Ready, Set, Go: Designing a Vehicle

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Introduction

"Truth is ever to be found in the simplicity, and not in the multiplicity and confusion of things." — Isaac Newton

In teaching 5th grade the level of physics I teach my students mostly contains the common sense of physics. We do not get too deep into equations just the simple ones like F=ma and speed=distance/time. When I introduce a unit on physics my students' stress level usually rises because it sounds so hard like something a college student would study. However, I have found that the concepts we are exploring are things they already know but just haven't formally defined. Newton's Three Laws of Motion always lead my students to a few "aha" moments as things they have witnessed now make sense. Like why it takes a tractor trailer so long to slow down and to speed up. The quote above sums up part of my goal as a teacher, to bring truth to my students in a simple way. I wish to take the confusing and bring it down to a simpler level.

In my experiences teaching science my students are always the most engaged when there is a hands-on experiment involved. They light up at the idea of manipulating materials whether it takes 5 minutes or an hour. This curriculum unit taps into my students' interests by giving them the opportunity to build a vehicle out of everyday items. Through exploring and experimenting with different materials this curriculum unit will give my students concrete examples of Newton's Laws of Motion.

Objectives

The students I teach are high performing, with over 90 percent on or above grade level. The parents support their children in anyway possible and most hold college degrees. This unit was designed for a class of 23 students where 6 are gifted, 2 have learning disabilities, and 2 are in the English as a second language program. The activities that are described in the unit are meant to be completed in heterogeneous groups. Heterogeneous grouping allows for students to work off of each other's strengths and to fill in weaknesses within the group. Carefully crafting small groups for experiments is essential in teaching productive and effective science labs.

In this curriculum unit I have taken Newton's Three Laws and created a design project that will build a foundation of the laws of physics for my students. I have crafted activities for the students to complete within the design project that tie together the foundations of the laws and show the connections between all three laws of motion. This curriculum unit will probably take 4-6 weeks to complete with classes being taught every other day for about 45 minutes each class.

From Newton's 1st Law of Motion my activities will focus on air resistance and friction. How does the design of a car affect air resistance and the friction applied to it? What designs would create a vehicle that could overcome these obstacles best? My students often do not make the connection of friction being a force that affects objects. I want my students to realize that even though air is invisible and we can easily walk through it, it has a great effect on objects in motion at a greater speed. My students will also think more deeply about the idea of friction. They have had life experiences with different types of friction and I want them to make the connection between those experiences and apply them to Newton's 1st Law.

From Newton's 2nd Law of Motion the focus will be on the relationships between force & mass, mass & acceleration, and force & acceleration. I want my students to understand how each effects the other when increased or decreased. I also want my students to understand the difference between acceleration and speed. Often my students think if something accelerates it has to speed up even though an object is also considered to be accelerating by slowing down or changing direction. I hope to clear up this misconception and clarify the scientific meaning. While testing their vehicle for motion students will also record data on distance and time and calculate speed. My students will graph this data and through this will begin to make the connection of science and math intertwining. There will also need to be an understanding of potential and kinetic energy. What items could store energy to be used to power a vehicle? My students will need background on how energy is transferred in order to think of everyday items that could power their vehicle.

From Newton's 3rd Law of Motion understanding balanced and unbalanced forces will provide the knowledge needed for powering the vehicle. Without an unbalanced force the vehicle will not move the distance required. Through this topic there will also need to be understanding of action and reaction. Being able to determine the action and reaction will allow students to properly attach the power source to their vehicle so it will move in the correct direction.

Background Information

Newton's 1st Law of Motion

The first law can be stated as, "An object stays at rest or in motion, in a straight line, unless a forces acts against it". The first law of motion seems obvious but doesn't exactly fit with what we observe in everyday life. On Earth the forces of gravity, friction, and air resistance seem to be invisible forces that make this law seem untrue. When I kick a soccer ball it doesn't go in a straight line forever. Rather the reason it stops is due to the rolling friction of the ground. When explaining this law to students they often bring up that in sports the balls do not go forever. This leads to discussion on the forces on Earth, like friction that are affecting objects.

