4

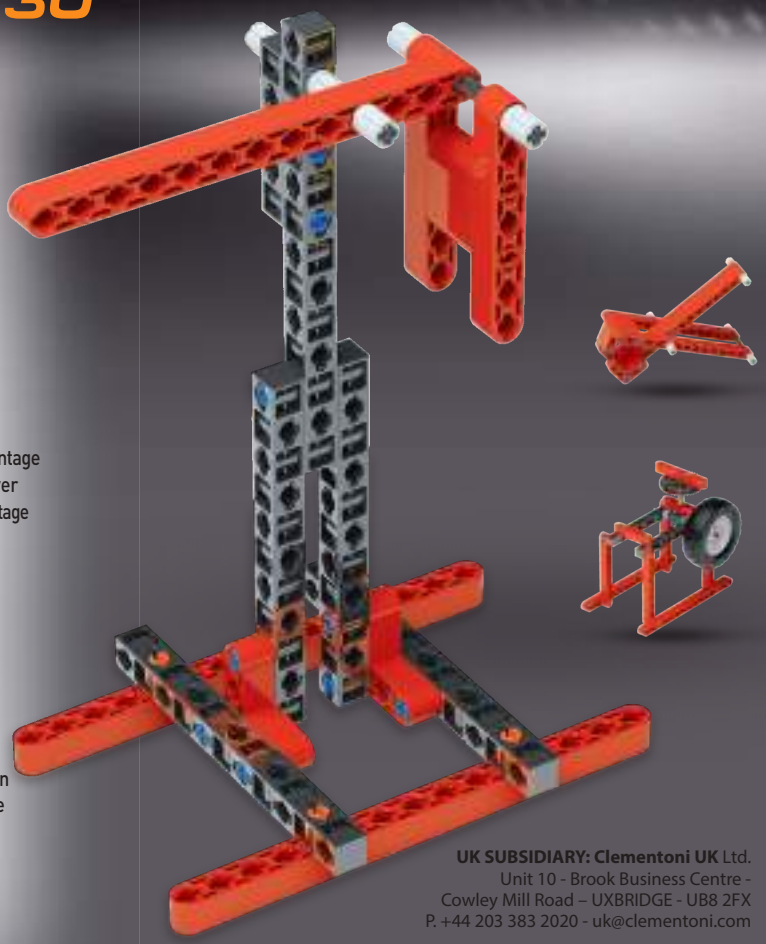
TECHNOLOGIC

MECHANICS Laboratory

RACING CARS

Constructions 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 parallelepiped
10-Build a simple bridge
11-Assemble cogwheels on a rod
12-Build a class 1 lever: pincers
13-Build a class 2 lever: nutcracker
14-Build a class 3 lever: tongs
15-Build the lever's fulcrum and weight
16-Assemble and test a lever with mechanical advantage
17-Assemble and test a mechanically neutral lever
18-Assemble and test a lever with mechanical disadvantage
19-Assemble a balance
20-Build and test a see-saw
21-Assemble the test stand for reverse rotation
22-Build and test forward rotation
23-Assemble and test alternating movement
24-Assemble a vertical gearbox
25-Build a horizontal to vertical gearbox
26-The worm screw for lifting
27-The worm screw as a reduction gear
28-Using the transmission module for counter-rotation
29-Assemble the gearbox with a differential cage
30-An ancient war machine: the battering ram



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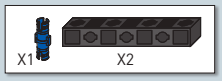
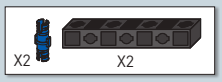
1 Stacking two beams

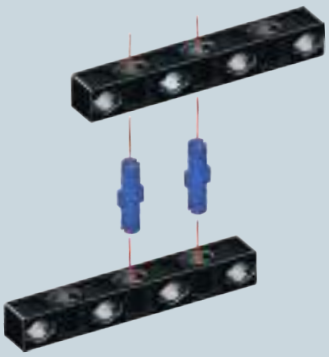


Assembled beams

2 Stacking beams with two pegs

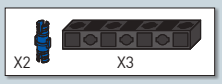
Two pegs make the construction very robust!

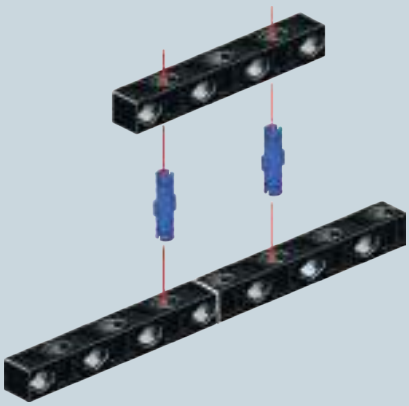


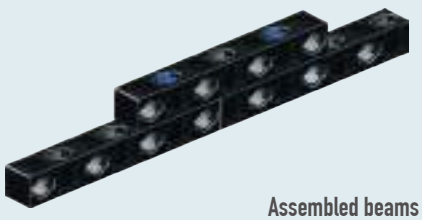


Assembled beams

3 Joining beams

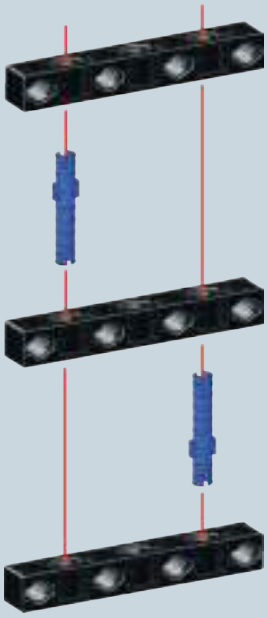


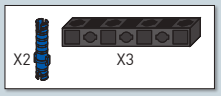


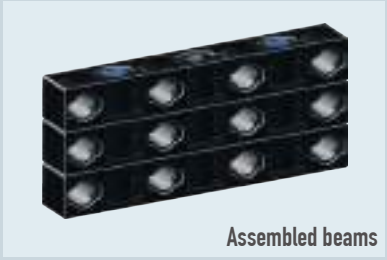


Assembled beams

4 Stacking three beams

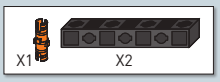


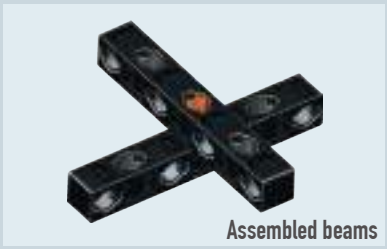




Assembled beams

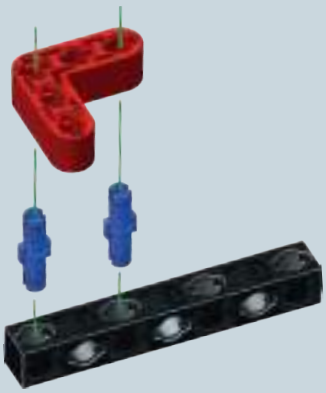
5 Stacking beams perpendicularly

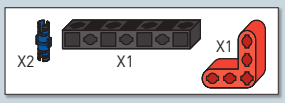




Assembled beams

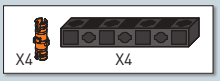
6 Stacking with an L-shaped beam

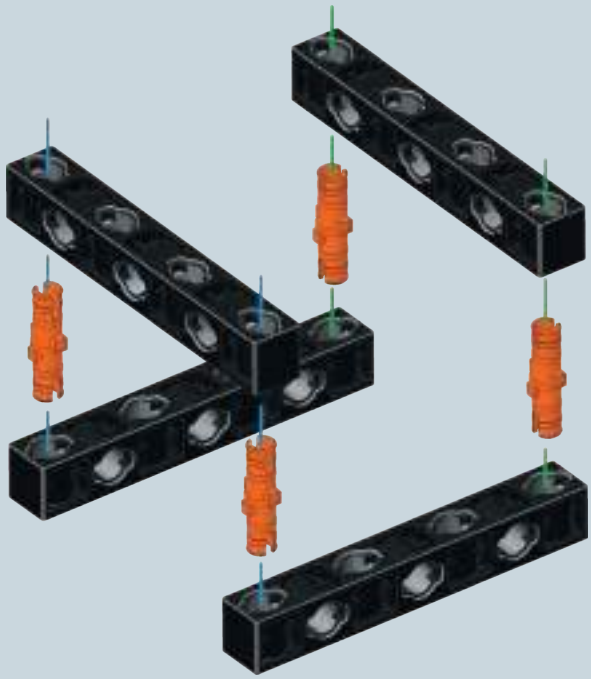




Assembled beams

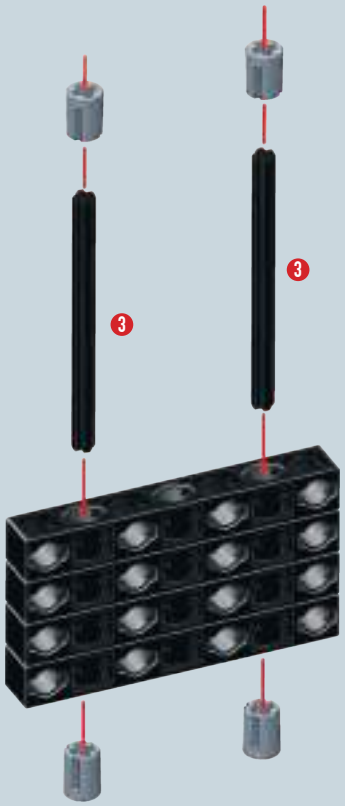
7 Build a square with beams

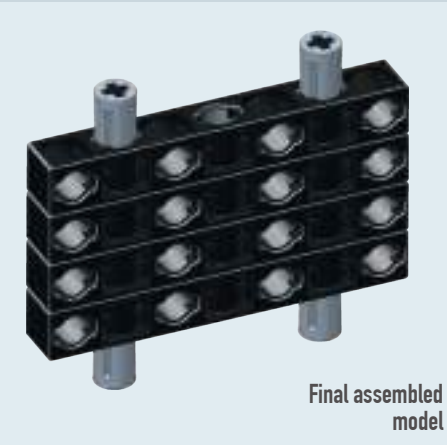




Final assembled model

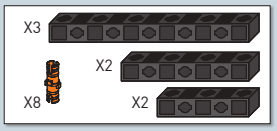
8 Stacking four beams





Final assembled model

9 Build a parallelepiped



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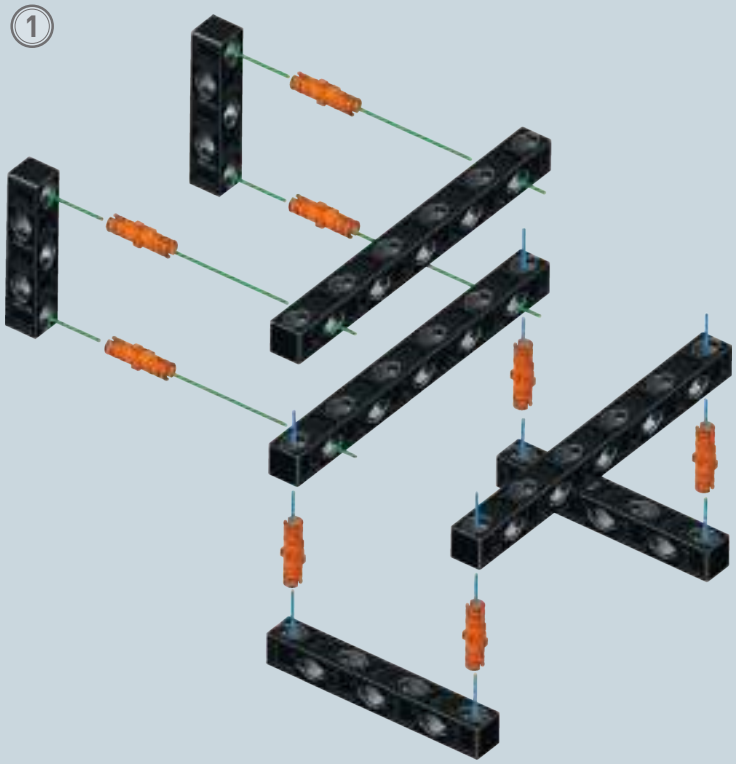

