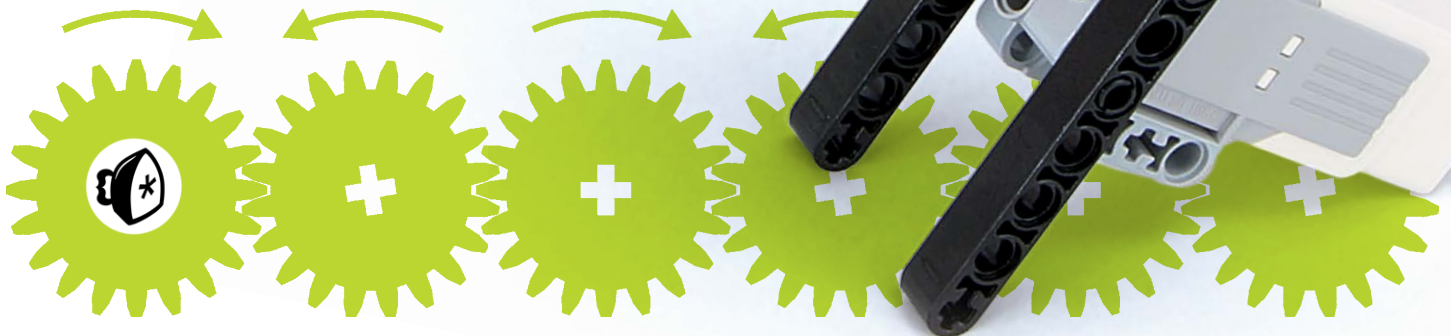


THE LEGO® MINDSTORMS® EV3 IDEA BOOK



YOSHIHITO ISOGAWA



181 Simple Machines and Clever Contraptions

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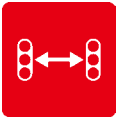
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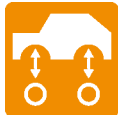
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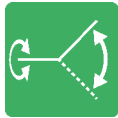
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Introduction

The LEGO MINDSTORMS EV3 set is designed to allow builders of any age to create robots, vehicles, and other contraptions with moving parts.

Each model in this book is only a small mechanism, but you can make an infinite variety of larger models by combining these ideas. LEGO bricks aren't designed to fit in just one specific place or in one particular way. Your imagination is your guide when building with LEGO, and I hope that you will create your own wonderful masterpieces using this book as inspiration.

To build the models in this book, all you need is the LEGO MINDSTORMS EV3 set (home edition #31313).

Where Are the Words?

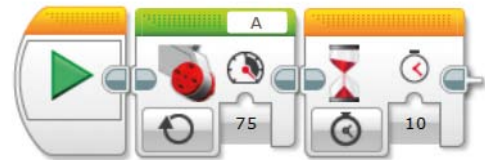
Other than this brief introduction and the table of contents, this book has almost no words. Instead, you'll find a series of photographs of increasingly complex models, each designed to demonstrate a mechanical principle or building technique.

While the book lists the pieces needed for each model, it does not include step-by-step building instructions. Look at the photographs taken from various angles and try to reproduce the model. Building in this way is something like putting together a puzzle. You'll get the hang of it after a little practice.

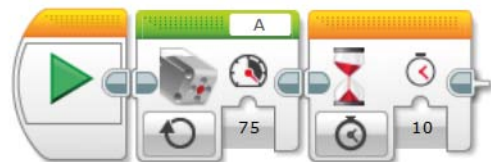
This is an idea book; it's about imagination. Rather than tell you what to see or think when you study the models, I encourage you to interpret them in your own way. Your interpretations will lead you to invent your very own models or use my mechanisms in entirely new ways!

What About Programs?

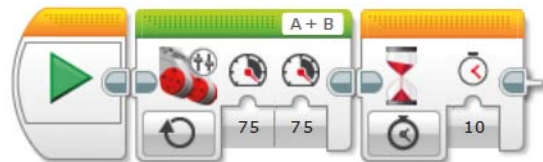
This book is about exploring the mechanical side of EV3 and robotics, rather than programming. You'll need only a few simple programs to test out your mechanical creations. Prepare these three simple programs in advance.



This program will rotate the Large EV3 motor, then rest for a period.



This program will rotate the Medium EV3 motor, then rest for a period.



This program will rotate two motors, then rest for a period.

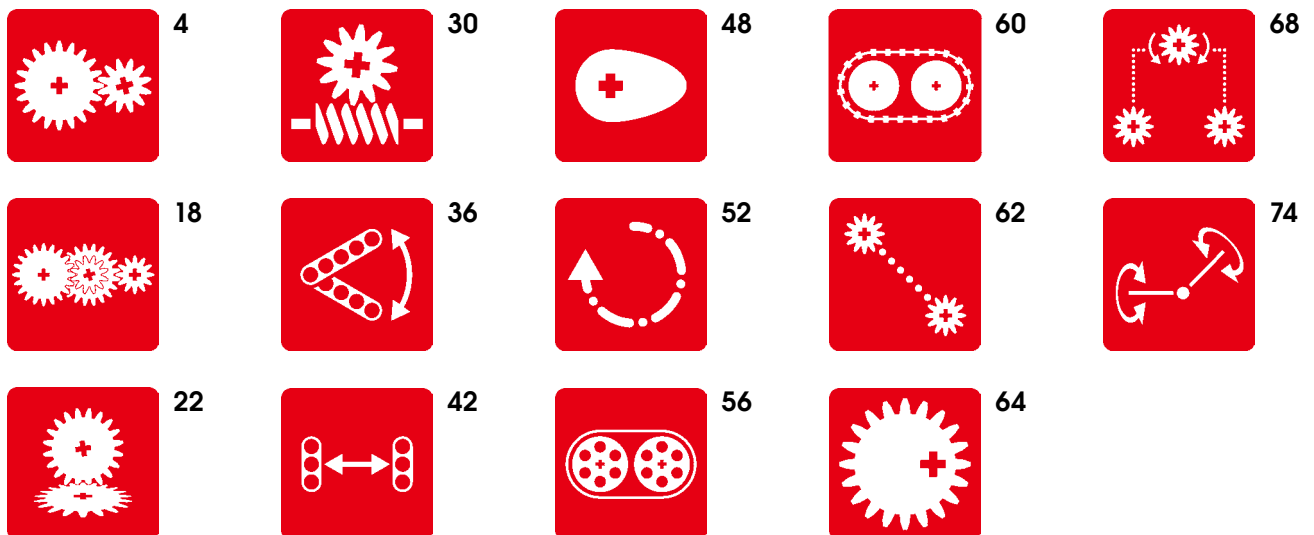
A few of the models in this book require special programs. Take note of these programs, as they are written to avoid damaging parts by overextending a mechanism's range of motion.

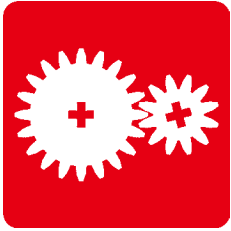


PART 1

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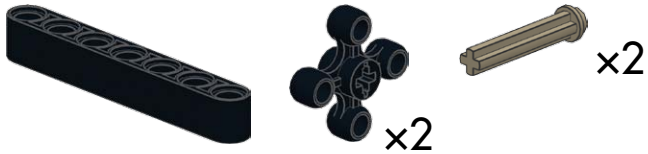
Basic Mechanisms





Gear ratios

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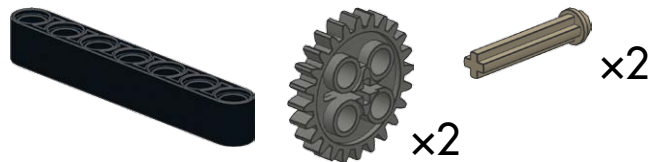


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#2

$24:24 = 1:1$

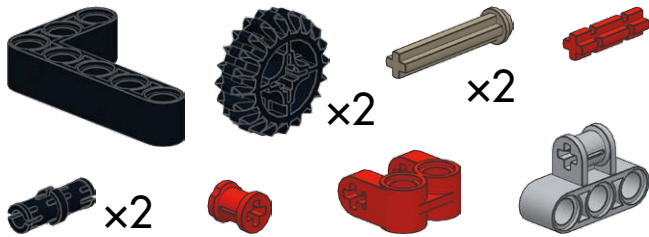


#3

36:36 = 1:1



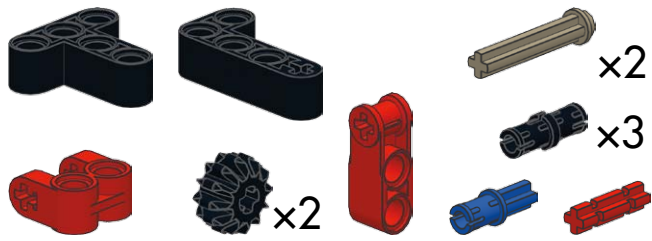
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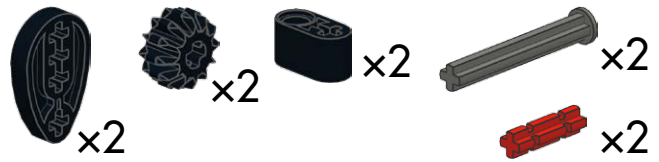
20:20 = 1:1

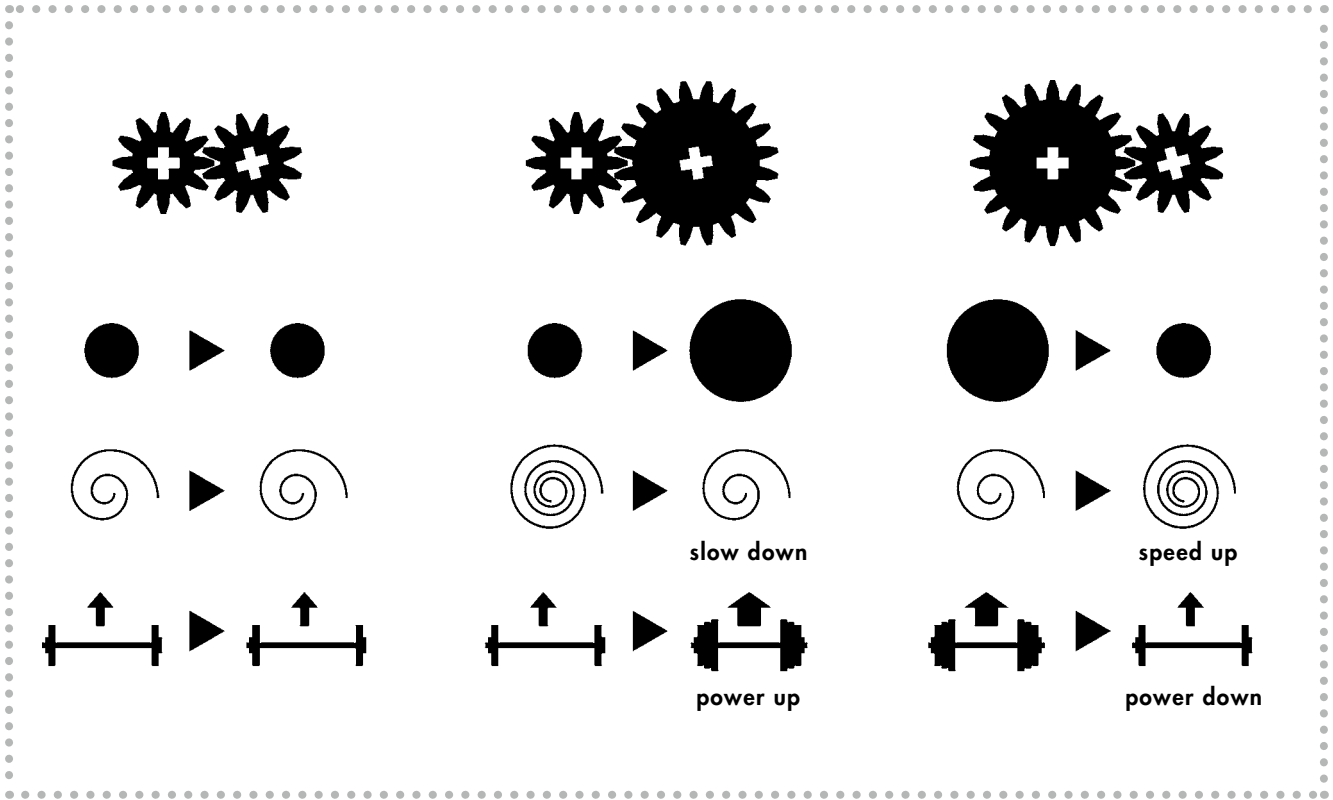


#5



#6





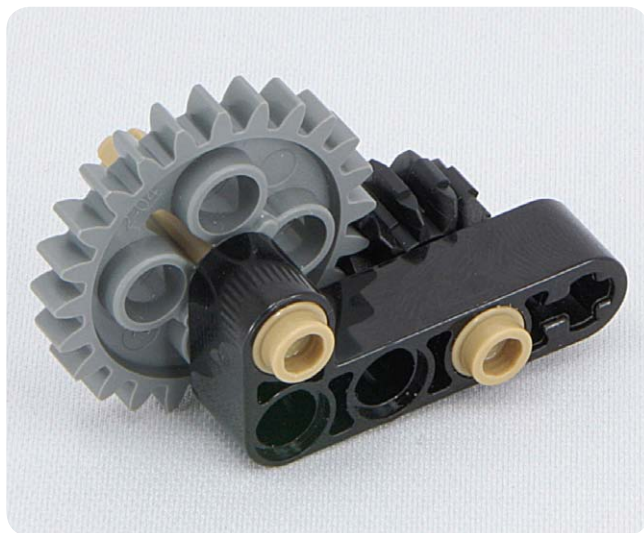
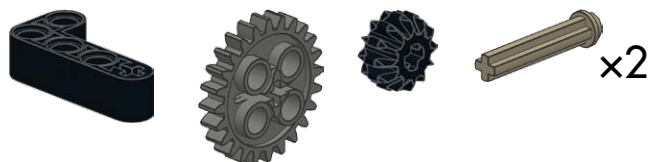
#7

$12:20 = 3:5$



#8

12:24=1:2



#9

12:36=1:3



#10



$20:36 = 5:9$

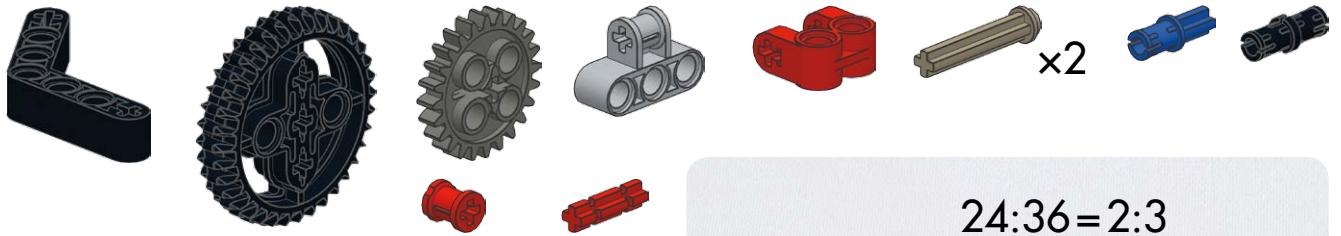
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$20:24 = 5:6$



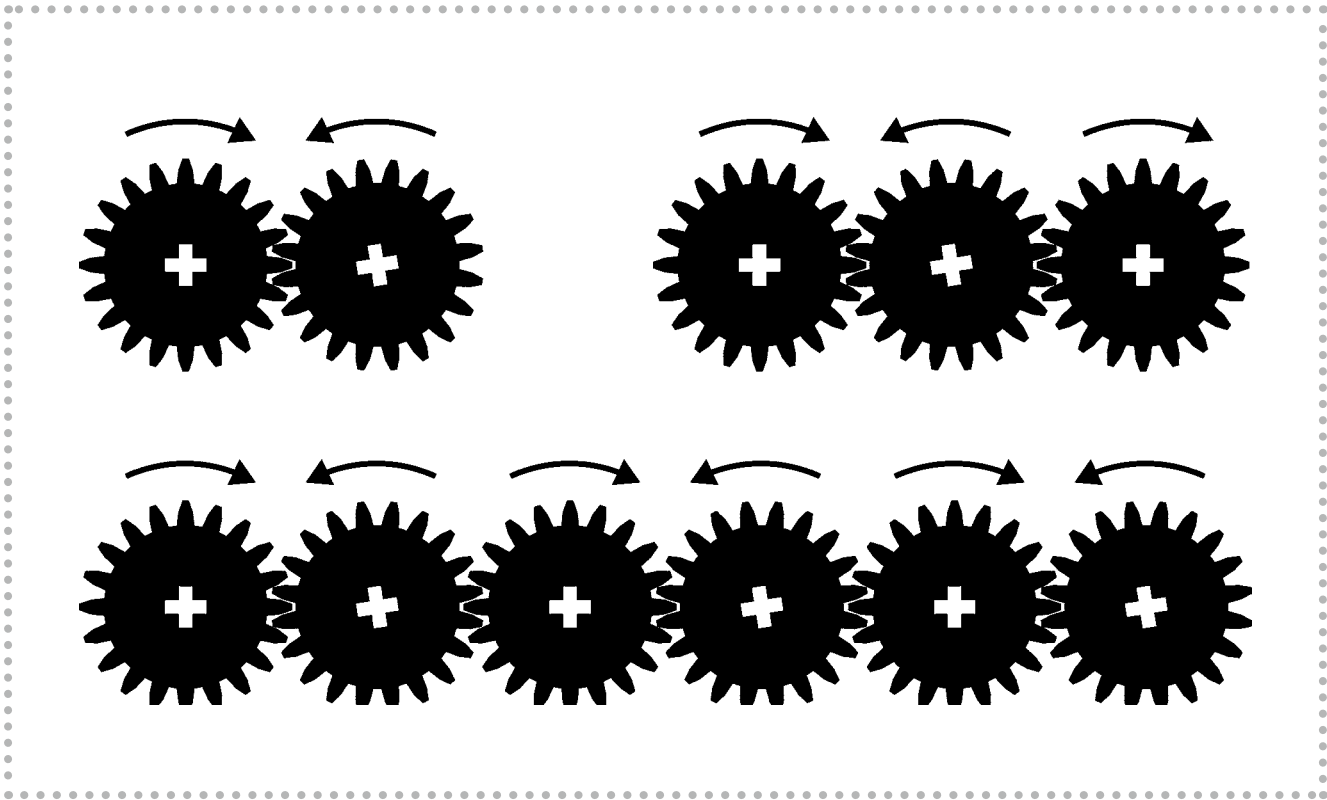
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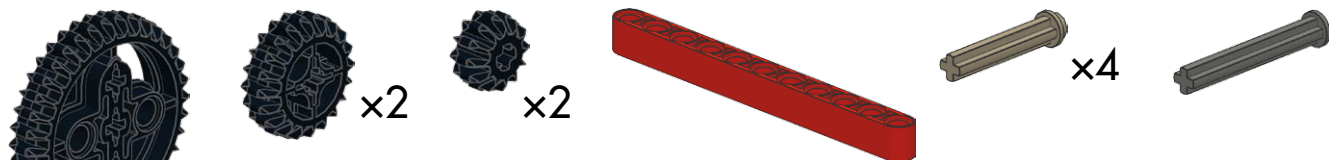
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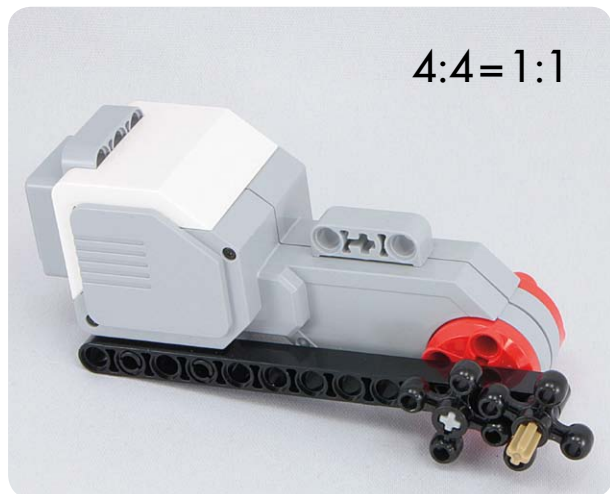
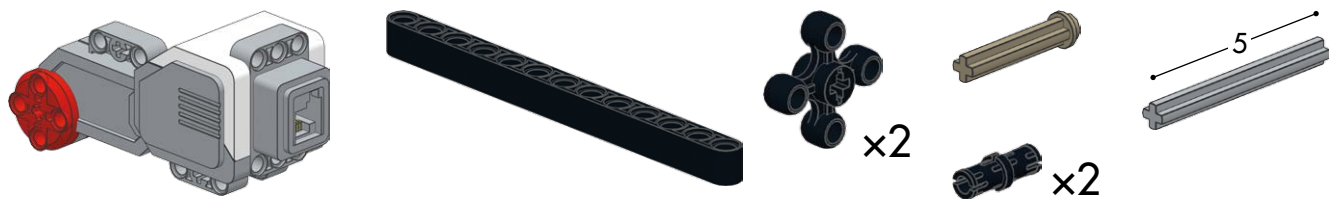
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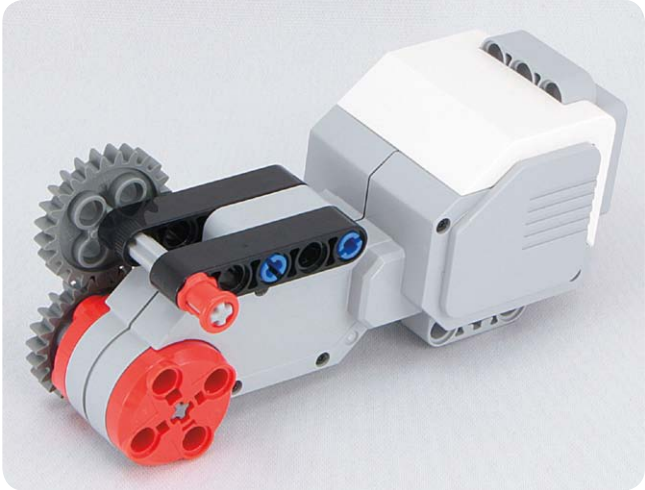
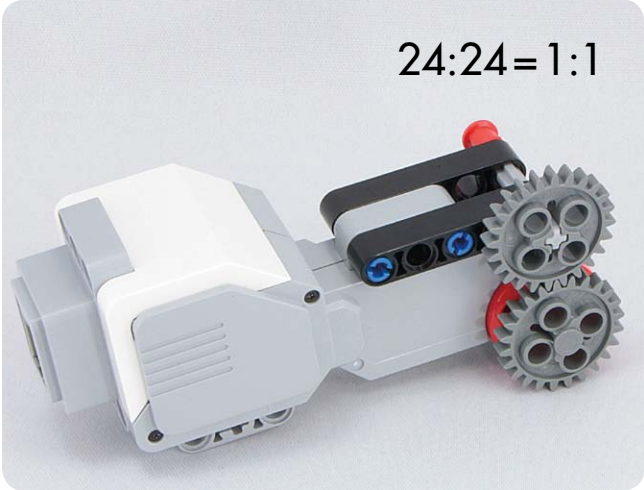
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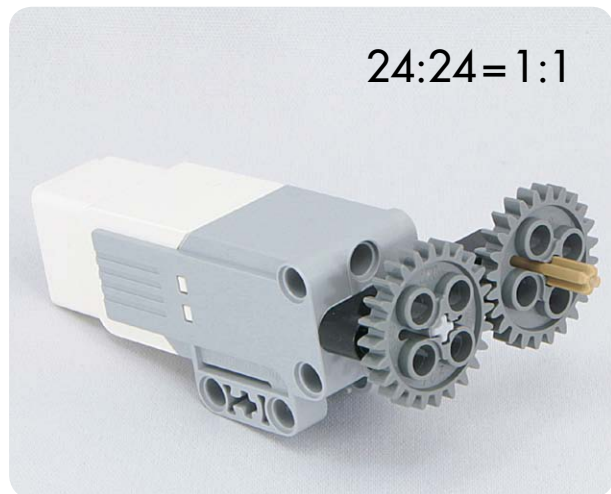
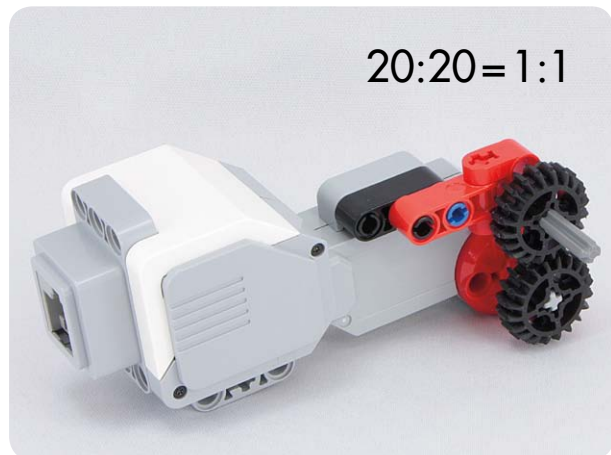


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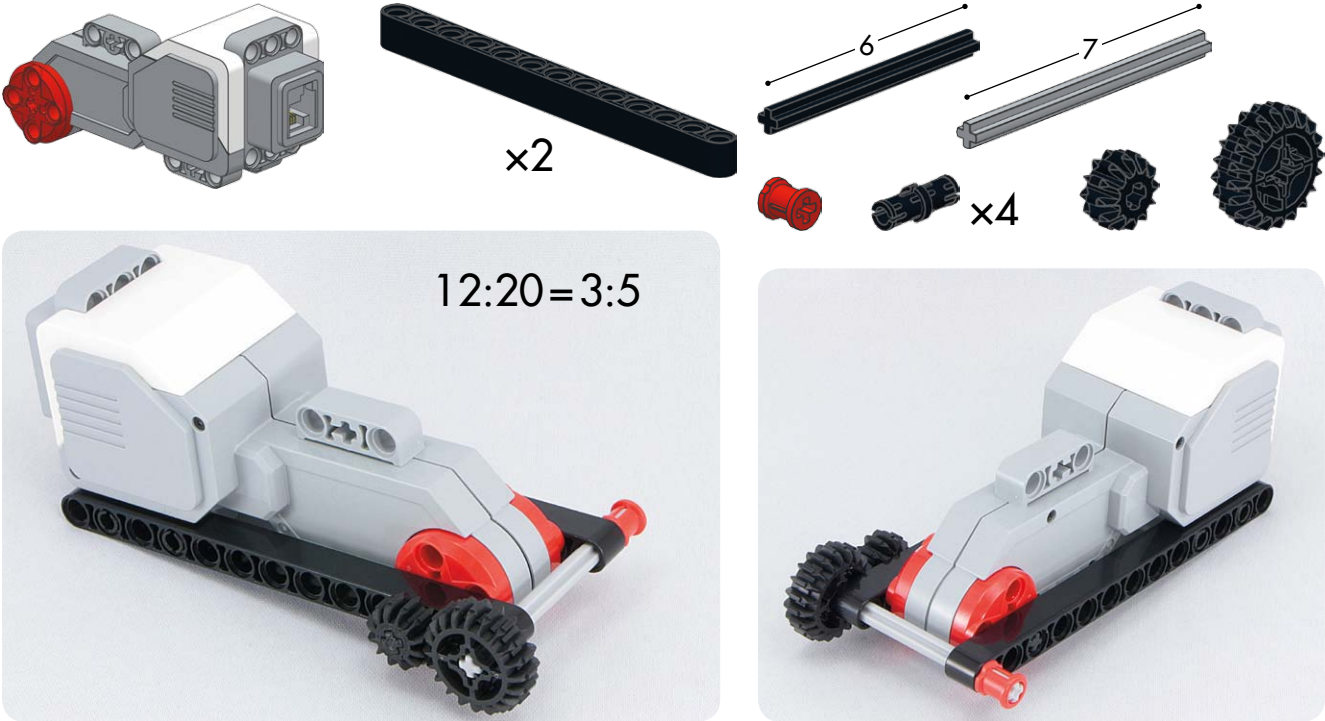


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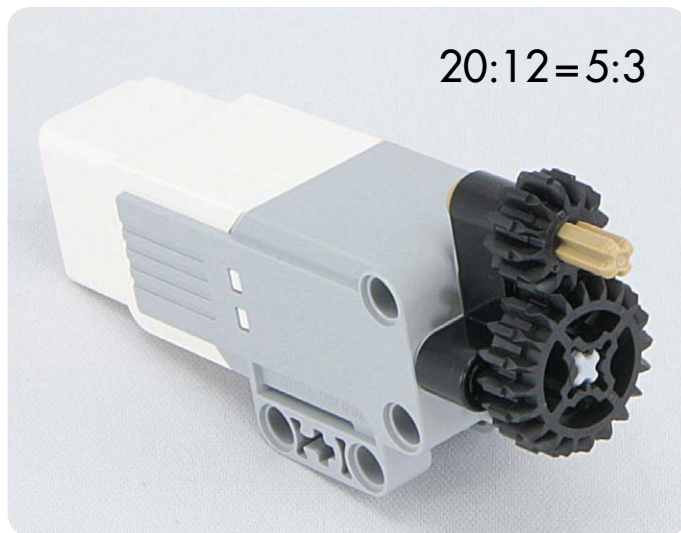
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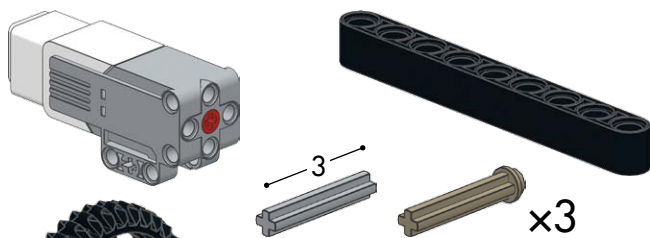
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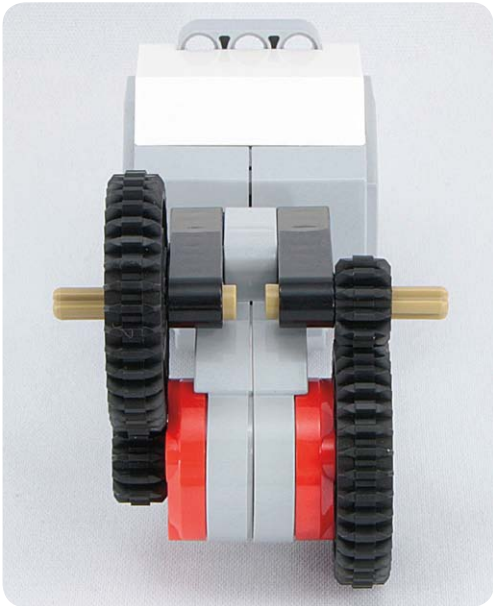
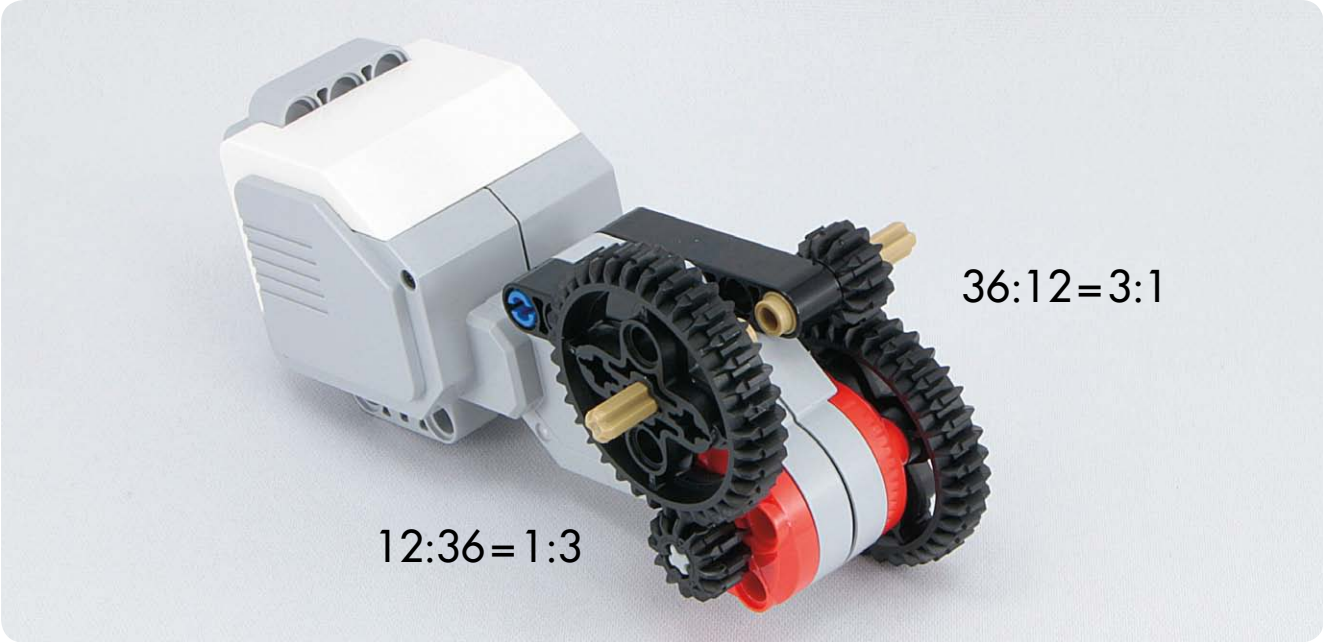
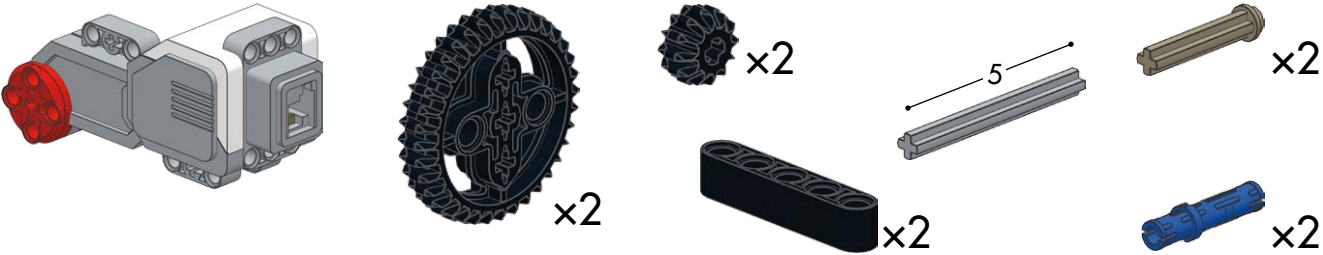
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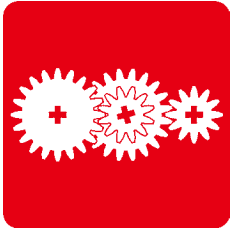


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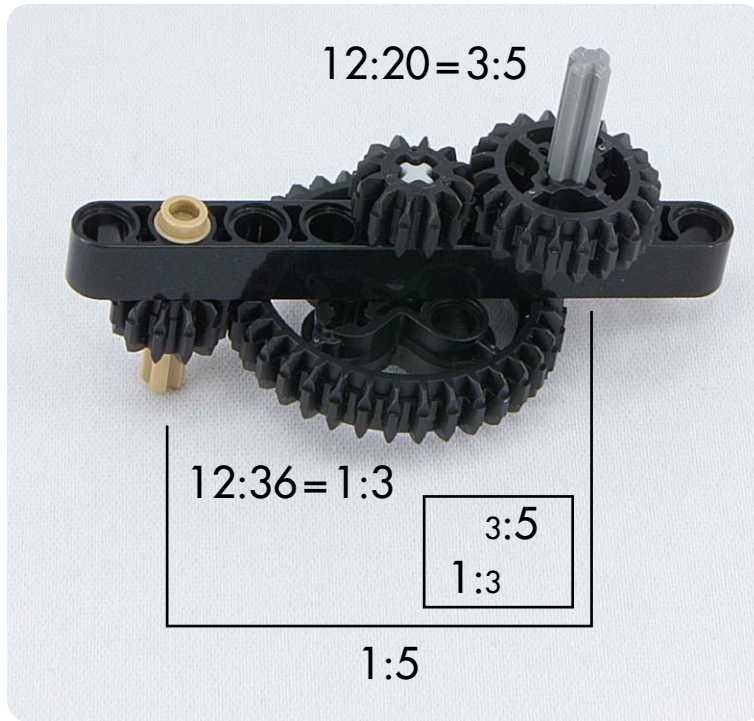


Compound gear systems

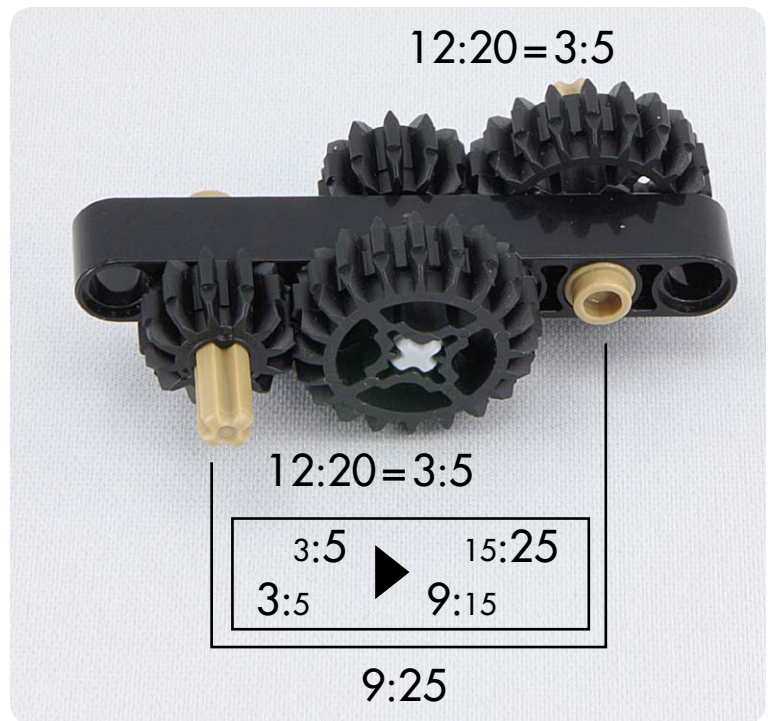
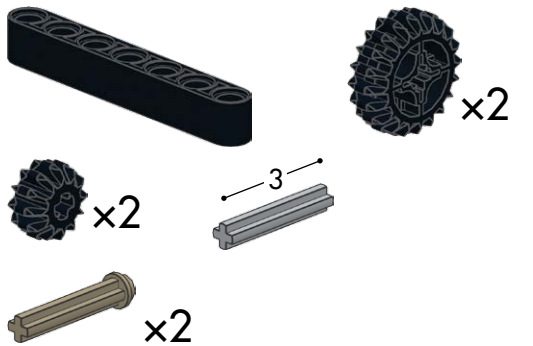
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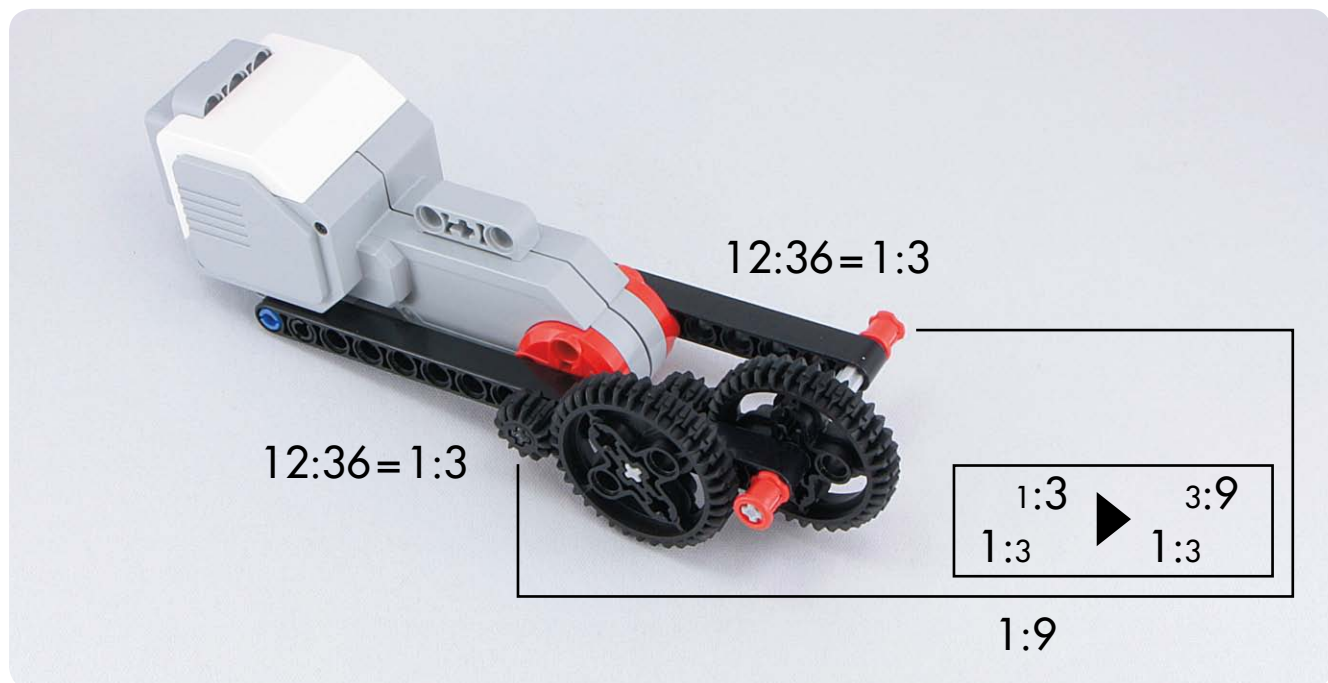
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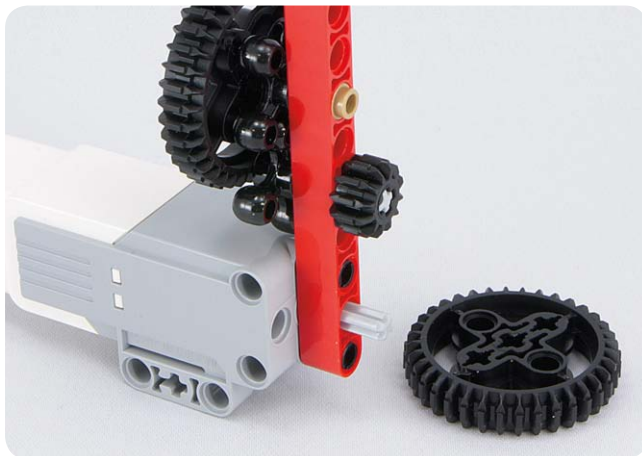
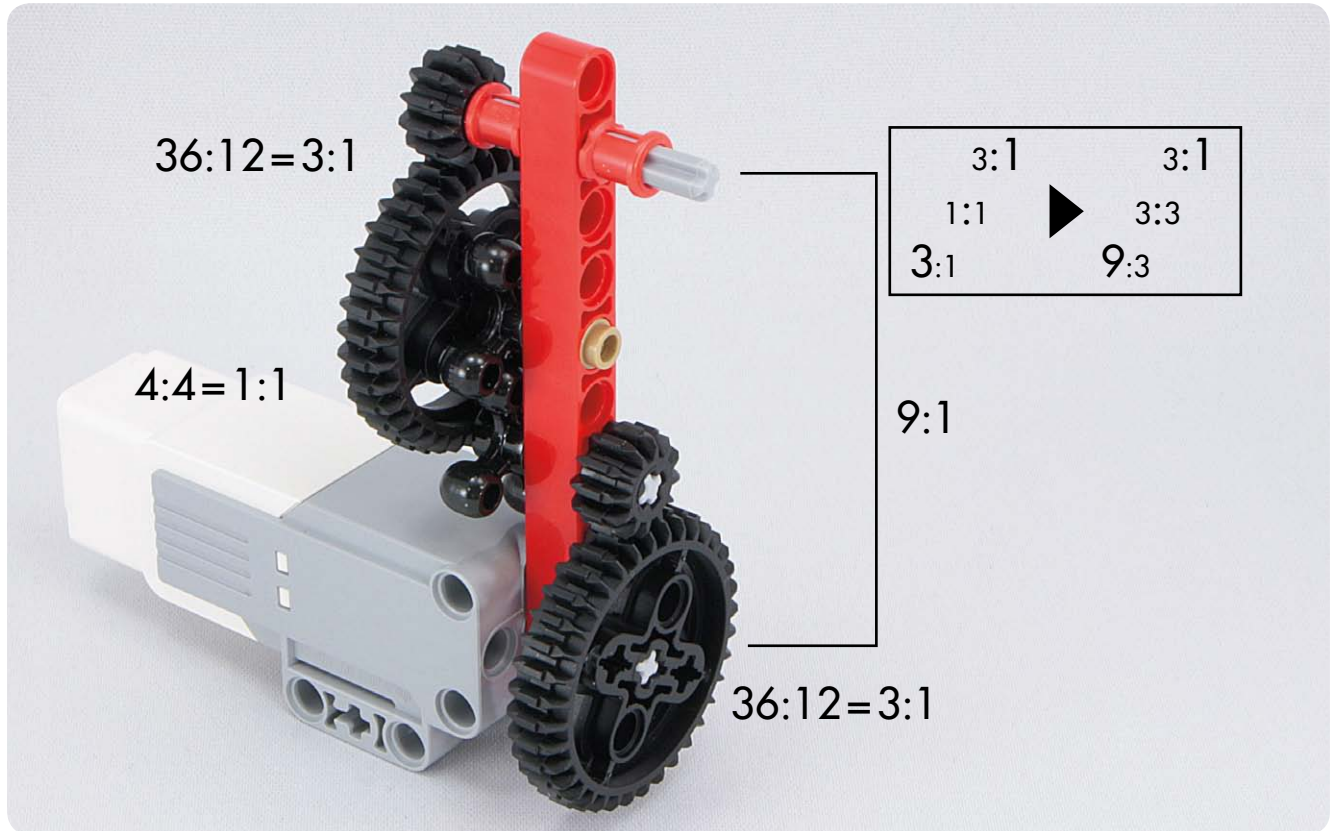
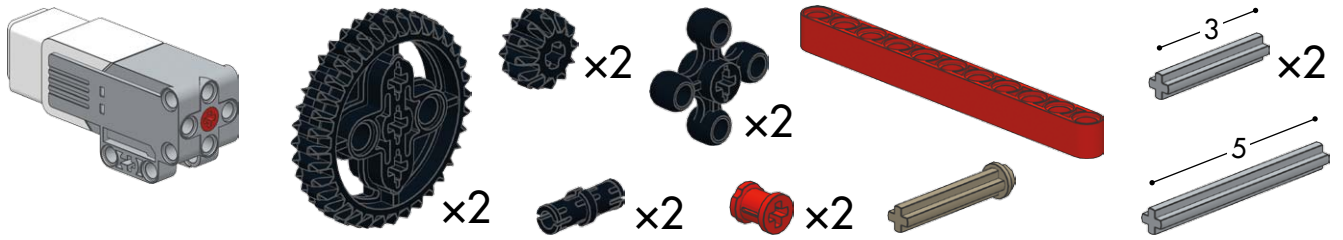
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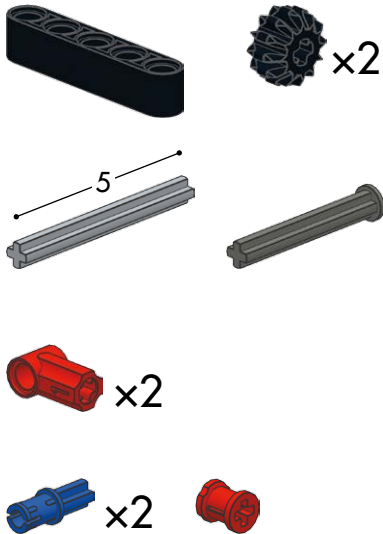
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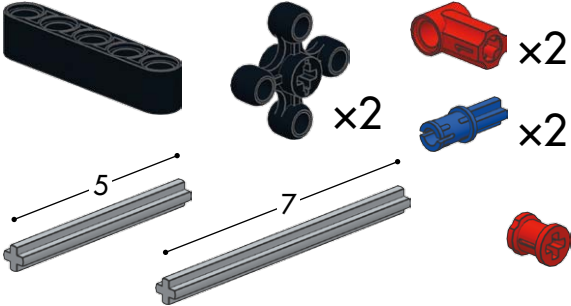


