Everyday Force and Motion

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My Background

When I became a special education teacher, I wanted to become the type of teacher that provided opportunities for all students to learn. Becoming a teacher was exciting. Thinking of all the good teachers I had when in school and all of the not so good experiences as well, I think of a teacher that helped me gain a vast knowledge of science and another teacher that gave me a love for math that I still have today. But most of all, my teachers gave me the love to become a lifelong learner. Wanting to give my students that same passion, tenacity, and capability to become lifelong learners, I want to give them engaging hands-on and meaningful activities. Students are very different today, but I still want my students to develop a true sense of how learning takes place. In science, my goal is to provide students with many hands-on activities, guided notes and scaffolding learning groups.

School Background

I have been working in the Special Education Field since 2007 and teaching in the Charlotte Mecklenburg School System for about one year. I teach a self- contained classroom at a school located in the inner city of Charlotte, NC. All of my students have some form of a disability, ranging from Autism to severe depression. Many of my students suffer from ADHD so it is very hard for them to stay engaged for long periods of time.

My school is Lincoln Heights Academy in the Charlotte-Mecklenburg School System, a large urban school district in North Carolina. Lincoln Heights Academy is a public separate setting for students with behavioral and emotional disabilities. Our school embraces the philosophy that all students can learn new behaviors, new coping skills and master the North Carolina Common Core State Standards at the same time. Teachers are encouraged to use a variety of teaching techniques and strategies all while meeting student's individual needs. We have the freedom to modify the content through the process by which we deliver the content and the ability to recognize our student's individual readiness for the content that we are exploring. The school has approximately 100 students consisting of several different subgroups, including 81% African-American, 5% Hispanic, and 3% Multi-Racial, 1% Native American, 10% White; Female, Male, Economically Disadvantaged, and Non Economically Disadvantaged. All of our students have some form of a disability.

According to Friend 2008, when a decision is reached for any type of separate education it is based on data about students academic and behavioral needs; it is monitored carefully to ensure that the cost to the student of this decision is worth the benefit the student is receiving; it is reviewed and revised based on changing needs rather than rigidly scheduled for an entire school year; and it is premised on the goal of reducing the separate service as soon as possible.

My particular class this year consists of 8 students. I have a very unique group of students. One of the students has multiple disabilities ranging from Autism to Bipolar disorder. Another student has Autism and Tourrettes, while another student has mild-Cerebral Palsy and Autism. The other five students have a variety of serve emotional disabilities. The class consists of all male students of which, 4 are African American and 2 are Caucasian. All of the students in my class have Individualized Education Plans (IEP's).

An IEP is a document prepared by the multidisciplinary team or annual review team that specifies a student's level of functioning and needs; the instructional goals and objectives for the student and how they will be evaluated; the nature and extent of special education, related services, and supplementary aids and services the student will receive; and the initiation date and duration of the services. Each student's IEP is updated annually. IDEA requires that every special education teacher monitor and report their students' progress quarterly at least four times each year.

Teaching students with disabilities can be challenging. An educator must use a wide variety of teaching techniques and strategies to meet each individual students needs. Many of my students are years behind academically and it is hard for them to grasp new concepts easily.

School District Learning Requirements

Our state essential standards requires that 10th grade applied science students must be able to (OA1.1) Understand Force and Motion, (OA1.1.1) Compare weight and mass, (OA1.1.2) Classify types of forces (gravity, friction, magnetism), and (OA1.1.3) Describe the effects of force (gravity, friction, magnetism) on an objects weight and motion.

In recent years, science educators and curriculum developers have realized that science is taught not only to prepare students for university studies and careers in science, but also to become citizens in a society that is highly dependent upon scientific and technological advances (Hofstein 1999).

High school students are naturally curious about everything that is happening around them, and through my unit I plan to help spark that curiosity in my students. I am a 10th grade Occupational Course of Study Teacher; I teach every subject that 10th graders are required to take. Last year in our General Science course we explored Newton's Laws, types of forces and magnetism.

This year I will take this curriculum to the next level and I want to explain to my students the role that physics plays in their everyday lives. I want my students to understand that physics exists in the car we ride in, the chairs we sit in, rockets, amusement parks, and our television and literally every object we can see or touch. Using Physics we can explain how a car works as we drive it and how force affects everything. Physics is the science of matter and its motion, space-time and energy. Physics describes many forms of energy such as kinetic energy, electrical energy, and mass; and the way energy can change from one form to another.

