ENERGY FUNDAMENTALS – LESSON PLAN 1.3

#

Newton's Second Law of Motion

This lesson is designed for 3rd – 5th grade students in a variety of school settings (public, private, STEM schools, and home schools) in the seven states served by local power companies and the Tennessee Valley Authority. Community groups (Scouts, 4-H, after school programs, and others) are encouraged to use it as well. This is one lesson from a three-part series designed to give students an age-appropriate, informed view of energy. As their understanding of energy grows, it will enable them to make informed decisions as good citizens or civic leaders.

This lesson plan is suitable for all types of educational settings. Each lesson can be adapted to meet a variety of class sizes, student skill levels, and time requirements.

Setting	Lesson Plan Selections Recommended for Use
Smaller class size, higher student ability, and /or longer class length	• The "Modeling" Section contains teaching content. • While in class, students can do "Guided Practice," complete the "Recommended Item(s)" and any additional guided practice items the teacher might select from "Other Resources." • NOTE: Some lesson plans do and some do not contain "Other Resources." • At home or on their own in class, students can do "Independent Practice," complete the "Recommended Item(s)" and any additional independent practice items the teacher selects from "Other Resources" (if provided in the plan).
Average class size, student ability, and class length	• The "Modeling" Section contains teaching content. • While in class, students complete "Recommended Item(s)" from "Guided Practice" section. • At home or on their own in class, students complete "Recommended Item(s)" from "Independent Practice" section.
Larger class size, lower student ability, and/or shorter class length	• The "Modeling" Section contains teaching content. • At home or on their own in class, students complete "Recommended Item(s)" from "Independent Practice" section.

Electrical Safety Reminder: Teachers should remind students that electricity is dangerous and that an adult should be present when any recommended activities or worksheets are being completed at home. Always obey instructions on warning labels and ensure one has dry hands when touching electronics or appliances.

Performance Objectives

By the end of this lesson, students will be able to:

- **Explain Newton's Second Law of Motion.**
- **Describe what causes an object to accelerate.**
- **Use Newton's Second Law equation, Force = mass x acceleration ($F = m \times a$), to solve word problems.**
- **Understand $F = m \times a$ can be used to solve for a ($a = F \div m$). Use this equation to find acceleration in word problems.**

Public School System Teaching Standards Covered

State Science Standards

- GA S3CS7 3rd
- KY 3.PS.2 3rd
- MS 9.a 4th
- NC 3.P.1.1 3rd
- NC 3.P.1.2 3rd
- NC 5.P.1.4 5th
- TN 3.GLE 0307.11.2 3rd
- TN GLE 0507.10.1 5th
- TN 0507.11.3 5th
- TN SPI 0507.11.1 5th

Common Core Language Arts/Reading

- GA ELA.CC4.RI.1,2,and 8 4th
- KY 3.RI.1,2, and 8 3rd
- CCR.R.10 MS 5th
- NC Integration and Knowledge of Ideas-Cluster 7, 8, 9 5th
- NC Key Ideas and Details-Cluster 1,2, 3 3rd

Common Core Mathematics

- 3.OA.A.3-KY, NC, TN 3rd
- 3.OA.4, 5, 7, 8 TN 3rd

I. Anticipatory Set (Attention Grabber)

Essential Question

What makes objects accelerate?

Display a block of foam and a brick; ask “Which do I have push harder, or apply more force, to make it move?” “Which do you think will go fastest?”

II. Modeling (Concepts to Teach)

Newton’s Second Law of Motion states that the acceleration produced by a net force on an object is directly proportional to the magnitude of the net force, is in the same direction as the net force, and is inversely proportional to the mass of the body. This means that whatever alteration is made to the net force, the same change will occur with the acceleration. Double, triple, or quadruple the net force, and the acceleration will do the same. On the other hand, whatever alteration is made of the mass, the opposite or inverse change will occur with the acceleration. Double, triple or quadruple the mass, and the acceleration will be one-half, one-third or one-fourth its original value. If both the net force and the mass are both doubled, then the acceleration will be unchanged.

