Newton's first law of motion

The ingenious English mathematician and physicist Sir Isaac Newton (1642 -1727) was the first to fully understand how objects actually move, expressing his three famous *laws of motion*. For this and many other discoveries he is recognised as one of the most influential scientists of all times.

Discover:
- How a force causes movement?
- What is Newton's first law of motion?

Level Of Difficulty ★★★★★

Materials Needed:
- Engino® Newton's Laws (STEM07).

Procedure:

1. Find the instructions online and build the **moving cabin** model.

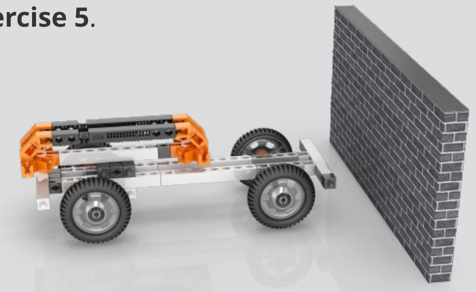
2. Place the model on a flat surface. Obviously it does not move by itself. Explain why in **exercise 1**.

3. Place the **cabin in the middle** and move your vehicle smoothly, holding it by the large rod on the edge. Observe how the cabin moves and answer **question 2**.

4. Keep the **cabin in the middle** and push the vehicle **sharply** this time. Observe again how the cabin moves and answer **question 3**.

5. For the final test, you are going to imitate an accident. Place the **cabin on one edge** and push the vehicle **sharply** from the large rod onto a wall or any other strong obstacle. **Be careful not to push too hard and have pieces flying around, as there is a risk of injury!** Make sure you **pick up any falling pieces**. Write your observations about the vehicle and how the cabin moved in **exercise 4**.

6. Read carefully Newton's first law of motion on the right and explain all your findings according to it about the cabin's motion in **exercise 5**.

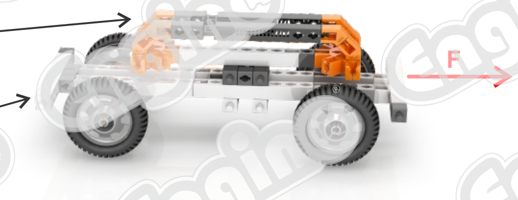


Push the model onto a wall and observe the cabin's movement.

1. Explain why the model stands still in step 2 of the experiment in reference to the sum of forces applied.

The model is not moving because there is no force acting on it big enough to exceed its inertia (mass) and set it into motion. In other words the sum of forces applied equals to zero or is very weak.

2. When the model is **moving smoothly** in step 3, how does the cabin move? Draw the sum of forces in the picture below.



When the vehicle is moving smoothly, the cabin also moves along with it in a smooth way. Therefore it stays in the same place, thus the middle of the model.

3. When the model is **pushed sharply** in step 4, how does the cabin move?

When the vehicle is pushed sharply, the cabin moves to the back side of it.

4. What happens to the vehicle when you **push it onto to the wall** in step 5? How does the cabin move this time?

When the vehicle is pushed onto a hard object, it stops completely and some pieces fall off. The cabin moves to the front of the vehicle.

5. Read Newton's first law of motion and discuss your findings according to it about the cabin's movement in steps 2, 3, 4 and 5.

> ***Newton's first law of motion:***
> *"Every object remains at rest or continues to move at a constant velocity, unless acted upon by an external force."*

In steps 2 and 3, the velocity is zero or constant, so the cabin stays in the middle. In steps 4 and 5, the force is sudden and the cabin "wants" to keep its velocity. This "unwillingness" to move in sudden changes is called ***inertia****. So, in step 4, the cabin is at rest and wants to keep this state by staying back. In step 5, the cabin is moving forward and tries to keep this after the hit.*

Newton's second law of motion

Another great scientist contributed to the discovery of the properties of forces and acceleration long before Newton's time: the Italian physicist Galileo Galilei (1564 - 1642). He was rolling balls down various inclined planes and came up with formulas, which were finally explained by Newton centuries after!

Discover:
- What is Newton's second law of motion?
- How force acting upon an object is related to the object's mass and acceleration?

Level Of Difficulty ★★★★★

Materials Needed:
- Engino® Newton's Laws (STEM07).
- Long rubber band and measure tape.

Procedure:

1. Find the instructions in **pages 24-28** and build the **ballistic catapult** model. Pass the rubber band twice through the holes and tie it in the end. Remove the wheels to use them as projectiles for the tests below.

2. For safety reasons, is better you conduct the experiment outdoors and make sure no one is standing in front of the catapult when it is loaded and ready to shoot. Also, be careful with the rubber band, as it can break under high tension.

3. In all launches is important that **two factors are kept constant**: the tension of the rubber band and the shooting point.

4. For **test 1**, place your catapult at a fixed point and load it with one wheel-pulley assembly (as shown in the table, projectile column). Hold the catapult with one hand and release the medium rod. A second person is required to see the exact point where the projectile touched first. With the help of a measure tape, find the distance between the catapult and that point and write it on the table (**1a**). Repeat the same procedure two more times and write the results for **1b** and **1c**. Then calculate the **average distance** by adding the 3 together and dividing by 3.

5. For **test 2** and **test 3**, add one and two wheel-pulley assemblies and repeat the same as before. Write the results in **2a, 2b, 2c** and **3a, 3b, 3c** and calculate the average distances.

6. Answer all the questions that follow. When you finish do not disassemble your model, as you will need it for the next experiment also.

1. Complete the table according to your measurements from the experiment.

Test	Projectile (number of wheels)		Projectile's distance (m)		Average distance (m)
1.		1	(a)	*1.54*	*1.61*
			(b)	*1.66*	
			(c)	*1.63*	
2.		2	(a)	*1.30*	*1.27*
			(b)	*1.24*	
			(c)	*1.27*	
3.		3	(a)	*0.70*	*0.76*
			(b)	*0.74*	
			(c)	*0.84*	

2. Compare the average distances in all 3 tests. What do you observe?

The results show that the lighter the projectile (e.g. one wheel) the larger average distance it covers and vice versa.

3. Read about Newton's second law of motion below and explain your observations from the experiment. Keep in mind that the force (rubber band's tension) is the same in all cases.

> **Newton's second law of motion:**
> *"The sum of forces* ***F*** *acting on an object is equal to the mass* ***m*** *of the object multiplied by the acceleration* ***a*** *of the object."*
> $$F = m.a$$

According to the observations above, as force is constant, mass and acceleration are inversely proportional to each other.

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