**Instructional Design**

**Forces and Motion**

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**Statement of Purpose**

Three years of science are required by the State of Ohio in order for one to receive their high school diploma. In addition to the required courses, students must take and pass the science portion of the Ohio Graduation Test. “Ohio Graduation Tests (OGT) are aligned to Ohio’s academic content standards, which were adopted by the State Board of Education in English language arts, mathematics, science and social studies. These standards have been carefully designed to ensure that students are armed with the knowledge they need to be successful in higher educational pursuits as well as the jobs and careers of the future (Ohio Department of Education)”.

Many wonder why science in important or relevant to every day life. Harvey Craft, Suite101.com, writes “In the physical world, however insignificant or small a part of it might be, science is involved at some level in defining it, describing it, or figuring out what it is and how it works. The activities that people take for granted ­– riding a bike, cooking, watching TV, using computers, and on and on – cannot be understood or explained without science. Science is concerned with the living and the non-living; it is about the past present, and future. Since science is primarily about how to think and process information, it trains the mind to be more orderly in problem solving. An understanding of science enables citizens to better evaluate an increasing number of issues like climate change, alternative energy, personal health, etc., thereby producing informed, responsible citizens (Craft, 2011).” Science, regardless of the topic being studied is important. In my science classroom, we use a mixture between the problem-based model and the project-based model. Not only do our “tend to result in a product (Chiarelott 2006)” but they also “tend to be process oriented (Chiarelott 2006).”

The focus of my unit is on the forces and motion, physics portion of the ninth grade Physical Science curriculum. I chose this area to focus on, because a lot of what we do throughout their freshman science year builds upon the formulas and concepts that they learn in this unit. There are also many questions on the OGT that are geared towards these concepts. It is my hope that with this specific unit, we will ensure that our students are getting the necessary instruction needed to become successful in their freshman science class as well as on their OGT’s.

The curriculum that I am creating for this unit is brand new to the upcoming students. While the concept is not new, I did a lot of research to find activities that will grab the students’ interests and help them to understand Newton’s laws of motion more easily. There are so many resources at our fingertips that we really do not have to recreate the wheel, rather find something that will work for our students, because not everything will. I also think that these activities/labs “can address either social issues or personal issues relevant to that student or classroom need (Chiarelott 2006).” Making learning relevant to the learner is important in getting the student to become engaged or buy into the activity or the lesson.

Students will walk away from this unit with an understanding of the motion, force, acceleration and Newton’s laws of motion. They will be able to use various formulas to calculate force and acceleration, and will be able to apply Newton’s laws of motion to their everyday lives.

References:

Chiarelott, L. (2006). Curriculum in context. Belmont, CA: Thomson Wadsworth.

Craft.H. (2011, January 17). How teachers can promote the importance of science to students. Scientific Inquiry by suite101, Retrieved from <http://www.suite101.com/content/how-teachers-can-explain-the-importance-of-science-to-students-a333919>

Ohio department of education. (2010, June 10). Retrieved from http:// www.ode.state.oh.us/GD/Templates/Pages/ODE/ODEDetail.aspxpage=3&TopicRelationID=216&ContentID=4347&Conten t=86702

**Learner Outcomes**

**Motion & Forces**

**Sub-Unit One: Motion, Acceleration, and Forces**

*Students will be able to:*

* Distinguish between distance and displacement. (comprehension)
* Calculate average speed. (application)
* Explain the difference between speed and velocity. (analysis)
* Interpret motion graphs. (comprehension)
* Identify how acceleration, time, and velocity are related. (analysis)
* Describe how to calculate the average acceleration of an object. (comprehension)
* Explain how positive and negative acceleration affect motion. (analysis)
* Explain how forces and motion are related. (analysis)
* Compare and contrast static friction and sliding friction. (analysis)
* Describe the effects of air resistance on falling objects. (comprehension)

**Sub-Unit Two: The Laws of Motion**

*Students will be able to:*

* Define Newton’s first law of motion. (knowledge)
* Explain how inertia and mass are related. (analysis)
* Define Newton’s second law of motion. (knowledge)
* Apply Newton’s second law of motion. (application)
* Describe the gravitational force. (comprehension)
* Distinguish between mass and weight. (comprehension)
* Explain why objects that are thrown will follow a curved path. (analysis)
* Compare circular motion with motion in a straight line. (analysis)
* State Newton’s third law of motion. (knowledge)
* Identify action and reaction forces. (application)
* Calculate momentum. (application)
* Recognize when momentum is conserved. (analysis)

**Pre-Assessment Survey:**

**Directions:** Mark each of the following situations as an example of Newton’s First (1st), Second (2nd), or Third Law (3rd) on the blank before the number.

