High School Physical Science

Day 1

Newton's Second Law

Isaac Newton is considered one of the most important scientists in history. He was born in 1643 and died in 1727 – almost 300 years ago. He studied physics and developed three laws describing and governing motion. We're going to explore these laws, examine what they mean, and learn to apply them.

Rephrase, in a complete sentence, what Newton did that was so important.

Activity

For this activity you will need the following items:

- A small cloth (like a wash cloth or a small towel),
- a mug or heavy coffee cup, and
- some water

Place the small cloth on the table or counter.

Pull on the cloth with just enough force to cause the cloth to just begin to move – as you pull, observe how hard you have to pull.

Describe how large the force must be to pull the cloth. (Words to consider: easy, tough, hard, lightly, large, small)

Place the cup on the small cloth.

Pull on the with just enough force to cause the cloth + cup to just begin to move – as you pull, observe how hard you have to pull. Describe how large the force must be to pull the cloth + cup. (Words to consider: easier, harder, tougher, larger, smaller)

Now fill the cup with water to about 1 cm below the top. Make sure the bottom of the cup is dry on the outside. Place the filled cup on the small cloth. Pull on the cloth with just enough force to cause the cloth + cup + water to just begin to move – as you pull, observe how hard you have to pull. Describe how large the force must be to pull the cloth + cup. (Words to consider: easiest, hardest, difficult, largest, smallest)

Since we didn't take any measurements, the data is considered qualitative. Qualitative means values and observations are not absolute (or a specific value) but usually compared (or relative) to something else.

Summarize your observations in Table 1. (Words to consider: light, heavy, easy, hard.) Remember these are comparisons so you may have to modify the words to compare the masses to each other and to compare the forces to each other.

Table 1 - Summary of Observations

Trial	Mass of the System	The Force Applied
1 – Cloth Only		
2 – Cloth + Empty Cup		
3 – Cloth + Full Cup		

Examine the evidence in Table 1.

Write a claim that answers, "How does the force applied to cause motion of a system change as the mass of the system changes?"

State the reasoning that connects the evidence in support of the claim.

In the space below, sketch Trial 1 (cloth only) and Trial 3 (cloth + full cup). Using arrows, show the direction you applied the forces to pull the cloth; use a larger arrow for the system that required the larger force.
[If you are drawing on a computer, go to the INSERT tab, choose SHAPES, and LINES. The last object in LINES is a scribble. When selected, it will turn into a pencil that lets you draw. When you lift your finger/mouse, the cursor goes back to normal.]

Day 2

Newton's First Law

Newton's first law essentially states, "unless acted upon by an unbalanced force an object at rest will stay at rest and an object in motion will continue on in that motion." After reading Newton's first law most people typically think – Duh. But let's look at the story of Newton's apple. There he was sitting in the garden and an apple fell from the apple tree. Most of us would probably think, "Yay – an apple!" But Newton thought, "Hmmmmm, why didn't that apple just stay where it was when the stem broke – what caused the apple to fall? Why does everything fall?" Newton's insight to question, "Why?" (to a whole bunch of things) is what led Newton to consider and ultimately figure out how to describe the effects of gravity.

Think of a behavior or something wondrous you have observed in your life that made you question, "Why or how?" State your question below.

Activity

For this activity you will need the following items:

- a playing card (like for Uno, a standard deck of cards, or an index card),
- a few coins (pennies will work)
- a mug or heavy coffee cup

Place the playing card on top of the cup. Place the coin in the center of the card, over the center of the cup. With the motion like you're flicking a fly off your arm with your thumb and index finger, flick the card off the top of the cup (try to flick the card so it stays level). Try it a few times. Describe what happens with the coin (Complete sentences please. Words to consider: fall, slide, bounce, slip, inertia, flick, mass.)

If things worked well, the card should have moved across the top of the cup while the coin remained in place. The coin would have then fallen into the cup. Keep trying until you can get the system to work.

What do you think would happen if you increased the mass? Decreased the mass? Predict what you think will happen if you stack another coin on top of the first coin.

Stack another coin on top of the first coin. Repeat the experiment. Describe what happens with two coins; can you get the same behavior from the coins now that there is more mass? Is it harder or easier to get the same response?

Summarize your observations below. This time, in your summary consider not just the mass, but how you had to change what you did. (Words to consider: flick, hard, soft, fast, fall, mass, heavier, lighter, slip, fall, drop)

Is there a limiting condition? A limiting condition is a condition where the experiment doesn't work anymore. Can you add too many coins? Predict and justify (with an example) if you think there is a limiting condition for too much mass.

