Force and Motion Discovery the Playground Way

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Introduction and Rationale

Elementary age boys and girls typically think only of "fun" and "competition" when playing sports, and probably not the "why" or "how" things happen. They likely don't think about any type of relationship between force and motion, although there is one! For these reasons, I created a unit where students are introduced to the facts and evidence that there is a relationship among sports and force and motion, and have the opportunity to test and experiment with what those relationships are.

As a newly hired first year fifth grade teacher, I immediately felt hesitant about my knowledge of the Science content that students would be tested on at the end of the school year. As school began, I spent time looking over the North Carolina Standard Course of Study for Science. I believed it couldn't be that hard to teach content related to the goals listed. I dived right into teaching weather at the beginning of the school year. Knowing that investigating and inquiry are necessary for students to form scientific explanations, I planned lessons that included simple experiments or hands-on discovery activities, but I also continued to rely on the textbook during instruction to deliver the concepts of the lesson. Using the textbook to teach such abstract concepts proved to be difficult, to say the least. I also found it relatively difficult to find needed materials and collect necessary resources for any type of extensive experiments.

As the year progressed, my students seemed to love the days and times we had Science scheduled, but they also seemed unengaged during the lesson if we were reading from the textbook and didn't get to complete any experiments or take part in any investigations.

When planning lessons for teaching Force and Motion in the spring, I tried to incorporate different activities to introduce or reinforce concepts. The students seemed to enjoy these simple experiments, but they just didn't seem as enthusiastic as I wanted them to be. Additionally, continuing to rely on the textbook during instruction to deliver concepts of the lesson proved to leave the students disengaged.

Upon reflecting on my first year of teaching fifth grade Science, I realized that if I wanted my students the next school year to be engaged during Science lessons through experimentation and inquiry, obtain higher scores on the End of Grade Tests, and be able to apply the content they were learning, I would need to do things differently. At about the same time, I was introduced to Charlotte Teachers Institute, and found they had a seminar titled, "Sports and Physics." I could not have been more eager to apply and felt anxious until I found out I had been accepted and had the opportunity to take part in a seminar with other educators.

My purpose in writing this unit is for teachers to find my unit useful, so that they may teach fifth grade students the concepts of force and motion in a way that students will enjoy and be excited about, while at the same time being able to grasp the concepts as they apply them when they participate in daily sports and activities. It is my desire that my unit will be a creative resource that will actively engage students during all lessons.

Most elementary school students enjoy the opportunity to be active whenever possible. They also feel joy when given the chance to engage in activity outdoors. This engagement in outdoor activity frequently includes both structured and unstructured activities of different kinds of sports. Therefore, I created a unit that enables my students to be active while engaging in outdoor activities. Simultaneously, I want my students to gain a comprehensive awareness and understanding of force and motion concepts. My desire is that my students will have the freedom to use the scientific method to test their questions about force and motion through engagement in a variety of sports.

Background of Instructional Content

The background of instructional content for my curriculum unit will be a presentation of the concepts that I intend to cover.

Newton's Laws

In the late 1600's, Isaac Newton proposed three basic laws of motion. These laws of motion describe a relationship between forces and motion. Newton's First Law of motion states that an object at rest will remain at rest, and an object moving at a constant velocity will continue moving at a constant velocity, unless it is acted upon by an unbalanced force. Newton's First Law of motion is also called the law of inertia. Inertia is a resistance to change in motion, and is related to an object's mass. Objects with greater mass have a greater inertia than objects that have less mass. An object's inertia is what keeps an object still until a force is acted upon it, and inertia is what keeps it moving when a force is applied to the object. Newton's Second Law of motion states that acceleration depends on the object's mass and on the net force acting on the object. Newton's Third Law of motion states that if one object exerts a force on another object, then the second object exerts a force of equal strength in the opposite direction on the first object. Another way to state Newton's Third Law is that for every action there is an equal but opposite reaction.

Motion

To describe the motion of an object, the words speed, velocity, and distance traveled can all be used. The object's displacement is another useful measurement to describe motion. Objects that are in motion are changing distance from another object. A reference point (place or object) can be used to determine if an object is in motion. If an object changes position from the place or object, that object is in motion. To describe the distance an object moves, or to describe its motion, scientists measure the length the object moves. Some of the units to measure distance include: inches, feet, yards, meters, and miles. It is very important to use the unit when measuring objects in motion. Finally, objects that are in motion have a speed, or a rate of motion.

Speed

The rate at which distance changes can be defined as speed. If a vehicle leaks a steady stream of engine oil, the oil will leave a trail on the pavement. The speed of the vehicle can be measured as the distance of the engine oil trail divided by the amount of time necessary to create the engine oil trail. Units of speed can be measured in miles per hour (mph), feet per sec., etc.; or a unit of distance divided by a unit of time. ($s=d/t$)

Velocity

Velocity is speed in a given direction. You will know the velocity of an object that is in motion if you know both the speed and direction of the object. Changes in velocity involve a change in either speed or direction, or both. Examples of velocity are 35mi/hr. west, or 12ft/sec. north.