Friction "is the push things give to each other when they rub together"[1]. Force is a push or pull on an object so in essence friction is a type of force. Friction comes in two forms, static and kinetic. Static friction is when the two surfaces do not move against each other. Kinetic friction is when two surfaces are slipping or rubbing against each other. It isn't simple enough to think static friction is not moving and kinetic is moving. In kinetic friction the thing to look for is sliding, two surfaces are dragging against each other[2]. In static friction there is a stable balance between the two objects. Static friction is the reaction force when you push against a table. Kinetic friction is the force against that table as it begins to slide across the floor.

When designing a vehicle, students must figure out how to overcome the rolling and sliding friction of the wheel relative to the axle to get their vehicle moving. One must consider the roughness or smoothness of the axle's surface the vehicle will encounter. For example a student could use sandpaper to smooth their axle of choice to obtain a smoother surface. In this example students would want a smoother surface to lessen friction and allow the wheel to turn more easily. This should be demonstrated by using two axles of the same material and smoothing one but not the other. Through this you could discuss friction due to relative surface conditions. When teaching friction it is important not to compare two completely different surfaces such as ice and grass because there are many other factors that contribute to the interactions between the car and the surface. To explain this would be beyond the scope of this unit. Another factor that influences friction is weight. The heavier an object the more friction or traction is generated. Students could ponder this in their car design to try to find the perfect weight for their car to travel the most efficiently.

Air is an invisible force all around us that affects the motion of objects. Dropping a crumbled piece of paper and a flat piece of paper at the same time will quickly show that air effects motion. A vehicle moves through air and the design of the vehicle's shape can affect the efficiency of this movement. The fancy science word for this concept is aerodynamics. At low speeds the force of air is negligible but at high speeds the force of the air is something to seriously consider in designing a vehicle. To test vehicles wind tunnels are used to simulate air passing around the vehicle and to measure the force and the airflow over the car. In a wind tunnel cars are placed on a platform and a giant fan creates winds so a device can measure the drag and downforce of the air.

When analyzing the aerodynamics of a vehicle scientists focus on surface friction and pressure drag. Surface friction drag results from the amount of friction between the layers of air near the car. For example examining how smoothly air passes over the car. Pressure drag deals with the shape of the car and how it dissipates at the end of the car. Surface friction and pressure drag also take into account objects sticking out of the vehicle such as rear-view mirrors, windshield wipers, door handles, wheels, and others. Internal drag influences both surface friction and pressure drag. It results from air passing through the car such as what is needed to cool the engine.[3]

On race cars a design feature is roof flaps located on the roof of the car. This front hinged little door on the roof aids in preventing the car from lifting into the air if the car gets turned around during a race. If a car gets turned in the wrong direction the roof flaps open to change the direction of the air flow over the car. The air is pushed up at the roof flaps creating a force that pushes down on the car preventing lift. Lift is created from the pressure differences at the bottom and top of the car. Roof flaps generate considerable wind drag which is good if you are crashing as it slows you down, but is bad if you want to race. This is why roof flaps only work if the car is backwards.

When considering aerodynamics the front cross sectional area of the vehicle is extremely important. To lessen air resistance the front should be kept as small as possible. The airflow over the vehicle should also aim to follow the vehicle's shape without breaking away and to not suddenly separate from the rear which would cause a vacuum behind the vehicle. The ideal shape for peak aerodynamics is the teardrop shape. Since a lot of drag is created in the underside of vehicles this has led race cars to be lowered closer to the ground. Features such as wings/spoilers are added to cars in an attempt to manipulate the air flow and create downforce. A spoiler is a piece of metal stretched across the back of the width of the car. The spoiler creates a downdraft on the car increasing friction between the road and the car.