Try something that has less mass than a coin, like a button or a piece of paper. Is there a limiting condition where you can have *too little mass* for this investigation to work? Predict and justify (with an example) if you think there is a limiting condition for too little mass.

This investigation reflects what Newton was saying in his first law; also called the Law of Inertia.

Day 3

Newton's First Law--Continued

What is inertia? Reflect on the activities you did in Lesson 10. The only thing that changed about the investigation was the mass of the material on the card.

Newton's First Law can be stated:

*An **object** at rest remains at rest and an **object** in motion remains in motion until it is acted upon by **an unbalanced force**.*

- Cross out and replace the word ***object*** in the statement above to ***mass***. All objects have mass.

Inertia is defined as: the tendency to do nothing or to remain unchanged.

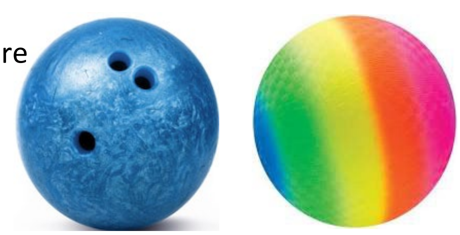
Reflect on your demonstration and the definition of inertia to complete the following sentence:

Inertia depends only on

Let's examine the second part of Newton's First Law – an unbalanced force. It might be obvious what that means, but just in case: If two rugby teams are huddled (scrum) and pushing against each other and going nowhere, their forces are balanced. But after a while the forces become unbalanced and the scrum begins to move. Using this example (or one of your own) define unbalanced force:

One of the main points of Newton's First Law is that it ties motion and how things move (or don't move) to the object's mass – not the object's size, not the object's shape (think satellites), not what the object is made out of – just mass.

Reflect back on this investigation and consider the two balls in the image provided; a bowling ball and a playground ball. Explain which ball will require a larger force to get the ball to move; cite Newton's First Law in your explanation. (Words to consider: mass, force, roll, inertia, unbalanced.)



Day 4

Newton's Third Law

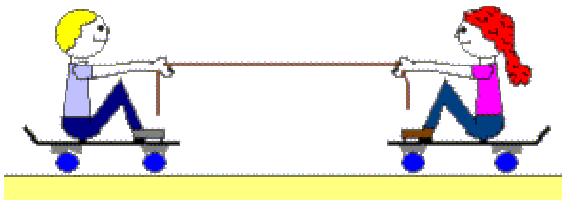
Newton was attending Cambridge (a very prestigious university in England) in 1665 when the Great Plague caused him to return to his home to shelter in place (Covid-19 is not the first pandemic to hit civilization). Upon his return home, he began developing his theories on calculus, light, and color. However, it wasn't until 1687 that Newton published the book "Principia" that shared his work on the laws of motion and gravity. (History, 2020)

Newton returned home to a remote farm with little to no daily contact with others besides his servants. At that time, the only means of communication was by letters sent via personal messenger. Reflect on the time Newton had to shelter in place; consider the challenges he faced compared with the challenges you face.

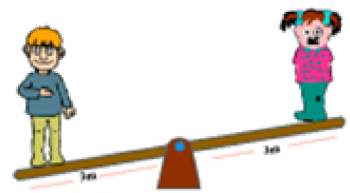
Explain why *you* would prefer to shelter in place in a crowded city with technology <u>or</u> shelter in place at a remote farm with only letters to communicate.

Newton's third law states: *For every action there is an equal and opposite reaction*.

A



B



C

Look at Images A, B, and C. While considering Newton's Laws, select one of each of the sentence strand choices in the table to complete the each sentence below.

Sentence Strand Choices

Forces	* Equal and opposite * Not equal but opposite
Motion	* Motion * No motion
Inertia	* Inertia * No inertia

Image A

The boy and the ball indicate the forces are ________________________________ , there is ______________ ________________, all matter has ________________ .

Image B

The two students on the skateboards indicate the forces are __________________________, there is ___ _______________, all matter has ____________________ .

Image C

The two students on the teeter-totter indicate the forces are __________________________, there is ___ _______________, all matter has ____________________ .

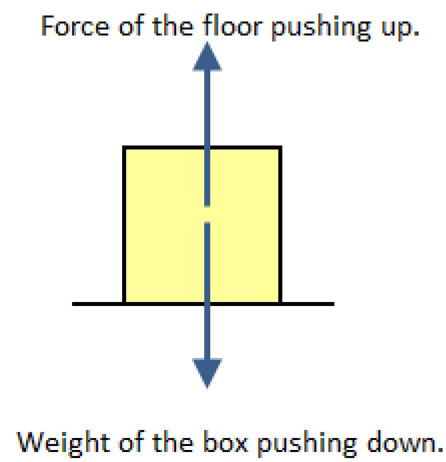
Day 5

Newton's Third Law--Continued

Go to the middle of the floor and jump. (Try not to disturb your neighbors or your family, though.)
Jump a couple of times and pay attention as you jump – what does the floor feel like on the bottom of your feet as you prepare to jump?