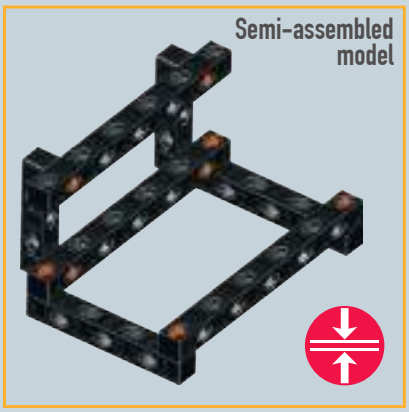

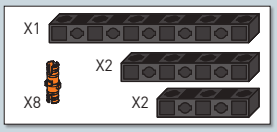

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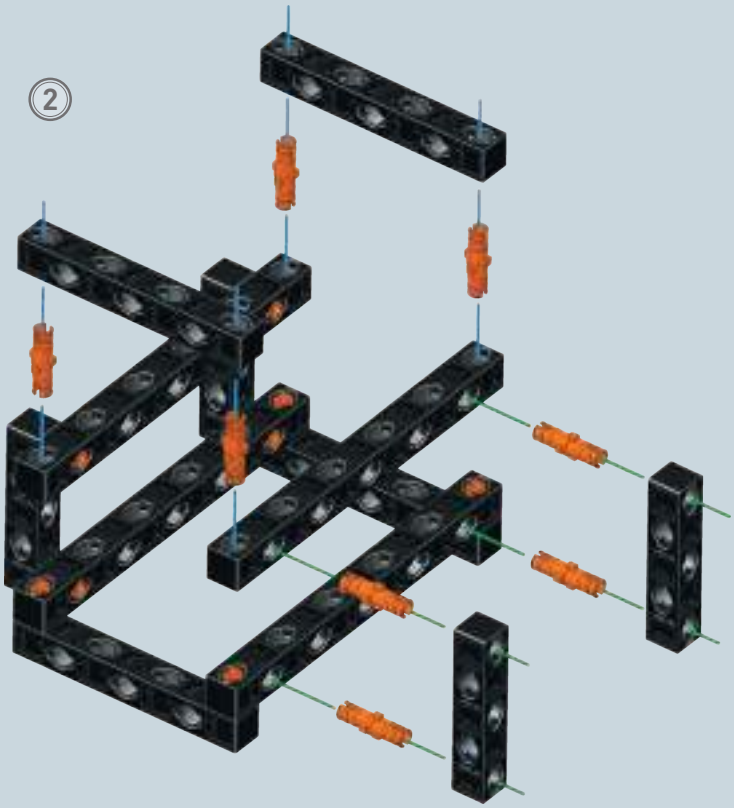
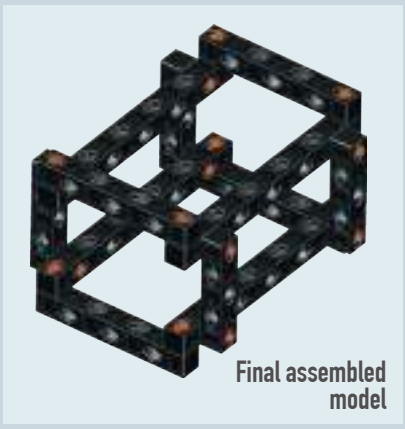
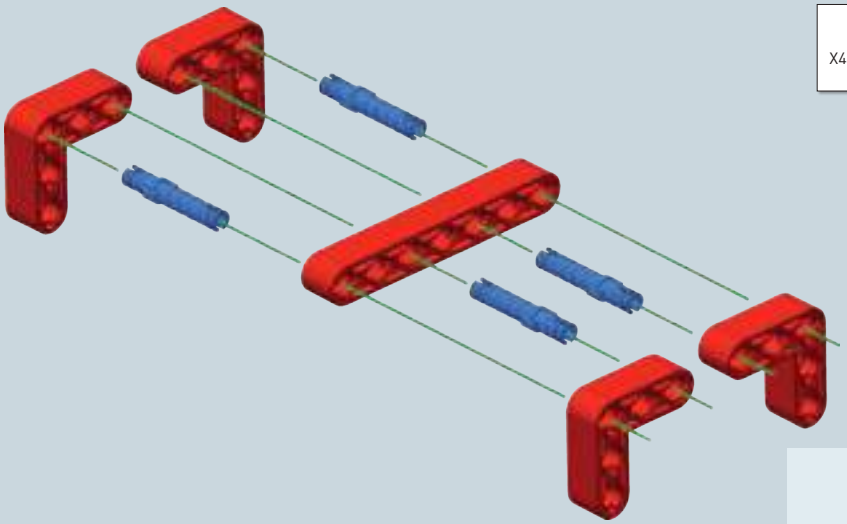
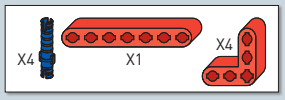
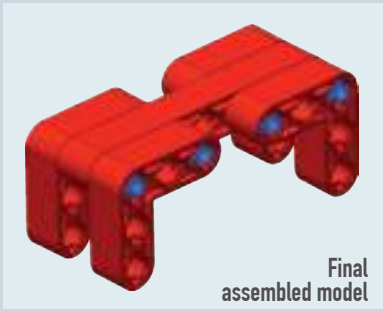




10 Build a simple bridge

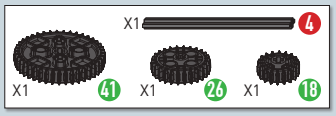


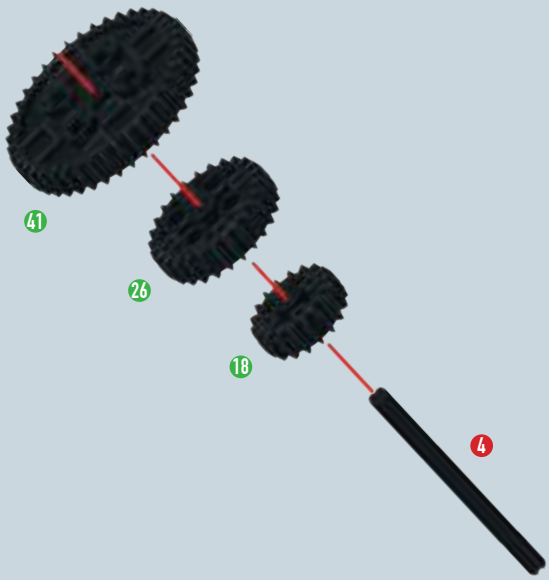


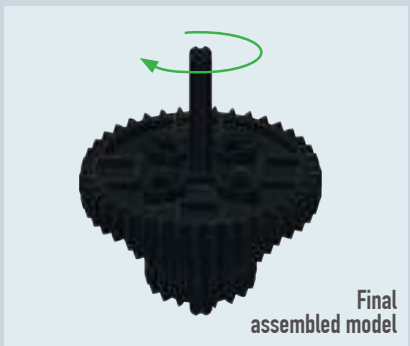


Final assembled model

11 Assemble cogwheels on a rod





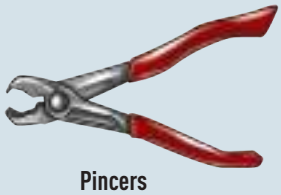


Final assembled model

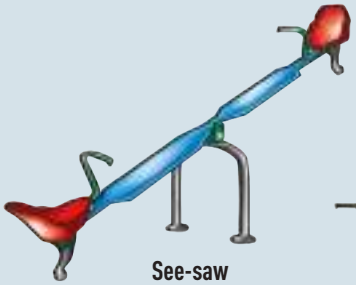
Try it out as a spinning top!

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**).

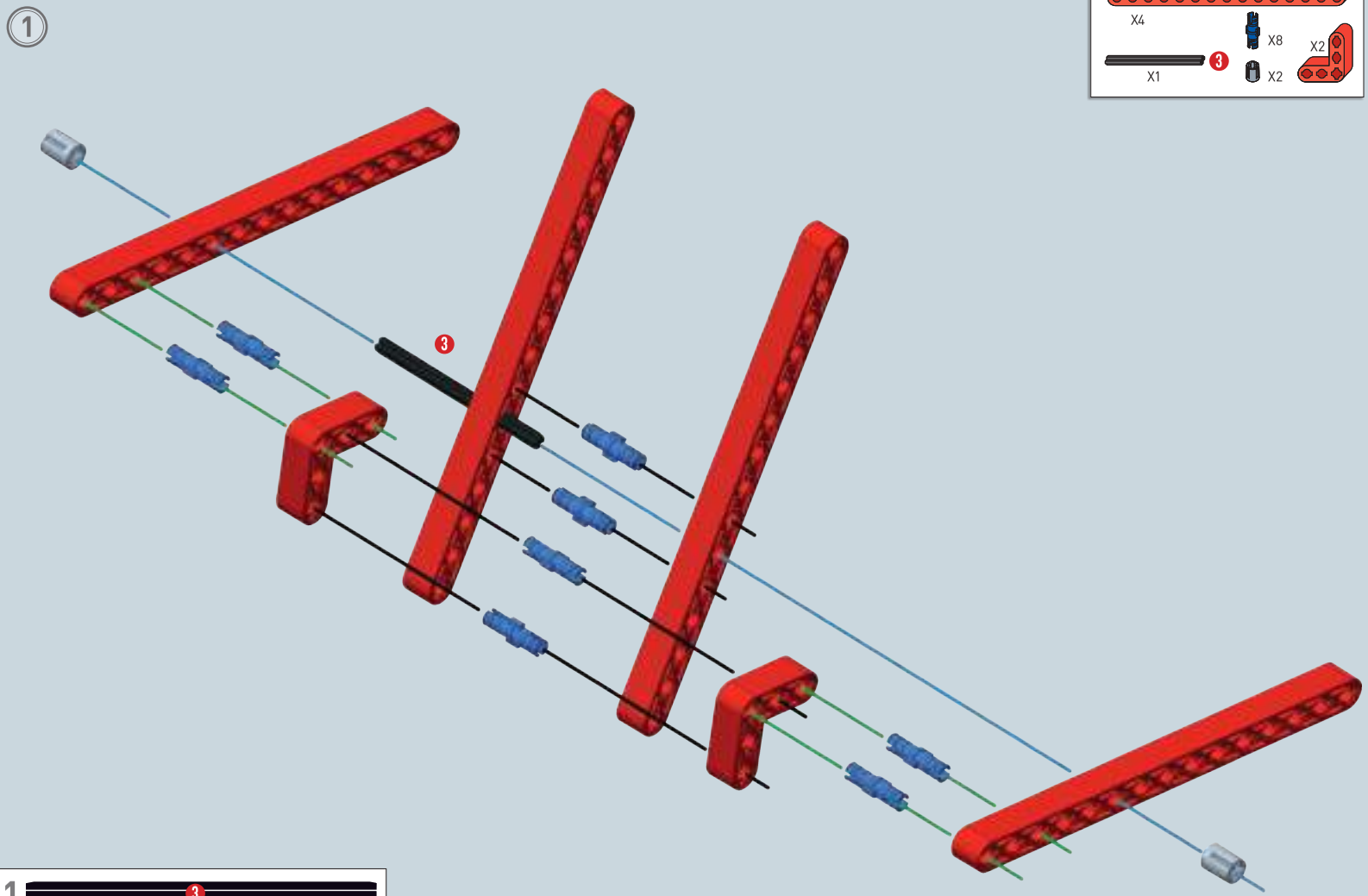
LEVERS

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

RESISTANCE **FULCRUM** **EFFORT**

- Pairs of levers also obey this principle.
- Levers are classified by the relative positions of the **EFFORT**, **RESISTANCE** and FULCRUM.

12 Build a Class 1 lever: pincers



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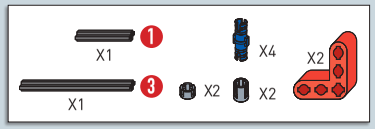


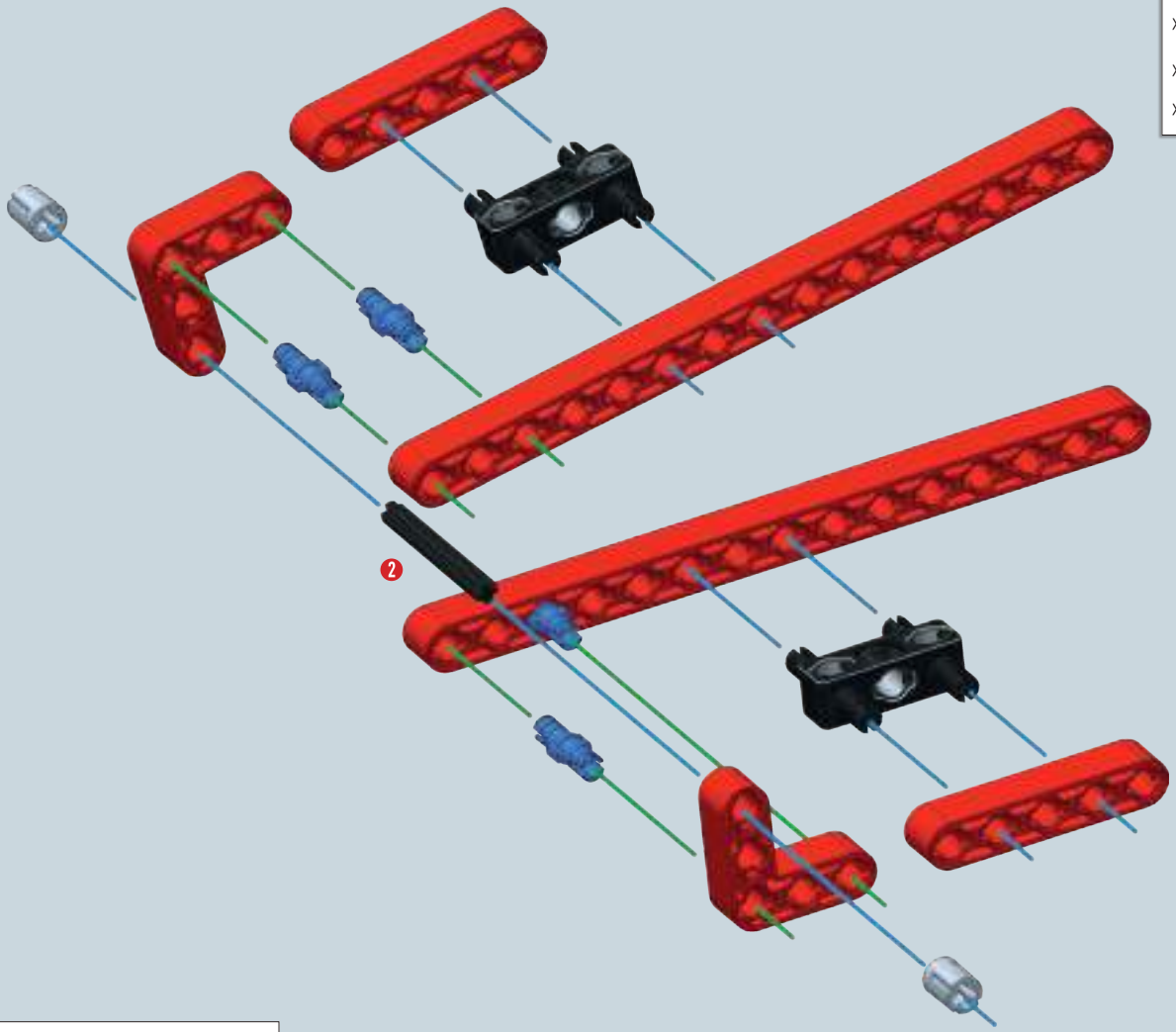
The FULCRUM lies between the RESISTANCE and the EFFORT.

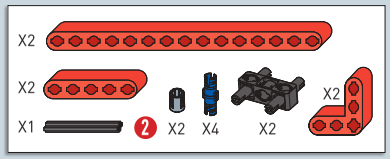
Final assembled model

1:1 1

1:1 3

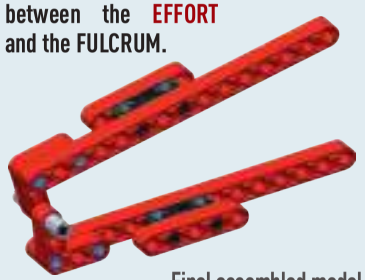
13 Build a Class 2 lever: nutcracker





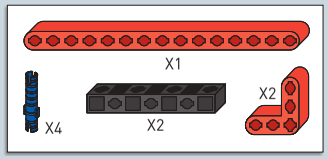
1:1 2

The RESISTANCE lies between the EFFORT and the FULCRUM.