In racing you often see many cars driving bumper to bumper through the track. The closer the cars ride behind each other the less air resistance there will be as the front car drags less air in its wake and the rear car has minimal resistance in the front allowing it to speed up and push the car in front of it. With less air resistance to overcome the cars will need less force to gain speed and will use less of the car's energy to gain speed.

Newton's 2nd Law of Motion

The second law of motion can be summed up in the formula F=ma or Force=mass x acceleration. William Robertson uses an illustration of a seesaw to visualize what this equation means[4]. If the force changes then so does either the mass or acceleration to balance the equation. If acceleration or mass changes then so does the force required to balance the equation. Above I defined force as a push or pull on an object. Force is measured in Newton's in the metric system. Mass is how much matter an object contains and is measured in kilograms in the metric system. The more mass an object has the more force will be required to move it or stop it to overcome the object's inertia as stated in the first law. So the less mass an object has the less force will be required to move it or stop it. You can think of this by imagining throwing a ping pong ball versus a bowling ball. It will take a lot more force to throw the bowling ball the same distance as the ping pong ball due to its mass/inertia being significantly more than the ping pong ball.

Along with an object's mass its weight distribution can affect the cars acceleration. A race car's weight distribution can cause it to drive tight or loose. If a race car is tight the front wheels lose traction first causing the front of the car to drift towards the outside wall. If a race car is loose the back wheels lose traction first causing the back end to drift towards the outside wall.

If two objects are rolling downhill at the same speed the one with more mass would have more momentum due to its inertia. An object's momentum is equal to its mass x velocity. When two people travel on a zip-line jumping off at the same time the person with more mass will have more momentum and reach the bottom first because the force of gravity is constant thus their acceleration and velocity will be the same. In this example I am disregarding frictional differences due to mass.

Acceleration is a change in an object's velocity, which is an object's speed and direction. An object can have acceleration by increasing or decreasing its speed. The more force you apply to an object the greater the acceleration. You can think of this by thinking of throwing a baseball. The more force you put into your throw the faster the ball will leave your hand and the further it will travel. An object could be moving without acceleration, as there has to be a change in speed or direction. If you are on an airplane with no turbulence, have reached cruising altitude, and are going in one direction you are not experiencing acceleration. However, once you feel change direction or speed your body will feel the acceleration. With that said you could also just change direction but keep a constant speed but still be accelerating (consider the force you feel as your car rounds a circular highway ramp).

The speed of an object is the distance it traveled divided by the time it took to travel that distance, s=d/t. When we calculate speed this way we are calculating an average speed that the object traveled. There is also instantaneous speed which is the speed you are moving at an exact moment. A car may have a speed of 55 mph from point A to point B using the speed formula, but at certain times the car may have been traveling 70 mph or even 5 mph. It is important for students to think about the instantaneous speed because when we calculate speed they probably assume the constant speed. Even though at a 5th grade level students do not calculate the instantaneous speed they should be challenged to think about when the object's speed may have altered from the average and why.

When objects are moving in a circle another force affects the motion of objects. Centrifugal force pushes objects away from the center of the circular path. So if you are driving a car and turning to the left you will be pushed to the right side of the car. The faster the object is moving in a circular path the more centrifugal force. So if a car is racing around curves the faster he/she is driving the more dangerous the turn will be if the driver loses friction (traction) with the ground. The car will go out in the direction it was traveling when the friction was lost according to Newton's First Law (objects continue in a straight line). While going around a turn, a race car might lose traction and "go straight into the wall".

Work is defined using the formula work=force x distance. Power is how much work gets completed in a certain amount of time, that is, Power=force x speed. When enough work is applied to an object it will be sent into motion which means it has energy. Energy of objects in motion is called kinetic energy. When a moving object rolls to a stop at the top of a hill its energy is not lost but is referred to as potential energy. Energy can transform into different types of energy such as heat or electrical but can never disappear.

