

Go, Car, Go

Newton's 2nd Law of Motion

K20 Center, Alexandra Parsons
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Grade Level	9th Grade	**Time Frame**	3-4 class period(s)
Subject	Science	**Duration**	145 minutes
Course	Physical Science, Physics		

Essential Question

How do mass and speed affect one another?

Summary

This lesson is an investigation of the relationship between force, mass, and acceleration (F=ma). The lesson includes a lab activity, research poster, and reflection to introduce and reinforce Newton's 2nd Law of Motion.

Snapshot

Engage

Students will watch a video about a child lifting a car and connect it to Newton's Second Law through the Preflections strategy.

Explore

Students will conduct an experiment to investigate how force and mass affect the acceleration of a cart.

Explain

Students will create a research poster to communicate their investigation, data, and conclusions.

Extend

Students will use a CER framework to justify why *F=ma* explains their experimental results.

Evaluate

Students will design and solve real-world problems that apply Newton's Second Law.

Standards

ACT College and Career Readiness Standards - Science (6-12)

IOD403: Translate information into a table, graph, or diagram
SIN401: Understand a simple experimental design
EMI401: Determine which simple hypothesis, prediction, or conclusion is, or is not, consistent with a data presentation, model, or piece of information in text

Next Generation Science Standards (Grades 9, 10, 11, 12)

HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

Oklahoma Academic Standards for Science (Grades 9, 10, 11, 12)

PS.PS2.1: Analyze and interpret data to support the claim of a causal relationship between the net force on an object and its change in motion, as described in Newton's second law of motion.

Attachments

- Claim-Evidence-Reasoning - Go, Car, Go.docx
- Claim-Evidence-Reasoning - Go, Car, Go.pdf
- Create the Problem - Go, Car, Go .docx
- Create the Problem - Go, Car, Go .pdf
- Data Tables and Graph - Go, Car, Go.docx
- Data Tables and Graph - Go, Car, Go.pdf
- Guided Inquiry Hanging Mass Lab - Go, Car, Go.docx
- Guided Inquiry Hanging Mass Lab - Go, Car, Go.pdf
- Lesson Slides - Go, Car, Go.pptx
- Open Inquiry Hanging Mass Lab - Go, Car, Go .docx
- Open Inquiry Hanging Mass Lab - Go, Car, Go .pdf

Materials

- Lesson Slides (attached)
- Guided Inquiry Hanging Mass Lab handout (attached; one per student)
- Open Inquiry Hanging Mass Lab handout (attached; optional; one per student)
- Data Tables and Graph handout (attached; one per student)
- Claim-Evidence-Reasoning handout (attached; one per student)
- Create the Problem handout (attached; one per student)
- Projector and speakers
- Physic Carts or cars
- Pully + Clamp
- String (non-stretchy)
- Hanging masses (suggested: 25 g, 50 g, 75 g, 100 g, 125 g)
- Meter sticks or tape measure
- Balance scales
- Timers or stop watches
- Tape
- Safety goggles
- Lab handouts, one for each student
- Sticky easel pad paper
- Markers (Mr. Sketch, Sharpie, etc.)

10 minutes

Engage

Teacher's Note: Lab Selection and Preparation

This lesson provides options for both a guided inquiry lab and an open inquiry lab. Prior to starting the lesson, review the materials and structure for both options. This lesson is written with the intention that students will complete either the guided inquiry lab or the open inquiry lab. Select the option most suitable for your students and prepare the corresponding handout (s). Depending on classroom needs, you may wish to use the same type of lab for all students, or you may wish to use both types of labs for differentiation and support within your class.

Use **slides 1-4** to introduce the topic, objectives, and essential question to the extent that you feel necessary. Display **slide 5** and play the "Hero Kid Lifts Car Off Dad" YouTube video. Instruct students to pay attention to how mass and force influence motion and to notice connections to real-world examples they are already familiar with. After the video, move to **slide 6** and introduce the Preflections strategy. Explain that students will write down their initial thoughts about what they expect to learn in the lab. Provide the prompt: How does this video relate to Newton's Second Law? Allow two minutes of quiet writing time for students to record their responses, then collect the Preflection responses to be revisited after the lab.

45 minutes

Explore

Assign students to work in groups of 2–4, using the provided lab materials to investigate how the net force on a cart affects its acceleration. Give each student a copy of either the **Guided Inquiry Hanging Mass Lab** or the **Open Inquiry Hanging Mass Lab**, depending on the level of independence appropriate for the group. Explain that in the Guided Inquiry version (explained on **slides 7-8**), they are to follow structured steps to collect and analyze data, while in the Open Inquiry version (explained on **slides 9-10**), they will design and carry out the experiment themselves, making decisions about what to test, how to measure, and how to record their data. Emphasize that this is an opportunity to apply critical thinking and problem-solving skills, to observe patterns in data, and to explore the relationship between force, mass, and acceleration. Remind students to collaborate, make careful measurements, and take thorough notes because the quality of their observations and analysis will support their later reflections and lab report.