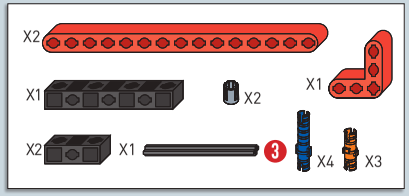
Final assembled model

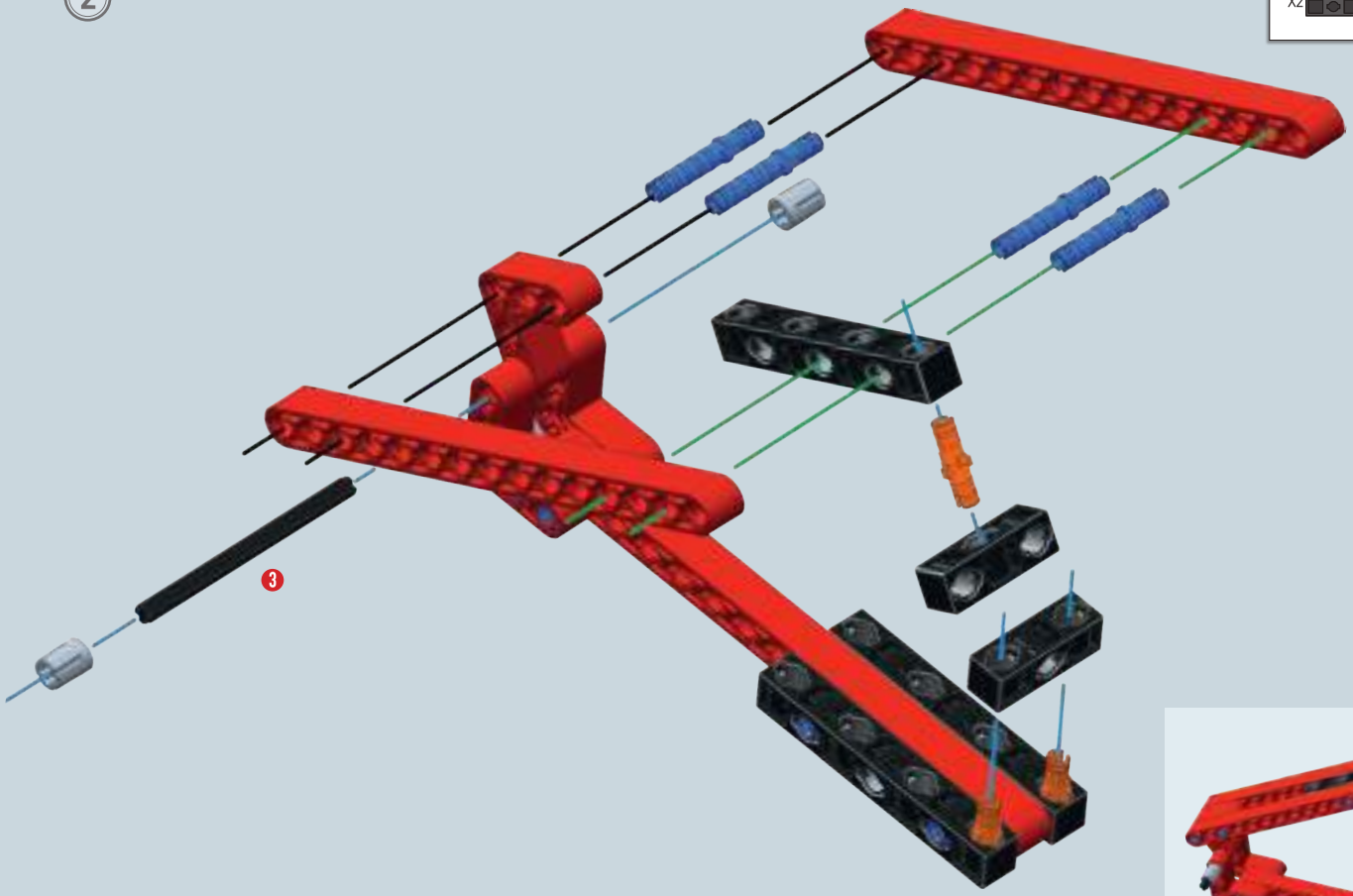
14 Build a Class 3 lever: tongs



1

2



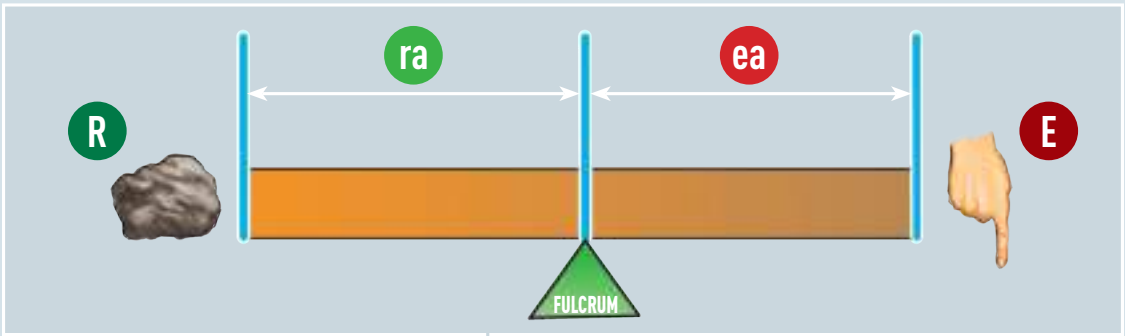


The EFFORT lies between the RESISTANCE and the FULCRUM.

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 on the rod: EFFORT and RESISTANCE. Using a lever, therefore, we have a MECHANICAL ADVANTAGE that can be calculated by considering also the length of the EFFORT and RESISTANCE arms. 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

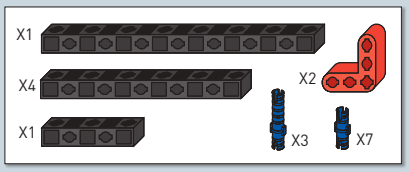
EQUILIBRIUM CONDITIONS: ra x R = ea x E

MECHANICAL ADVANTAGE: A = R / E

ASSEMBLE AND TEST THE LEVERS

15 Build the lever's fulcrum and weight

1



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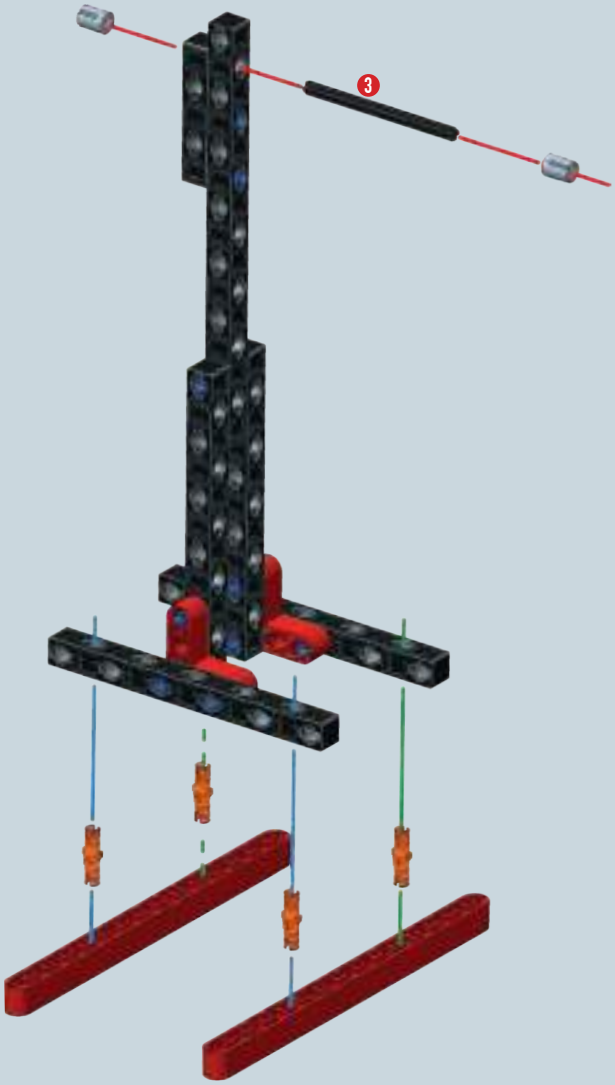
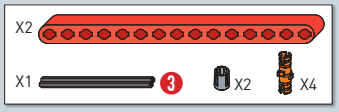
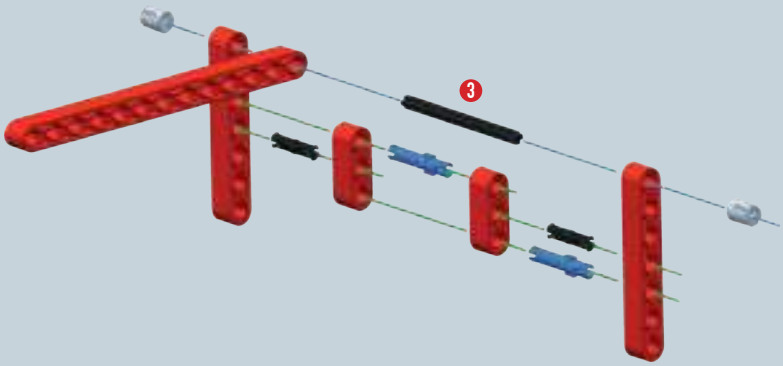
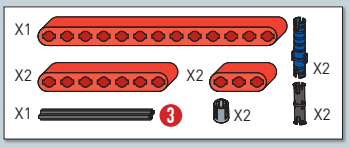
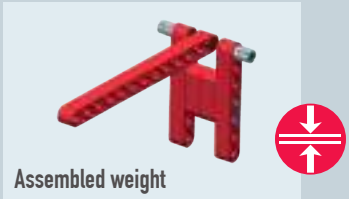




ASSEMBLING THE WEIGHT







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.

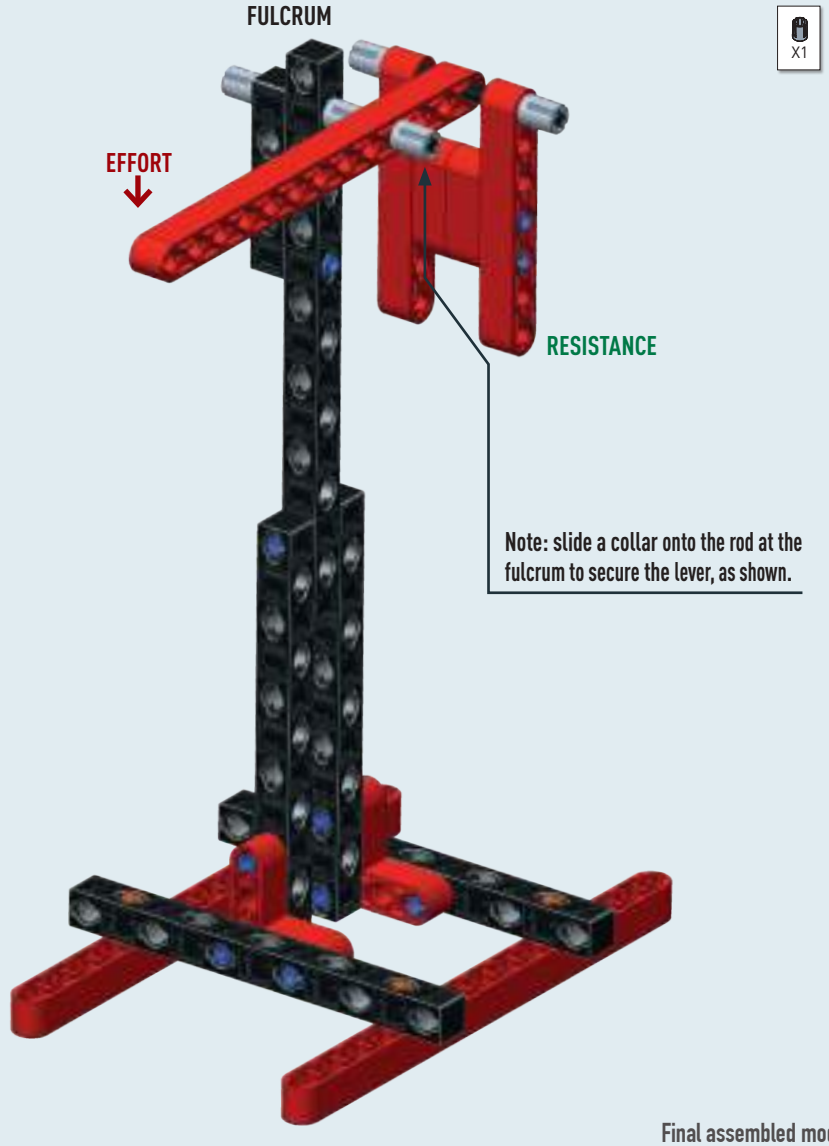
16 Assemble and test a mechanically advantaged lever

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

TRY IT OUT!



Final assembled model

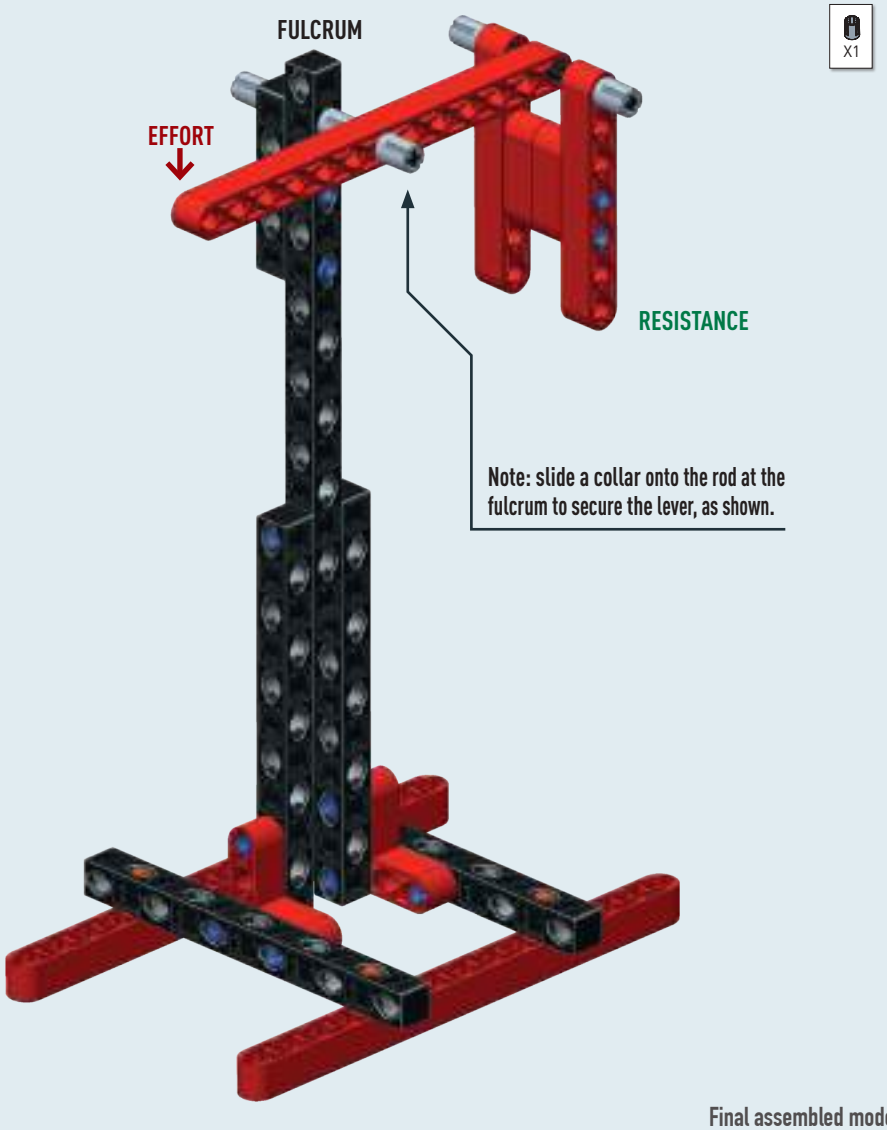
17 Assemble and test a mechanically neutral lever