Acceleration

Although we think of acceleration to mean "speeding up," acceleration has a more exact definition in regards to science. Acceleration of an object refers to three things: increasing speed of the object, decreasing speed of the object, and changing direction of the object. An object accelerates when its speed increases. An object also accelerates when its speed decreases, however this is called deceleration, or negative acceleration. Objects that are traveling at a constant speed are also accelerating if the object is changing direction. Acceleration is any change in an object's speed or direction of motion. There must be a net force on an object for it to accelerate. The amount of acceleration is determined by the size of the force and the object's mass. (Newton's Second Law of motion) When force is held constant, there will be decreased acceleration with a greater mass. When mass is held constant, there will be increased acceleration with a greater force. If an object is moving in a straight line, and the following are known: initial speed, the final speed, and the time, then the acceleration can be found. Using the final speed minus the initial speed, then dividing by the time, will give you the acceleration.

Force

A force is a push or a pull. It is the cause that makes an object start moving, stop moving, or change direction. When a force is exerted on an object, the object may move slowly at first. One object may push or pull another object, which causes this force. Often, more than one force acts on an object at a time. For instance, when playing pool, the pool stick is pushed towards the white ball, and the white ball is pushed towards the striped or solid ball. The pool stick is a force and the white ball is a force. Net force is calculated when this combination of forces acts on an object. There would be a net force with this combination of the pool stick and the white ball. There are also balanced and unbalanced forces. Two forces that act in the same direction can be unbalanced and the net force is the sum of those two forces. Two forces that act in opposite directions can also be unbalanced and the net force is the difference between those two forces. Lastly, two forces that act in opposite directions can be balanced because they cancel each other out. In this balanced force, the motion does not change. For example, if an offensive lineman on a football field exerts a force on a defensive lineman, according to Newton's Third Law, the force is exerted back on the offensive lineman. If the offensive lineman wants to keep from moving backwards, he must push backward on the ground with his feet and legs in order for the ground to push him forward toward the defensive lineman.

Mass

Mass is the amount of matter in an object, or the stuff that something is made of. Objects that have more mass resist being set in motion. It doesn't matter where in the universe an object is located, the mass will stay constant. On Earth, an objects weight is measured as the mass of an object times the acceleration due to gravity.

Friction

A resistive force that acts in the opposite direction to velocity is called friction. Friction is the force from two surfaces exerted on each other when rubbed together. Friction acts on objects and affects the motion and momentum of objects. Friction depends on how the objects or surfaces push together and the types of surfaces involved. For example, if two hands are rubbed together lightly, there will be friction, but if two hands are rubbed together more vigorously, there will be much more friction. If two pieces of sandpaper are rubbed together lightly, there will also be friction, but if two pieces of sandpaper are rubbed together more vigorously, there will be much more friction as a whole as the surfaces are much rougher. There is more friction when surfaces are pushed hard against each other. There is also more friction with rough surfaces and less friction with smooth surfaces.

Gravity

A force that pulls objects with mass toward each other without touching is called gravity. Gravity acts on objects and affects the motion and momentum of objects. Gravity depends on mass of object and distance traveled. Additionally, the pull of gravity is greater the closer one is to the center of the Earth. Close to Earth, where we all experience most of our lives, all objects accelerate very close to $g=9.8\ m/sec^2$ towards the Earth. This number decreases slightly as we go to higher altitudes, as in the mountains. As you get farther away from Earth's center, the pull becomes less.

Momentum

Momentum can simply be stated as the mass of an object times the velocity of the object. Force is required for momentum of an object to change.

Strategies

The strategies for my curriculum unit will be a layout of the actions to be used in order for learning to take place within the curriculum unit.

The first strategy that will be used will be to introduce that force and motion are concepts which are not only Science related, but are part of our real world and incorporated in everything we do on a daily basis! I will introduce the unit with a Discovery Education video titled, *Let's Move It: Newton's Laws of Motion*. This 15-minute video uses visuals, especially the sport of hockey, to demonstrate the three laws of motion. The video also introduces vocabulary related to force and motion. The video will be stopped at several intervals in order for students to take simple notes in their Journal, about the laws of motion, and to list the new vocabulary introduced. Class discussion will be conducted as it relates to the new vocabulary. Students can speculate on the meanings of the different words, however the exact definition needs to be stated and clarified so students have a general idea of these words as they begin playground exploration and experimentation.

Using daily multimedia presentations will be a strategy that is used to introduce each new concept of the force and motion unit. The daily video that is shown will introduce and teach new vocabulary to the students before they go outside to the playground to explore and experiment. These multimedia presentations will also be used to reteach or reinforce concepts and or vocabulary for the unit.

Additional multimedia presentations that will be used are: *Acceleration*, a 5 minute video which explains that acceleration is a change in velocity. (Disc. Ed) *Inertia*, a 2 minute video which explains Newton's First Law; that objects at rest tend to stay at rest and objects in motion tend to stay in motion, unless acted upon by an outside force.