\_\_\_\_1. A magician pulls a tablecloth out from under dishes and glasses on a table without disturbing them.

\_\_\_\_2. A person’s body is thrown outward as a car rounds a curve on a highway.

\_\_\_\_3. Rockets are launched into space using jet propulsion where exhaust accelerates

 out from the rocket and the rocket accelerates in an opposite direction.

\_\_\_\_4. A picture is hanging on a wall and does not move.

\_\_\_\_5. A person not wearing a seatbelt flies through a car window when someone slams

 slams on the breaks because the person’s body wants to remain in continuous

 motion even when the car stops.

\_\_\_\_6. Pushing a child on a swing is easier than pushing an adult on the same swing,

 because the adult has more inertia.

\_\_\_\_7. A soccer ball accelerates more than bowling ball when thrown with the same

 force.

\_\_\_\_8. A soccer player kicks a ball with their foot and their toes are left stinging.

\_\_\_\_9. A student leaves a pencil on a desk and the pencil stays in the same spot until

 another student picks it up.

\_\_\_\_10. Two students are in a baseball game. The first student hits a ball very hard and it

 has a greater acceleration than the second student who bunts the ball lightly.

**LESSON 1: Newton’s First Law of Motion, Part 1**

Objective: To demonstrate the first part of Newton’s first law of motion.

Materials Needed: 5 checkers, 1 ruler, lab sheet (this will also work with sugar cubes or wooden blocks).

Allotted Time: 45 minutes

Procedures:

* Discuss Newton’s First Law of Motion (students will take notes)
* Define inertia (students will take notes)
* Break students into small, cooperative groups
* Have one student from each group gather supplies from the front of the room.
* Ask students to stack the checkers to make a tower.
* On their lab sheets, students will predict what they think will happen to the checkers when you hit only the bottom checker with a ruler.
* Students will lay the ruler flat on the table. Swing the ruler sideways quickly so that you only hit the bottom checker. Students should record their results on the lab sheet.
* Students will stack the checkers again. They will try to remove the checkers one by one without knocking over the tower.

Results: As the ruler hits the bottom checker, the checker should slide out of the way without knocking over the rest of the tower. The remaining checkers are not acted upon by the force of the ruler, so they remain at rest.

Assessment: Students will answer the questions regarding Newton’s First Law that are on the lab sheet.

**Checker Challenge Lab Sheet**

Procedures:

1. Stack the checkers to make a tower.
2. Predict what will happen to the checkers when you hit only the bottom checker with a ruler. Record your predictions on the lab sheet.
3. Lay the ruler flat on the table. Swing the ruler sideways quickly so that you only hit the bottom checker. Record your results on the lab sheet.
4. Stack the checkers again. Try removing the checkers one by one without knocking over the tower.

A. Predict what will happen to the tower of checkers when you hit only the bottom checker with a ruler.

B. Record what happened when you hit the bottom checker.

C. Were you able to remove the checkers one by one without knocking over the rest of the towers?

Questions:

1. What is inertia?
2. Give an example of an object in the classroom that remains at rest. What could cause it to move?
3. If both sides are even in a tug of war, no one will win. This is an example of balanced forces. If one side is weaker, then the forces are unbalanced and the stronger side will win. What unbalanced force acted upon the bottom checker?
4. Why didn’t the tower of checkers react in the same way as the bottom checker?
5. How is this lab similar to the magic trick of pulling a tablecloth out from underneath dishes?
6. Explain how this lab demonstrates Newton’s First Law of Motion?