Changing the angle of rotation

#31



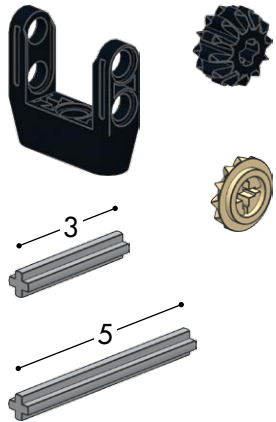
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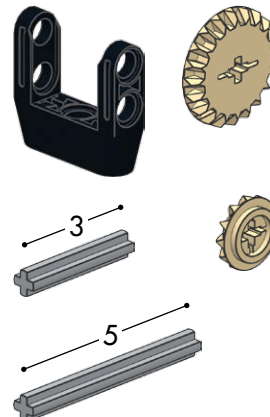
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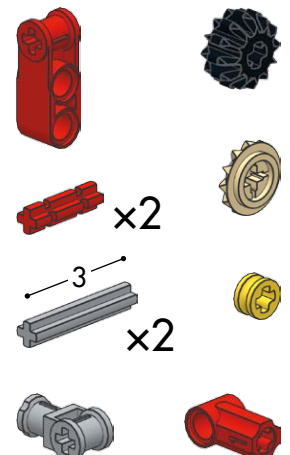
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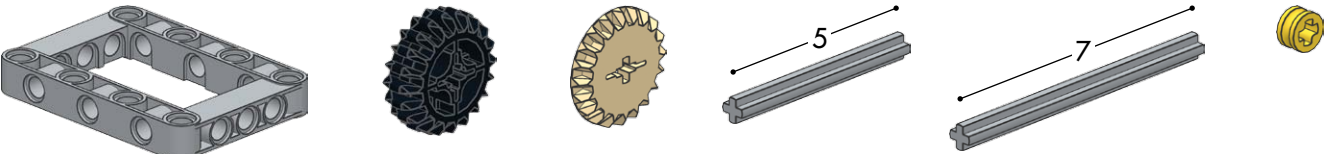
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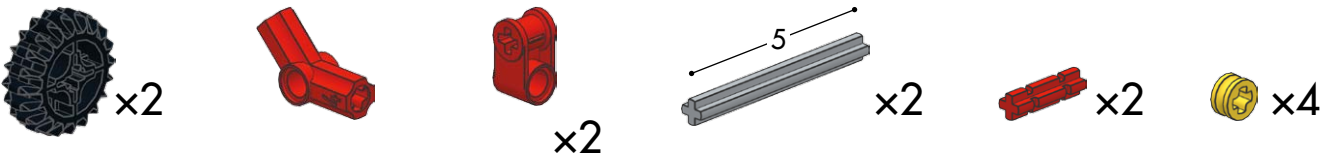
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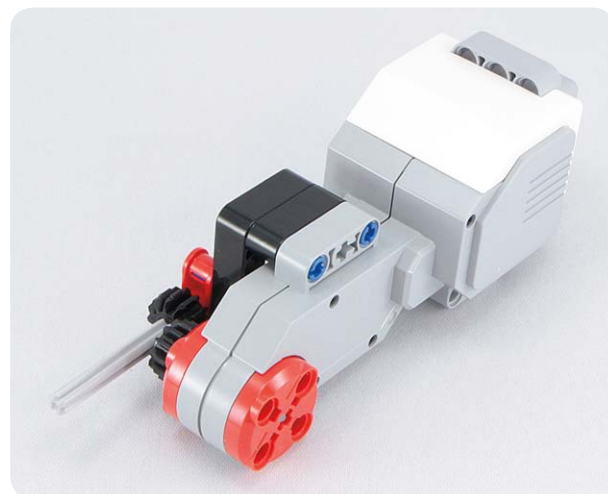
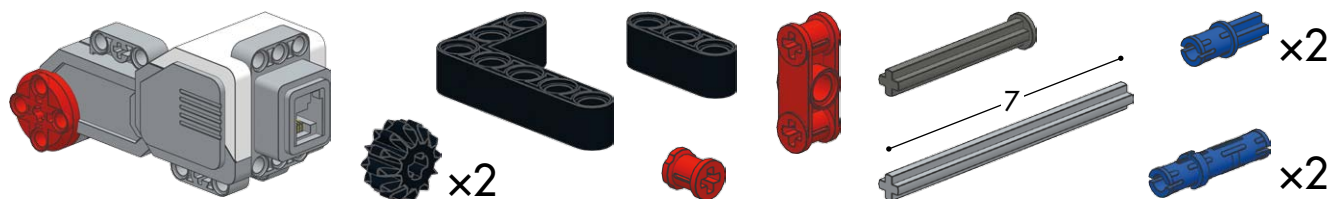
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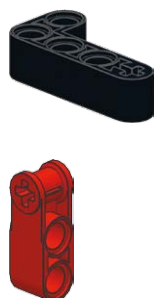
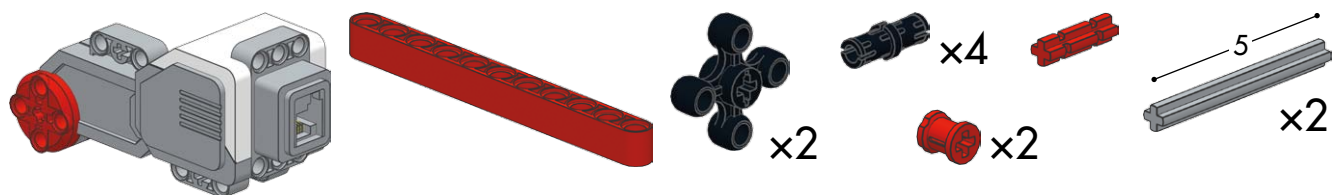
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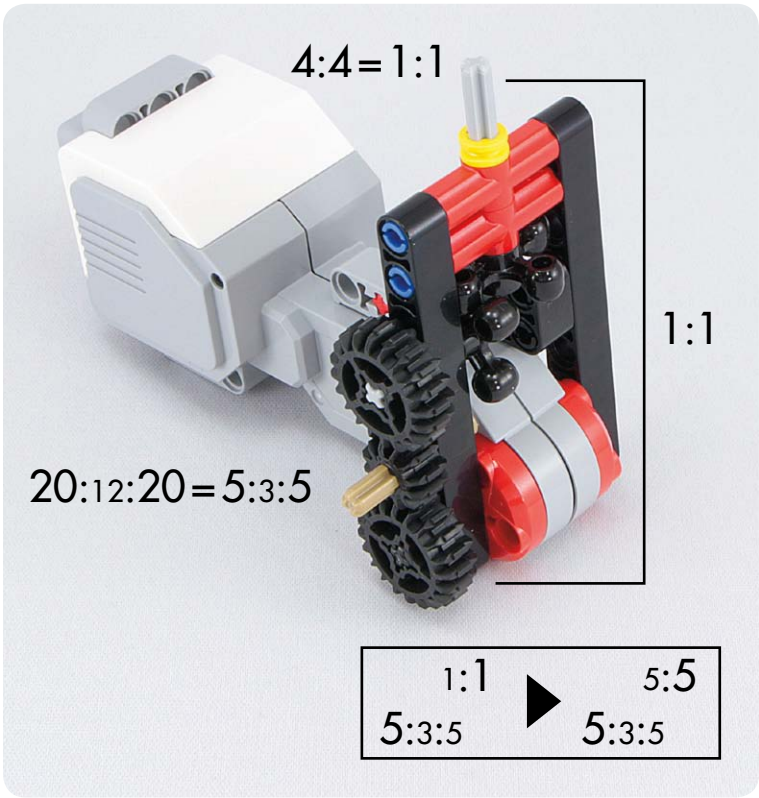
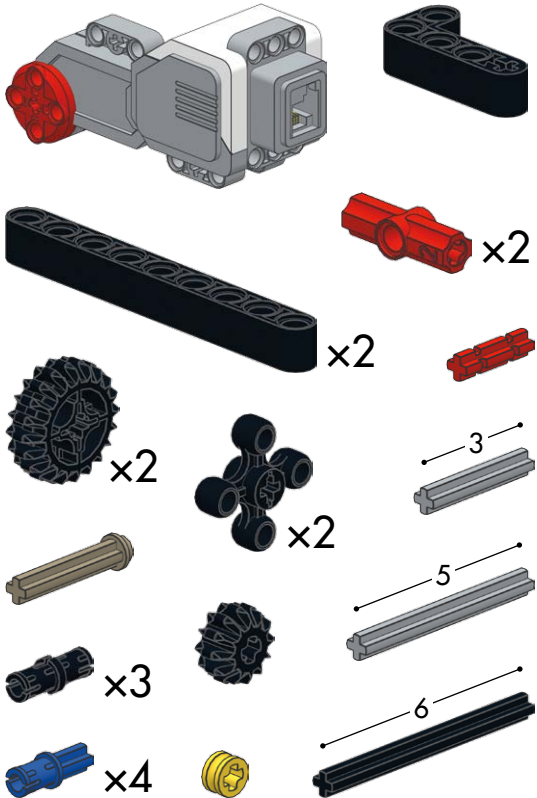
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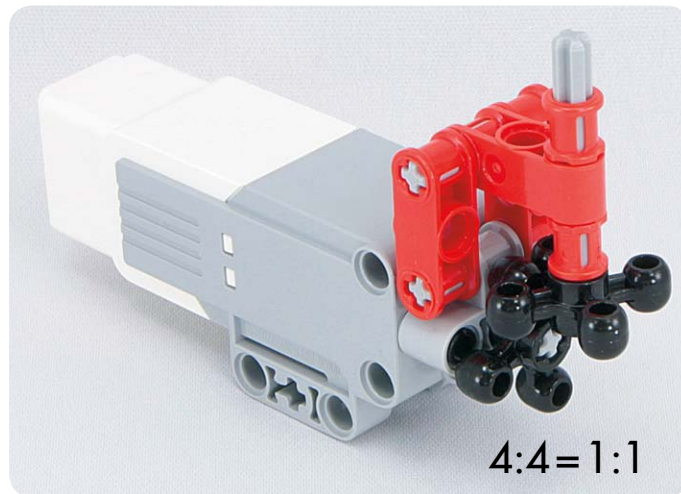
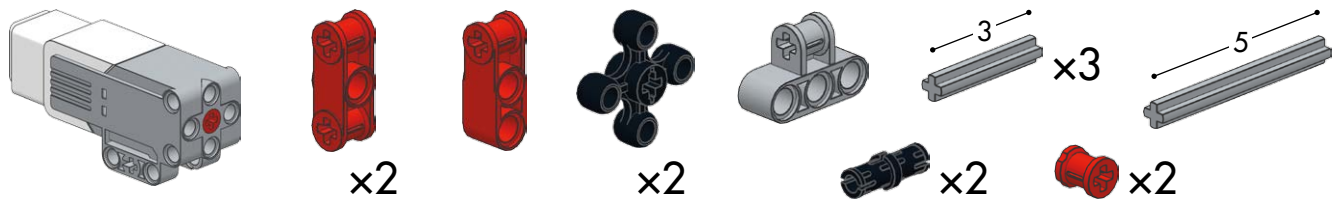
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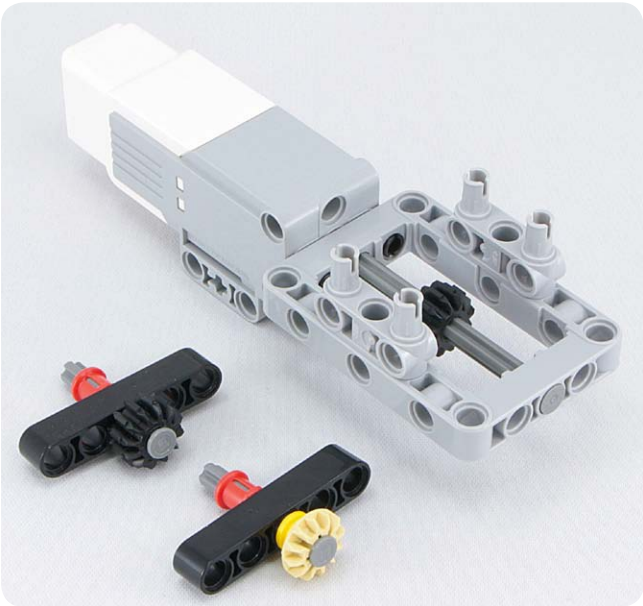
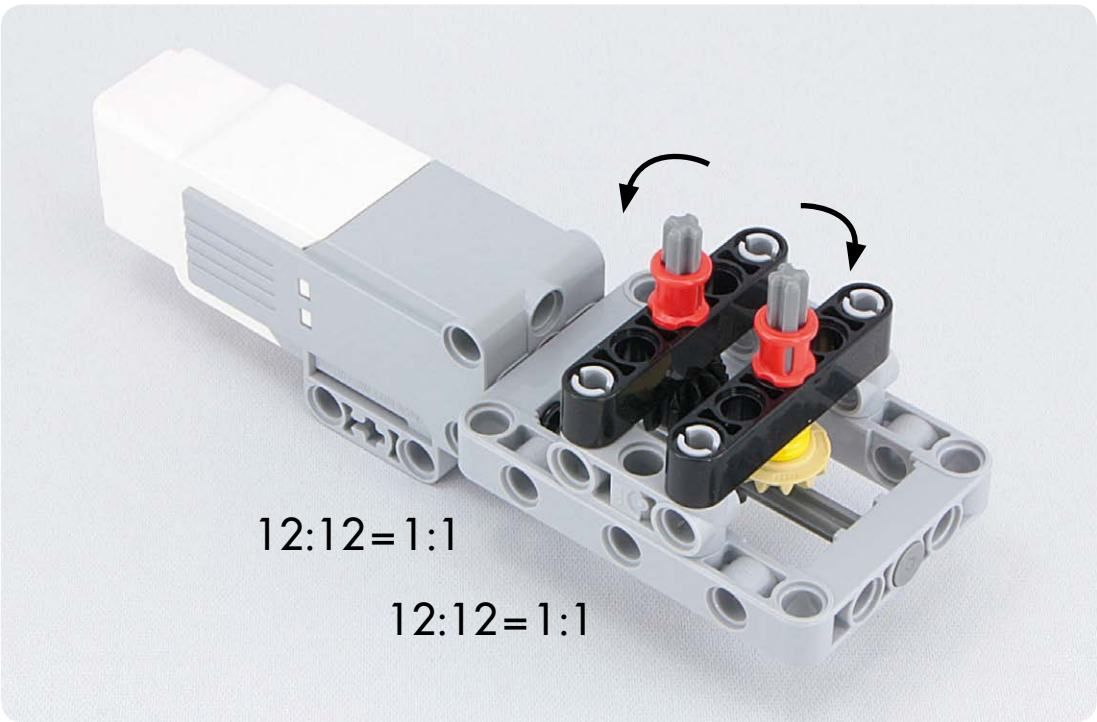
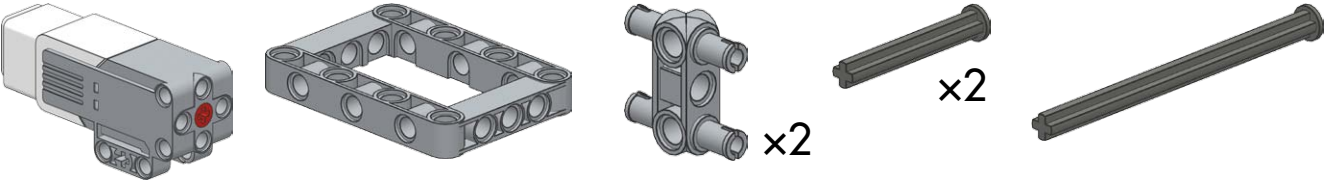
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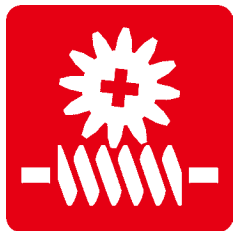


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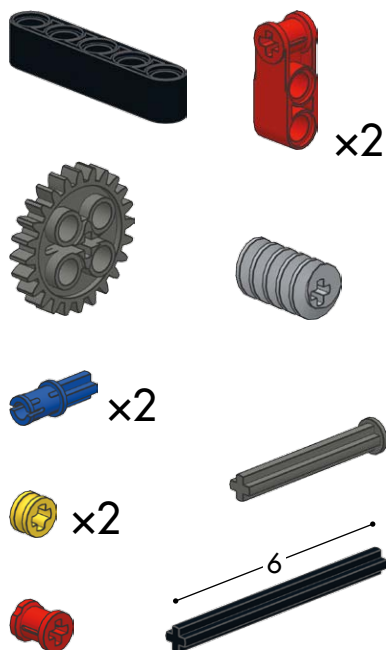
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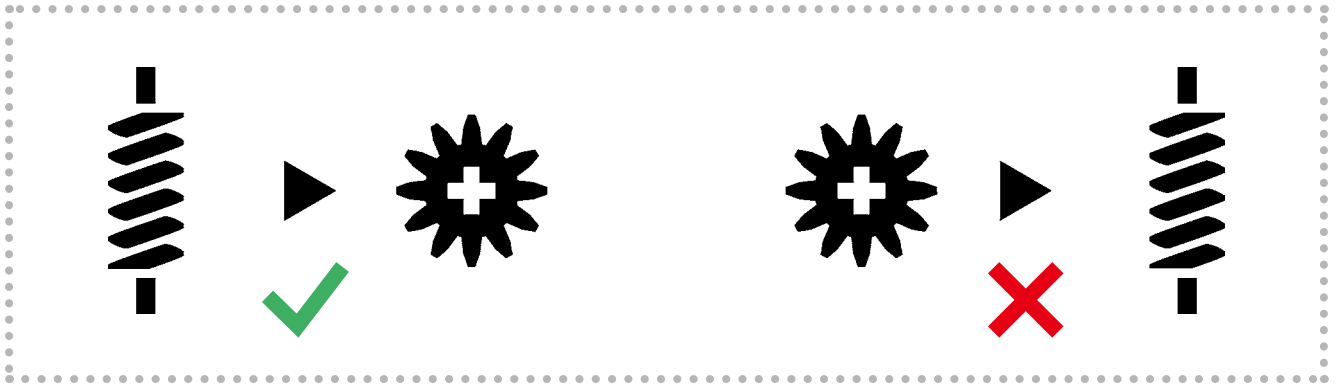




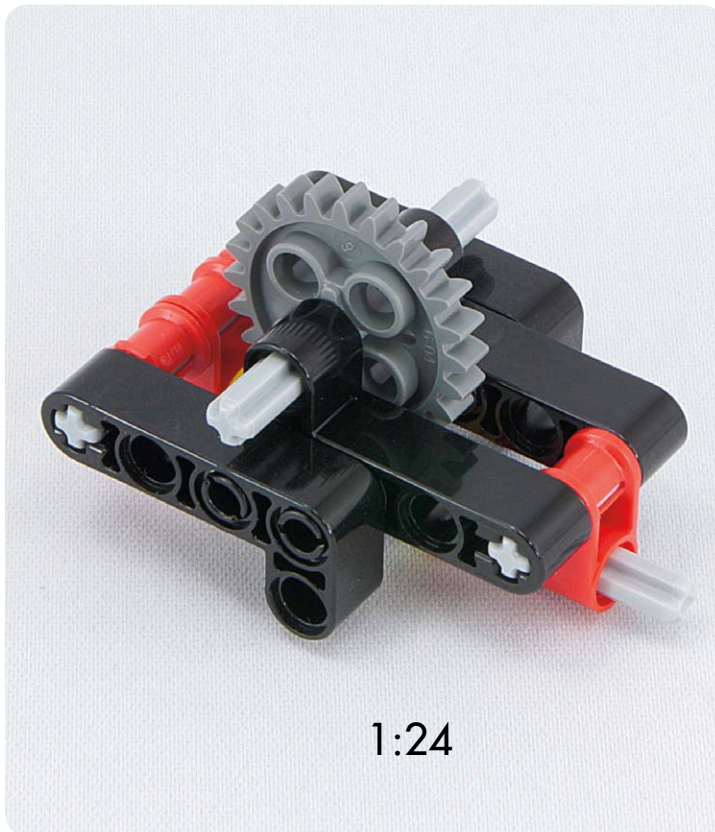
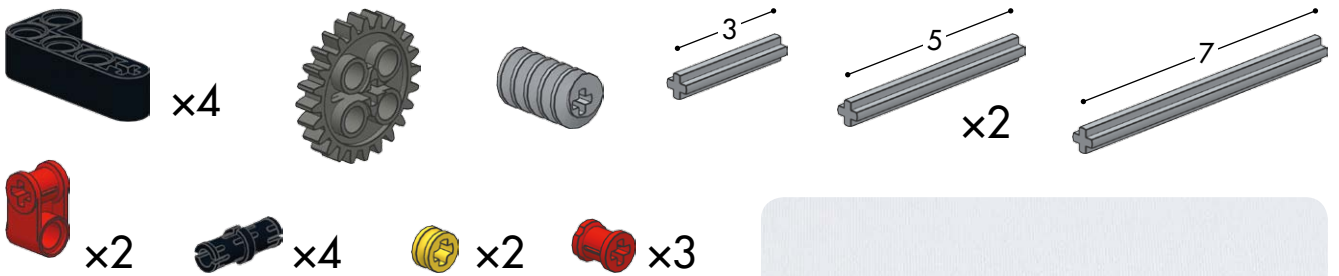
Using worm drives

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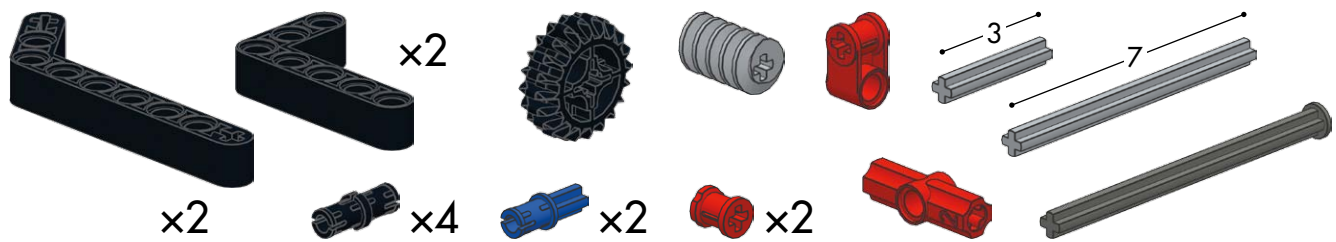




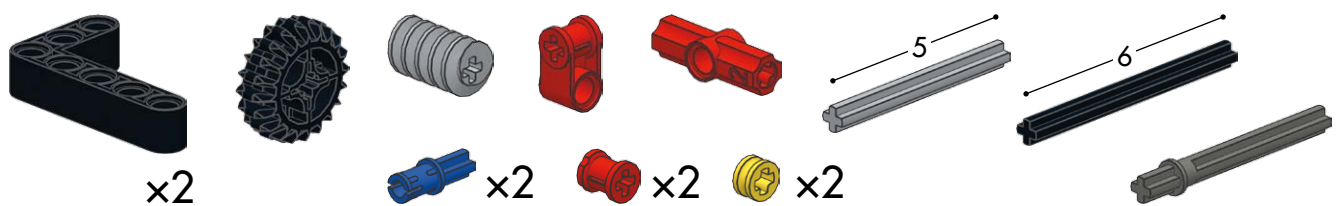
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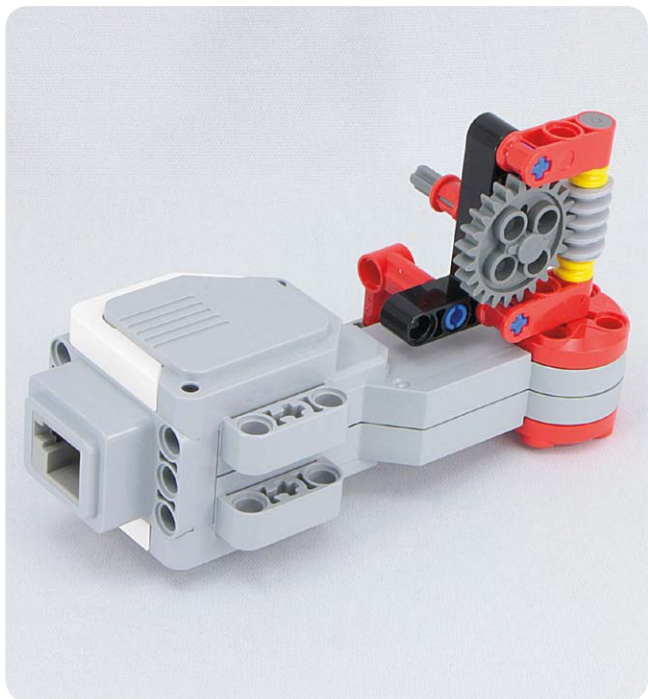
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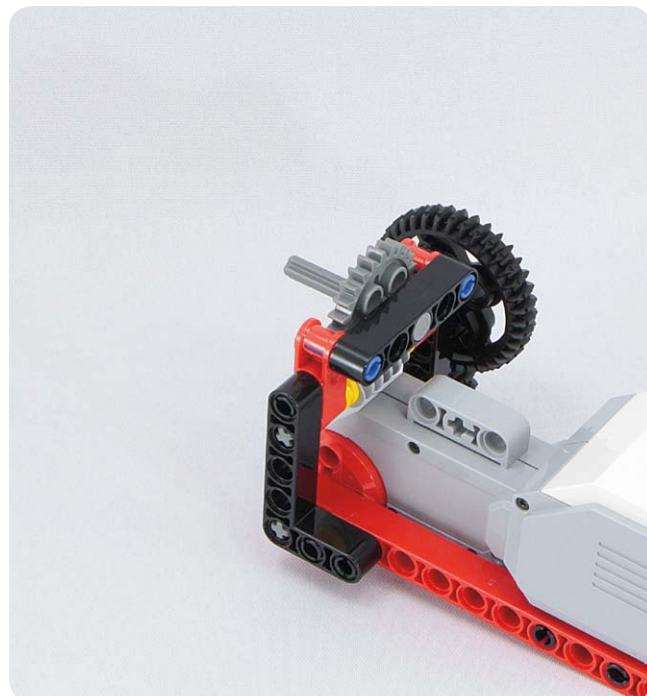
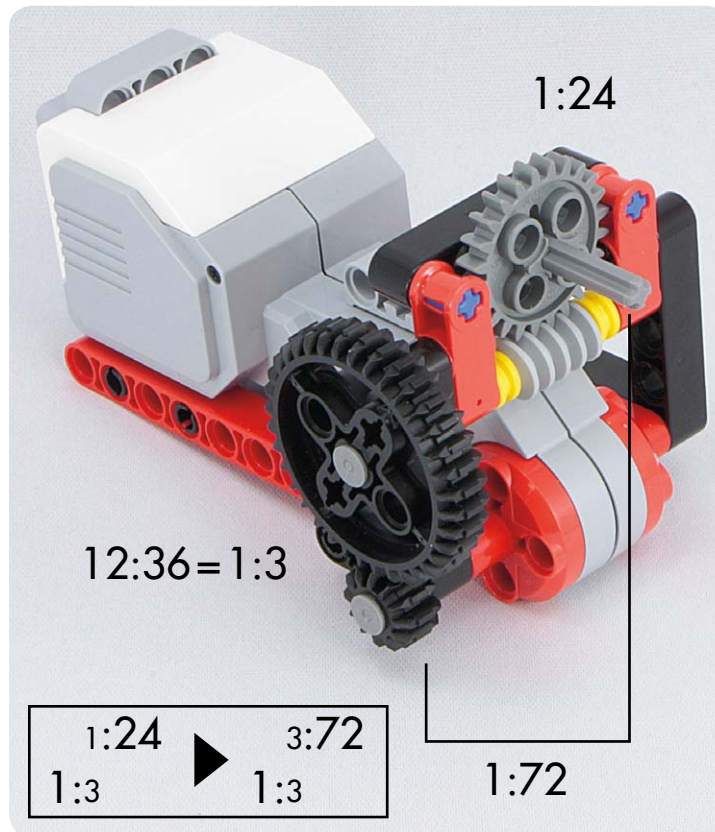


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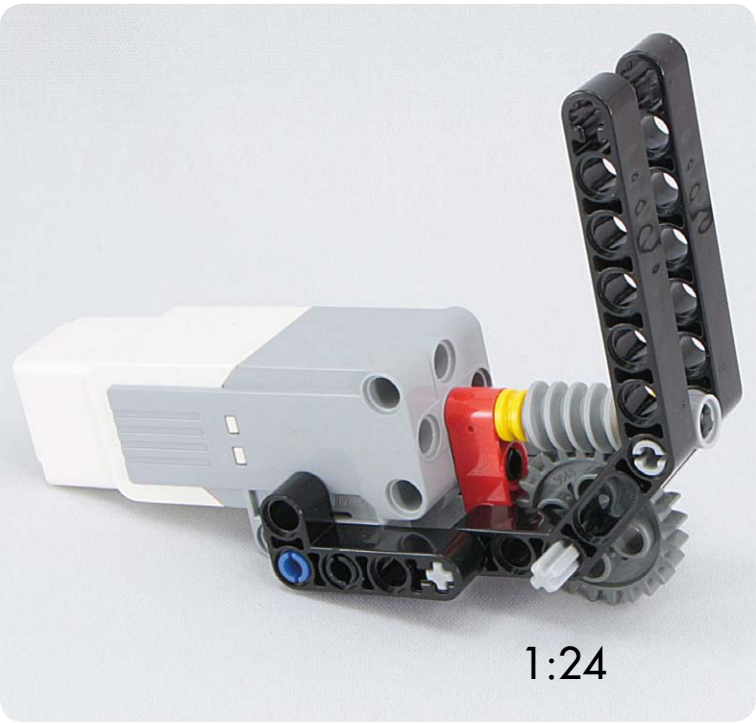
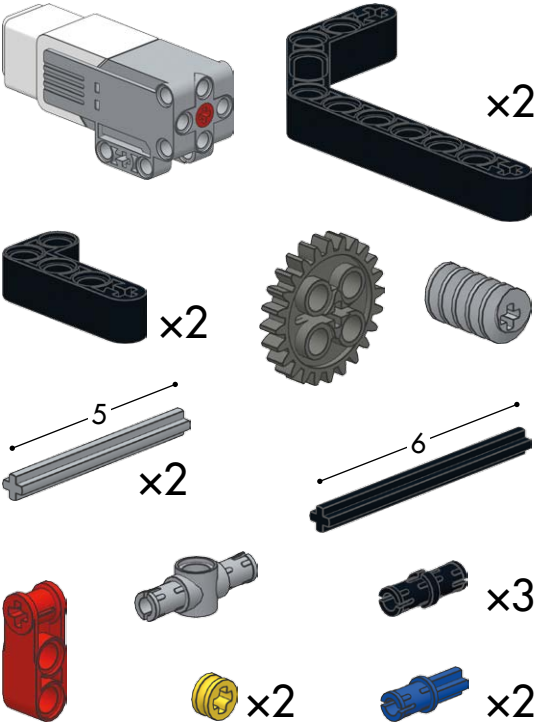


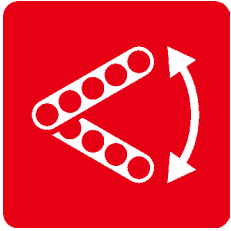
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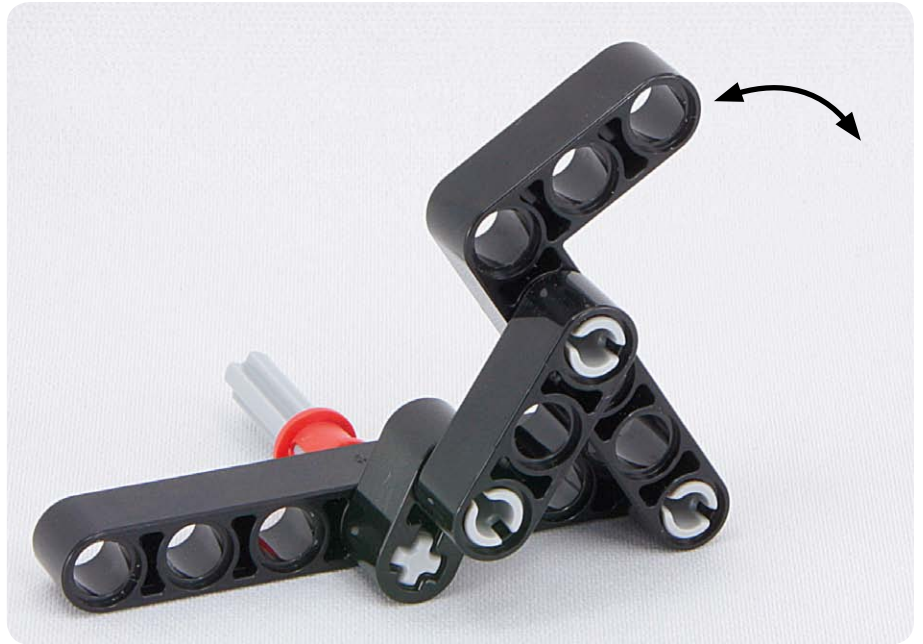
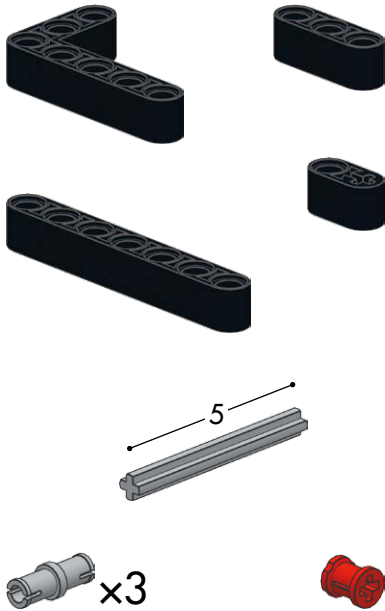
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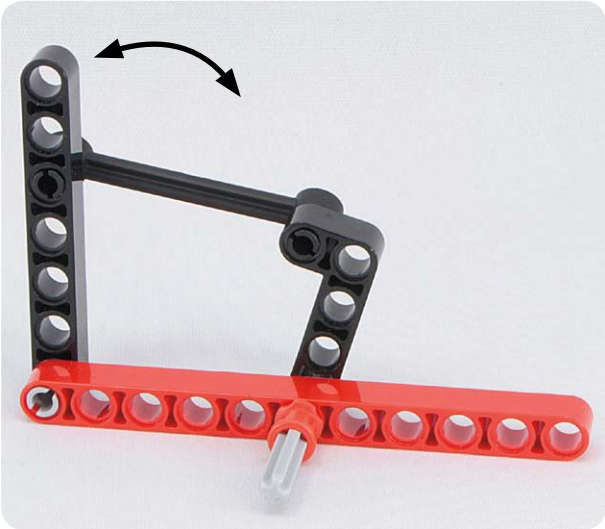
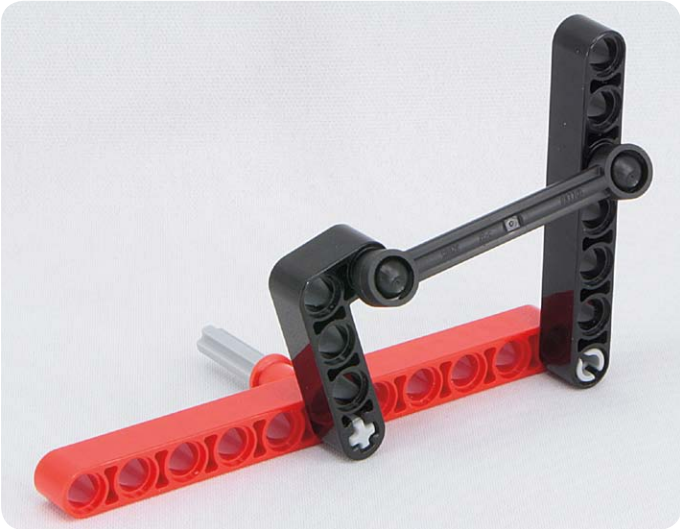


Swinging mechanisms

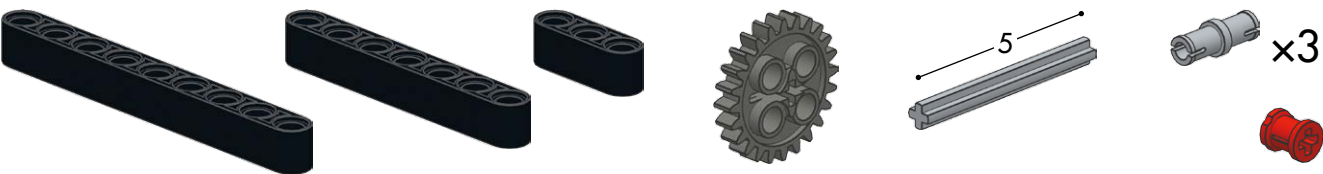
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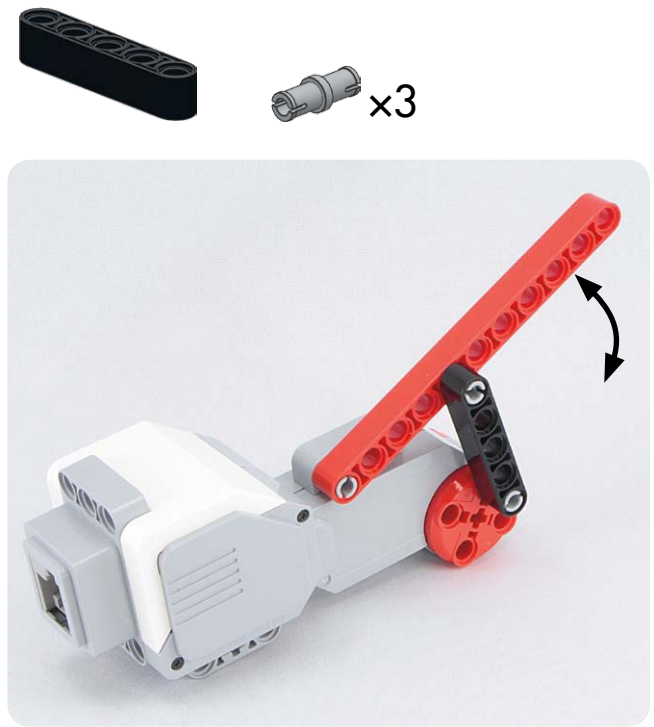
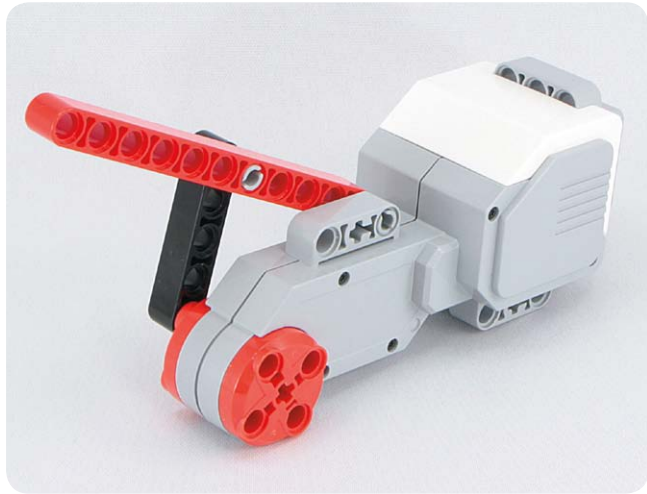
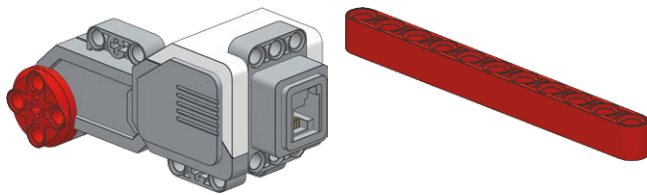
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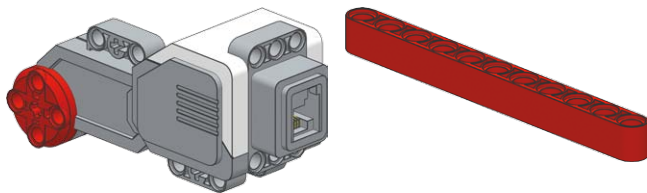
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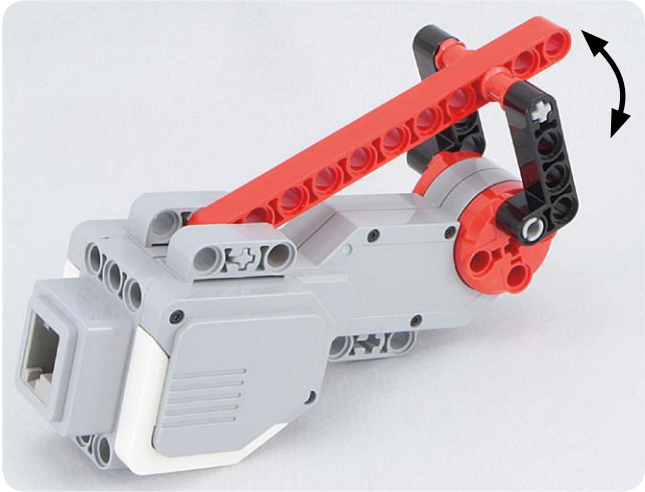
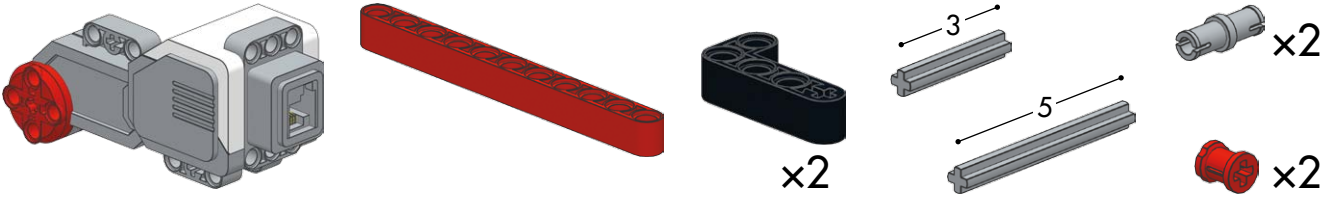
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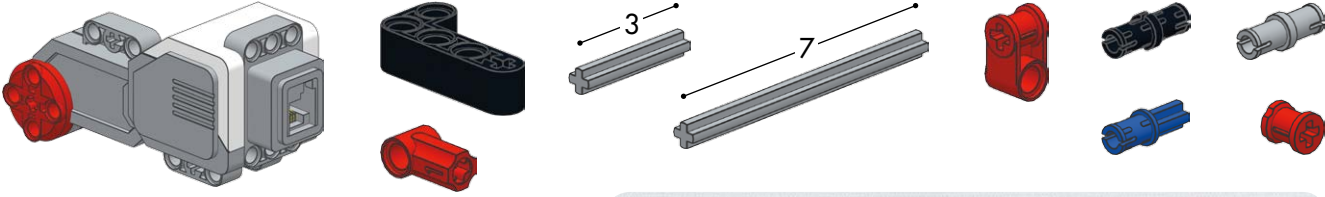
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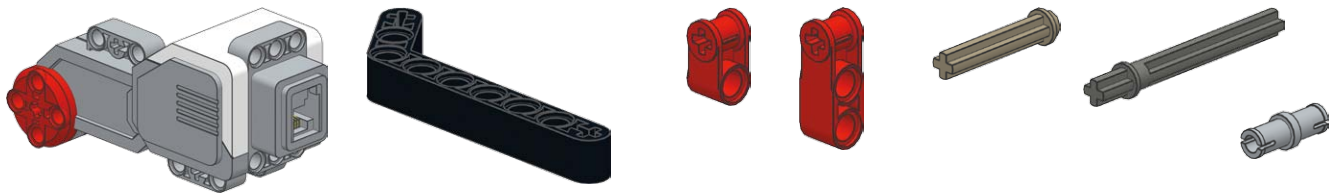
#57



