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The Pascaline

Name of the object	Pascaline or Arithmetic Machine
Recommended ages	10 - 15 years old
Thematic areas combined (STEAM)	Engineering, Mathematics, Technology
Materials needed	• Lego (if it is possible, parts from Lego Technic) • Paper Card • Angle protractor
Instructions step by step	Step by step, we will show how to make a working Lego calculator that can be used for addition (+), subtraction (-), multiplication (x) and division (/). It uses a gear train that converts one rotation of the control knob into one tenth of a rotation on the tens dial. By engaging, turning to numbers, and disengaging the control knob in patterns, you can do basic arithmetic. Based on the Pascaline, created by Blaise Pascal in 1644. **Step 0**: Preliminary introduction to Lego gears. **Step 1**: Build a Lego structure to receive the gears engine. **Step 2**: Build three systems of gears. **Step 3**: Connect all the parts. **Step 4**: Create the numbers display. **Step 5**: How does it work?

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Step by step: how to build the "Pascaline"

Step 0. Preliminary introduction to Lego Gears

Time required: 10 minutes

It is necessary to have a good understanding of how Lego gears work. In the image below you can see the different shapes of gears and their relationship to the teeth that make them up.

You can download the discontinued gears for a 3D printer from the following website: https://www.thingiverse.com/thing:4258996

Step 1. Build a Lego structure to receive the gears engine

Time needed: 10 minutes

Build the base with two levels of flat Lego boards with dimensions of 18 x 6 pins each. (Images 1 and 2).

The walls to hold the gears should be made of Lego Technic bricks, with holes that allow the axles to pass through.

These two walls must be separated by two pins. Here they are placed centred on the base plate. The height of the walls is related to the height of the cardboard indicator to be created, so be sure to leave enough room to place the numbers. (Image 3 and 4).

Pictures of the pieces needed

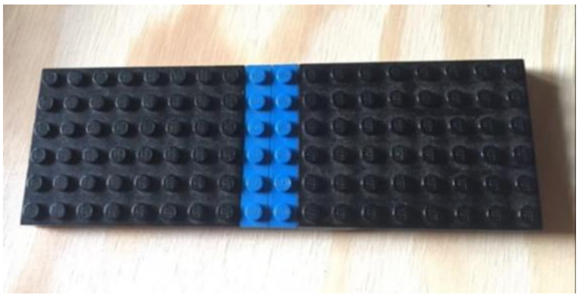
Image 1


Image 2


Image 3


Image 4

Step 2. Build three systems of gears

Time needed: 12 minutes

The first set of gears is the control gear: there must be space between the gear and the two technic 4x1 bricks so that the gear can slide on the shaft forwards and backwards (Image 5). This makes it possible to alternate the engagement of the gear unit.

The second assembly is just a 1:1 transfer and output to another (Image 6).

The third assembly is the first step in the tens output (Image 7).

Pictures of the gears systems

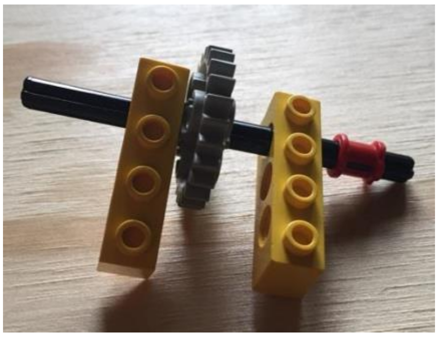

Image 5

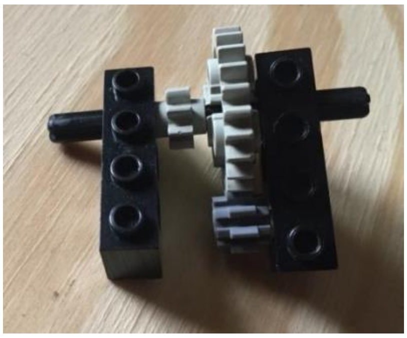

Image 6

Image 7

Build gears for the last indicator, for the tens. Gear of image 8 connects with gear of image 7.

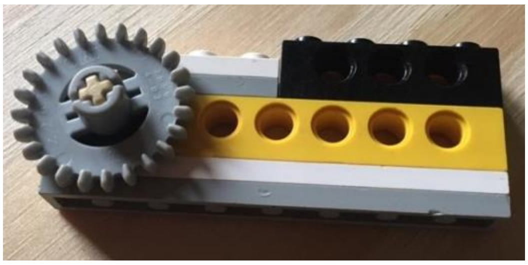

Image 8

Image 9

Build the axle for the tens with their structure (Images 10 and 11).