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

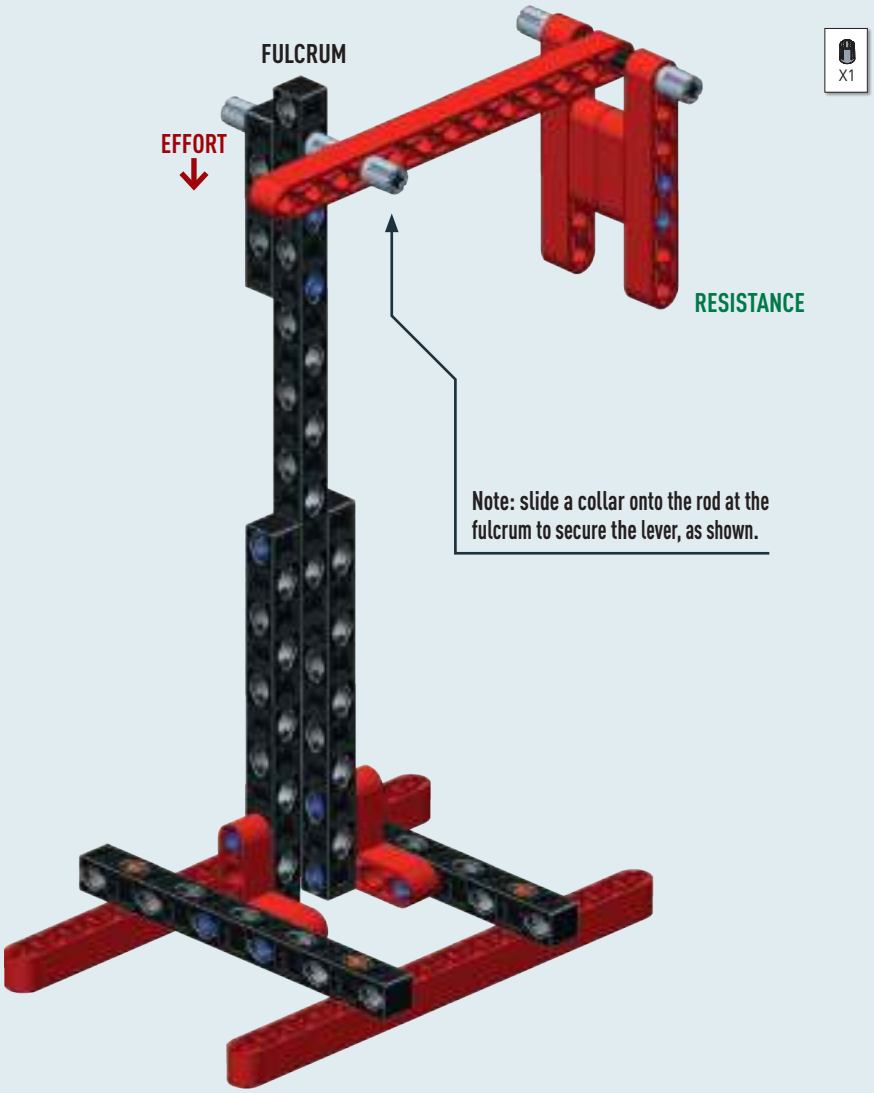
18 Assemble and test a mechanically disadvantaged lever

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!

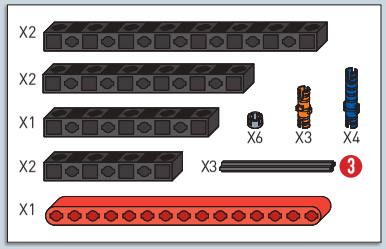
- The arms are the same.
- The EFFORT is **equal** to the RESISTANCE.

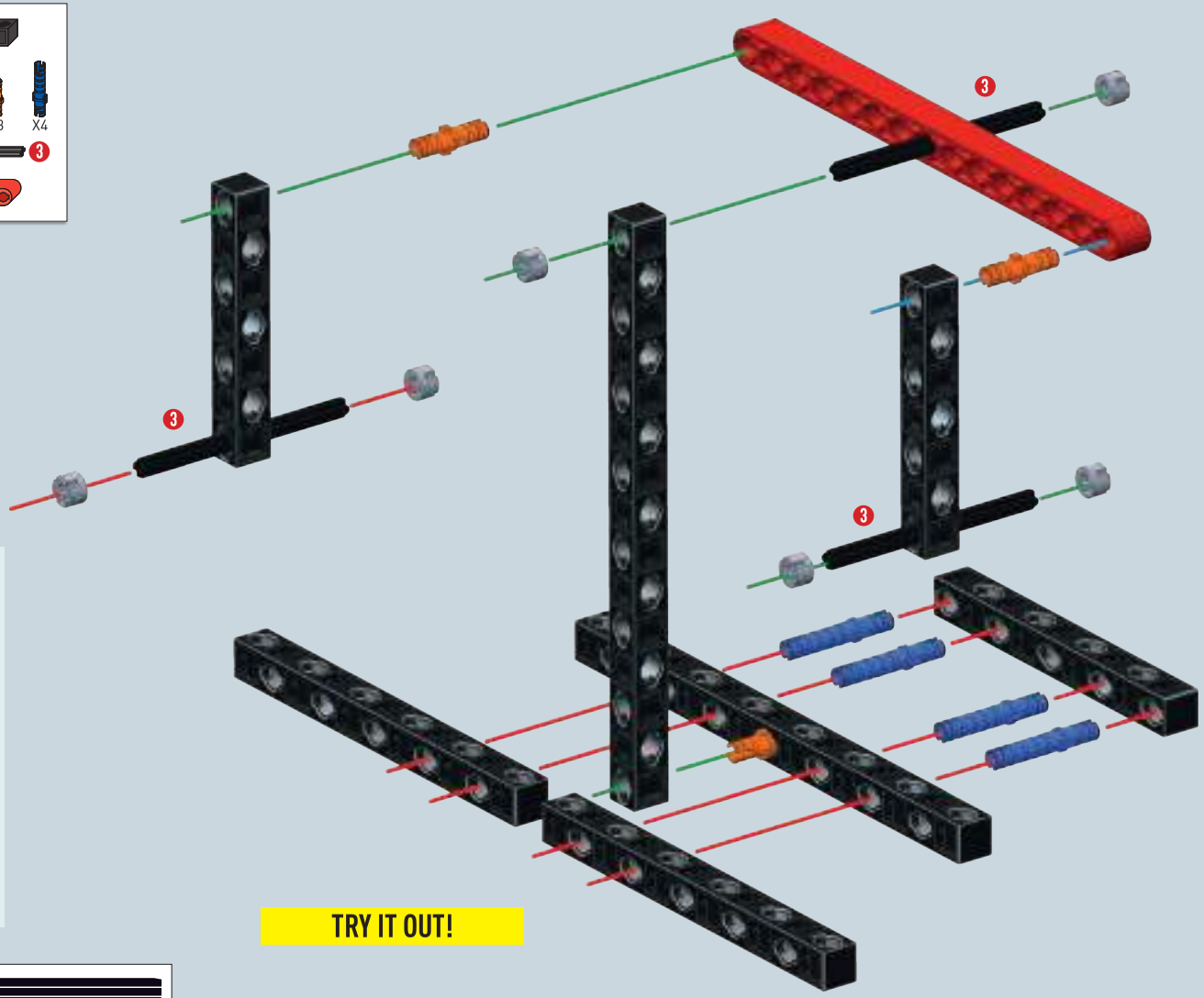
TRY IT OUT!



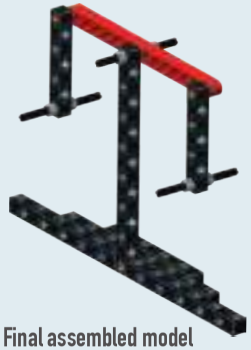
Final assembled model

19 Assemble a balance





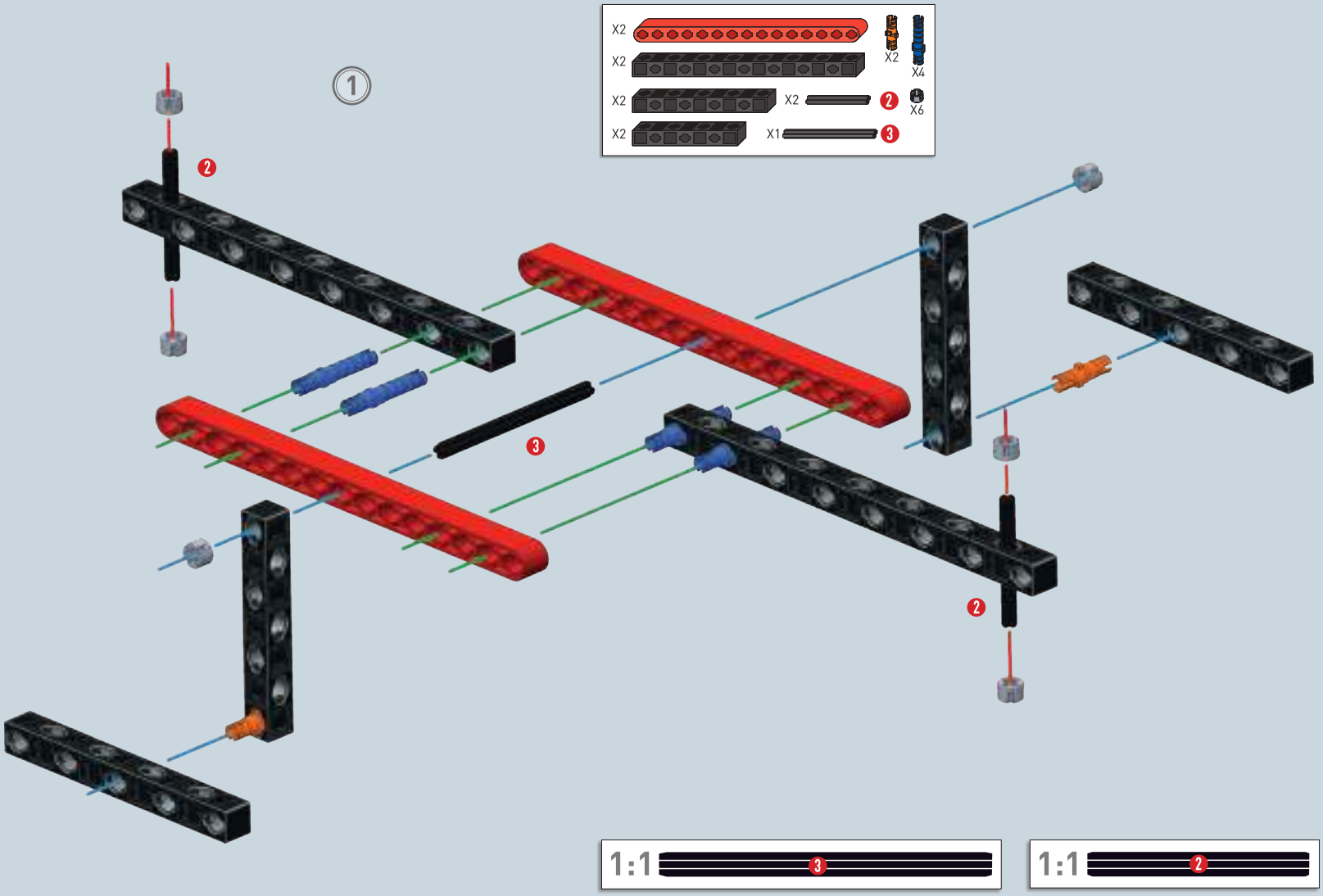
The balance is a class 1 lever



Final assembled model

TRY IT OUT!

20 Build and test a see-saw



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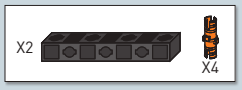


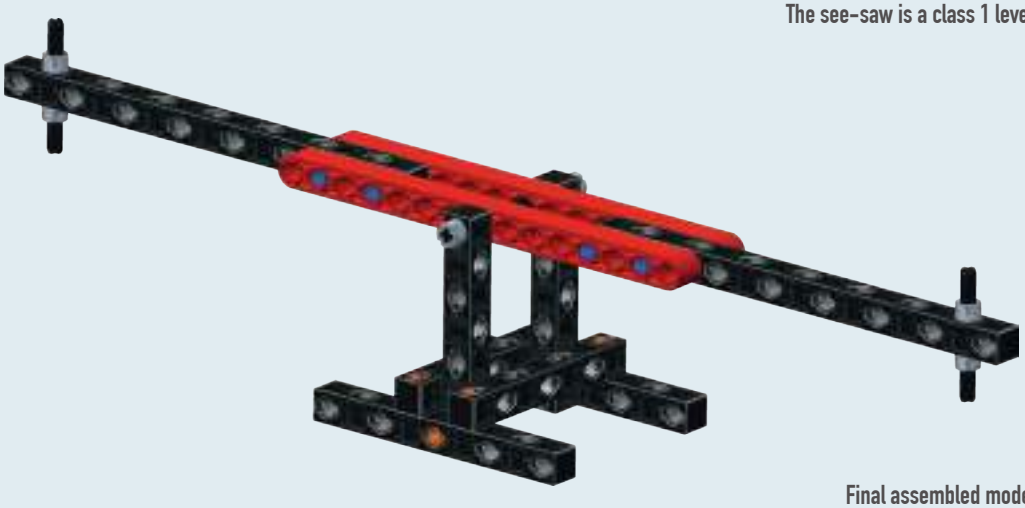
In the third century BC, Archimedes was a great scientist and experimenter with levers.

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

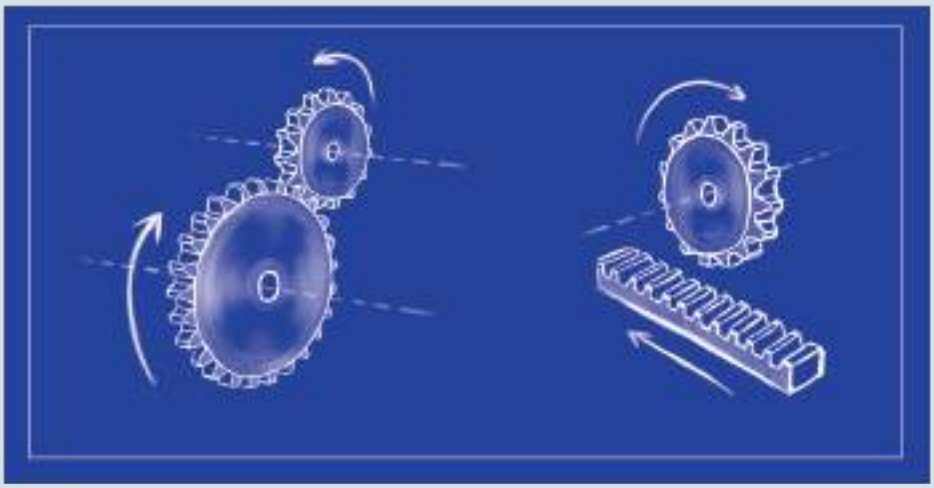


Final assembled model

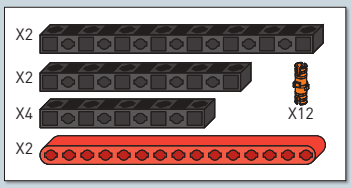
COGWHEELS

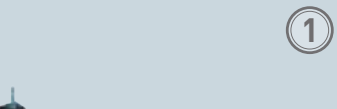
Cogwheels transmit motion between suitably positioned axles (rods) via teeth.