#58



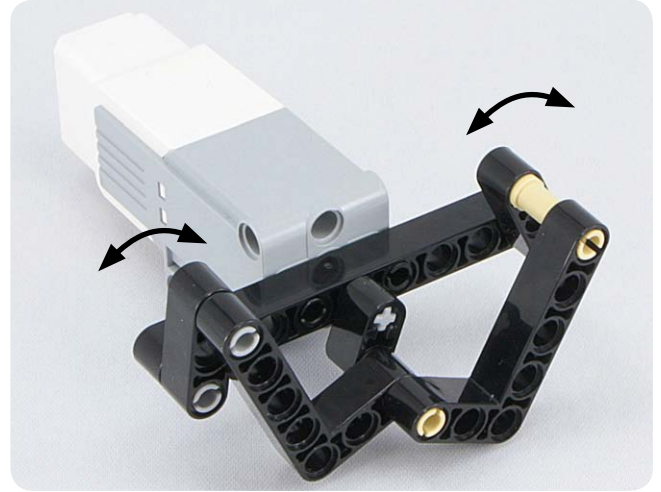
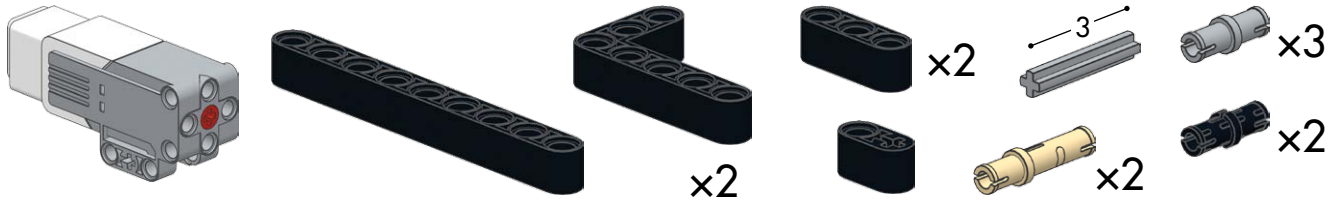
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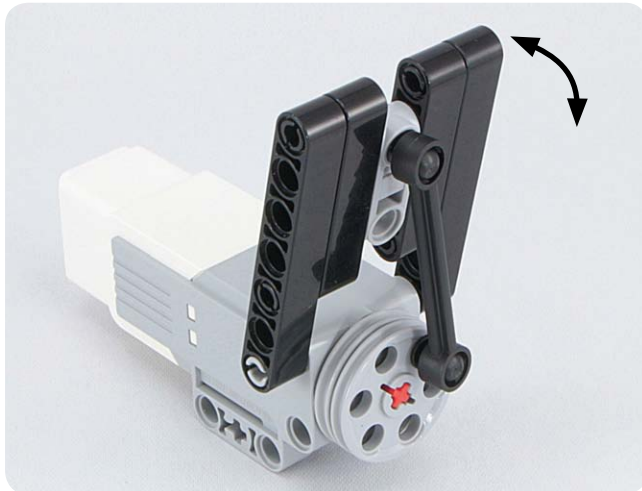
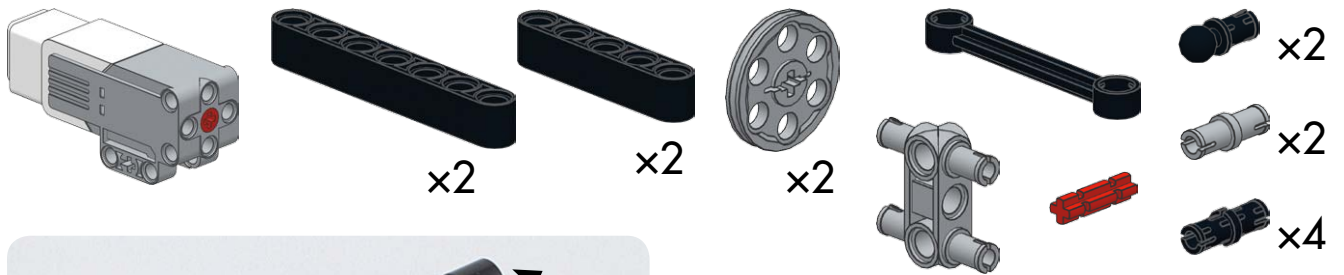
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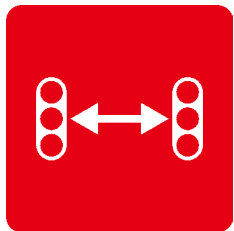


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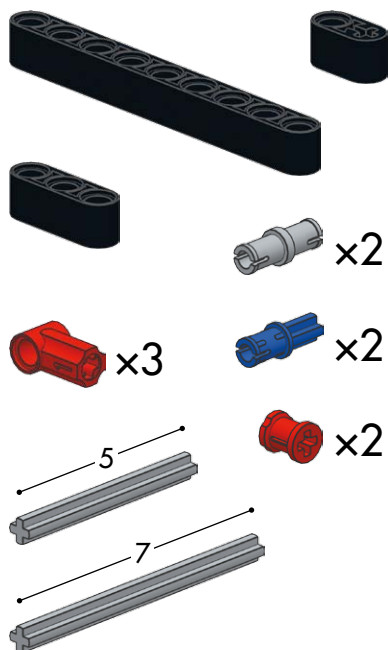
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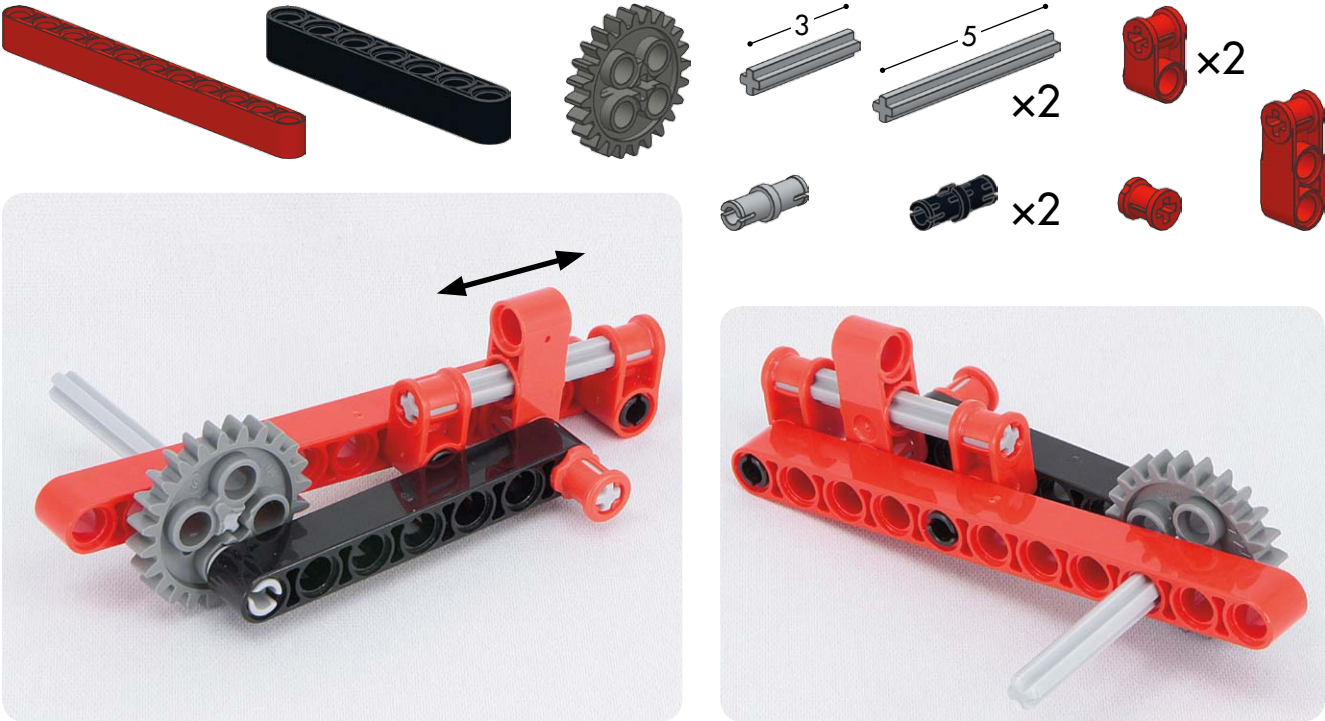


Reciprocating mechanisms

#63



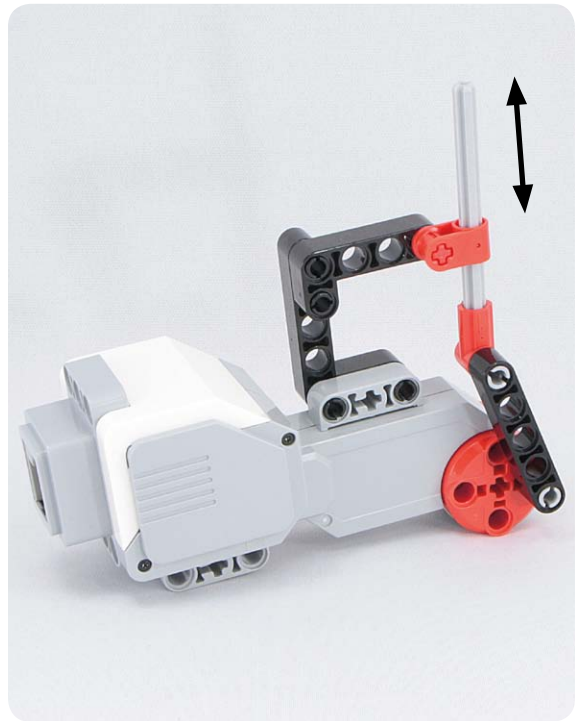
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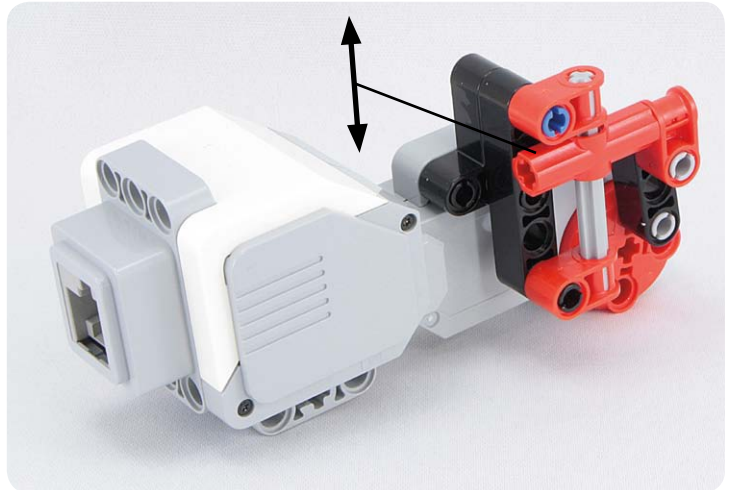
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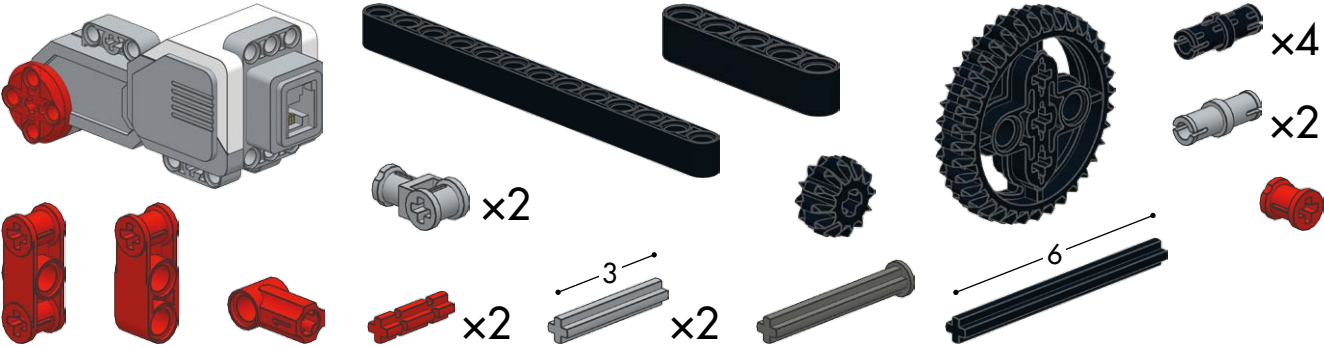


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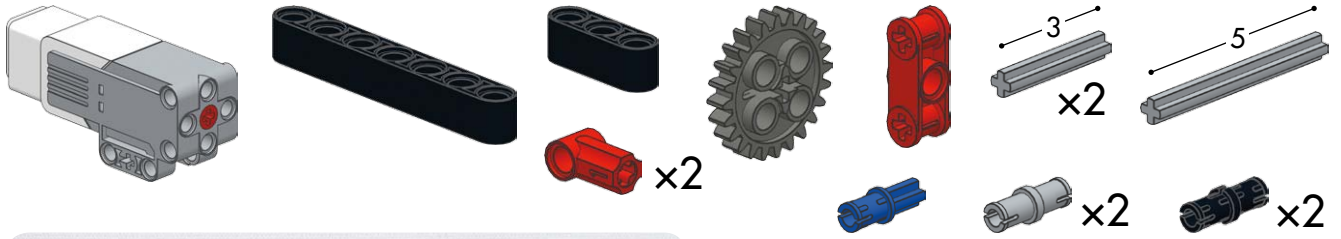


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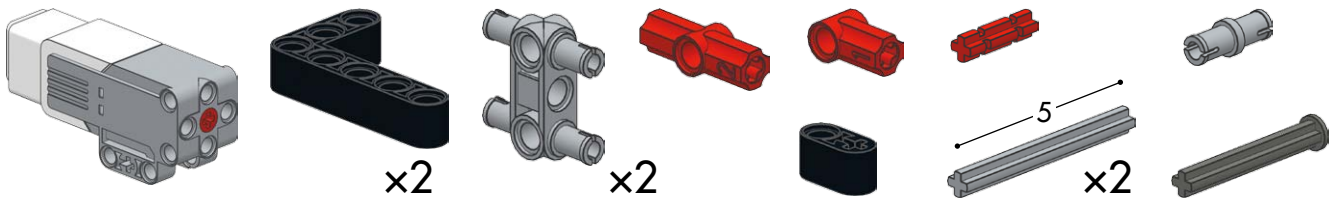




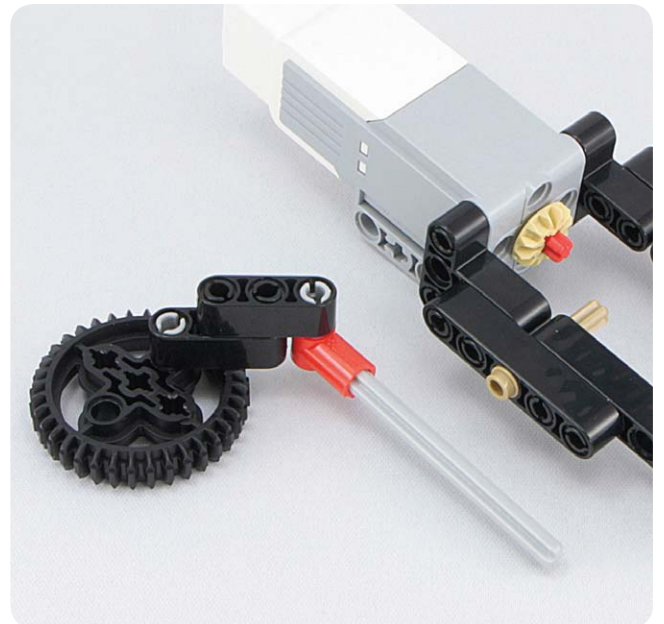
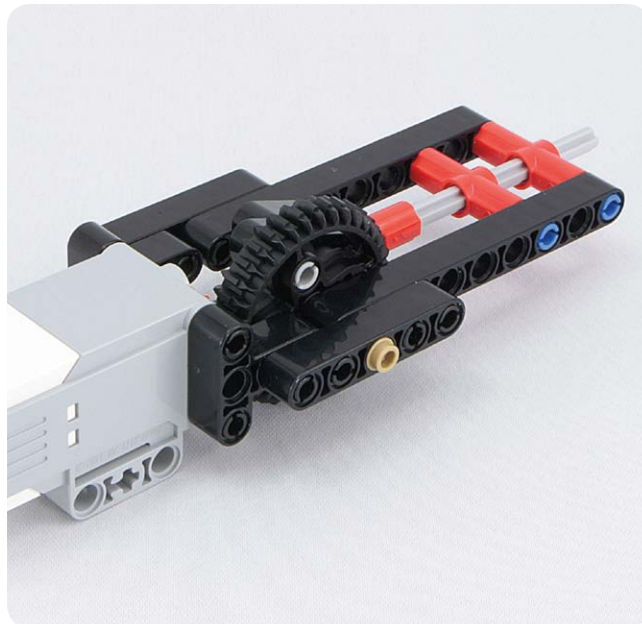
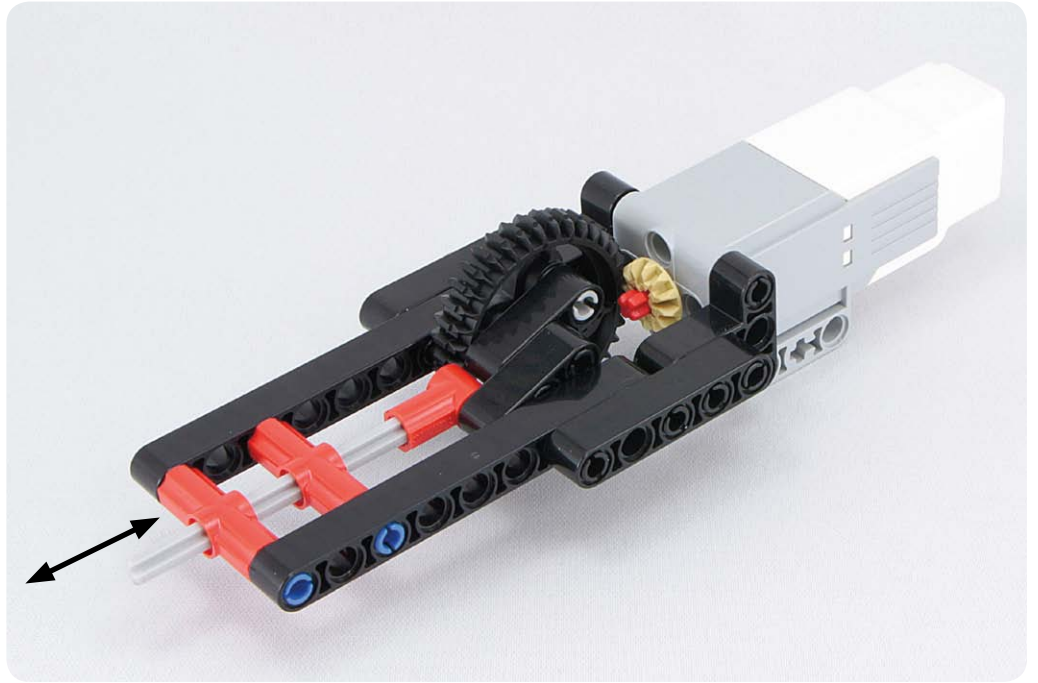
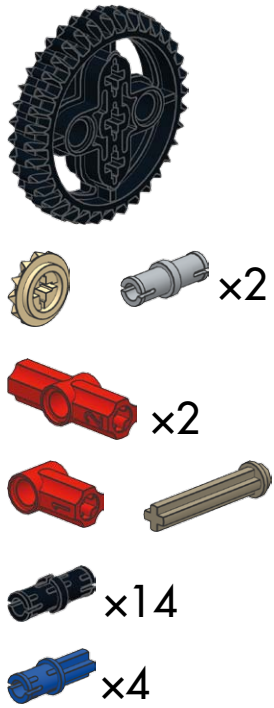
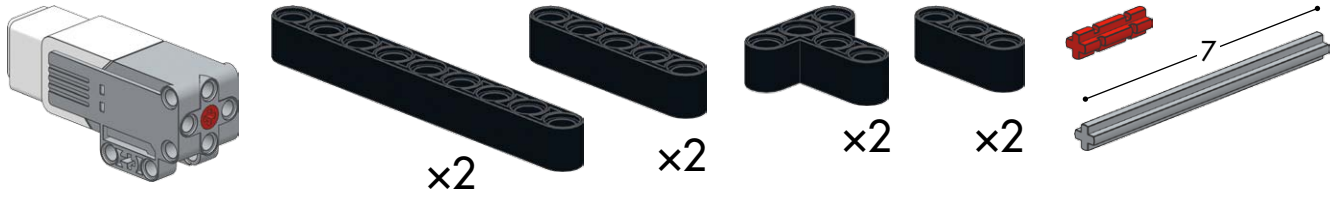
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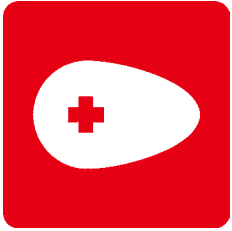


#70



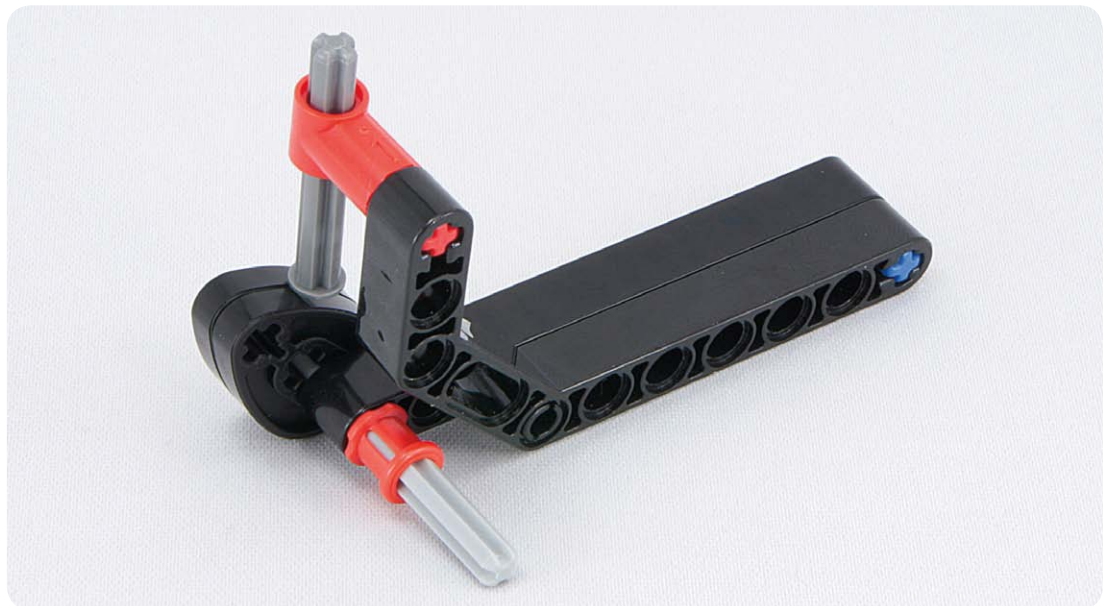
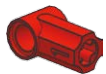
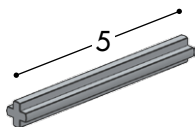
#71





Cam mechanisms

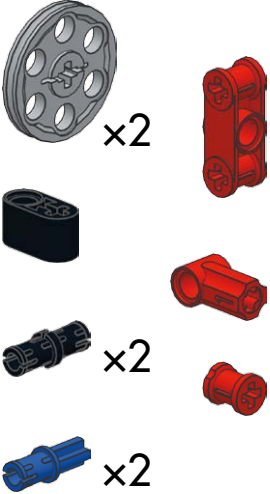
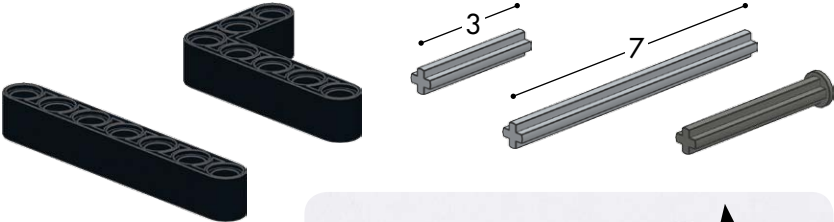
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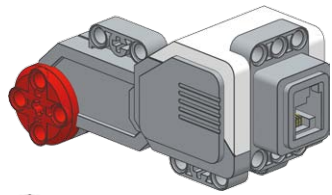


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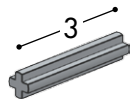
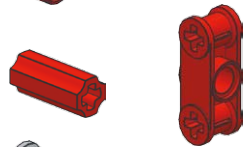


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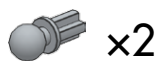




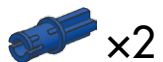
x2



3



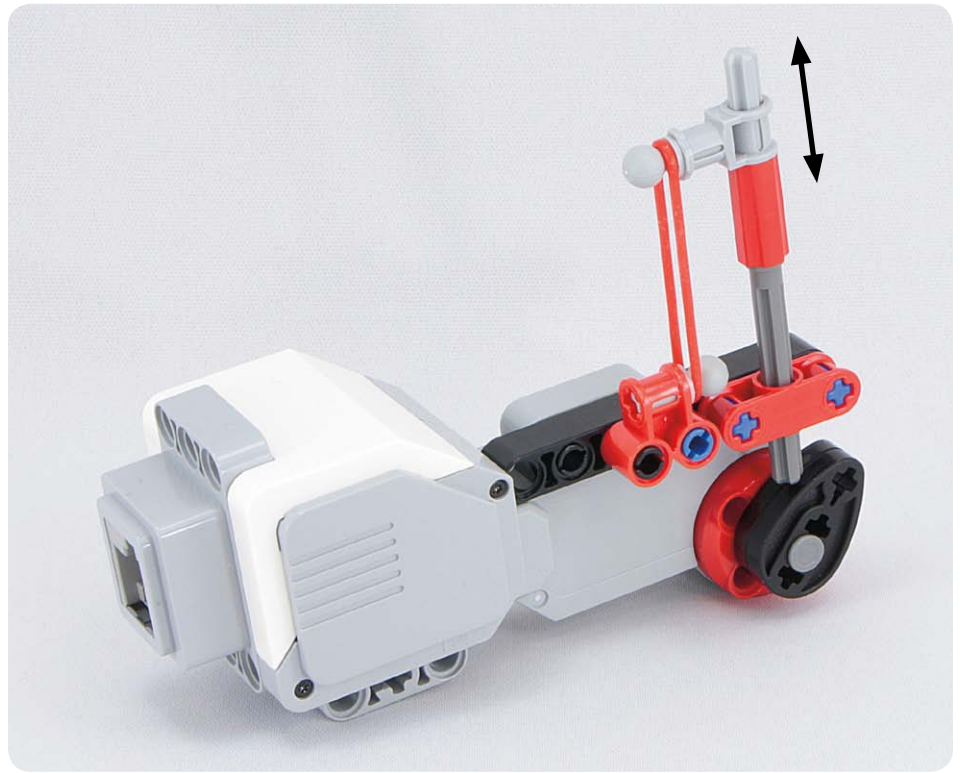
x2



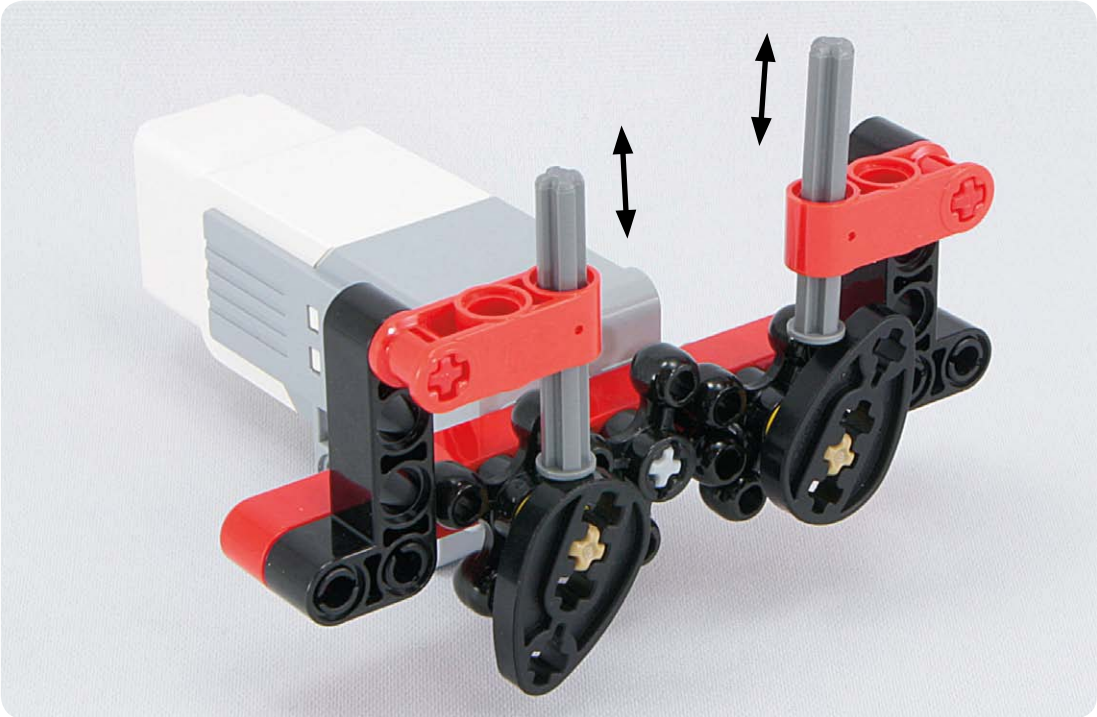
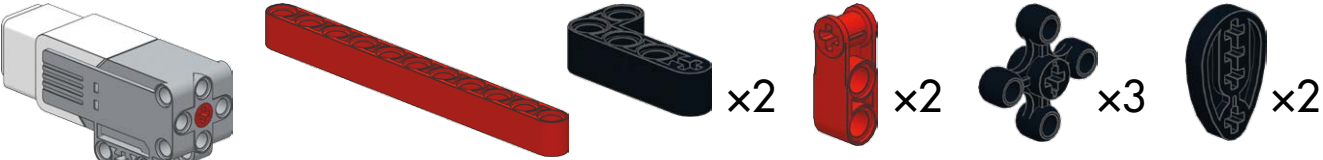
x2

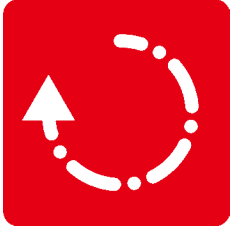


x2



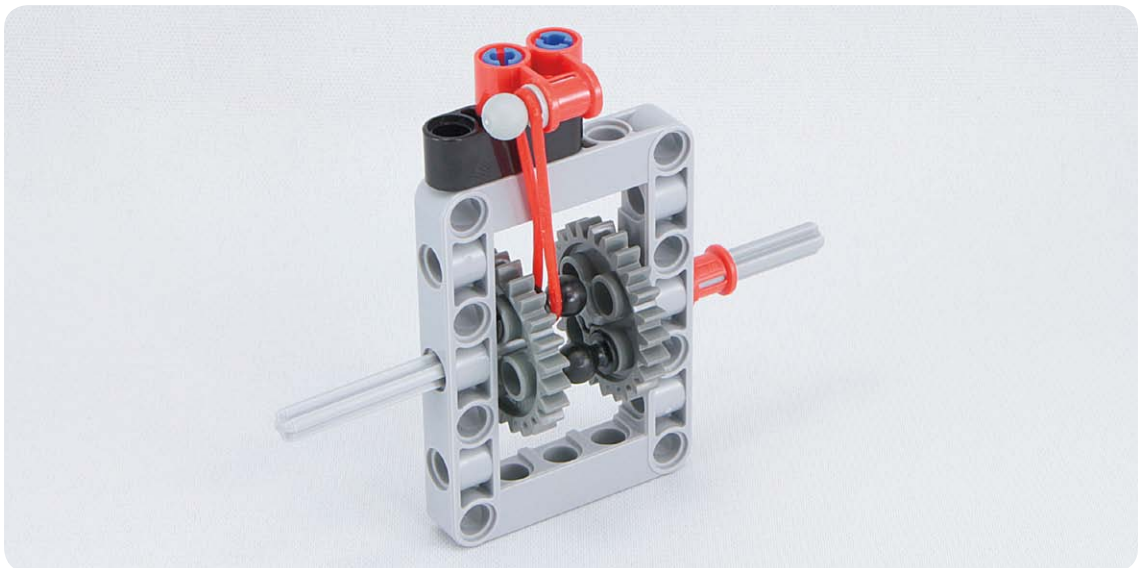
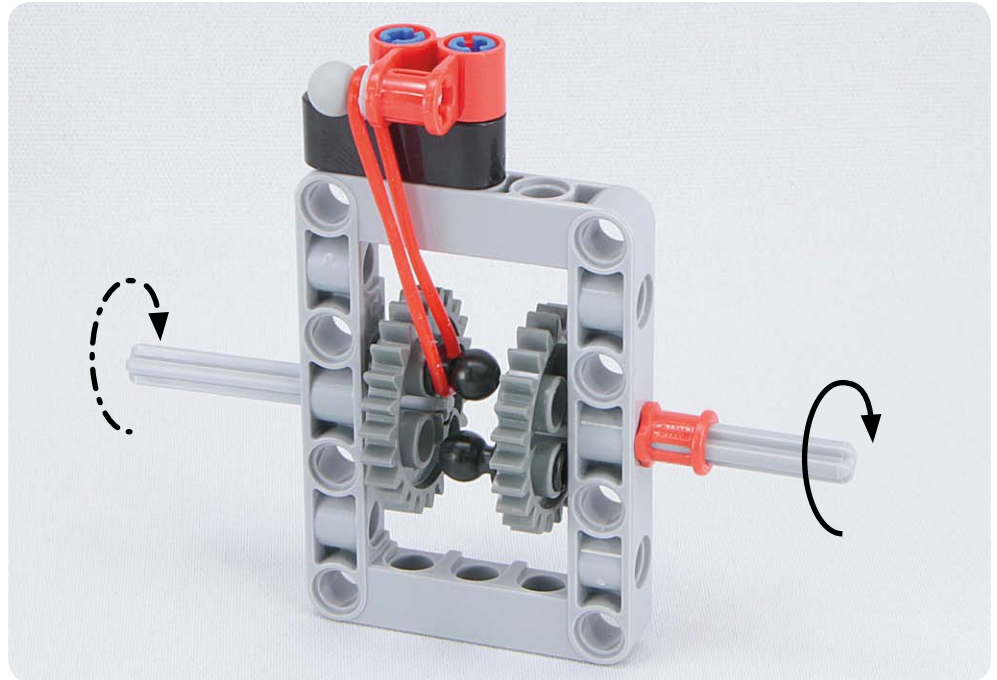
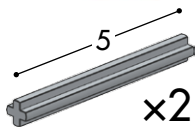
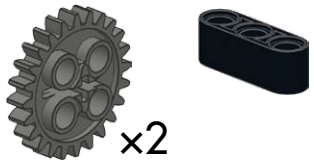
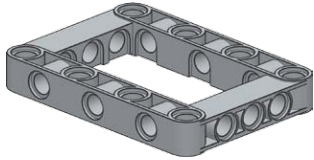
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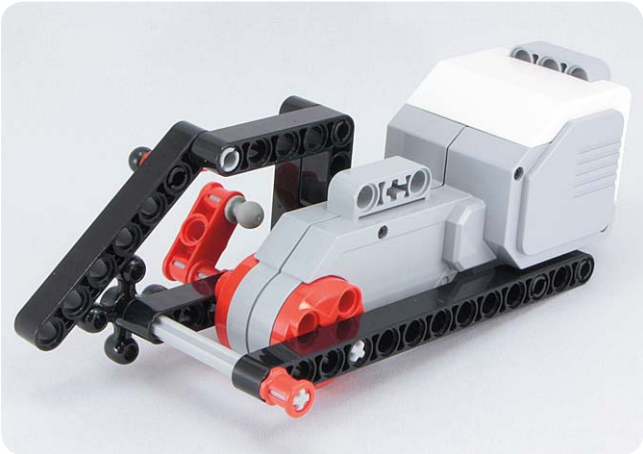
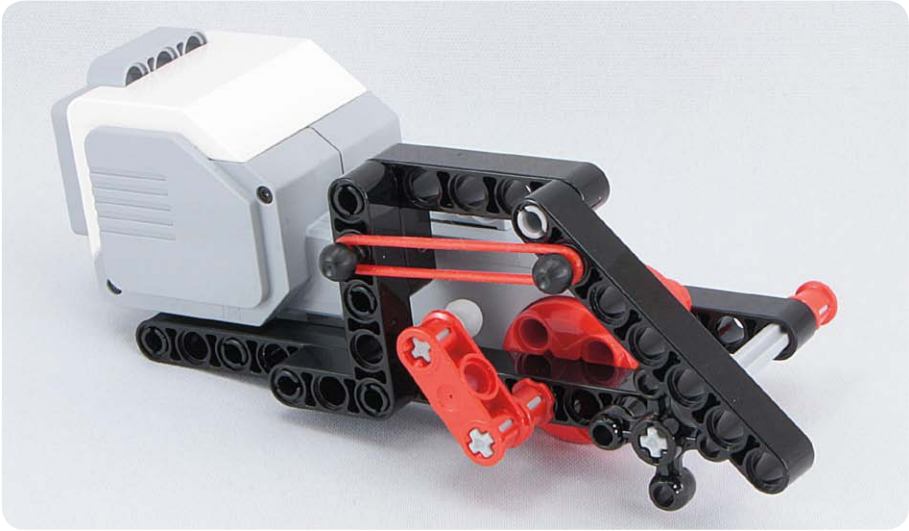
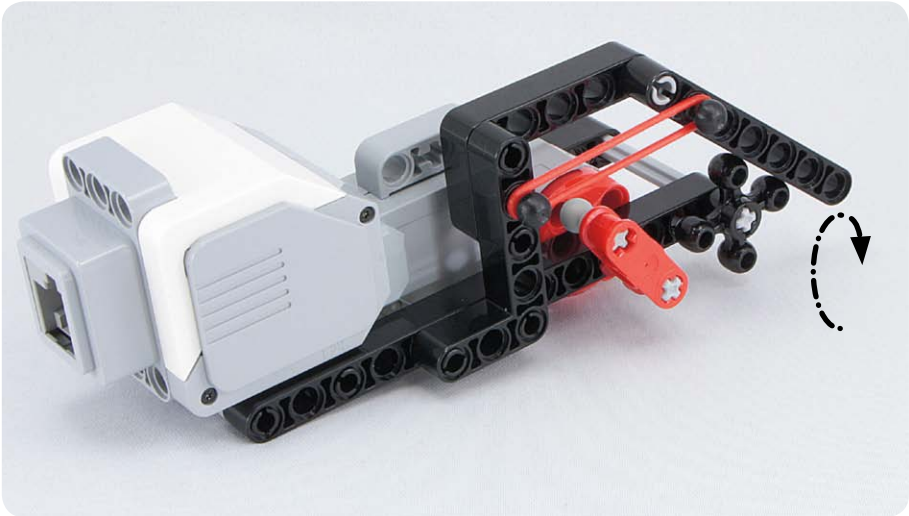
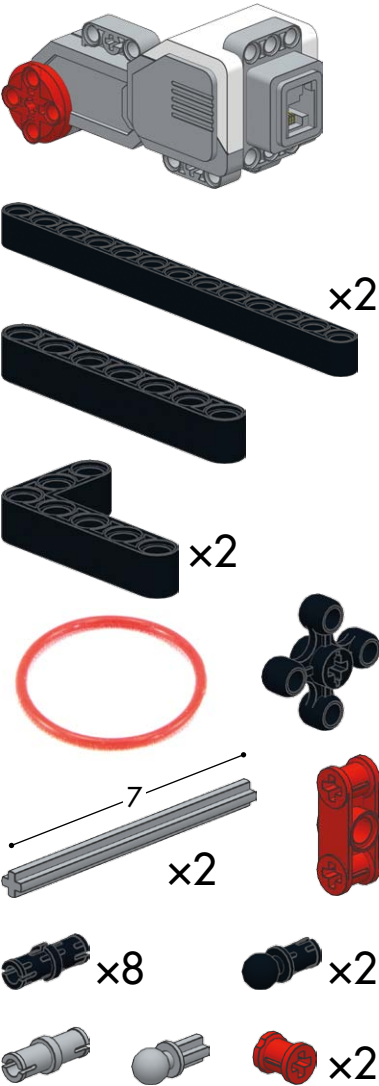


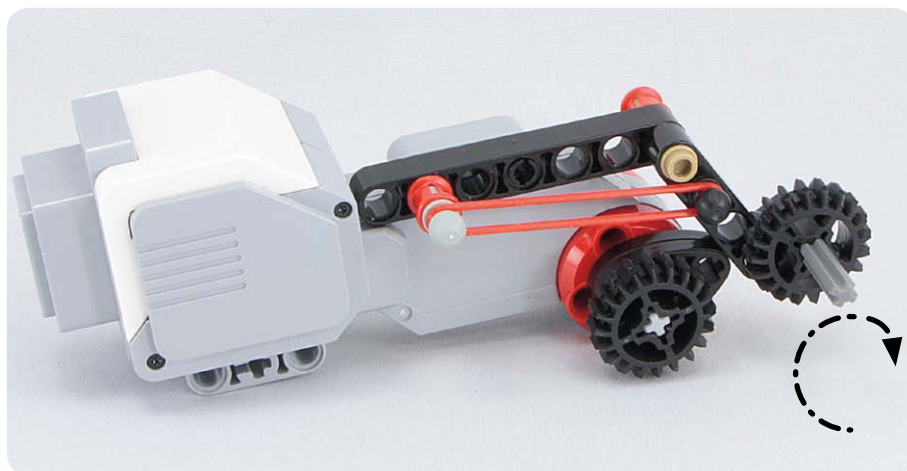


Intermittent motion

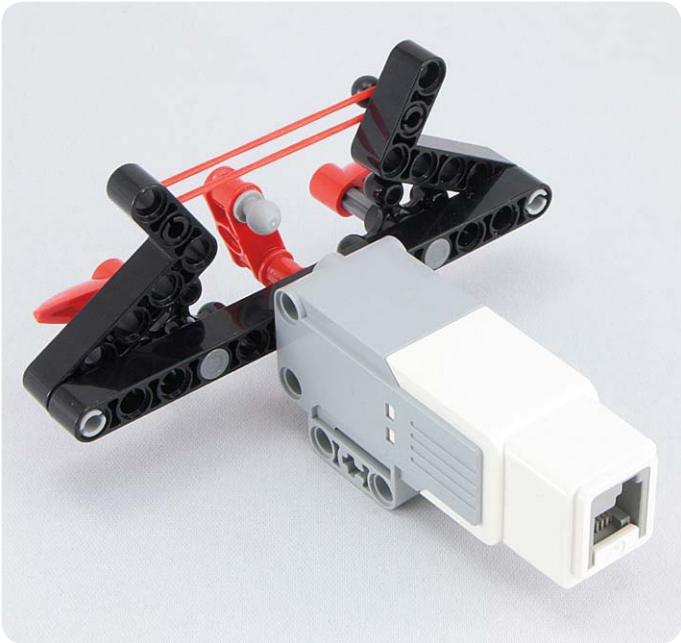
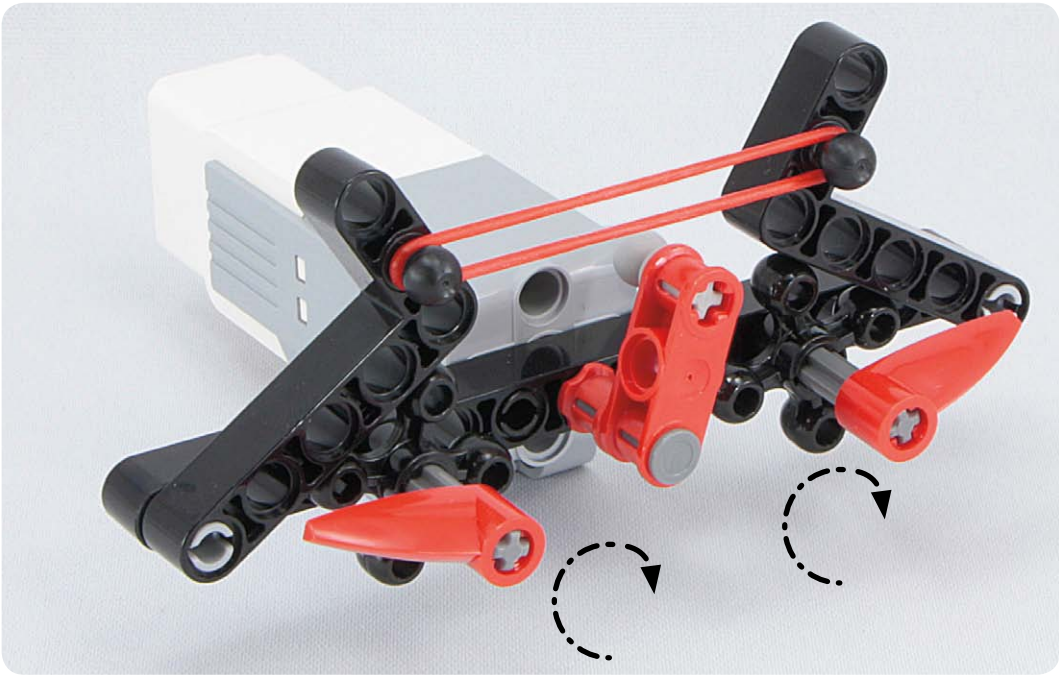
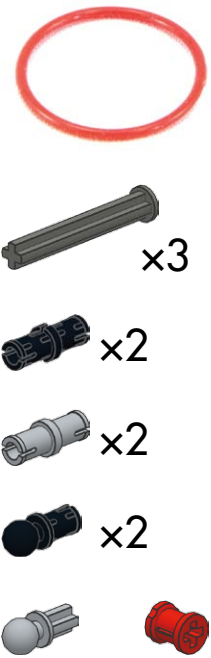
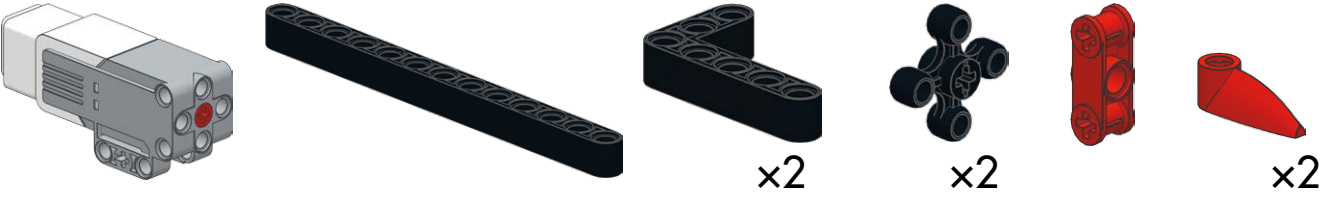
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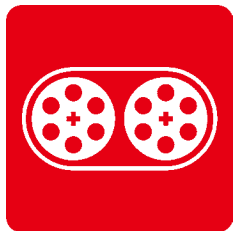