Finally, StudyJams, through Scholastic online, offers three videos for Newton's Laws, a video about gravity and inertia, and an additional one on force and motion. These videos provide a clear explanation about these concepts in student-friendly terms. These videos will be great strategies to use prior to sport activities, during, or at the conclusion of sport activities. Therefore, these StudyJams are not listed specifically aligned with any one activity.

The main strategy students will be using to gain a deep understanding of the abstract concepts of force and motion will be inquiry. Following introductory lessons in the classroom, students' will be exploring and experimenting while participating in sports activities outside on the playground. They will be able to answer questions related to force and motion concepts, as well as formulate new questions; those that may or may not be answered.

Students will discuss activities completed with partners and or groups and will keep a journal of notes from the introductory lessons, as well as notes from their exploration and experimenting during the outside playground activities. These observational notes will be shared with classmates orally at the close of each activity. A template for each lesson that includes journal writing should be given to students to guide them as they take notes for the activities.

To integrate other subjects into the curriculum, students will analyze and graph data collected during observations.

Activities

Activity One: Baseball Bobble

Objective: Students will gain a basic understanding of force, acceleration, inertia, and Newton's Laws.

Students will go outside with their journals to the playground and will be placed into groups of two. Half of the students will toss and catch while the others will be observing and taking notes in their journals. Each tossing and catching group will be given a baseball. Students will spend a few minutes tossing the baseball back and forth to each other. The focus on this activity will be the "tossing and catching." Groups will switch roles after approximately five minutes. The activity will be stopped and a class discussion (partner to partner) will evolve about how tossing the baseball back and forth to each other associates with Newton's First Law of motion. Questions posed by the teacher: How does Newton's First Law apply to the baseball toss? (Objects at rest tend to stay at rest unless a force acts on it) What object was at rest? (Baseball) How did the object begin moving? (A force acted upon it) What force made the baseball begin to move? (Arm moving)

Why did the object stop moving? (A force acted on it) What force acted on the baseball and made it stop moving? (Partners hand) What do we call the object's tendency to keep doing what it's doing? (Inertia) How does Newton's Second Law apply to the baseball toss? (Acceleration depends on mass and the amount of force applied to it) Why didn't the ball go very far or fast? (The baseball has little mass and little force applied to it)

Activity Two: Football Fling

Objective: Students will gain a basic understanding of force, acceleration, inertia, and Newton's Laws.

Students will go outside with their journals to the playground and will be placed into groups of two. Half of the students will throw and catch while the others will be observing and taking notes in their journals. Each throwing and catching group will be given a football. Students will spend a few minutes throwing the football back and forth to each other. The focus on this activity will be the "throwing and catching." The activity will be stopped and a class discussion (partner to partner) will evolve about how throwing the football back and forth to each other associates with Newton's First Law of motion. Questions posed by the teacher: How does Newton's First Law apply to the football throw? (Objects at rest tend to stay at rest unless a force acts on it) What object was at rest? (Football) How did the object begin moving? (A force acted upon it) What force made the football begin to move? (Arm moving)

Why did the object stop moving? (A force acted on it) What force acted on the football and made it stop moving? (Partners hand) What do we call the object's tendency to keep doing what it's doing? (Inertia) How does Newton's Second Law apply to the football throw? (Acceleration depends on mass and the amount of force applied to it) Why didn't the ball go very far or fast? (The football has little mass and little force applied to it)

Activity Three: Baseball Bust!

Objective: Students will gain an understanding of force, gravity and Newton's Laws.

Use an anticipatory set to draw excitement from students. Explain that they will be going to the playground for Science today! Explain that students will be experimenting to see how far they can throw a baseball. Allow students to predict orally how physics is associated with throwing a baseball. Pose the question about what they will do to make the baseball go the farthest distance. Choose groups of three students randomly and explain that each student will have a job for the activity and that they will switch roles so that each student gets to do each job during the activity. The roles the students will have are: thrower, videographer, and record keeper. The group of students will decide in what order they will perform each role. Students will go to the playground and the throwers will form two single file lines. The videographer for the first two throwers will wait on the sidelines with their video camera. The record keeper will also be waiting on the sideline so they are ready to collect their data after their partner throws three baseballs.

Each student at the front of the line will be given three baseballs to throw towards the opposite end of the field. The field will already be marked in yards with chalk lines. This will help in documenting the distance of student baseball throws. Students will throw each baseball, one at a time. After they finish, the record keeper will use their journal to document the distance markings of where their teammate's balls landed. Students will switch roles until all three students in said group have performed each role. The class will continue to take turns until all groups have had a chance to perform each role. After completing this activity, take the class back to the classroom and model how to create and complete a grid with the points plotted of where each baseball thrown landed in feet. Example:

Table 1

Baseball Bust Throw!