The legacy from Galileo and Newton

The legacy from Galileo and Newton is that forces change motion. Apply a force and the object will change speed or direction. But apply no force and the object stays moving at constant speed (which might be zero) and direction. No matter how many times we refer to Newton's Second Law, pupils will insist that moving objects have a force driving them and they stop when this 'runs out'. They cannot see that the object slows due to the force of friction and that without this friction the object would continue forever.

The problem is that there are few common examples relevant to them where there is no friction. When we push a trolley we need a driving force to keep going, only because of friction. So the word force becomes used by most of us to mean something like inertia. Inertia is a measure of how difficult an object is to change direction or speed.

Isaac Newton

Cars, football and skidding

The plan is to ask a student to run and stop or run and change direction. We will talk about the need to get a grip on the floor or grass in order to stop or change direction. We will then talk about icy roads, wet floors and football shoe cleats. If a football player, or anyone else, needs to change their motion they need to have grip. It is only when you attempt to change your motion and can't get that grip, that skidding, slipping or sliding happens. People often associate skidding, or slipping, with turning corners, and it is true that it is during cornering (or trying to start or stop) that cars and footballers slide. But this happens when there is a reduced frictional force from the ground, so your attempt to slow down or turn a corner fails, and you carry on in the same direction that you were going. People and cars can't change direction without frictional force (or grip).

Force Arrows (Vectors)

Children find the force arrows in diagrams difficult to understand. Part of this is because scientists use force arrows from the center of gravity not the top or bottom of an object. So there is no distinction between pushes and pulls.

The motion of an aircraft through the air can be explained and described by physical principals discovered by Sir Isaac Newton over 300 years ago. Newton worked in many areas of mathematics and physics. He developed the theories of gravitation in 1666, when he was only 23 years old. Some twenty years later, in 1686, he presented his three laws of motion in the "Principia Mathematica Philosophiae Naturalis." The laws are described below, and the applications of these laws to aerodynamics are given on separate slides.

Newton's first law states that every object will remain at rest or in uniform motion in a straight line unless compelled to change its state by the action of an external force. This is normally taken as the definition of inertia. The key point here is that if there is no net force acting on an object (if all the external forces cancel each other out) then the object will maintain a constant velocity. If that velocity is zero, then the object remains at rest. If an external force is applied, the velocity will change because of the force.

Newton's first law of motion

Consider some of your experiences in an automobile. Have you ever observed the behavior of the liquid in a drink cup filled to the rim while starting a car from rest or while bringing a car to rest from a state of motion? The drink "keeps on doing what it is doing." When you accelerate a car from rest, the road provides an unbalanced force on the tires to push the car forward; yet the drink (that was at rest) wants to stay at rest. While the car accelerates forward, the drink remains in the same position; subsequently, the car accelerates out from under the drink and the drink spills backwards into your lap. On the other hand, when braking from a state of motion the drink continues forward *with the same speed and in the same direction*, ultimately spilling forward, or hitting the dash. A drink in motion stays in motion.

Inertia and Mass

We have all experienced inertia (resisting changes in your state of motion) in an automobile while it is braking to a stop. The force of the road on the braking tires provides the unbalanced force to change the car's state of motion, yet there is no unbalanced force to change your own state of motion. Thus, you continue in motion, sliding along the seat in forward motion. A person in motion stays in motion with the same speed and in the same direction... unless acted upon by the unbalanced force of a seat belt. Seat belts are used to provide safety for passengers whose motion is governed by Newton's laws. The seat belt provides the unbalanced force that brings you from a state of motion to a state of rest. Perhaps you could speculate what would occur when no seat belt is used.

Newton's first law of motion states that "An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force." Objects tend to "keep on doing what they're doing." In fact, it is the natural tendency of objects to resist changes in their state of motion. This tendency to resist changes in their state of motion is described as inertia. Inertia: the resistance an object has to a change in its state of motion. Aristotle said that it was the natural tendency of objects to come to a rest position. Moving objects, so he believed, would eventually stop moving. A force was necessary to keep an object moving but if left to it, a moving object would eventually come to rest and an object at rest would stay at rest. Thus, the idea for nearly 2000 years prior to Newton was that it was the natural tendency of all objects to assume a rest position.