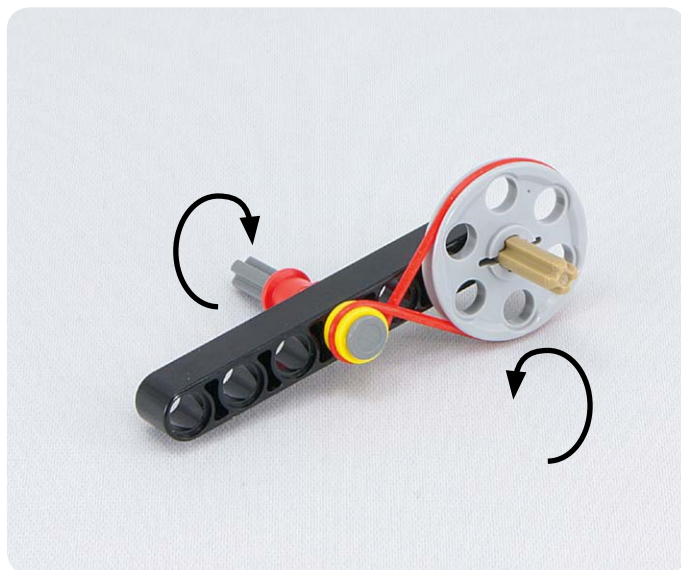
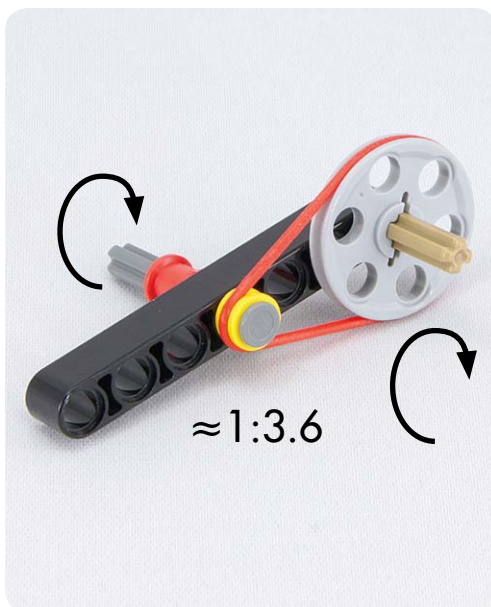
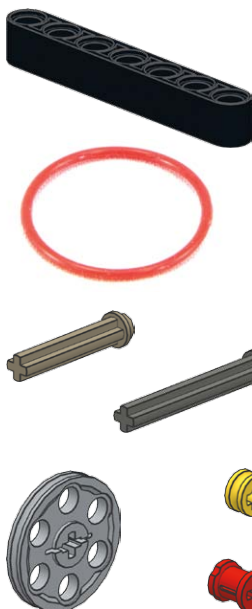
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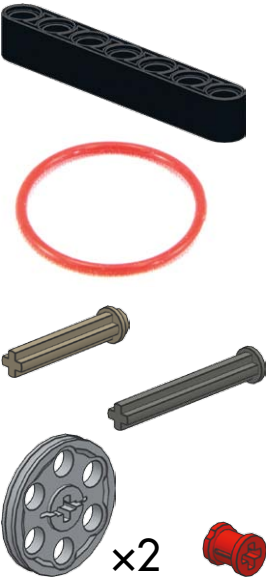


Transmitting rotation with rubber bands

#81

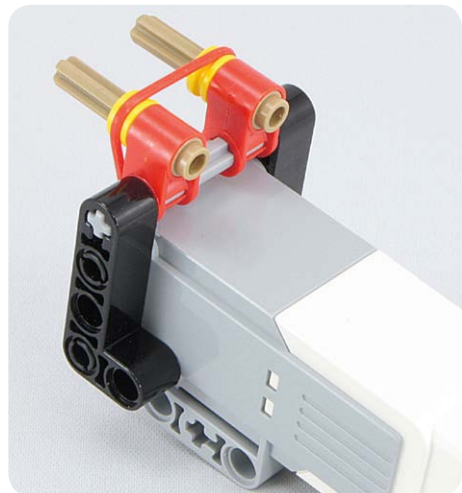
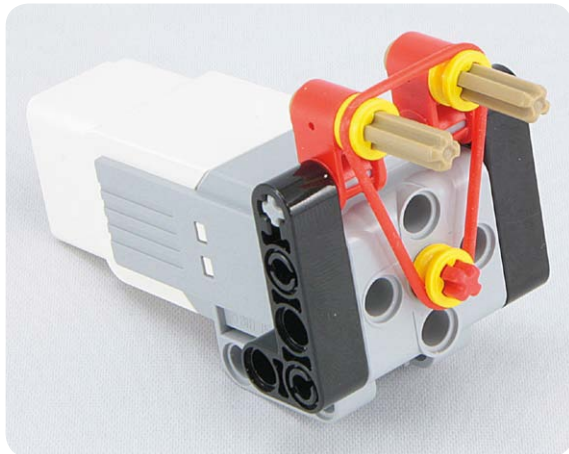
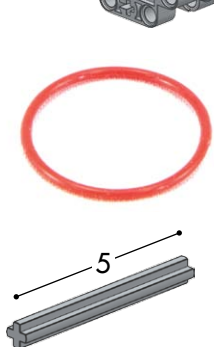
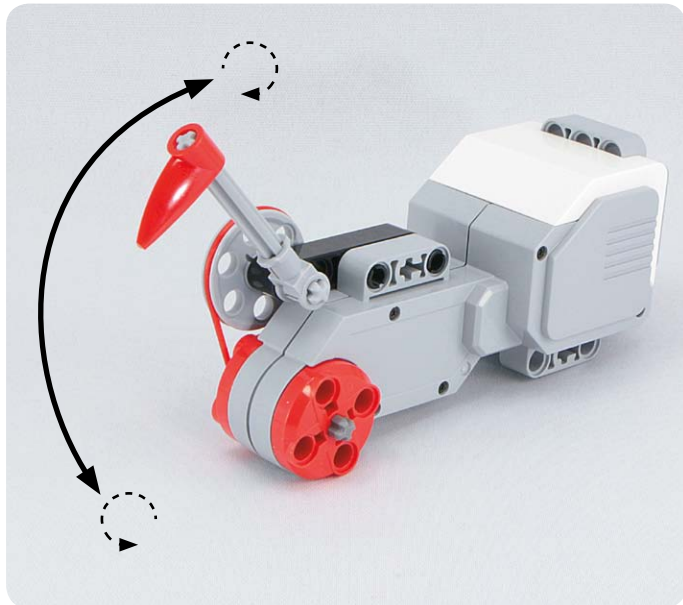


#82

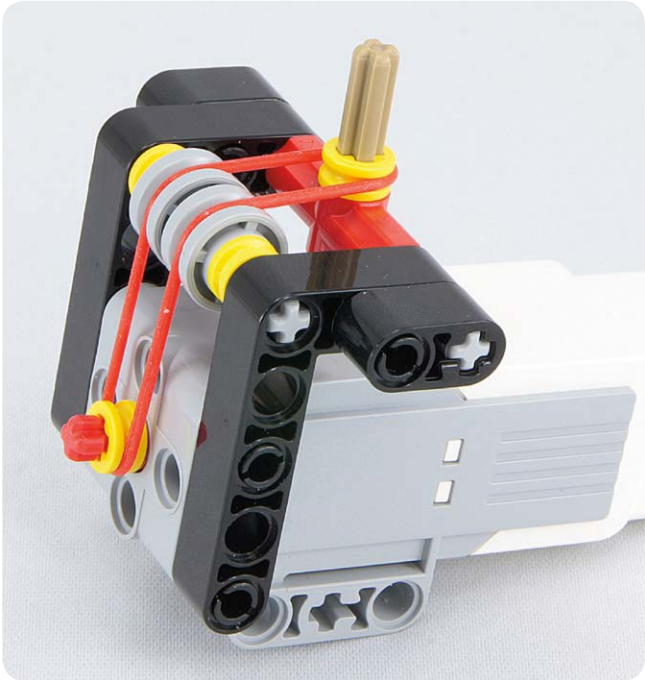
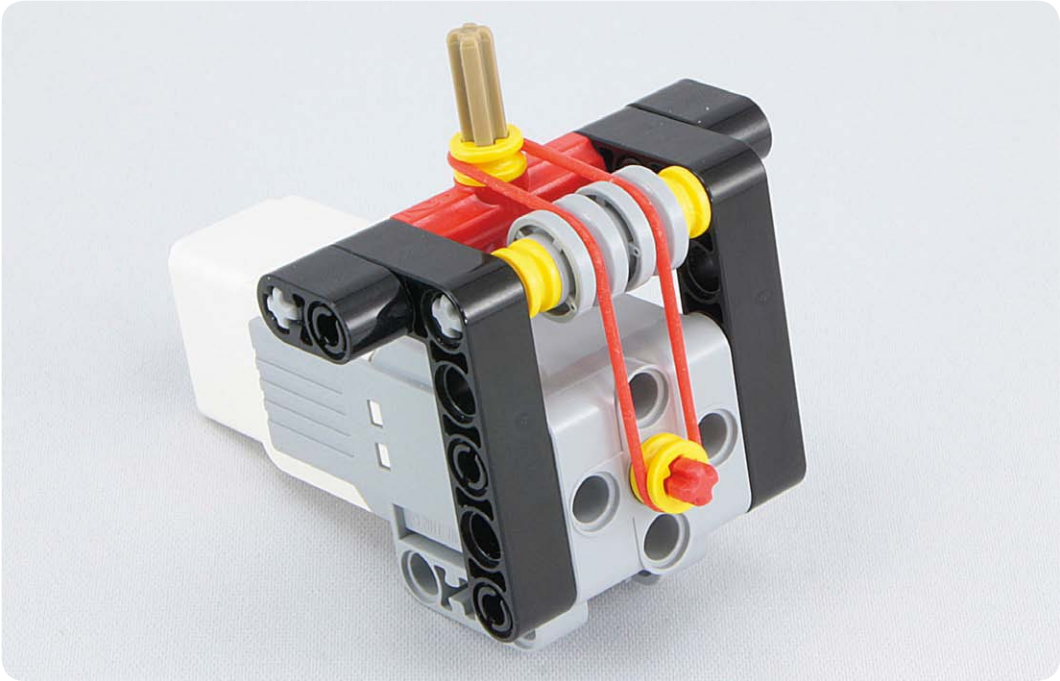
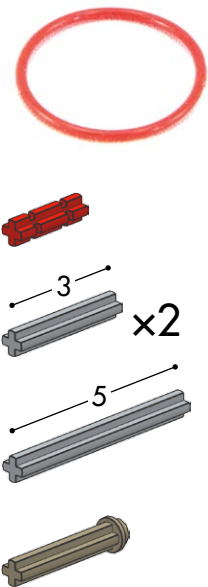
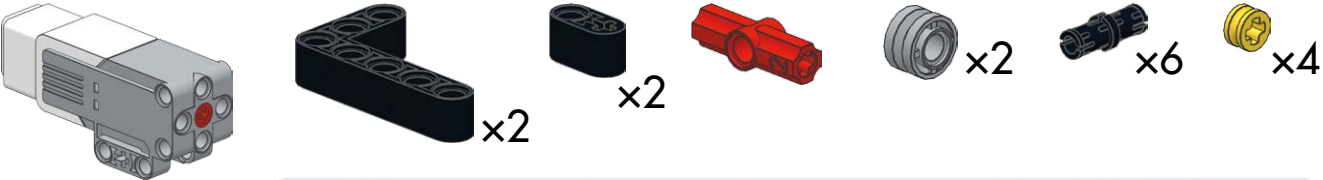


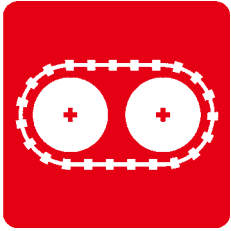
#83





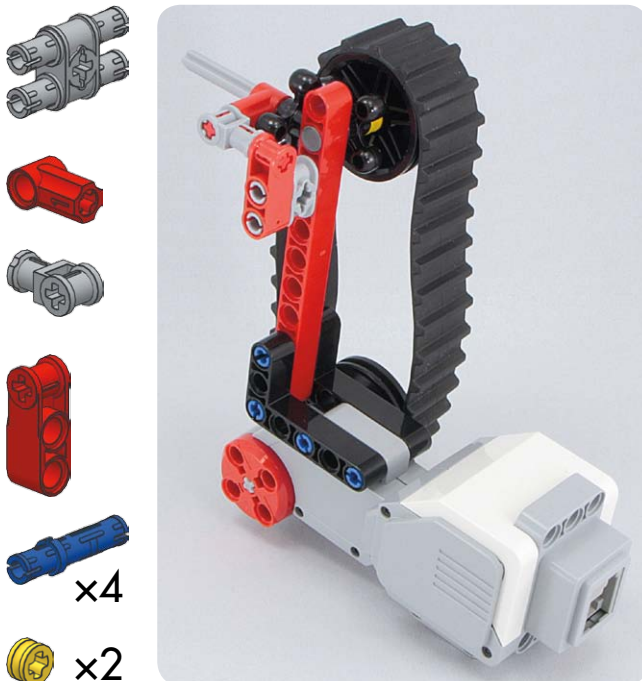
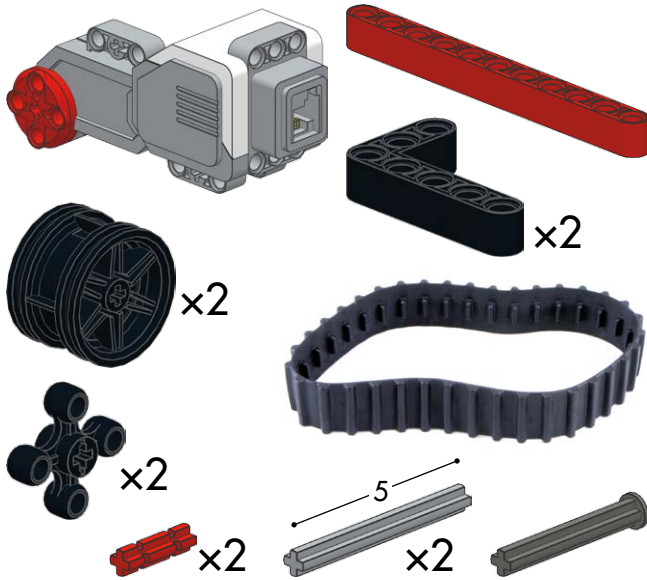
#86

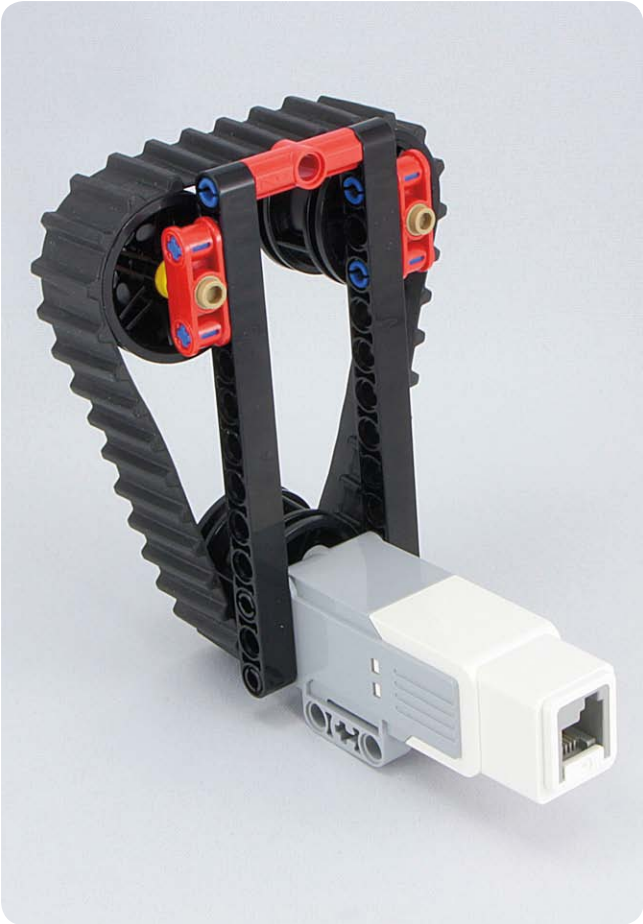
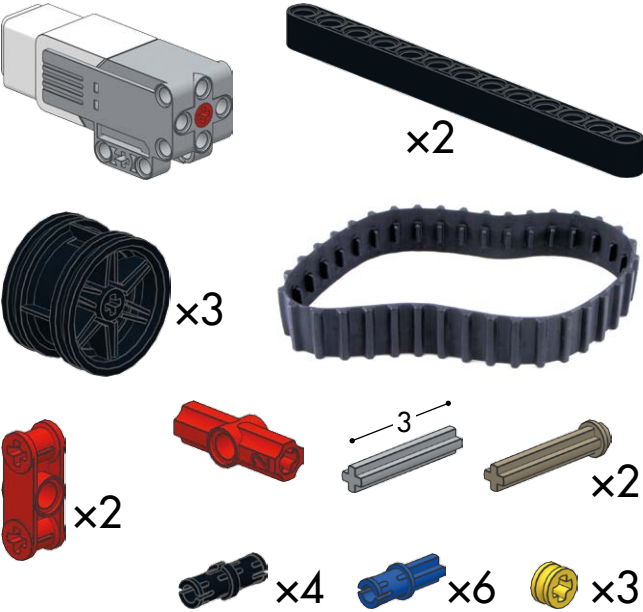


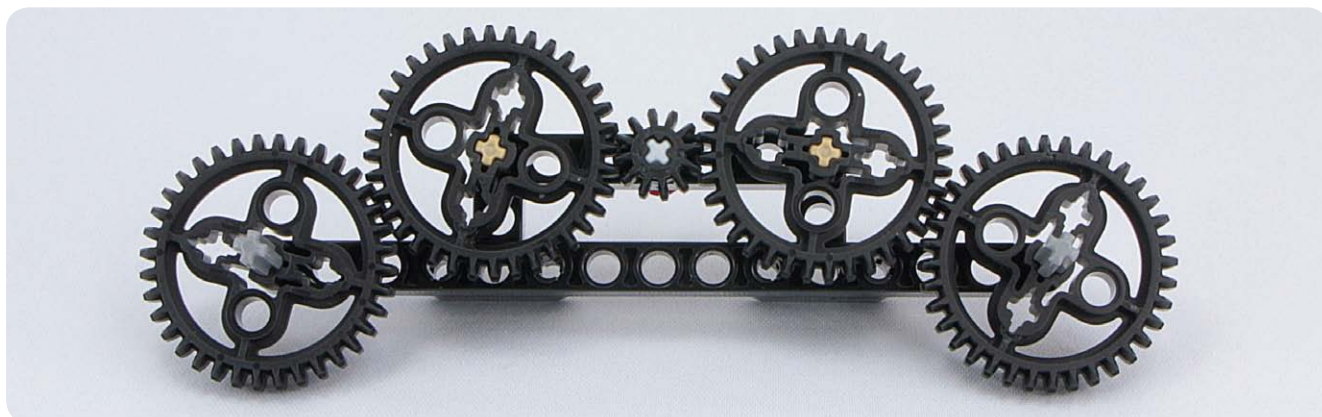


Transmitting rotation with caterpillar treads

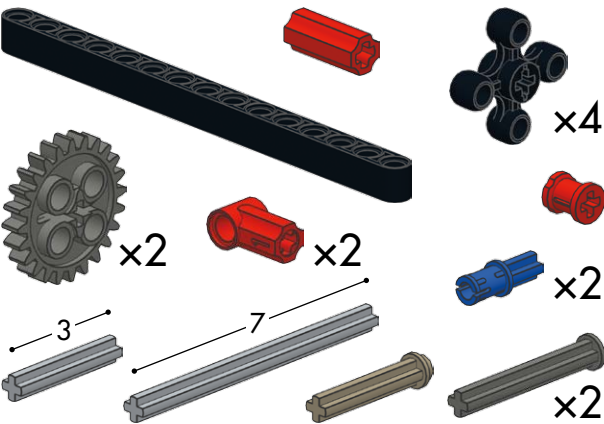
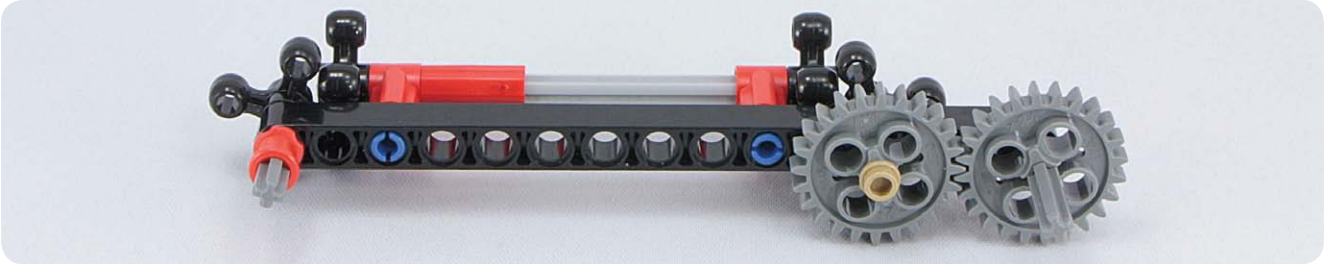
#87



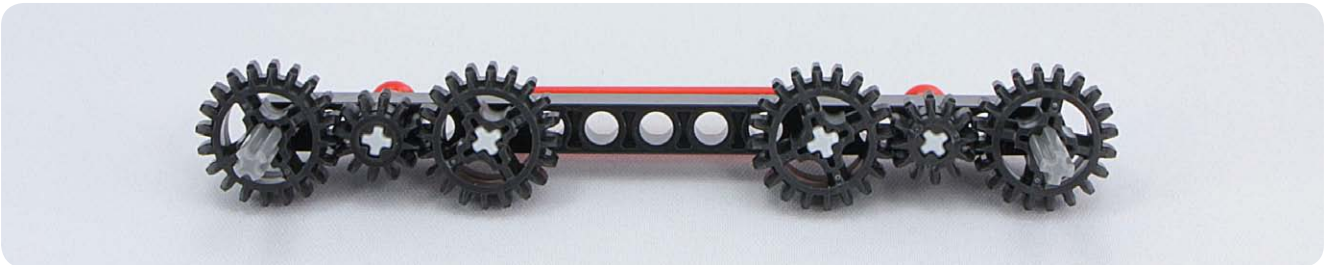




#90



#91

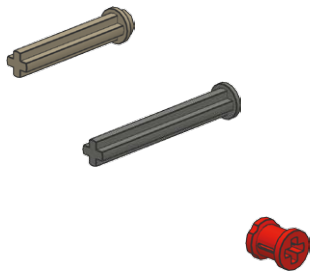
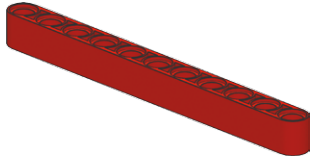


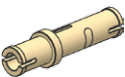
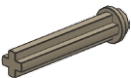


Off-center axes of rotation

.....

#92

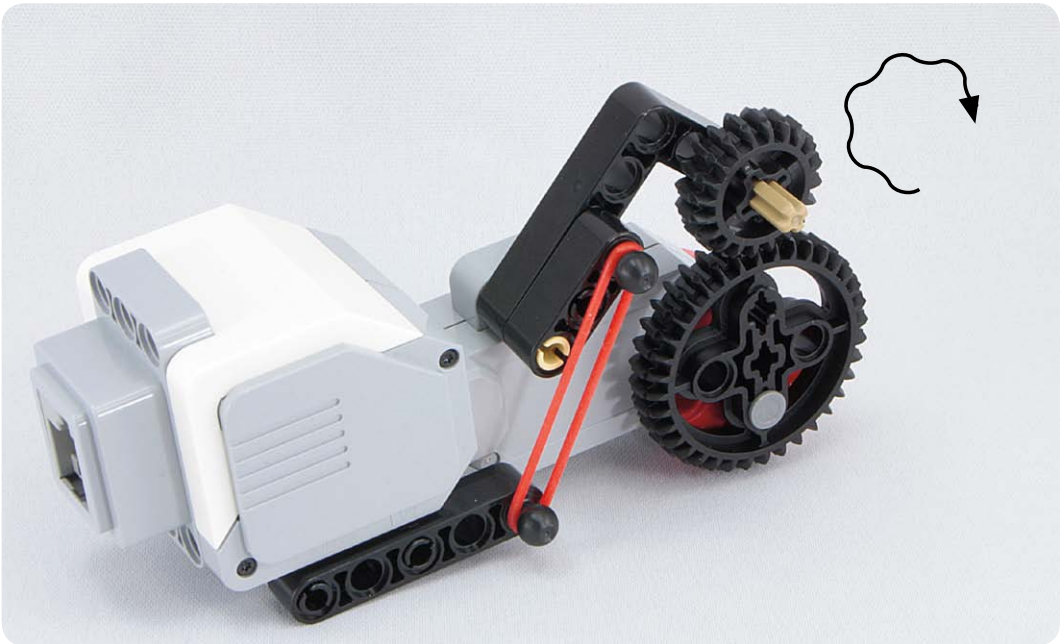


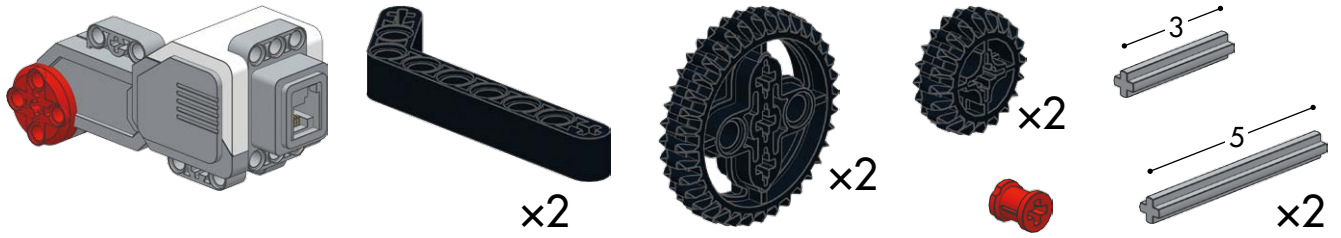


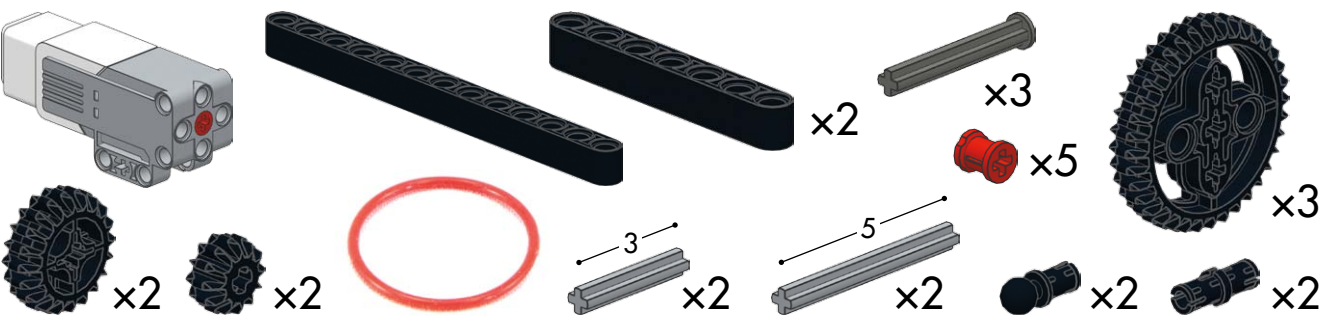
x2

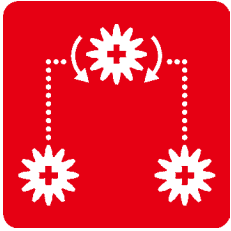


x3



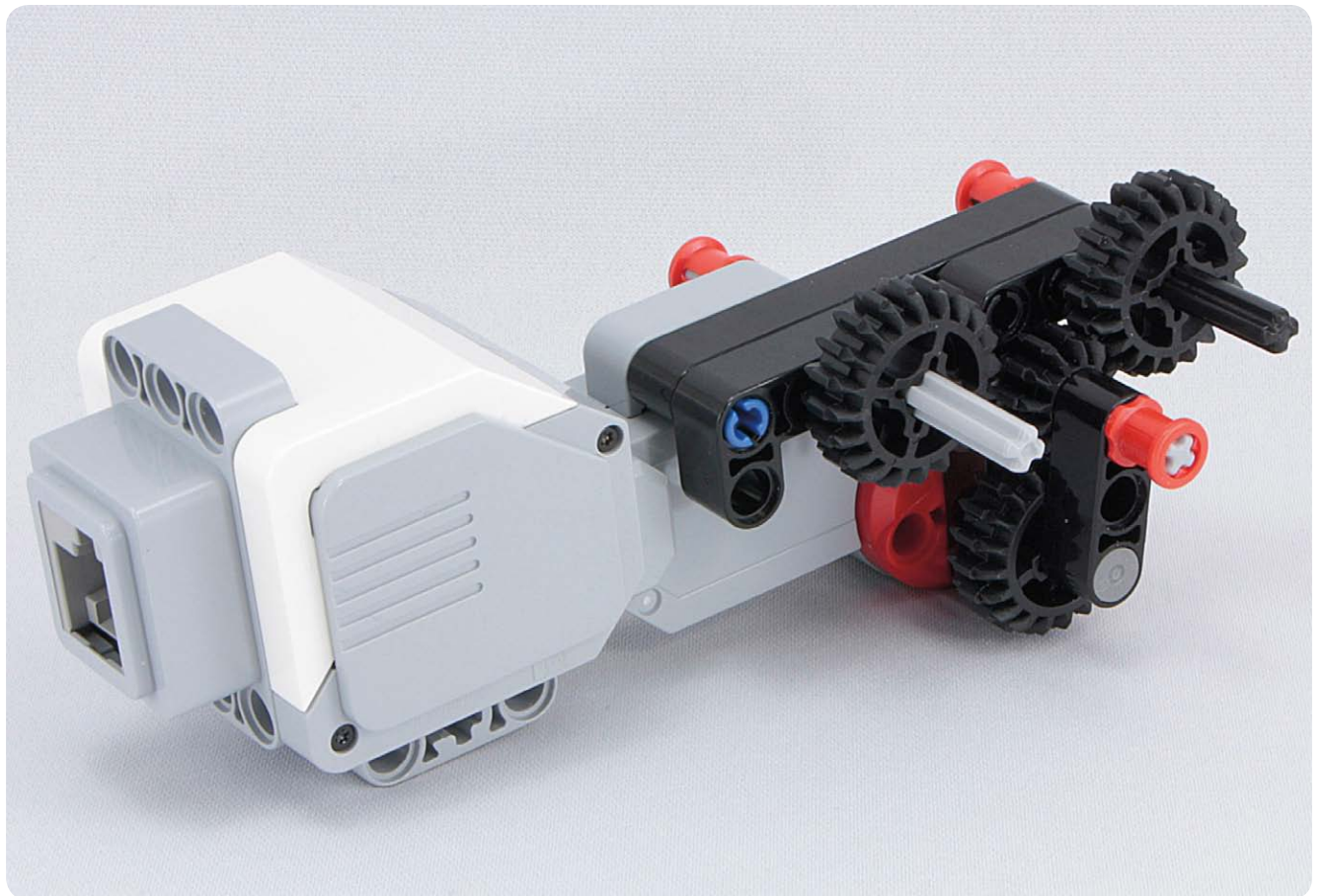
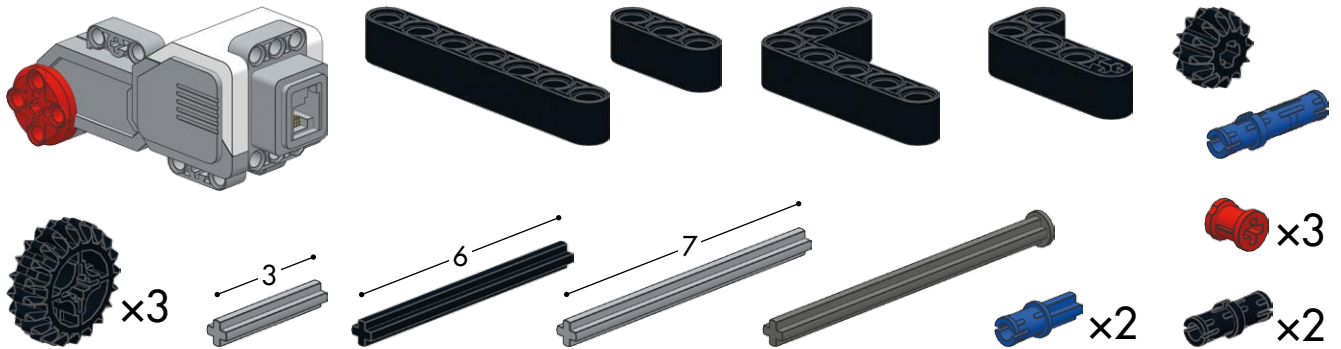


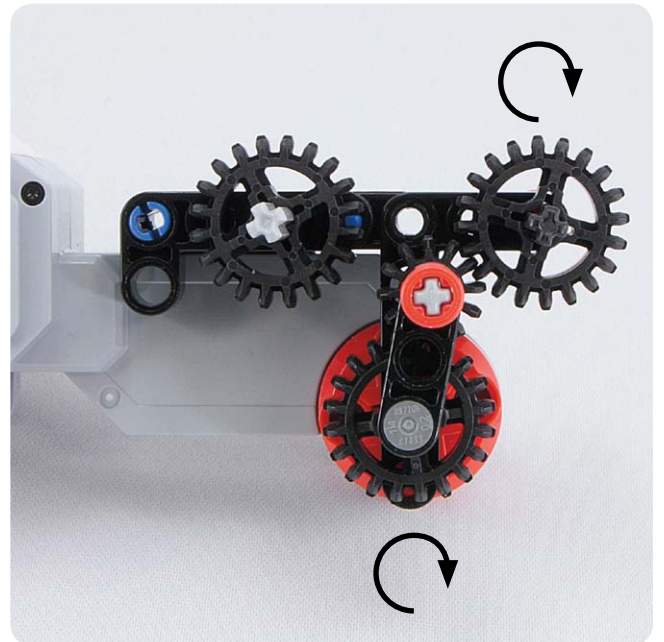


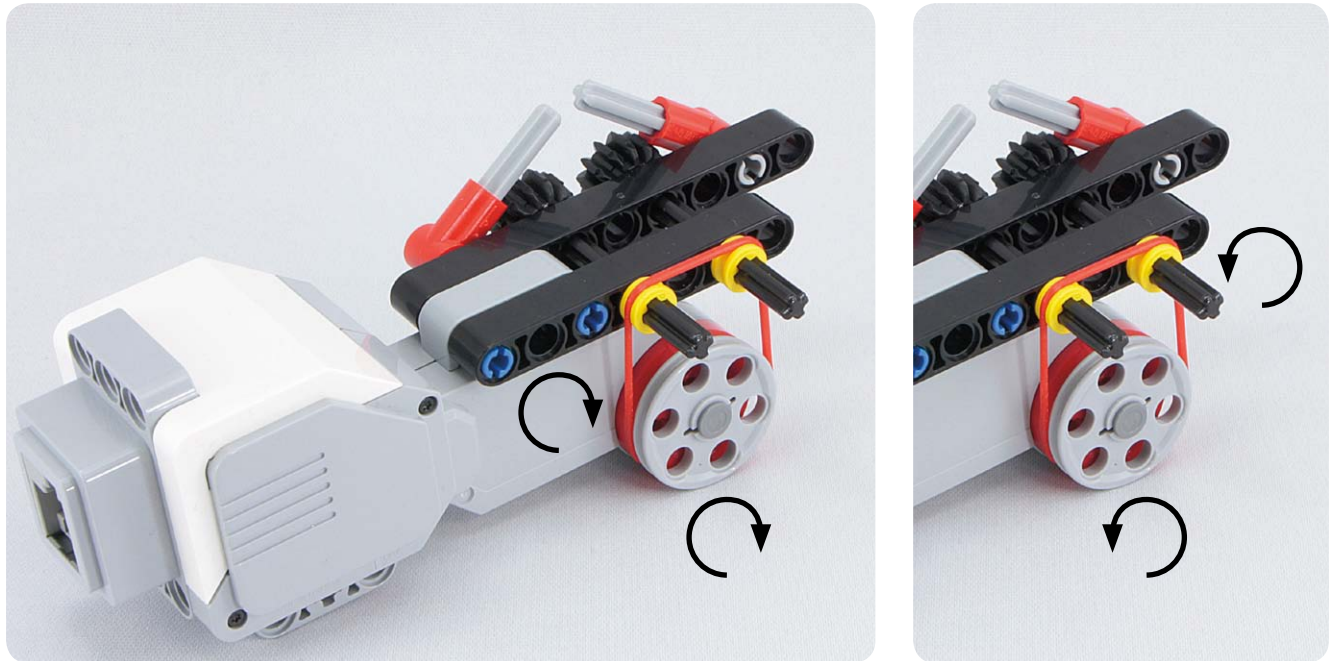


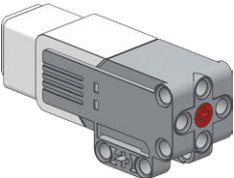
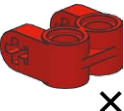
Changeover mechanisms using rotational direction

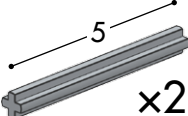
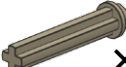
#96

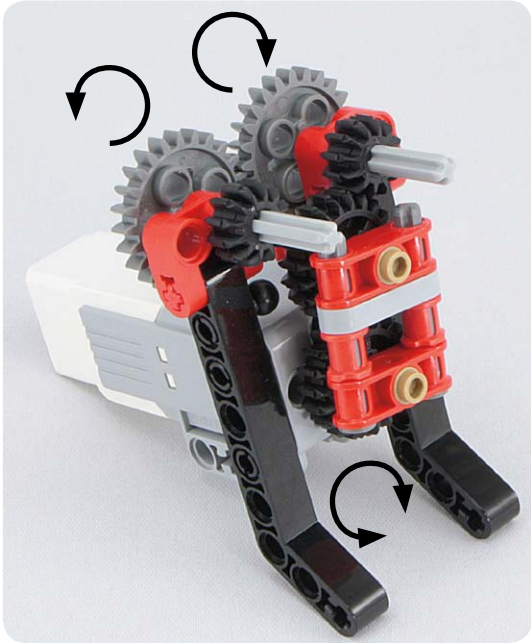


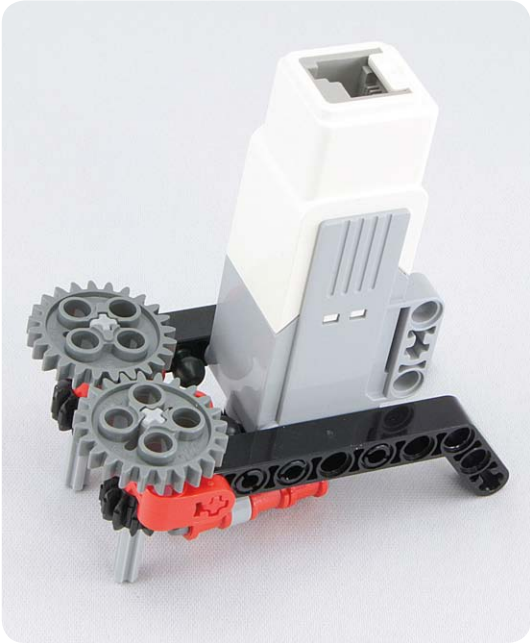




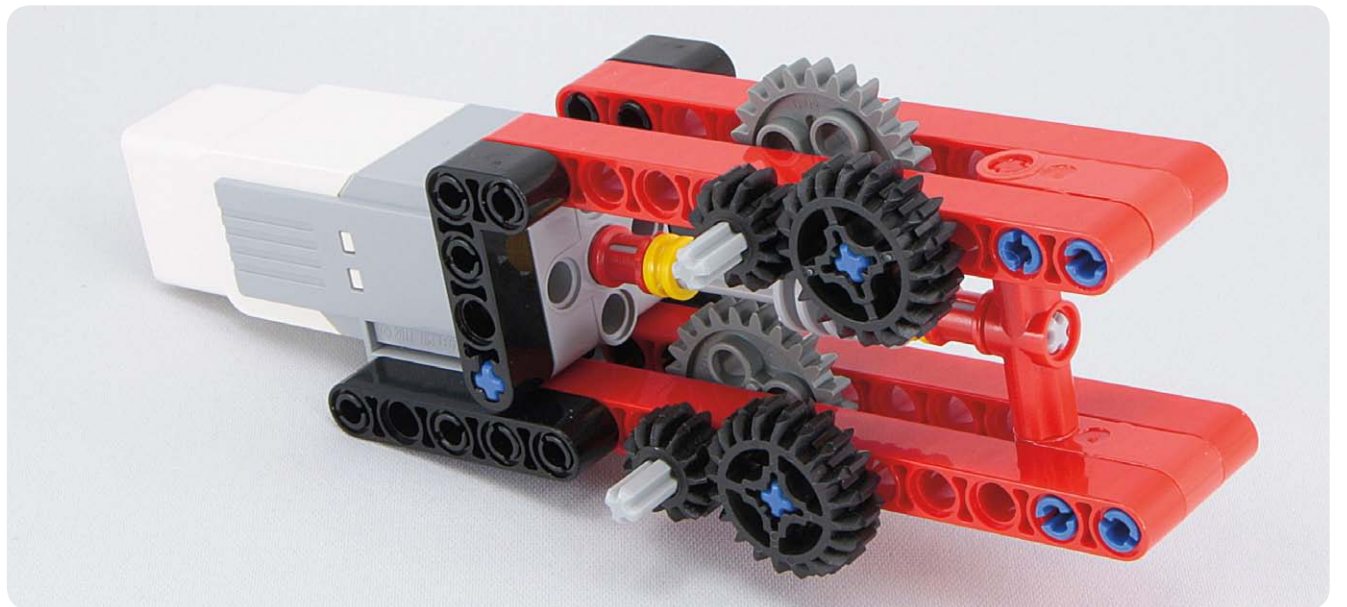
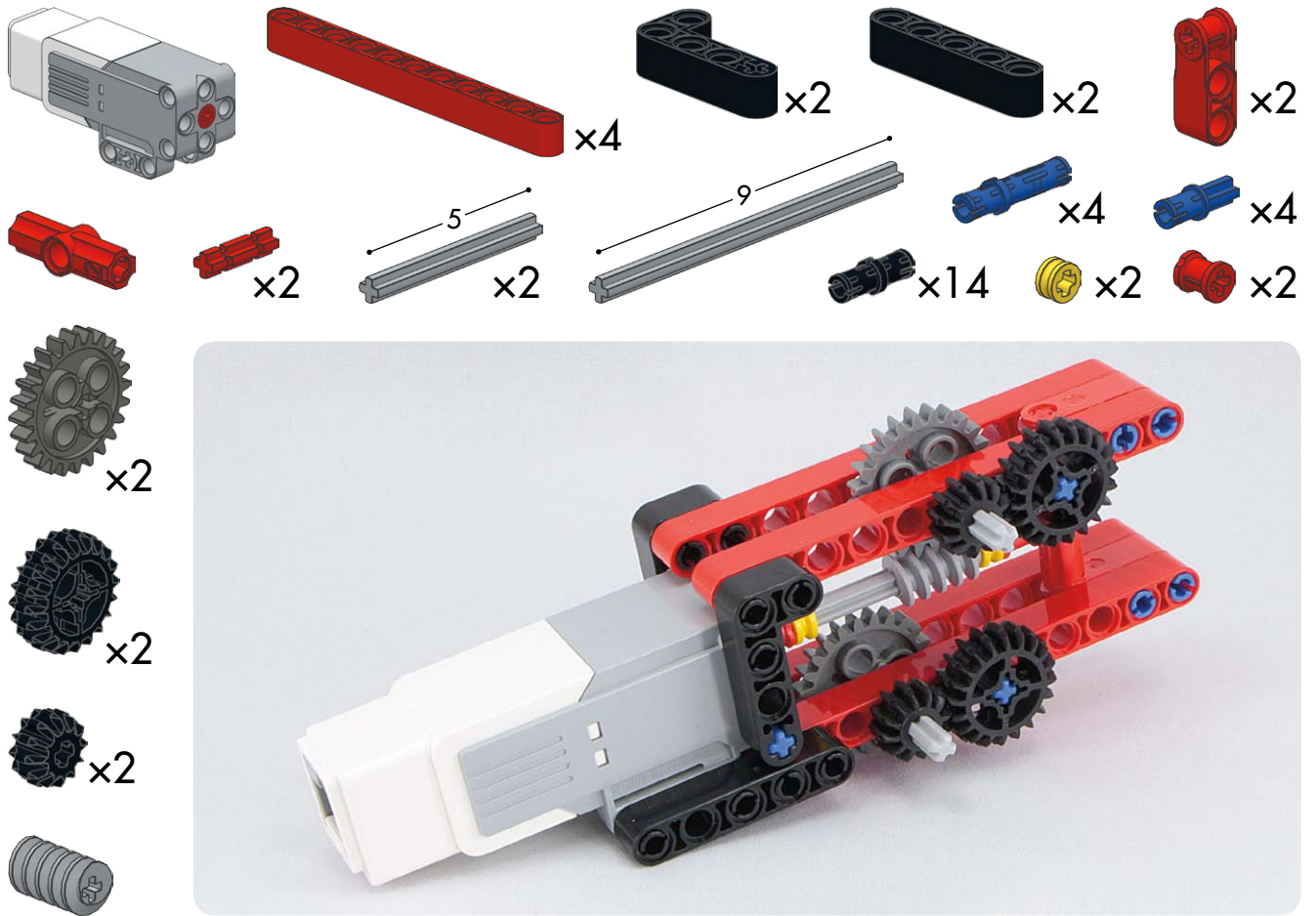
 x2 x2 x2 x2 x2