**LESSON 2: Newton’s First Law of Motion, Part 2**

Objective: To demonstrate the last part of Newton’s first law of motion. To measure, record, and interpret data.

Materials Needed: 5 thick books, wooden board-which can be used as a ramp, modeling clay, rolling car, meter stick, string, lab sheet (to save time, two sizes of objects, such as small and large plastic figurines, could be used instead of the clay figures.)

Allotted Time: 45 minutes

Procedures:

* Review Newton’s First Law of Motion and Inertia
* Divide students into small groups.
* Have one student from each group gather the materials from the front of the room.
* Using the board and four books students will make a ramp. Place the fifth book at the bottom of the ramp to form a barrier.
* Students will use half of the clay to make a simple model of a seated person. Be sure that it will fit inside the cart. Place the clay model inside the cart.
* Students will set the cart at the top of the ramp.
* On the lab sheet, students will predict what will happen to the clay model when you release the card.
* Release the cart and let it crash at the bottom of the ramp. Observe what happened to the clay model. Measure in centimeters the distance from the barrier to the clay model. Students will record their observations on the lab sheet.
* Use the rest of the clay to make a larger model. Repeat steps 3-4 using the larger clay model.
* Use the string to tie the large clay model to the cart. Set the cart at the top of the ramp. Predict what will happen to the model when you release the cart. Record your prediction on the lab sheet.
* Release the cart and let it crash at the bottom of the ramp. Observe what happened. Record your observations on the lab sheet.

Results: The smaller clay model should be thrown from the cart. The larger model should also be thrown and should travel farther than the smaller model. The tied model should remain in the cart. Students should infer that it is safer for a passenger to wear a seat belt when riding in a vehicle.

Assessment: Students will answer the questions regarding Newton’s First Law that are on the lab sheet.

**Buckle Up! Lab Sheet**

Procedure:

1. Use the board and four books to make a ramp. Place the other book at the bottom of the ramp to form a barrier.
2. Use half of the clay to make a simple model of a seated person. Make sure it will fit inside the cart. Place the clay model inside the cart.
3. Set the cart at the top of the ramp. Predict what will happen to the clay model when you release the cart. Record your prediction.
4. Release the cart and let it crash at the bottom of the ramp. Observe what happened to the clay model. Measure in centimeters the distance from the barrier to the clay model. Record your observations.
5. Use the rest of the clay to make a larger model. Repeat steps 3-4 using the larger clay model.
6. Use string to tie the large clay model to the cart. Set the cart at the top of the ramp. Predict what will happen to the model when you release the cart. Record your predictions.
7. Release the cart and let it crash at the bottom of the ramp. Observe what happened. Record your observation.

Answer the following questions on a separate sheet of paper:

1. Predict what will happen to the small clay model when you release the cart.
2. What happened when you released the cart?
3. Predict what will happen to the large clay model when you release the cart.
4. What happened when you released the cart?
5. Predict what will happen to the model tied with string when you release the cart.
6. What happened when you released the cart?

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| --- | --- |
| **Model** | **Measurement from barrier** |
| **Small model** |  |
| **Large model** |  |
| **Model with string** |  |

QUESTIONS:

1. State Newton’s First Law of Motion.
2. In step 4, the cart and the clay model were in motion together on the ramp. Did this motion together change? If so, how?
3. How did the mass of the clay model affect its motion?
4. When you are riding in a car, you are in motion together with the vehicle because of inertia. If you are not wearing a seatbelt and the driver must stop suddenly, describe your motion.
5. Why does wearing a seat belt in a moving vehicle make you safer?
6. Explain how this lab demonstrates Newton’s First Law of Motion

**LESSON 3: Newton’s Second Law of Motion**

Objective: To demonstrate Newton’s Second Law of Motion. To measure, record and interpret data.

Materials Needed: 3 felt chalkboard erasers, string, paper clip, spring scale, lab sheet (the erasers should be approximately the same size. Other items could be used instead of erasers, such as wooden block or small flat cans (tuna). It is important that students try to use the same amount of force each time. The spring scale should be helpful in measuring the amount of force used.)

