2

science & play

TECHNOLOGIC

MECHANICS Laboratory

LIFTING EQUIPMENT

Models 1 to 30

1 - Stacking two beams
2 - Stacking beams with two pegs
3 - Joining beams
4 - Stacking three beams
5 - Stacking beams perpendicularly
6 - Stacking with an L-shaped beam
7 - Build a square with beams
8 - Stacking four beams
9 - Build a cuboid
10 - Build a simple bridge
11 - Assemble cogwheels on a rod
12 - Using pulleys
13 - Build a Class 1 lever: pincers
14 - Build a Class 2 lever: nutcracker
15 - Build a Class 2 lever: wheelbarrow
16 - Build a Class 3 lever: tongs
17 - Build the lever's fulcrum and weight
18 - Assemble and test a mechanically advantaged lever
19 - Assemble and test a mechanically neutral lever
20 - Assemble and test a mechanically disadvantaged lever
21 - Assemble a balance
22 - Build and test a see-saw
23 - Assemble the test stand for reverse rotation
24 - Build and test forward rotation
25 - Assemble and test alternating movement
26 - Build and observe right-angle rotation
27 - Assemble a vertical gearbox
28 - Build a horizontal to vertical gearbox
29 - An ancient war machine: the battering-ram
30 - Assemble a manual gearbox with gears

WARNING

In order to ensure correct function of the electric motor, a small quantity of grease is added during the manufacturing process. As grease can melt at high temperatures, it may dirty the motor. However, it can simply be wiped off with a piece of kitchen paper or a napkin. The grease used is neither toxic nor hazardous.

WARNING!

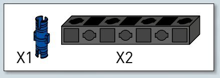
Suitable for children aged 8 years and older.
The instructions for adults are included and must be observed.

Read and keep this manual for future reference.

Clementoni S.p.A.
Zona Industriale Fontenoce, s.n.c.
62019 Recanati (MC) - Italy
Tel. +39 071 75 811 - Fax +39 071 75 81234
www.clementoni.com

Clementoni®

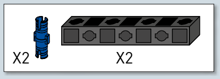
1 Stacking two beams

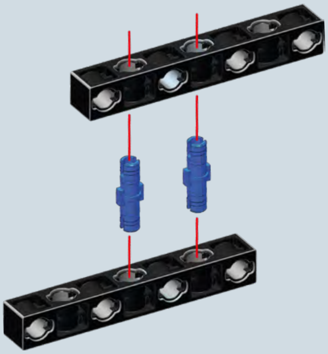


Assembled beams

2 Stacking beams with two pegs

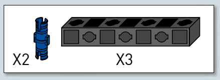
Two pegs make the construction very robust!

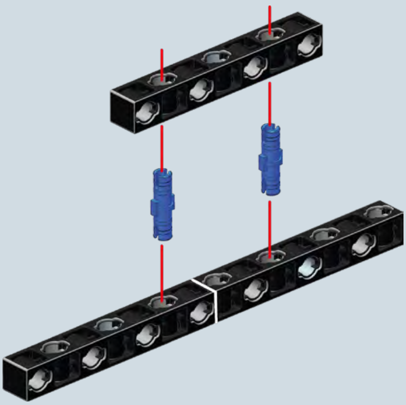




Assembled beams

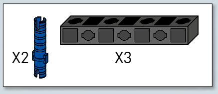
3 Joining beams



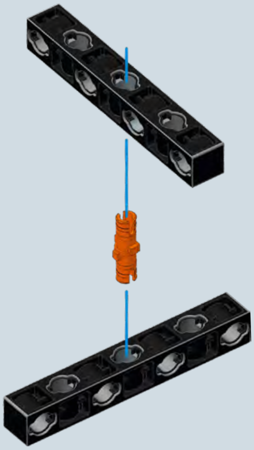


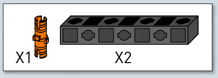
Assembled beams

4 Stacking three beams

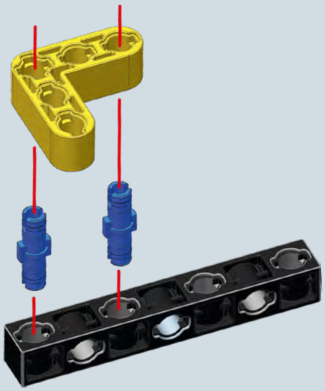


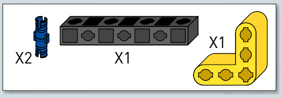
5 Stacking beams perpendicularly

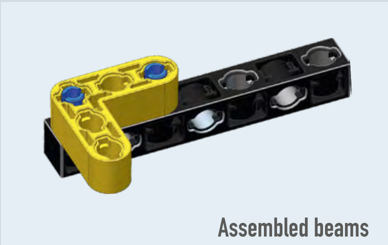




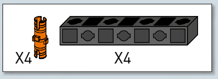
6 Stacking with an L-shaped beam

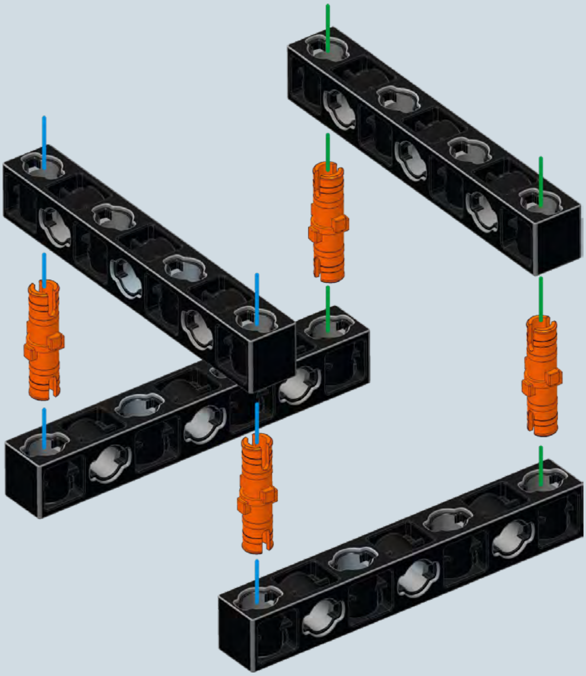


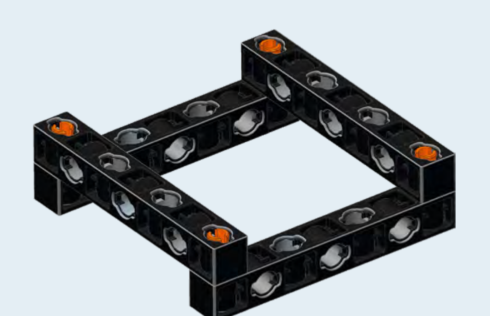




7 Build a square with beams

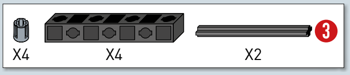


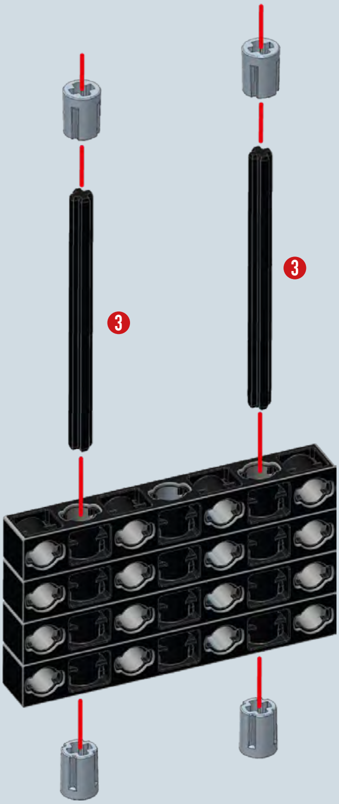




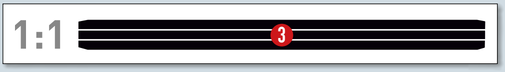
Final assembled model

8 Stacking four beams



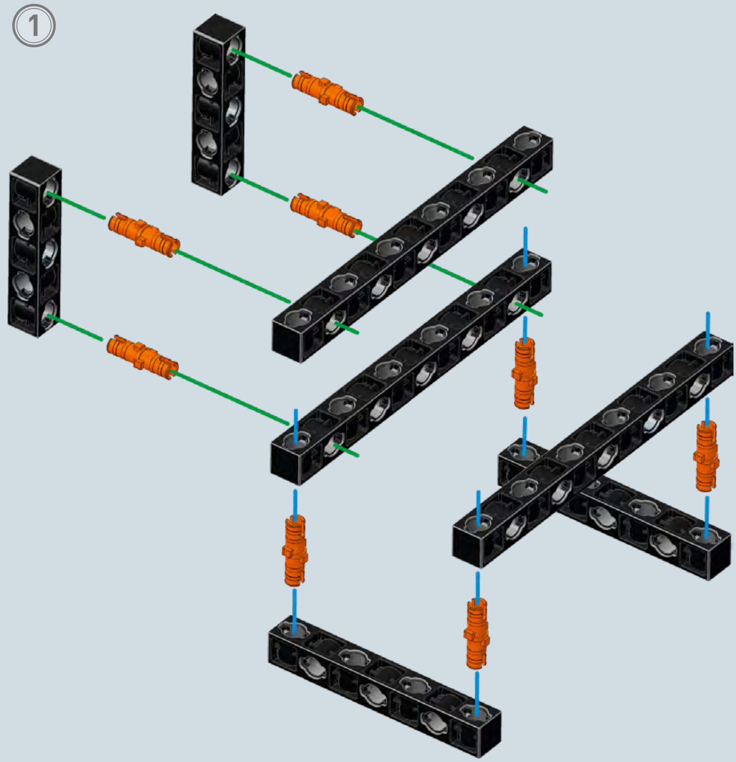


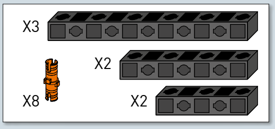
Final assembled model



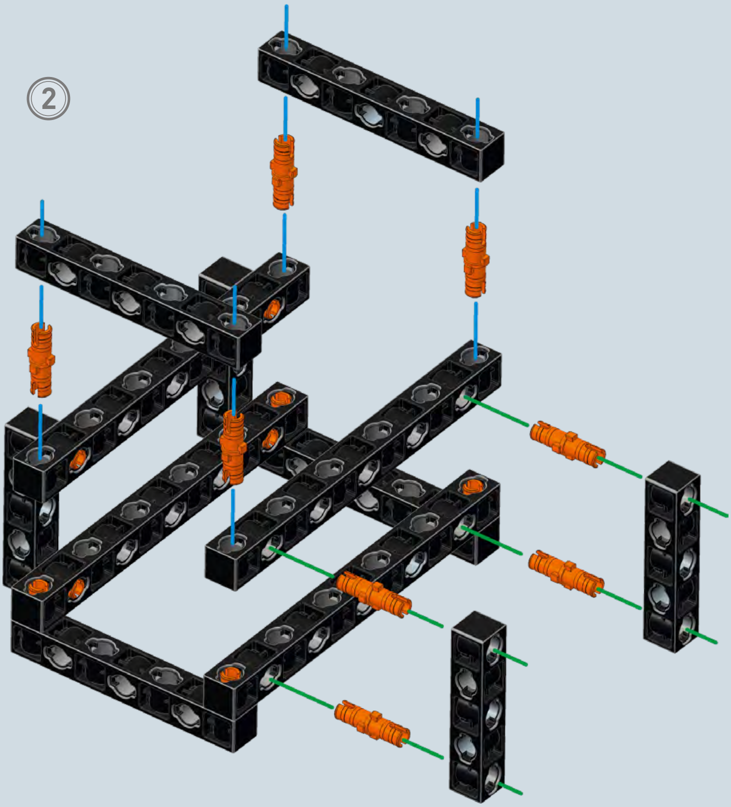
9 Build a cuboid

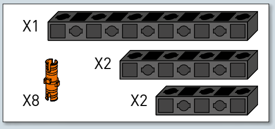
①



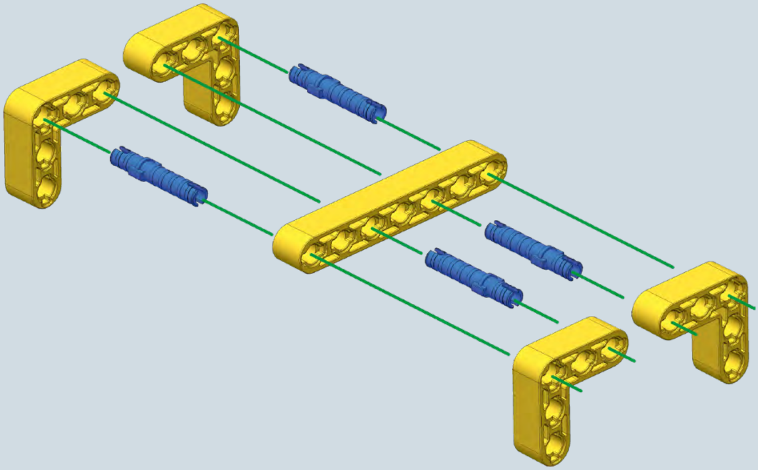


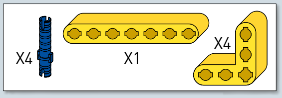
②

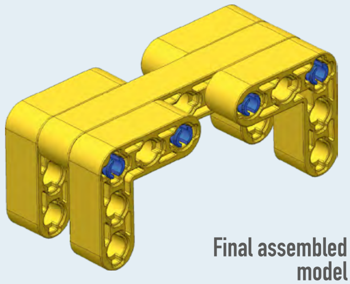




10 Build a simple bridge

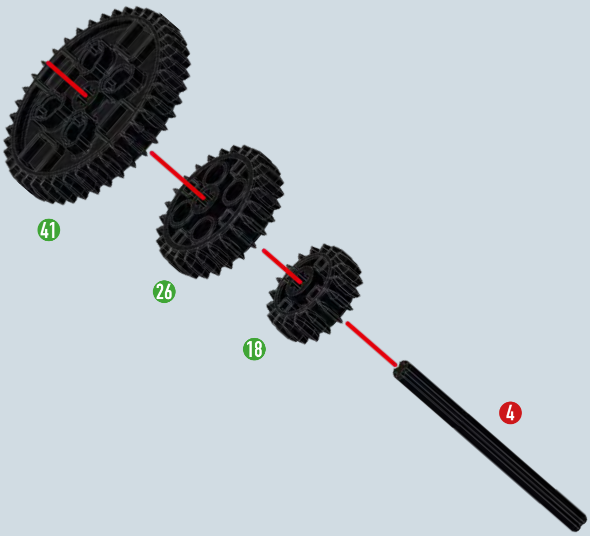


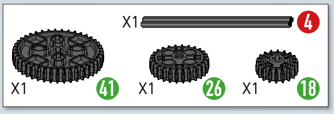


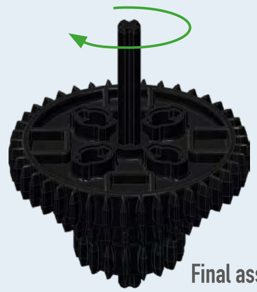


Final assembled model

11 Assemble cogwheels on a rod



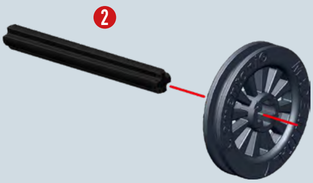


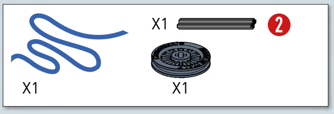


Final assembled model

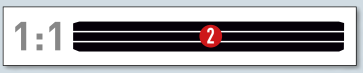
Try it out as a spinning top!

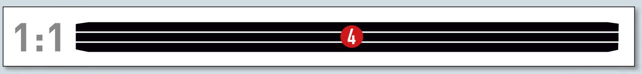
12 Using pulleys





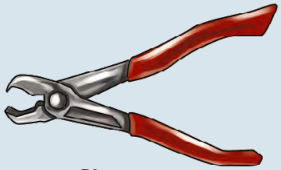
Final assembled model



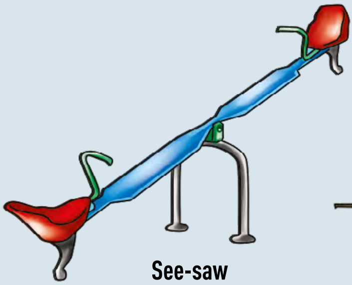


Since ancient times humans have made use of many of these mechanisms to increase their strength and enable them to accomplish great feats which can still be admired today.

