Learning about: **Wheels, Axles & Inclined Planes**

Wheel size and friction

When you see a truck or a tractor the first thing you notice is the size of their enormous wheels. Besides support, do you know for what other reason these wheels are used? Also, in a formula car race the driver must make one pit stop in order to change the wheels. Follow the next experiment to find out why.

Discover:
- What is the wheel and axle mechanism?
- What difference does it make if we use big or small wheels?
- What is friction?

Level Of Difficulty ★★★☆☆

Materials Needed:
- Engino® Simple Machines (STEM40) or Wheels, Axles & Inclined Planes (STEM02).
- A ruler and various materials as surfaces.

Procedure:

1. Find the instructions online and build the **launching platform** model.

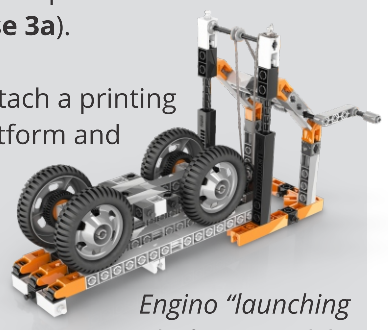
2. For **test A**, place your experimental car with the big wheels on the elevating platform, as close to the extendable rod as possible and turn the crank slowly. When the car starts moving down the platform, stop turning the crank.

3. Measure the height at which the platform has been elevated placing a ruler from the base of the platform (2nd hole of the extendable rod). Write your measurement in the table for **case 1**.

4. For **case 2,** remove the big wheels from the experimental car and replace them with the small ones. Repeat the procedure like in step 3 and complete the table.

5. In **test B** we are going to explore the properties of friction. Take the vehicle without any wheels (see picture on the right) and repeat the same procedure as the previous test (**case 3a**).

6. For **case 3b**, attach a printing paper on the platform and measure the elevation again. Repeat the test using three other materials: paperboard (**case 3c**), sticky tape (**case 3d**) and sandpaper (**case 3e**). Complete the second table with your observations.



Engino "launching platform" model

1. Complete the following table according to your observations in **test A**.

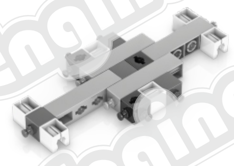
Test A	Type of vehicle	Elevation (cm)
case 1		*3*
case 2		*7*

2. In which case did you notice the smallest elevation? What is your conclusion about the size of the wheels?

The smallest elevation is observed in case 1. The bigger the wheels, the more M.A. is gained from the wheel and axle machine, so the car needs less elevation to overcome static friction as it has more force.

3. Complete the following table according to your observations in **test B**.

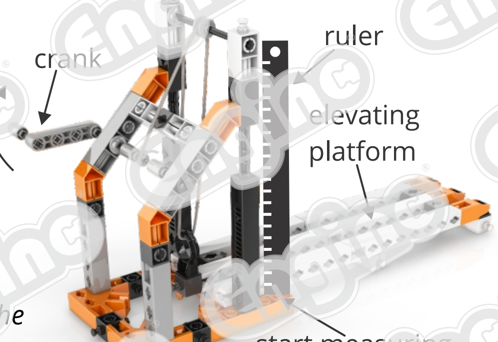
Test B	Surface of the platform	Elevation (cm)
case 3a	initial surface	*4*
case 3b	printing paper	*5*
case 3c	paperboard	*8*
case 3d	sticky tape	*7*
case 3e	sandpaper	*12*



Vehicle for the second test. Use only this type for test B, which is about friction.

4. In which case did you measure the biggest elevation? Why did this happen?

The biggest elevation occurs in case 3e. The rougher the surface of the material, the more difficult it gets for the car to slide, due to the increased friction between the sandpaper and Engino parts.



Elevating platform's elements

Learning about: **Wheels, Axles & Inclined Planes**

Wheel and axle as a lever

There are many types of doors that open and close in a variety of ways. Some of them function automatically. In ordinary doors there are two main ways of use: the **knob** and the **handle**. Do they work in the same principle? Find out through the next experiment.

Discover:
- Is there any other way that the wheel and axle mechanism can be used?

Level Of Difficulty ★★☆☆☆

Materials Needed:
- Engino® Simple Machines (STEM40) or Wheels, Axles & Inclined Planes (STEM02).

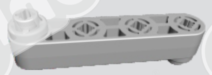
Procedure:

1. Find the instructions online and build the **door with knob** model.

2. Play a bit with your model in order to understand how it works. Observe how the wheel and axle are connected together. Is it a **"fixed"** wheel and axle mechanism or a **"free rotation"** one?

3. Observe also the locking mechanism that is fixed on the axle. As the wheel and axle turn, the lock turns in the same direction securing the door.

4. Now, remove the wheel from the model and replace it with a crank (see picture below). Try to open the locking mechanism again. You will notice that practically nothing changes and the door opens in the same way as before.



Engino® crank

Engino® "door with knob" model

1. Place an arrow on the knob (wheel) and on the crank to show the direction we need to apply our force in order to unlock the door.

2. Are the arrows pointing in the same direction? Do we have the same result in both cases? What does this mean?

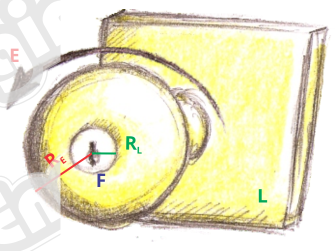
*Yes, the arrows are pointing in the same direction and the result is the same (door opens). This means that the wheel and axle mechanism works as a **lever able to rotate 360°**.*

3. What is the mechanical advantage of the Engino® "door with knob" model?

The mechanical advantage (M.A.) can be found by measuring the radii of the wheel and axle in mm and applying the formula below:

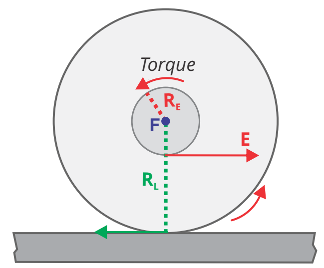
$$M.A. = \frac{\text{wheel radius}}{\text{axle radius}} = \frac{30\text{ mm}}{1.5\text{ mm}} \Rightarrow \mathbf{M.A. = 20}$$

4. In the following examples the wheel and axle mechanism behaves as two different types of levers. Can you identify the correct class of lever for each case? A schematic of the forces applied is provided in order to help you.



A door's wheel and axle mechanism

Wheel and axle working as a ....*first*........-class lever



A car's wheel and axle mechanism

Wheel and axle working as a ....*third*........-class lever