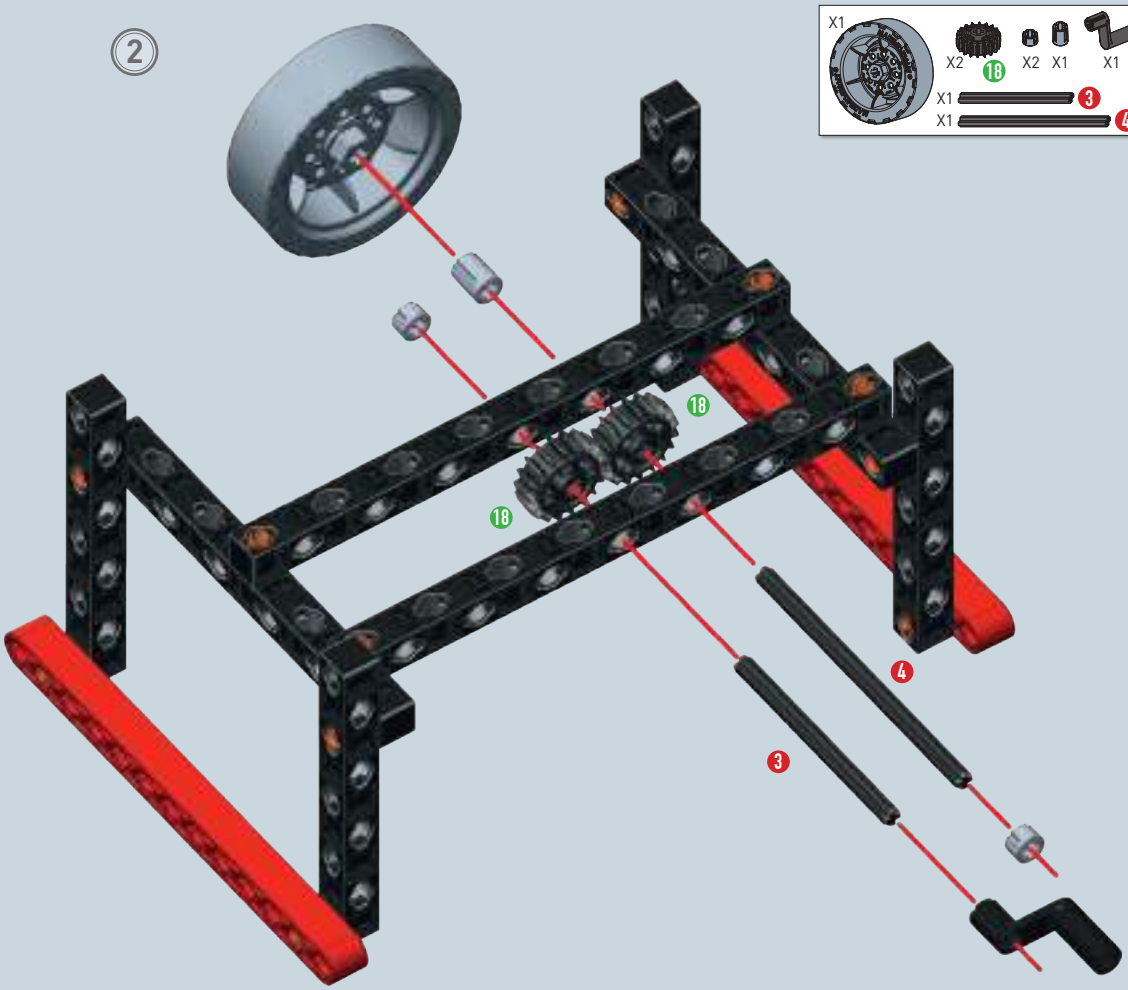
- In a pair of cogwheels, if one cogwheel turns in one direction the other turns in the opposite direction. One of the two wheels transmits motion (drive wheel) while the other receives it (driven wheel).
- To maintain the same direction of rotation a third *cogwheel must be inserted between the two*.
- 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.

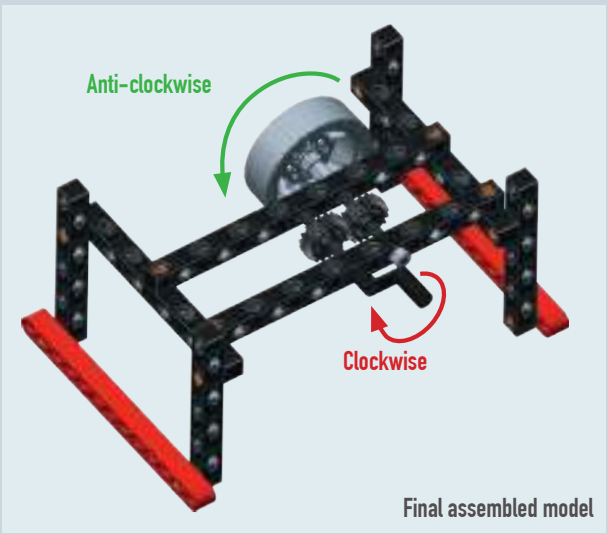


21 Assemble the test stand for reverse rotation



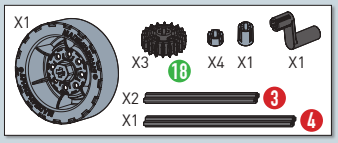


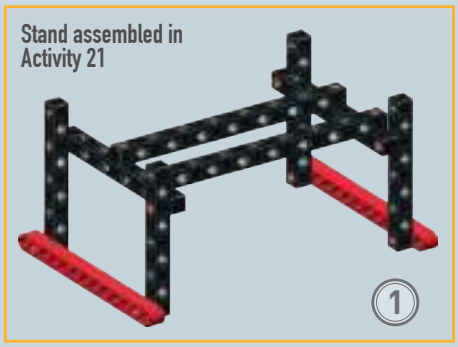

2
X1
X2
18
X2
X1
X1
X1
3
X1
4
18
18
4
3

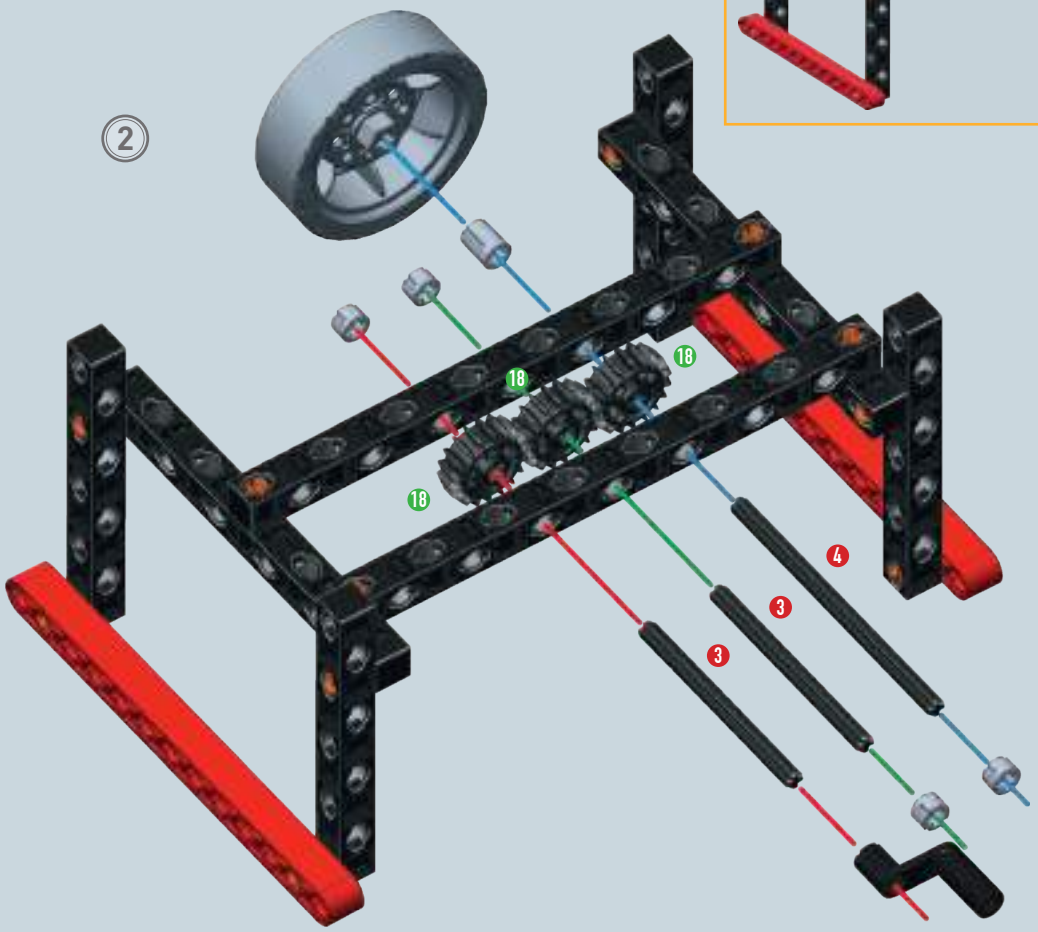

Anti-clockwise
Clockwise
Final assembled model

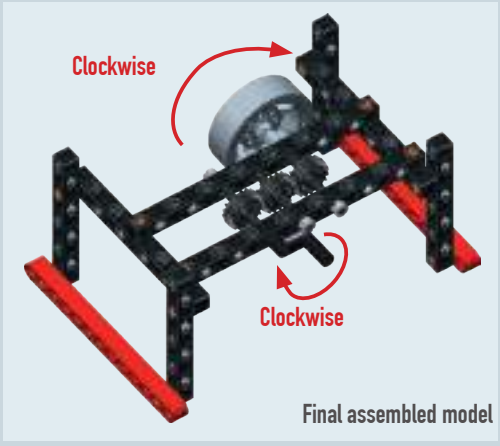

1:1
3
1:1
4

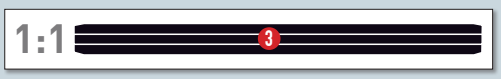
22 Build and test forward rotation



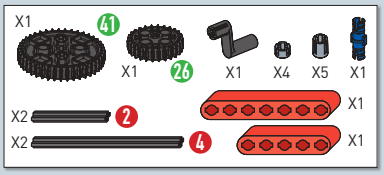


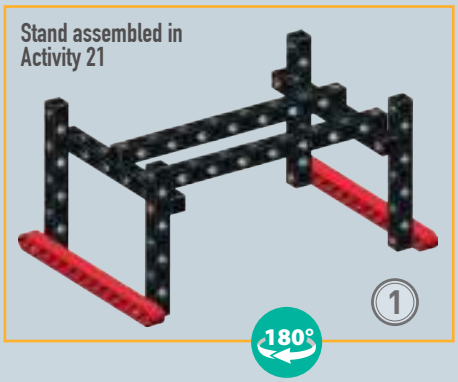


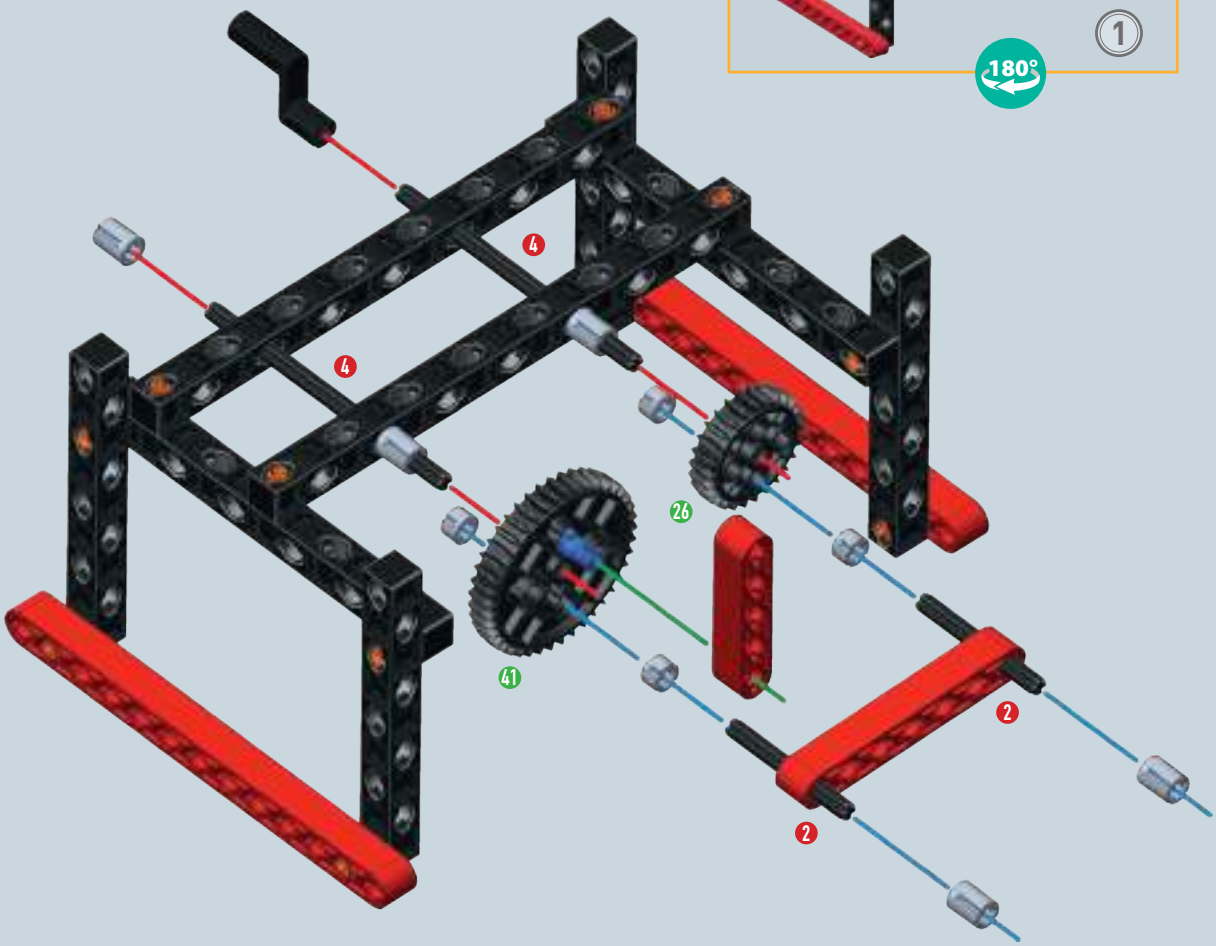


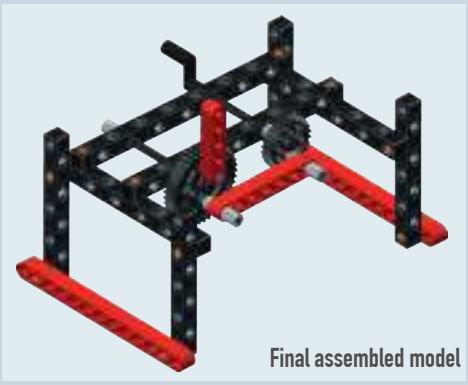


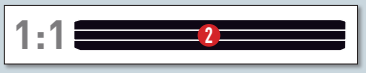
23 Assemble and test alternating movement