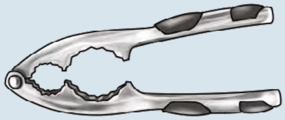
Wheelbarrow



Pincers

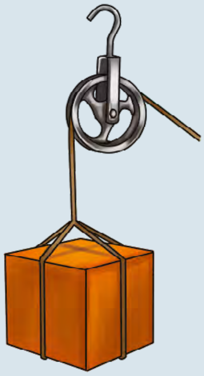


See-saw



Nutcracker

Balance

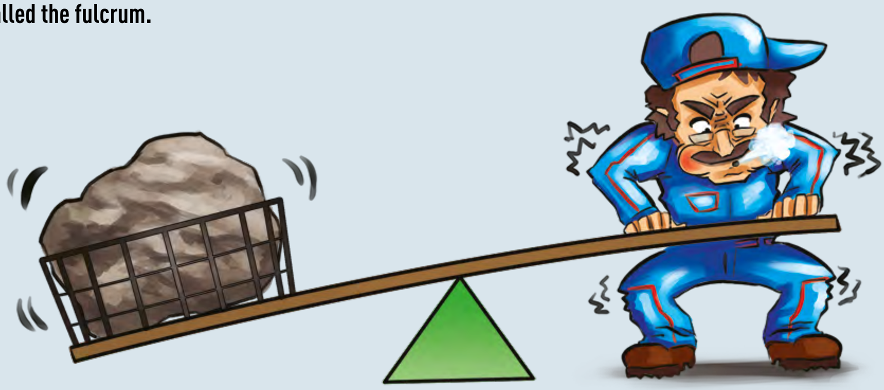


Pulley

A simple machine is an instrument that allows for balancing and overcoming **RESISTANCE** (weight, resistance force = **R**) with **EFFORT** (manpower = **E**).

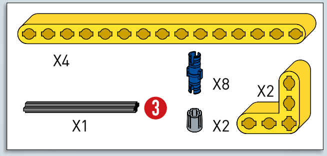
LEVERS

A lever is a simple machine that is made up of a rigid bar which can rotate around a fixed point called the fulcrum.

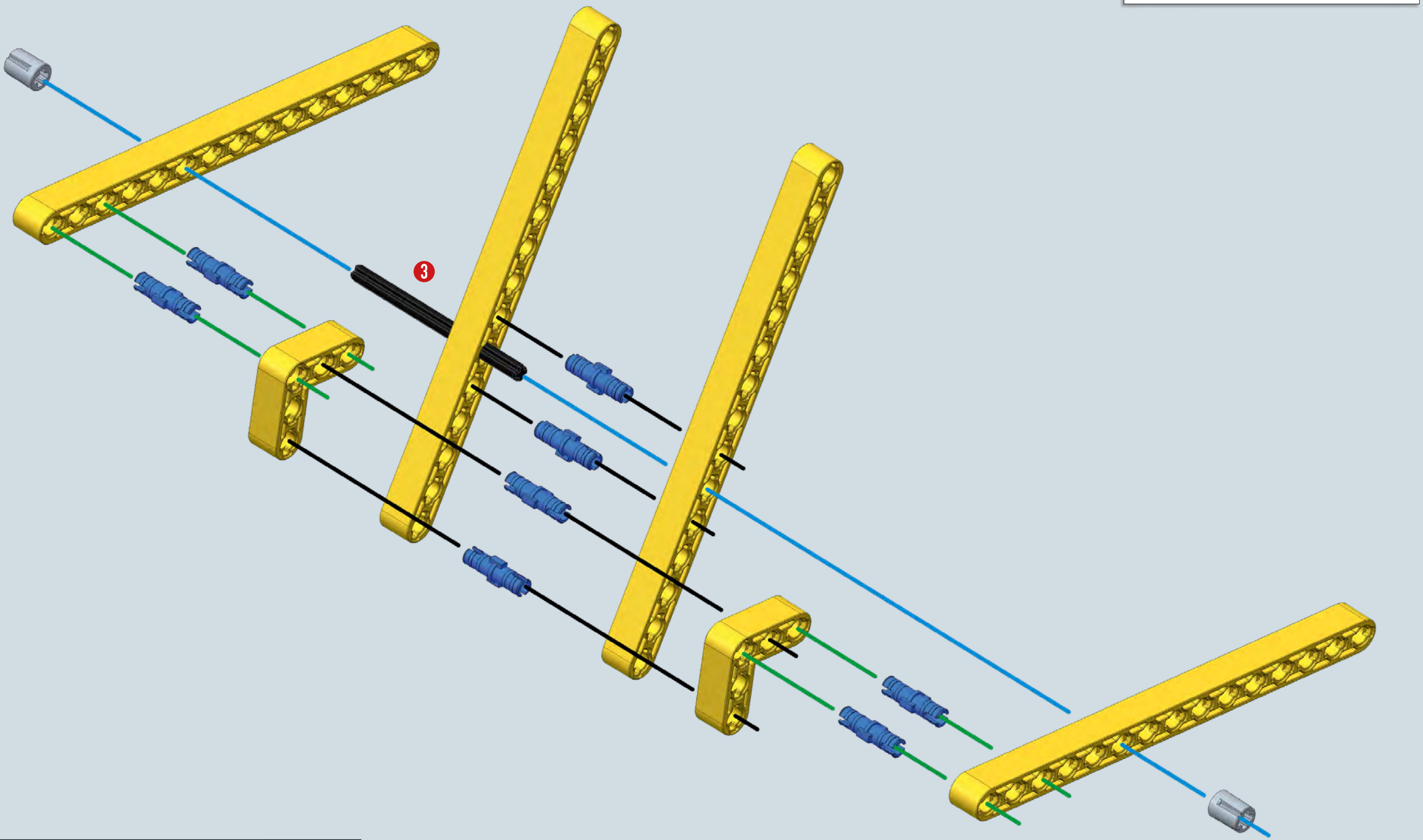


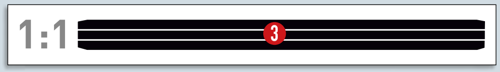
- Pairs of levers also obey this principle.
- Levers are classified on the basis of the relative position of the EFFORT, RESISTANCE and FULCRUM.

13 Build a Class 1 lever: pincers

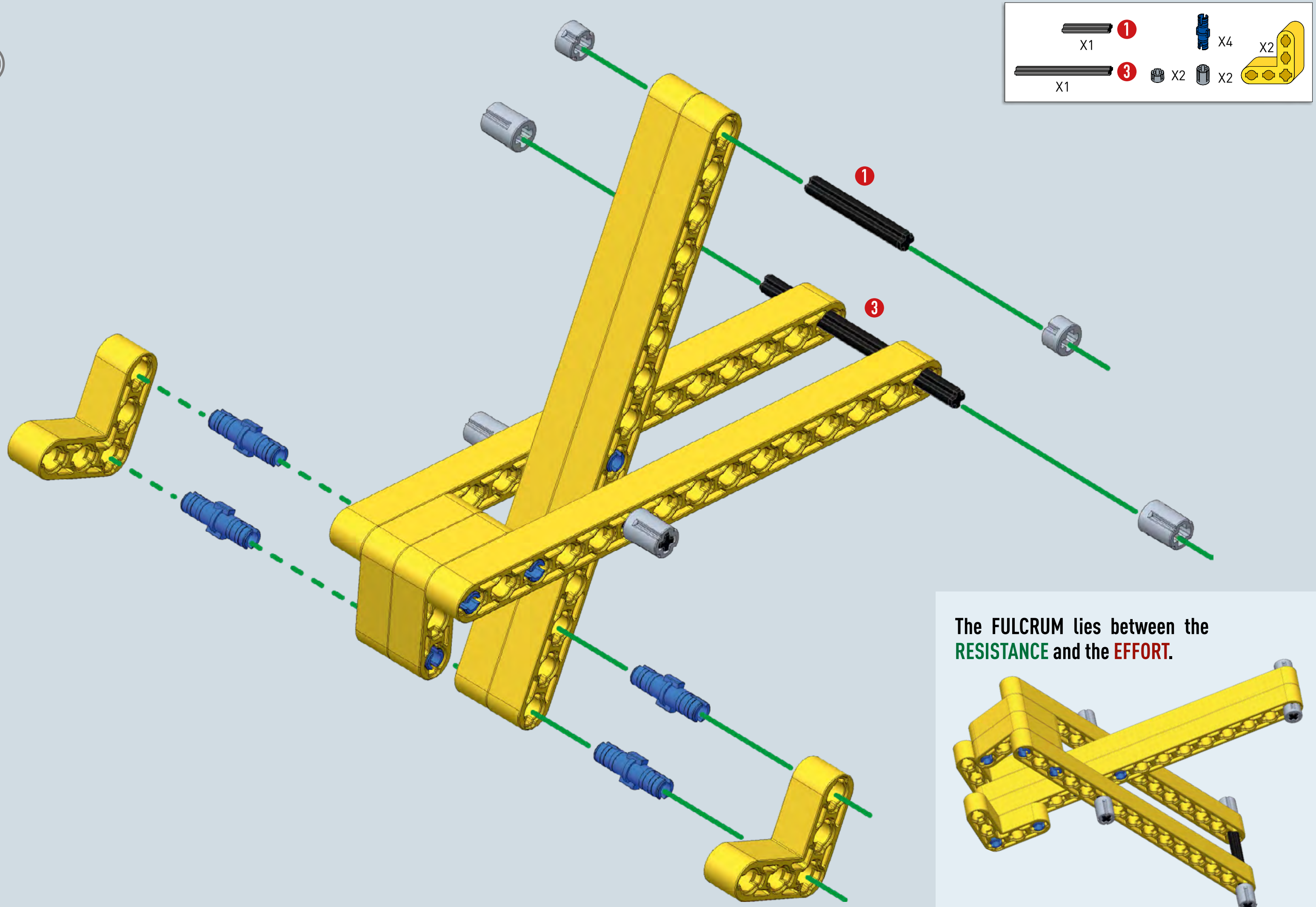


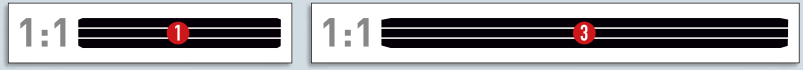
1





2

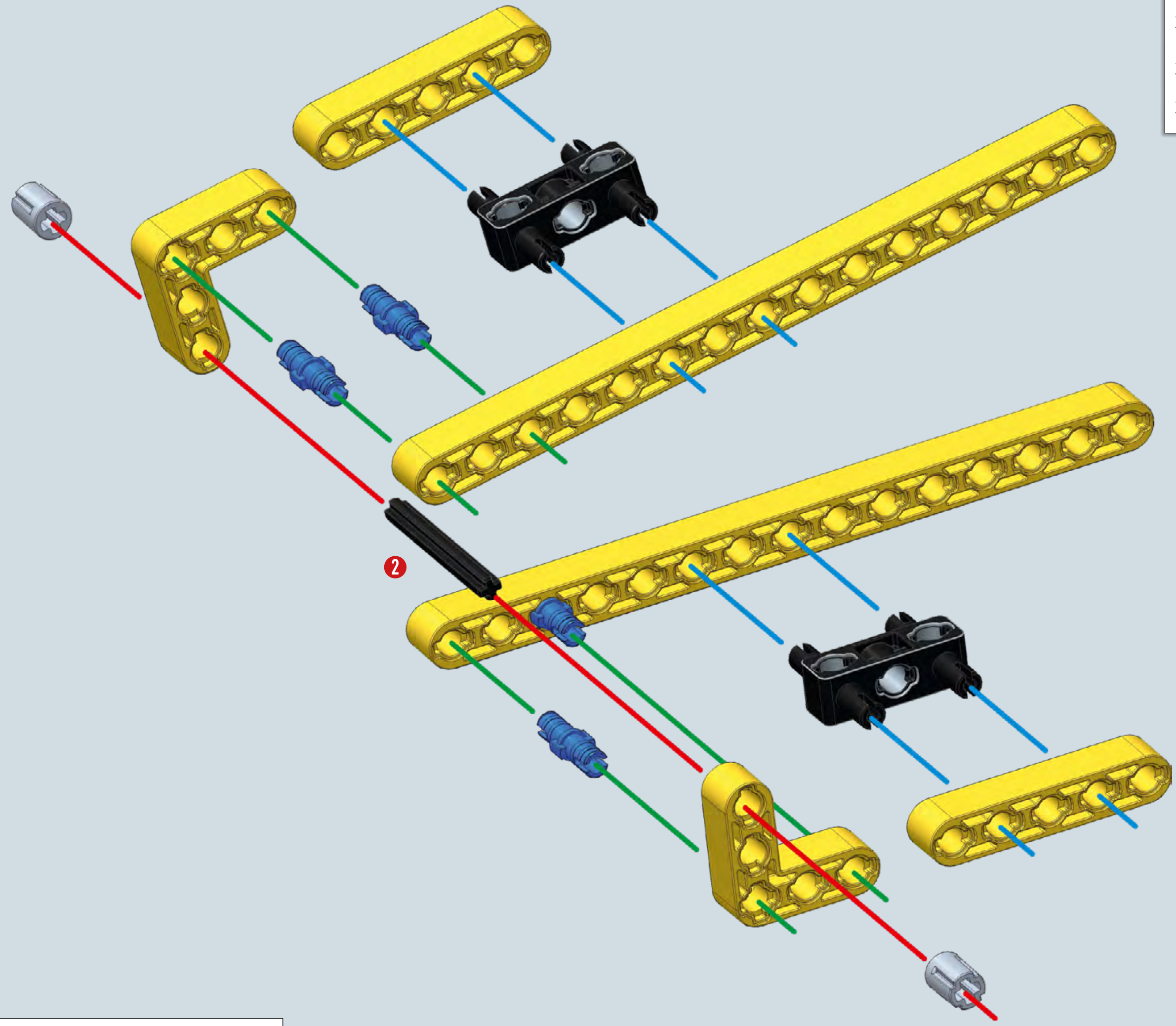


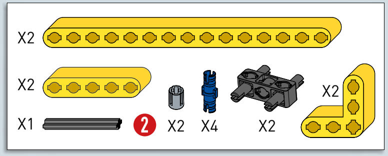


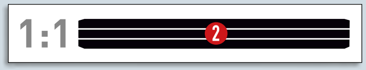
The FULCRUM lies between the RESISTANCE and the EFFORT.