Newton’s Second Law: **http://www.youtube.com/watch?v=nO7XeYPi2FU**

$a = F_{net} \div m$

or

$F_{net} = m \times a$

A semi-truck is a good example of a massive vehicle. In order to change its motion, a large net force must be applied. A go-kart is a good example of a less massive vehicle. In order to change its motion, only a small net force must be applied. This explains the need for “Runaway Ramps” on mountainous roads. Large vehicles have a hard time slowing down and need alternatives to change their motion.

Newton's Second Law of Motion: Acceleration is produced when a force acts upon a mass. The greater the mass (of the object being accelerated) the greater the amount of force needed (to accelerate the object).

The second law states that force equals mass times acceleration or $F = m \times a$. For example, the amount of force needed to move a 1,000kg object at 5 meters per second is 5,000 Newtons.

Read more: http://www.ehow.com/facts_5515989_example-newtons-three-laws-motion.html

SIMPLY: Pushing or pulling an object produces acceleration, a change in the speed of motion. Believe it or not, acceleration mean can be a slow-down OR a speed-up. The heavier the object, the more force it takes to make the object speed up or slow down. It takes more strength to push a bowling ball one foot than it does to push a marshmallow the distance of one foot.

III. Checking for Understanding

Teachers can ask students these questions to determine understanding of concepts.

REMEMBER	What does Newton's Second Law of Motion state? (Class discussion)
UNDERSTAND	Explain Newton's Second Law of Motion in your own words. (Class discussion)
APPLY	What is needed to cause an object to accelerate? Would a bowling ball and a marble roll at the same speed if pushed with the same force? Which would be faster? Which would stop sooner? (Class discussion)
ANALYZE	Read: **http://teachertech.rice.edu/Participants/louviere/Newton/law2.html**, the first two of Newton's Three Laws of Motion. Compare and contrast Newton's First Law of Motion with the Second Law using a Venn diagram. **http://www.learninggamesforkids.com/graphic_organizers/writing/venn-diagram.html**
EVALUATE	Would more force be needed to stop a school bus or a Smart Car? A paper airplane or a Frisbee? (Class discussion)

IV. Guided Practice Ideas

Recommended Items

Comet Cratering and Hot Wheels Experiments (see below)

Experiments

- **Comet Cratering**: **http://www.imcpl.org/kids/blog/?p=8871** to see *F* = *m* x *a* in action.
  This experiment keeps the acceleration the same/consistent by dropping all 3 marbles from the same distance (*F* = *m* x *a*, the *a* is the same). What is changing (the variable) is the mass of the object, thereby changing the force and making the craters larger in the bottom of the pan. Students should find that the larger the marble (the larger the mass), the larger the crater (the force it landed with was larger). Example to teach: *m* x *a* = *F*, so when *m* is changed, there is a different answer. For example, if *a* = 5 in *m* x *a* = *F*, if mass is 3, the force would be 15 Newtons because 3 x 5 = 15. But if mass is 4, the force would be 20 Newtons. The *F*, the *a*, and the *m* all affect each other. So to cause acceleration, mass or force needs to act on the acceleration. Students can use this experiment to show that if the mass is larger, the force will also be larger (using principals of multiplication). *F* = *m* x *a*

Force (*F* = *m* x *a*)	Mass	Acceleration
F = 15 Newtons	3	5
F = 20 Newtons	4	5
F = *x* Newtons	*m*	*a*

- **Hot Wheels Experiment**: **http://www.ehow.com/list_6952612_second-law-motion-experiments.html**
- **Spring Loaded and Toy Truck Ramp Project**: **http://www.ehow.com/list_6158774_science-newton_s-second-law-motion.html**
- **Drop a rock and a crumpled piece of paper from standing on top of a desk. Which lands first? Why?** **http://www.hometrainingtools.com/a/newton-s-laws-of-motion-science-projects**
- Use this formula *(F* = *m* x *a)* to measure force. Let's do an experiment with this formula: **http://www.racemath.info/forcesandpressure/what_is_f=ma.htm**.
  Apply/Analyze: If the acceleration is larger, what will happen to the force in the experiment? For instance, what if some marbles were dropped higher than others, giving them more room and more time to accelerate? What would be seen in the widths of the craters, as made by the force of the marbles? Try it and see.