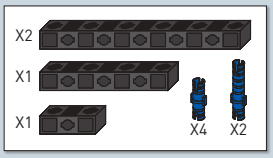


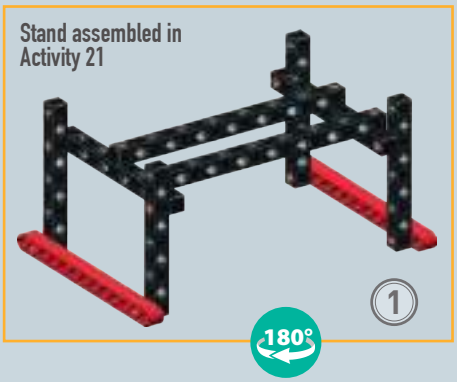



Final assembled model



24 Assemble a vertical gearbox





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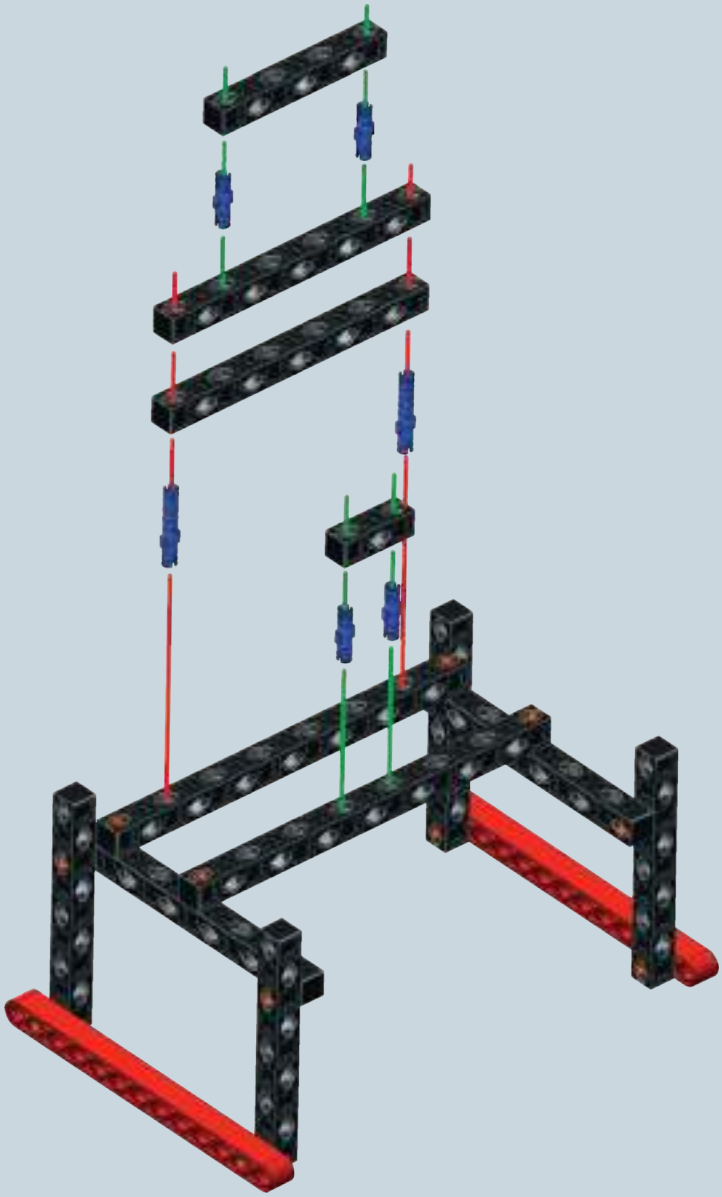

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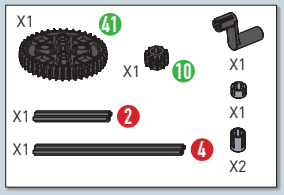
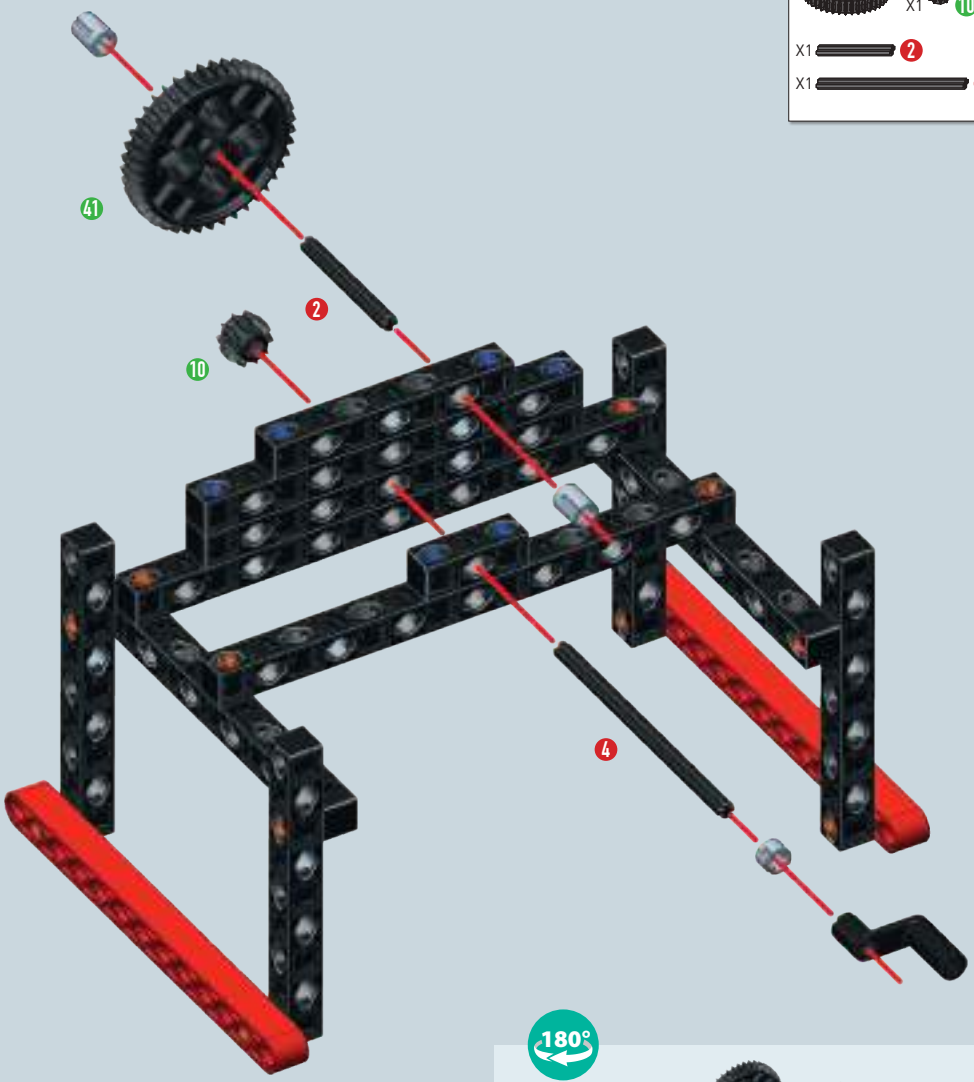
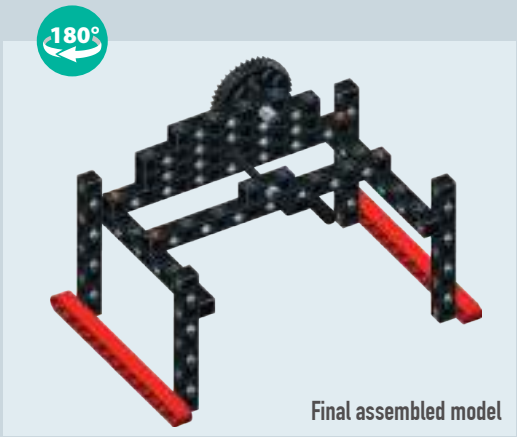
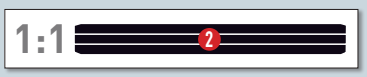


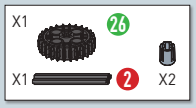


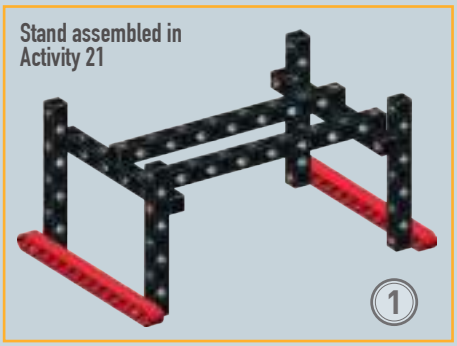


Final assembled model



25 Build a horizontal to vertical gearbox





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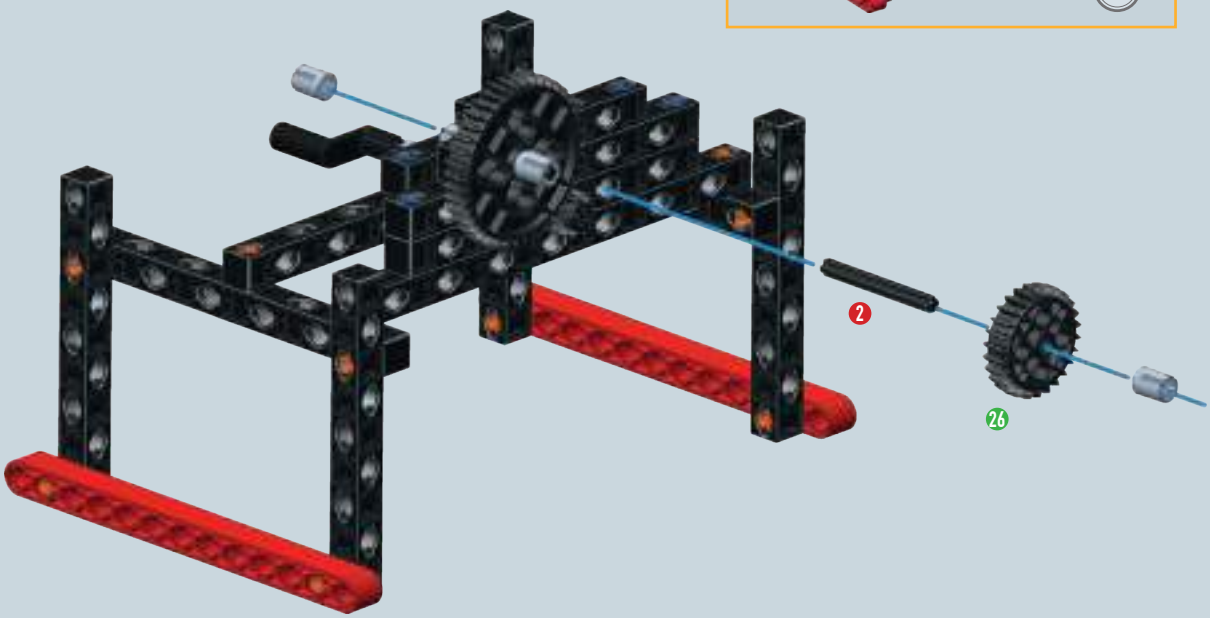
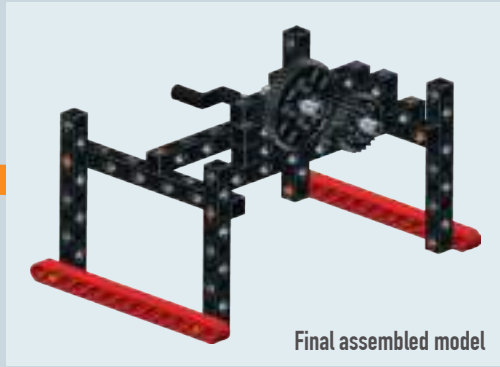


GEAR RATIO

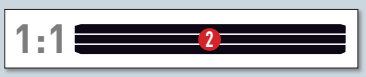
Carefully observe the cogwheels when they rotate and compare the number of revolutions completed by the various cogwheels. When the larger cogwheel has completed a revolution, the smaller one will have completed 4. You can prove this by dividing the number of teeth of the two cogwheels (ratio).

Example: how to calculate the gear ratio.