Final assembled model

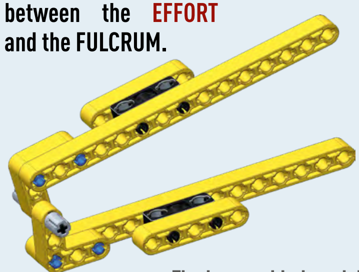
14 Build a Class 2 lever: nutcracker





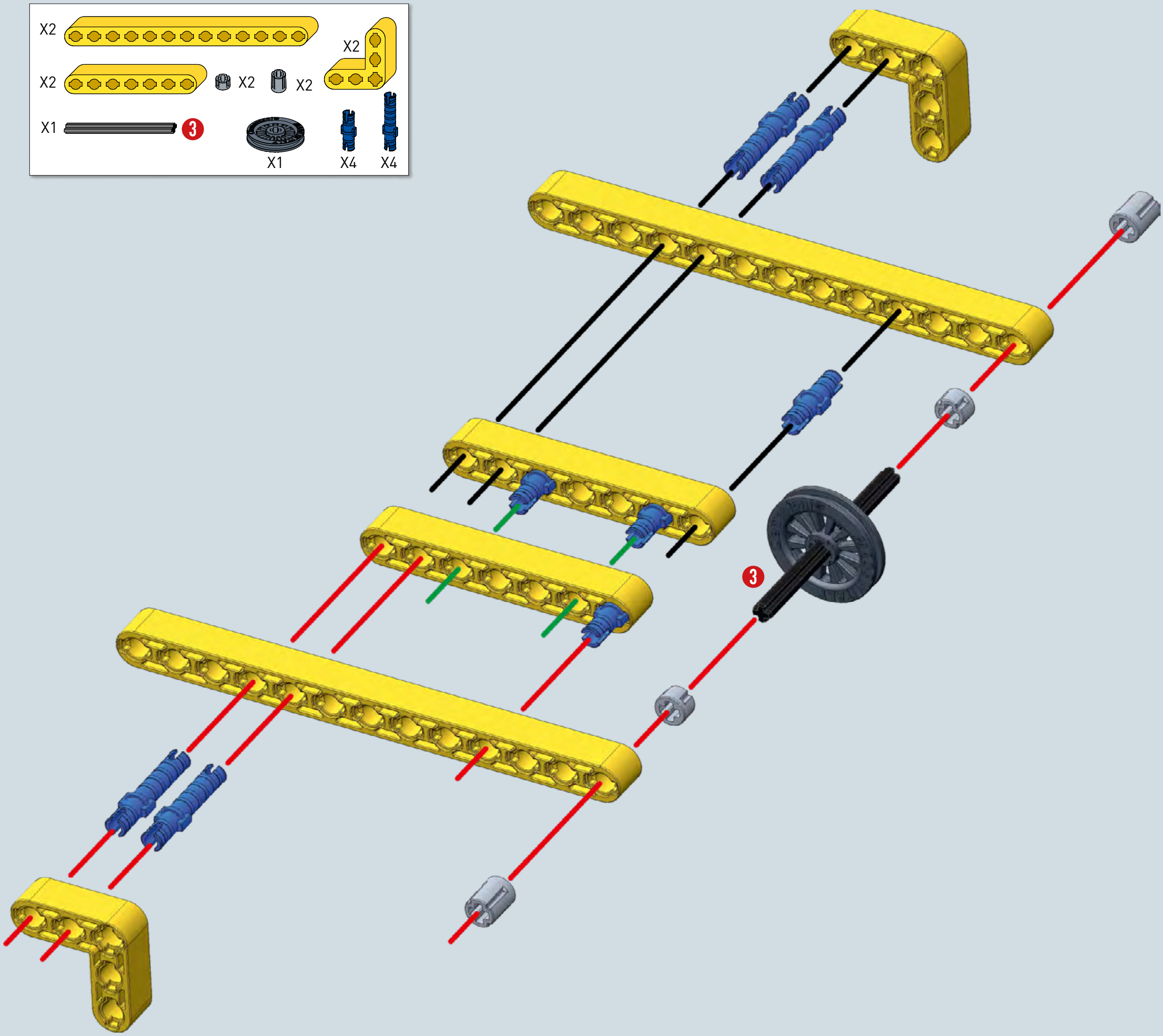


The RESISTANCE lies between the EFFORT and the FULCRUM.

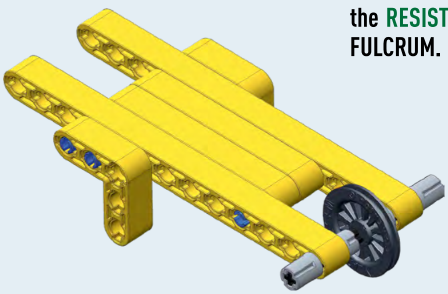


Final assembled model

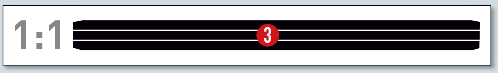
Build a Class 2 lever: wheelbarrow



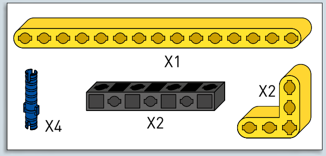
The EFFORT lies between the RESISTANCE and the FULCRUM.



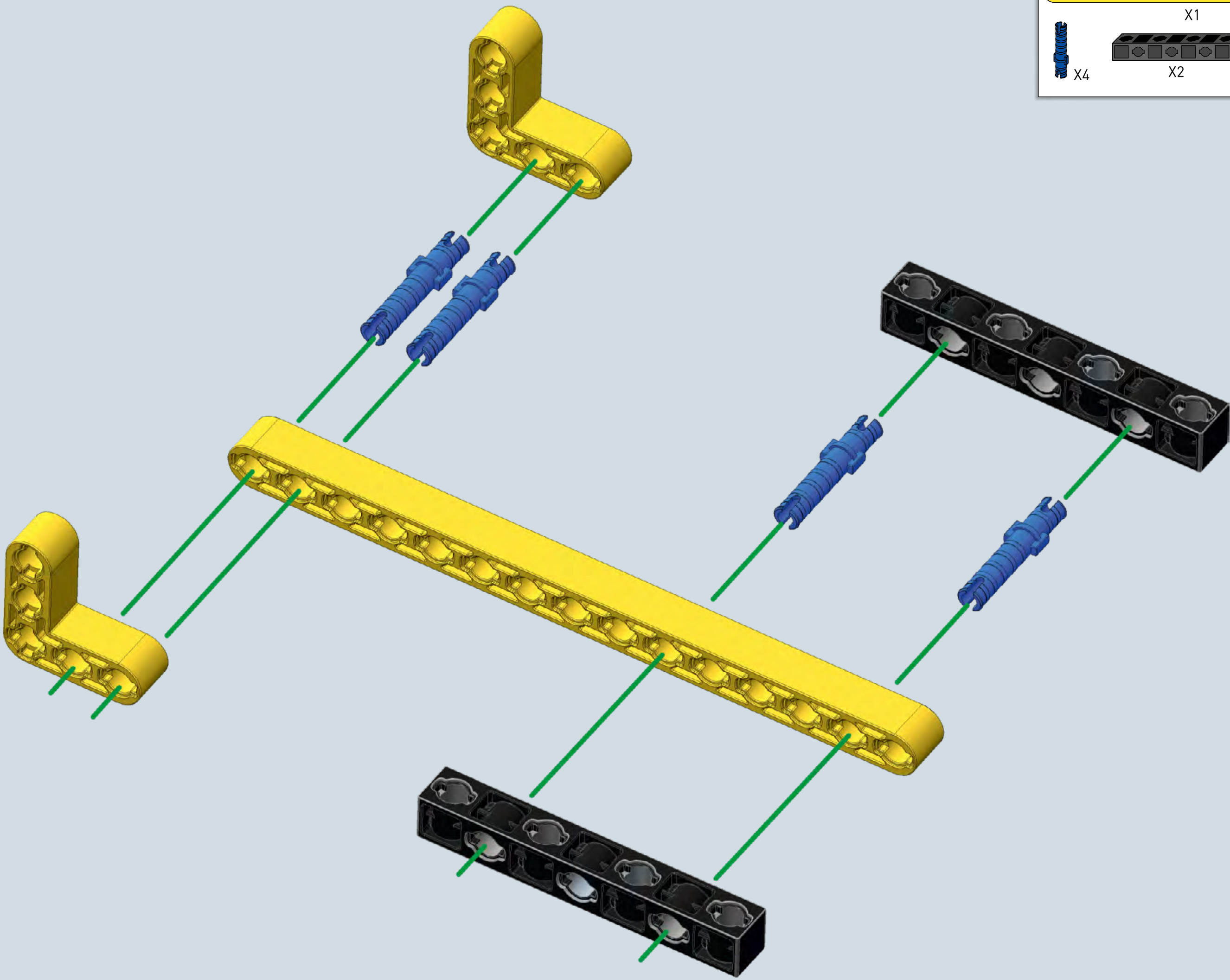
Final assembled model



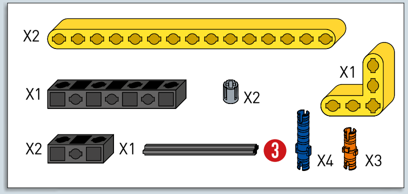
16 Build a Class 3 lever: tongs

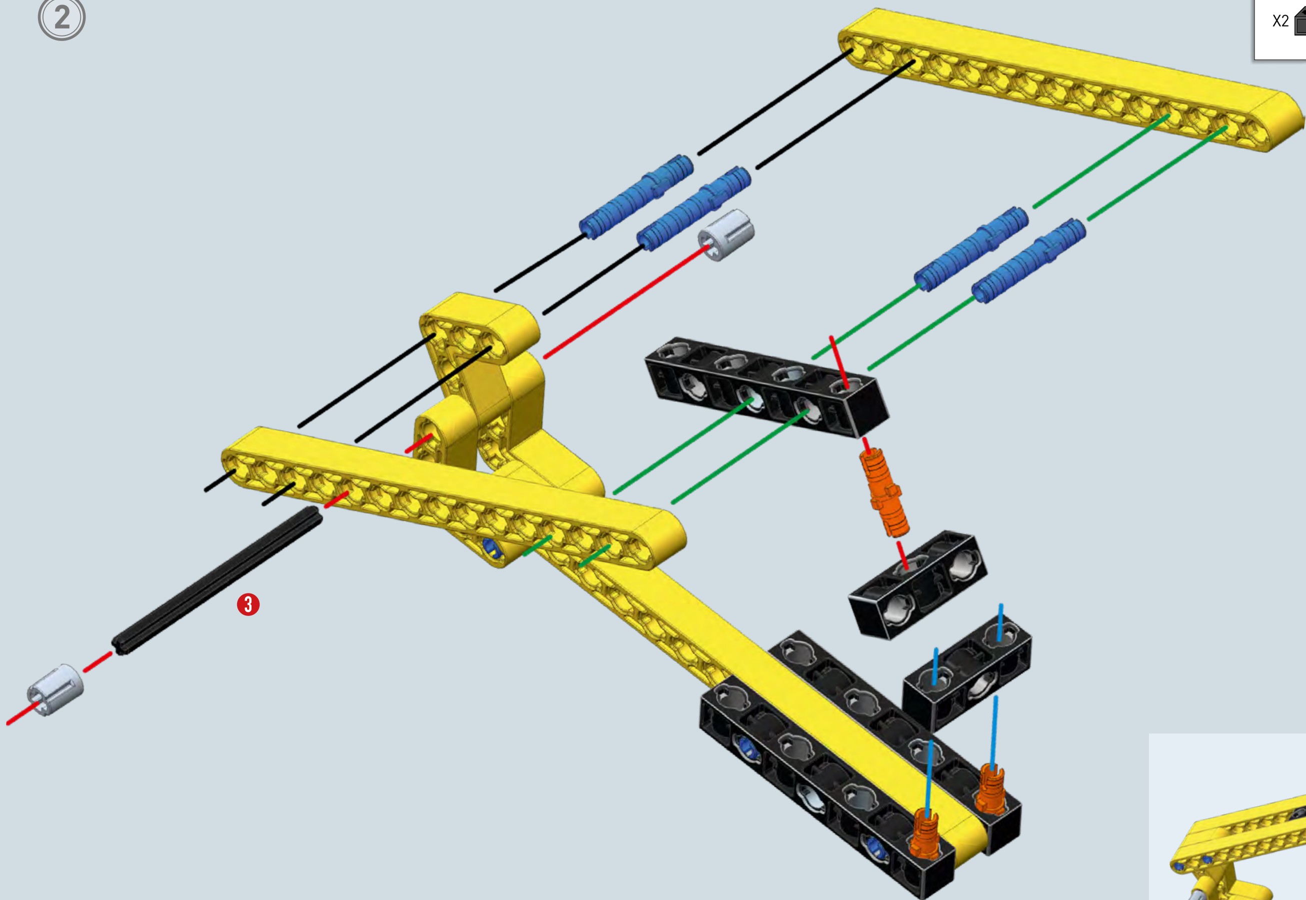


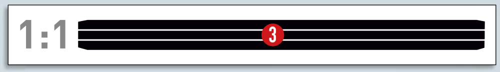
1



2





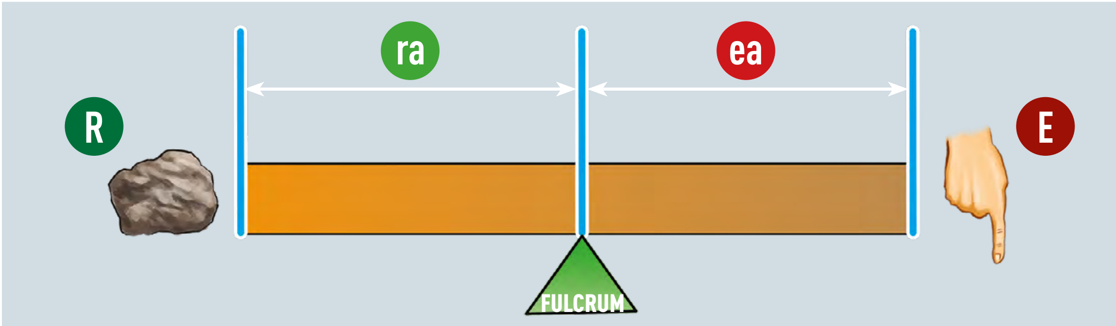


The **EFFORT** lies between the **RE-SISTANCE** and the **FULCRUM.**

Final assembled model

Scientific analysis: mechanical advantage with levers

The lever is a simple machine built by man to perform work by reducing the force required. Two forces are applied to the rod: the EFFORT and the RESISTANCE. Using a lever, therefore, we have a MECHANICAL ADVANTAGE that can be calculated by considering also the length of the EFFORT and of the RESISTANCE. In the lever, the lengths of the arms correspond to the distances from the fulcrum.



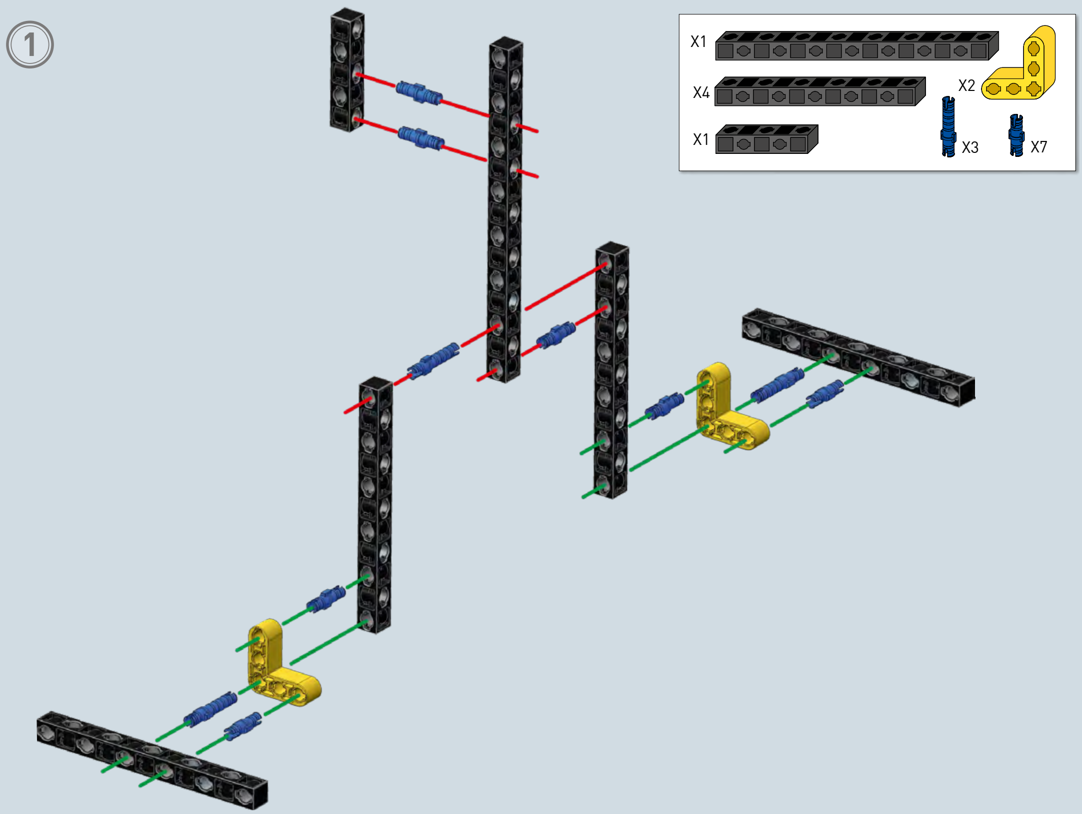
Key:
- ea = EFFORT arm
- ra = RESISTANCE arm
- E = EFFORT force
- R = RESISTANCE force