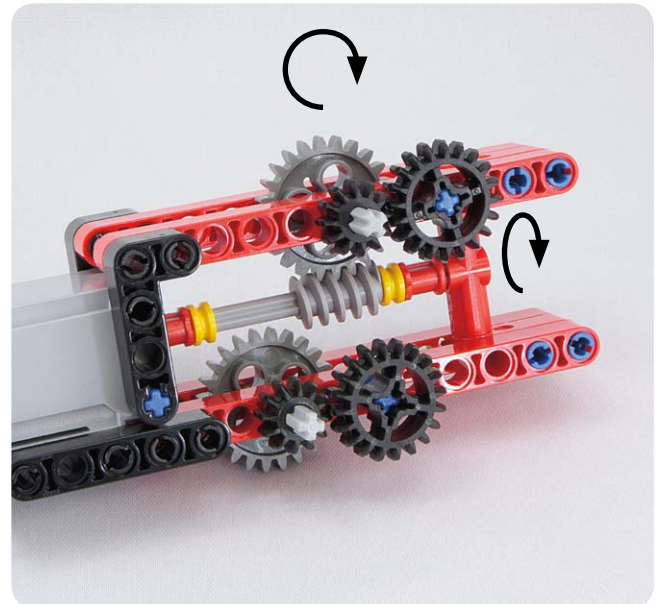
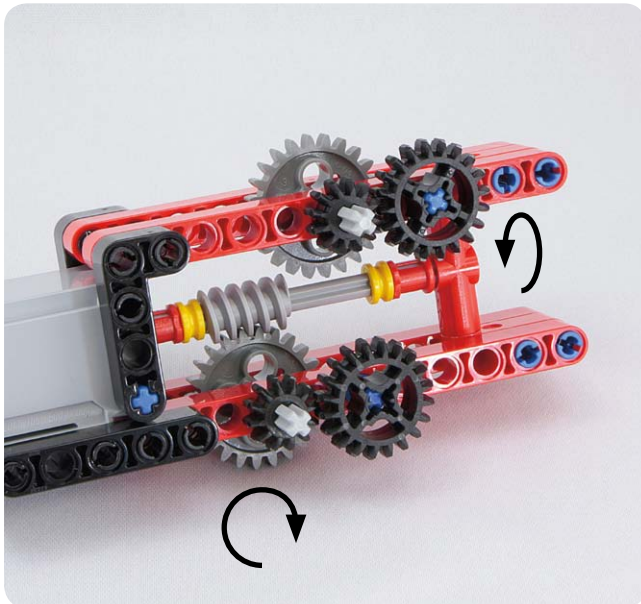
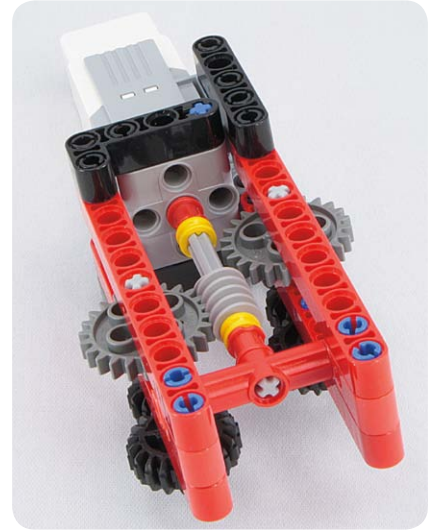
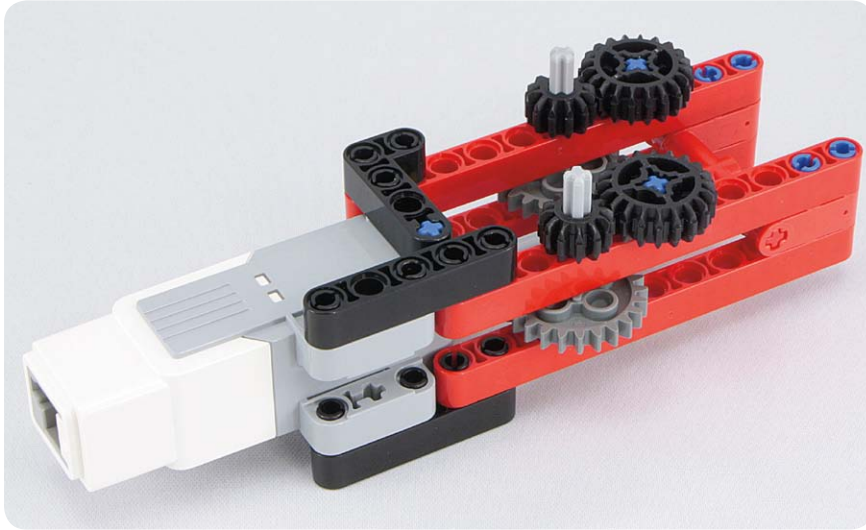
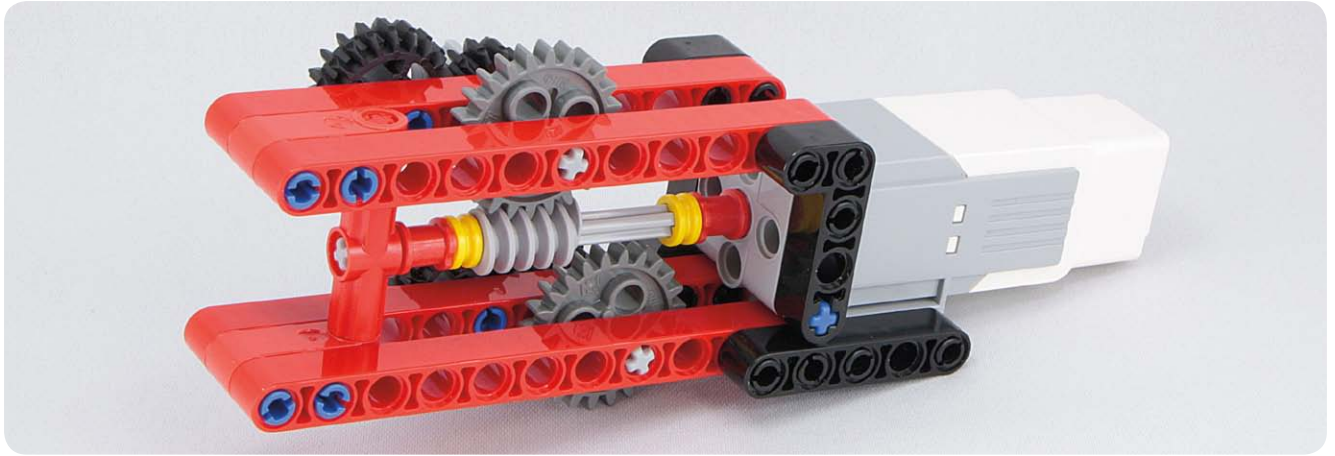
 x2 5 x2 x2 x2 x2 x4 x3











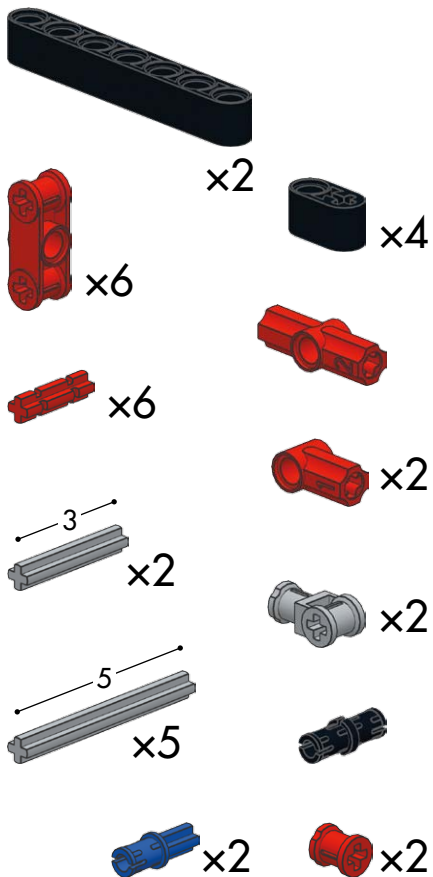


Parts list for step 10:

- 1 x 3 Black Technic Beam
- 2 x 1 Red Technic Pin
- 2 x 1 Red Technic Pin
- 1 x 3 Red Technic Beam
- 1 x 3 Red Technic Beam
- 4 x 1 Red Technic Pin
- 1 x 3 Yellow Technic Beam
- 1 x 3 Black Technic Beam
- 1 x 3 Black Technic Beam
- 2 x 1 Red Technic Pin



#101





PART 2



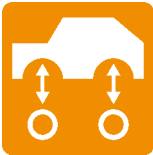
Vehicles



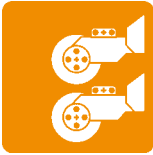
78



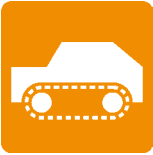
90



100



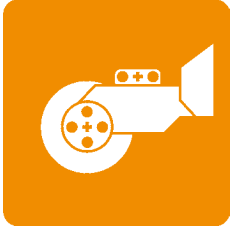
82



94

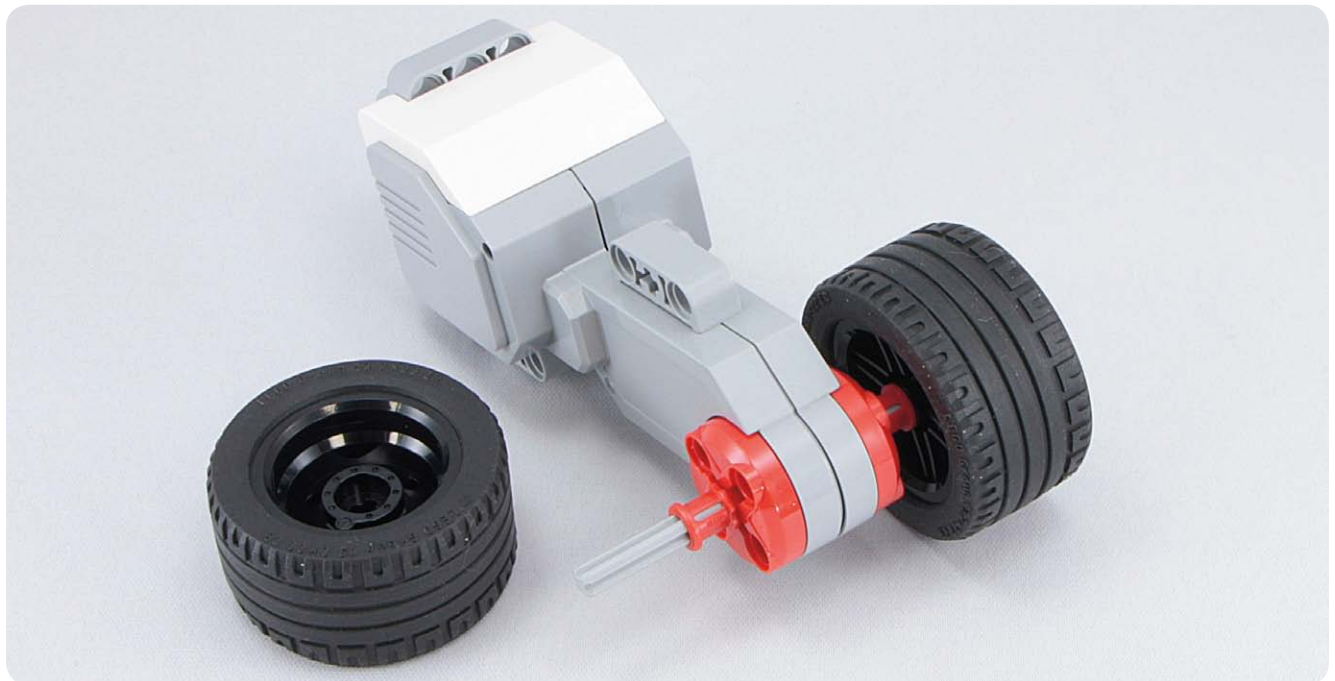
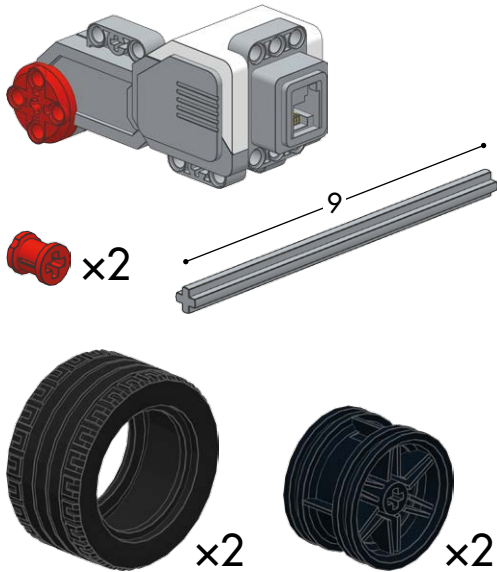


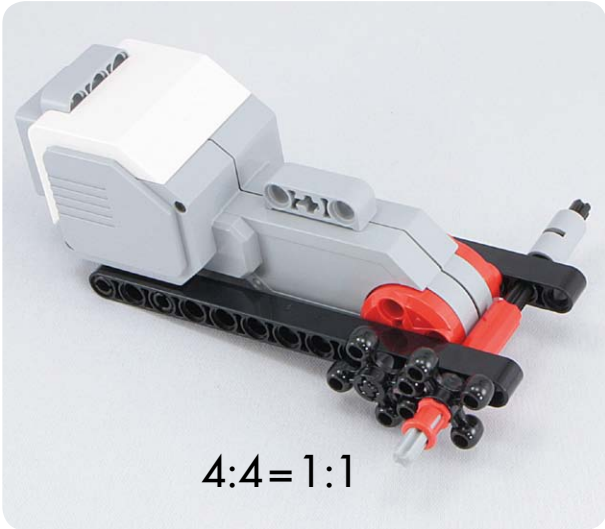
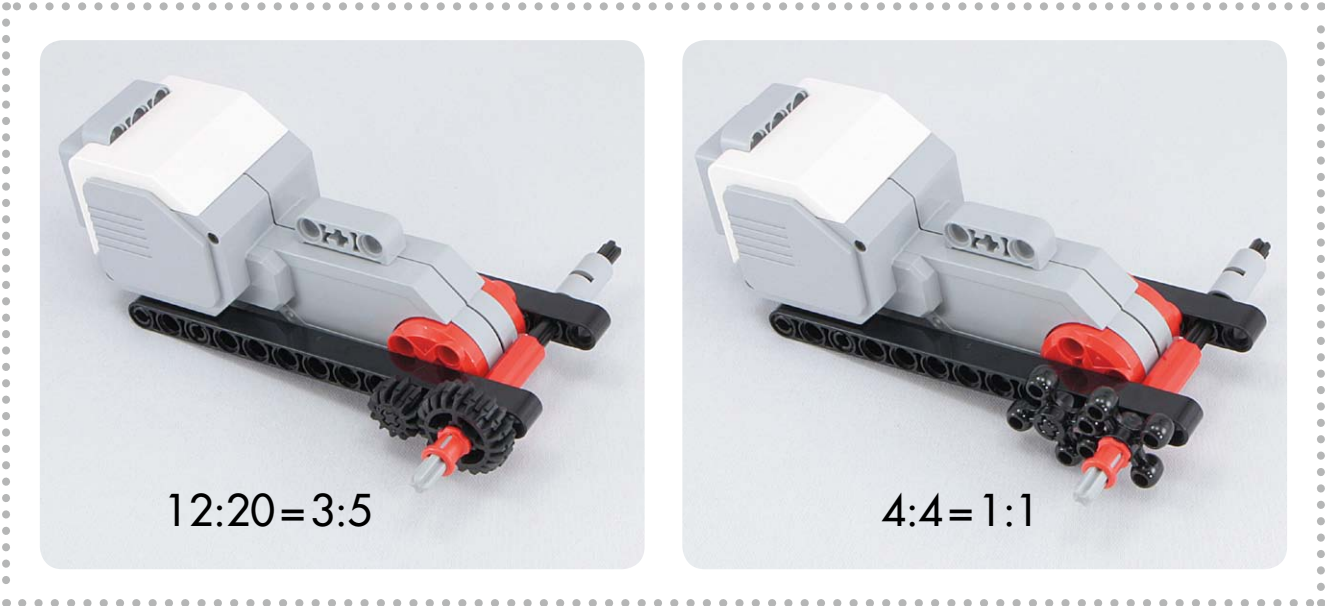
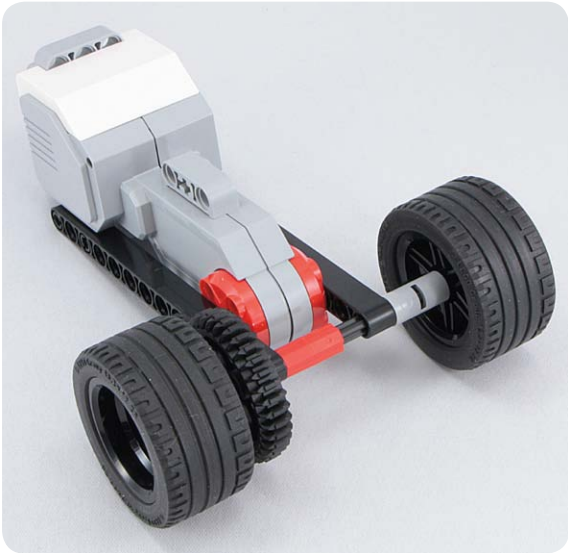
104

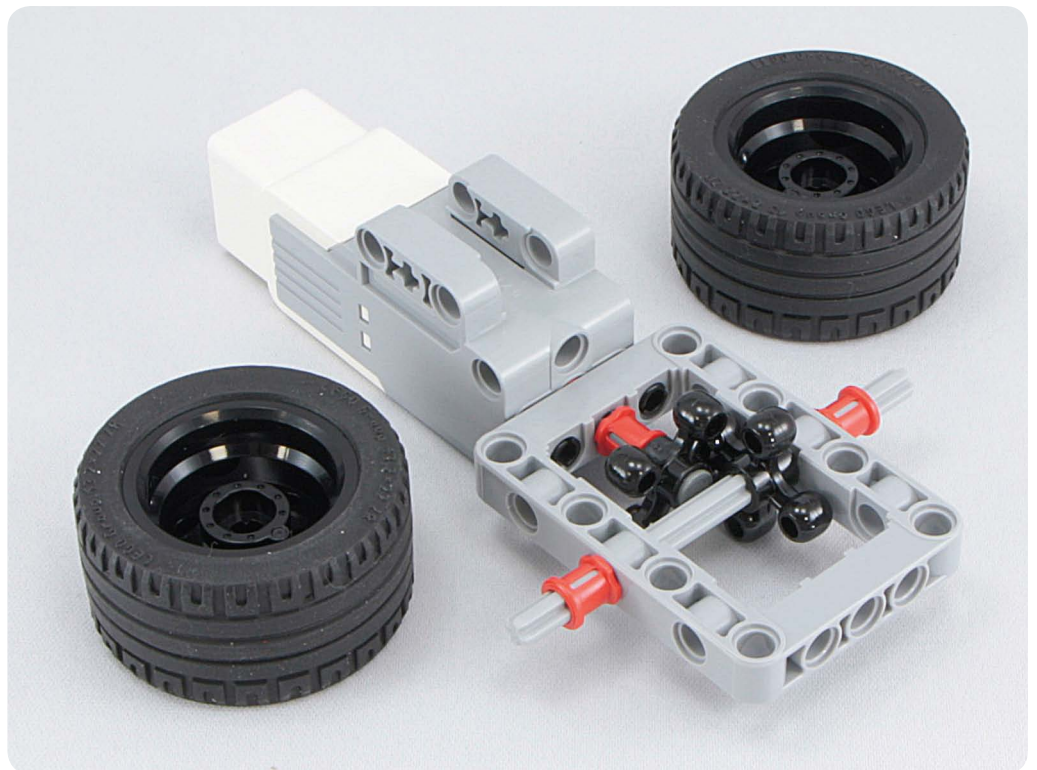
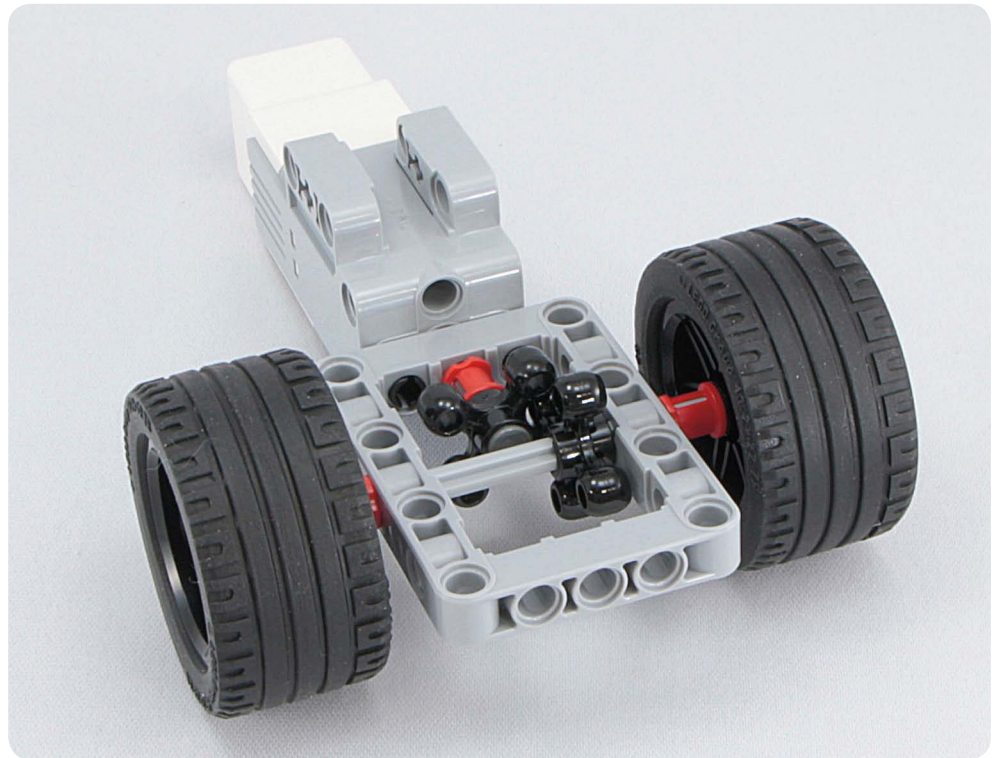
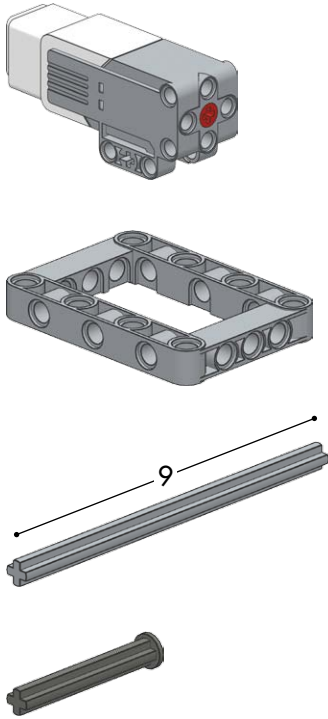


Driving wheels with a motor

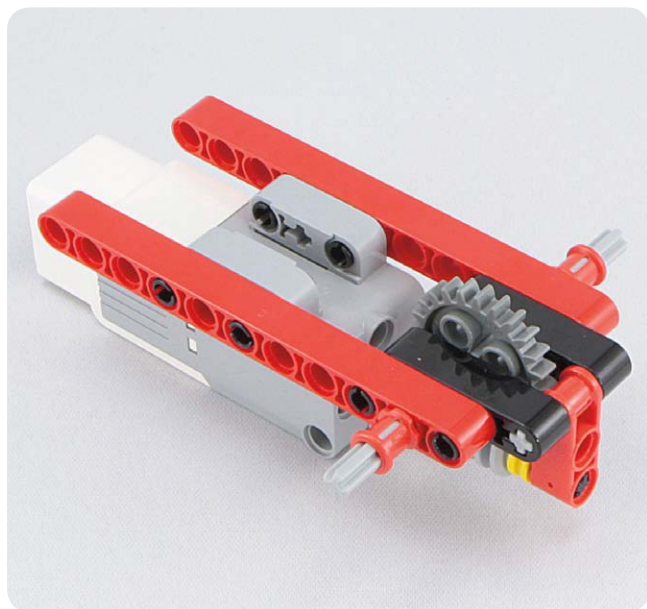
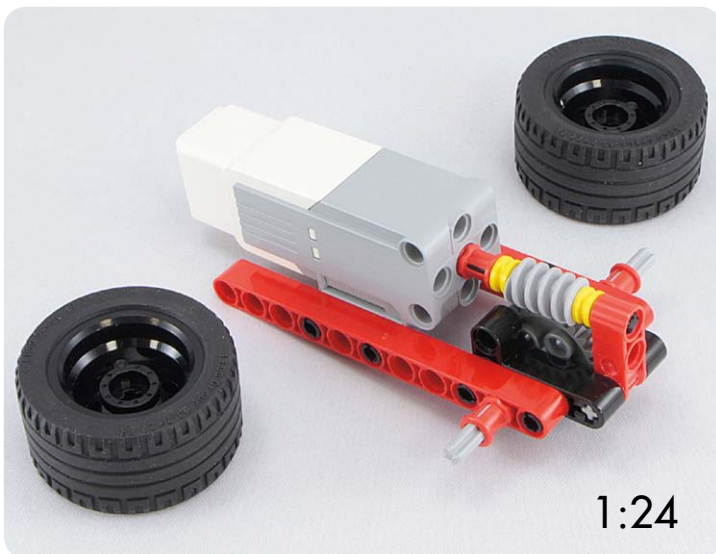
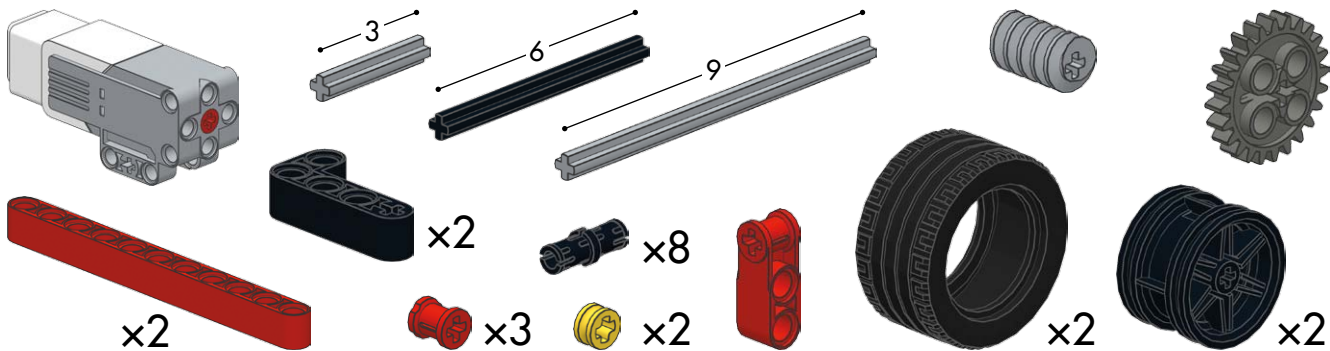
#102

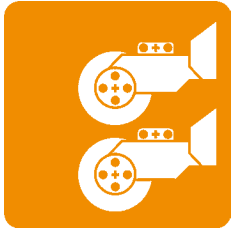






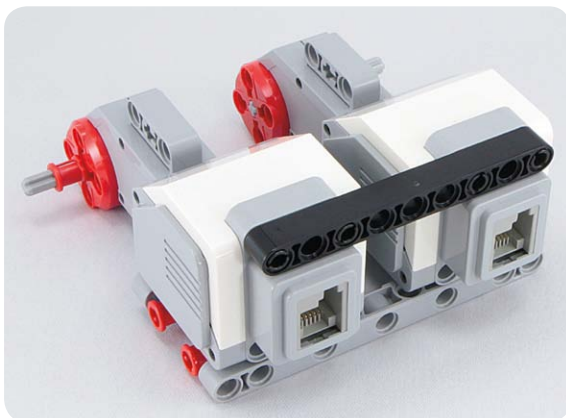
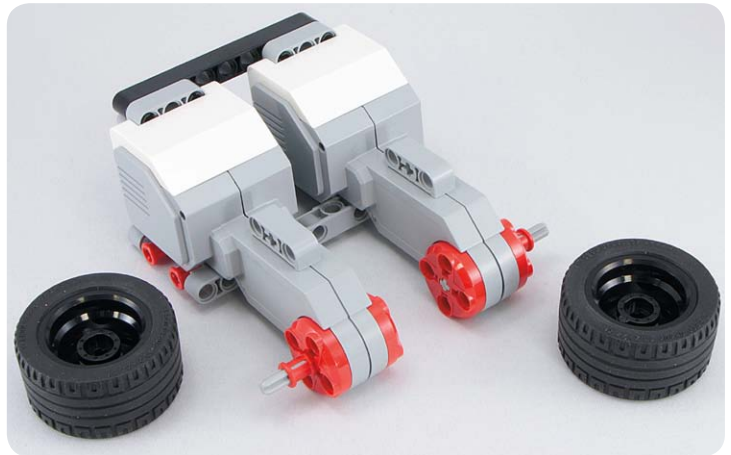
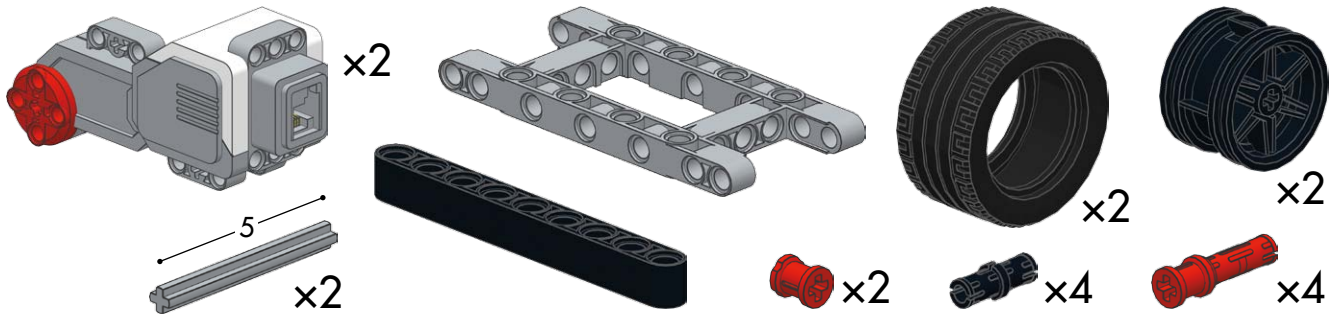
#105

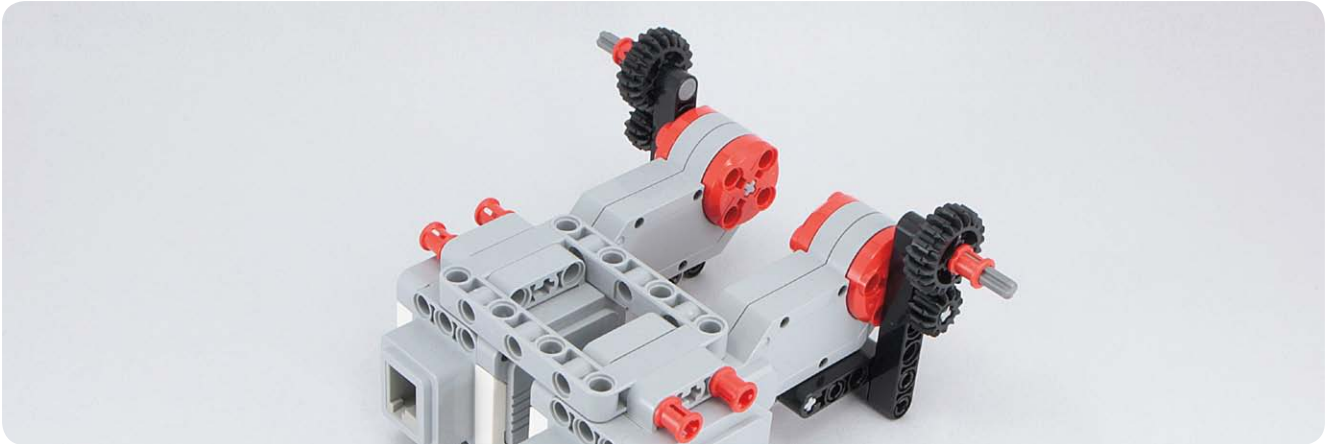
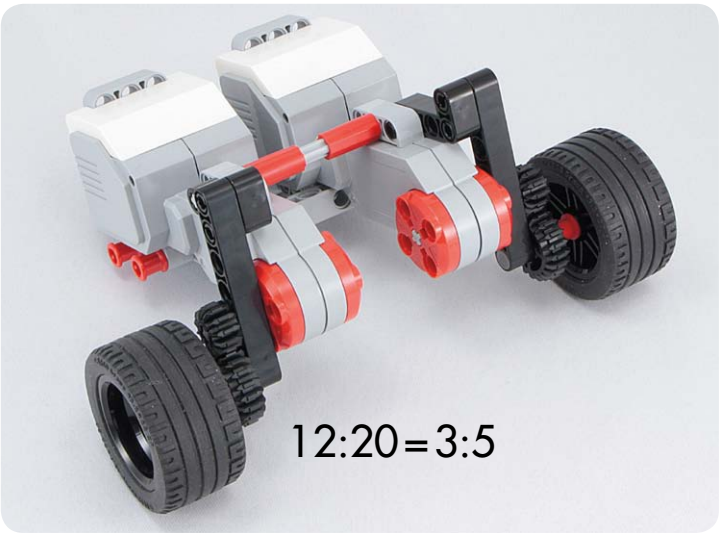


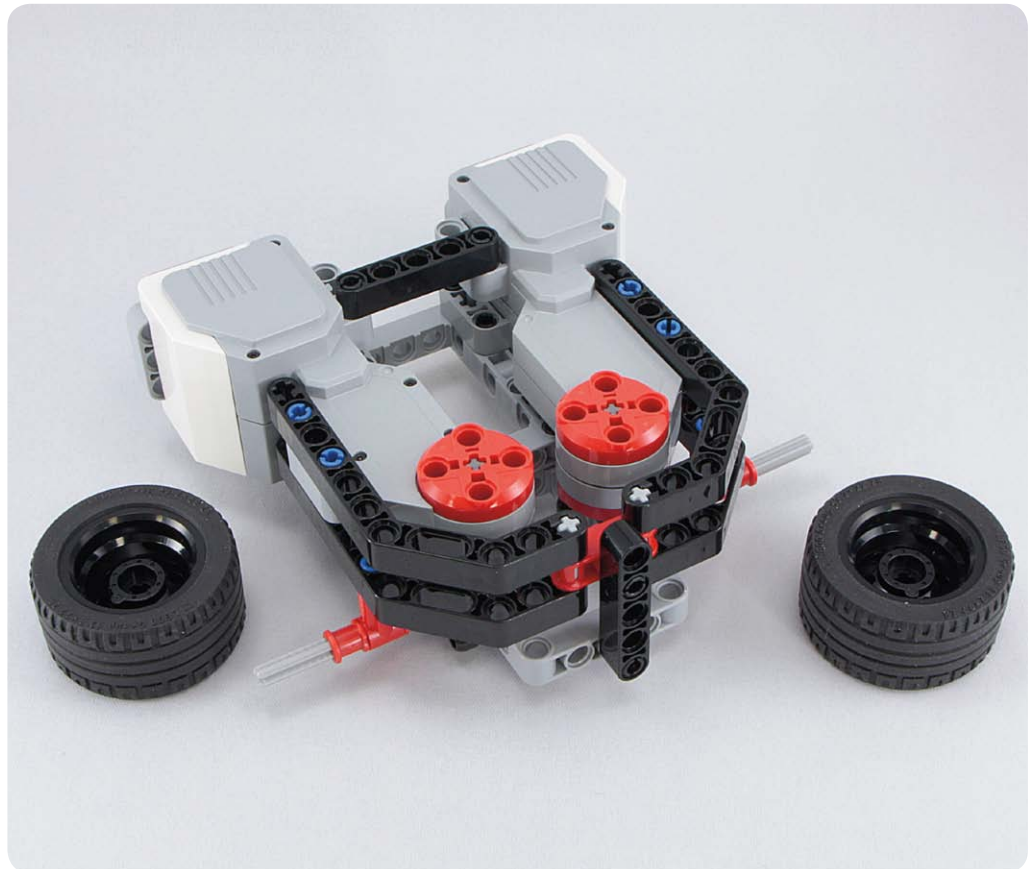
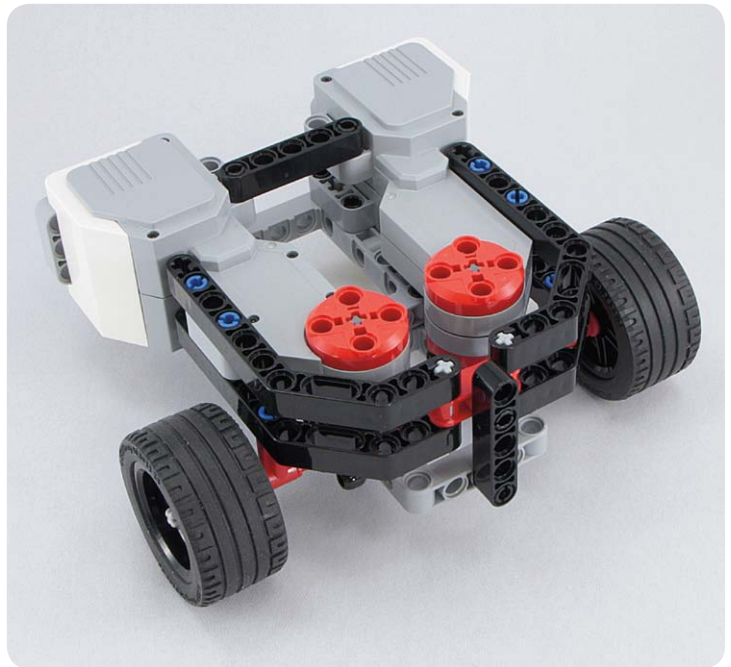


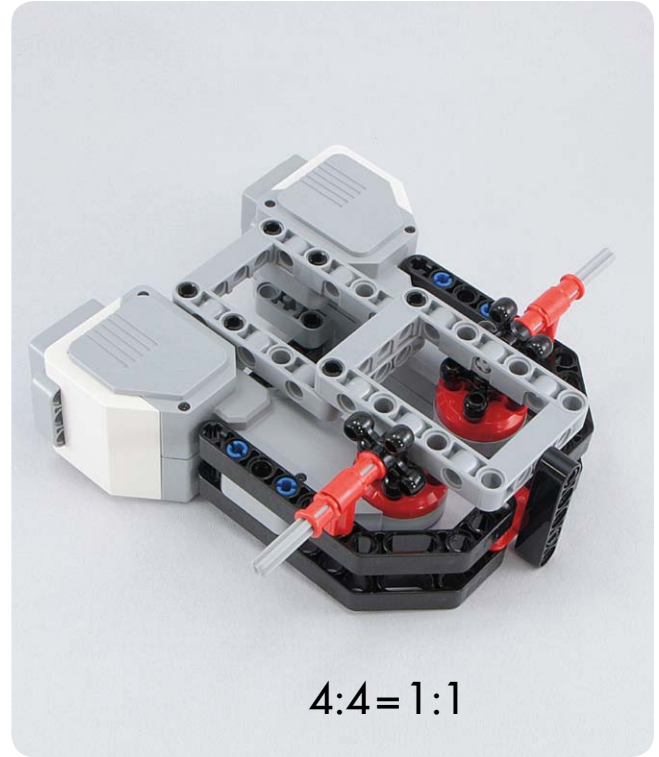
Driving wheels with two motors

#106

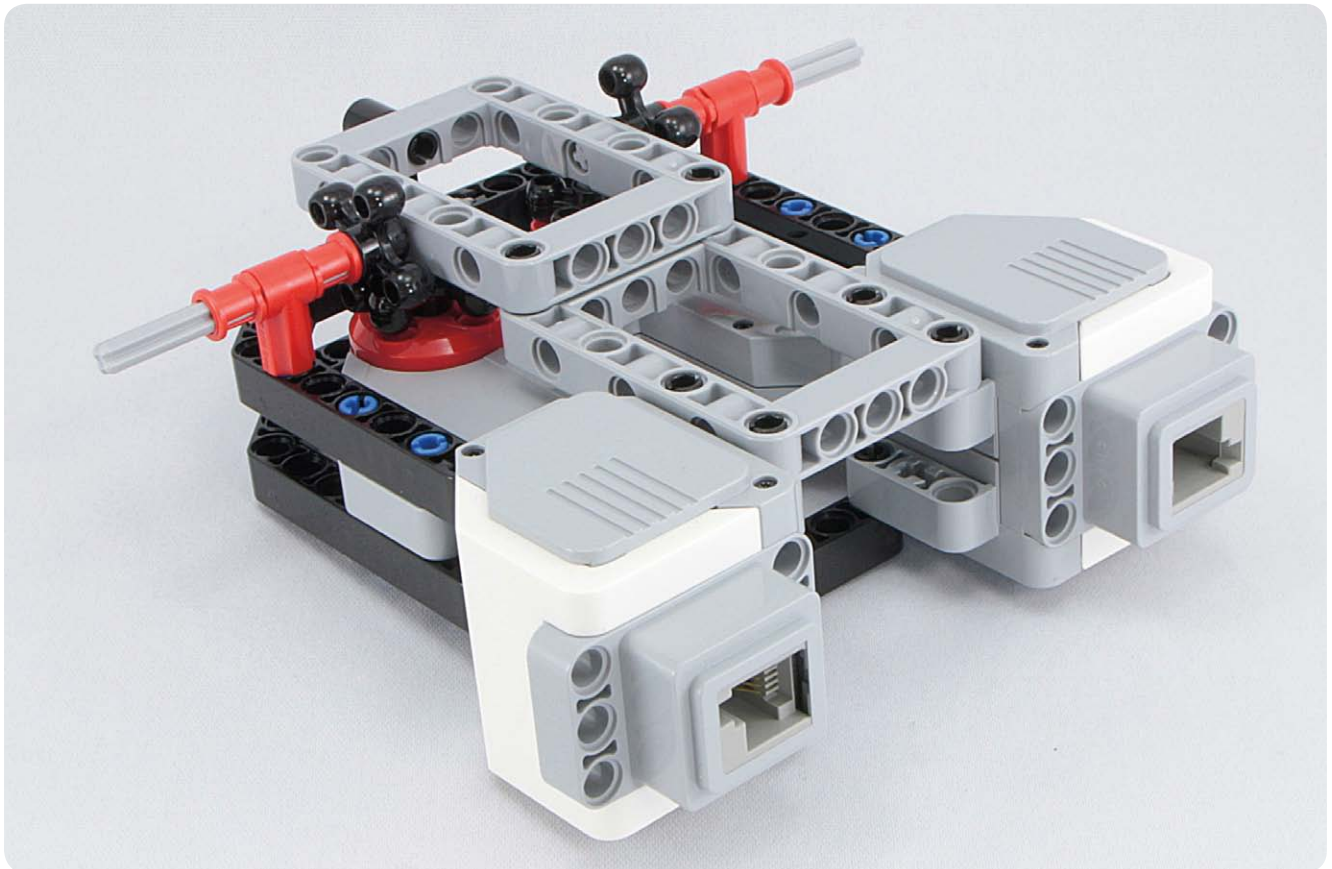


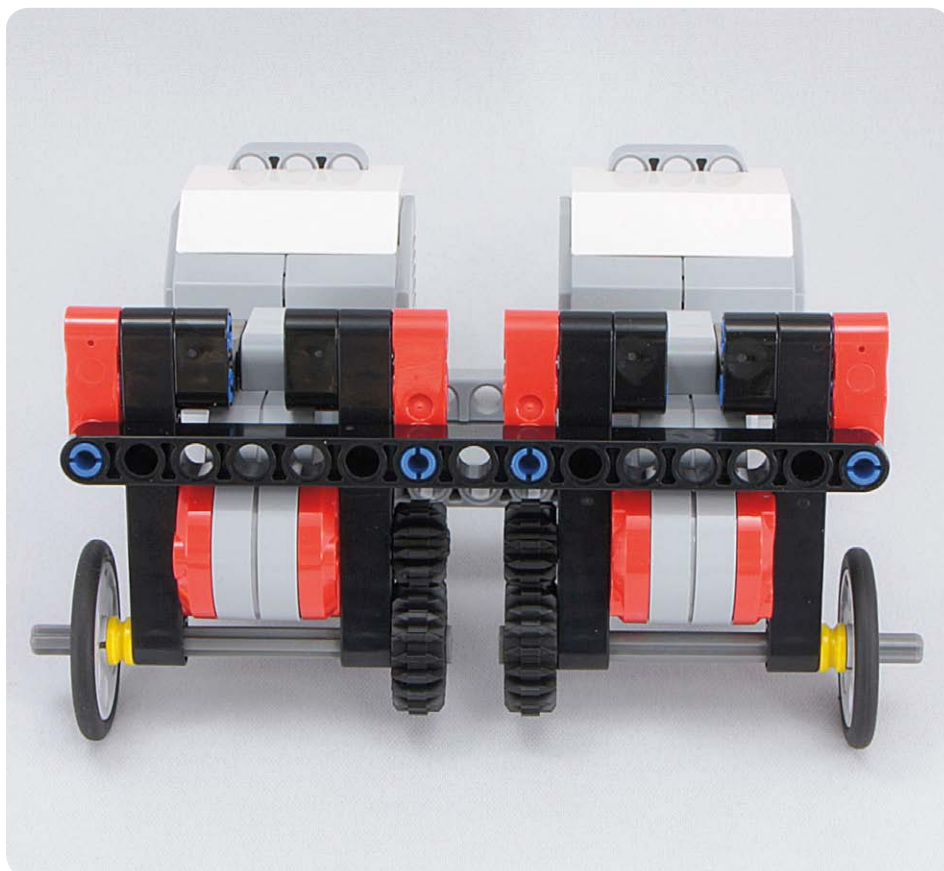
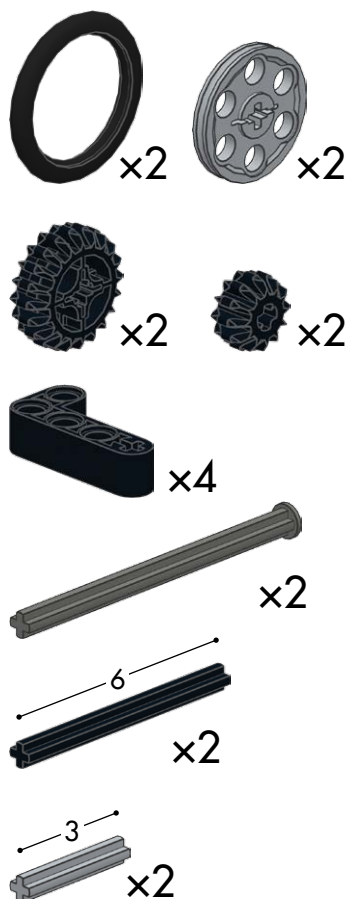
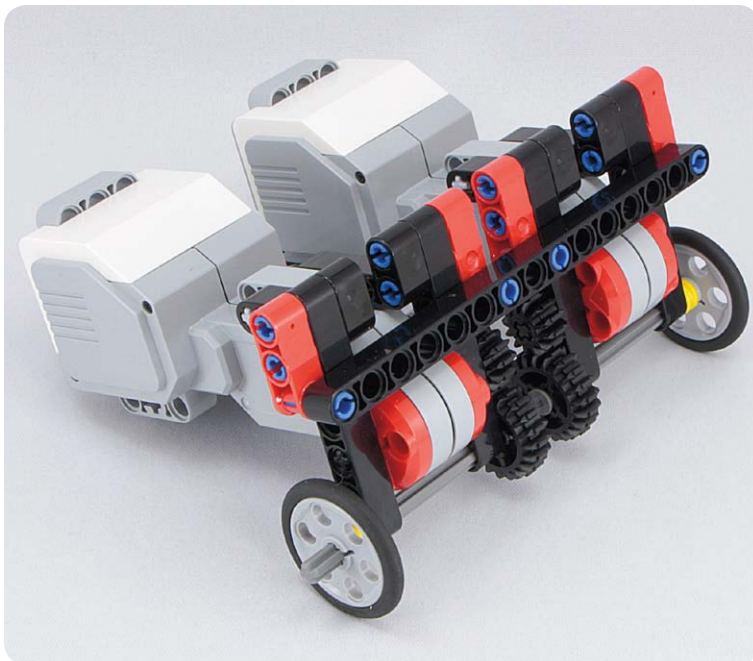
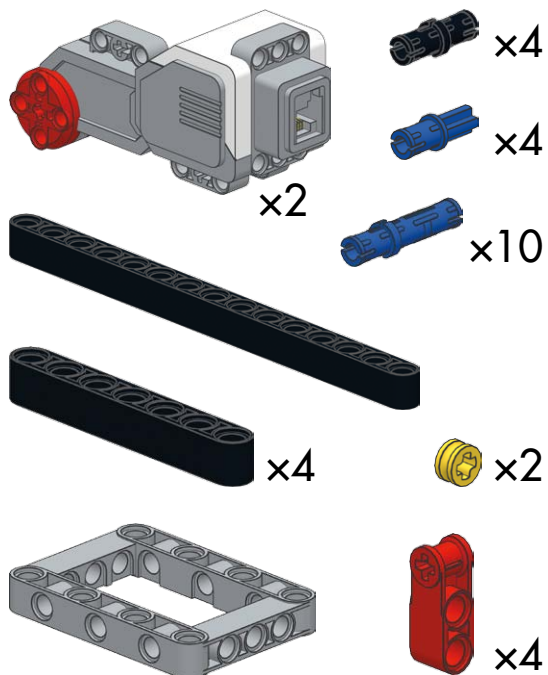


