ANDRETTI FASTTRACK XPERIENCE | KIA Official Partner

LESSON 2:
Newton's Second Law

NEXT GENERATION SCIENCE STANDARD
MS-PS2-2 Motion and Stability: Forces and Interactions

Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Time: 1-2 50 minute classes

Lab 1:

The purpose of this lesson is to help students better understand Newton's Second Law of Motion which is defined as

The motion of an object is determined by the sum of the forces acting on it.

If the total force on the object is not zero, its motion will change.

The greater the mass of the object, the greater the force needed to achieve the same change in motion.

For any given object, a larger force causes a larger change in motion.

It is suggested that the instructor start with a discussion about each of these variables (force, mass, change of motion) by using a simulation on PHET.

https://phet.colorado.edu/sims/html/forces-and-motion-basics/latest/forces-and-motion-basics_en.html

Open "Motion" option.

Here's a sample dialogue:

Questions	Possible Answers
Show the person pushing to the right with a force of 100 N. What happens to the motion of the cart?	**Velocity increases to the right is a good starting answer.**
If this force is applied for a while, the person eventually falls. Why?	**Cart keeps going faster and the person can't run that fast.**
After the person falls, the cart keeps going. Why? What force acts on the cart to keep it going?	**Newton's First Law, Objects in motion stay in motion. No forces required.**
Let's try a bigger force now. Let's apply a force of 200 N to the right. How does this compare to the 100 N force? What evidence do you have?	**Motion speeds up faster. Looks like it speeds up faster, person falls down faster.**
Let's go back to the 100 N force, and let's increase the mass of the car. We'll place a person on top. What do you notice now?	**Doesn't speed up as fast.**
Let's try the 100 N force and two people on top. What do you notice?	**Speeds up even slower.**
Let's try placing a 200 N force to the left on the cart. What's your prediction of what will happen? Have students answer before showing the result.	**It will speed up in the other direction.**
Would you say there is a connection between the mass of the cart, the net force on the cart and change of motion of the cart? Have students give some observations.	**An increase of the force increases the way the motion changes. Increasing the mass makes the motion change slower. The change of motion is in the direction of the net force.**

Lab 2: Relationship Between Variables

Let the students know that they will plan an investigation to determine a relationship between these three variables. The students are to plan an investigation to find a relationship between mass, force and acceleration. You may want to review independent, dependent and control variables.

If the students struggle with an idea for an investigation, you may want to provide a few ideas to get them started.

A) Students can use the same PHET program to collect data and find relationships.

B) Students can use a rubber band and water bottle to find a relationship. For example, the student can launch a water bottle on the ground with a rubber band. The force can be varied by changing the pull back distance of the rubber band. The mass of the water bottle can be varied by changing the amount of water in the bottle.

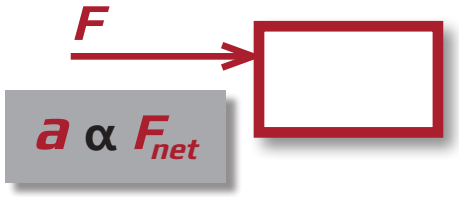
C) Students can download the "Physics Toolbox Suite" app or an app with an accelerometer on their cell phones which measures acceleration. (change in motion) The students can then use this tool to measure acceleration as needed.

D) Students can push another student on a rolling chair to find the desired relationships. Maintaining a constant force may be difficult with this set up.

Upon finishing the experiment have the students whiteboard their results and present it to the rest of the class. They should show some type of graphic for each relationship found. Have the class combine their results and develop a few overall models that are consistent with the data found.

The desired results are as follows:

The change of motion (acceleration) of an object is directly proportional to the net force on the object.



- If the net force is doubled, the acceleration will double.
- If the net force is tripled, the acceleration will triple.

The **acceleration** of an object is inversely proportional to the **mass** of the object.

$$a \propto \frac{1}{m}$$

If the net force on an object is constant and:

- Mass is doubled, then the acceleration will be cut in half.
- Mass is tripled, then the acceleration will be cut by 3.

Lab 2 Student Worksheet - Motion of an Object

1) A net force of 3000 N is applied to Jeff's car and causes it to accelerate at 4 m/s/s. If the net force is doubled, find his new acceleration.

2) A net force is applied to Mario Andretti's car and causes it to accelerate at 4 m/s/s. If the mass of the car is doubled (because it was filled with fuel), and the same net force is applied, what happens to the acceleration?

3) A net force of 4500 N is applied to Jeff's car and causes it to accelerate at 6 m/s/s. After the first turn, Jeff pushes the pedal hard and causes the net force to triple, find his new acceleration.

4) A force of 4000 N is applied to a car and causes it to accelerate at 4 m/s/s. If the net force is tripled and the mass of the car is doubled, determine the new acceleration.

5) An egg is thrown against a wall and breaks. The same egg is thrown against a vertical sheet and doesn't break. Explain how this is possible.

6) How can the concept in problem 5 above be used to help solve the challenge problem?

Lab 2 Student Worksheet - Motion of an Object

ANSWER KEY

1) A net force of 3000 N is applied to Jeff's car and causes it to accelerate at 4 m/s/s. If the net force is doubled, find his new acceleration.

8 m/s/s

2) A net force is applied to Mario Andretti's car and causes it to accelerate at 4 m/s/s. If the mass of the car is doubled (because it was filled with fuel), and the same net force is applied, what happens to the acceleration?

2 m/s/s

3) A net force of 4500 N is applied to Jeff's car and causes it to accelerate at 6 m/s/s. After the first turn, Jeff pushes the pedal hard and causes the net force to triple, find his new acceleration.

18 m/s/s

4) A force of 4000 N is applied to a car and causes it to accelerate at 4 m/s/s. If the net force is tripled and the mass of the car is doubled, determine the new acceleration.

(4 m/s/s)(3)(1/2) = 6 m/s/s

5) An egg is thrown against a wall and breaks. The same egg is thrown against a vertical sheet and doesn't break. Explain how this is possible.

The egg takes longer to stop, which means the change in motion is less (less acceleration) so there is less net force applied to the egg.

6) How can the concept in problem 5 above be used to help solve the challenge problem?

Good question ☺ !! Many answers depending on how you decide to solve the challenge problem.