Allotted Time: 45 minutes

Procedures:

* Discuss Newton’s Second Law of Motion (student will take notes)
* Demonstrate how to calculate acceleration. Have students try examples.
* Review force.
* Explain how to use and read a spring scale.
* Divide students into small groups.
* Have one student from each group come to the front of the room to gather supplies for the lab.
* Students will tie the string around the outside edge of one eraser. Attach the paper clip to the string on one of the narrow edges of the eraser. Stack the remaining erasers on top of the first eraser.
* Students will hook the spring scale to the paper clip and slowly pull the stack of erasers across a table. Record the amount of force needed (as shown on the spring scale) to accelerate the three erasers.
* Students will remove the top eraser. Pull the remaining two erasers across the table using the same amount of force used in step 2. Record what happened to the acceleration of the erasers on the lab sheet.
* Students will remove the top eraser. Predict what you think will happen to the acceleration of the eraser when you pull one eraser using the same amount of force. Repeat step 3 using just one eraser. Try to use the same amount of force as you did in step 2. Record what happened to the acceleration of the eraser on the lab sheet.

Results: As the mass of the erasers decreased, the acceleration of the erasers should have increased. Students should then be able to infer that as mass increases, acceleration decreases.

Assessment: Students will answer the questions regarding Newton’s Second Law that are on the lab sheet.

**Eraser Racers Lab Sheet**

**Procedures:**

1. Tie the string around the outside edge of one eraser. Attach the paper clip to the string on one of the narrow edges of the eraser. Stack the remaining erasers on top of the first eraser.
2. Hook the spring scale to the paper clip and slowly pull the stack of erasers across a table. Record the amount of force needed (as shown on the spring scale) to accelerate the three erasers.
3. Remove the top eraser. Pull the remaining two erasers across the table using the same amount of force you used in step 2. Record what happened to the acceleration of the erasers on the lab sheet.
4. Remove the top eraser. Predict what you think will happen to the acceleration of the eraser when you pull one eraser using the same amount of force. Repeat step 3 using just one eraser. Try to use the same amount of force as you did in step 2. Record what happened to the acceleration of the eraser on the lab sheet.
5. Record the amount of force needed to accelerate three erasers.

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1. What happened to the acceleration rate with two erasers?

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1. What happened to the acceleration rate with one eraser?

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**QUESTIONS:** Answer the following questions on a separate sheet of paper.

1. State Newton’s second law of motion.
2. What happened to the acceleration rate as you used fewer erasers?
3. What was being decreased as you removed erasers from the stack?
4. How does mass affect acceleration when the amount of force stays the same?
5. You are pushing a friend on a swing. If your friend wants to go faster, how can you increase the acceleration rate?
6. How does the amount of force affect acceleration when mass stays the same?
7. Infer why some freight trains have more than one engine.
8. A motorcycle and a dump truck sit next to each other at a stoplight. Which one will accelerate more easily? Explain.
9. Which material would be better for a racing bike, iron or aluminum? Explain.
10. Explain how this lab relates to Newton’s second law of motion.

**Lesson 4: Newton’s Third Law of Motion**

Objective: To demonstrate Newton’s third law of motion

Materials: empty aluminum soft drink can with pull-tab attached, hammer, small nail, string, water, deep sink or bucket, lab sheet

Allotted Time: 45 minutes

Procedure:

* Discuss Newton’s third law of motion (students will take notes).
* Students will have an adult use the hammer and nail to punch two or three evenly spaced holes around the can close to the bottom. When the nail is in each hole, push it to the left to angle the hole slightly.
* Students will pull the tab straight up and tie one end of the string to it.
* Over the sink or bucket, students will fill the can with water. Hold the loose end of the string and observe the action and reaction.

Result: As the water goes out of the holes (the action), the can should begin to spin (the reaction). The can spins more quickly at first. As the water pressure decreases in the can, the spinning slows down.

Assessment: Students will answer the questions regarding Newton’s Second Law that are on the lab sheet.

