced forces are present, objects will either keep moving without a change in velocity or they will remain still.
- force – a push or a pull. Forces tend to change the state of rest or motion of an object.
- friction – the force of two objects rubbing against one another.
- gravity – the force that pulls things towards the center of Earth.
- inertia - a property of an object that is related to its mass - moving objects tend to stay moving and motionless objects remain motionless.
- mass – the amount of matter an object has – commonly called "weight" by students, but mass is a more accurate term as weight is tied directly to gravity.
- motion – the changing position of an object.
- relative speed – the speed of an object when compared to a starting point or another object.
- speed – how fast an object is changing positions.
- unbalanced force - two forces with unequal strength acting an on object at the same time. When unbalanced forces are present, objects will either change direction or speed.
- velocity – speed in a given direction.
- weight – how much gravity is pulling down on an object.

Background Content for Teachers

Force and motion is a study of physical science. For this particular unit, we will focus on content that is directly related to motion and can be described through the three laws of motion.

First Law of Motion

Newton's 1st law of motion, also known as the Law of Inertia, is often stated as:

> An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

Objects have a natural desire to keep doing what they are already doing. An object sitting still will stay still until some force causes it to move. An object in motion will continue its motion until a force slows or stops it. This resistance to a change in motion is known as inertia and the constant motion is an example of balanced forces acting upon an object.

It is easy for our students to conceptualize objects at rest, but in a world full of gravity and friction, it is very difficult for them to understand that moving objects would keep moving without a force. They will argue that a baseball thrown across a field does not just keep going – but it does, until gravity pulls it down to earth. They will say that an untouched marble rolling across the floor eventually stops – not truly understanding that it is friction that slows it down. These are examples of unbalanced forces acting upon an object.

Even objects that remain untouched by people or other objects will eventually stop moving on Earth because our gravity or the friction of air or the ground will slow them down.

Some applications of Newton's First Law include:

- To get to the ketchup at the bottom of a ketchup bottle, it is often turned upside down and hit downward with force and then the motion is quickly stopped.
- When you stop quickly in your moving vehicle, your body moves forward until it is stopped by your seatbelt
- While riding a skateboard, you fly forward off the board when hitting a curb or rock or other object that abruptly halts the motion of the skateboard.
- When standing on a bus or train, you will fall backwards as it starts to move or fall forward as it comes to a stop.

Second Law of Motion

Newton's 2nd law is often stated as:

The acceleration of an object is dependent upon the force acting upon the object and the mass of the object (Force is equal to mass times acceleration or F = ma)

The greater the force placed on an object, the greater the change in motion. The more massive an object is, the more force will be needed to move the object the same distance or speed relative to a less massive object. Less massive objects require less force for a change in speed or direction.

Some applications of Newton's Second Law include:

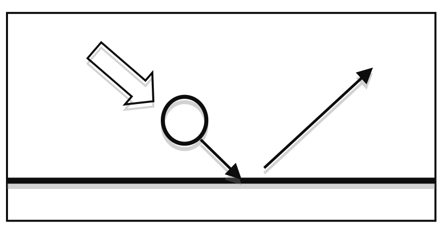
- A large school bus requires a longer distance to stop than a small passenger car traveling at the same speed.
- A 15-pound bowling ball will require more force to roll down a long hallway than a tennis ball.
- It requires more force to lift a box of books than it does to lift a single book.

Newton's Third Law

Newton's 3rd law is often stated as:

For every action there is an equal and opposite reaction.

What this means is that for every force there is an opposite force that is equal in size. When you drop a ball to the ground, it is pulled down by gravity, but the ground pushes it back up (causing the bounce).



When you push against a wall, the wall pushes back against you, preventing you from falling through the wall. Think about what happens when you roll a ball against a wall – it bounces back in the opposite direction!

Some applications of Newton's Second Law include:

- An inflated balloon is released. As air pushes out the back of the balloon, the balloon pushes forward. (This is how rocket ships work too.)
- Two people standing on roller skates stand facing each other and use their hands to push against one another. Both move backwards.
- As you use your feet to the push the pedals of the bike behind you, the bike moves forward.

Strategies for Learning

Learning Teams

Students are grouped into learning teams in my room. I often randomly assign their learning teams so that they are working with students who are not necessarily their best friends. Science groups change as often as every few days because I want students to hear from a variety of different viewpoints as we work through the concepts and standards in a unit.