Galileo and the Concept of Inertia

Galileo Galilee, a premier scientist ahead of Newton, developed the concept of inertia. Galileo reasoned that moving objects eventually stop because of a force called friction. In experiments using a pair of inclined planes facing each other, Galileo observed that a ball would roll down one plane and up the opposite plane to approximately the same height. If smoother planes were used, the ball would roll up the opposite plane even closer to the original height. Galileo reasoned that any difference between initial and final heights was due to the presence of friction. Galileo postulated that if friction could be entirely eliminated, then the ball would reach exactly the same height. Galileo further observed that regardless of the angle at which the planes were oriented, the final height was almost always equal to the initial height. If the slope of the opposite incline were reduced, then the ball would roll a further distance in order to reach that original height.

Forces Don't Keep Objects Moving

Isaac Newton built on Galileo's thoughts about motion. Newton's first law of motion declares that a force is not needed to keep an object in motion. Slide a book across a table and watch it slide to a rest position. The book in motion on the table top does not come to a rest position because of the *absence* of a force; rather it is the *presence* of a force - that force being the force of friction - that brings the book to a rest position. In the absence of a force of friction, the book would continue in motion with the same speed and direction - forever! (Or at least to the end of the table top.) A force is not required to keep a moving book in motion. In actuality, it is a force that brings the book to rest.

Mass as a Measure of the Amount of Inertia

All objects resist changes in their state of motion. All objects have this tendency - they have inertia. But do some objects have more of a tendency to resist changes than others? Absolutely yes! The tendency of an object to resist changes in its state of motion varies with mass and shape. For non-rotational motion, inertia is that quantity that is solely dependent upon the mass of an object. The more mass an object has, the more inertia it has. A more massive object has a greater tendency to resist changes in its state of motion.

For rotational motion, the inertia is related to the shape. If you hang a large dumbbell vertically from a rope and try to twirl it about the shaft, it will rotate and stop easily. But if you change the shape by hanging it horizontally and rotate it about the rope, you will find that it doesn't want to spin. You will then find that it doesn't want to stop either!

Suppose that there are two seemingly identical toy cars at rest on the physics lecture table. Yet one car is full of lead and the other is empty. Without lifting the cars, how could you tell which brick was the *lead filled car*? You could give them an identical push in an effort to change their state of motion. The car that offers the greatest resistance is the car with the most inertia - and therefore the car with the greatest mass (i.e., *the lead filled car*).

The second law explains how the velocity of an object changes when it is subjected to an external force. The law defines a force to be equal to change in momentum (mass times velocity) per change in time. Newton also developed the calculus of mathematics, and the changes expressed in the second law are most accurately defined in differential forms. For an object with a constant mass m, the second law states that the force F is the product of an object's mass and its acceleration a:

$$F = m \times a$$

For an external applied force, the change in velocity depends on the mass of the object. A force will cause a change in velocity; and likewise, a change in velocity will generate a force. The equation works both ways.

The Relationship of Force

A force is a push or pull upon an object resulting from the object's interaction with another object. Whenever there is an *interaction* between two objects, there is a force upon each of the objects. When the *interaction* ceases, the two objects no longer experience the force. Forces only exist as a result of an interaction.

For simplicity sake, all forces (interactions) between objects can be placed into two broad categories:

- contact forces, and
- forces resulting from action-at-a-distance

Contact forces are those types of forces that result when the two interacting objects are perceived to be physically touching each other. Examples of contact forces include frictional forces, tensional forces, normal (pressure) forces, air resistance forces, and applied forces.

Action-at-a-distance forces are those types of forces that result even when the two interacting objects are not in physical contact with each other, yet are able to exert a push or pull despite their physical separation. Examples of action-at-a-distance forces include magnetism and gravitational forces. For example, the sun and planets exert a gravitational pull on each other despite their large spatial separation. Even when your feet leave the earth and you are no longer in physical contact with the earth, there is a gravitational pull between you and the Earth. Electric forces are action-at-a-distance forces. For example, the protons in the nucleus of an atom and the electrons outside the nucleus experience an electrical pull towards each other despite their small spatial separation. Magnetic forces are action-at-a-distance forces. For example, two magnets can exert a magnetic pull on each other even when separated by a distance of a few centimeters.