Newton's 3rd Law of Motion

The third law states that for every action there is an equal and opposite reaction. When objects interact both are exerting a force. As I push on a wall the wall is pushing back, how can a wall push back? It's hard to think of inanimate objects reacting to a force but you cannot think of a force as a conscious decision. If you were at an ice skating rink with skates on and you push on the wall you would begin to move backwards. This proves my point that the wall is pushing back. When you push on the wall the friction of the ground is keeping you in one place. In order for an object to experience acceleration there must be an unbalanced force. If two forces are acting on each other and they are equal you will not observe any acceleration but that doesn't change the fact that there are forces present. An unbalanced force overcomes friction, and with the mass/inertia causes acceleration. Since F=ma, when you push with a force against the ice rink wall, the wall forces pushing back accelerates your mass across the ice.

At race tracks there are various degrees of banking. Banking is when the corners of the track are sloped up at an angle. These angles demonstrate the law of action and reaction. As the road is pushing back on the car at an angle it is neutralizing the centrifugal force. The car would need less force to keep it going around the corner and into the wall. Gravity pushes the car downhill on the slope but centrifugal force pushes the car out (and therefore up). This is the same concept that makes a marble roll around a big bowl.

NASCAR

The following information was compiled from the following website http://www.nascar.com/kyn/.

In organizing the students for the classroom activities, and for connecting real life to the students work I will also be informing students along the way of how the world of NASCAR works. It will be necessary for the teacher to have a basic understanding when showing video clips, sharing news stories, or explaining the different aspects of classroom activities and the main project of designing the vehicle.

In NASCAR drivers receive points during each race for various reasons. There are 43 positions in the race so you earn points for the amount of people you beat, so the 1st place person earns 43 points, the second place winner 42 points and so on. You also earn a point for leading a lap during the race, a point for leading the most laps during the race, and the race winner earns a bonus 3 points. For each race there is a maximum of 48 points.

NASCAR includes three main racing series, Sprint Cup, Nationwide, and Craftsman Truck. The Sprint Cup includes the top drivers and holds 36 races each season. In the Sprint Cup the first 26 races determine who is eligible for the Chase (for the cup). The first 12 receive 2,000 points and receive 3 bonus points for each victory in the first 26 races. The Nationwide Series has a mixture of veterans and young drivers and holds 35 races a season. The Craftsman Truck Series holds 25 races between American made trucks. NASCAR also has international, regional, and local series.

At the track the drivers of NASCAR have two special events to prepare them for the race, practice and qualifying. During practice drivers can experience the track and test out their car. This allows the drivers to communicate with his/her team about any adjustments to make to the car. During qualifying drivers have two laps to record their fastest lap time. Drivers then begin the official race in order of fastest qualifying lap time.

Many students would probably predict that the fastest car would win a NASCAR race. This is not always the case and NASCAR teams have to think through many factors when planning for a race. One thing they must consider is tire consumptions during the race. Over the course of the race the friction of the track against the tire causes them to wear out. Drivers must take pit stops to have their tires changed. Teams also have to consider what type of tire to use based on the degree of banking and track composition which could be asphalt, concrete, or both. Another area of concern during racing is fuel usage. Teams have to strategize when to stop for fuel, and drivers may need to change their driving style to conserve fuel. Taking a pit stop for fuel will cause the driver to lose precious race time and their position in the field of race cars. On the day of the race teams have to consider outside factors such as temperature, wind, and precipitation. Teams may decide to adjust aspects of the car on race day depending on the conditions.

Teaching Strategies

Notebook

For the following strategies a science notebook/journal is needed for each student in the class. These should be treated valuably and the students should be referred to as scientists during class. Referring to the students as scientists will build a classroom climate that anyone can conduct their own scientific experiments. It is important for the students to realize every time we ask “why” we create an opportunity to experiment.