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

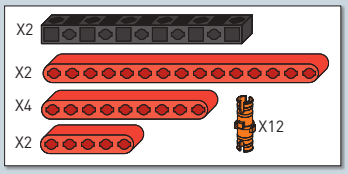


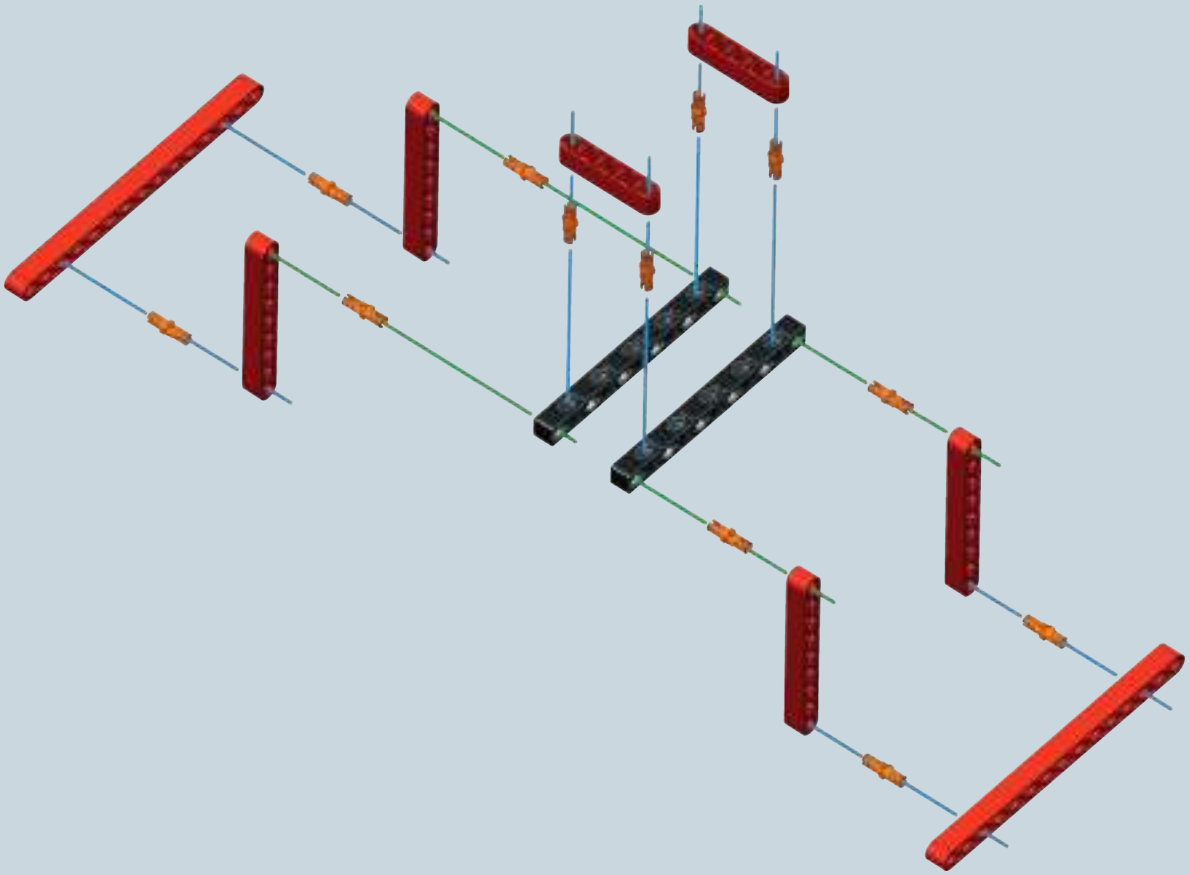
Final assembled model

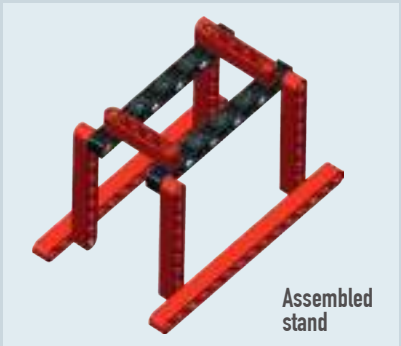


PRE-ACTIVITY TASK

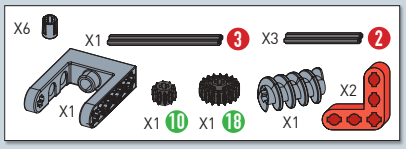
Assemble a test stand for the gearbox elements





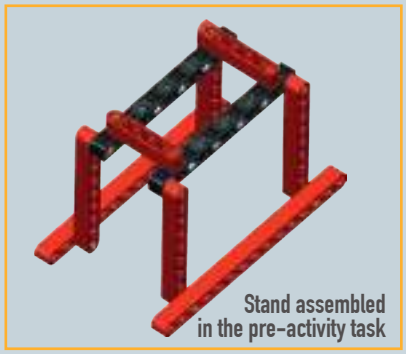


Assembled stand



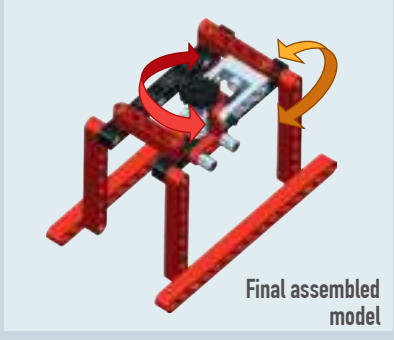
Technical and scientific analysis

Technically called an **involute**, the **worm screw** is a cylindrical helical gear.
In a worm-and-gear set, the former is called the 'driver', because motion can only be transferred from the worm screw to the gear and not vice-versa. The worm screw can therefore be used to **lock** the mating gear in a certain position.

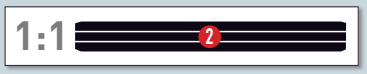


Stand assembled in the pre-activity task

Assembled stand

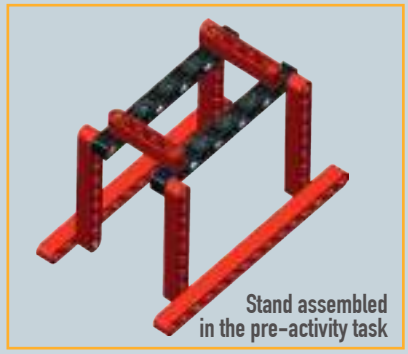


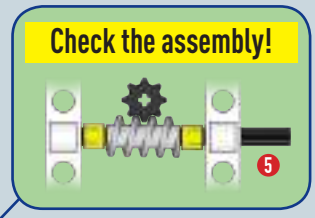
Final assembled model



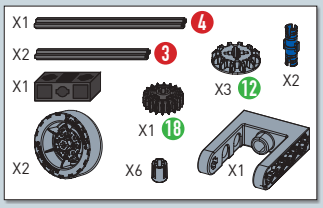
Gear ratio

The worm screw makes it possible to achieve **high reductions.**
Turn the wheel and see how the gear rotates slowly.

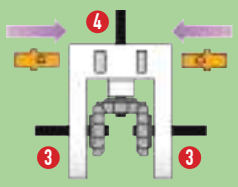

Stand assembled in the pre-activity task

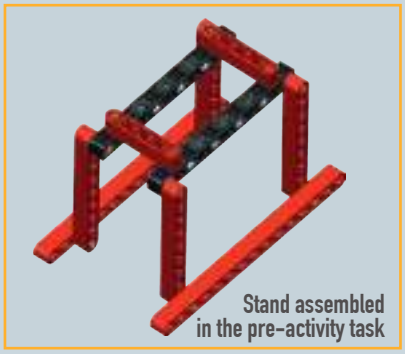


Final assembled model



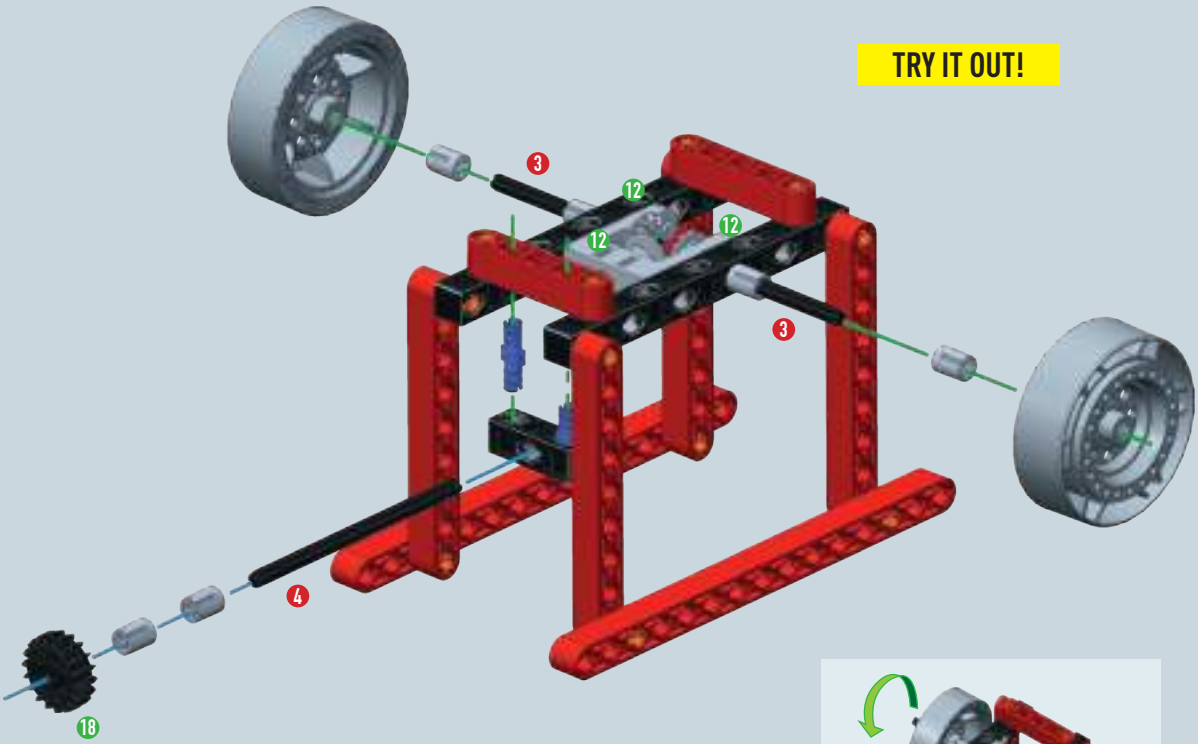
Insert the module between the beams, by partially disassembling the stand. Then arrange the gears as shown in the picture.

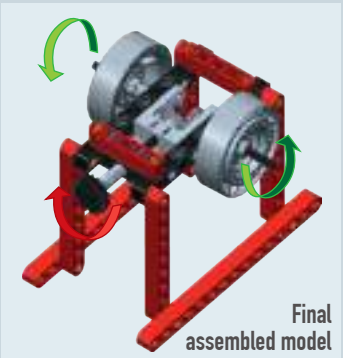




Stand assembled in the pre-activity task

TRY IT OUT!



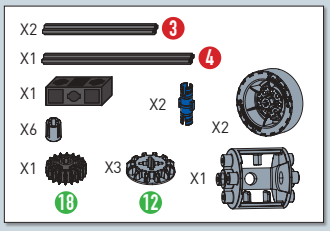


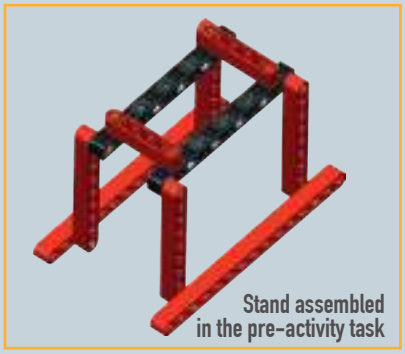
Final assembled model

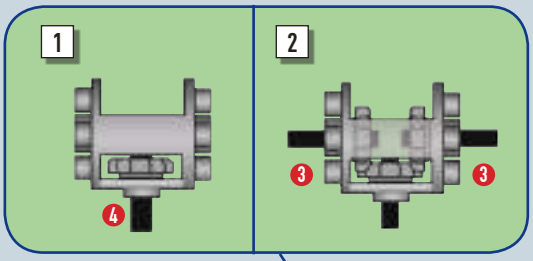
1:1 4

1:1 3

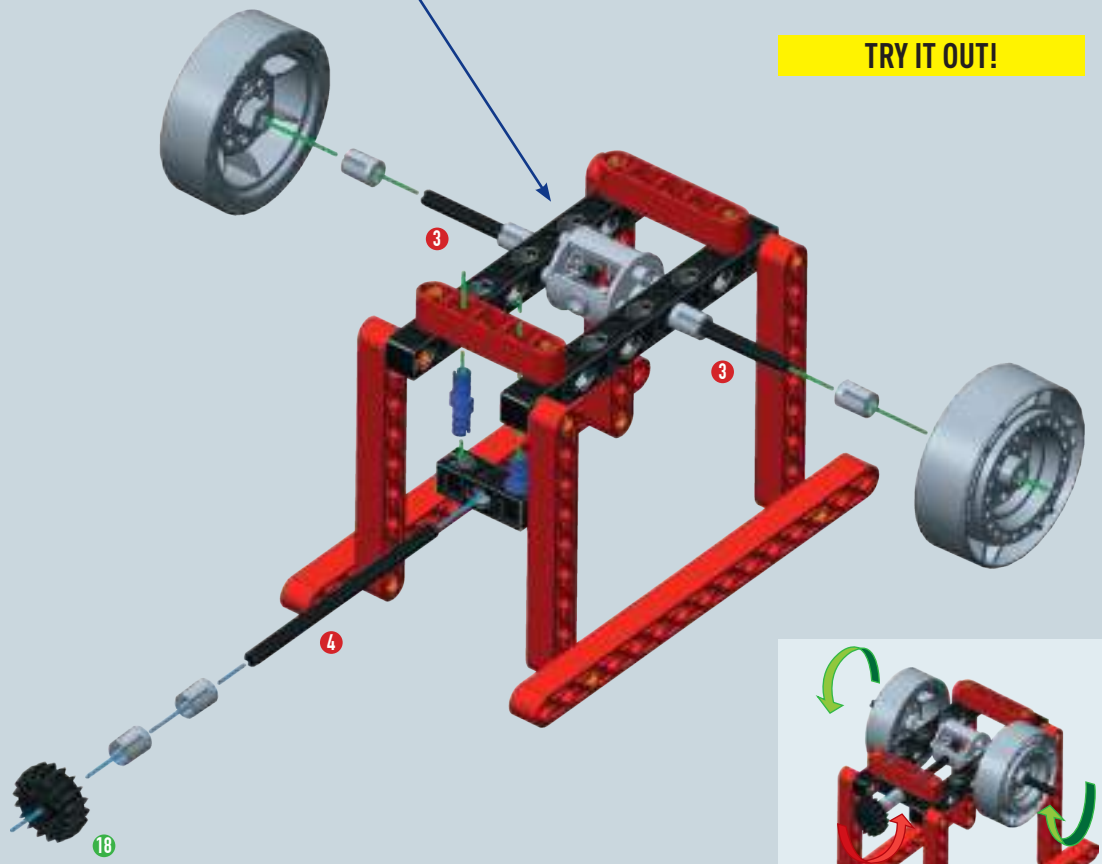
29 Assemble the transmission with a differential cage




Stand assembled in the pre-activity task



TRY IT OUT!