Examples of Contact Forces and Action-at-a-Distance Forces

Contact Forces	**Action-at-a-Distance Forces**
Frictional Force	Gravitational Force
Tension Force	Electrical Force
Normal Force	Magnetic Force
Air Resistance Force	
Applied Force	
Spring Force	

Force is a quantity that is measured using the standard metric unit known as the 'Newton' abbreviated 'N' (and the 'Pound' abbreviated 'lb' in English units). To say "10.0 N" means 10.0 Newton's of force. One Newton is the amount of force required to give a 1-kg mass an acceleration of 1 m/s/s. Thus, the following unit equivalency can be stated:

$$1\ Newton = 1\ kg \times \frac{m}{s^2}$$

A force is a vector quantity so it has both magnitude and direction. To fully describe the force acting upon an object, you must describe both the magnitude (size or numerical value) and the direction. Thus, 10 Newton is not a full description of the force acting upon an object. In contrast, 10 Newton's downward is a complete description of the force acting upon an object; both the magnitude (10 Newton) and the direction (downward) are given.

Because a force is a vector that has a direction, it is common to represent forces using diagrams in which a force is represented by an arrow. Such vector diagrams were introduced in an earlier unit and are used throughout the study of physics. The size of the arrow is reflective of the magnitude of the force and the direction of the arrow reveals the direction that the force is acting. Furthermore, because forces are vectors, the effect of an individual force upon an object is often canceled by the effect of another force. For example, the effect of a 1000 Newton upward force acting through the tires of a race car would be *canceled* by the effect of a 1000 Newton downward force of gravity . In such instances, it is said that the two forces *balance each other*; there would be no unbalanced force acting upon the book.

Other situations could be imagined in which two of the individual vector forces cancel each other ("balance"), yet a third individual force exists that is not balanced by another force. For example, imagine the race car as a light turns green (or the race green flag). In the horizontal direction (gravity is already balanced), as the driver hits the gas, the road is pushing back against the tires rotation. Since there is nothing pushing at the front of the car, the force (F) against the tires then accelerates (a) the mass (m) of the car forward with F = m x a. In this case, an unbalanced force acts upon the book to change its state of motion.

The third law states that for every action (force) in nature there is an equal and opposite reaction. In other words, if object A exerts a force on object B, then object B also exerts an equal force on object A. Notice that the forces are exerted on different objects. The third law can be used to explain the generation of the force of the pavement against the tires and the traction force of the tires against the ground.

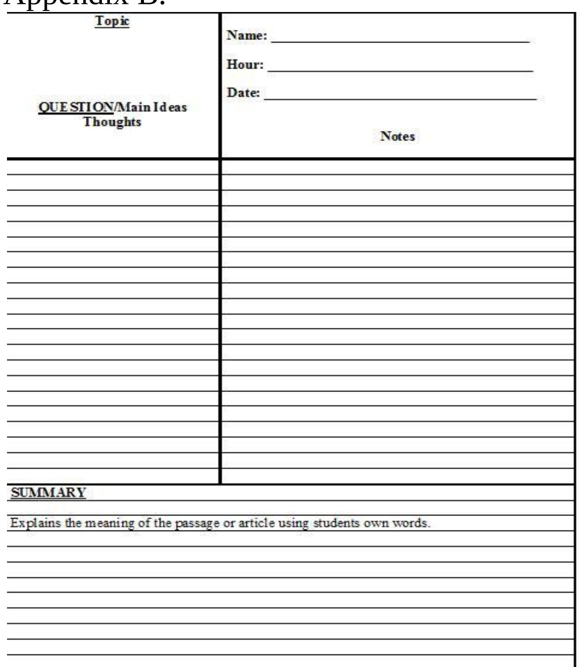
Objectives

OA1.1	**Understand force and motion.**
OA1.1.2	**Classify types of force (gravity, friction, magnetism).**
OA1.1.1	**Compare weight and mass.**
OA1.1.3	**Describe the effects of force (gravity, friction, magnetism) on an object’s weight and motion.**