EQUILIBRIUM CONDITIONS ra x R = ea x E

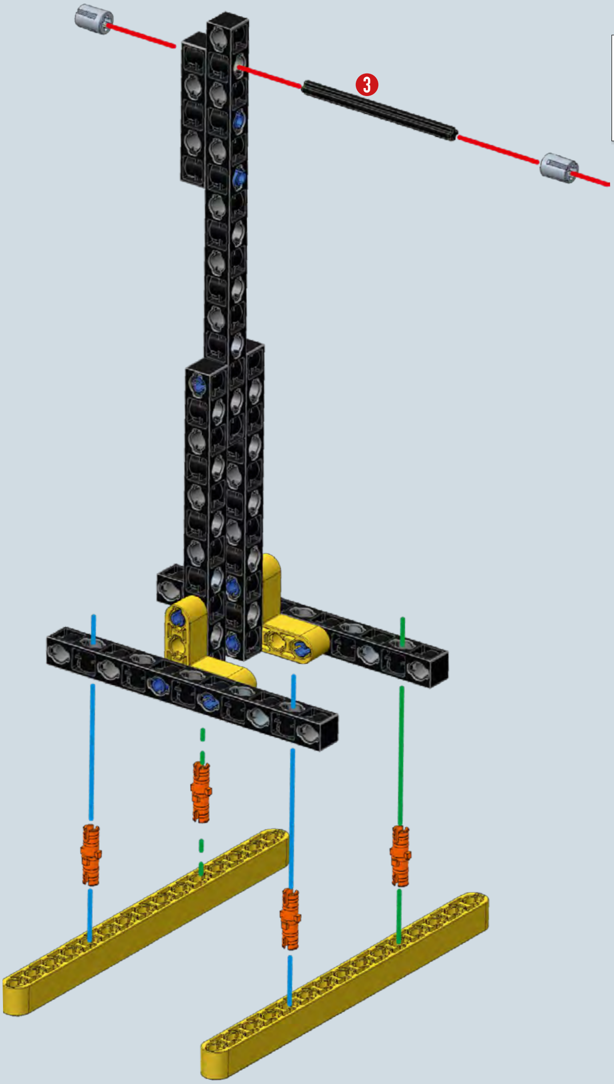
MECHANICAL ADVANTAGE A = R / E

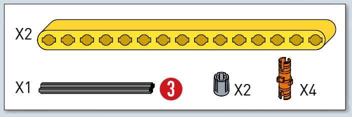
ASSEMBLE AND TEST THE LEVERS

17 Build the lever's fulcrum and weight

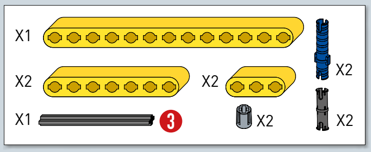


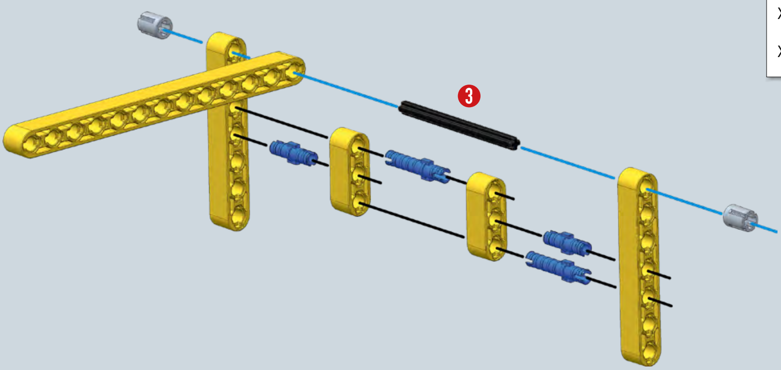
2





ASSEMBLING THE WEIGHT






Assembled weight

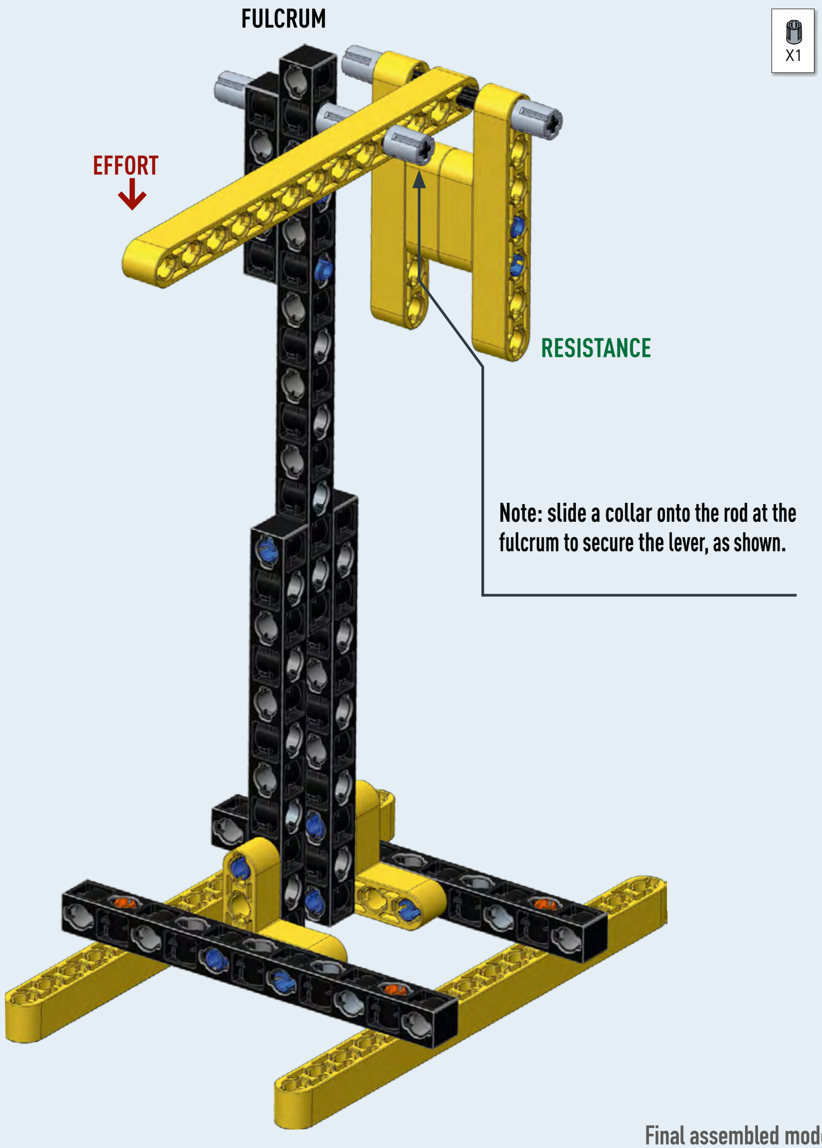
In Activities 16-17-18 try moving the fulcrum and then applying downward pressure to the EFFORT arm with your hand to see the differences between the levers.

Find the equilibrium of this type of mechanical device: position the weight (RESISTANCE) on one side of the lever and gently press down with your hand (EFFORT) on the other side.

Note the position of the fulcrum!

- The EFFORT arm is longer.
- The EFFORT is **less** than the RESISTANCE.

TRY IT OUT!



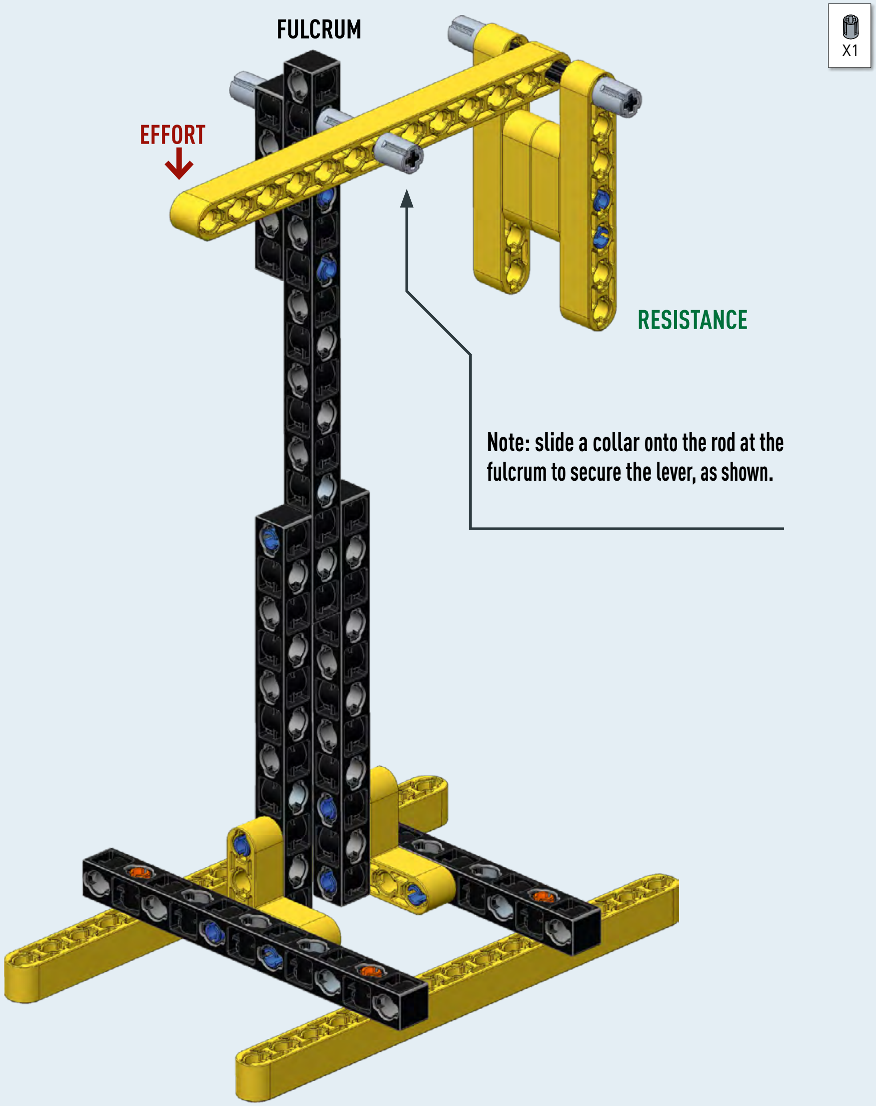
Final assembled model

19 Assemble and test a mechanically neutral lever

Find the equilibrium of this type of mechanical device: position the weight (RESISTANCE) on one side of the lever and gently press down with your hand (EFFORT) on the other side.

Note the position of the fulcrum!
- The arms are the same.
- The EFFORT is **equal** to the RESISTANCE.

TRY IT OUT!



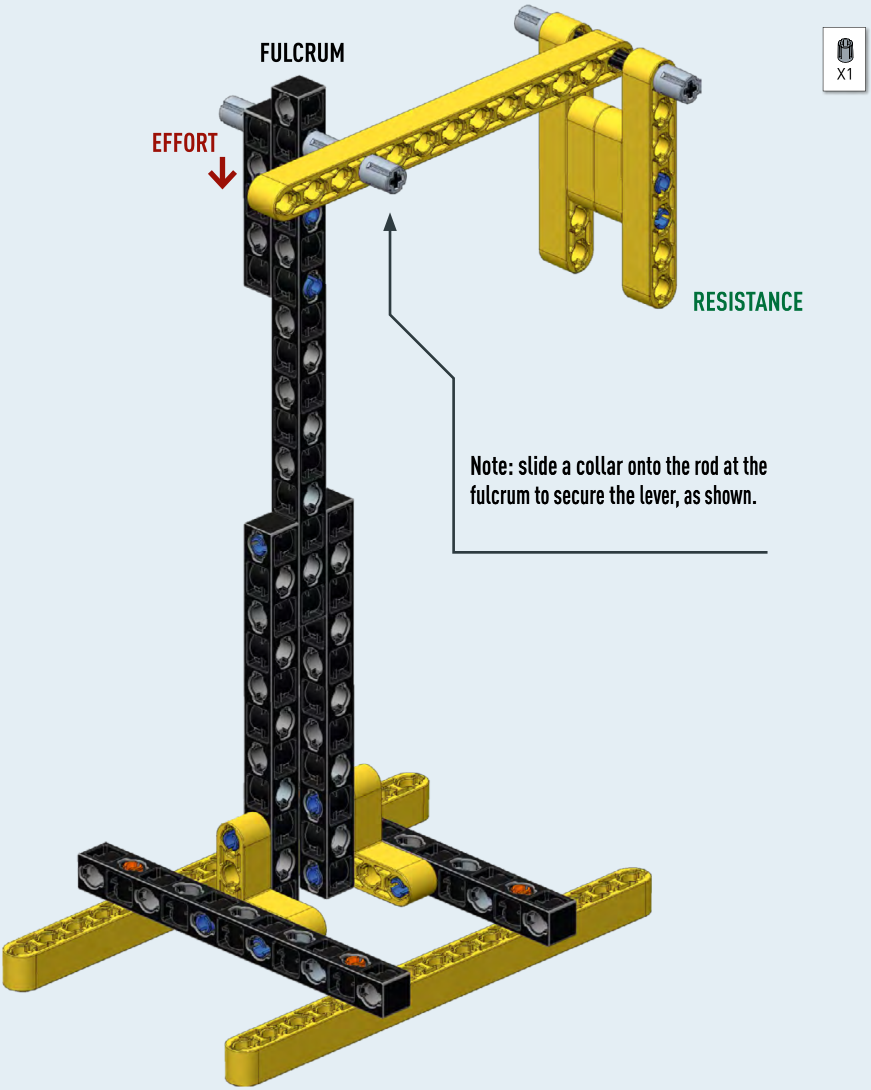
Final assembled model

Find the equilibrium of this type of mechanical device: position the weight (RESISTANCE) on one side of the lever and gently press down with your hand (EFFORT) on the other side.

Note the position of the fulcrum!

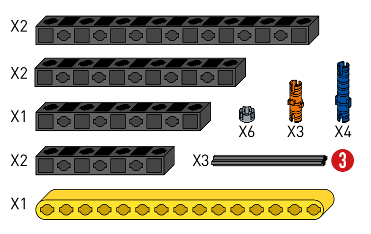
- The arms are the same.
- The EFFORT is **equal** to the RESISTANCE.

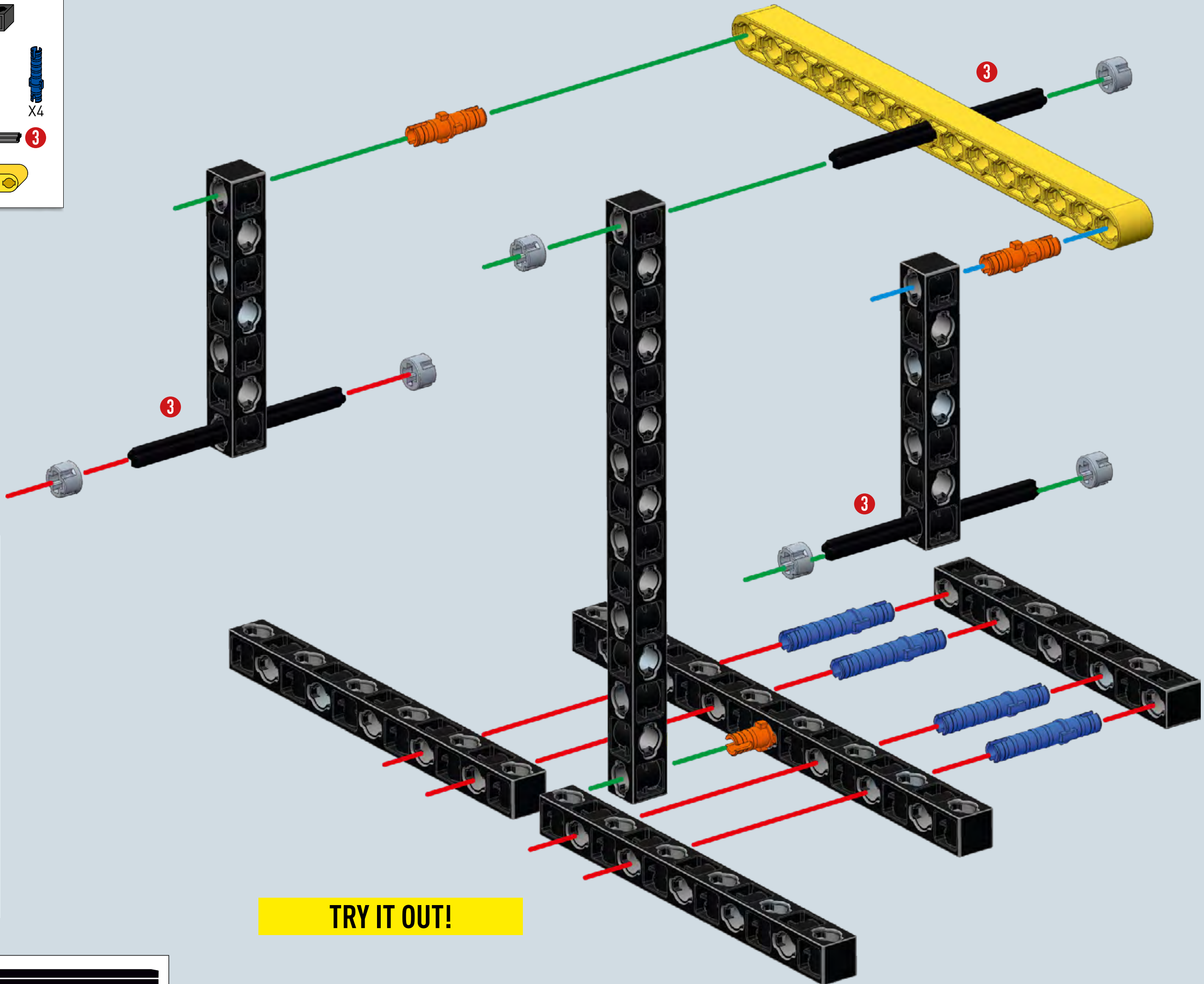
TRY IT OUT!