  Find out what happens when the force is the same, but the mass is different: Students can try it with a ping pong ball and a baseball. If the same force is applied to roll each one, which one accelerates faster? (*a* = *F* ÷ *m)*. The smaller the mass, the more it can accelerate.

  Apply/Evaluate: If *F* = *m* x *a*, what is the math equation for *a*? (*a* = *F* ÷ *m*) For *m*? (*m* = *F* ÷ *a*) Students can do example problems solving for each equation. Use examples from **http://share.nanjing-school.com/sciences/files/2013/02/8Sci_FM_2ndLawWS-1fdv8aq.pdf**

V. Independent Practice Ideas

Recommended Items: Venn diagram; Poster/skit/story

- Journal on results of experiment (if the students have a journal). Teachers ask students to record the results of their experiment in their journals.
- Create an experiment that proves Newton's Second Law as true. Teachers can ask students to brainstorm ideas and teachers write them on the board. Students can conduct the experiments if materials are available.
- Complete a Venn diagram comparing Newton's First Law of Motion and Newton's Second Law. **http://www.learninggamesforkids.com/graphic_organizers/writing/venn-diagram.html**
- Create a poster, perform a skit, or write a story that explains Newton's Second Law of Motion.
- Acceleration Worksheet and Answer Key provided
- Newton's Second Law of Motion Worksheet: **https://d3jc3ahdjad7x7.cloudfront.net/znhVNmBOirAd3Bjuoi27oQ6C0iuc8IEBrpVWua55YBo2rSxy.pdf**

VI. Assessment

These items provide a check for understanding so teachers can easily determine whether concepts need to be reinforced. These items can be graded, if grades are desired.

- Acceleration Worksheet and Answer Key provided
- Journal (if completed as Independent Practice, as shown above)
- Venn diagram (if completed as Independent Practice, as shown above)
- Poster (if completed as Independent Practice, as shown above)

VII. Materials Needed

The following materials are needed for the Essential Question in the Anticipatory Set and the **Comet Cratering Experiment** in the Guided Practice Ideas section.

- Foam brick and real stone/brick, balls (Essential Question, Anticipatory Set)
- 3 marbles of different sizes, rulers, etc. (Comet Cratering experiment, Guided Practice)

VIII. Closing the Lesson

In addition to the Essential Question shown below, teachers can reference Performance Objectives at the top of the Lesson Plan.

Essential Question

What makes objects accelerate?

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WORKSHEET FOR NEWTON'S SECOND LAW OF MOTION LESSON 1.3

Acceleration

NAME: ______________________

Objective: Students will be able to explain Newton's Second Law of Motion, describe what causes an object to accelerate, and provide examples of objects with different masses.

1. How does net force impact acceleration?

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2. What is needed for an object to accelerate?

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3. Would more force be needed to stop a motorcycle or a semi-truck? Why?

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4. Draw and identify an object that is more or less massive than you. Would you need more or less force to move it?

5. Explain Newton's Second Law in your own words.

Answer Key

ANSWER KEY FOR WORKSHEET: ACCELERATION

1. **How does net force impact acceleration?**

   Ex. Whatever alteration is made to the net force being exerted upon an object, the same will be true for the acceleration of that object.

2. **What is needed for an object to accelerate?**

   Ex. Acceleration is produced when a force acts upon a mass.

3. **Would more force be needed to stop a motorcycle or a semi-truck? Why?**

   Ex. More force would be needed to stop a semi-truck because it has more mass than a motorcycle.

4. **Draw and identify an object that is more or less massive than you. Would you need more or less force to move it?**

   Example
   More mass is needed to move me than to move the cup.

5. **Explain Newton's Second Law in your own words.**

   Ex. A net force is required to move any object. The more mass an object has, the more net force is required to make it move.