Strategies

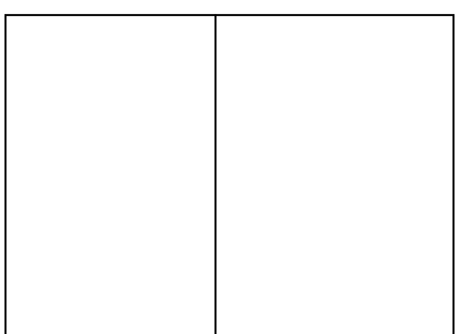
Cornell Note Taking

Cornell note taking is a note taking system that was designed by Walter Paulk, a professor at Cornell University. Cornell notes are divided into three sections. The first section is the questions section, which is located on the left hand side of a sheet of notebook paper. The second section is the notes section, this is the section where students and write any notes that they have taken. Last but not least is the third section, titled the summary section [xv]. The summary section is used as a tool for students to summarize the entire day's lesson. This is the time for students to focus on key ideas that were presented during the lesson. Students will use the Cornell Notes Handout, located in Appendix B.



Vocabulary Foldable

Vocabulary foldable is used for students to write the unit's vocabulary and study the vocabulary when they need to review. A vocabulary foldable is used as a study tool for vocabulary words. Many students enjoy using a vocabulary foldable because they are easy to keep inside of their books or notebooks.

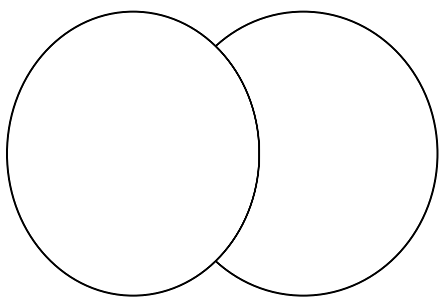


Words

Definitions

Graphic Organizers

There are two types of graphic organizers commonly used to compare different objects. A Venn- Diagram is used to compare two objects similarities to the objects differences. A Venn - Diagram provides students a visual display of the similarities and differences between two items. (Marzano) In this unit we will use a Venn-Diagram to compare various physics concepts.



K-W-L Chart

As a warm up activity students will begin by completing a KWL chart. Students will brainstorm, K- what they know about photosynthesis and cellular respiration. W- what they want to know about photosynthesis and cellular respiration. L- What they have learned about photosynthesis and cellular respiration will be completed at the conclusion of this curriculum unit. (See Appendix B)

K- What I Know	**W- What I Want To Know**	**L- What I have Learned**

Students Activities

Activity 1: What is energy?

Students will begin by reviewing the terms associated with this activity.

- Force- the push or pull on an object
- Motion- the change in position or place of an object
- Friction- the force that resists the relative motion of an object
- Mass- the amount of matter in an object; on Earth's surface, it is thought of as the objects weight.
- Energy- the ability to do work.
- Kinetic Energy- Energy of motion
- Potential Energy- Stored energy
- Law of conservation of energy- energy cannot be created or destroyed.

Students will take these terms and place them in a vocabulary foldable.

Bouncing Tennis Balls Lab

Energy is constantly being changed from one form to the other. Potential energy, which is stored energy, can be converted into kinetic energy, the energy of motion. During the conversion, some energy may be changed into sound or heat, but energy is never completely lost. In this activity student will observe how potential energy changes to kinetic energy.

Materials

Tennis Balls
Meter Stick

Activity

1. Stand the meter stick on the floor, so that the 0 end touches the floor.
2. Hold a tennis ball at the 100- centimeter mark of the meter stick. Students will practice dropping the tennis ball straight down and catching it at its highest point of its bounce.
3. Once students have mastered this skill, drop the tennis ball from the 100-centimeter mark and catch the ball at the maximum height of its first return bounce. Note that height on the meter stick.
4. Drop the tennis ball from the 75- centimeter mark and catch the ball at the maximum height of its first return bounce. Note that height on the meter stick.
5. Drop the tennis ball from the 50- centimeter mark and catch the ball at the maximum height of its first return bounce. Note that height on the meter stick.
6. Drop the tennis ball from the 25- centimeter mark and catch the ball at the maximum height of its first return bounce. Note that height on the meter stick.
7. Record all data on a lab results sheet.