Final assembled model

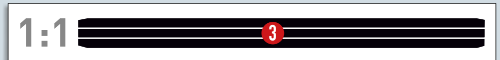
21 Assemble a balance



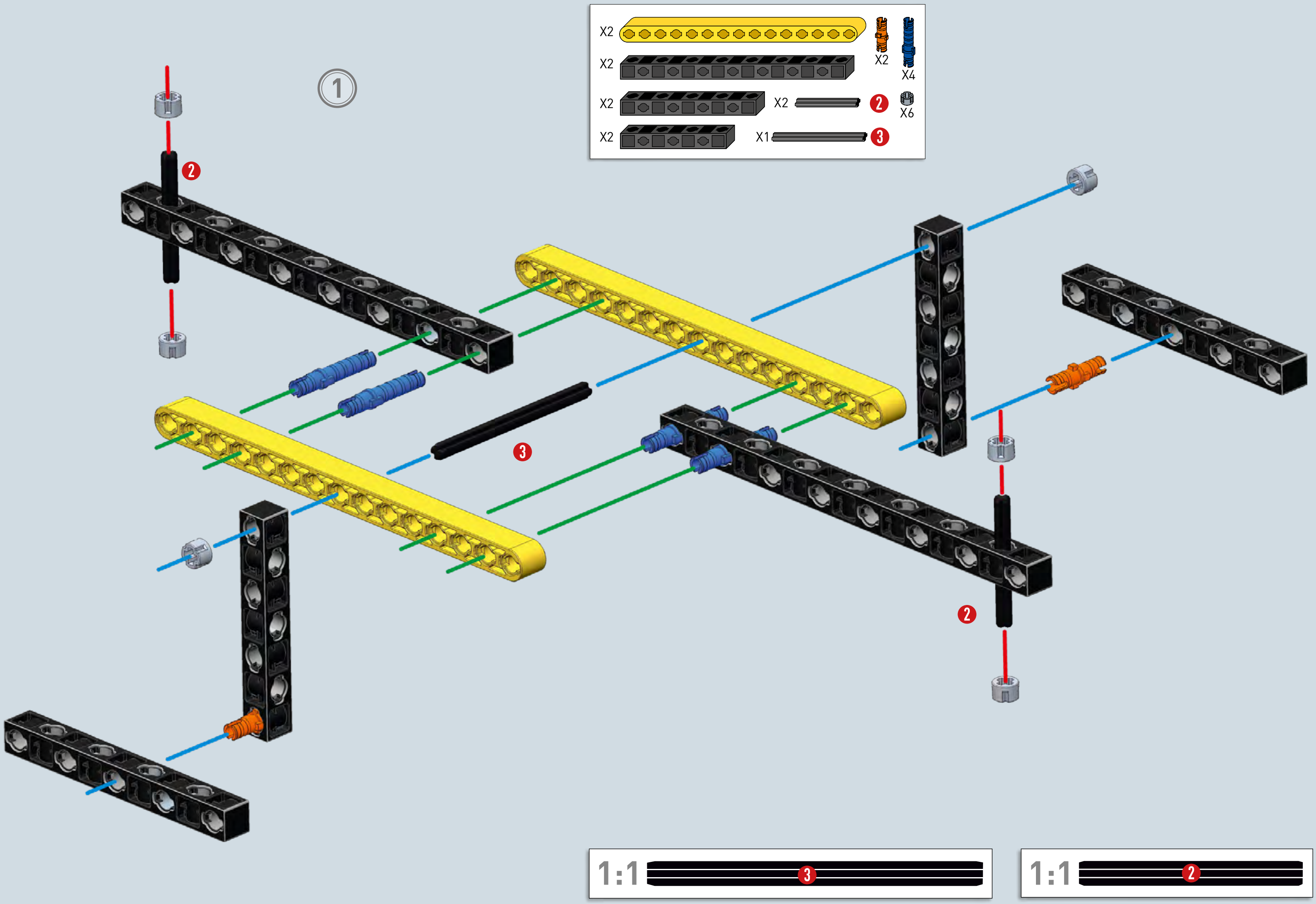


The balance is a class 1 lever

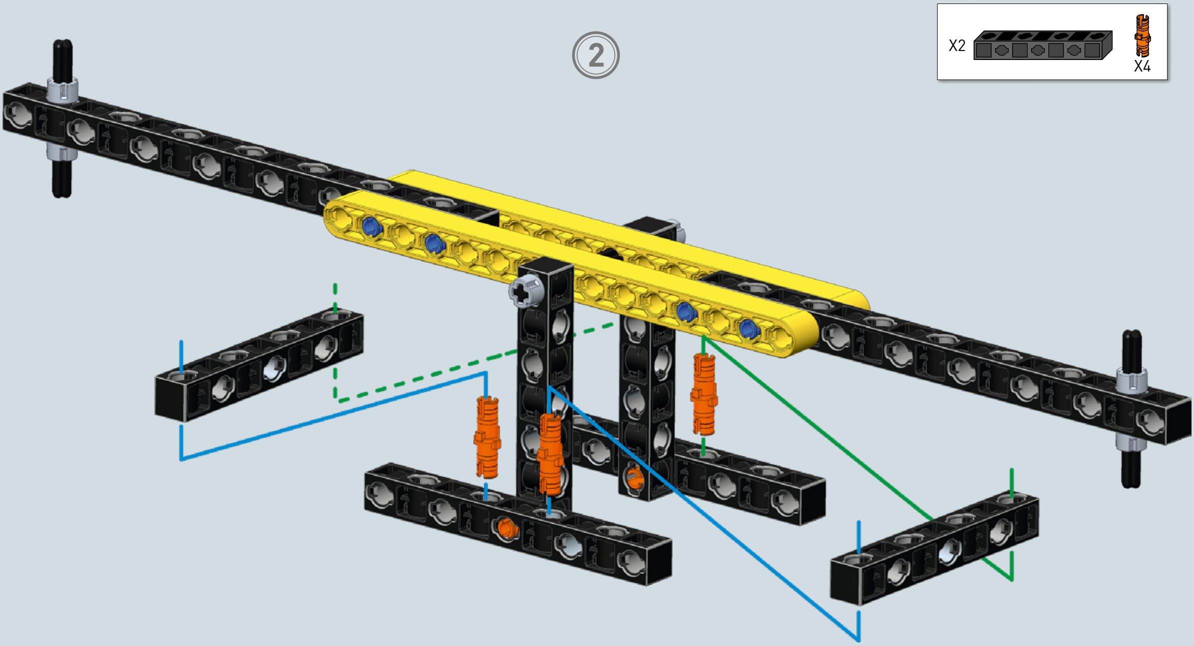
Final assembled model



TRY IT OUT!


1
X2
X2
X2
X2
X2
X4
X2
2
X6
X1
3
2
2
3
1:1
3
1:1
2

2



In the third century BC, Archimedes was a great scientist and experimenter with levers.

Note: the lever of the see-saw must rotate freely around the fulcrum.

Try it yourself: find the equilibrium of the see-saw by varying the weight and distances from the fulcrum of the Resistance and Effort forces.

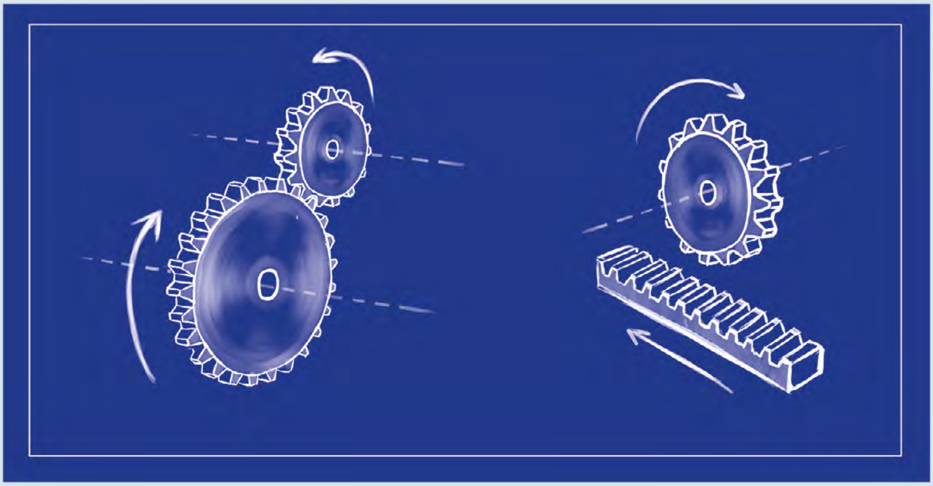
TRY IT OUT!

The see-saw is a class 1 lever

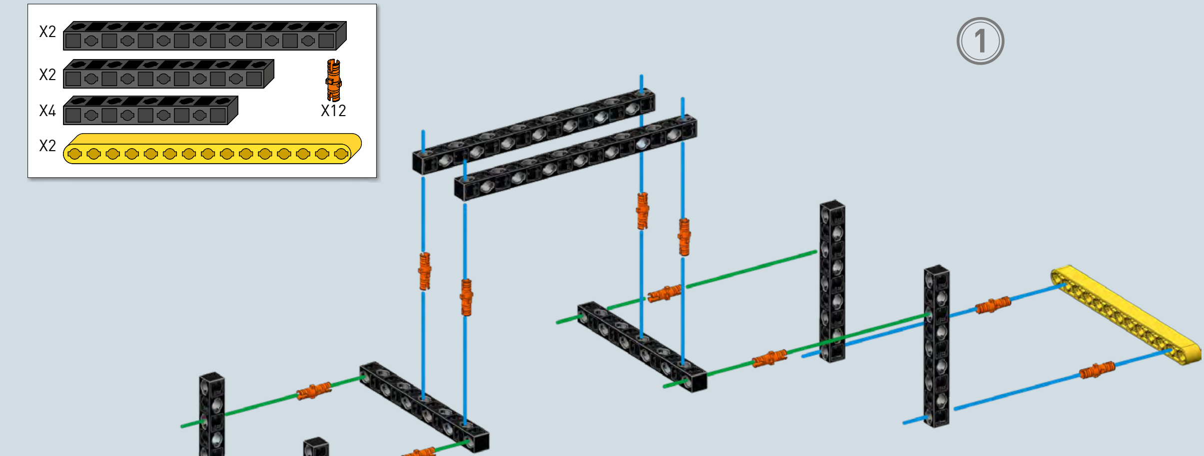
Final assembled model

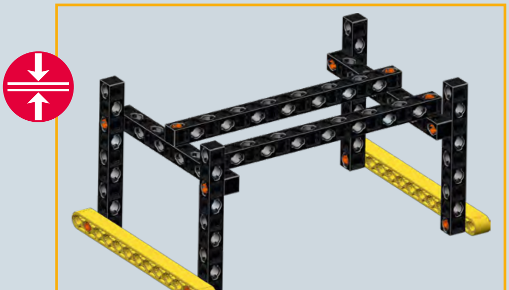
Cogwheels transmit motion between suitably positioned axles (rods) via teeth.

- In a pair of cogwheels, if one cogwheel turns in one direction the other turns in the opposite direction. One of the two wheels transmits motion (drive wheel) while the other receives it (driven wheel).
- To maintain the same direction of rotation a third *cogwheel must be inserted between the two*.
- With two different cogwheels, the smaller one – having only a few teeth – is called the **pinion**, while the one with many teeth is called the **crown wheel**. Multiple cogwheels make up a gear train.

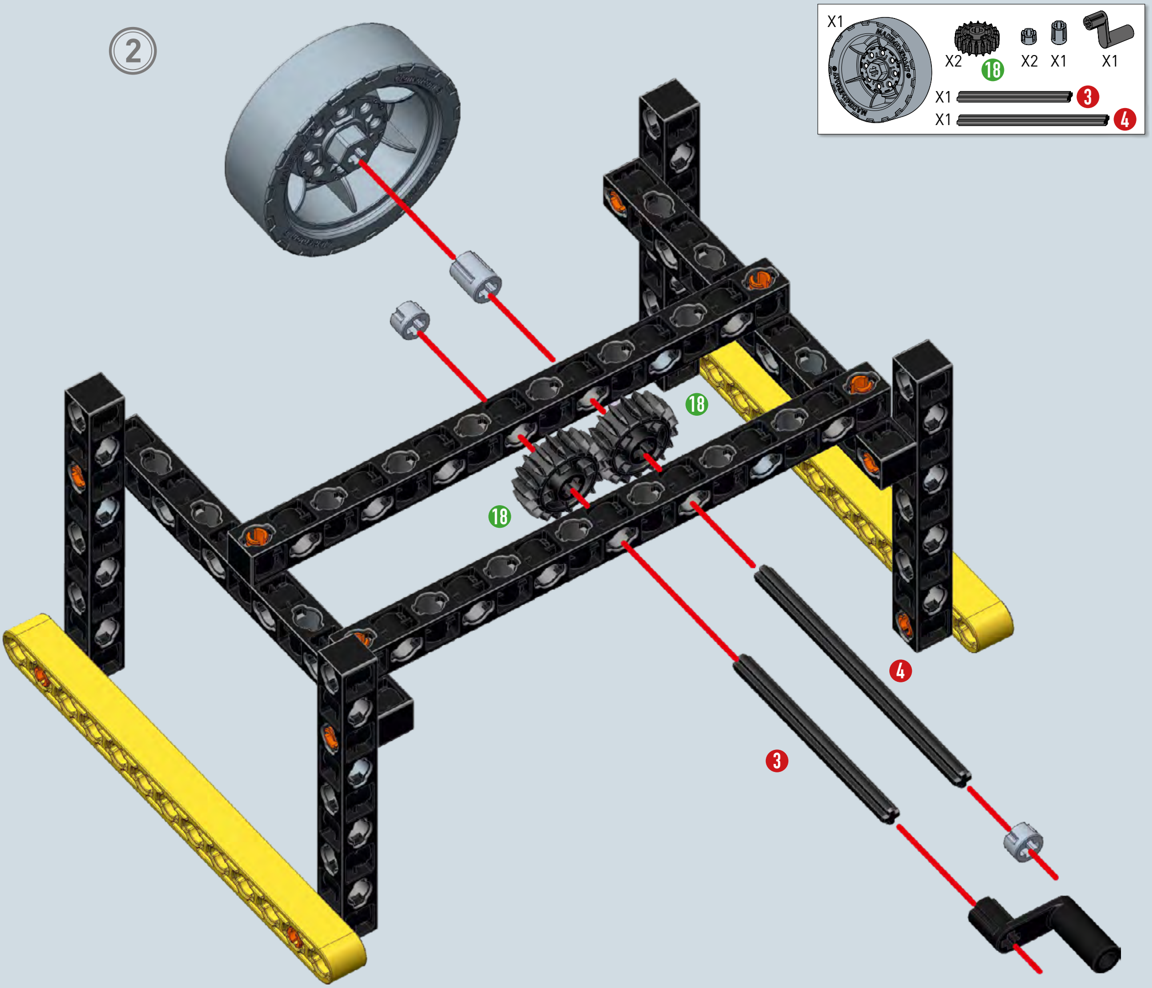


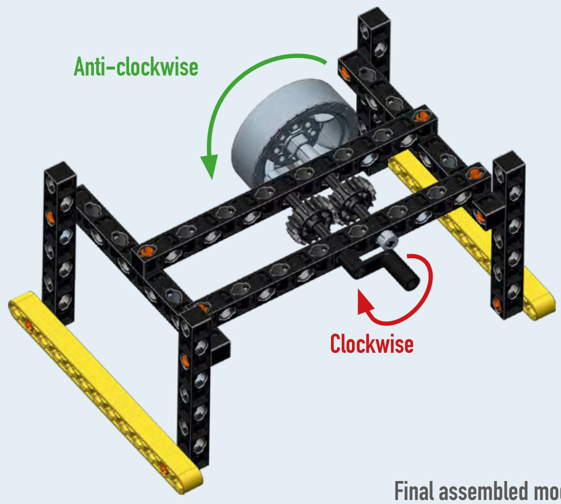
23 Assemble the test stand for reverse rotation