Flexible Seating

Flexible seating is utilized in my classroom to give students freedom to work in spaces that are comfortable for them. We have a carpet for students who like to work on the floor, a standing table for students who prefer that, and several table/desk options throughout the room. They also have exercise balls available to them instead of chairs. This creates a more casual work environment, but also one in which students are never forced to sit longer than they want to.

Science Notebooks

Science notebooks play a large role in science instruction in my classroom. These notebooks are meant to be a way to tie-in literacy (which is heavily pushed in CMS), as another tool for different types of learners and for my students to have another way to save their learning for reference on another day. We use our notebooks each day to write questions, record data or draw about what we have observed. Students spend several lessons at the beginning of the school year learning how to properly use a notebook – including how to record observations and learning by using words and diagrams.

Mini-Lessons

Each day, classes will begin with a mini-lesson on specific force and motion content. Mini-lessons will always take place on the carpet at the front of the classroom and will always be based in scientific discussion and teacher demonstration after which students will process their thinking by writing/drawing their understanding of words into the glossary section of their science notebooks. Through our mini-lessons, students will be able to define basic terms and make connections between different science topics.

Day 1: What is a Force?

This mini-lesson is meant to tap into student background knowledge and get them thinking about forces again.

Write the word FORCE on the board have students share what they know about the word. As they use key words such as push, pull or gravity, add these words to the board around the word FORCE. Ask students what forces do and as they describe motion, add these words to the board as well.

Day 2: Balanced Forces

Display for students a drinking cup with an index card placed on top and a penny on top of that. Ask what they observe. What's moving? Why is there no movement? What forces do you think are present?

When you hear the word balance, what do you think of? As students describe balance, relate it back to the forces working on the penny, card & cup and how they are balanced. (All forces are equal so no change in motion is occurring.)

Ask students: Do you think that forces could be balanced so that an object continues moving?

Day 3: Unbalanced Forces

Display for students the drinking cup from the day before. What can we do to make the penny move into the cup without touching it? Flick the index card so that the penny falls into the cup. What forces are at work there?

When you hear the word unbalanced, what do you think of? As students describe balance, relate it back to the unbalanced force (gravity) that moves the penny into the cup.

Ask students: Give an example of unbalanced forces causing an object to stop moving.

Day 4: Gravity

Hold up two different objects of different mass – a book and a marker, for instance – and ask students what would happen if they were both dropped from the same height as the same time. Allow students time to discuss and share their reasoning.

Drop both objects and have students observe how they fall (they will both hit the ground at the same time). Discuss with students that the acceleration caused by gravity is the same for all objects – despite the mass of the object.

Next repeat with a piece of paper and a marker. Why doesn't the paper fall to the ground at the same rate? (Air pushes it back up, slowing it down.)

Day 5: Mass

Pass around two objects (golf ball and ping pong ball, ping pong ball and rock) that are about the same size but have much different masses. Have students hold one in each hand and discuss why they don't weigh the same (or have the same mass).

Relate the discussion back to the definition of mass – how much matter an object is made up of. The objects are made of different types of matter and different types of matter have a different mass.

Day 6: Friction

Have students rub their hands together and then put their hands on their cheeks. What do they feel? Tell students that the heat that they feel comes from the friction that they created when rubbing their hands together.

Next roll a marble across the carpet and another across the tile floor of the classroom. Which one travels farther? Why do you think? (Carpet has more friction because it has a rougher surface, causing the marble to slow down quickly. The smooth texture of tile has less friction allows the marble to roll faster and farther.)

Day 7: Speed

Questions for students: What is speed? How do we know if something is going fast or slow? What do we measure or how do we measure it?

Allow students to use their own words to describe what we know about speed, how we measure it and how we can change it. This is also an opportune time to introduce the word "acceleration" to the students.

Day 8: Inertia

Place an object inside a toy car and roll it across the room and into a wall. What happens to the object in the car? Why? How does this relate to why we wear seatbelts in cars?

Show students the Eureka inertia video that describes inertia more in depth.

Classroom Activities

I will now share 6 lessons/activities that spread from 1 to 3 days each, assuming a 45-minute science block after mini-lessons. It is recommended that you teach the lessons in the order given. Lessons are written using the 5-E format – engage, explore, explain, elaborate, evaluate.