Vocabulary

In science many new vocabulary words are introduced. These words are often not used in everyday language which makes it extremely important for the students to be exposed to the words and to use it in writing/speech. In the past I have found that my students can study for a vocabulary quiz, memorize the definitions, ace the quiz but not have an understanding of the concept. One way to foster a deeper understanding of the vocabulary words is to have the students write definitions in their own words, and to include an illustration to help remember the definition. I have my students split their notebook paper into four boxes on each side, and assign the vocabulary words and page number for each box. The students work in groups to read through the lesson associated with the force and motion concept. As they read a section which covers a vocabulary word they stop to discuss what it actually means and why. They then record the definition in their own words, and draw a picture which will help them remember what the word means. After all the students have completed this process, I assign each group a word and have them create a short skit to show the meaning of the word. When discussing force and motion concepts in class it is imperative to use the correct vocabulary as a teacher, as well as to encourage the students to during class conversations.

Recording Experiments

With every force and motion concept providing students with the opportunity to experiment creates a valuable lesson. Reading and discussing science concepts alone will not foster the inquiry based learning experience necessary for a depth of understanding. When providing the students with an experience to experiment they should also record the process in their science notebook. The students should first write a hypothesis (an educated guess) of what they believe will happen. Next they should write out a step by step procedure, as well as a method for recording observations/data (chart). The students should then reflect on their hypothesis and their observations and write a conclusion. The conclusion also provides an opportunity for you to provide guiding questions that will help the students discover the purpose of the experiment. Finally, the students should write down any other questions they have that may have been created from this experiment or unanswered by it. For the first several experiments the students will have to be walked through this lab report. However, after modeling it several times your class will be able to set up their notebook and carry out the steps of the experiment on their own. The questions the students write down at the end of their report can serve as a tool in assessing what the students still do not understand, as well as a starting point for the students creating their own experiment to answer the question.

Another strategy using the science lab report is to provide the students with a goal for the experiment, provide a list of materials for the students to use, and then allow the students to design their own experiment to prove the goal. Allowing the students to design the experiment will foster discussion of "why" between the group members as they decide on the process of the experiment. It will also help to guide the students toward creating their own experiments from their own questions without any materials or direction from the teacher.

Observation

Treating your students as scientists requires for everyone to master the skill of observation. On a science pretest, I had a student ask me if he could go look out the window to help him answer a question about clouds because he never looks at the sky. It seems that life gets so busy we keep looking forward but do not take the time to look around us or up! When it comes to the concept of force and motion there are many things your students can observe and record in their notebooks. Encourage students to observe cars versus tractor trailers at stoplights and how long it takes them to start going again. Students could also observe how drivers change their driving during rain or snow. This could lead to a discussion of why they are slowing down. Students could also observe during sports they play after school or during school at recess/PE class. Specifically looking to explain how friction, gravity, and force are effecting their interactions with the sport equipment.

Background Knowledge

Each time you begin teaching a new concept it is worth the time to create a list as a whole class to record what the students know. This list can then serve as a tool in future lessons. The list created can be referred back to in several ways. Ideas the students knew could be reinforced as you teach why those things are happening. Ideas the students knew that weren't necessarily correct can be reviewed with the newly learned information to reteach misunderstandings. The list should be posted in the classroom over the course of the unit.

Models

In every science book there tends to be the same pictures that are supposed to make a complex idea visual. I have realized that I can understand these pictures as a teacher because I already understand the concept. However for a 5th grader learning the concept the picture looks like a foreign language. Instead of using these pictures, provide models which you can hold and manipulate to create a more concrete visualization. Appendix B provides detailed directions on how to create an adjustable ramp for racing toy cars. The adjustable ramp will allow you to demonstrate the relationship between height and acceleration. You could also use cars of differing masses to demonstrate the relationship between mass and acceleration. Adding clay or paper to the cars could also lead to experimenting with the relationship between air resistance and speed.