**Newton’s Third Law of Motion: Water Whirl Lab Sheet**

Procedure:

1. Have an adult use the hammer and nail to punch two or three evenly spaced holes in the can close to the bottom. When the nail is in each hole, push it to the left to angle the hole slightly.
2. Pull the tab straight up and tie one end of the string to it.
3. Over the sink or bucket, fill the can with water. Hold the loose end of the string and observe the action and reaction.
4. What happened to the water in the can?

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1. What happened to the can?

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There are always two objects involved when there’s an action and a reaction.

1. What was the action force?

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1. What was the reaction force?

QUESTIONS: Please answer the following questions on a separate sheet of paper.

1. State Newton’s third law of motion.
2. If you roll up to a wall on roller blades and push on the wall, what happens to your motion?
3. If you jump off a wagon and the wagon moves backwards, it is an example of Newton’s third law of motion. What is the action force? What is the reaction force?
4. How is jumping on a trampoline an example of Newton’s third law of motion? What is the action force? What is the reaction force?
5. How could you use bumper cars at a carnival to demonstrate Newton’s third law of motion?
6. Explain how this lab demonstrates Newton’s third law of motion.

**Post-Assessment**

**Directions:** Mark each of the following situations as an example of Newton’s First (1st), Second (2nd), or Third Law (3rd) on the blank before the number. Then explain in complete sentences how the situation is an example of that particular law.

\_\_\_\_1. A magician pulls a tablecloth out from under dishes and glasses on a table without disturbing them. **Explain Your Answer:**

\_\_\_\_2. A person’s body is thrown outward as a car rounds a curve on a highway.

**Explain Your Answer:**

\_\_\_\_3. Rockets are launched into space using jet propulsion where exhaust accelerates

 out from the rocket and the rocket accelerates in an opposite direction.

**Explain Your Answer:**

\_\_\_\_4. A picture is hanging on a wall and does not move. **Explain Your Answer:**

\_\_\_\_5. A person not wearing a seatbelt flies through a car window when someone slams

 slams on the breaks because the person’s body wants to remain in continuous

 motion even when the car stops. **Explain Your Answer:**

\_\_\_\_6. Pushing a child on a swing is easier than pushing an adult on the same swing,

 because the adult has more inertia. **Explain Your Answer:**

\_\_\_\_7. A soccer ball accelerates more than bowling ball when thrown with the same

 force. **Explain Your Answer:**

\_\_\_\_8. A soccer player kicks a ball with their foot and their toes are left stinging.

**Explain Your Answer:**

\_\_\_\_9. A student leaves a pencil on a desk and the pencil stays in the same spot until

 another student picks it up. **Explain Your Answer:**

\_\_\_\_10. Two students are in a baseball game. The first student hits a ball very hard and it

has a greater acceleration than the second student who bunts the ball lightly. **Explain Your Answer:**

\*\*In addition to the post-assessment quiz/worksheet students will have the opportunity to choose from several different project options in order to communicate/show the knowledge that they have gain from these lessons.

The options are:

* Students can create a poster/powerpoint/imovie/etc. to demonstrate Newton’s three laws of motion using pictures or video depending on the type of presentation they choose.
* Students can write an essay describing how Newton’s three laws are present or effect their every day lives.
* Students can create activities that would explain/illustrate Newton’s three laws of motion for the class to participate in.

Lessons are not a Katie Beard original. Lessons were found on the Internet, accessed several weeks ago. When trying to relocate the site in order to cite for the project, it was not available. I was only able to view via Google docs. The following url is what was provided by Google docs.

http://docs.google.com/viewer?a=v&q=cache:ILJKGKTsXC0J:sec.maypearlisd.org/download.axd%3Ffile%3D01f20bac-13c4-494f-b49f-b662f180c2fe%26dnldType%3DResource+Checker+challenge+newton's+first+law+of+motion&hl=en&gl=us&pid=bl&srcid=ADGEESi3UMIRb9mrhyMi19z0dhNXs8NuVkAAaOO9QYOE4CeYjDRA1lCEIbxpsb0jIMsdCLkSjHmoxdY33RzXKDLHMMnOfNucrXy8o6XvAv8cSppgsFJnMF7WJrlQYuZl1xk2Pvb5hnNz&sig=AHIEtbTAVlvQFAkEFT5h4J1ZRisY6XcHDA