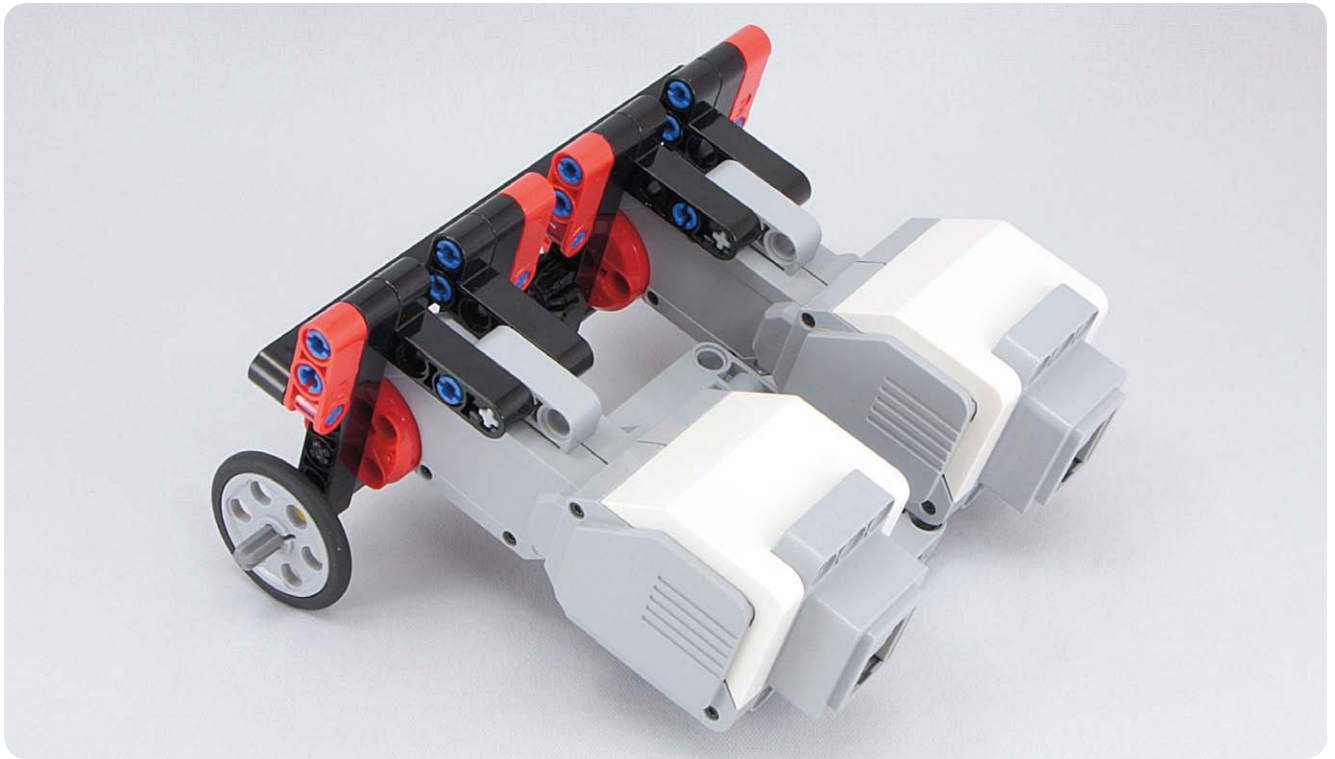


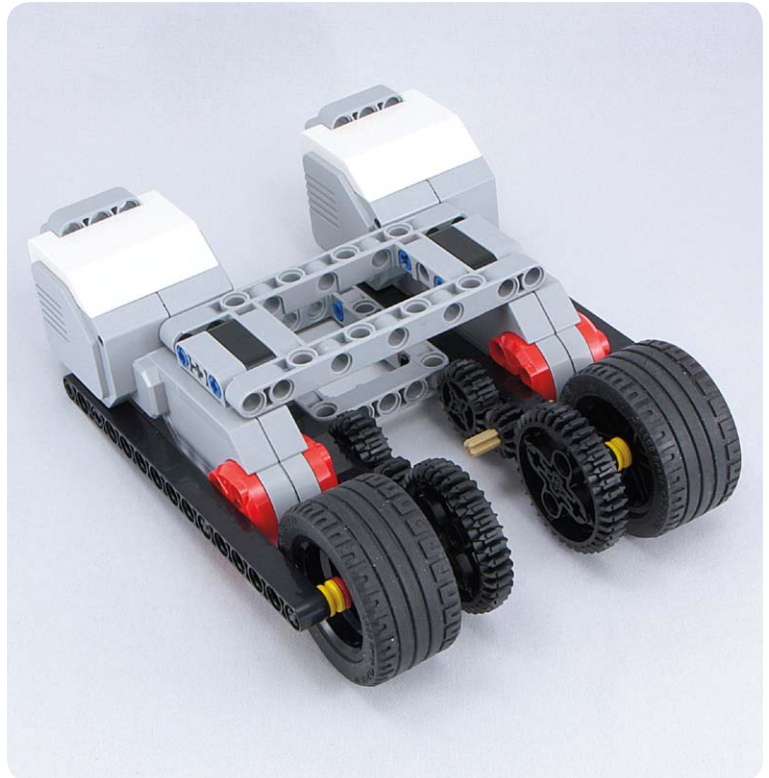
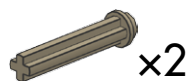
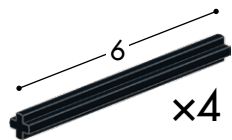
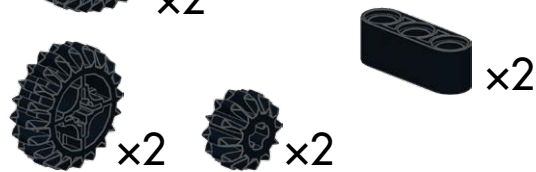
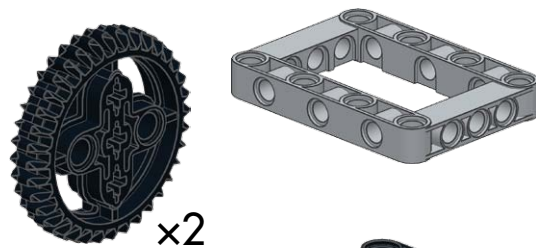
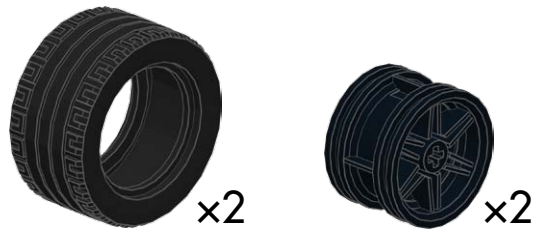
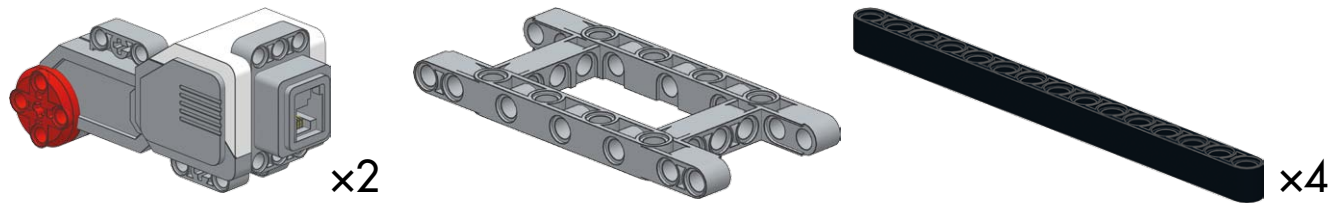


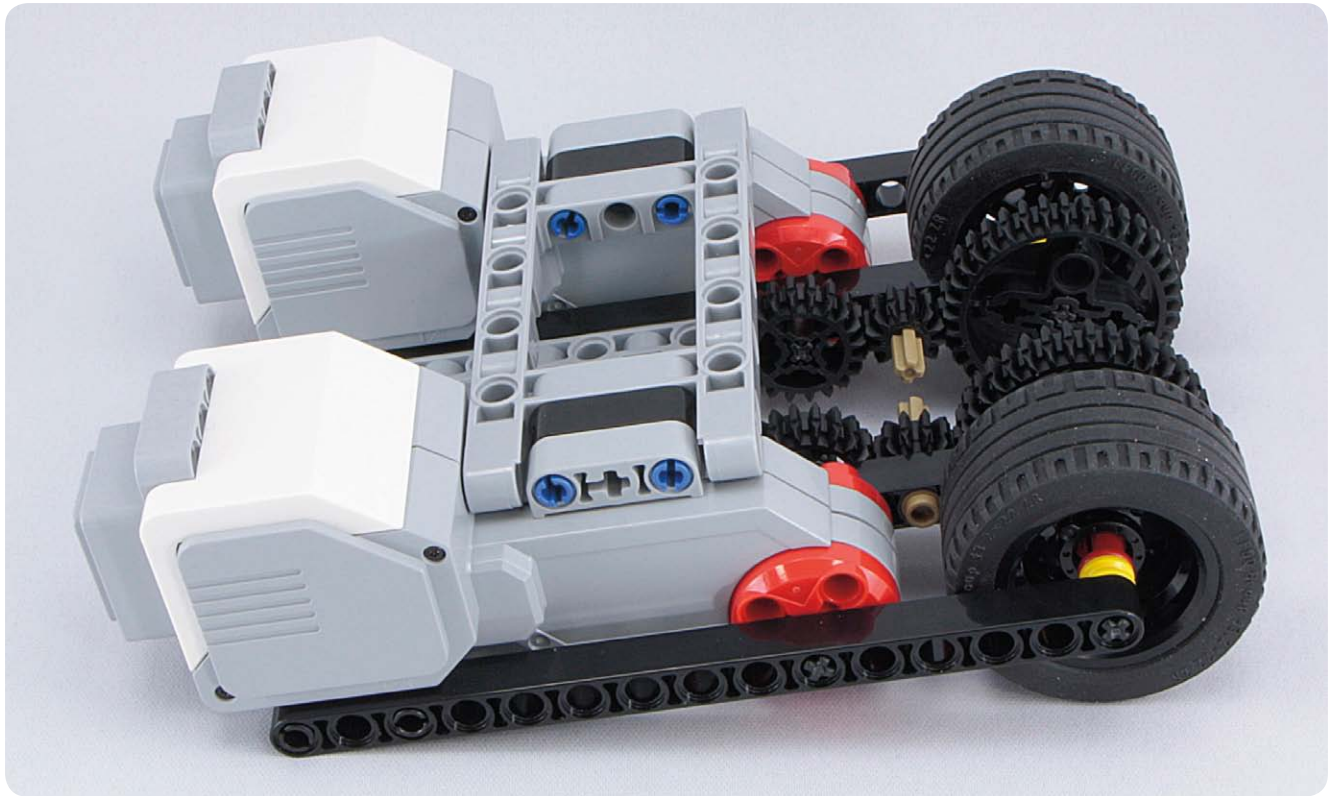
4:4 = 1:1











$$20:36=5:9$$

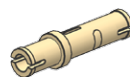
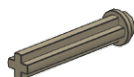


Caster wheels

#111



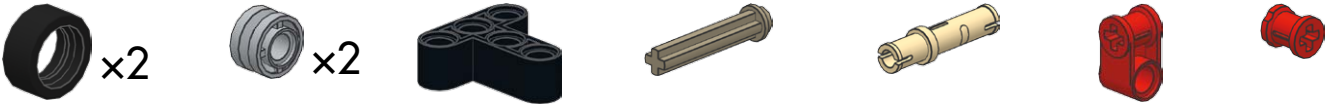
x3

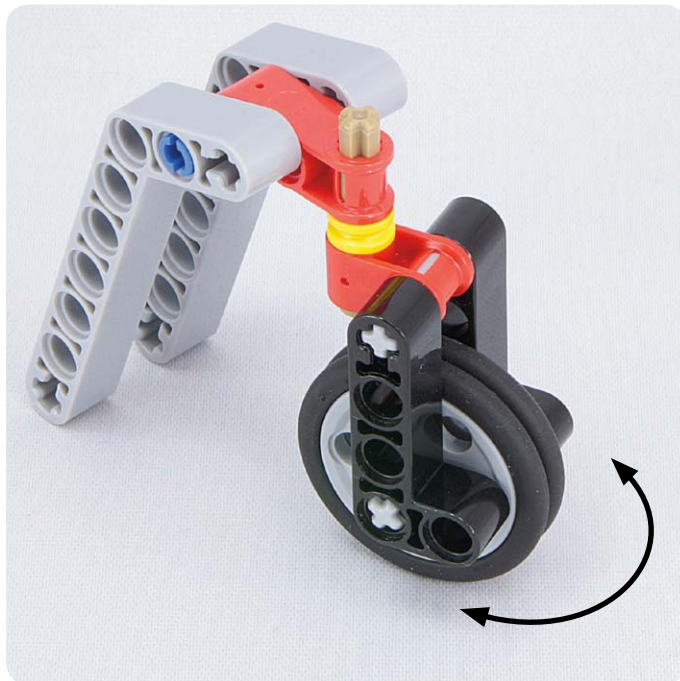
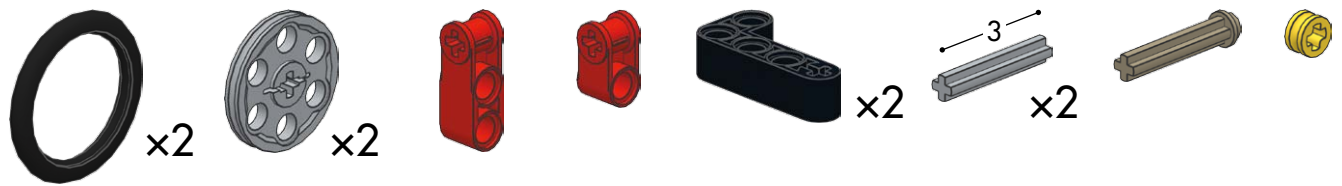


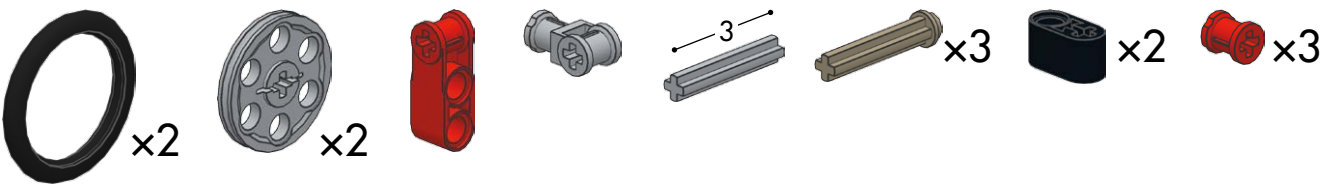
x2

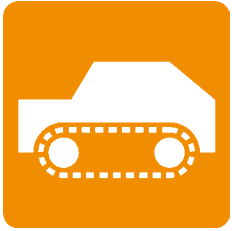


#112



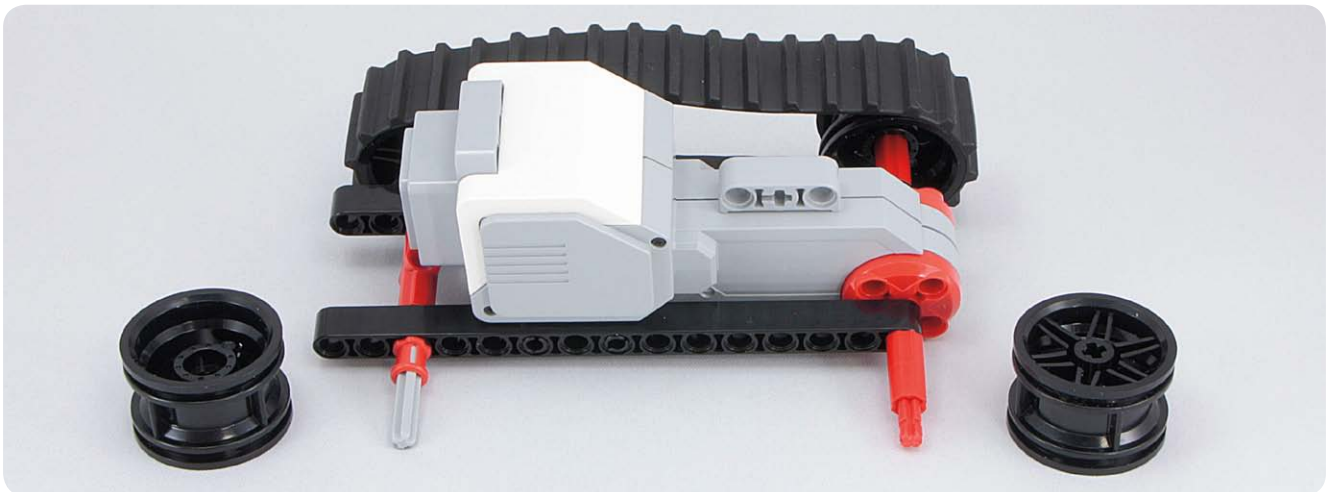
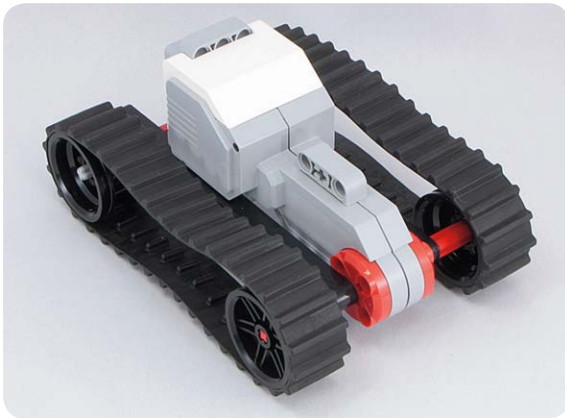
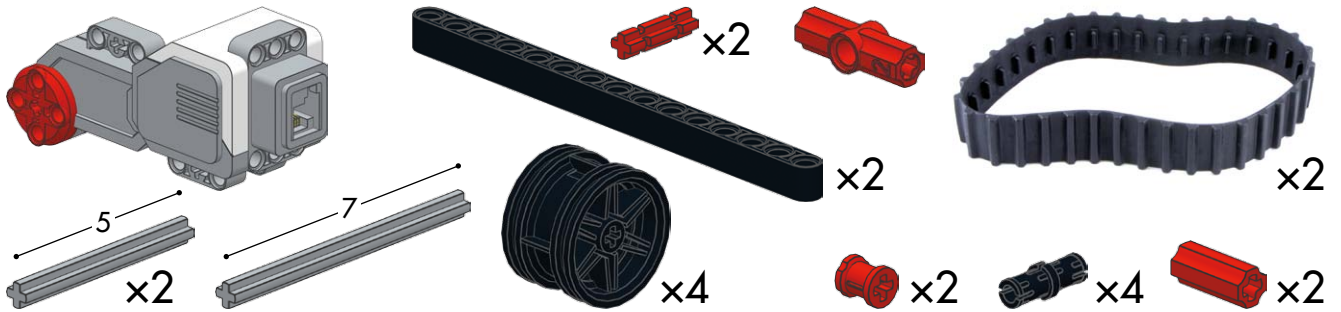


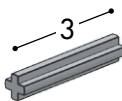
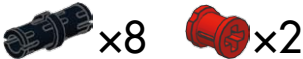
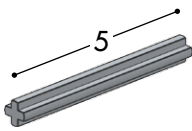
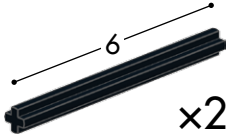
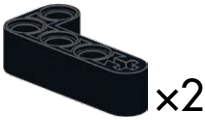
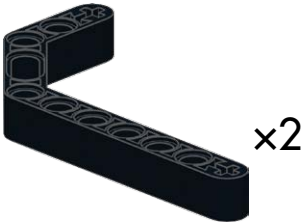
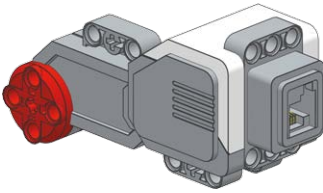




Crawlers

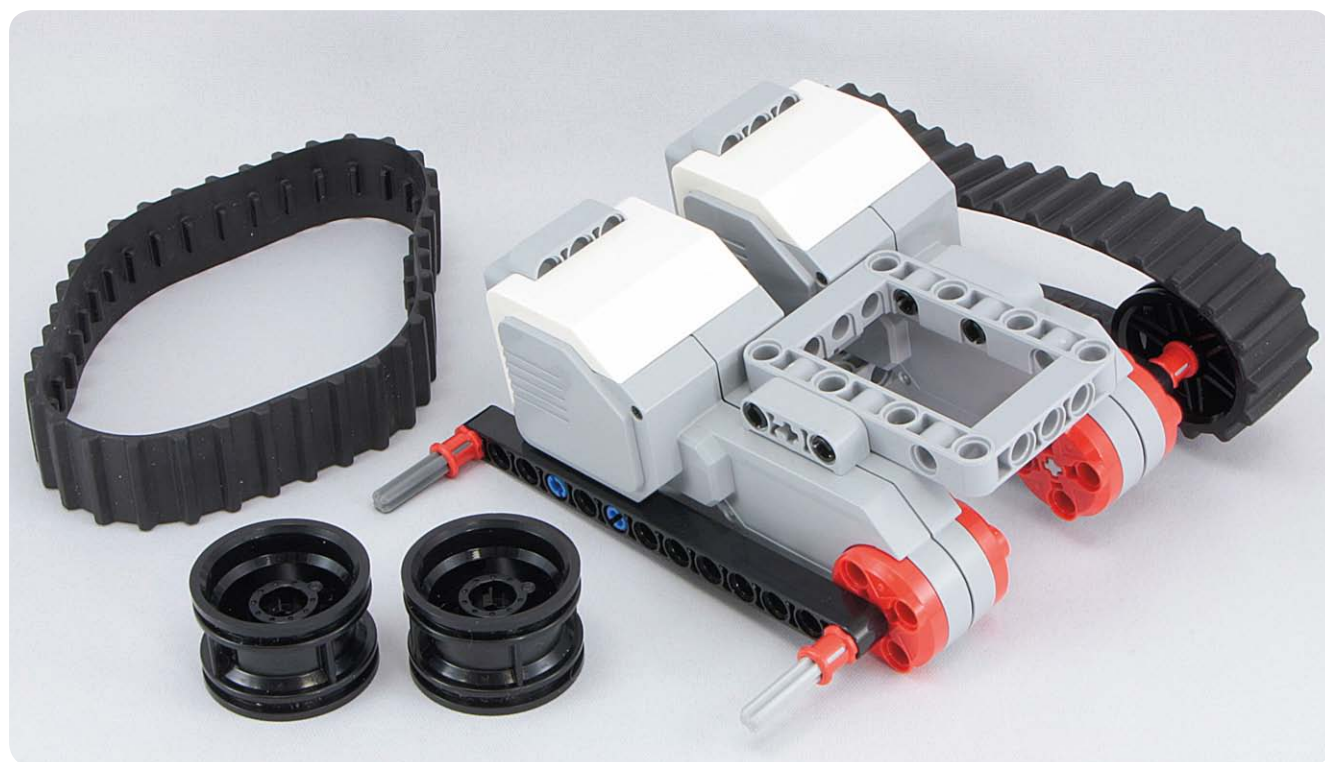
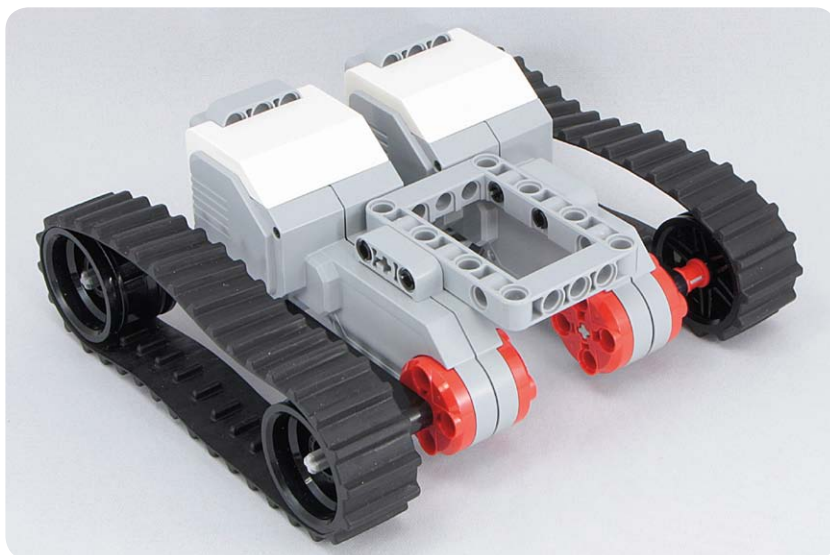
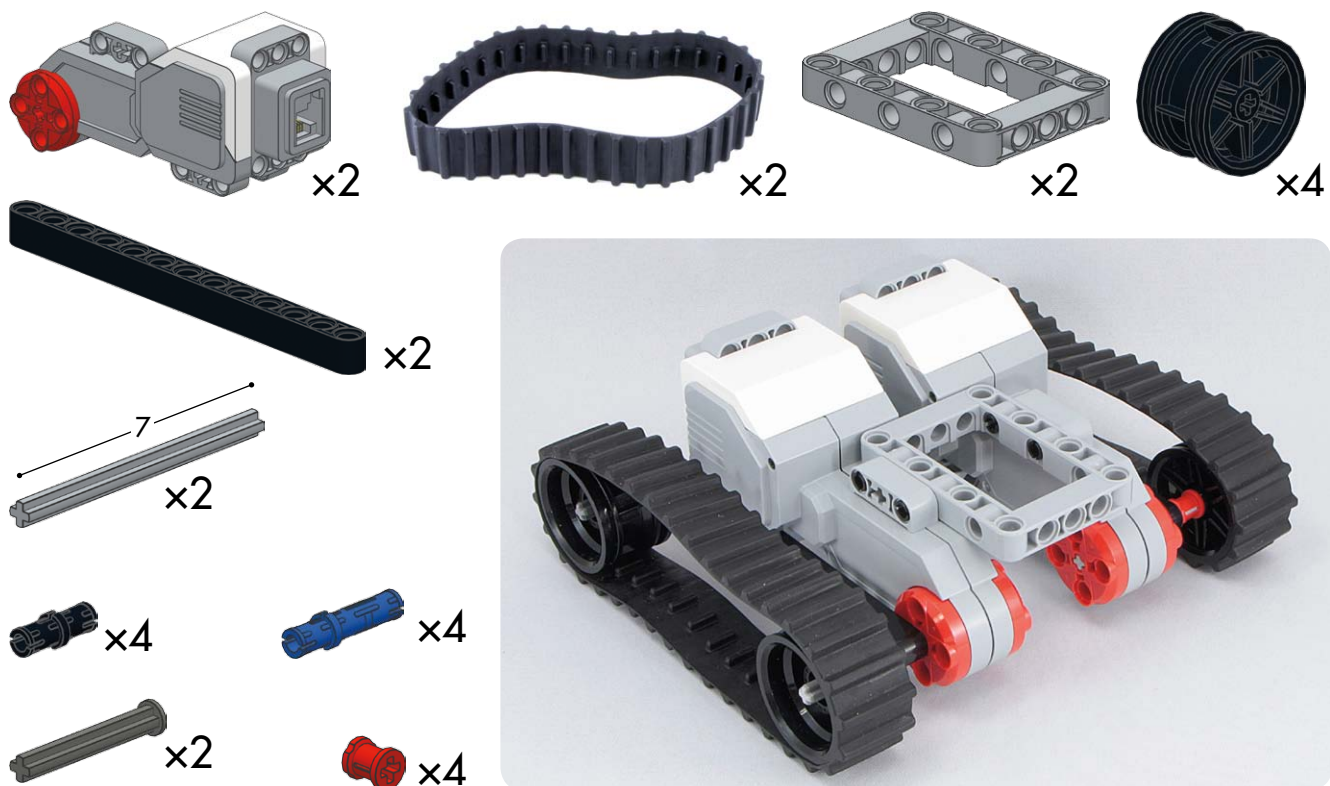
#115

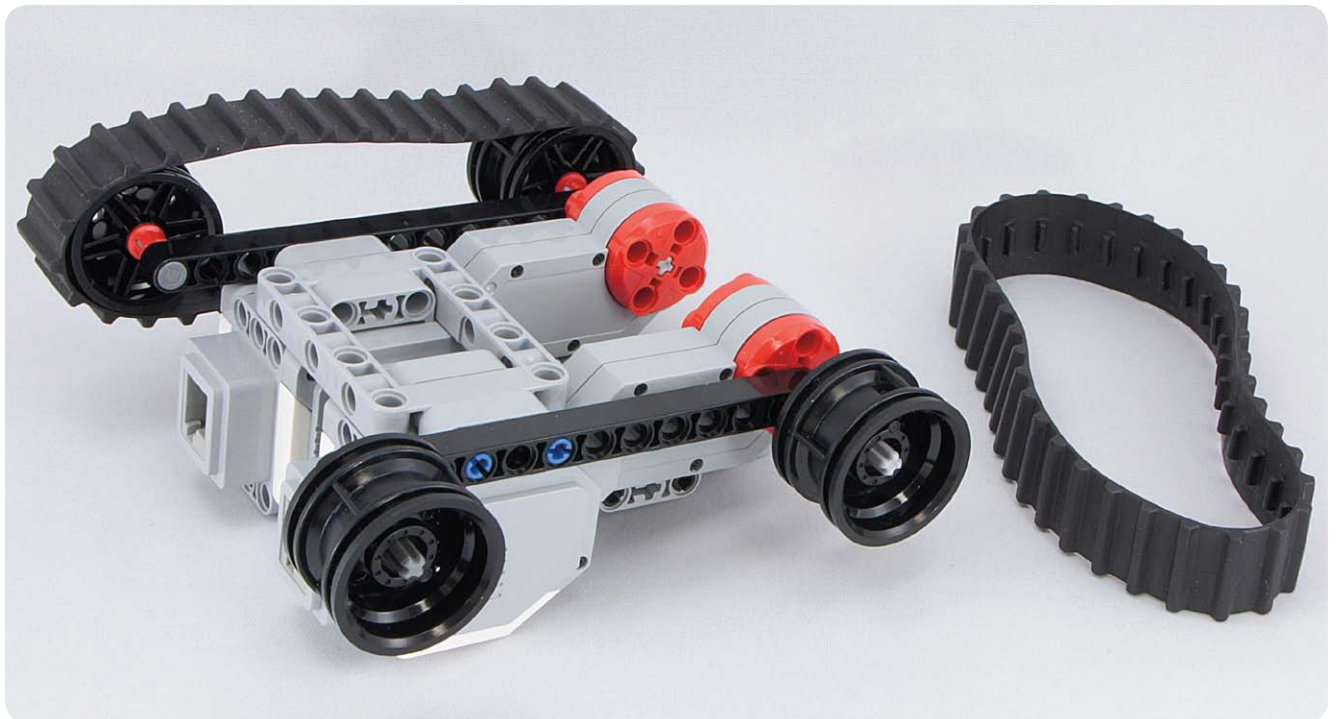
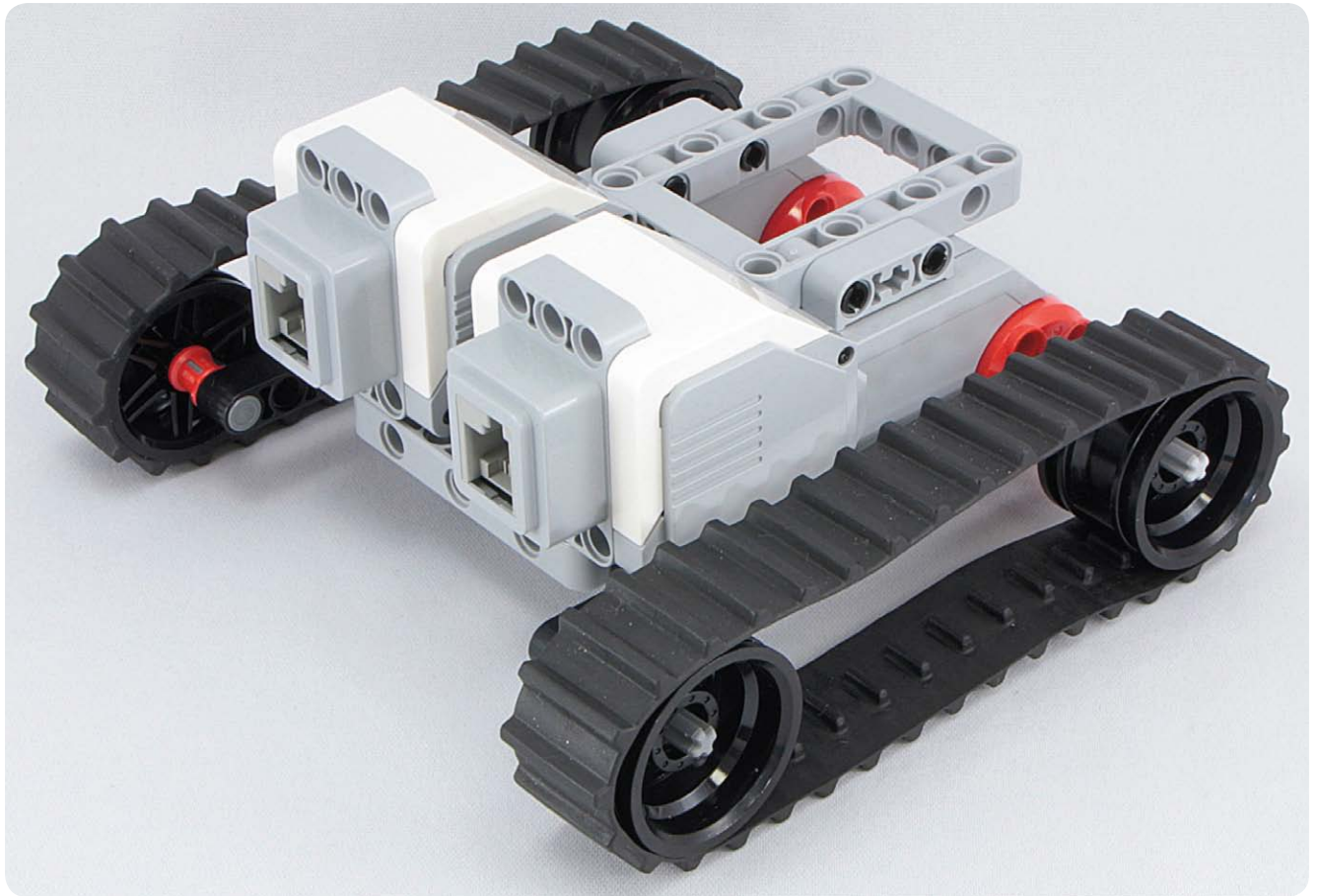


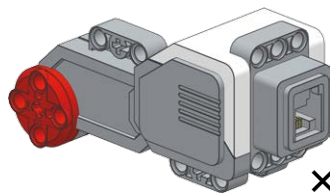


20:12:20 = 5:3:5









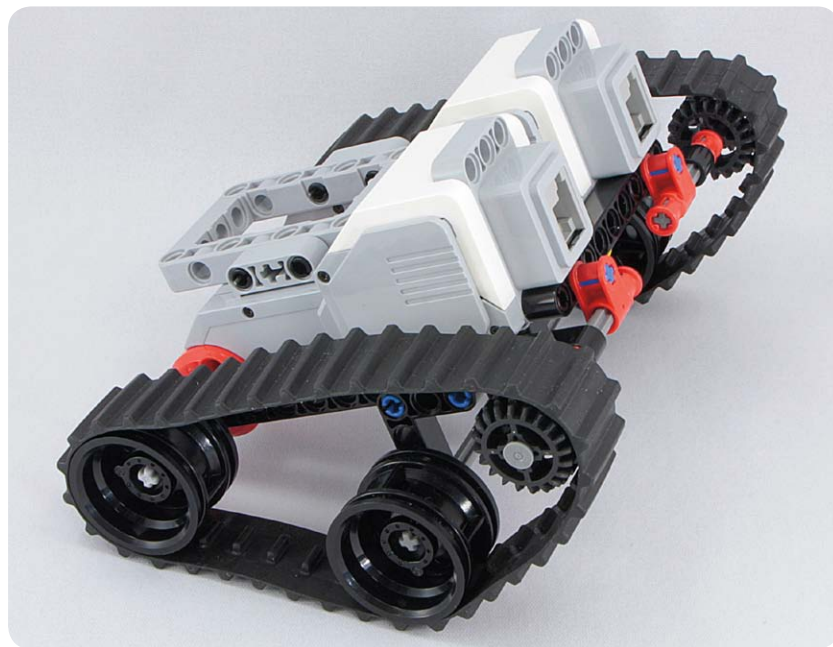
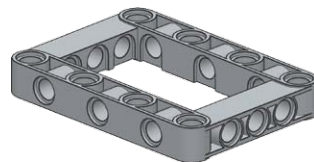
x2



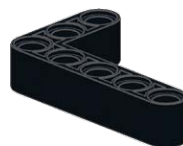
x2



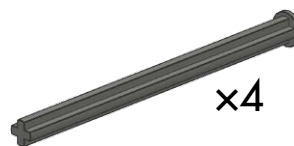
x4



x2



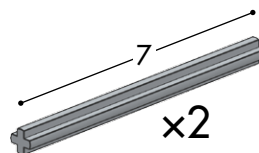
x4



x4



x2



x2



x4



x12



x2



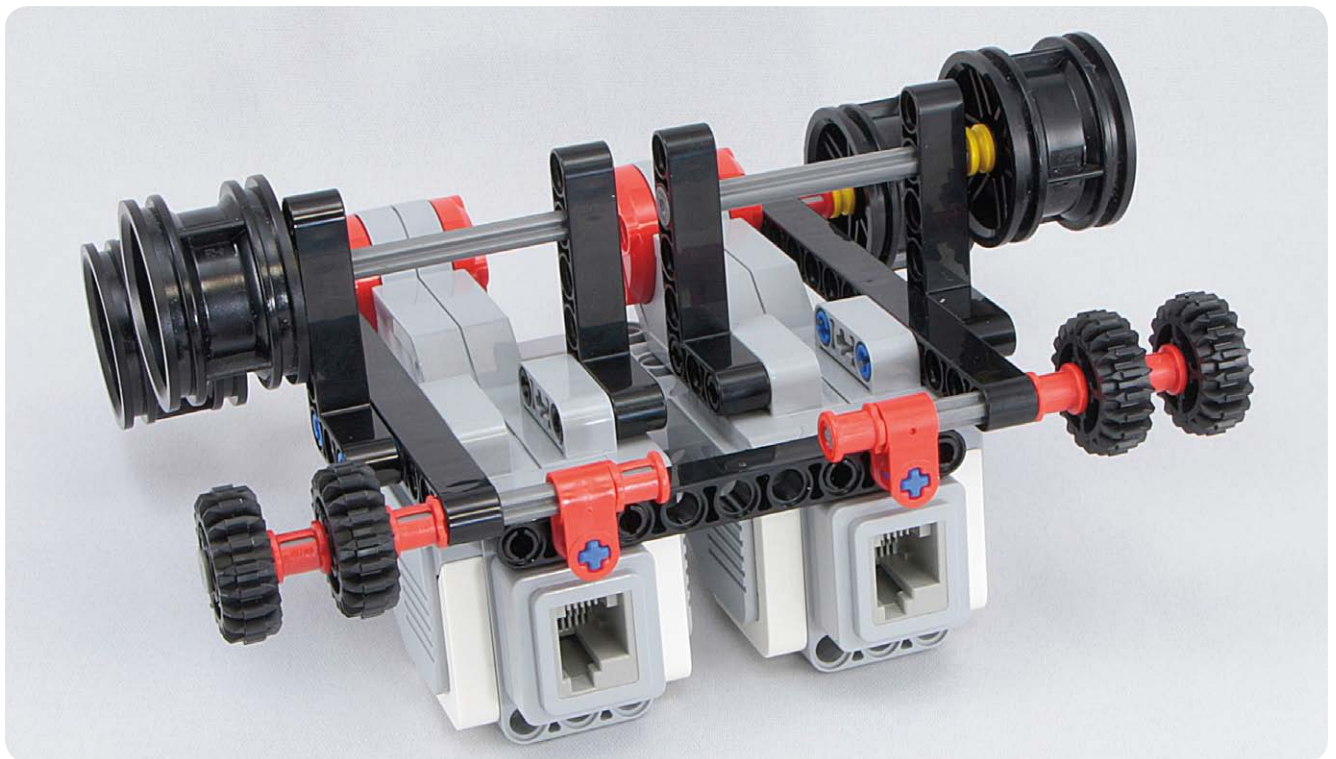
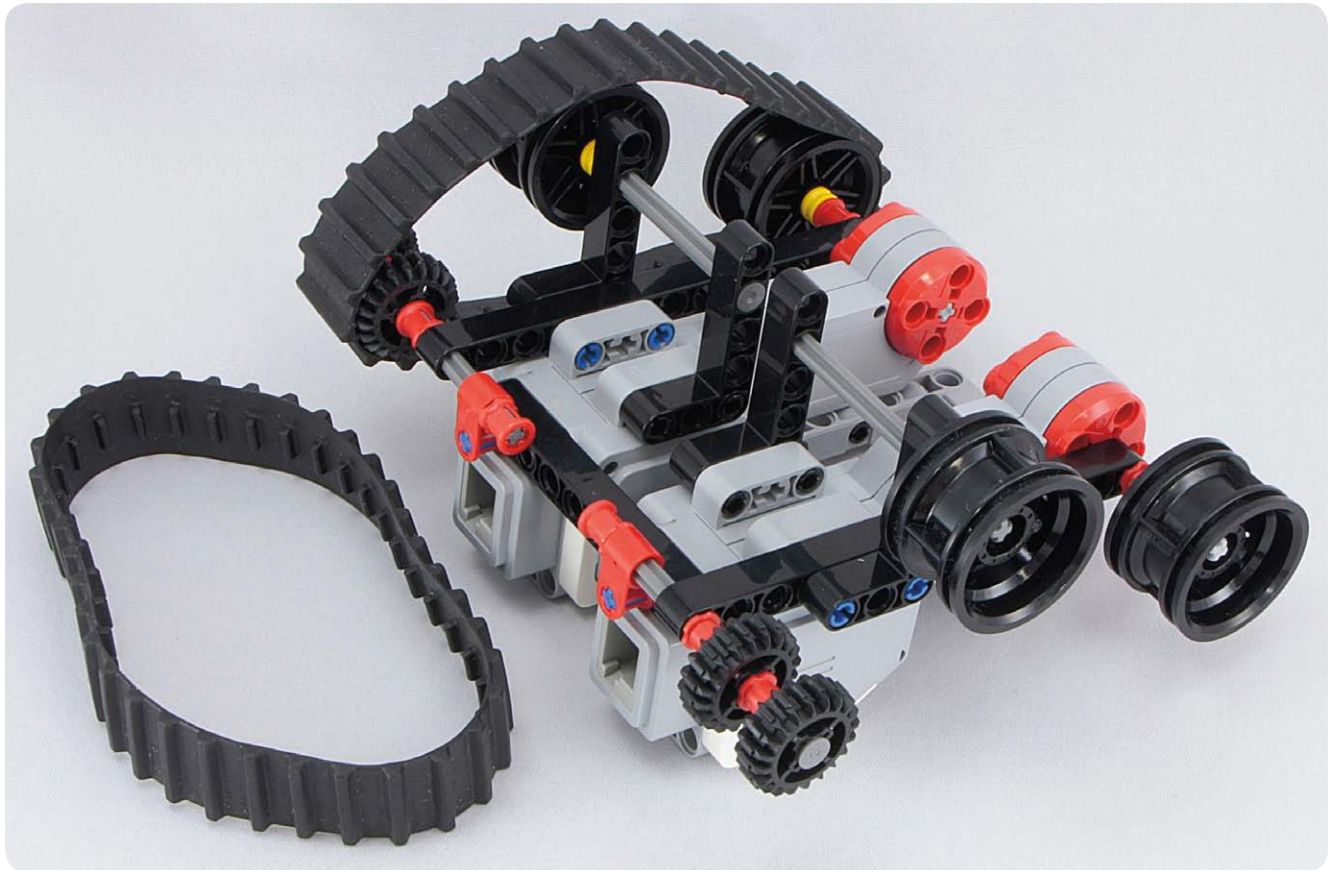
x4