Activity 1: How Much Force?
Length of Time: two 45-minute science blocks

Vocabulary: force, speed, friction

Materials: soccer balls, cones, soccer goals (or some alternative, such as hula hoops or cones)

Engage: Ask students what they think science has to do with sports. Begin recording their answers on an anchor chart headed "Sports & Science" that can be displayed in the room throughout the unit.

Show students a short clip of a soccer game. Ask questions such as, "What forces do you see?" or "What motion do you see?"

Explore: Divide class into four teams. In a field, set up goals at four different distances away from a set of cones.

Rotate groups through each set of cones so that they have to explore with the amount of force needed to shoot the ball into each goal.

Explain: In their notebooks, have students draw a diagram of the field with the cones and goals. Beneath their diagrams, have students write which goal required the most amount of force to reach and which required the least amount of force to reach.

Elaborate: Introduce the word friction to students. Have a large poster made up ready to display to them while outside so that visual learners can see what friction means. Ask students to explain what friction has to do with soccer.

Move the goals to a blacktop or sidewalk surface and repeat the activity. Ask students how force required changes on the different surfaces.

Evaluate: Write a "rule" that describes how force applied to an object is related to the distance traveled. (This can be related back to Newton's Laws of Motion during the Day 3 or Day 7 mini-lessons.)

Activity 2: Catapult Basketball
Length of Time: one 45-minute science block

Vocabulary: force, motion, speed

Materials: marbles, double sided tape

Engage & Explore: Students will create their own mini-basketball court with their groups – they will construct a backboard with paper and tape. The teacher will provide catapults made from clothespins mounted on a piece of cardboard with a two-liter soda bottle top glued on top.

Discuss the rules of table-top basketball. Player 1 will shoot their "basketball" – a ping-pong ball – into the hoop from a spot of their choice. If they miss, they will earn a letter ("F-O-R-C-E") and it will be player 2's turn to pick a starting point. If player 1 makes their shot, player 2 must make their shot from the same place. Next it will be player two's turn to pick the starting point with the same rules. The first player to spell out the word "FORCE" loses.

Explain: In their science journals, students should diagram the game played and answer the following questions.

"What forces did you use to play this game?"

"How did the amount of force used change as the distance from the goal changed?"

"How do you think this would be different if you had an object with a different mass?"

Elaborate: Have students play with a marble or a ball of rolled up paper to see how mass changes the game.

Evaluate: Have students work in groups to create a poster that uses diagrams to describe how force and mass changed the game.

Activity 3: Friction Scooters
Length of Time: one 45-minute science block

Vocabulary: force, friction, speed

Materials: ropes, scooters (you can usually get these from your school's PE teacher)

Set-Up Note: Tie ropes to a sturdy surface – like a large table leg or a cabinet – to allow students to sit on the scooter and pull themselves across the room. You want there to be about a 5-foot length of rope. Set up in two different areas – one carpeted and one not carpeted. To get an idea of what this activity will look like, watch this video (https://www.youtube.com/watch?v=13SQr8ZdN_s).

Engage: To introduce students to what they will be doing, select a few students to come to one of the scooter and rope set-ups and pull themselves to the end of the rope. Next, have them do the same on the other set-up and have them describe to their classmates what was different between the two.

Explore: Rotate each group through the scooter stations for about 5 minutes each. While groups are in the scooter station, they should be writing and diagramming in their notebooks what the experience and observe.

While students are waiting for other groups to work in their scooter stations, they will log into Discovery Education and explore the resources found on the 3rd Grade Friction Board: https://app.discoveryeducation.com/builders/boards/assetGuid/FAD37A75-3CC4-4658-AFE9-0DB887EF0B35/# (You will need a Discovery Education log-in to access this link.)

Explain: As a class, discuss the results of what they experienced today. How were the scooter stations different? Which required more force?

Elaborate: What real world applications can you make with this lesson?

In notebooks, have students describe one real-world application – skateboard on sidewalks instead of grass, playing baseball on clay instead of grass, riding bike on street instead of rocky path, how friction allows us to walk and run without sliding all over the place, etc.

Evaluate: On an index card, have students describe how increased friction changes the amount of force needed to move an object a given distance.