Image 10

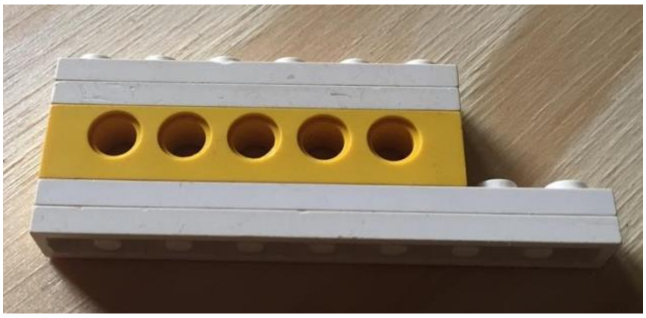
Image 11

Step 3. Connect all the parts

Time needed: 12 minutes

Attach the gears to the structure in the order displayed from image 5, image 6 and image 7. The red piece marks the control axle (image 12 and image 13).

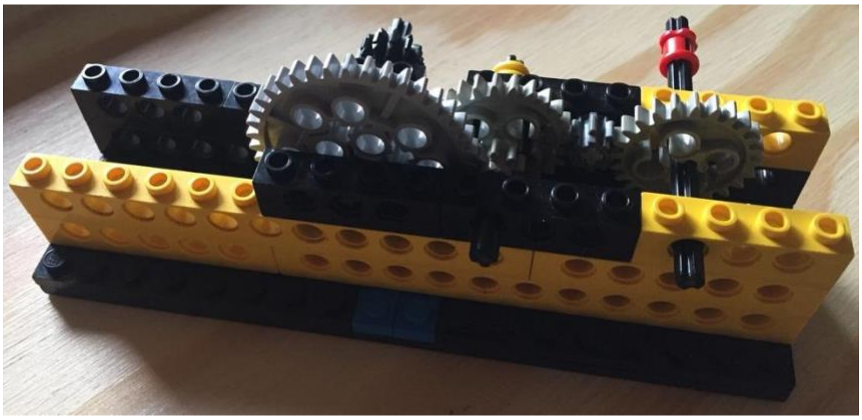
Image 12

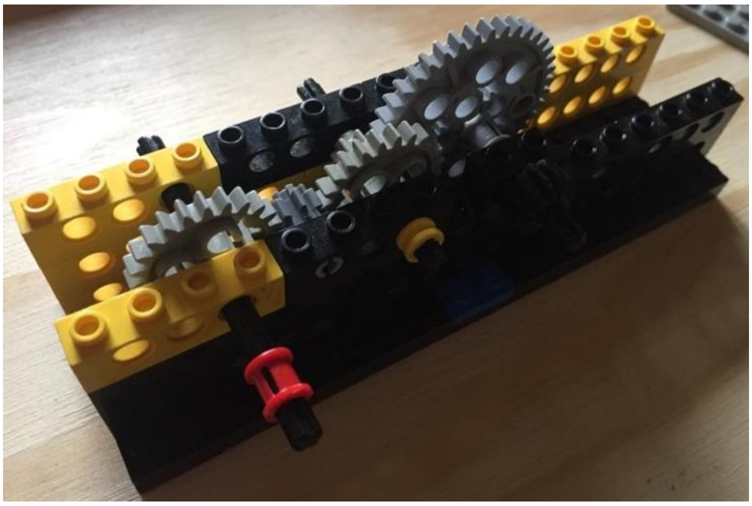
Image 13

Add the gears for the tens (image 14 and image 15), connecting this to the previous gears in the position shown in the pictures.