Video Clips

Watching video clips of race cars will help to grab my student's attention. The video clips will also provide launching off points to discuss the concepts behind force and motion described in my background information. These clips can be used throughout the unit on force and motion to help add variety to your lessons and to keep the students wanting more! I have found that when I start each science class with a video clip or two it really reels them in for the rest of the activities in the lesson. Below are a few video clips I think are worthy of showing in class, there are tons more out there but I chose a few that really caught my attention.

http://www.youtube.com/watch?v=aDZQIrAHHEc (68 car crash pile up)

http://www.youtube.com/watch?v=Wgl-NLdS89Y (cars going through grass in race-shows roof flaps)

http://www.youtube.com/watch?v=5nyrYgkSe08&feature=related (cars avoiding crashing with other cars, shows the cars riding altogether for drag)

Classroom Activities

Students should follow directions for recording experiments as outlined above. At the end of each activity time should be spent as a whole group discussing each group's observations and conclusions.

Also, key vocabulary should be recorded in their notebooks as described above. Vocabulary to include: force, friction, inertia, acceleration, mass, speed, air resistance, velocity, action, reaction, balanced force, unbalanced force.

For each activity students should be placed in groups of 3-4 students. Students should be assigned roles to help keep organization and to balance the workload within the groups. Possible role names that follow the theme of racing Crew Chief (leads group through process and manages all roles), Driver (conducts the actual experiment), Pit Crew (manages materials), and Media (records data for group during experiment to then be shared with group).

See Appendix C for student handouts and tables to be used through the various activities.

1-Friction

Purpose: In this activity students will explorehow the surface effects the distance the car travels when the same force is applied.

Materials: 1 toy car/group, science notebook/student, 2 wooden boards with hooks/group, 1 large rubber band/group, indoor/outdoor space with different surfaces

Procedure: Students will choose 3 different surfaces from around the school to test the distance the car travels with same amount of force on different surfaces. These may include tile, carpet, grass, concrete, and asphalt however your school may also have other options. The students use the wooden boards and wrap each end of the rubber band to one of the hooks. The students hold the wooden boards apart to create tension in the rubber band. The car is then placed in front of the rubber band and is pushed against the rubber band and released. Students should measure how far apart the boards are pulled and how far they pull the rubber band back. Each time the students conduct a trial the same measurements must be used in order to keep the experiment's focus on friction. At each surface students should conduct 3 trials. For each trial students should measure the distance in centimeters and then find the average distance. In the conclusion section of their lab report students should answer the following questions:

Which surface allowed your car to travel the furthest distance?

Why was there a difference in the distances traveled by your car?

If you were to design a race track what material would you use and why?

Why do you think roads are dangerous to drive on during rain, snow, and ice storms?

2-Air Resistance

Purpose: Students will explore how air resistance affects the speed of a car with different designs of the car's body.

Materials: 3 strips of cardboard/group (at least 6 inches across by 3 feet long), textbooks, 3 toy cars/group, construction paper, tape

Procedure: Students will use the textbooks and cardboard strips to create 3 ramps. Students will leave one car unaltered and use the construction paper and tape to add features to the car. The 3 toy cards should be identical so that the only changed factor is the added paper. Their goal should be to have one of the car's to go slower and the other to go faster than the unaltered car. Students should release all 3 cars down the ramps at the same time to compare their speeds. Students should continue to alter their cars after each trial until they reach the desired effects explained above. In the conclusion section of their lab report students should answer the following questions:

Describe the features added to your car that caused it to slow down. (include a drawing)

Describe the features added to your car that caused it to speed up. (include a drawing)

Look at the pictures of the wing and spoiler on the race cars (display a picture on your interactive board or hang on your board). How do you think they attempt to overcome air resistance?

http://www.studybreaks.com/blog/wp-content/uploads/2012/08/busch-nascar-cup-pole.jpgfind

How do you think air resistance affects large vehicles such as buses and tractor trailers? Include a drawing to explain your thinking.