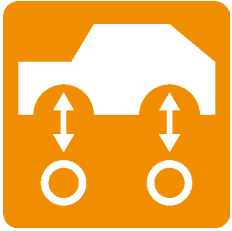


x8



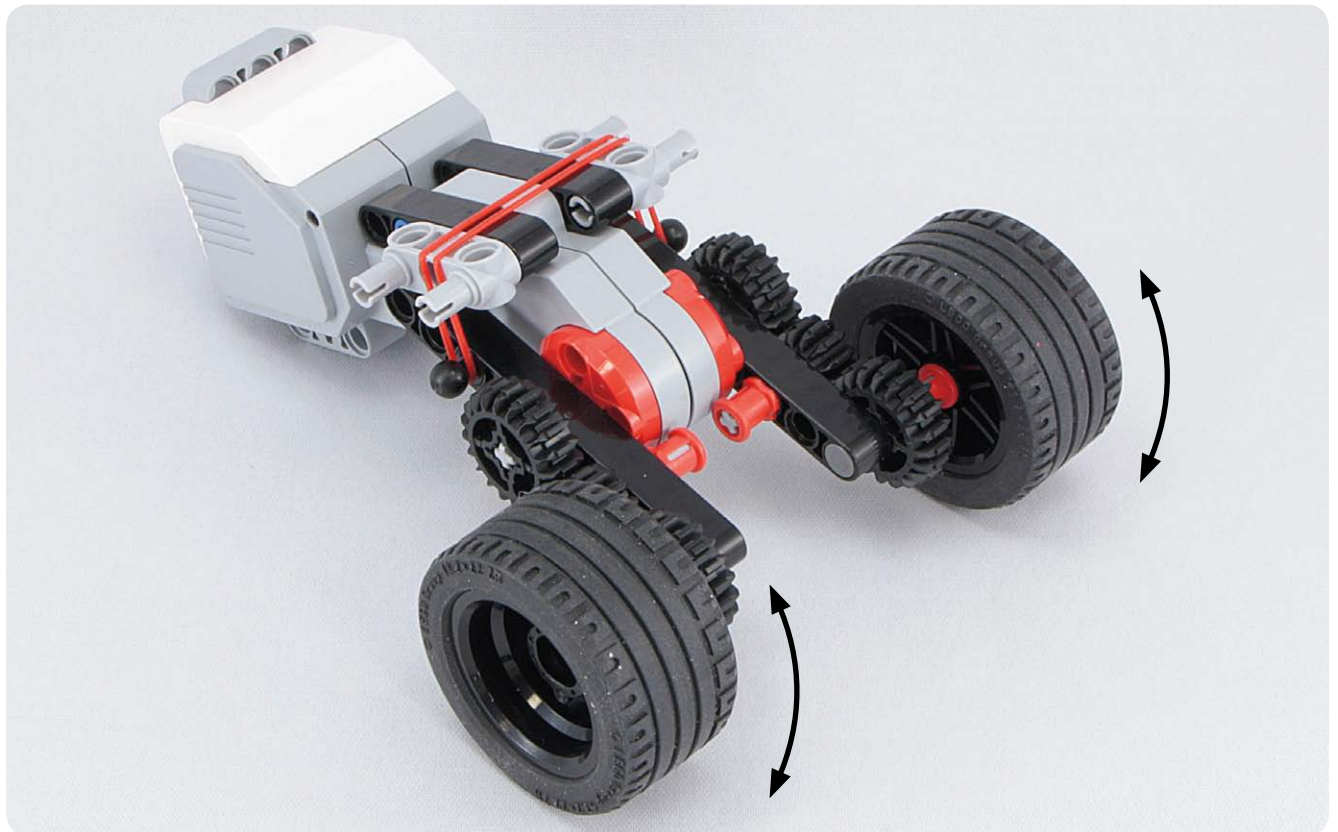
x4

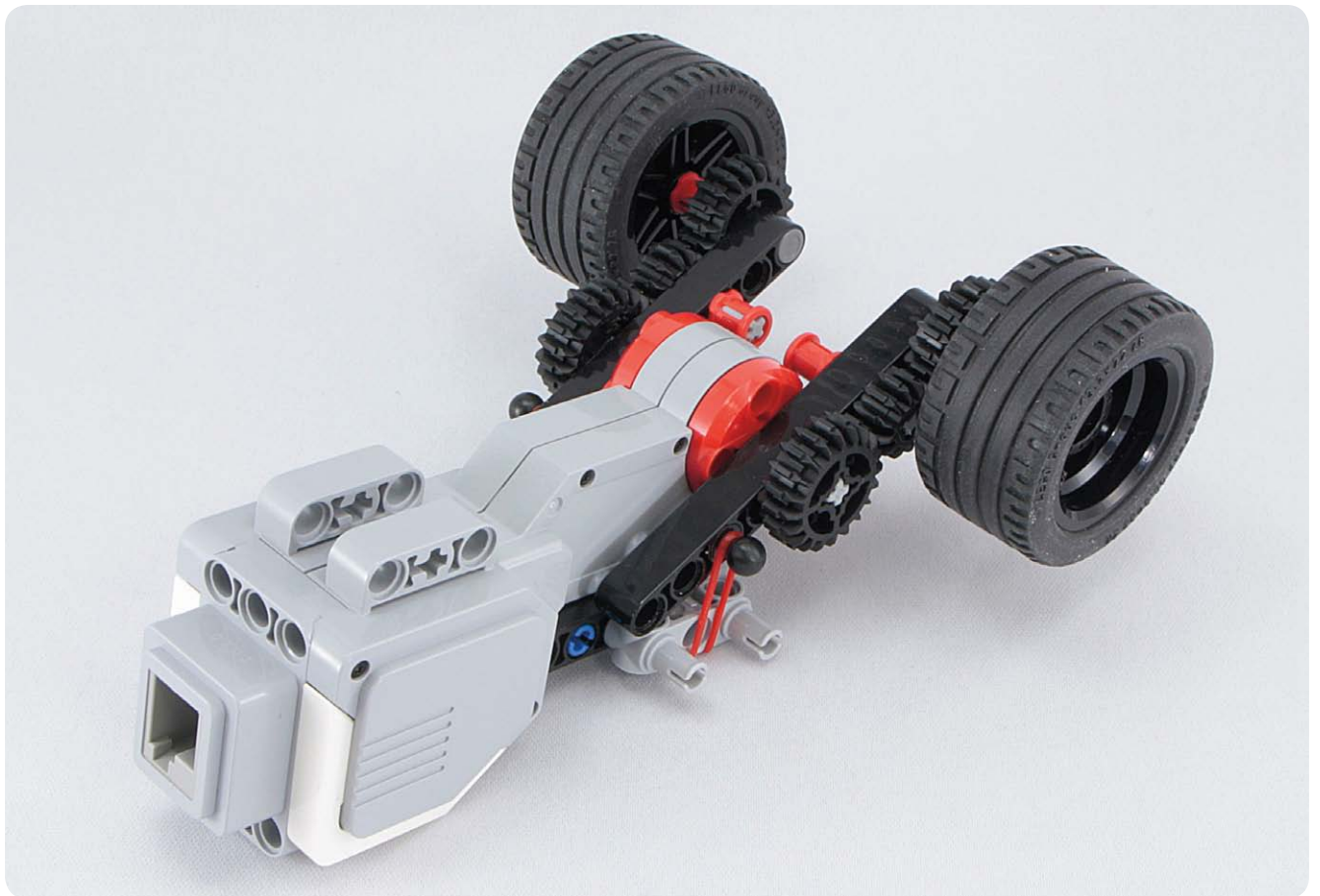
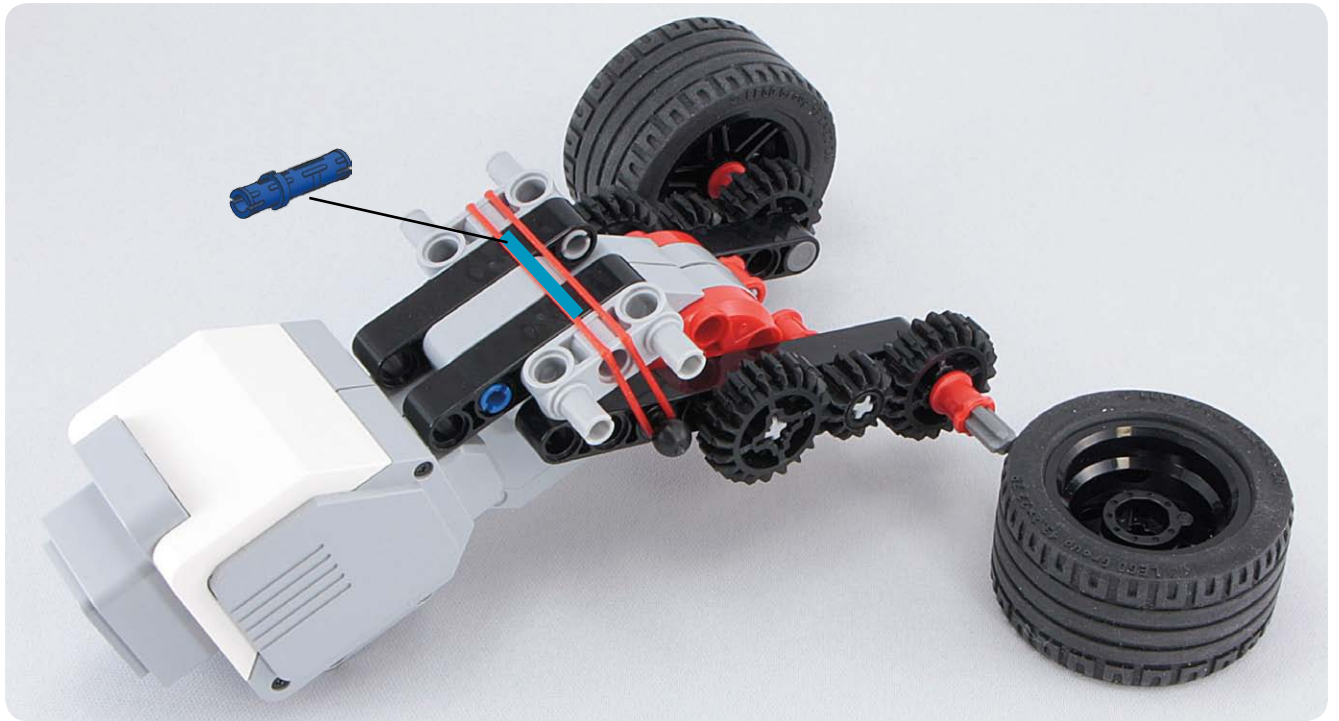




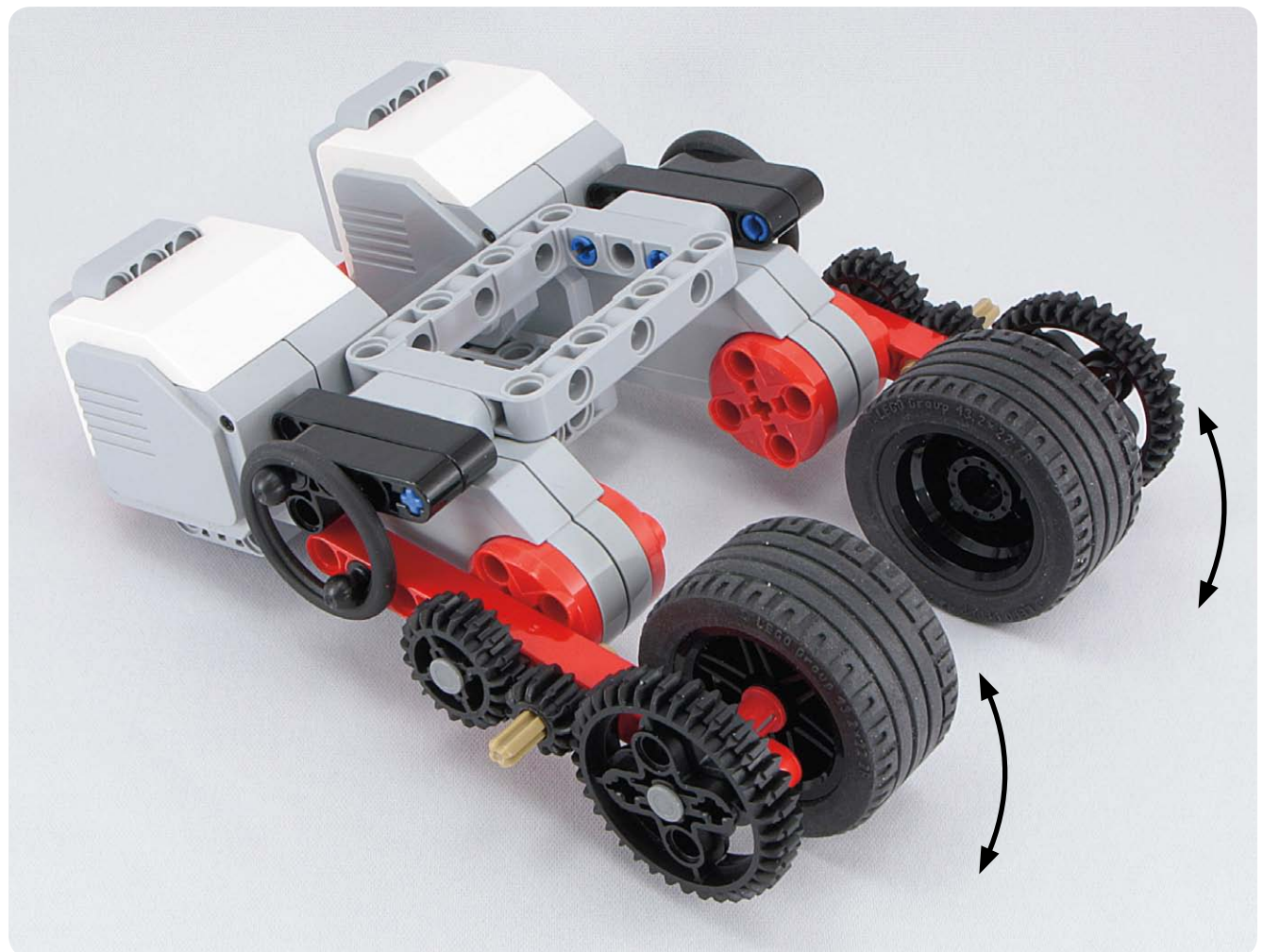
Suspended wheels

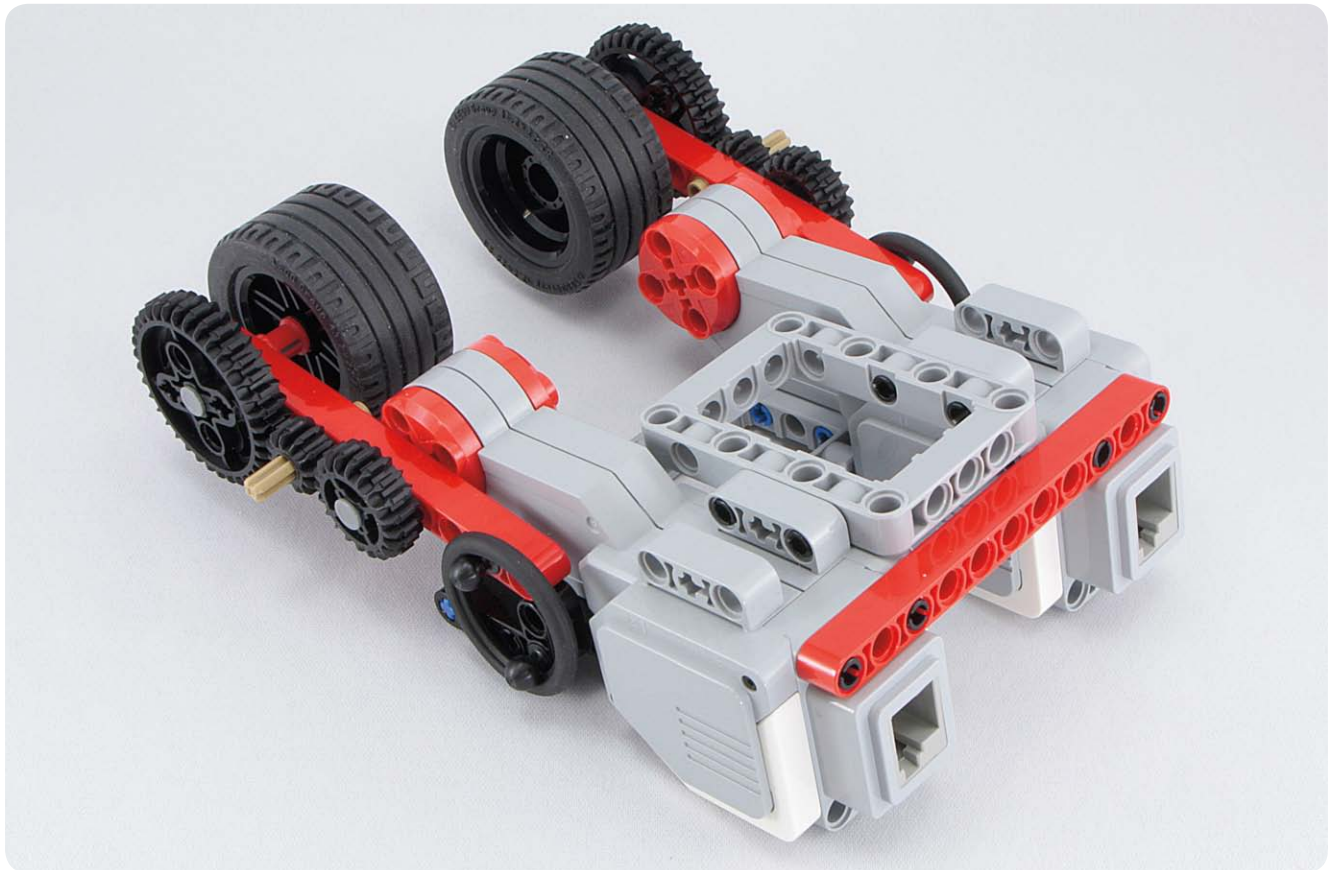
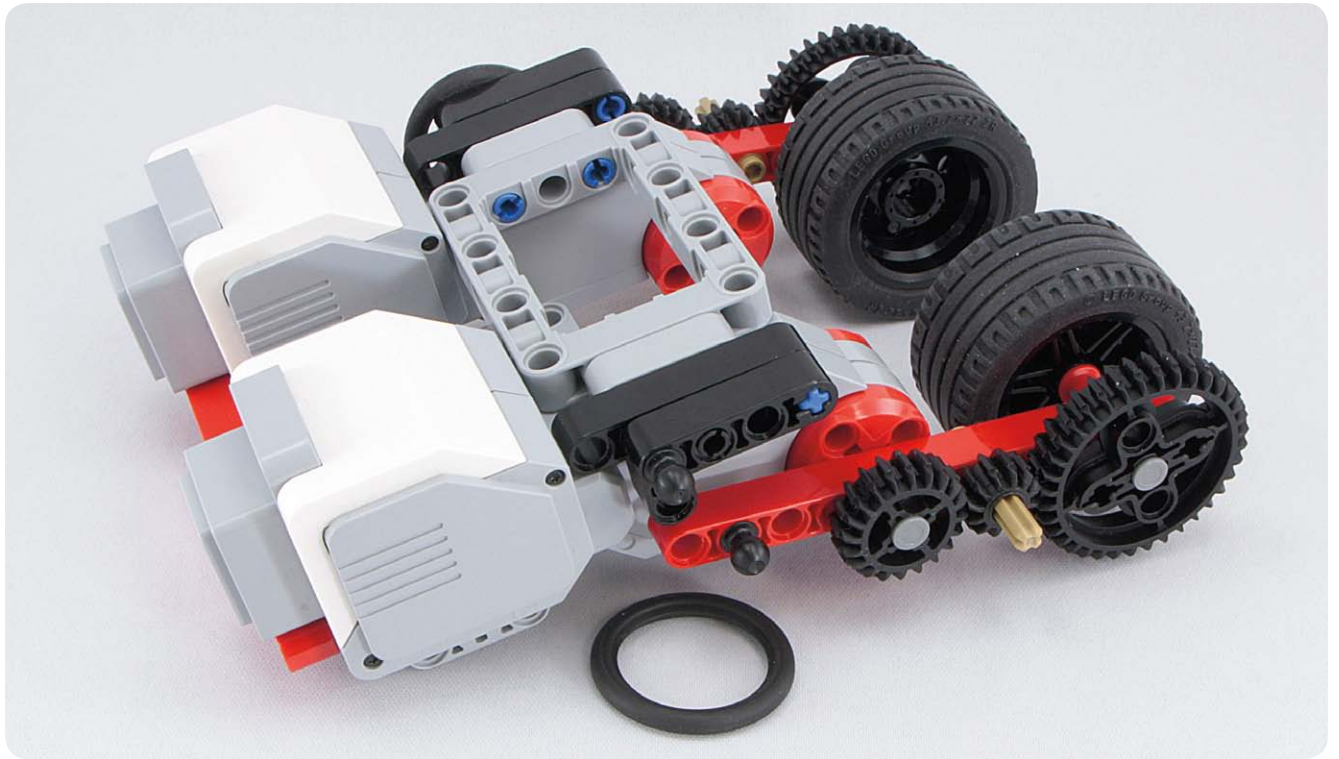
#119





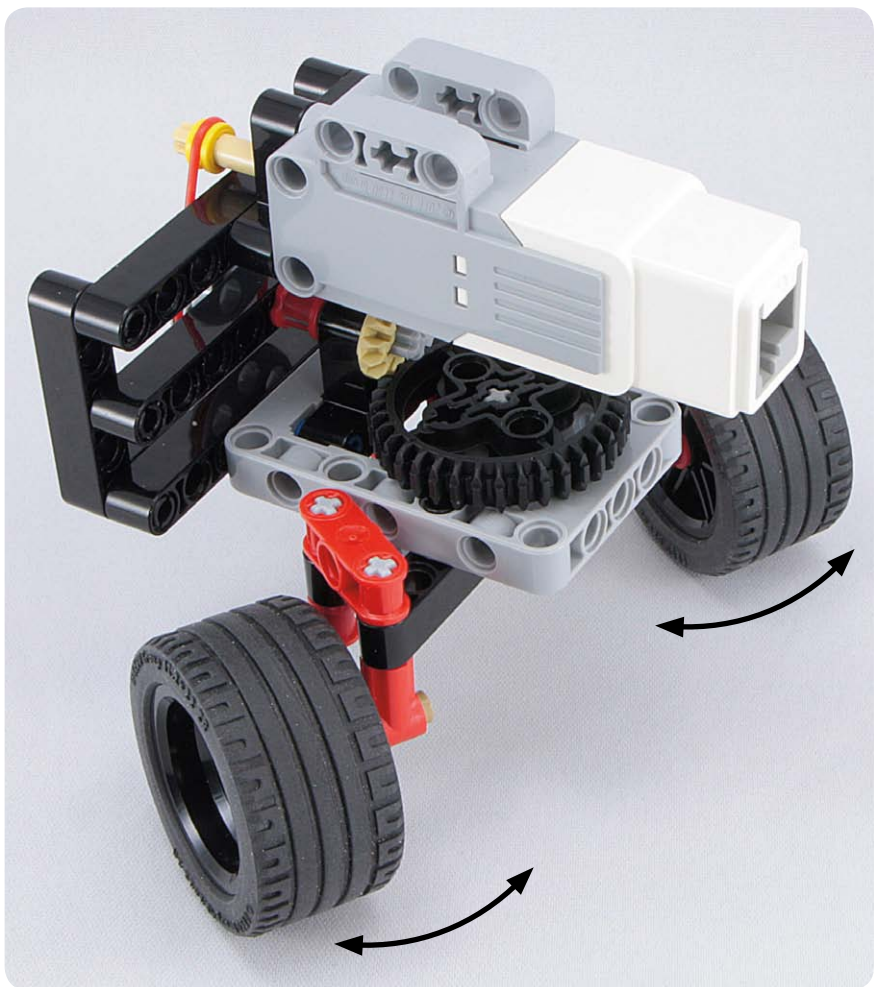
#120

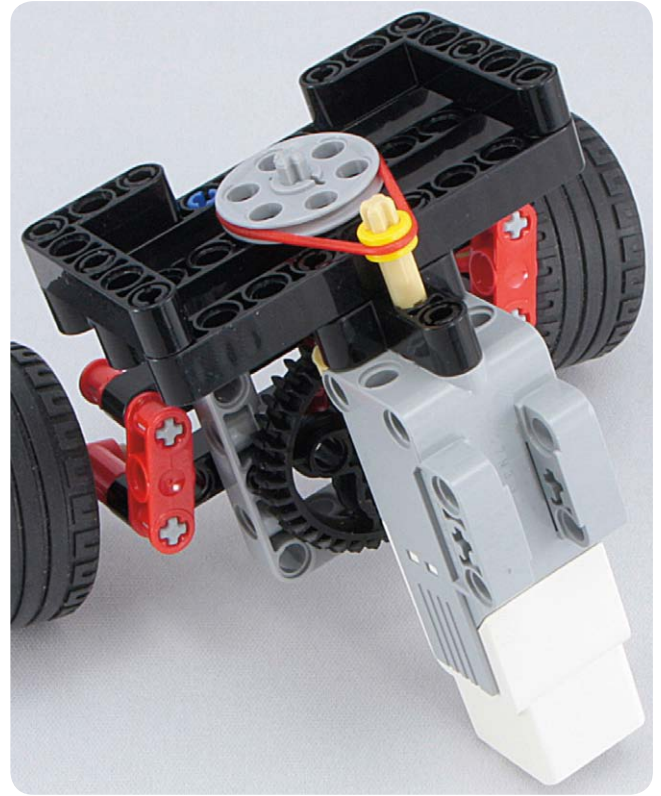
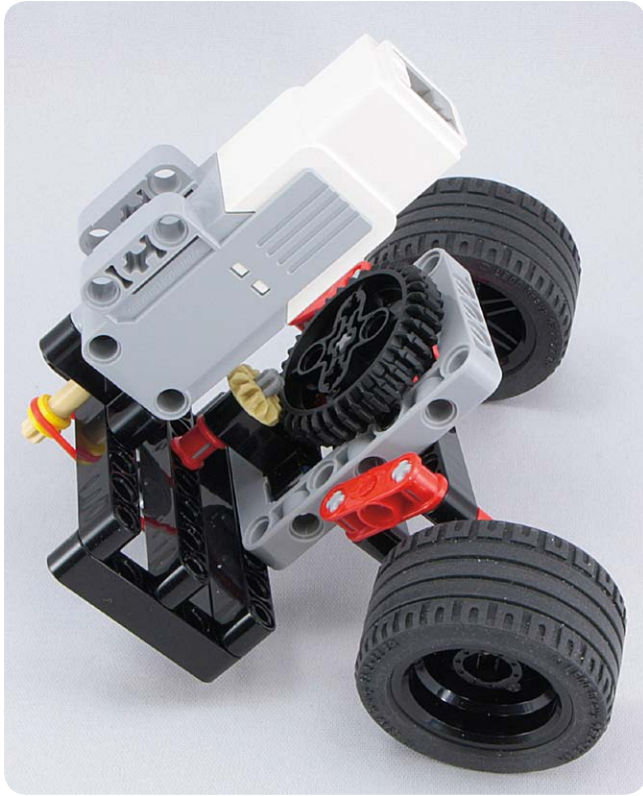


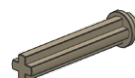
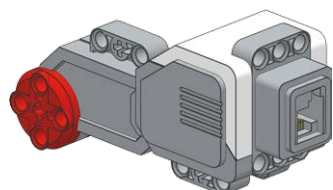
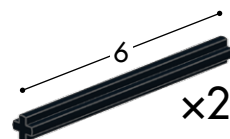
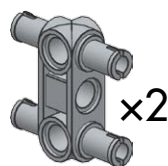
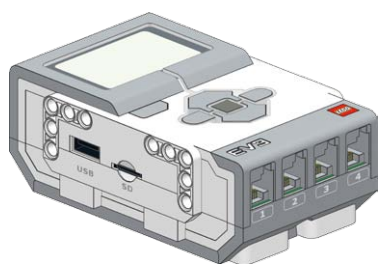


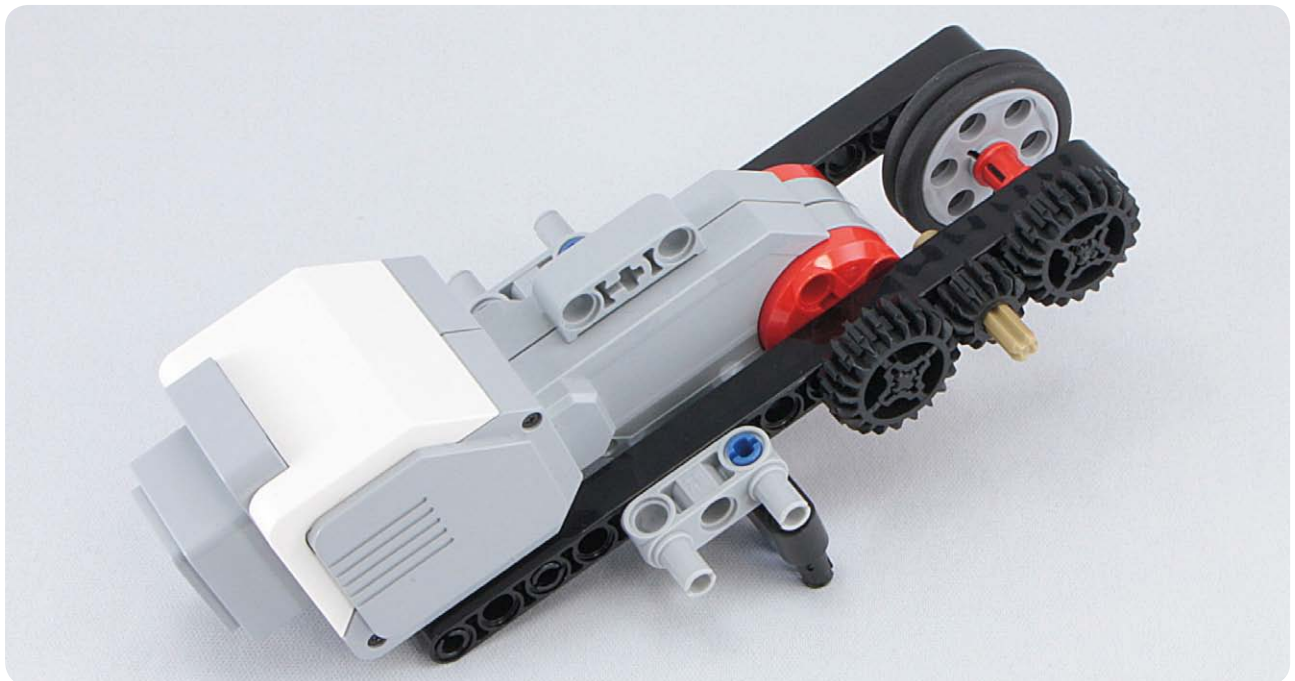
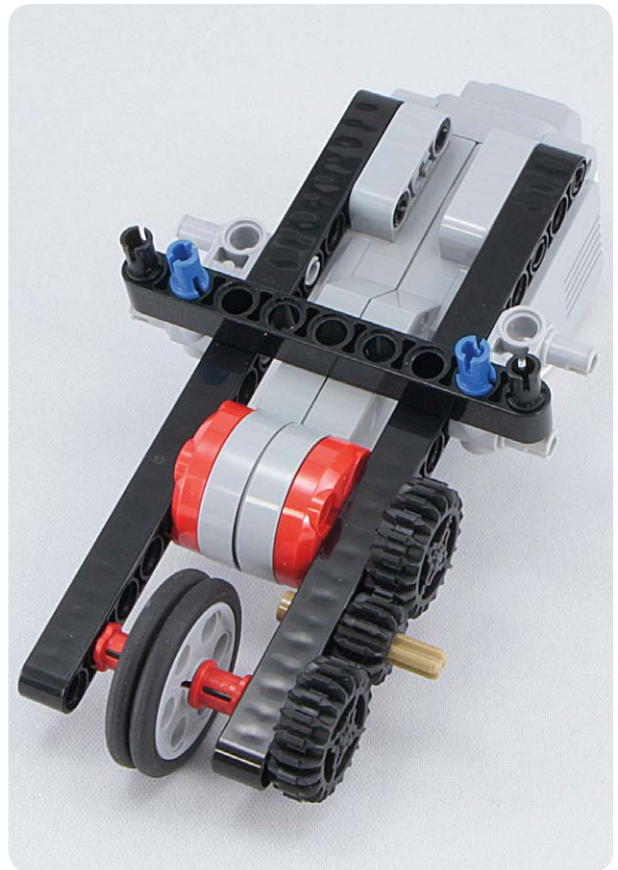


#121











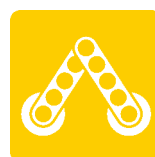
PART 3



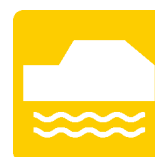
Moving Without Tires



110



122



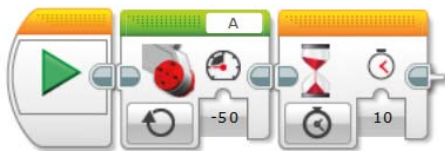
126

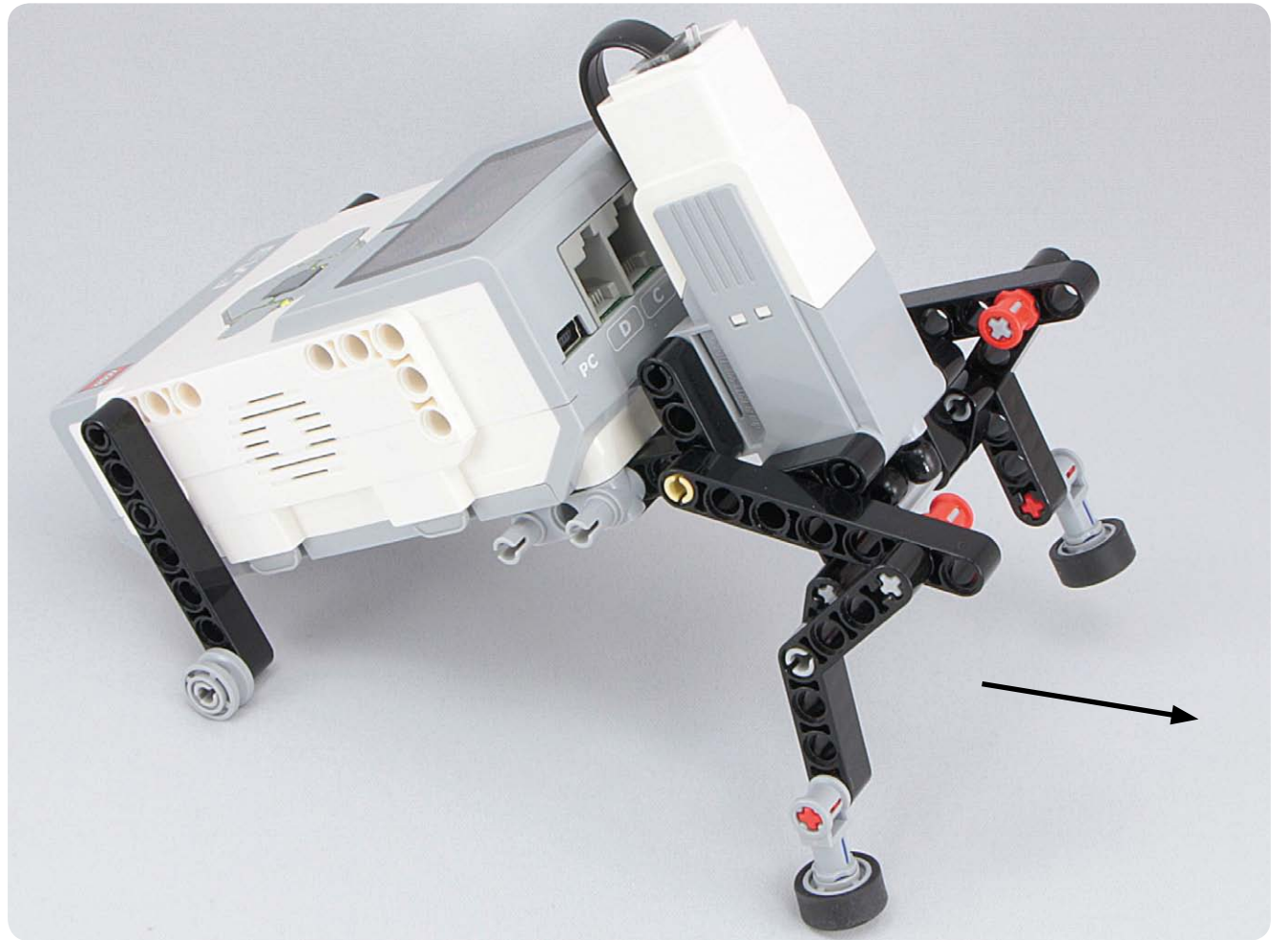


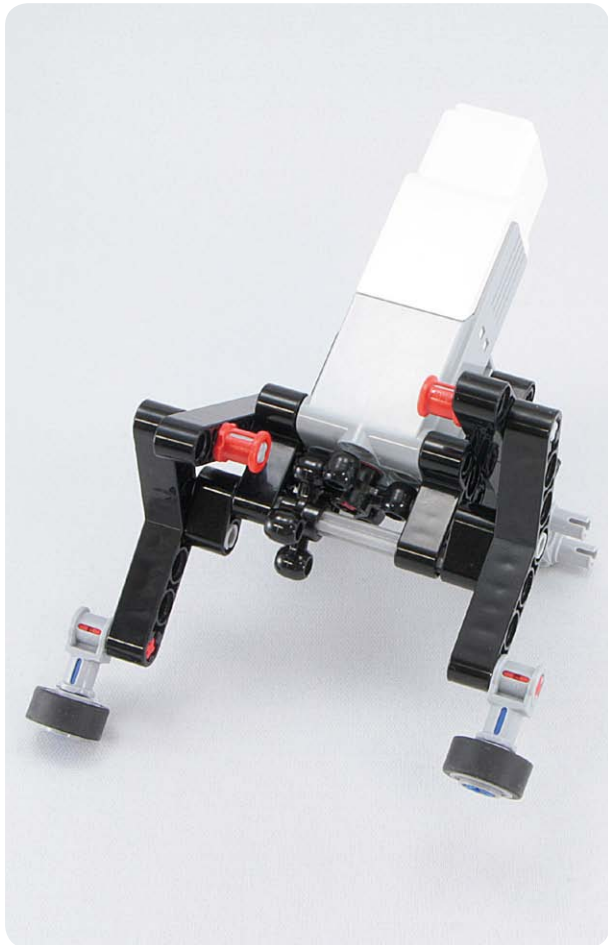
LEGO parts list for step 10:

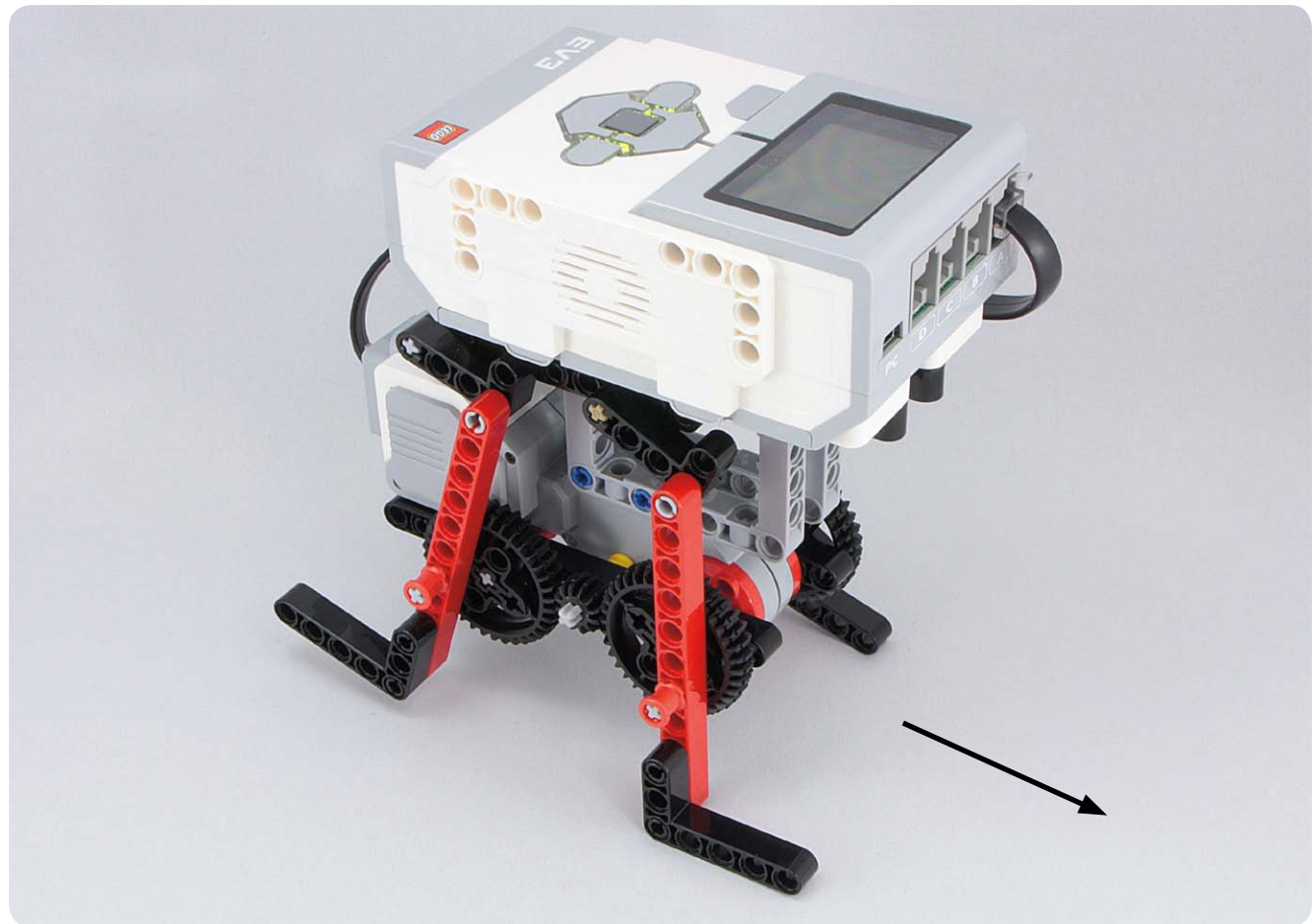
- 1x LEGO Mindstorms NXT 3.0
- 1x LEGO Cable (USB to Serial)
- 2x LEGO Technic Beam 1x5 (Black)
- 2x LEGO Technic Beam 1x5 (Red)
- 2x LEGO Technic Axle 1/2
- 2x LEGO Technic Axle 3/4
- 2x LEGO Technic Axle 1
- 2x LEGO Technic Axle 1 1/2
- 2x LEGO Technic Axle 2
- 2x LEGO Technic Axle 3
- 2x LEGO Technic Axle 4
- 2x LEGO Technic Axle 5
- 2x LEGO Technic Axle 6
- 2x LEGO Technic Axle 7
- 2x LEGO Technic Axle 8
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- 2x LEGO Technic Axle 100