Activity 4: Newton’s Cradles
Length of Time: two 45-minute science blocks

Vocabulary: force, reaction, momentum

Materials: Newton’s Cradles (one per group), iPads or Chromebooks

Technology Note: In this lesson, I use an app called Nearpod. Nearpod is an online presentation tool that allows teachers to push a presentation out to students on their own devices so that instead of just looking at a presentation on the board, they are interacting with it. Once students have “joined” the presentation, they can respond to teacher questions, take pictures of their work using their device and share their learning – all through Nearpod. Teachers can access data from the session by logging into personal account and seeing what each student has answered.

The Nearpod Presentation can be accessed here – you must have your own NearPod account to view it.

Engage: Bill Nye video on Newton’s Cradle and its relation to Newton’s Laws of Motion https://www.youtube.com/watch?v=JtctIfNcgN4

Explore & Explain: Using NearPod online presentation tool, students will complete several explorations with their Cradles and respond on their devices.

Elaborate: Free exploration – what questions do you have about Newton’s Cradle?

Evaluate: “For every action there is an equal and opposite reaction” – how does our Cradle show us this is true?

Activity 5: Running with Inertia

Length of Time: one 45-minute science block

Vocabulary: motion, speed, inertia

Materials: bean bags, hula hoops

Engage: Give each group a bean bag and ask them to stand next to a hula hoop. Ask them to drop the bean bag into the hula hoop. Once they do, have students explain how the bean bag moved ("It fell straight down.") and why ("Gravity pulled it down.")

Next have students talk to their groups about whether they think objects ever fall at an angle or not in a straight line when dropped. Emphasize that we are not talking about objects that are thrown, only dropped.

Explore: Move groups down to the other end of an open area, like a field, across from their hula hoops. Have them take turns walking back towards the hula hoop and dropping their bean bag into the hoop. Discuss what was observed.

Repeat this activity but have students jog lightly toward the hula hoop and then again with students running full speed toward the hula hoop.

Students should observe that it becomes harder to land the bean bag in the hoop as the bag continues to move forward as it falls, often landing past the hoop on the ground.

Explain: Show students this video on inertia from Discovery Education: https://app.discoveryeducation.com/learn/videos/145a7014-b8f9-48f2-88c9-32121f208afd?hasLocalHost=true

Discuss with students what inertia has to do with the motion of an object and why it got harder to land the bean bag into the hoop

Elaborate: Application to real world: Discuss with students what happens when you're riding in a car that stops quickly.

Evaluate: What would it take to land the bean bag into the hoop when running at full speed? (Dropping it before you get to the hoop.)

Personalized Learning Integration: Force & Motion Pathway
Length of Time: Three 45-minute science blocks

Vocabulary: all

Materials: Chromebooks or other computer technology

A pathway is a set of student activities that allows them to self-direct and self-pace their own learning. In the pathway that is shared in this unit, you will see that the activities are broken up into activities that involve students seeing things, hearing things and creating/doing things. This allows students to select activities based on how they know they learn best. My students explored the idea of learning modalities at the beginning of the year through a series of discussions, activities and a learning style quiz.

When working on the pathway, students will select two activities from each row. This can be modified for your EC learners by having them choose just one from each row. Before moving on to the next row, students will conference with the teacher. The teacher will review the work they have completed, provide feedback and either send them back for corrections or give permission for them to move on to the next row.

Box 6: This pathway includes a formative assessment probe from Page Keeley's book *Uncovering Student Ideas in Physical Science.* This book is full of wonderful probes that get students think more deeply about science.

Box 9: See Appendix 2 for Graphic Organizer.

Force & Motion Pathway

Complete 2 activities from each row.

	I learn better by seeing	I learn better by listening	I learn better by creating
Conference _______	**1** Read this reading passage. After reading, complete a main idea & details graphic organizer.	**2** https://goo.gl/K4DQ3B Watch the Study Jams video on Forces. Take the quiz and record your score.	**3** Create 3-4 Frayer Model diagrams on vocabulary words from our force & motion unit.
Conference _______	**4** https://goo.gl/qSxkFf Complete the activity. After completing, write 4-5 sentences in your science notebook describing what you did, what happened and why.	**5** https://goo.gl/yos2G1 Watch the first 10 minutes of the video. Use 5 Post-It notes to write facts you learned from the video.	**6** Find the formative assessment probe, *"Does It Have to Touch?"* Read and respond to the probe with complete sentences.
Conference _______	7 https://goo.gl/XvgZIh Complete the activity. After completing, take the quiz and record your score below ________	**8** https://goo.gl/6TzUqj Watch the video and then write or illustrate each of the 3 laws of motion.	**9** https://goo.gl/PEKSY5 Use the graphic organizer provided by your teacher to complete the activity.