You can jump because as you push on the floor to jump, the floor pushes back with an equal and opposite force. If you wanted to jump higher you would have to push with more force – the floor would push with more force. Imagine instead that the floor gave way as you tried to jump. This would be like trying to put a cup of water on a floating helium balloon. The balloon cannot provide an equal and opposite force to the cup and the cup would fall until something could push back.
Think of that next time you jump.

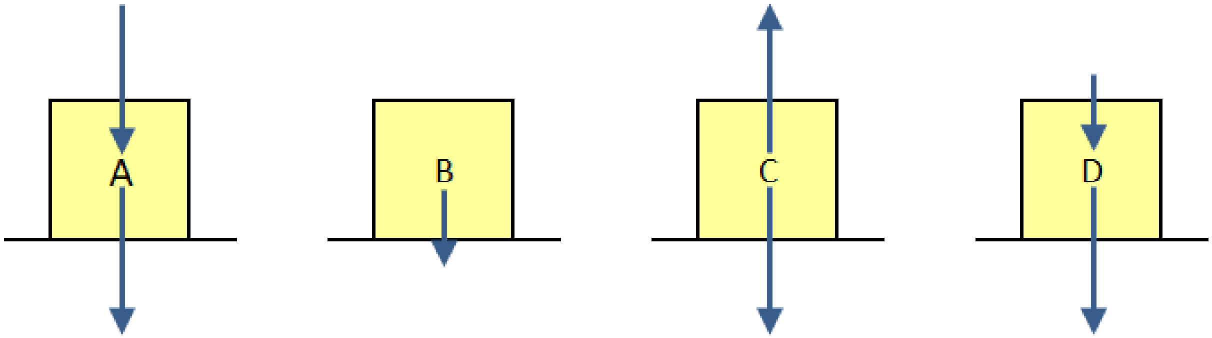
Drawing vectors and free body diagrams are an easy way for a scientist to explain what's going on in a system. We will briefly review drawing free body diagrams and then practice.



Look at the image. It shows a box resting on the floor. The weight of the box is pushing on the floor, the floor is holding the box up with an equal, but opposite, force. These arrows are called vectors. The direction of the vector is the direction of the force. The lengths of the vector show which force is greater or if they are equal.

Remember the unbalanced force that Newton's first law mentioned? If the forces on the box weren't balanced, motion could occur. But thankfully, the box and the floor always react with equal and opposite forces.

Look at the free body diagrams A, B, C and D. In the Free Body Diagram Summary Table indicate the relationships between the forces and predict if you think motion would occur.



Free Body Diagram Summary Table

Forces	Box	Would motion occur? (Y or N)
equal and opposite		
equal and same		
unequal and opposite		
unequal and same		

Look at the free body diagrams A, B, C and D again. Which diagram represents the cup on the helium balloon? Which box represents your jump? Justify your answers for both questions.

You won't need to draw free body diagrams with this online learning class. However, remembering what they are and what they represent will be helpful in the next activity.

References

https://www.teachengineering.org/lessons/view/ucd_newton_lesson03
https://www.history.com/topics/inventions/isaac-newton