Feet Thrown

```
30--------------------
25-----------x---------
20-----------------x---
15----x----------------
10----------------------
5----------------------

Ball  1      2      3
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Each student will create and complete a grid using the data collected by their partners of their own baseball throws. Additionally, students will be provided with questions to answer in relation to their throws.

Are there forces involved?
Why did some baseballs go further than the other balls?
Did the ball accelerate and how do you know?
Did the ball have the same speed as it flew through the air until it landed?

Support a class discussion after orally sharing and displaying several student grids. Use the questions students were provided with to initiate this discussion among the class. Videos taken of the baseball throws will be used for a future Animoto creation. Student groups will spend time together creating a video of the activity, which will include music and narration. The narration should include physics concepts, or explanations about force and acceleration that are student friendly. Upon completion, the Animoto videos will be presented to their classmates.

Activity Four: Football Fury!

Objective: Students will gain an understanding of force, gravity and Newton's Laws.

Use an anticipatory set to draw excitement from students. Explain that they will be going to the playground for Science today! Explain that students will be experimenting to see how far they can throw a football. Allow students to predict orally how physics is associated with throwing a football. Pose the question about what they will do to make the football go the farthest distance. Choose groups of three students randomly and explain that each student will have a job for the activity and that they will switch roles so that each student gets to do each job during the activity. The roles the students will have are: thrower, videographer, and record keeper. The group of students will decide in what order they will perform each role. Students will go to the playground and the throwers will form two single file lines. The videographer for the first two throwers will wait on the sidelines with their video camera. The record keeper will also be waiting on the sideline so they are ready to collect their data after their partner throws three footballs. Each student at the front of the line will be given three footballs to throw towards the opposite end of the field. The field will already be marked in yards with chalk lines. This will help in documenting the distance of student football throws. Students will throw each football, one at a time. After they finish, the record keeper will use their journal to document the distance markings of where their teammates balls landed. Students will switch roles until all three students in said group has performed each role. The class will continue to take turns until all groups have had a chance to perform each role. After completing this activity, take the class back to the classroom and, model how to create and complete a grid with the points plotted of where each football thrown landed in feet.

Example:

Feet
Thrown

```
30---------------------
25-----------x---------
20-----------------x---
15----x----------------
10---------------------
5----------------------

