Go, Car, Go

Newton's 2nd Law of Motion

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Grade Level	9th – 12th Grade	**Time Frame**	2-3 class period(s)
Subject	Mathematics, Science	**Duration**	120 minutes
Course	Algebra 1, Physical Science, Physics		

Essential Question

How do mass and speed effect each other?

Summary

This lesson is an investigation of the relationship between force, mass, and acceleration (F=ma). It's a classic investigation then determining conclusions kind of lesson, so multiple abilities of students can access the information.

Snapshot

Engage

Students will watch a video about a child lifting a car.

Explore

Students will run an experiment over the relationship between mass and final speed & acceleration.

Explain

Students will create a research poster over their findings.

Extend

Students will construct the mathematical formula for mass, acceleration, and force.

Evaluate

Students will use their formula to validate their experimental findings.

Standards

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

IOD202: Identify basic features of a table, graph, or diagram (e.g., units of measurement)
IOD301: Select two or more pieces of data from a simple data presentation
IOD304: Determine how the values of variables change as the value of another variable changes in a simple data presentation
IOD403: Translate information into a table, graph, or diagram
IOD504: Determine and/or use a simple (e.g., linear) mathematical relationship that exists between data
SIN301: Understand the methods used in a simple experiment
SIN401: Understand a simple experimental design
SIN403: Identify a control in an experiment
EMI401: Determine which simple hypothesis, prediction, or conclusion is, or is not, consistent with a data presentation, model, or piece of information in text
EMI501: Determine which simple hypothesis, prediction, or conclusion is, or is not, consistent with two or more data presentations, models, and/or pieces of information in text
EMI502: Determine whether presented information, or new information, supports or contradicts a simple hypothesis or conclusion, and why

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 (Physical Science)

CH.PS4.1.1: The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.

Oklahoma Academic Standards (Physical Science)

PS.PS1.1.1: Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.

Attachments

- Full Inquiry Lab Explore - Spanish.docx
- Full Inquiry Lab Explore - Spanish.pdf
- Full Inquiry Lab Explore.docx
- Full Inquiry Lab Explore.pdf
- Guided Inquiry Lab Explore - Spanish.docx
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Materials

- Projector and speakers
- Carts or cars
- Weights of some kind
- Yardsticks
- Timers
- Ramps
- Lab handouts, one for each student
- Sticky easel pad paper
- Markers (Mr. Sketch, Sharpie, etc.)

Engage

Start by playing this video about a son that had to use a jack to lift a car off his dad. After the video, ask the students what they found most interesting about the video.

Usual Observations

The observation that the boy was able to push the jack lever in the moment of crisis but not in a recreation is usually something that's mentioned. If you want to have kids rephrase using science words like force, you totally can.

Explore

Put the students in groups of 2-3 (preferably, if you have the supplies), and pass out the lab supplies (specifically the cars, weights, timers, and rulers/yardsticks, store bought or homemade ramps). Also pass out either the guided inquiry or the full inquiry lab sheet to each student.

To Inquire Or Not To Inquire?

Full inquiry labs are awesome for the students critical thinking and process skills, and they should be done in every classroom. HOWEVER, they are only awesome if the students have already done guided inquiry labs before, or are used to that level of independence. Do not use their lack of experience as an excuse to do traditional labs, because this lab is simple enough to be either guided or full inquiry. You know your students, you know what they can handle, but also think about how to push them farther.

Explain

After the groups are done with their lab conclusions, have the students create a Research Poster over their findings.

Worth It?

Honestly, research posters work best when the groups have different ideas and different approaches and different findings. Therefore, this would work best in the full inquiry option of the lab. However, that doesn't mean it can't be interesting in the guided inquiry, since each poster will be creative in different ways.

Making It Fab And Not A Flop

Research posters can be SUPER boring, or they can be SUPER useful. On the strategy card there is a student powerpoint that helps students learn how to make a 'good' research poster (what to include or not to include, how to lay it out, etc.) versus a 'bad' research poster. If students have never made a research poster before, helping them figure it out is a must.

After the posters are complete, display them around the room, and have each group share their main findings/conclusions.

Steering The Ship

Even though this is student's sharing, you aren't passive. You are using this as a chance to figure out where your students stand and intervene if they came up with bad results.

Extend

At this point, students may or may not (probably not, honestly) have came up with a mathematical equation to illustrate the correlation between mass and acceleration (or speed changes and time, if that's what they measured instead of some derivative of acceleration). So, now is the time to prompt them to derive that equation and apply it to their experiment.

This is done in a modified Create The Problem strategy, where students look at their data and trends and determine the equation from the trends.

This Will Probably Be Difficult

If students have never had to correlate general trends to mathematical functions, this will BLOW THEIR MINDS. Be ready for that. Do **not** derive the equation for them, but if they need help show them other equations and ask students if that relates to their situation. Examples like d=m/V or y=mx may help, since, as mass increases, volume also increases in the first example and as slope increases the x-value decreases in the second example. If you need more help or ideas of how to help students figure this out email astroukoff@ou.edu.

When they have come to the point of determining a mathematical relationship, tell the students that the mathematical correlation determines the amount of force exerted upon an object.

Unit Analysis!!!

This teacher's note has three exclamation marks because unit analysis is so so so important right now. Use the mathematical correlation, or formula, to determine the units of force (that is, a Newton is a g*m/s2).

Evaluate

Have students take their formula that they made in Extend back to their data from Explore. Have them plug their data into their formula to determine the amount of force exerted in each trial. If students can determine trends from that, allow them to, and add onto their research posters.

Resources

- Lab Inspiration (Explore): https://betterlesson.com/lesson/resource/3173363/f-ma-lab-write-up
- Research Poster (Explain): https://learn.k20center.ou.edu/strategy/1643efb18793d632c1f6f6639d0068ed
- Create The Problem (Extend): https://learn.k20center.ou.edu/strategy/d9908066f654727934df7bf4f506ae04
- Youtube video (Engage): https://www.youtube.com/watch?v=KiUUMnqnNXk