Assessment

On the final day of the unit, students will be assessed on what they have learned. See Appendix 3 for layout of the assessment to be used.

Other Classroom Activities

Some other possible classroom activities are as follows. Some of these will be used as "filler" activities on days when a class finishes an activity before class time is over; other activities can be used as a re-teaching tool for when students haven't mastered an objective or struggled with a previous lesson.

- Watching Bill Nye's Motion episode on SchoolTube
- Creation of anchor charts that show student understanding of content terms or content topics.
- Having students create a board on Discovery Education that teaches others about a force & motion related topic.
- Use of data tables to describe how things move
- An iPad project that involves students using an interactive whiteboard app to teach about a physical science concept

Appendix 1: Implementing Teaching Standards

North Carolina Science Objectives

3.P.1.1 *Infer changes in speed or direction resulting from forces acting on an object.*

This objective is implemented in several ways through the unit. In each of the five hands-on activities, students are exploring how speed and direction are changed in a variety of ways – by friction, force and inertia.

Mini-lessons on days one (forces), two (balanced forces, three (unbalanced forces) and eight (inertia) also elaborate on this objective.

3.P.1.2 *Compare the relative speeds (faster or slower) of objects that travel the same distance in different amounts of time.*

This concept is explored in activities one (How Much Force?), three (Friction Scooters), & five (Running with Inertia) where students are changing a variable but object are traveling the distance.

Mini-lessons on days five (mass), six (friction), and seven (speed) also explain to students how objects travel the same distance in different amount of times.

3.P.1.3 *Explain the effect of earth's gravity on the motion of any object on or near the earth.*

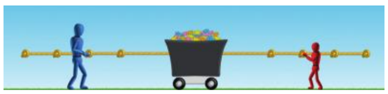
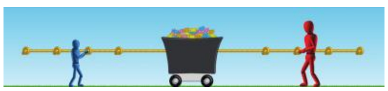
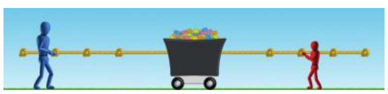
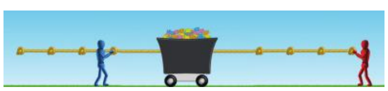
Gravity is covered in the mini-lesson on day four. Students explore how gravity affects objects in the same way, despite their differences in size and mass.

Appendix 2: Force and Motion Graphic Organizer (Box 9 of Pathway)

Name ____________________

Forces and Motion: Graphic Organizer

Which way do you think the cart will move in each of the pictures below? Explain your predictions using drawings and words.