Teacher's Note: Sample Data Tables and Calculations

Slides 11-12 Provide examples of what data tables may look like. These tables are also available for student use in the **Data Tables and Graph** handout.

Slides 13-17 Provide sample calculations that may be helpful for students. The calculations provided are:

- Slide 13: Converting grams to kilograms
- Slide 14: Calculating average time
- Slide 15: Calculating measured acceleration
- Slide 16: Calculating force
- Slide 17: Calculating percent difference

45 minutes

Explain

After groups have completed their lab conclusions, use the Research Poster instructional strategy to enable the students to showcase their findings. Display **slide 18** and explain that the information included on the poster should reflect the different sections of the lab report they completed during the lab (Title, Goal, Hypothesis, Procedure, Data Tables, Graph, Analysis, and Conclusion) so that the poster is a clear and accurate summary of their investigation.

Teacher's Note: Research Posters

Research posters work particularly well for open inquiry labs, where groups may have tested different variables, used different methods, or observed slightly different outcomes, but they can also be engaging in guided inquiry by allowing creativity in presentation and design.

Provide students with guidelines about how to create an effective poster. For students who need additional assistance, direct them to https://guides.nyu.edu/posters. This is a resource that outlines what to include and provides assistance with how to lay it out. Emphasize to students the importance of clarity, readability, and visual organization. These qualities will make the findings easy to understand.

Once the posters have been completed, display them around the room. Move to **slide 19** and have each group share their main findings and conclusions. While students are presenting their findings, actively observe their understanding, identify misconceptions, and intervene as needed to clarify results or guide discussions.

Teacher's Note: Connecting Concepts

This is also a valuable opportunity to connect the lab data to Newton's Second Law and ensure that students can articulate the relationships between force, mass, and acceleration.

30 minutes

Extend

Teacher's Note: Framing and Understanding

By this point, students have carried out their own investigation, collected data, and likely noticed that greater applied force generally results in greater acceleration. However, their understanding needs to go beyond recognizing the pattern; they need to justify explicitly why $F = ma$ is the governing equation for their results.

Pass out the **Claim-Evidence-Reasoning** handout. Display **slide 20**. Have students frame their explanation as a CER (Claim, Evidence, Reasoning) response. Their claim should state that Newton's Second Law accurately describes the relationship between force, mass, and acceleration. Their evidence should draw directly from their lab data, comparing measured accelerations with the net force applied (from the hanging mass) and showing how changes in the system mass affected results. Their reasoning should connect these patterns to the physics principle: the net force on an object is what causes its acceleration, scaled by its mass.

Encourage them to:

- Use their graphs to support that acceleration is proportional to force when mass is constant and inversely proportional to mass when force is constant.
- Explicitly connect "the data shows this" to "the data shows this because Newton's Second Law predicts it."

Teacher's Note: C-E-R and Justification

This CER structure will help students move beyond observation into justification, strengthening their understanding that the mathematical relationship $F = ma$ is not just a formula, but a law supported by their own experiment.

15 minutes

Evaluate

Pass out the **Create the Problem** handout. Display **slide 21**. Using the Create the Problem strategy, explain to students that they will design their own real-world problem based on a given solution, such as "*F = 6 N*." They should include the object's mass, acceleration (or force), and a realistic context like a cart, bike, or ball. Display **slide 22** and ask students to solve their own problem to ensure it works and provide an explanation of how their problem demonstrates Newton's Second Law.

Next, display **slide 23** and have students trade problems with a partner and solve each other's scenario. At the end of the activity, instruct students to turn in their problems, solutions, and justifications for the teacher to review.

Teacher's Note: C-E-R and Reasoning

This activity reinforces CER reasoning while giving students an opportunity to apply their understanding in a new context.

Resources

- East Idaho News. (2017, March 3). *Idaho boy says angels helped him save his dad after a car fell on him* [Video]. YouTube. https://www.youtube.com/watch?v=I_dDPNOwx3U
- K20 Center. (n.d.). CER. Strategies. https://learn.k20center.ou.edu/strategy/156
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- Parker, J. (2014). Discovering Newton's 2nd law. *Better Lesson*. https://web.archive.org/web/20150803072455/https://betterlesson.com/lesson/633456/discovering-newton-s-2nd-law