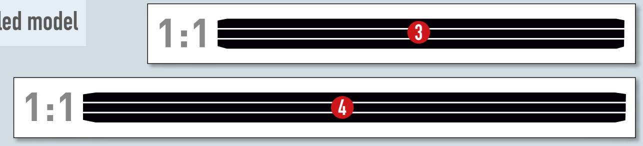


Assembled stand

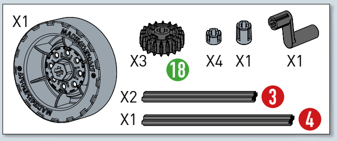


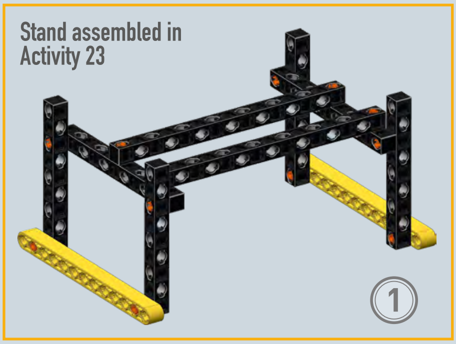


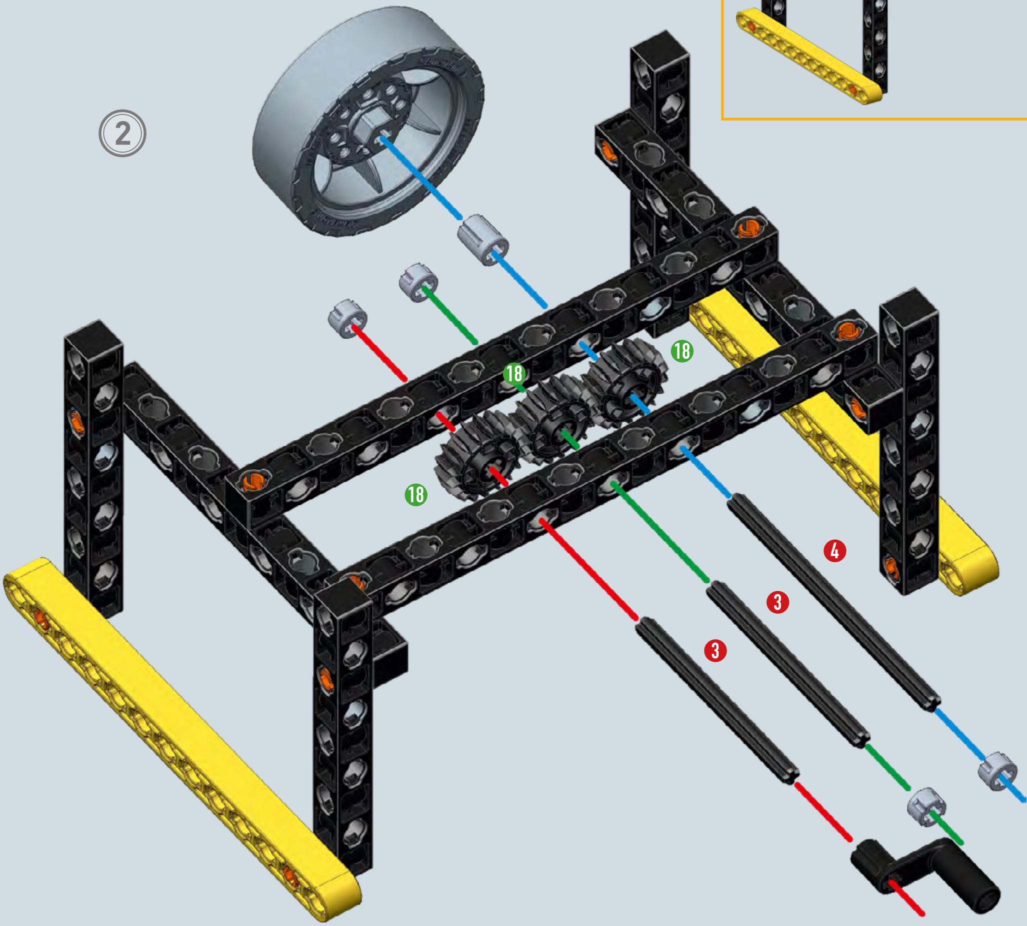
Final assembled model

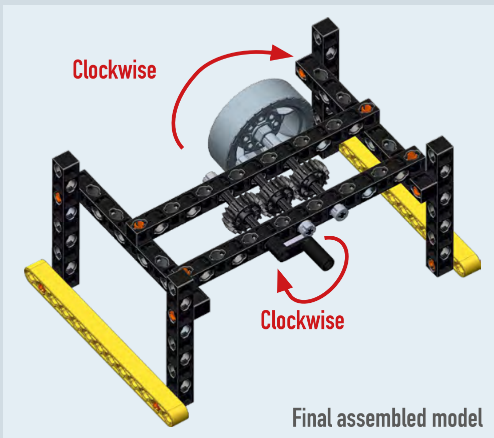


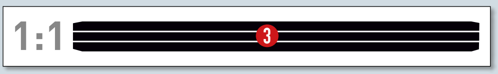
24 Build and test forward rotation

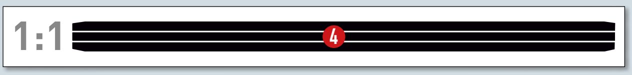




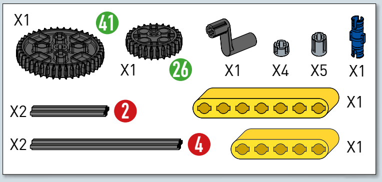


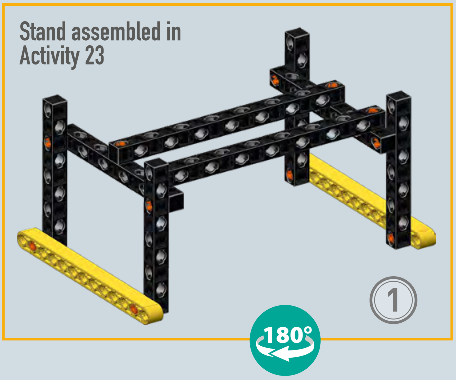


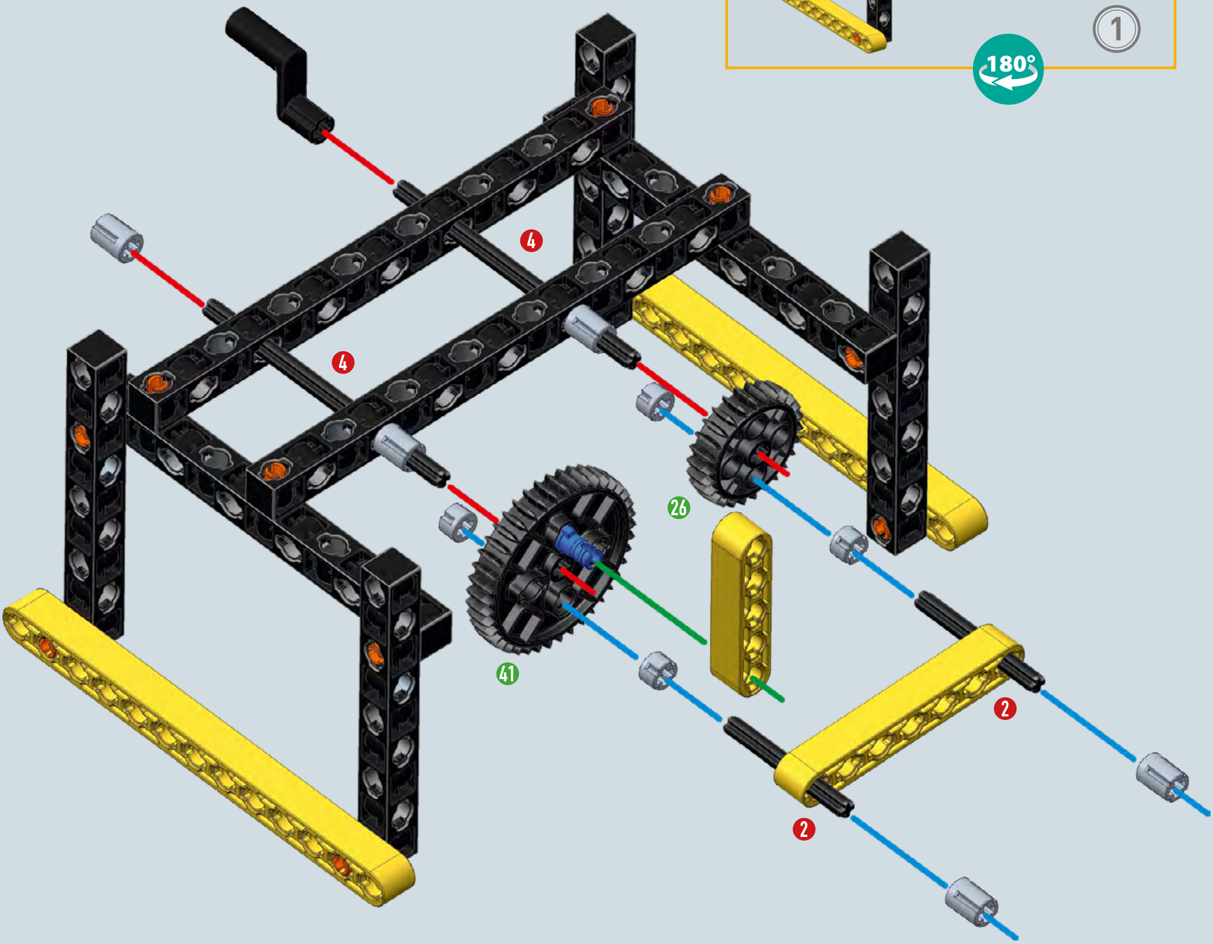




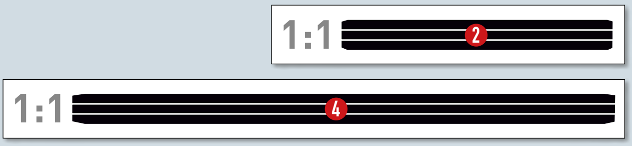
25 Assemble and test alternating movement





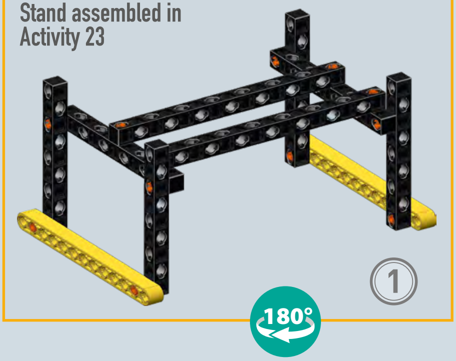


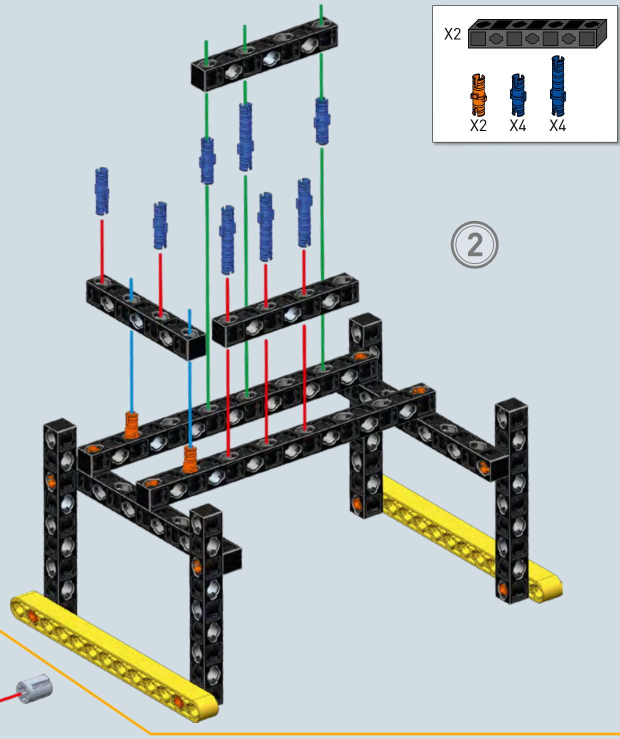
Final assembled model

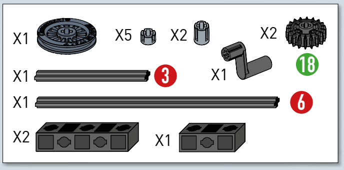


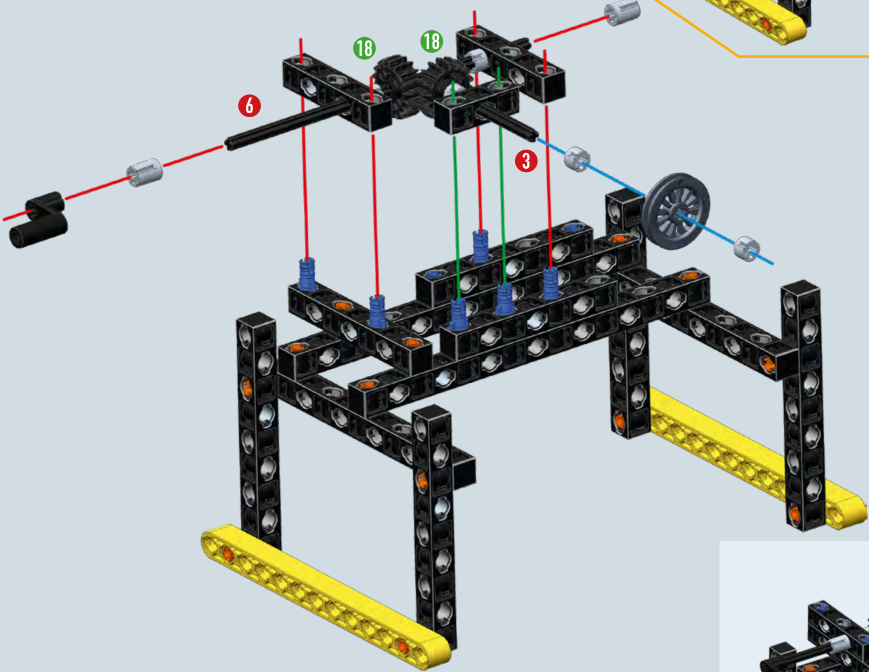
26 Build and observe right-angle rotation

Stand assembled in Activity 23

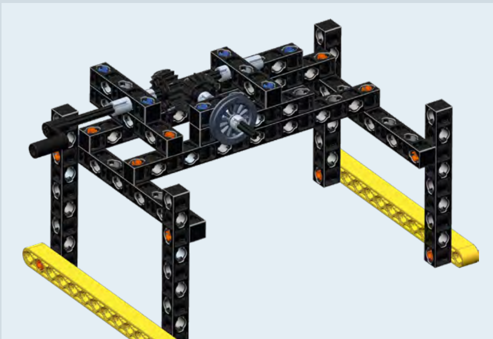




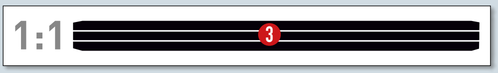


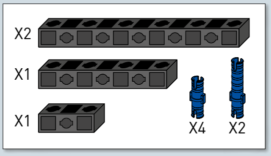


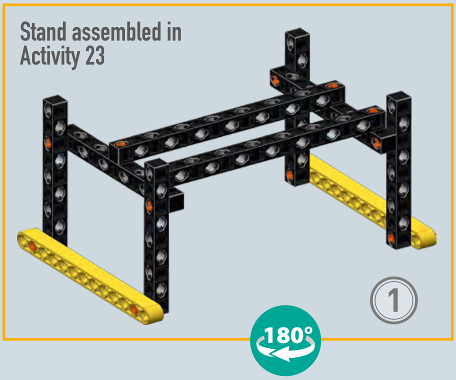
The two cogwheels must engage with each other at right angles, with the two rods almost touching.