Ball  1       2       3
```

Each student will create and complete a grid using the data collected by their partners of their own football throws. Additionally, students will be provided with questions to answer in relation to their throws.

Are there forces involved?
Why did some footballs go further than the other balls?

Did the ball accelerate and how do you know?
Did the ball have the same speed as it flew through the air until it landed?
Support a class discussion after orally sharing and displaying several student grids. Use the questions students were provided with to initiate this discussion among the class.

Videos taken of the football throws will be used for a future Animoto creation. Student groups will spend time together creating a video of the activity, which will include music and narration. The narration should include physics concepts, or explanations about force and acceleration that are student friendly. Upon completion, the Animoto videos will be presented to their classmates.

Activity Five: Better ball?

Objective: Students will gain an understanding that objects have different mass, and the force used is a factor in the speed and distance an object is thrown.

Activity three and four were both similar and different. In activity three, students threw three different baseballs to see how far they could throw them. In activity four, students threw three different footballs to see how far they could throw them. For activity five, students will use the data and analyze which ball went further and why? What could make the football or baseball go further if these activities were repeated? (more force) Demonstrate for the students how the data can be compared and graphed using a double bar graph to integrate math. Have students study their data in comparison to their partners and look for any relationships among the balls thrown and for themselves and their partner.

Activity Six: Drop the Ball!

Objective: The students will gain an understanding of gravity.

For this activity, have students sit with a partner to complete a "Think, Pair, Share" activity. Explain that they will go outside shortly and demonstrate dropping a football and a baseball at the same time, from the same height. What do they predict will happen? Will the baseball and the football land on the ground at the same time? If so, why? If not, why?

Take the class outside and use the football and the baseball to demonstrate gravity. Have a student stand on a stable object such as a chair, picnic table, or raised deck. The student must hold each ball in one hand, with arms extended straight out, and the baseball and the football must be at the same height above the ground. Have a couple student volunteers lay on the ground as well, so that their eyes are level with the ground and they are able to clearly see when the two different balls reach the ground. Choose student volunteers to demonstrate dropping the two different balls several times, and that when the football and the baseball are dropped at the same time, they will fall at the same rate

and land at the same time, although they are different balls with different masses. Initiate discussion among the students as to why they think this is happening.
Questions for discussion: What, if anything, is trying to stop or slow down the baseball and football? (Air resistance) Why do the balls eventually stop falling? (Gravity)
To summarize the concept of gravity, read *Experiments with Gravity*, by Salvatore Tocci, *What is Gravity*, pages 8-10, as well as Experiment 2, *Timing the Drop*, pages 13-15.
To initiate further inquiry about all objects that are dropped at the same time from the same height, encourage students to try doing this same activity using everyday household objects. For example, they can try standing at a higher than ground level position and dropping a spool of thread and an apple from the same height at the same time. Or they can experiment with dropping a dollar bill and a quarter from the same height at the same time. Will the results be the same each time? Why or why not? Is there something interfering with the objects that are being dropped? What is it? Students need to know in the end that the force of the air resistance depends on the size and texture of the object, as well as its speed. The force of the air resistance also depends on the air density, or temperature and water in the air.

Activity Seven: Go, then Stop! But Go!

Objective: Students will gain an understanding of momentum and inertia.

Explain to students that they will get to spend some time completing a running activity on the playground. This activity resembles Red Light, Green Light, an activity that students move when the command green light is given, and stop, when the command red light is given.

Question students if they have ever been riding in a car that stopped abruptly. Ask them if they remember what happened and why that happened. Explain that inertia is what caused them to continue to move forward, even when the car came to a complete stop. Before students perform their running activities, have them make predictions in their journal. Students should write at least one sentence indicating what they believe will happen during the activity and why. Once outside, students will line up side-by-side in a horizontal line, with enough space between them to allow for movement while running. On the signal to go, students will run as fast as they can until they come to each chalk line, which has been marked at ten feet, twenty feet, and finally thirty feet. They will run to the first chalk line (ten feet) and abruptly stop. The students will continue from the ten-foot line and run to the twenty-foot line and abruptly stop. Finally, students will continue from the twenty-foot line and run to the thirty-foot line and abruptly stop. Bring students back together to discuss what happened when they abruptly stopped each time when they were running. Students will be provided with questions to answer. What concepts of force and motion applied to their run?

They will draw a diagram of the activity they just completed and use explanations of what they believe occurred.

Activity Eight: Mixing up the Mass!

Objective: Students will gain an understanding of mass.

To demonstrate the concept of mass, two students with differences in mass will be asked to run together outside on the running track from the start to the finish line. Do not explain that two students with different masses are being chosen to demonstrate this concept, but make it appear that students were chosen randomly to run together from start to finish. Choose two students for each group until all students have been placed with a partner to run. When completing this activity, it will be repeated three times in order for the students to grasp that the same results are occurring over and over again. Lead students out to the running track and allow only two students of the different masses to run at the same time so that all the other students are able to observe the two runners. Rotate running pairs until all students have had three chances to run. Meanwhile, have several student volunteers use chart paper to collect data for each running group as they run and finish. Lead the students back into the classroom and have them analyze the data that was collected. Assign questions that students must answer before they are given the opportunity to share the conclusions they were able to draw about the activity. Allow students to volunteer their observations and speculate why the winner appeared to be the same person in the group each time.