Activity 2: Motion and Speed

Materials

Metal Ramp (See Appendix)
Toy Car
Stopwatch
Meter Stick

Procedures

1. Use inclined plane ramp at different heights.
2. Put the toy car at the top of the ramp. Push the car to start it moving down the ramp. Time how long it takes to reach the bottom.
3. Use the meter stick to record the distance the car rolls after it leaves the ramp.
4. Record this information on a lab results sheet.
5. Change the height of the ramp to increase the height of the ramp and repeat the experiment.
6. Change the height of the ramp to increase the height of the ramp and repeat the experiment.
7. Calculate the speed each the speed formula. Speed = Distance ÷ Time

Activity 3: Newton's First Law of Motion

Materials

Plastic Cup
Index card
Penny

Procedure

1. Place an index card on top of the mouth of the plastic cup.
2. Put the penny on top of the card, so that it's directly above the mouth of the cup.
3. Using your index finger thump the index card, so that the card flies off the cup and the penny drops into the cup below.
4. Continue this activity for 5 trials.
5. Discuss as a class how this activity demonstrates the law of inertia.

Activity 4: Law of Conservation of momentum

Materials

Metal Ramp (See Appendix)
Small marbles (5)
Large marbles (2)
Meter sticks (2)

Procedures

1. Place the metal ramp flat on the floor.
2. Place a small target marble in the center of the track. Place another small marble at one end of the track. Flick the small marble toward the target marble. Describe the collision.
3. Repeat step 2, replacing the two small marbles with the two large marbles.
4. Repeat step 2, replacing the small shooter marble with a large marble.
5. Repeat step 2, replacing the small target marble with a large marble.
6. Repeat step 2, replacing the small target marble with four small marbles that are touching.
7. Place two small marbles at opposite ends of the track. Shoot the marbles toward each other and describe the collision.
8. Place two large marbles at opposite ends of the track. Shoot the marbles toward each other and describe the collision.
9. Place a small marble and a large marble at opposite ends of the track. Shoot the marbles toward each other and describe the collision.

Annotated Bibliography

Amico, Joan, and Kate Gallaway. *Differentiated instruction for the middle school science teacher: activities and strategies for an inclusive classroom*. San Francisco: Jossey-Bass, 2010.

Includes strategies for teaching a standards-based science curriculum, the book also contains a wealth of activities that can be adapted for learners of all abilities. This book offers information for delivering effective instruction, measuring success, and student collaboration.

Gonick, Larry, and Art Huffman. *The cartoon guide to physics*. New York, NY: HarperPerennial, 1991.

The Cartoon Guide to Physics puts the user in the driver's seat of this highly interactive physics environment. Students can observe how gravity affects falling objects, find out what constant acceleration actually means and experience the principles of physics in action.

Holzner, Steven, and Daniel Wohns. *Physics essentials for dummies*. Hoboken, NJ :: Wiley Pub., Inc., 2010.

For students who just need to know the vital concepts of physics, whether as a refresher, for exam prep, or as a reference, *Physics Essentials For Dummies* is a must-have guide. It provides discrete explanations of critical concepts taught in an introductory physics course, from force and motion to momentum and kinetics. This guide is also a perfect reference for parents who need to review critical physics concepts as they help high school students with homework assignments, as well as for adult learners headed back to the classroom who just need a refresher of the core concepts.

Kuhn, Karl F.. *Basic physics, a self-teaching guide*. 2nd ed. New York: J. Wiley, 1996.

This book offers a course in basic physics at the high school level that can easily be completed in a home setting. Each chapter contains frames that present some new concept or material. The key concept is followed by comprehension questions and the answers to those questions. End-of-chapter tests reinforce knowledge learned.

Pelecky, Diandra L.. *The Physics of NASCAR: the science behind the speed*. New York: Plume, 20092008.

This book explains the basics of NASCAR in simple language.

Walker, Pam, and Elaine Wood. *The science teacher's activity-a-day: over 180 reproducible pages of quick, fun projects that illustrate basic concepts*. San Francisco: Jossey-Bass ;, 2010.

Includes strategies for teaching a standards-based science curriculum . The book also contains a wealth of activities that can be adapted for learners of all abilities. This book offers information for delivering effective instruction, measuring success, and student collaboration.