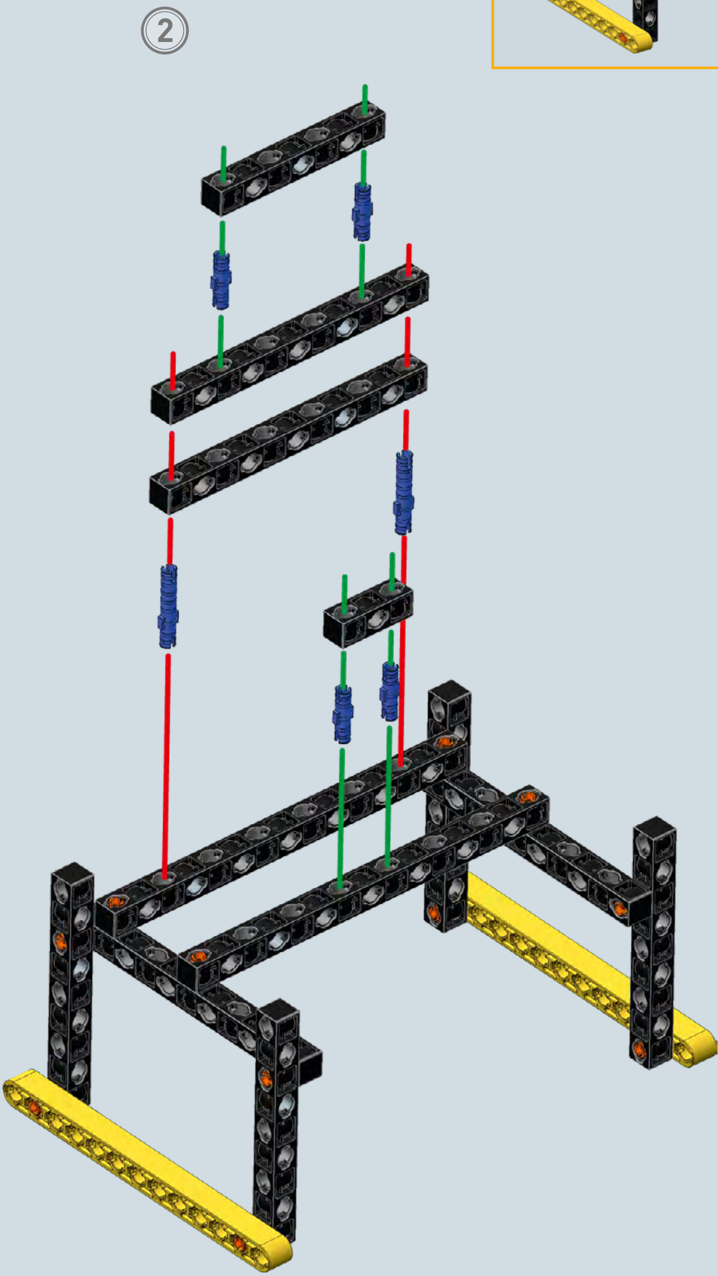


Final assembled model

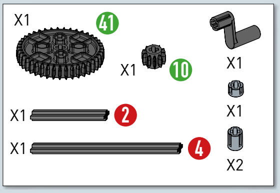


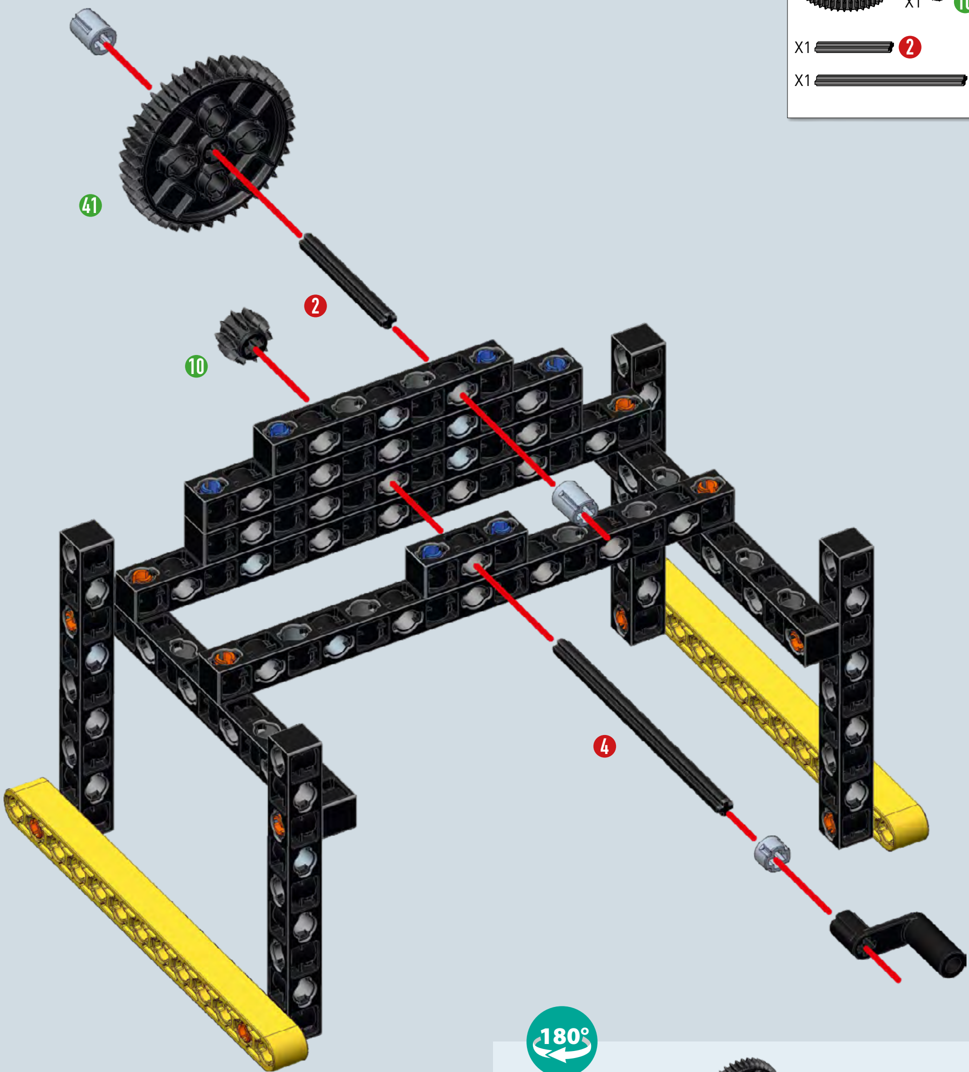

X2
X1
X1
X4
X2

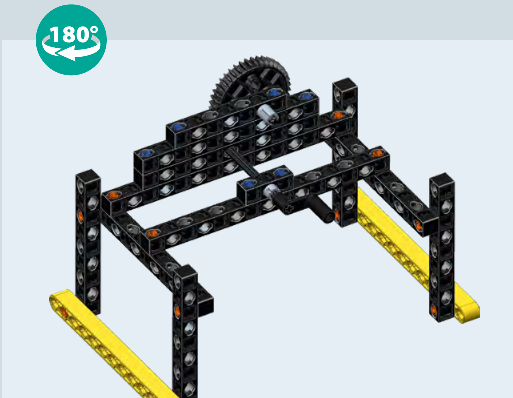

Stand assembled in
Activity 23
1
180°


2

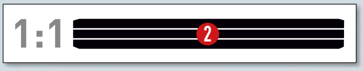
3

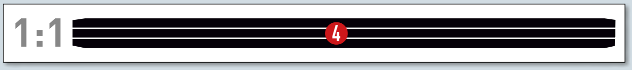


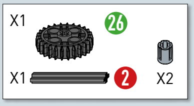




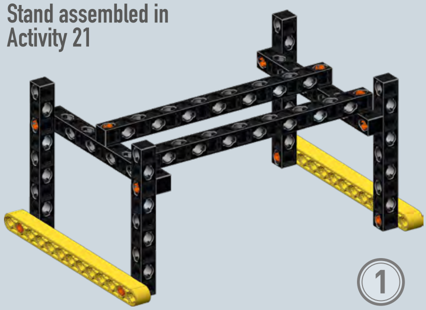
Final assembled model



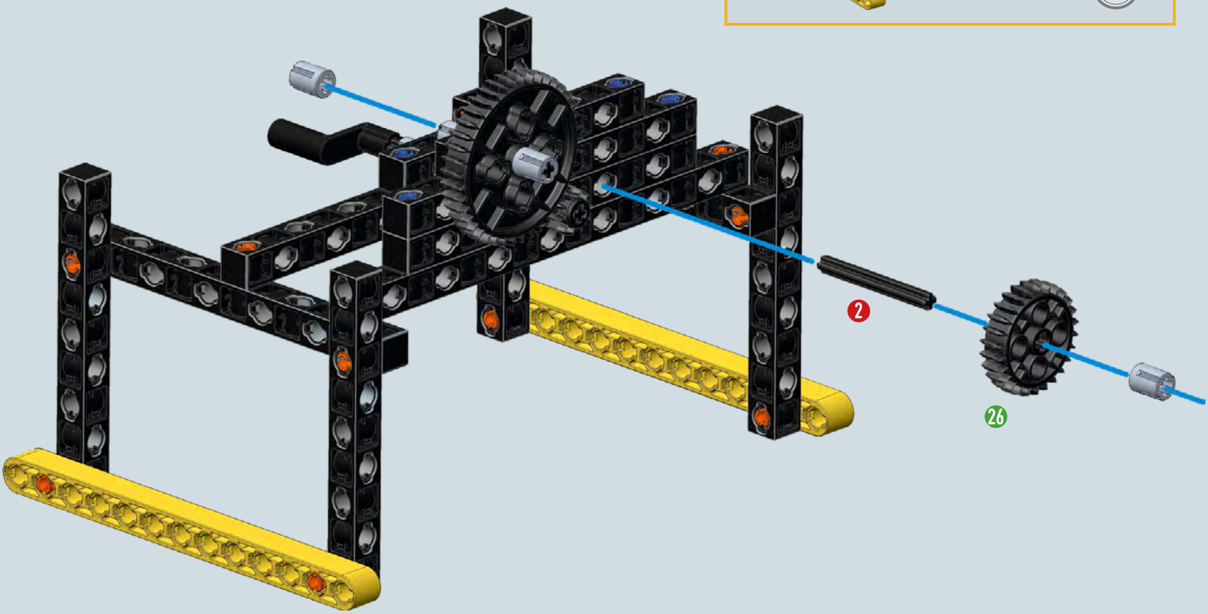


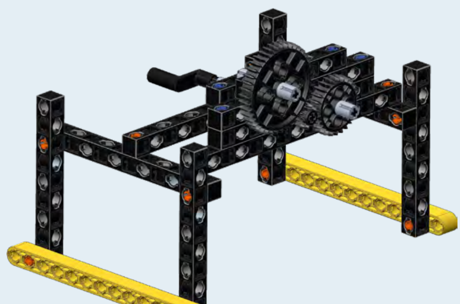


Stand assembled in Activity 21



2





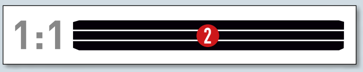
Final assembled model

GEAR RATIO

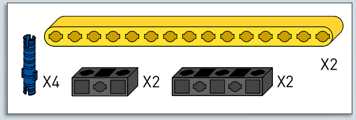
Carefully observe the cogwheels when they rotate and compare the number of revolutions completed by the various cogwheels. When the larger cogwheel has completed a revolution, the smaller one will have completed 4. You can prove this by dividing the number of teeth of the two cogwheels (ratio).

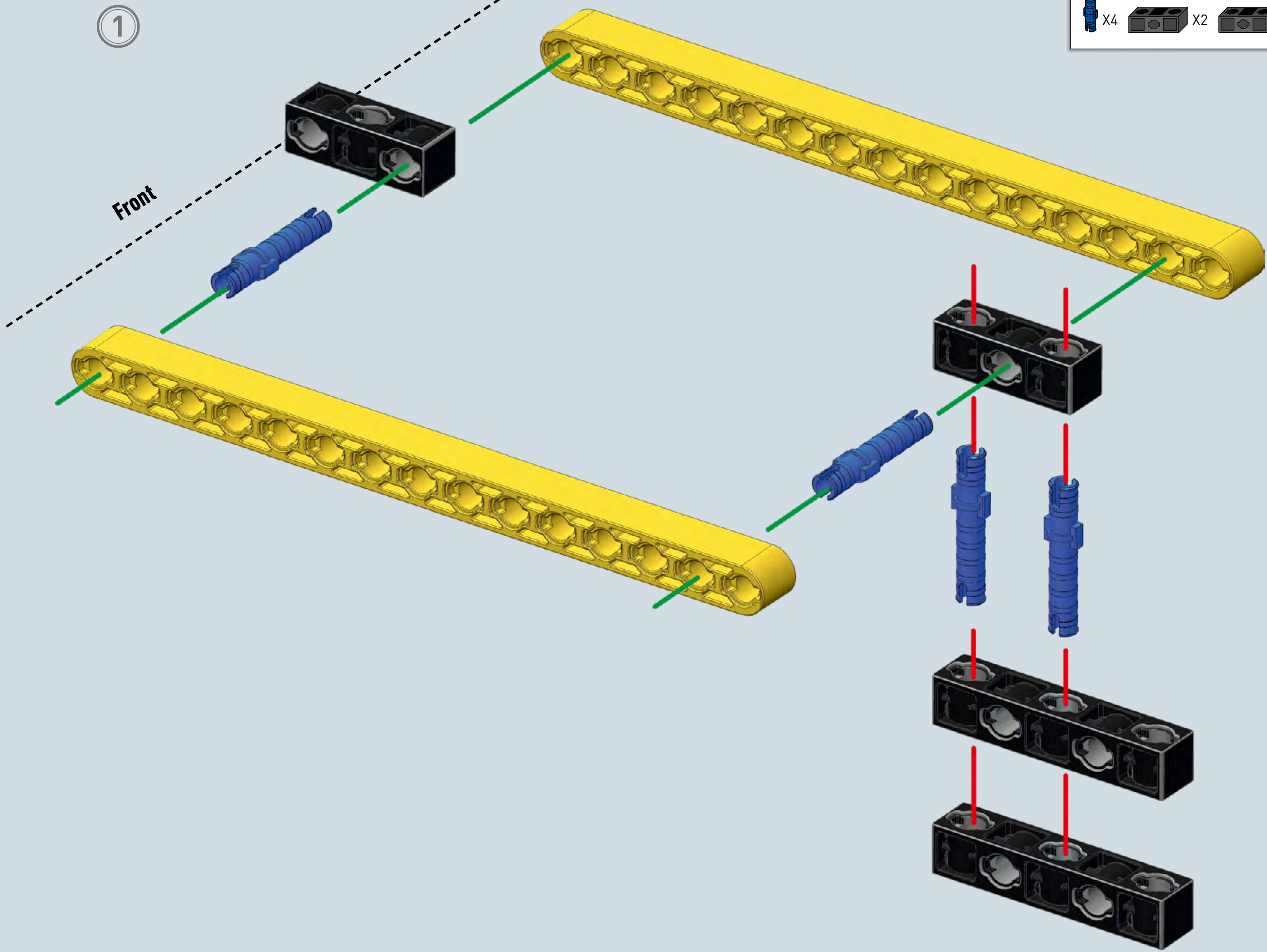
Example: how to calculate the gear ratio.