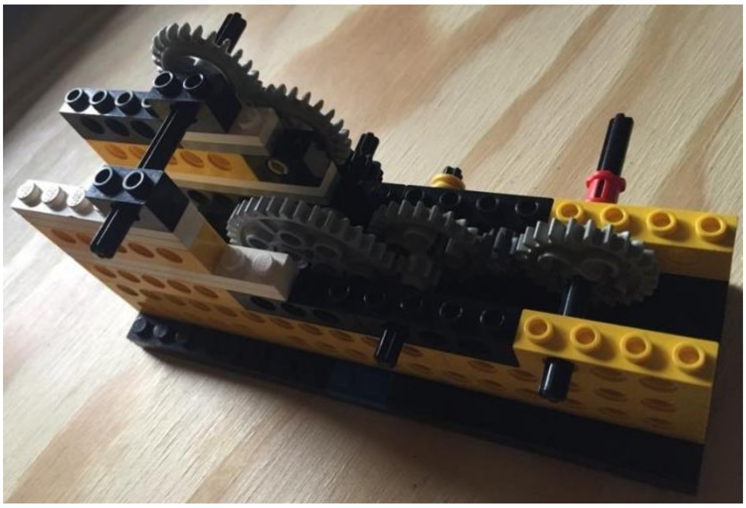
Image 14

Image 15

Step 4. Create the numbers display

Time needed: 15 or 20 minutes

Build and design the numbers display. Each number in the three circles must be separated from the other adjacent numbers by 36 degrees. Bear in mind that the numbers 0 and 5 are placed at the two ends of the vertical axis.

Calculate the size of the circles so that the numbers do not overlap (a little better than shown in the picture).

The size of the display can be made according to the size of your Lego engine (image 16). This part can be more creative.

The final creation is pictured in Image 19.

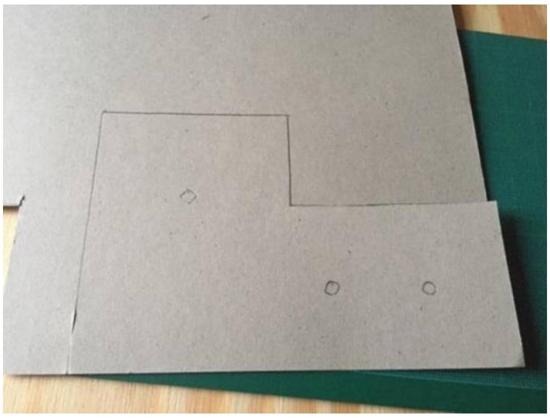

Image 16

Image 17

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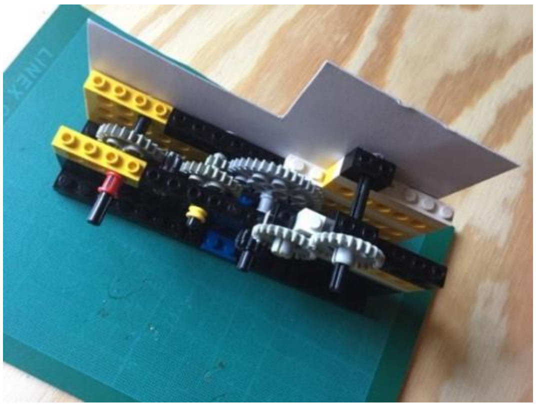

Image 18

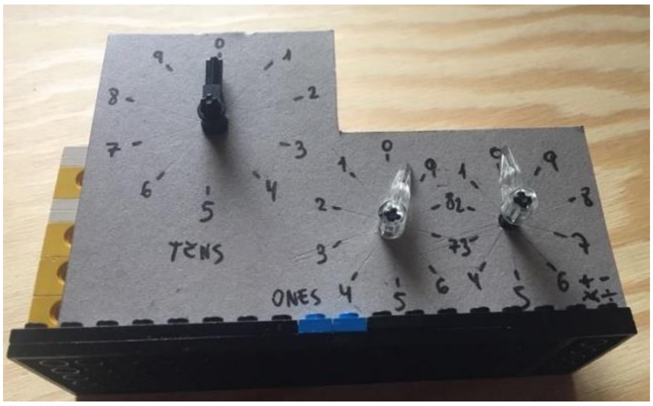

Image 19

Step 5. How does it work?

Time needed: 10 minutes

Let's learn how to use the calculator we have just built and take look at a practical example.

To add, you turn the control knob counter-clockwise to the first number you want to add, then unhook the control knob, turn it back to 0, and turn the knob counter-clockwise to the next number you add: your answer will be on the tens and ones indicators.

To subtract, you set it to 0, then disengage the control knob, go to the number you want to subtract, disengage it, go to the number you want to subtract, engage it, then turn it clockwise to 0.

Multiplying is simply adding the same number over and over again, while dividing is subtracting the same number over and over again.

Thanks for reading this and have fun with your new calculator!