3-Force/Acceleration/Mass

Purpose: Students will explore how an increase in mass effects acceleration, how an increase in force effects acceleration, and how force and mass are connected.

Materials: 1 water bottle/group, 5 bottle caps/group, 1 balloon/group, 2 wooden skewers/group, 2 straws/group, tape, 1 nail/group, 1 hammer/group

Procedure: First students will need to create the car for the experiment. First attach the straws using the tape to the bottom of the car (you may need to cut the straws depending on their length). Use the hammer and nail to create a hole in the center of the bottle caps.

Put each skewer through the straw and attach the wheels to the ends of the skewers. To use the car the balloon should be blown up but not tied. The balloon should then be taped to the car. When ready to race students should release the end of the balloon to begin the car's journey!

The students will then complete several trials to test the relationship between force, acceleration, and mass. To explore force and acceleration the students should blow the balloon up to 3 different amounts. The students should measure the distance the car travels in centimeters each time. To explore mass and acceleration students should measure the distance the car traveled empty, with a quarter of it filled with water, and with half of it filled with water (the 5th bottle cap should be used to close the bottle and keep the water in). Students will need to blow the balloon up to the same amount each time for this exploration. To explore the relationship between force and mass students should fill the water bottle three fourths with water and blow the balloon halfway. Students should then try to move the car the same distance with a fourth of the bottle filled and with nothing in the bottle. In the conclusion section of their lab report students should answer the following questions:

In the first experiment which inflation of the balloon caused the car to travel the furthest?

What can you conclude about the relationship between force and acceleration?

In the second experiment which water bottle traveled the furthest?

What can you conclude about the relationship between mass and acceleration?

In the third experiment did you need more air or less air for the car to travel the same distance?

What can you conclude about the relationship of force and mass?

At a stoplight Billy complains because the tractor trailer in front of his car takes a long time to begin to accelerate, explain why.

4-Design Car and Compete

Purpose: Students will combine their knowledge of Newton's three Laws to design a car to either go the fastest or slowest over a set distance.

Materials: Various household items

Procedure: See appendix C for a student step by step direction sheet. You will need 6 groups of students. 3 groups will compete to design the fastest car and 3 groups will compete to design the slowest car. The materials listed on the student sheet could be brought in by the students. After introducing the project have students begin to bring in the supplies listed for use by the entire class. In the points section visual appeal and creativity should be voted on by the students. The 3 groups for fastest car will vote for the 3 cars for slowest car and vice versa. You will also need to establish an area where the cars will race that is 5 feet long. The cars will go one at a time and should be timed with a stopwatch. Students should then calculate the speed using the formula distance/time. The time should end once the car crosses the finish line.

Classroom Materials

Science notebook/student
3 toy cars/group
2 wooden boards with hooks/group
1 large rubber band
Access to areas around the school with difference surfaces
3 strips of cardboard (at least 6 inches across by 3 feet long)
Construction paper
Tape
Textbooks
1 water bottle/group
5 bottle caps/group
1 balloon/group (and extras in case any pop) 2 wooden skewers/group
2 straws/group
1 nail/group
1 hammer/group
Various household items (these could be brought in by students)

Teacher Books

Parker, Barry R... *The Isaac Newton School of Driving: Physics and Your Car.* Baltimore, MD: Johns Hopkins University Press, 2003.
This book explores the ideas of Newton's Three Laws in the realm of racing. The book includes many illustrations to help better understand the concepts. It also has a table of contents and index to help pinpoint your interest. The book also contains a bibliography which could guide you to further books for research.

Robertson, William C... *Stop faking it!: Finally Understanding Science so you can Teach it*. Arlington, VA: National Science Teachers Association, 2002.
This book makes force and motion simple. It includes many illustrations and real life examples to help make abstract ideas concrete.

Zimba, Jason. *Force and Motion: An Illustrated Guide to Newton's Laws*. Baltimore: Johns Hopkins University Press, 2009.
This book is written as a high school or college textbook. It gets very technical about the math used in physics and includes practice problems.