Day 6

Applying Newton's Laws

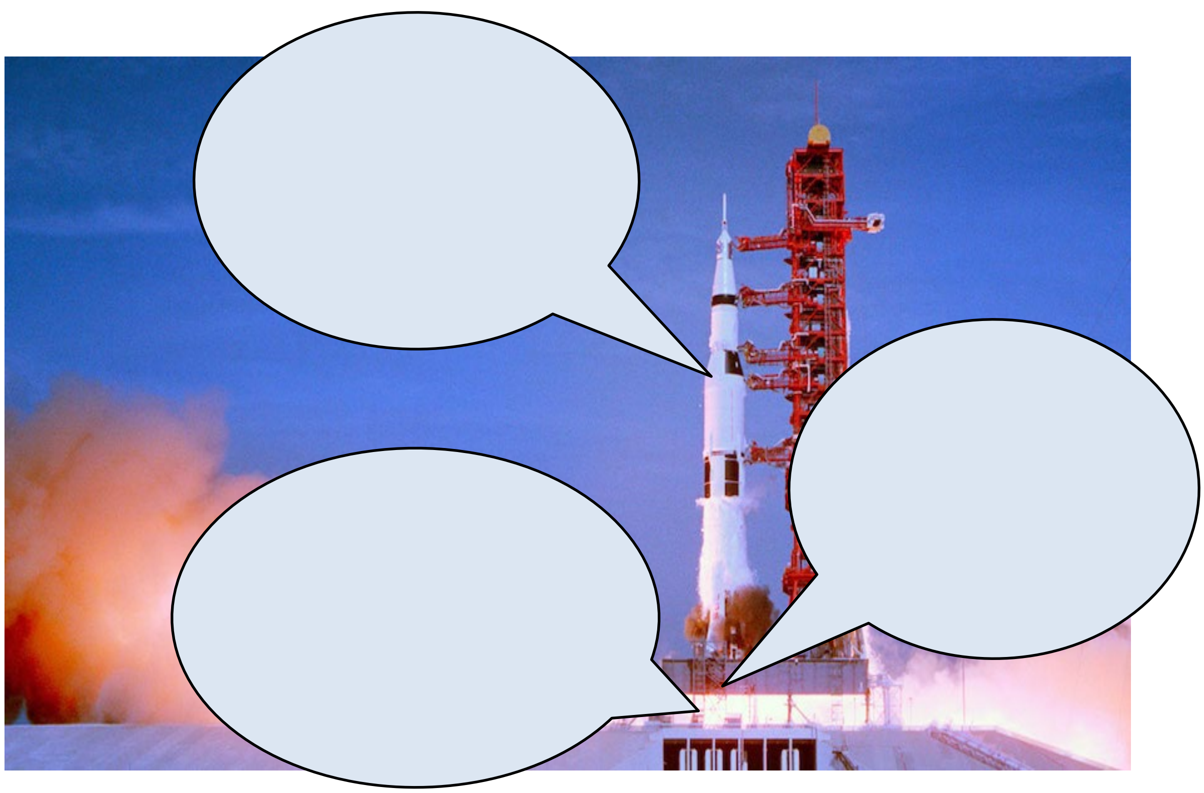
Newton didn't get to live long enough to see the technology that his science brought to the rest of us. In this lesson, we are going to explore the world of rockets and examine how Newton's Laws are the underlying science for the launch of rockets.

It was almost 250 years after Newton published his ideas on motion and gravity when Robert Goddard designed and built the first liquid fuel rocket. Goddard's rocket only flew for 2 ½ seconds and 41 feet – but our first meaningful attempts at something are almost always met with some part that's successful and a big part that can be improved. It only took 40 more years for the USA to use a rocket to launch a team of astronauts to the moon. Today's rockets travel fast and far to deliver their payload or to explore the vastness of space. Voyager 1 has been traveling for more than 30 years and is currently approximately 10 billion miles from Earth (That's 100,000 miles per day.). (NASA, 2020)

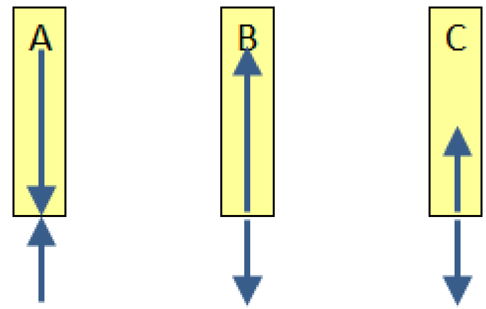
Activity

Look at the image of the rocket. Write/type one of the following phrases into each of the bubbles below.

- A body at rest will stay at rest unless acted upon by an unbalanced force.
- An unbalanced force acting on an object will cause the object to accelerate.
- For every action there is an equal and opposite reaction.



Now that you've examined the image of the rocket during takeoff, select the free-body diagram (A, B, or C) which best represents the forces on the rocket at liftoff. Explain why you chose the one you did. Use the appropriate Newton's Law in your explanation. (Words to consider: gravity, force, liftoff, thrust (push), ground, inertia, mass, acceleration)



Complete the graphic organizer below. Review what you have explored over the past few lessons to develop your reasoning. Reference (identify) and apply Newton's Laws when stating your reasoning.

The Claim, Evidence and Reasoning of Rocket Science

Question to answer: How does a rocket launch?	
Evidence (Analyzed data and interpretation of the data)	**Reasoning** (Scientific ideas, principles, theories)
A larger force was applied to the system to move a larger mass (cup and cup + water).	
The inertia (mass) of the coin caused the coin to stay in the same place even though the card underneath moved.	
When I jumped from the floor the floor pushed back. The harder I jumped, the harder the floor pushed back.	
Claim: (Answer to the question)	
Write an explanation paragraph that answers the question and that applies and connects your evidence with your scientific reasoning.	