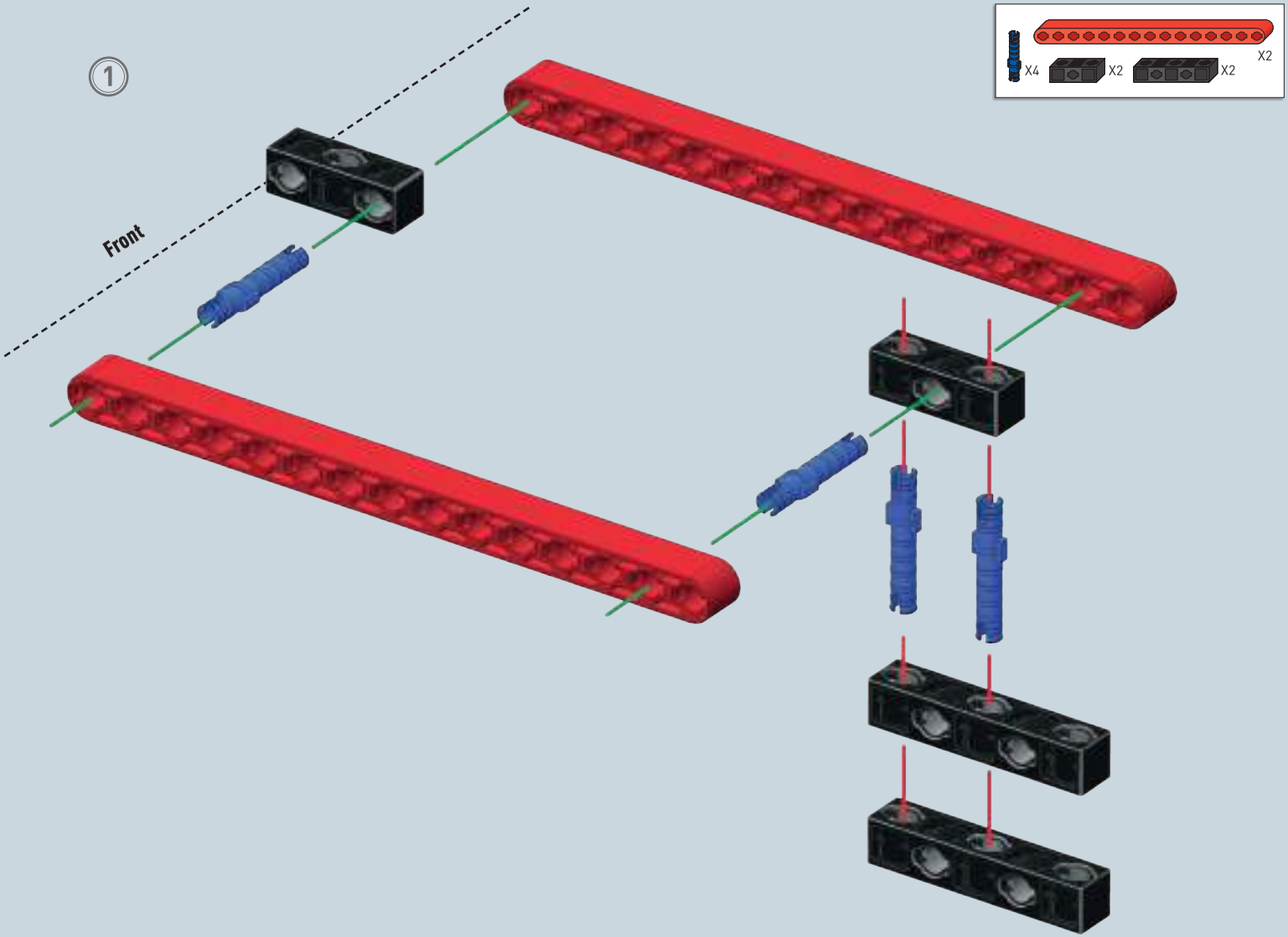


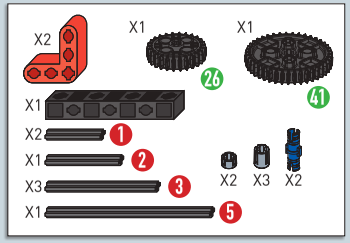
Final assembled model

1:1 4

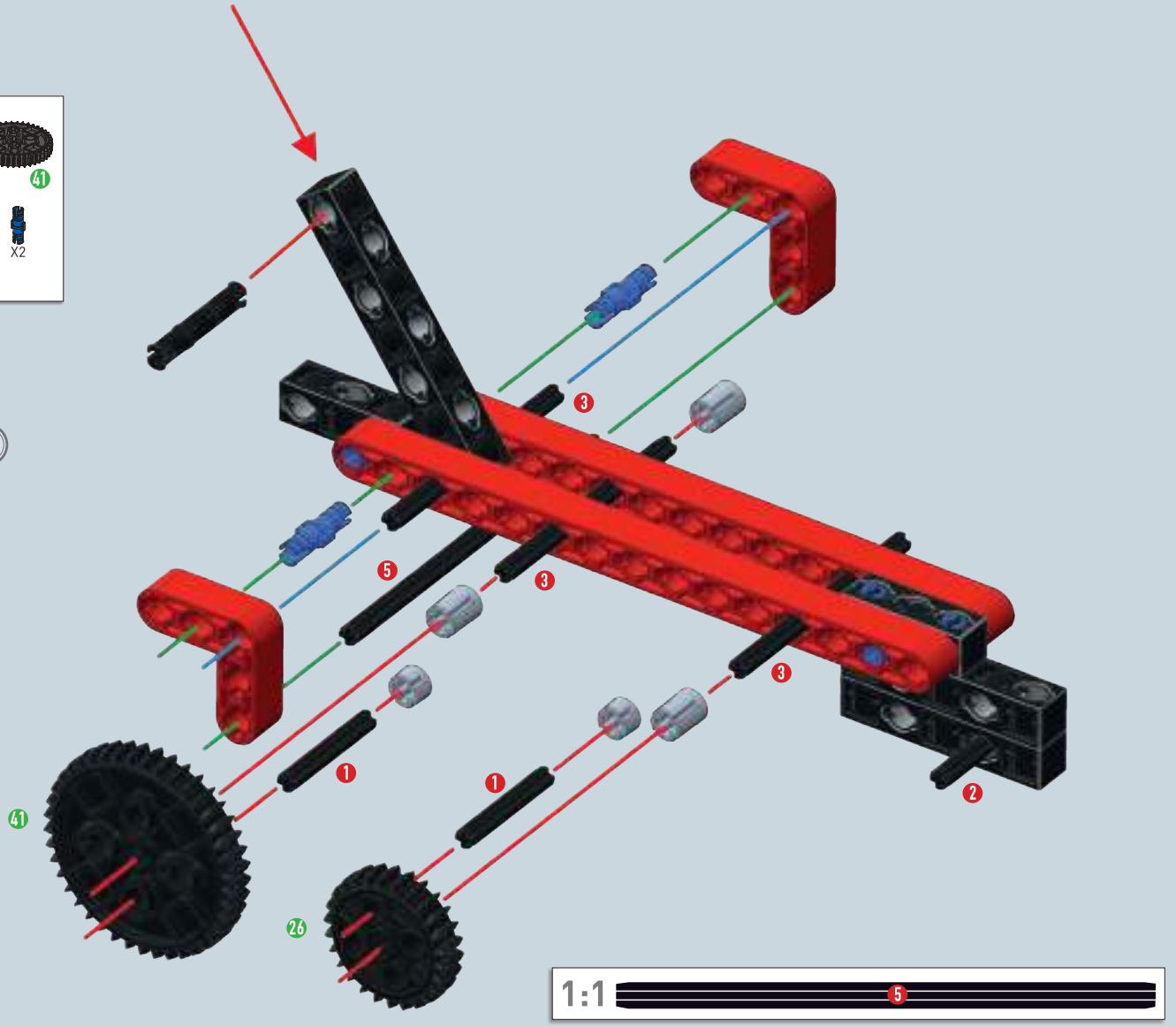
1:1 3

30 An ancient war machine: the battering-ram




X2
X1
X1
26
41
X1
X2
1
X1
2
X3
3
X1
5
X2
X3
X2

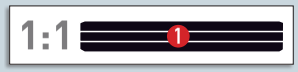
2

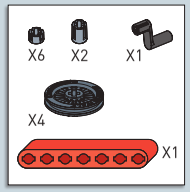

3
5
3
3
1
1
41
26
2

1:1
5


1:1
3


1:1
2


1:1
1



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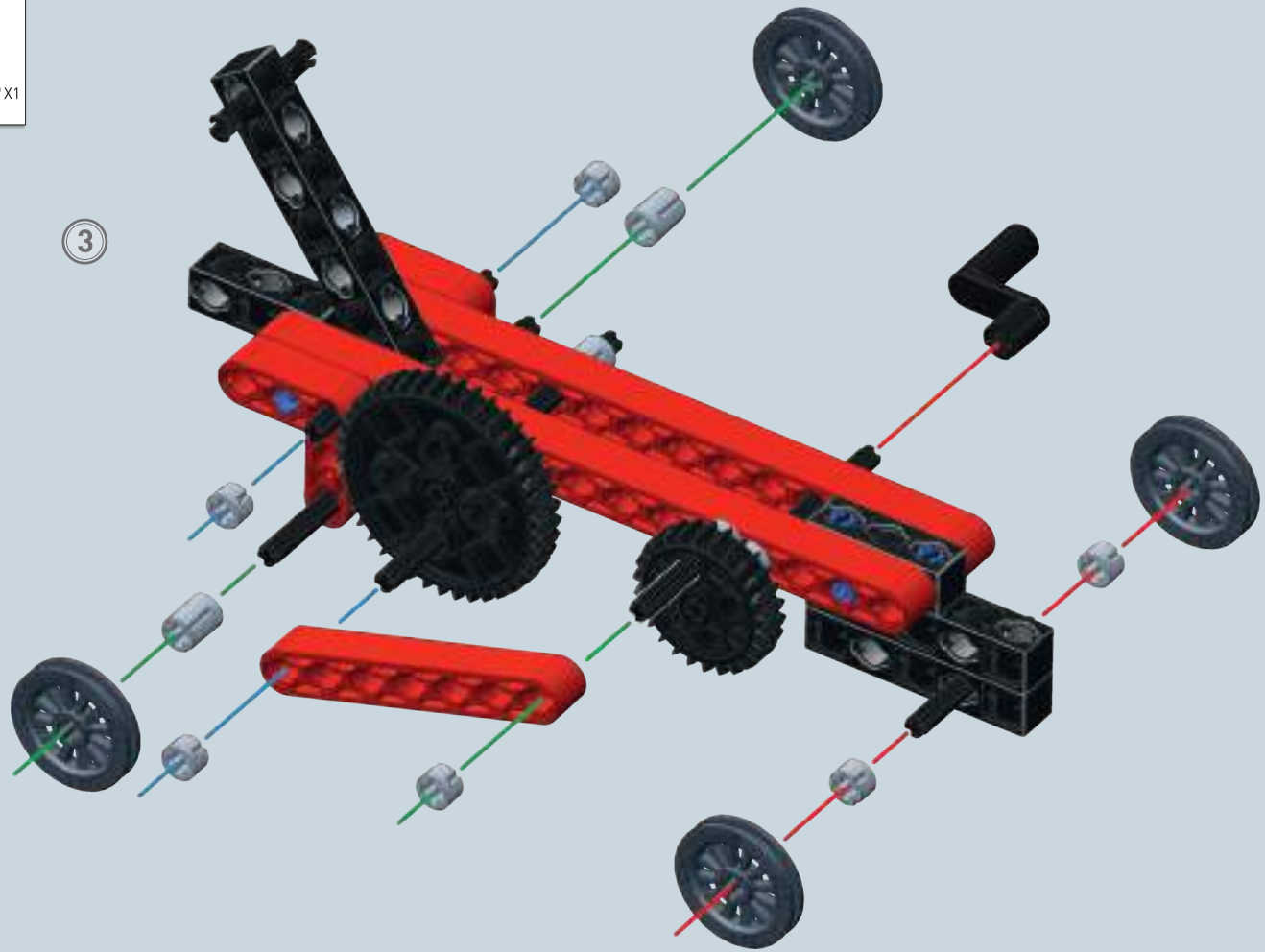
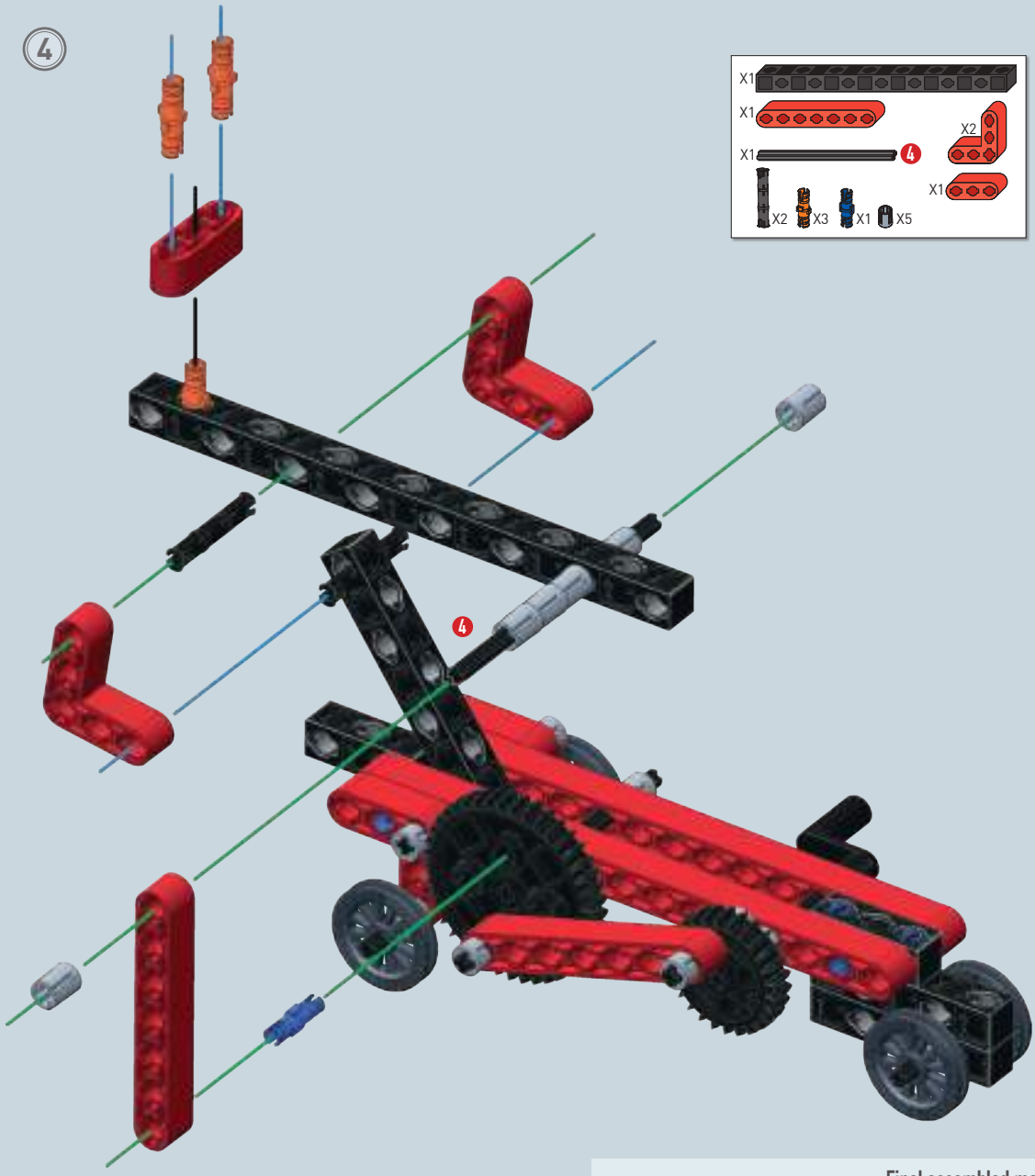
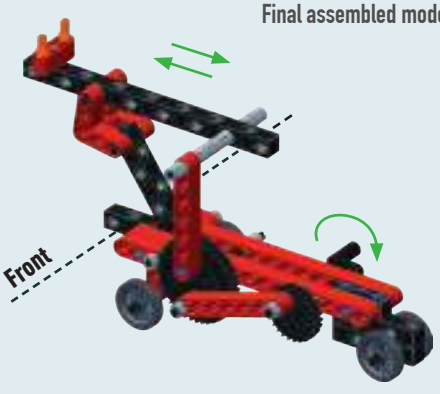




Final assembled model



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