Why was one student able to run faster than the other? (Was it possibly because one student had less mass?) Were Newton's Laws present in this activity? Which laws? (All three of Newton's Laws? Why?)

Activity Nine: Batting the Best Shot!

Objective: Students will gain an understanding of force and acceleration.

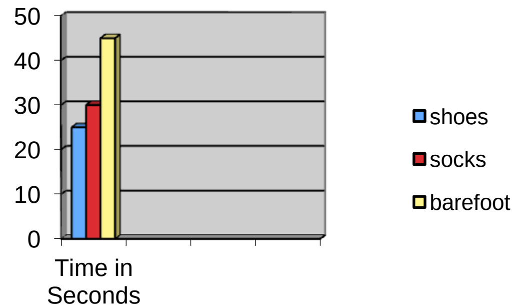
Begin by telling students that today they will have the opportunity to play baseball outside! They will have the opportunity to see how far they are able to hit the baseball using a baseball bat. Have students' present ideas about how the baseball can be hit as far as possible. What do students need to do to hit the ball at all, as well as to hit the ball any distance away? (Make contact with the baseball bat and the baseball, and use as much force as possible to make it go further) After discussion, take the students outside to the playground and demonstrate how to hit a baseball with a baseball bat, using a tee.
Let students take turns hitting the baseball in a few small groups in a large area on the field.

Finalize and end the activity with reading, *Experiments with Sports,* pages 31 and 32. (*Do You Need Accuracy*?) This experiment in the text explains to students about the "sweet spot" on a baseball bat. It provides students with the knowledge that hitting a baseball with the "sweet spot" on the baseball bat transfers the power from the batter to the ball. Hitting the baseball as far as possible during this activity is the goal. Learning about the "sweet spot" after the activity is complete will strengthen students understanding that not only is making contact with the baseball and the bat important, but that making contact with the "sweet spot" will reduce stinging when hitting and also send the baseball a further distance!

Activity Ten: Friction Fever!

Objective: Students will gain an understanding of friction.

Begin with an attention getter and explain to students that they will go outside to participate in a few running activities. Question students about their experiences with running and how they believe running relates to physics. Make a list on the board of the students' thoughts and ideas about how running relates to physics. Question students about ways that enable a runner to go faster, or what possibly makes a runner go slower. Make a list on the board of students thoughts and ideas about what might make a runner go faster or slower. Explain that students will go outside and experience running down the field and back using different methods, to see if any of the trials make them a faster or slower runner. Partner students into groups of two and explain that they will be partners throughout the entire experiment for the activity. Take students outside and line them up side-by-side, with half of the students ready for running, and the other half prepared to calculate the time of the runners as they run down the field and back (approximately 50 meters). They will be wearing tennis shoes for trial number one. On the whistle signal, students will run down the field and back. Students who are calculating the time will record the data for their observed runner in their student journal. Students will switch roles, and the process will be repeated, including recording the data for the new observed runner in the student journal. Students will then be given the instruction to take off their shoes so that for trial number two they will only be running in their socks. Runners will prepare for running and the other students will prepare to calculate the time of the runners as they run down the field and back. On the whistle signal, students will run down the field and back. Students who are calculating the time will record the data for their observed runner in their student journal. Students will switch roles, and the process will be repeated, including recording the data for the new observed runner in the student journal. Students will then be given instruction to take off their socks so that for trial number three they will be running in their bare feet. Runners will prepare for running and the other students will prepare to calculate the time of the runners as they run down the field and back. On the whistle signal, students will run down the field and back. Students who are calculating the time will record the data for their observed runner in their student journal. Students will switch roles, and the process will be repeated, including recording the data for the new observed runner in the student journal. With all three running activities complete, lead the students back into the classroom and initiate a discussion about why they might have run down the field and back first with tennis shoes on, then just socks on, and finally barefoot. Use this oral discussion within the class to connect the running activities and how it relates to friction. Using data from one student pair, begin to model how to create a bar graph that displays their data. Each student will make a bar graph that displays the data of their partner. Students will also be able to calculate their speed as they divide distance by the time. For example, 50m/25sec = 2m/sec. and 50m/45sec = 1.111m/sec.



Upon completion of student graphs, conclusions can be made about what physics concept made each runner go faster or slower. The main idea for students to comprehend is that when running, the feet, whether with tennis shoes, only socks, or barefoot, (one surface) and the ground (second surface) are rubbed together, it causes friction and affects the momentum and motion of the objects.

Have the students present ideas about different types of footwear that provides friction for running in sports (cleats help football and baseball players have better traction while running). Encourage students also to think and discuss how different running surfaces when combined with different running footwear would change the outcome or results of the experiment completed today. (Would running in the school gym, on the sandy playground, on the blacktop parking lot, or on the rubberized running track change the outcome of the experiment?)

For closure of the activity, read *Experiments with Sports*, by Salvatore Tocci, Experiment One, *Increasing Friction*, and Experiment Two, *Reducing Friction*.

Activity Eleven: Very Velocity!

Objective: Students will gain an understanding of velocity.

Using the same concept of running a relay race, students will experiment with velocity, speed in a particular direction. Remind students that in the previous activity, students were able to calculate their speed by dividing distance by the time. For this activity, they will also run a race, but one with a twist! Explain to the students that they will go outside to run a race, but will need to listen to their partner as their partner gives commands as they run. Choose partners using prior activity data, choosing pairs with similar running times from the previous activity. Line up students and then go outside. Have pre-made instructions that can be given to the student partner of the runner. Directions might be:

Turn left! Turn left again! Turn right! Turn left! Turn right! Turn right! Have a starting line and finish line set up prior to taking the students outside. Do a simple demonstration of what the students are expected to do so they do not become confused when they hear their partner shout out directions to turn right or left. (They will realize quickly they are heading back to the starting line rather than the finish line after they make a couple turns) After about 30 seconds of running, blow a whistle and yell STOP! See which student is near or closest to the finish line and declare the winner of the race. The student who "lost" may appear to be upset or claim the race was unfair, however, remind the student that today's race is a race with a twist. Continue letting pairs of students run together and give commands as they race to the finish line. When all students have had an opportunity to run, lead the class back inside the classroom for discussion. Ask students why, when two students who began running at the same time and ran the same average speed, did they end up in different directions or locations? Allow students to discuss their thoughts with their partner before calling students to share with the class. Students will have grasped that what they observed was a demonstration for velocity. Use the speed of one student to demonstrate the velocity. For example 21S, or 23N. Ask students if any other physics concepts were a part of the activity. Acceleration? When?

Activity Twelve: Running Rivalry!

Objective: Students will gain an understanding of force, motion, and acceleration.

Create interest in the upcoming activity by explaining to students that they are going to have a relay race today. Inquire about what physics concepts are used when a person is running a race. Have students use a small portable whiteboard to list ideas for this. After a few minutes, call on a handful of students to share one or two of their ideas. Next, inquire how a winner in a relay race can be chosen. Allow students to use the small portable whiteboard to list ideas for this. After a minimal wait period, call on a few students to share their ideas. (Most students will likely state that only the time needs to be calculated for each runner to decide the winner of the race) Finally, inquire about how one can figure out how fast one is going when they are running. Again, have students use the small portable whiteboards to list ideas for this. Choose a handful of students to share one of their ideas. Explain to the students that they will go outside to run a 100-meter race. Choose partners randomly and then go outside. Five students will be running at one time, beginning at the starting line and finishing when they reach the 100-meter mark. The partners of those five students will use a stopwatch to record the time of their running partner from the start line to the finish line. The timekeeper in this group will record their partner's time in their journal, and then these two students will switch roles. The process will be repeated with the switching of roles until all the students in the class have had a chance to run 100 meters. Lead the class back inside the classroom for the after race data assignment. Call on all students so that they can state the time of their partner's 100-meter run. All names and times will be listed on the board. Then students will look over the data collected and integrate math as they make a stem and leaf plot using the data. Lastly, and most importantly, the speed of each runner will be calculated, which is equal to distance/time. Show an example on the board of how to calculate the speed when distance is divided by time. For example, 100 meters divided by 20 seconds is equal to 5 meters per second. Check for student understanding, and if necessary, do an additional example. Let students calculate their partner's speed and check for accuracy. For an extension to this activity, students can run the 100 meter race each day for one week and then plot their running times on a line graph.

Activity Thirteen: Run Baby Run!

Objective: Students will create a distance vs. time graph of their own individual run, and compute the average speed as they divide the distance to run by the time needed to run said distance.

Students will go outside to complete this running activity. Each student will get a turn to be a runner, a data collector, and several turns being a stopwatch recorder. As the activity begins, half of the class (ten students) will be holding stopwatches so that they can record the time it took the runner to reach him/her. These students should be standing ten feet apart. All the students holding stopwatches will push start when the runner begins to run, and immediately push stop when the runner passes them. One selected student, which will also be rotated to a runner and stopwatch holder at some time during this activity, will also be needed to record time data collected about the runner. Data can be collected in a column form on a template created specifically for this activity. The student name and times will be added on the template. All students should have an opportunity to run and participate in this activity.

After all students have had an opportunity to run, the class will go back into the classroom and graph the data using graph paper, placing the distance run on the vertical axis (0 - 100 feet using a ten-foot scale) and the time on the horizontal axis (use a 2 sec. scale so that students can easily place decimal numbers between seconds as necessary. Model how to create a graph by example prior to students creating their own graphs. Use any one student's data to model the graphing. Check for understanding before students work independently to create their graph. Display several students' graphs and question what connection to physics concepts were involved in this activity and why.

Teacher Annotated Bibliography

"FOSSweb - Force and Motion." Welcome to FOSSweb!. http://www.fossweb.com/modulesMS/ForceandMotion/index.html (accessed November 28, 2011).
This is a link to FOSSweb references for the middle school module, Force and Motion, but can be used as resource and lists books, videos, and websites.

"Acceleration." Welcome to Discovery Education | Discovery Education.

http://discoveryeducation.com/ (accessed November 27, 2011).
This 5-minute video explains that acceleration is a change in velocity.

Bradley, Kimberly Brubaker, and Paul Meisel. *Forces make things move*. New York: HarperCollins, 2005.
An ideal text to use to teach students about force, friction, and gravity. The illustrations and simplistic language engage students since they are able to make connections to self as they read.

Mc-Graw Hill. "MHSchool: McGraw-Hill scienceematics." Macmillan/McGraw-Hill. http://www.mhschool.com/science/2002/student/lessonlist.php3?vGrade=6&vUnit=F&v (accessed November 27, 2011).
This resource is from a sixth grade Mc-Graw Hill Science textbook; Unit F Motion, Work and Machines. Chapter 12 includes lessons on Speed and Distance, Forces and Motion, and Acceleration and Momentum.

Mc-Graw Hill. "MHSchool: McGraw-Hill scienceematics." Macmillan/McGraw-Hill. http://www.mhschool.com/science/2002/student/lessonlist.php3?vGrade=5&vUnit=F&v Alt=Tiger (accessed November 27, 2011).
This resource is from a fifth grade Mc-Graw Hill Science textbook; Unit F Motion and Energy. Chapter 12 includes lessons on Newton's Three Laws and Newton's Laws of Gravitation. Also, in Lesson Three, Chapter 12 links, a link is included for Newton's Three Laws of Motion; force and motion topics which are much more in-depth.

Olien, Rebecca. *Motion*. Mankato, Minn.: Capstone Press, 2005.