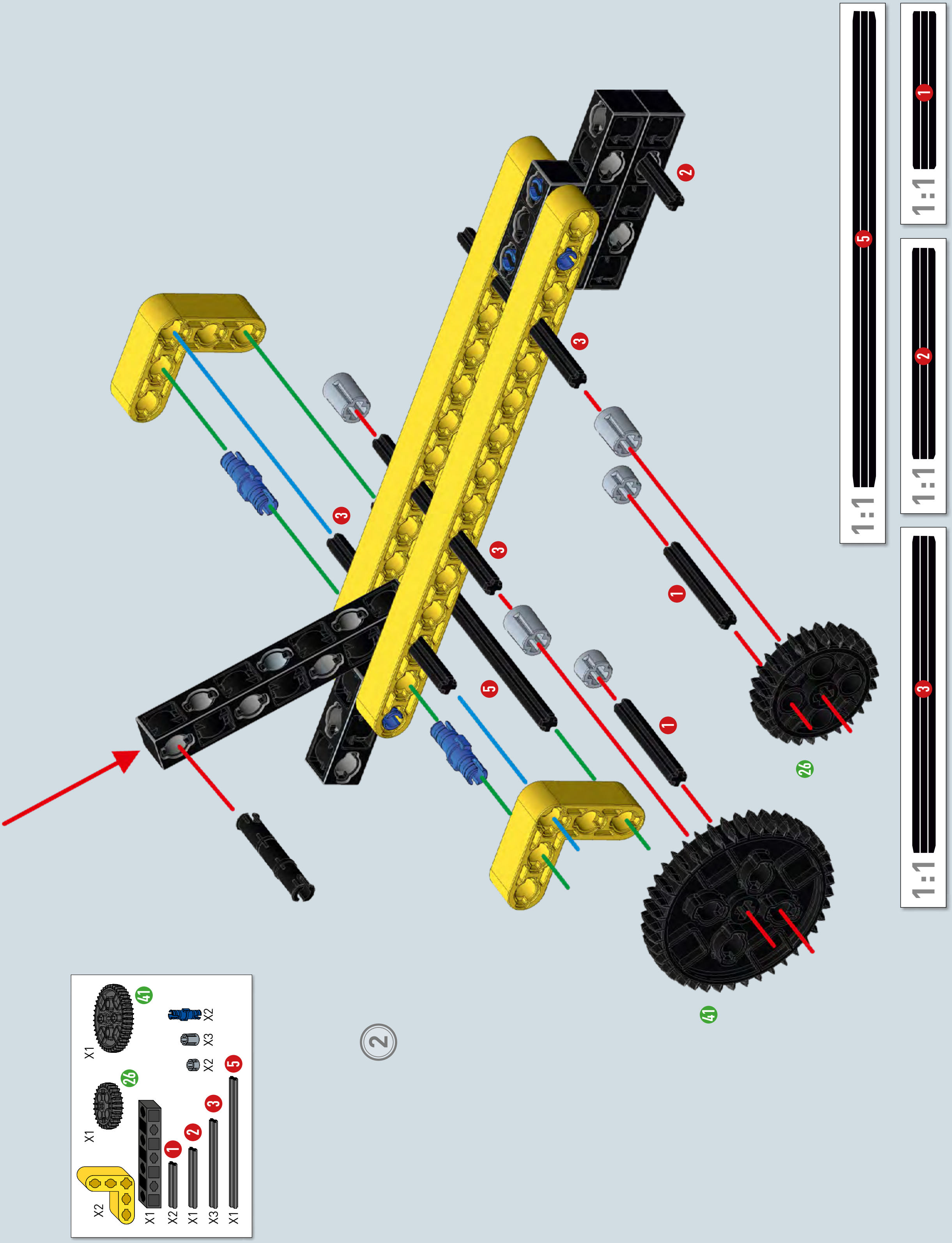
$$\frac{\text{41 teeth (larger wheel)}}{\text{10 teeth (smaller wheel)}} = \text{4.1 revolutions}$$



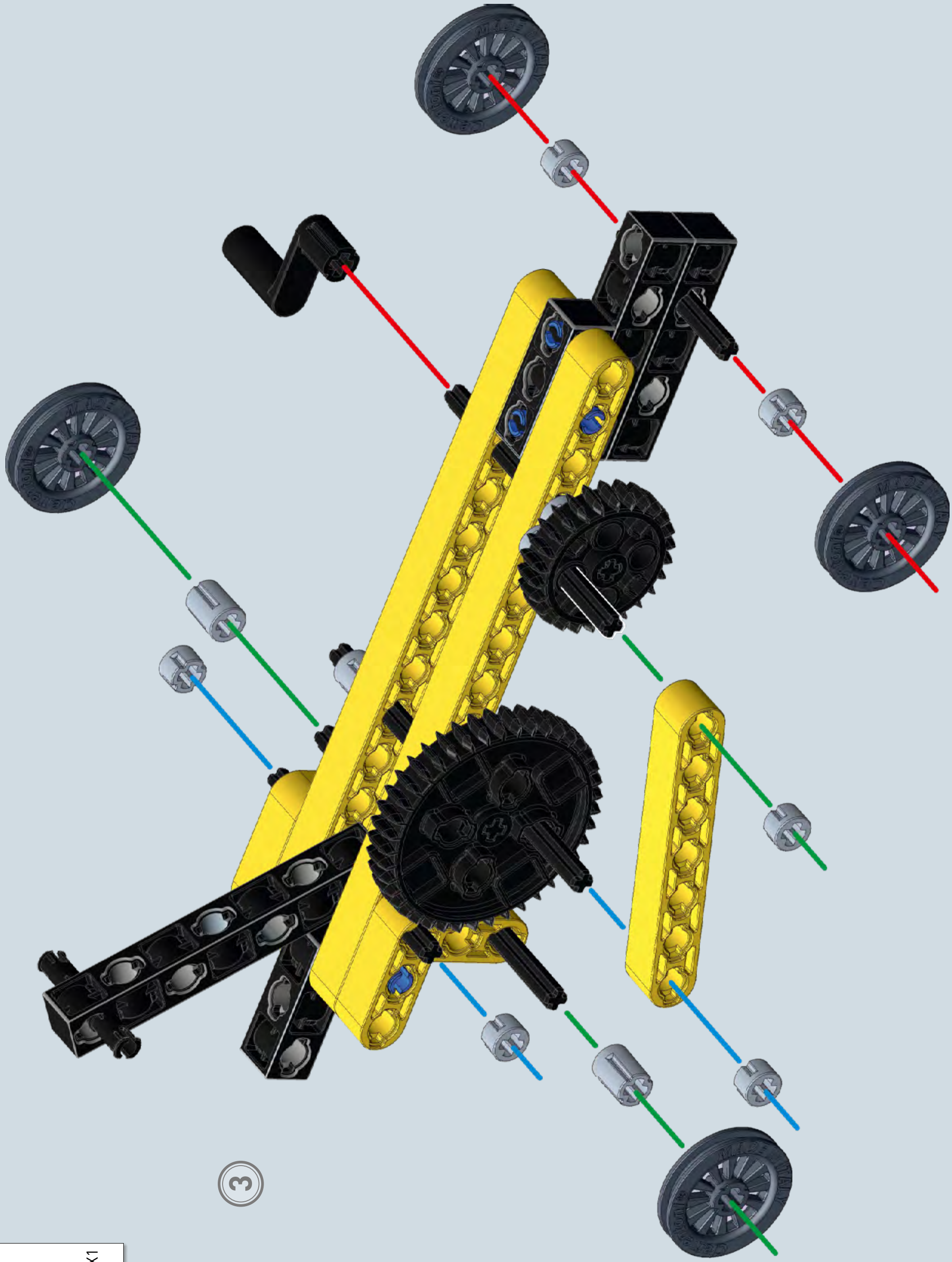
29 An ancient war machine: the battering-ram



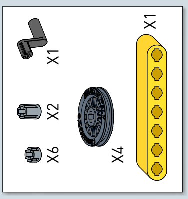




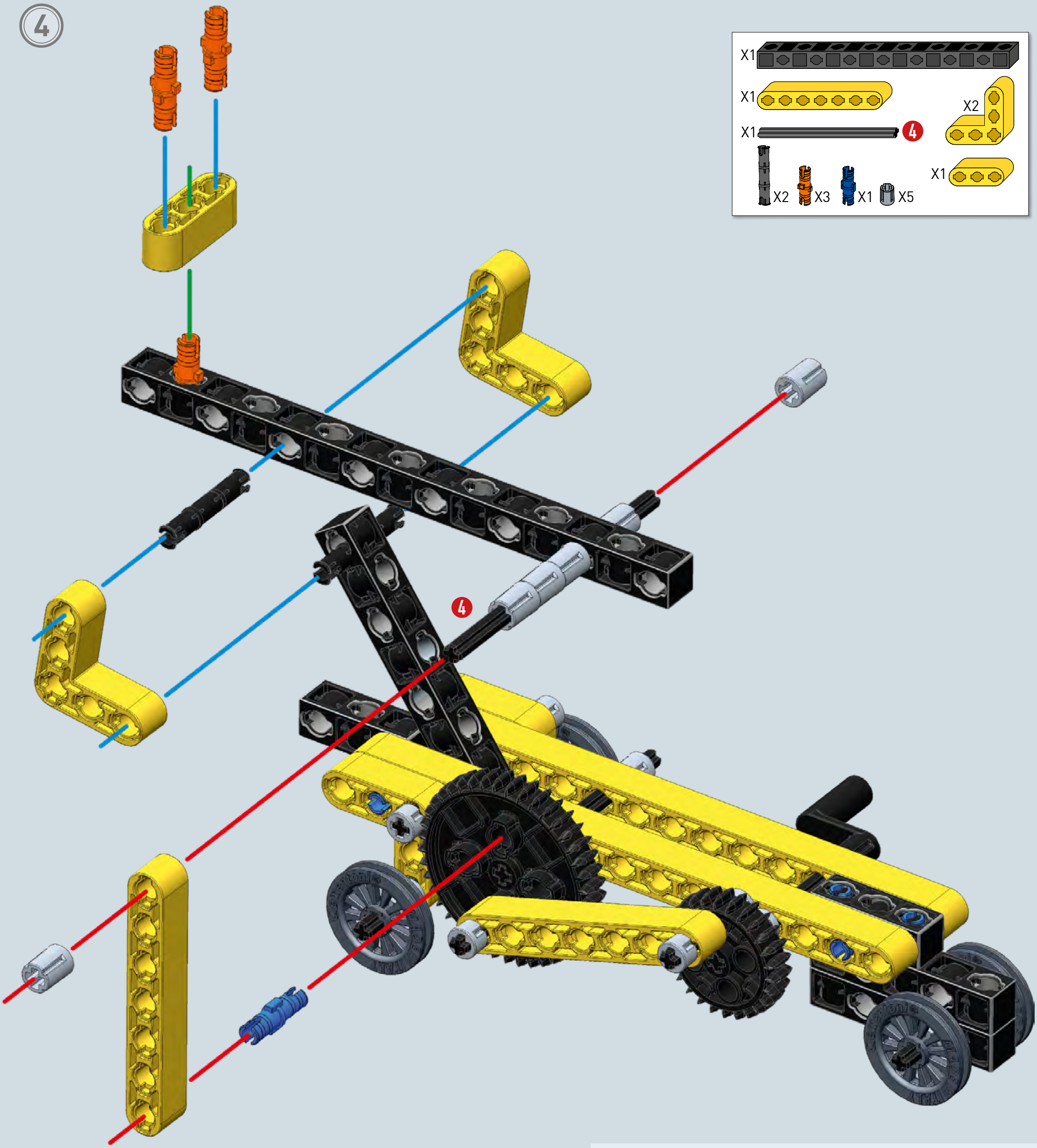
1:1
1:1
1:1
1:1
2
X2
X1
X2
X1
X3
X1
X1
X1
X2
X3
X2

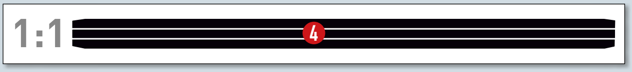


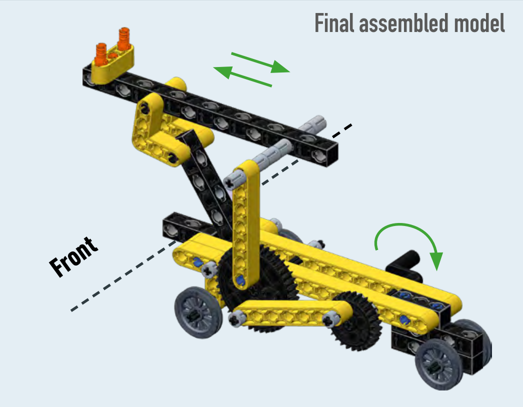
3



4

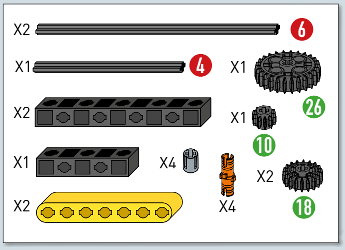


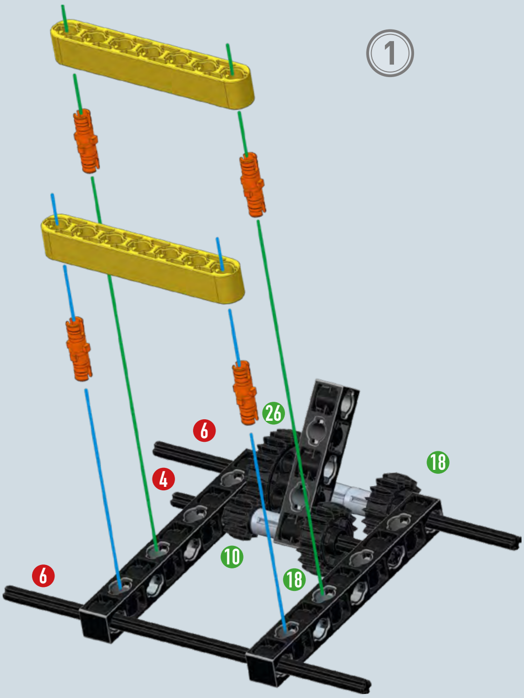


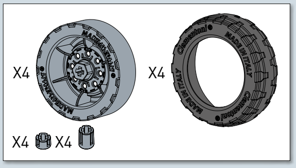


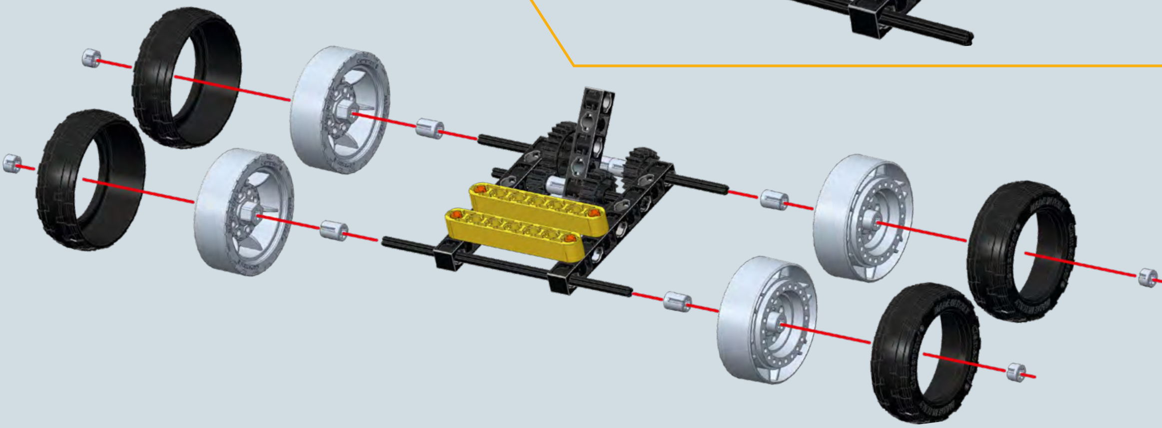
Final assembled model

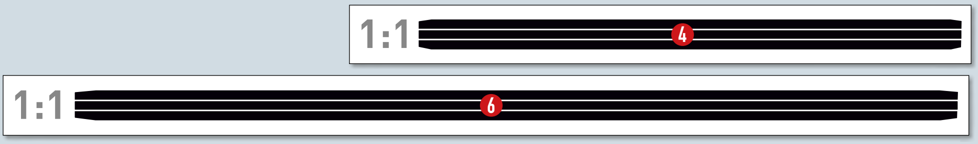
30 Assemble a manual gearbox with gears

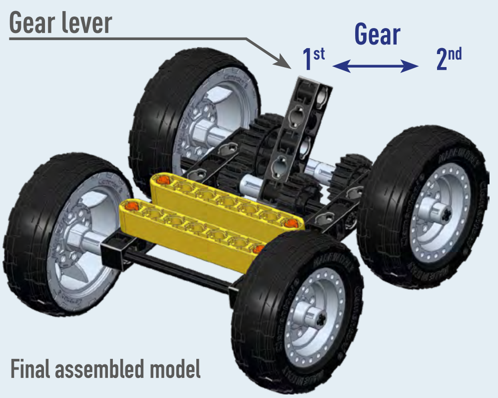












Final assembled model

Technical facts on manual gearboxes

In a real car the gears are sealed inside a box, called the gearbox, which is positioned between the engine axle and the wheel axles.

Ways of changing gear

The lever (see figure) can be used to move the various-sized cogwheels horizontally on the transmission axle to make them engage with the cogwheels on the wheel axles. Depending on the driving wheel, this causes a change in the rotation of the wheels and a change in the speed of the car.