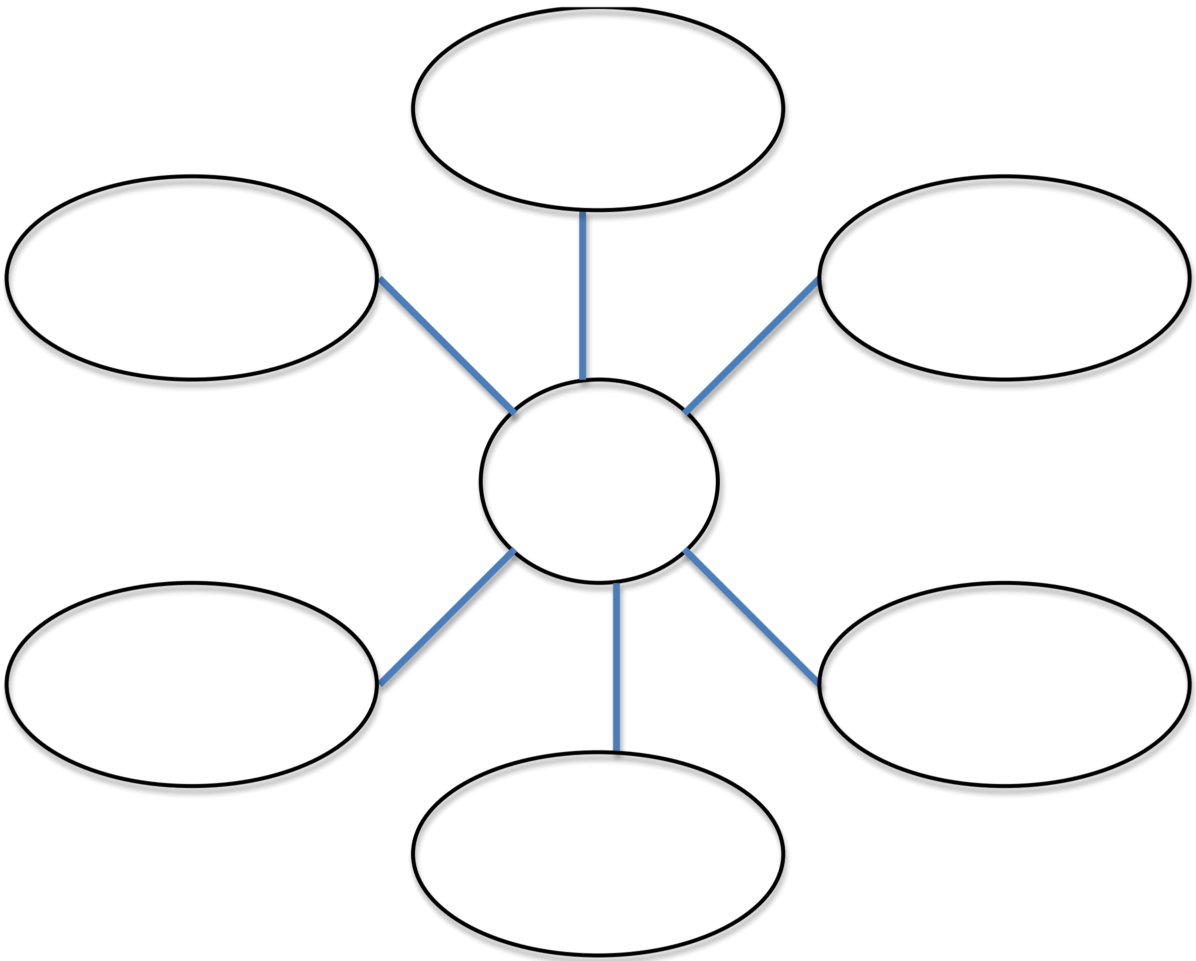
Trial	**Predict which way the cart will move**	**Explain your prediction**
		
		
		
		
		

1. Go to PhET Force and Motion Basics and click "Net Force" to test your predictions using a series of trials. Try new combinations!

2. Compare the predictions that you made in the table above to what happens to the cart of candy in each trial. If some of your predictions are not right, use a different color pencil to correct them.

PhET Interactive Simulations – http://phet.colorado.edu

Appendix 3: Assessment



What have you learned about force and motion over the last two weeks? Include at least one thing each you have learned about force, friction, mass, and speed.

Classroom Links from Unit

Eureka Video:
https://www.youtube.com/watch?v=VrWgDnkIjE8&list=PL07249EFA9038FDC1&index=1

Nearpod Presentation:
https://np1.nearpod.com/sharePresentation.php?code=24772cb240c11c1cc7fa481bfd733301-1

Resources

Keeley, Page and Harrington, Rand. *Uncovering Student Ideas in Physical Science*. NSTA Press, June 2010.

A collection of 45 formative assessment probes that enable teachers to see how students think about science.

Kontra, C., Lyons, D. J., Fischer, S. M., & Beilock, S. L. (January 01, 2015). Physical experience enhances science learning. *Psychological Science, 26*, 6, 737-49.

A study that shows how physical experience with a topic, particularly in science, is integral to student learning.

Price, J. F., Pimentel, D. S., McNeill, K. L., Barnett, M., & Strauss, E. (October 01, 2011). Science in the 21st Century: More than Just the Facts. *Science Teacher, 78*, 7, 36-41.

An article that explains how five key scientific skills, including problem-solving, adaptability and thinking, are important to students meeting 21st century challenges.

Ruby, Allen. Hands-on Science and Student Achievement. Santa Monica, CA: RAND Corporation, 2001. http://www.rand.org/pubs/rgs_dissertations/RGSD159.html.

This chapter explores the relationship between hands-on science and student achievement.

Triona, Lara M. and Klahr, David. Hands-On Science: Does it Matter What Students' Hands are on? http://www.psy.cmu.edu/~klahr/pdf/SER.triona%26klahr07.pdf

A comparison of physical hands-on science to virtual hands-on science.