This book introduces motion, force, speed, and friction. Isaac Newton and the third law of motion is also noted in the text.

Padilla, Michael J., Martha Cyr, Ioannis Miaoulis, and Griffith T. Jones. "Forces." In *Motion, forces, and energy*. Needham, Mass.: Pearson Prentice Hall, 2005. 34H-M55.
The Forces chapter from this teacher edition is comprehensible to both the teacher and would be to the student. Examples are included to aid in content understanding.

Padilla, Michael J., Martha Cyr, Ioannis Miaoulis, and Griffith T. Jones. "Motion." In *Motion, forces, and energy*. Needham, Mass.: Pearson Prentice Hall, 2005. 4F-13M.
The Motion chapter from this teacher edition is comprehensible to both the teacher and would be to the student. Examples are included to aid in content understanding.

Robertson, William C., and Brian Diskin. *Force and motion*. Arlington, Va.: NSTA Press, 2002.
This text correlates with Companion Classroom Activities for Stop Faking It! Force and Motion. Each chapter includes facts about force and motion concepts, as well as an activity or two that can be completed to gain an understanding of the motion concepts in that chapter.

Robertson, William C.. *Companion classroom activities for stop faking it!: force & motion*. Arlington, Va.: NSTA Press, 2011.
This text contains classroom activities aligned with force and motion concepts. A teacher guide is included for each activity and includes explanations to share with students as well as procedures for the activity. Objectives and standards are addressed. Needed materials and time are also listed.

Student Annotated Bibliography

"Action and Reaction." Illinois Institute of Technology | Office of Technology Services. http://mypages.iit.edu/~smile/ph9116.html (accessed November 27, 2011).
A quick activity students can do to demonstrate action and reaction; Newton's Third Law of Motion.

"Animoto - Video Slideshow Maker with Music." Animoto - Video Slideshow Maker with Music. http://animoto.com/ (accessed November 27, 2011).
Animoto can be used to create video slideshows, which can then be shared via social networks, YouTube, email, and be placed on a dvd. This is a free resource and integrates technology into teaching and learning.

Chase, Sara B.. *Moving to win: the physics of sports*. New York: Messner, 1977.
Although this book is older, the content is aligned with how sports are related to the basic laws of motion. Easy to understand for students at elementary level.

"From Apples to Orbits: The Gravity Story." ThinkQuest : Library. http://library.thinkquest.org/27585/index.html (accessed November 27, 2011).
A great Thinkquest resource from the Oracle Foundation for student presentation and interaction with facts on what gravity is, the history of it, small and large-scale effects, gravity and us, and a lab with activities.

Padilla, Michael J., Martha Cyr, Ioannis Miaoulis, and Griffith T. Jones. "Forces." In *Motion, forces, and energy*. Needham, Mass.: Pearson Prentice Hall, 2005. 34H-M55.
The Forces chapter from this teacher edition is comprehensible to both the teacher and would be to the student. Examples are included to aid in content understanding.

Materials for Classroom Use Bibliography

"Slinky Drop Answer - YouTube." YouTube - Broadcast Yourself. http://www.youtube.com/watch?v=eCMmmEEyOO0 (accessed November 27, 2011).
A quick demonstration of a stretched out slinky whose bottom end stays stationary as the slinky top is released. Demonstrates that gravity is pulling down and tension is pulling

up, and there is no motion in the bottom end until the bottom end receives the information that the tension has changed.

"FearOfPhysics.com: Do an experiment with Friction." FearOfPhysics.com: See physics in action, get physics homework help. http://www.fearofphysics.com/Friction/friction.html (accessed November 27, 2011).
A quick animation experiment that demonstrates how several factors, including friction, speed, the mass of the object, and stopping distance, affect stopping an object that is in motion.

"Inertia." Welcome to Discovery Education | Discovery Education. http://discoveryeducation.com/ (accessed November 27, 2011).
This 2-minute video explains that objects at rest tend to stay at rest, and objects in motion tend to stay in motion, until they are acted on by an outside force.

"Let's Move It! Newton's Laws of Motion." Welcome to Discovery Education | Discovery Education. http://discoveryeducation.com/ (accessed November 27, 2011).
This 15-minute video uses visuals, especially the sport of hockey, to demonstrate the three laws of motion. Vocabulary related to force and motion is also introduced.

"Science of Baseball: The Scientific Slugger | Exploratorium." Exploratorium. http://www.exploratorium.edu/baseball/scientificslugger.html (accessed November 27, 2011).
This link has a short paragraph that explains what affects a baseballs travel distance, and also a short paragraph that explains the effect gravity has on a baseball.

SlaveZero1234. "Slinky Drop Extended - YouTube." YouTube - Broadcast Yourself. http://www.youtube.com/watch?v=oKb2tCtpvNU (accessed November 27, 2011).
A simple demonstration which shows a stretched out slinky attached to a tennis ball; the tennis ball stays stationary until the top end of the slinky reaches the ball. Demonstrates gravity pulling down on the top end of the slinky but tension from the bottom also. There is no motion in the bottom end until the bottom end receives the information that the tension has changed.

Stille, Darlene R., and Sheree Boyd. *Motion: push and pull, fast and slow*. Minneapolis: Picture Window Books, 2004.
A simplified text with fun facts and a few experiments. A great book that elementary students can make text to self-connections with in order to introduce or reinforce concepts of motion.

"StudyJams." StudyJams. http://studyjams.scholastic.com/studyjams/jams/science/index.htm (accessed November 26, 2011).
StudyJams offers three videos for Newtonâ€™s Laws, a video for gravity and inertia, and

an additional one on force and motion. These videos provide a clear explanation about these concepts in student-friendly terms.

Sullivan, Navin. "What is Weight?." In *Weight*. New York: Marshall Cavendish Benchmark, 2007. 5-8.
Chapter one of this text explains that mass and weight are related but not the same thing. It also explains gravity and gives examples of it. Additionally, facts about Isaac Newton and the Law of Gravity are included.

Tocci, Salvatore. *Experiments with gravity*. New York: Children's Press, A Division of Scholastic, 2002.
This text has multiple, simple experiments to introduce and reinforce the concept of gravity. Other suggested books, organizations, and online sites are included as well. It is a great resource for elementary school students!

Tocci, Salvatore. *Experiments with motion*. New York: Children's Press, 2003.
Completing simple experiments listed in this text reinforces the concept of motion and those forces that cause motion. Other suggested books, organizations, and online sites are included as well. Students will enjoy learning about motion with use of this text.

Tocci, Salvatore. *Experiments with sports*. New York: Children's Press, 2003.
This text has multiple, simple experiments that focus on friction, the center of gravity, as well as accuracy in sports. Other suggested books, organizations, and online sites are included as well. It is a great resource for elementary school students!

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