Teacher Websites

"NASCAR.COM." The Official Site of NASCAR News, Video, Drivers, Tracks, Schedules & Fantasy | NASCAR.COM. http://www.nascar.com/kyn/ (accessed September 23, 2012).
This section of the NASCAR website explains the basics of racing and includes a history of NASCAR. It also includes a glossary of terms which is helpful when studying Newton's Three Laws.

Student Books

Book, Inc. *Learning About Energy, Forces, and Motion*. Chicago: World Book, 2012.
This book includes illustrations to explain each concept about Force and Motion. It also includes sample activities that students could experiment with at school or home. The chapters also include real life examples that make abstract ideas concrete.

Hollihan, Kerrie Logan. *Isaac Newton and Physics for Kids: His Life and Ideas with 21 Activities*. Chicago, Ill.: Chicago Review Press, 2009.
This book includes 10 chapters describing Isaac Newton's life beginning with his childhood through the end of his life. Each chapter also includes activities to create objects that relate to Newton's life. Not all of the activities match force and motion as some relate to Newton's other contributions to science.

Krull, Kathleen, and Boris Kulikov. *Isaac Newton*. New York: Viking, 2006.
This book is a novel written for students 10 and up. The book includes twelve chapters that explore the journey of Isaac Newton and his contributions to science.

Lafferty, Peter. *Force & Motion*. New York: Dorling Kindersley; 1992.
This book includes 29 sections on concepts that relate to force and motion. For each concept the author includes a short explanation and a series of real life examples including pictures and explanations.

Weakland, Mark. *Zombies and Forces and Motion*. Mankato, Minn.: Capstone Press, 2012.
This book breaks down the ideas of force and motion in a graphic novel. The author writes about each law and uses zombies to illustrate their meaning.

Student Websites

"BBC - Schools Science Clips - Forces in action." BBC - Homepage. http://www.bbc.co.uk/schools/scienceclips/ages/10_11/forces_action.shtml (accessed October 17, 2012).
This simulation allows you to explore how far a car travels when changing the slope of the ramp. You can also manipulate the weight of the car.

"BBC - Schools Science Clips - Friction." BBC - Homepage. http://www.bbc.co.uk/schools/scienceclips/ages/8_9/friction.shtml (accessed October 17, 2012).
This simulation allows you to explore how the surface of the track effects the distance traveled by a car. The surface choices include vinyl, wood, carpet, and ice.

"FOSSWeb - Rollercoasters!" Welcome to FOSSweb!http://www.fossweb.com/modulesK-2/BalanceandMotion/activities/rollercoaster.html (accessed October 17, 2012).
This website allows you to build a roller coaster simulation. A marble is then released and you can see how far it travels based on your design.

"NASA - DIY Podcast: Newton's Laws Video Clips." NASA - Home.http://www.nasa.gov/audience/foreducators/diypodcast/nl-video-index.html (accessed October 17, 2012).
This website includes a series of videos recorded by an astronaut aboard the International Space Station. He explains all the laws of motion and includes examples taking advantage of the absence of gravity.

Notes

[1] Robertson, William C. *Stop faking it!: Finally Understanding Science so you can Teach it*. Arlington, VA: National Science Teachers Association, 2002. Location 364/2459 in e-book.
[2] Zimba, Jason. *Force and Motion: An Illustrated Guide to Newton's Laws*. Baltimore: Johns Hopkins University Press, 2009. Page 304.
[3] Parker, Barry R.. *The Isaac Newton School of Driving: Physics and Your Car.* Baltimore, MD: Johns Hopkins University Press, 2003. Pages 138, 153.
[4] Robertson, William C. *Stop faking it!: Finally Understanding Science so you can Teach it*. Arlington, VA: National Science Teachers Association, 2002. Location 821/2459 in e-book.