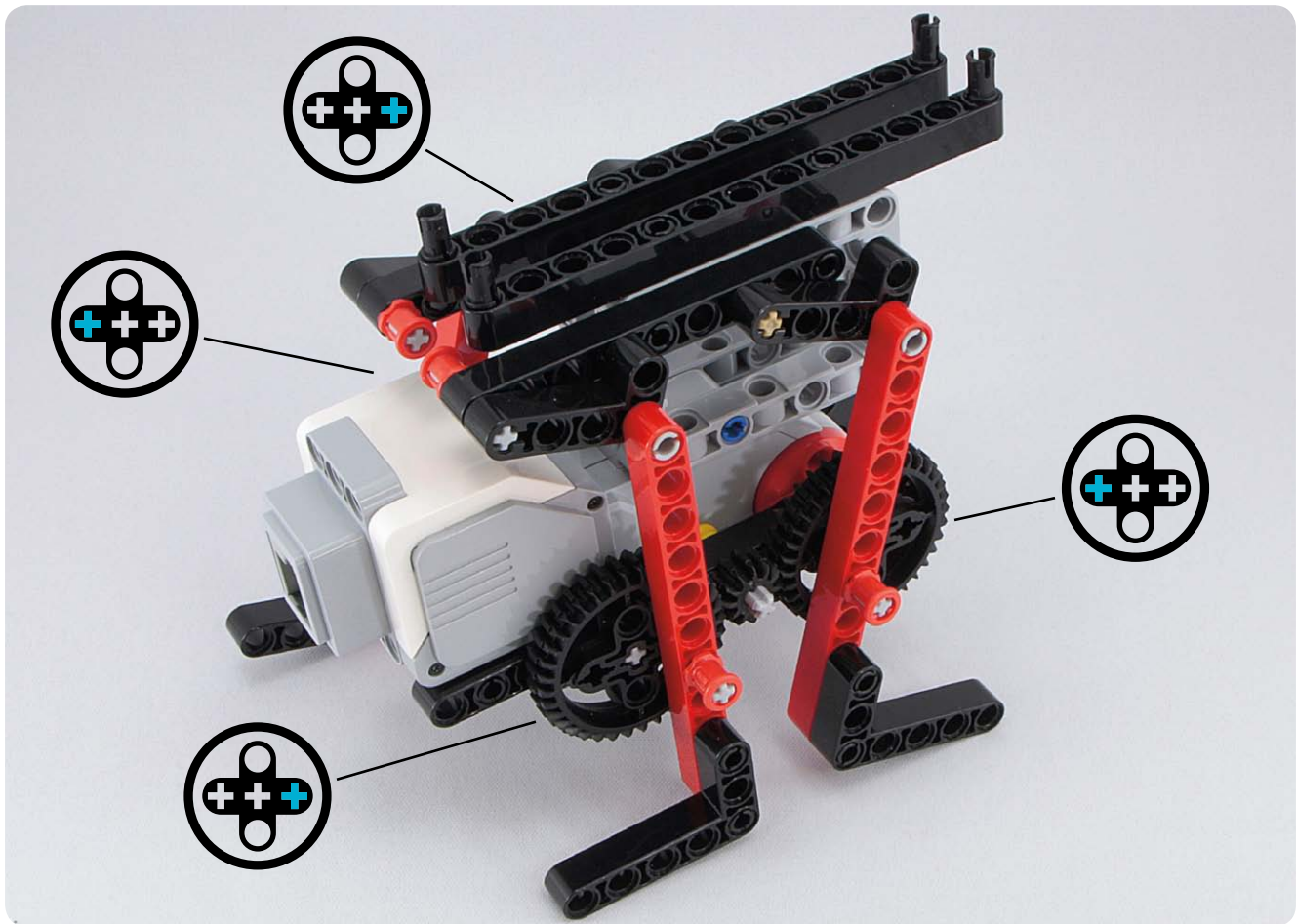
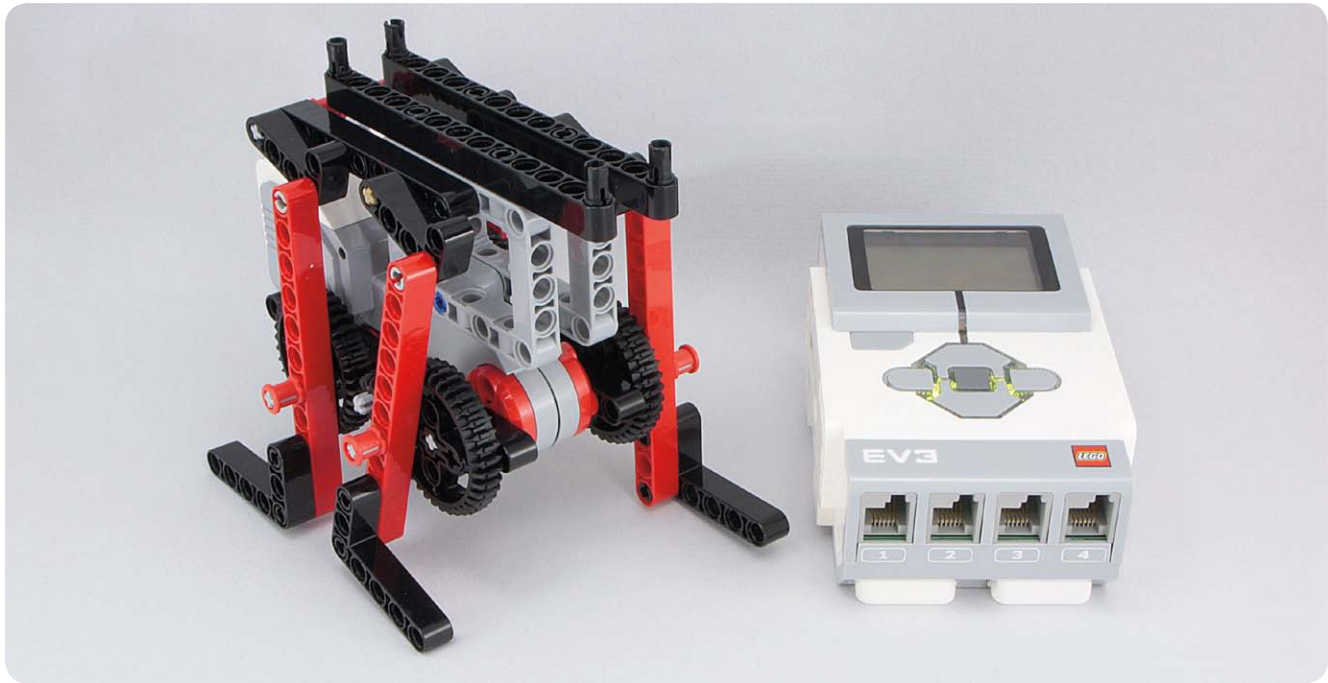




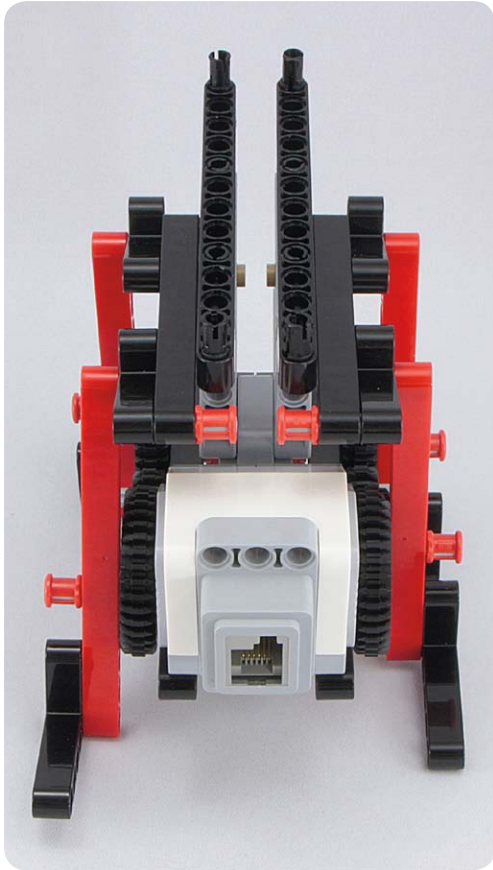


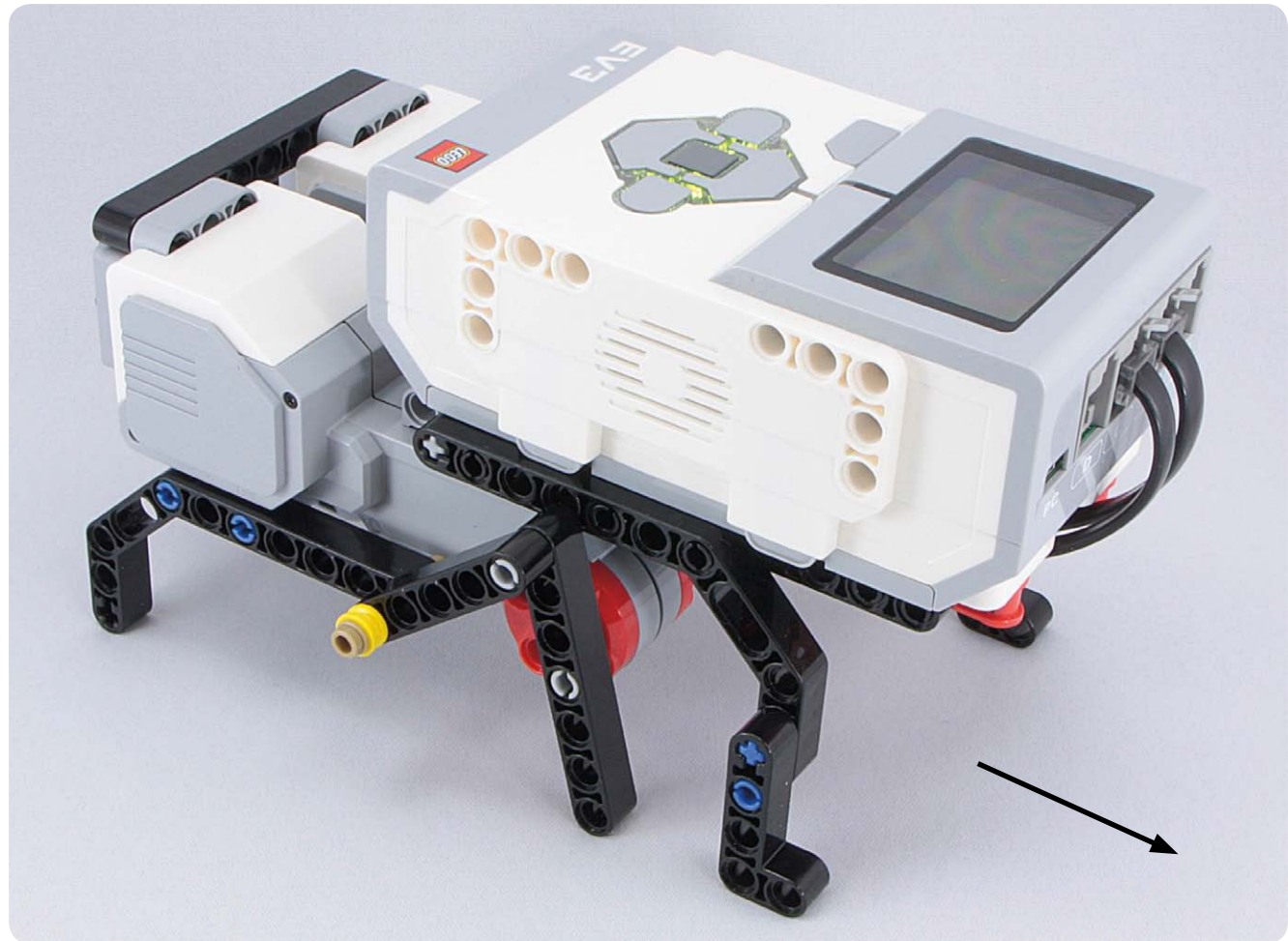


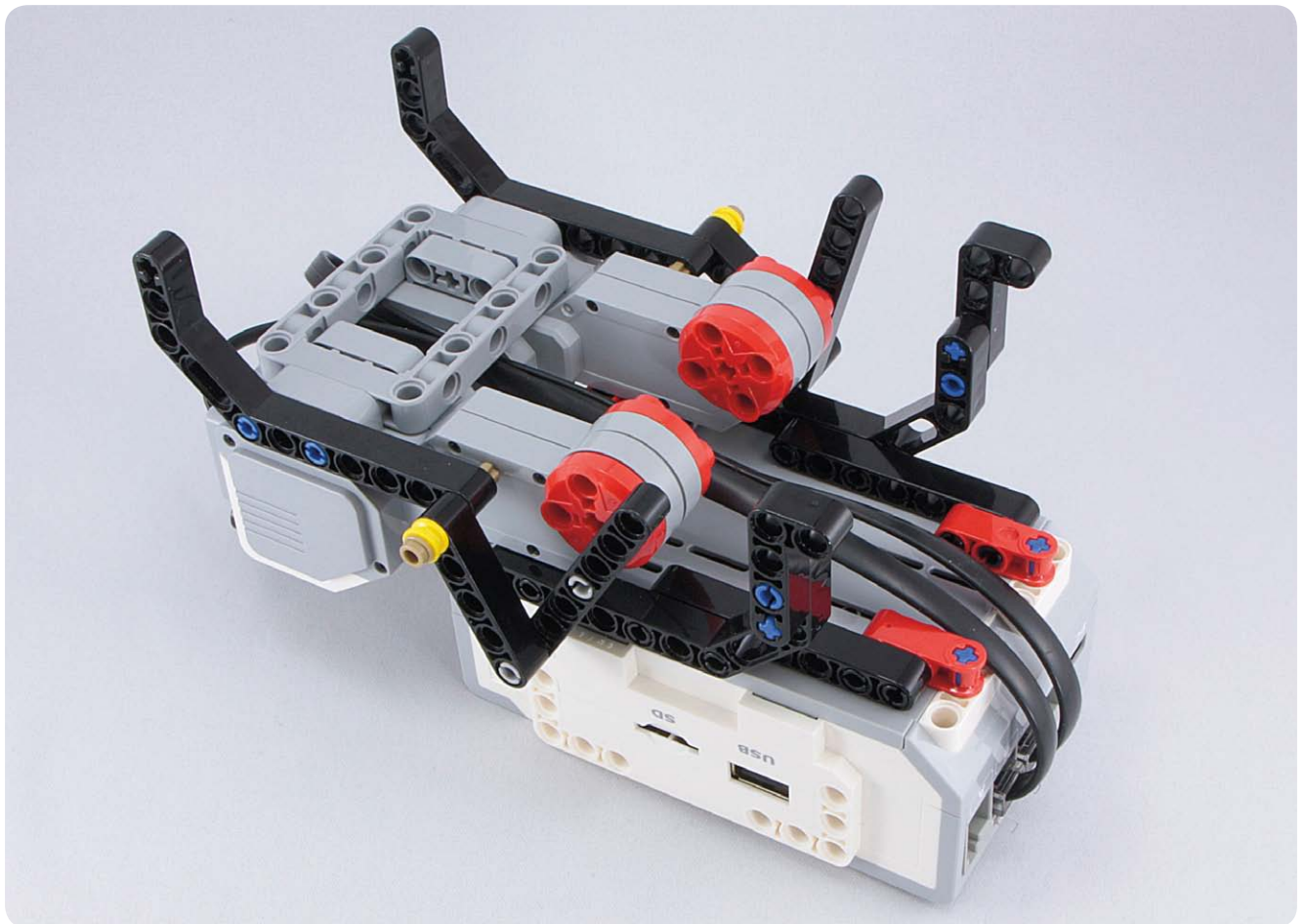


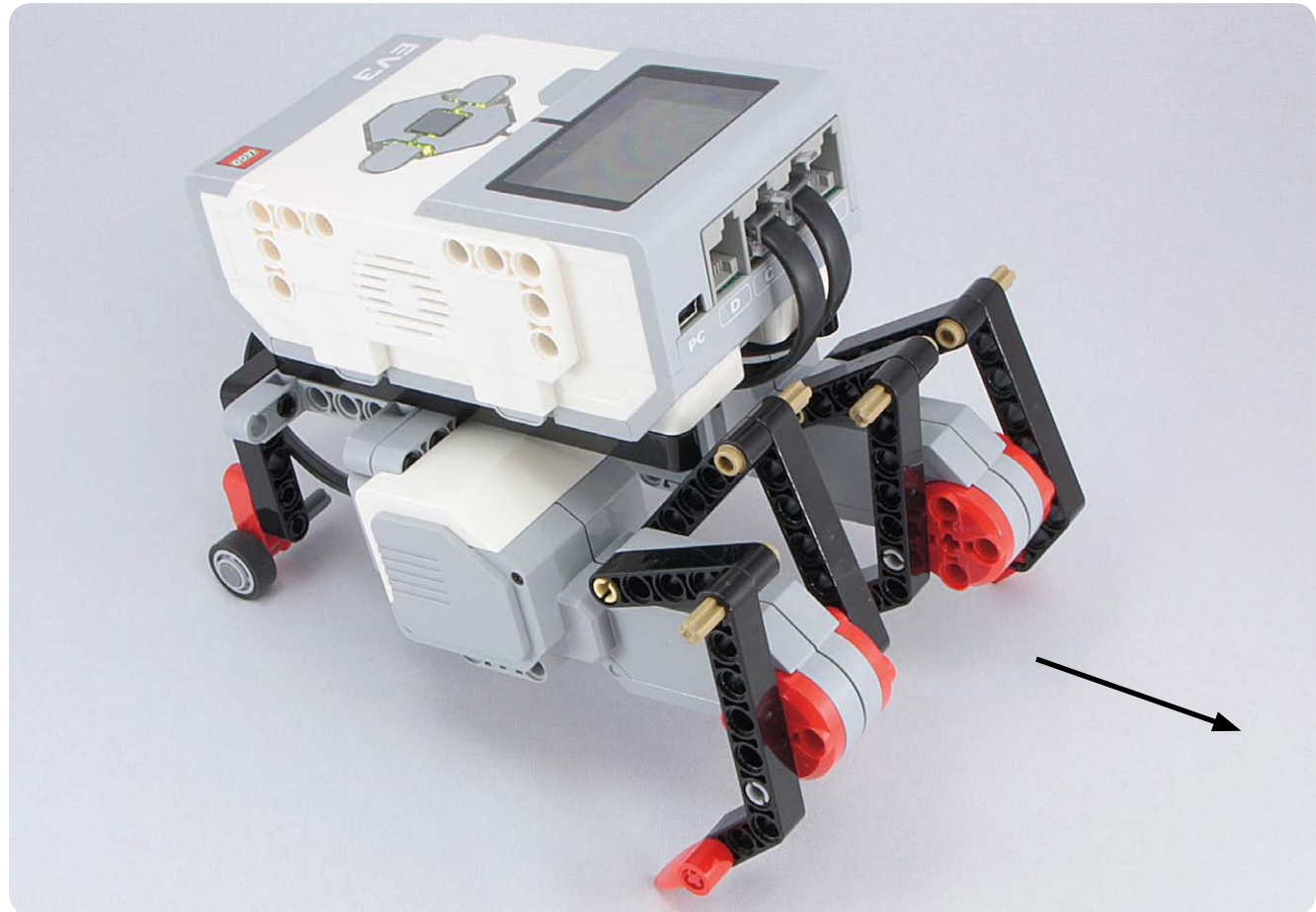


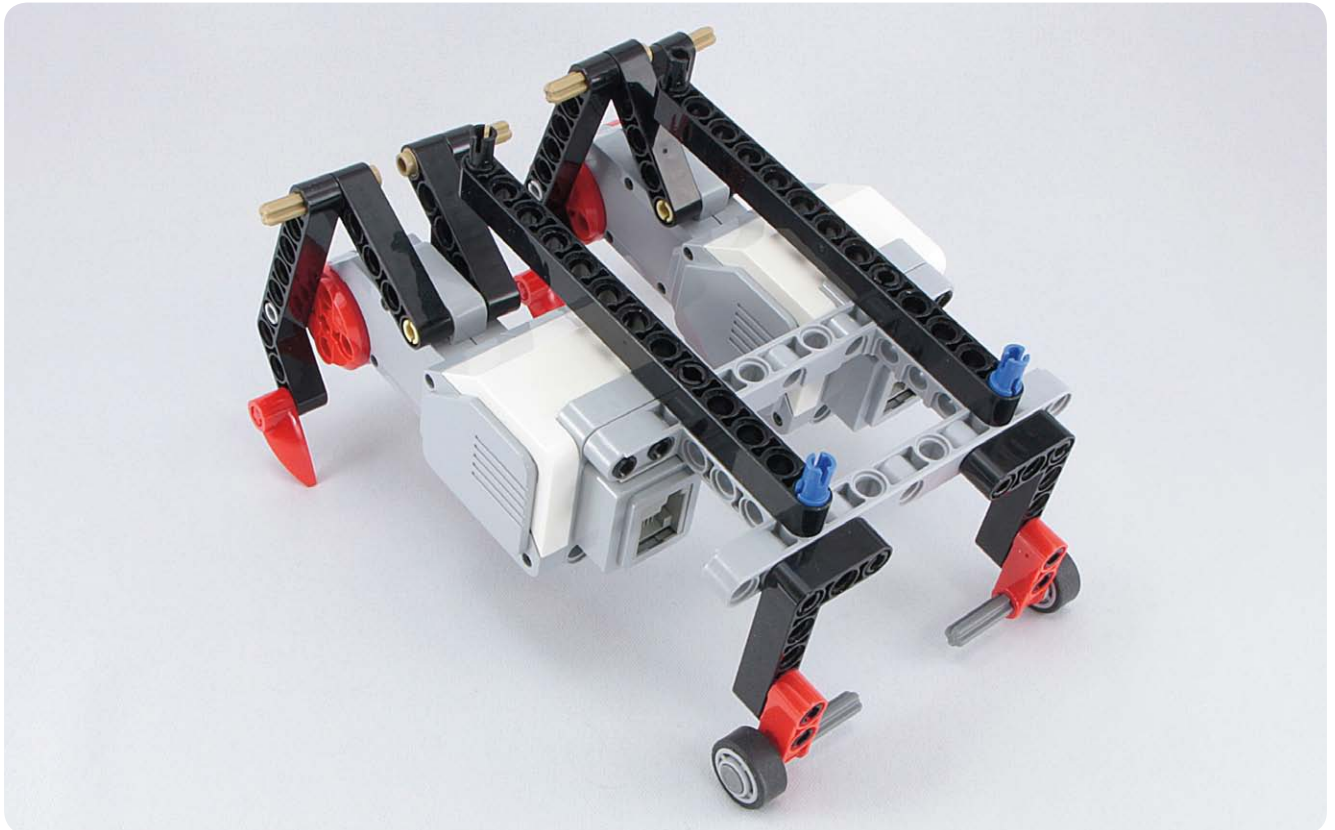
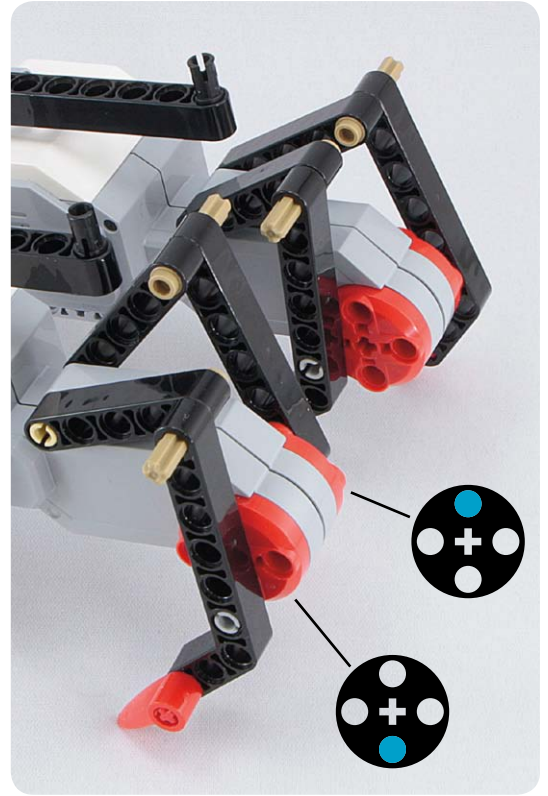
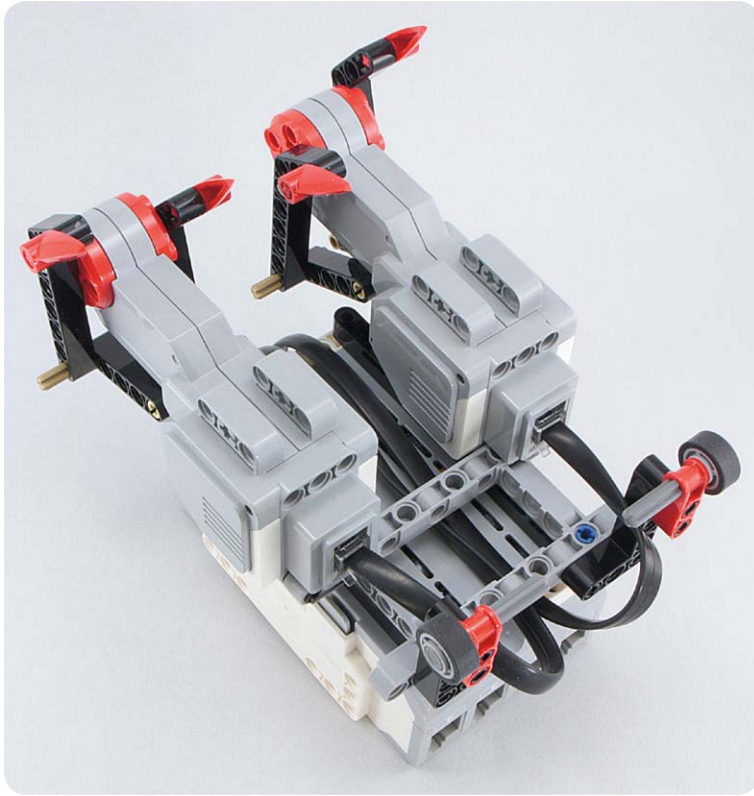




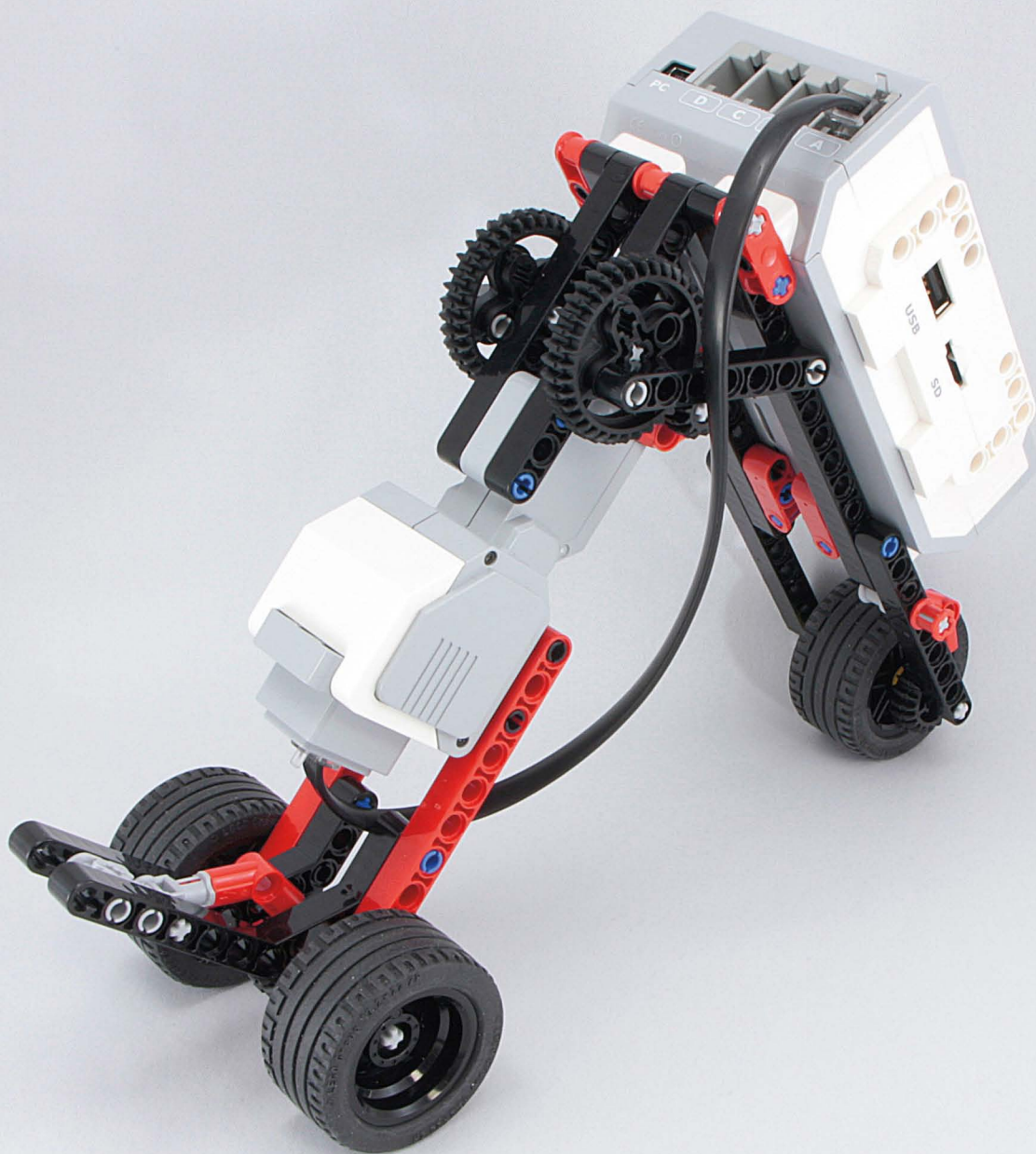


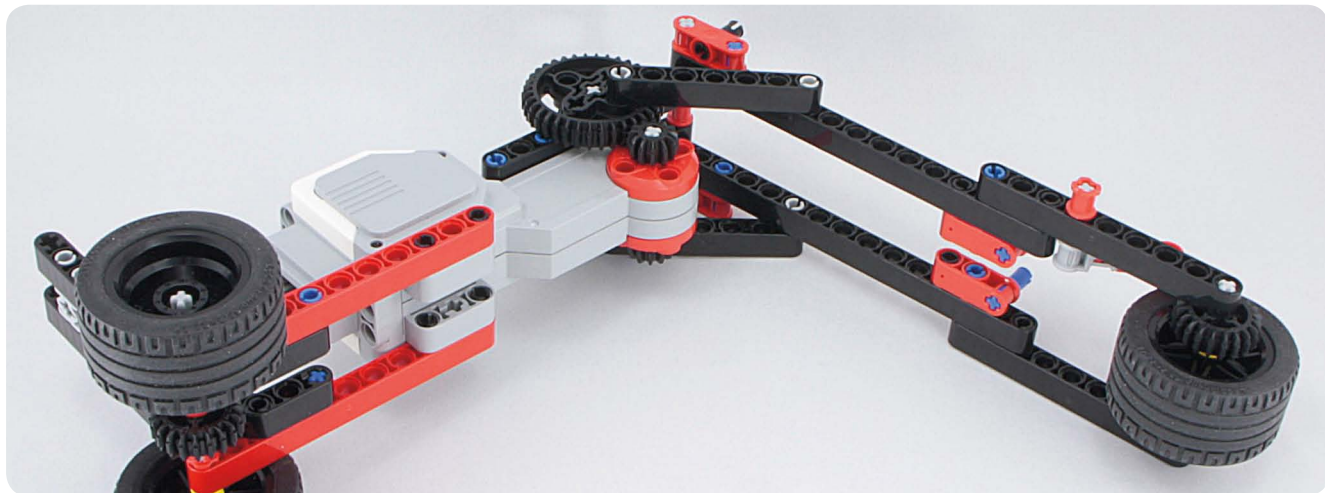
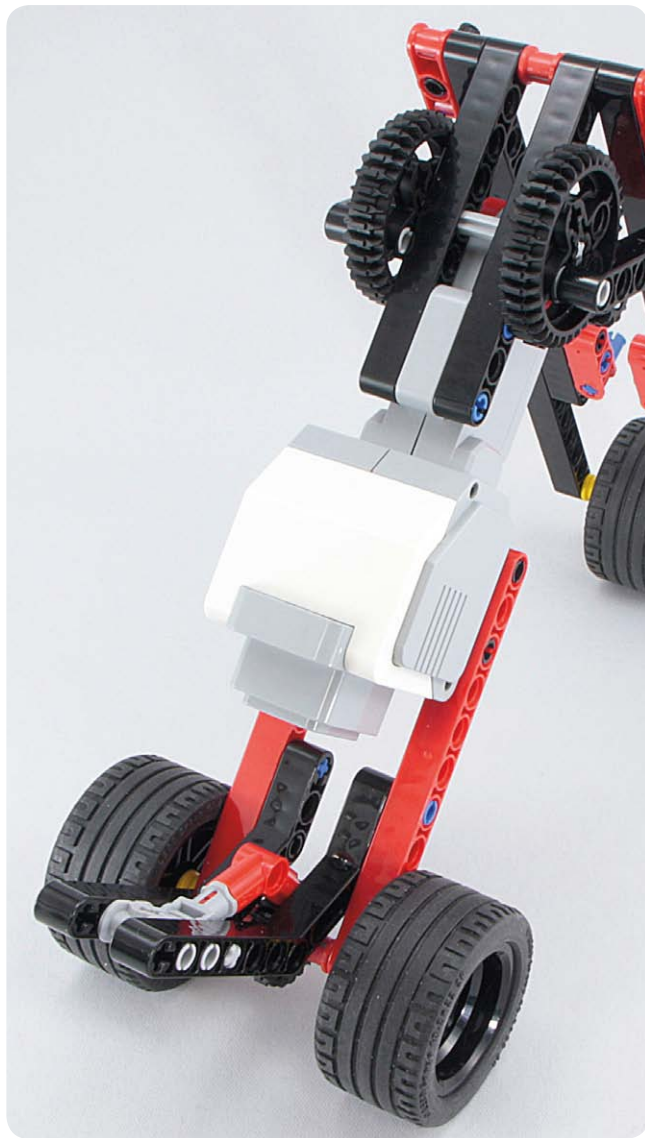


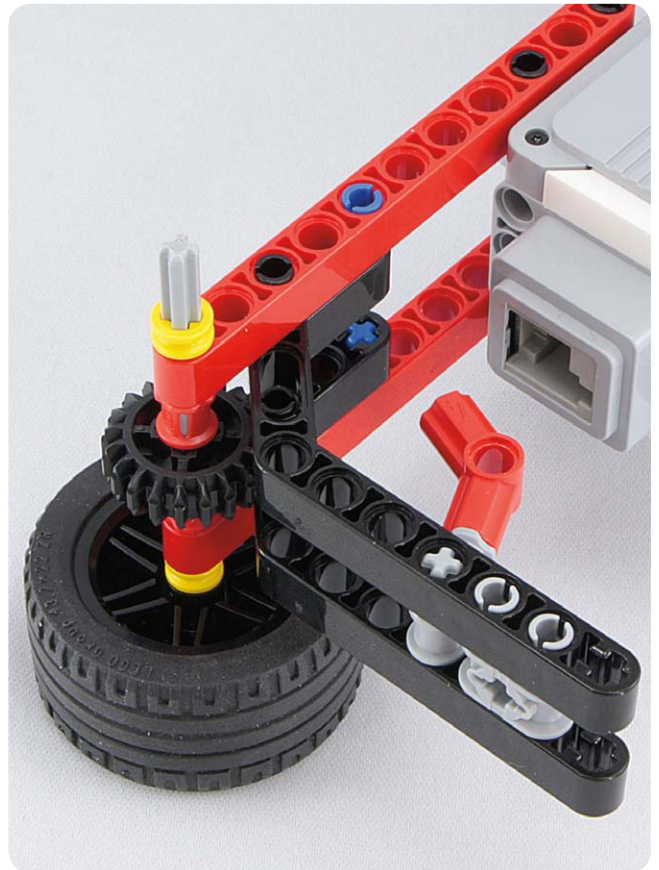
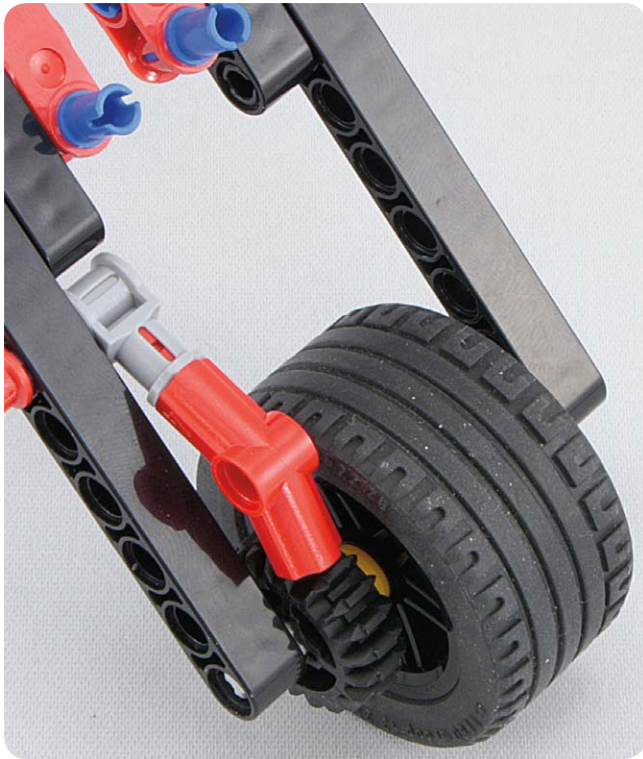




[illegible]



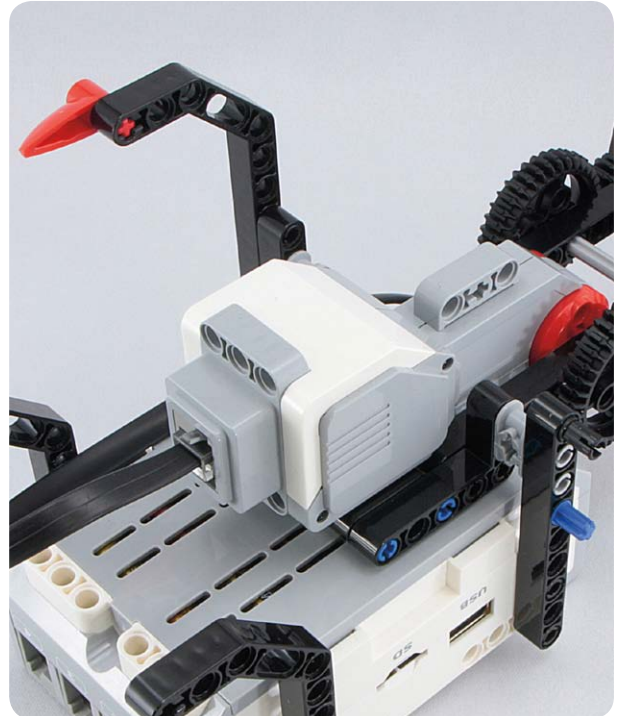
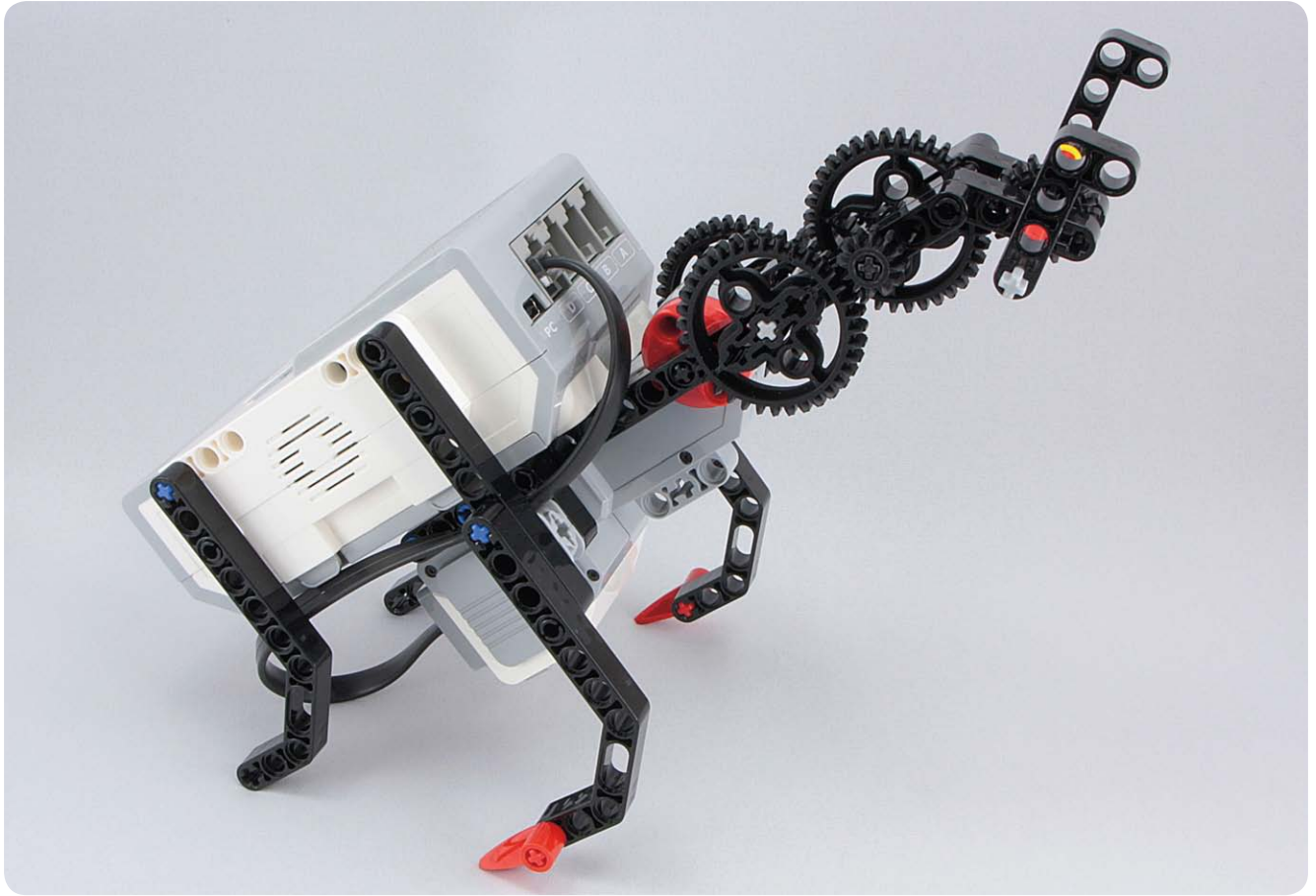






#128







PART 4

● ● ● ● ○ ○

Arms, Wings, and Other Movements



130



158



180



194



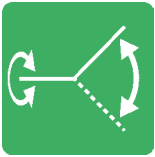
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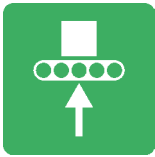
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184



198



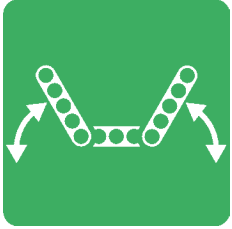
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176

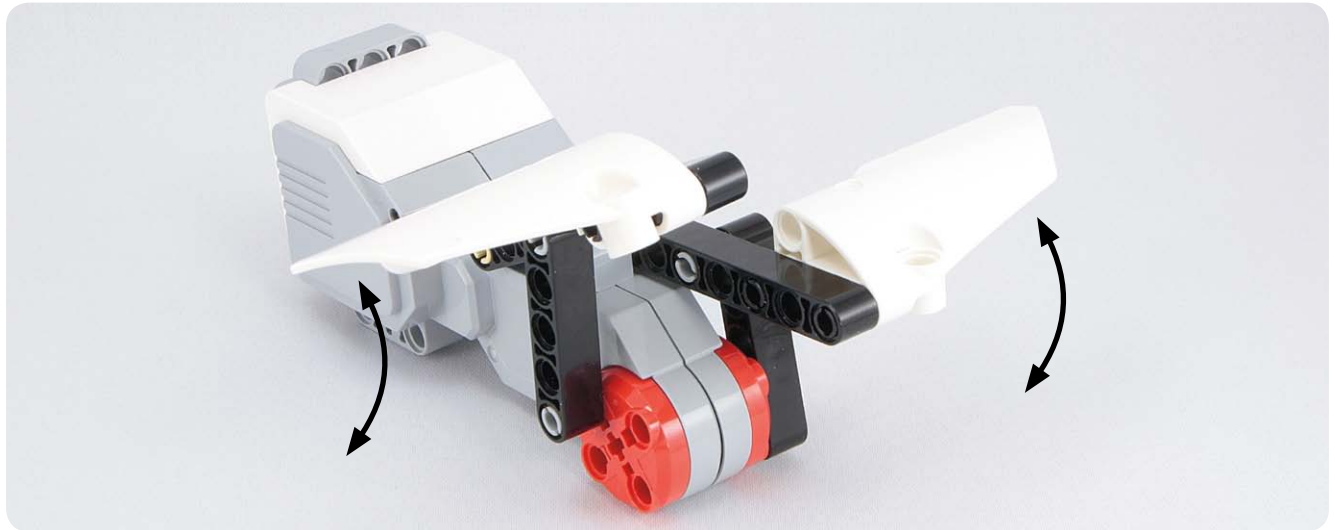
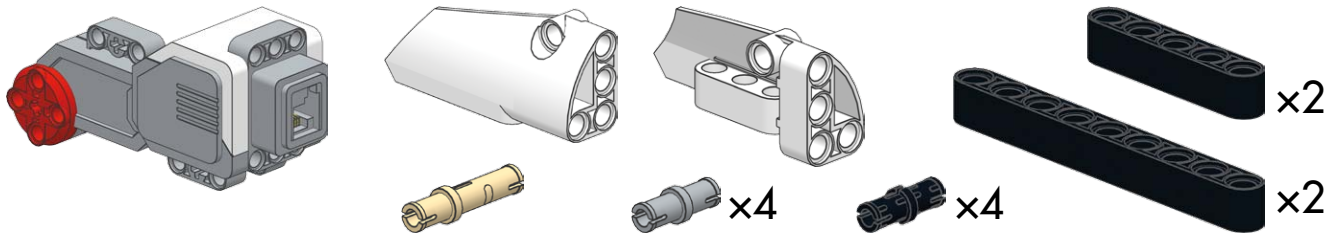


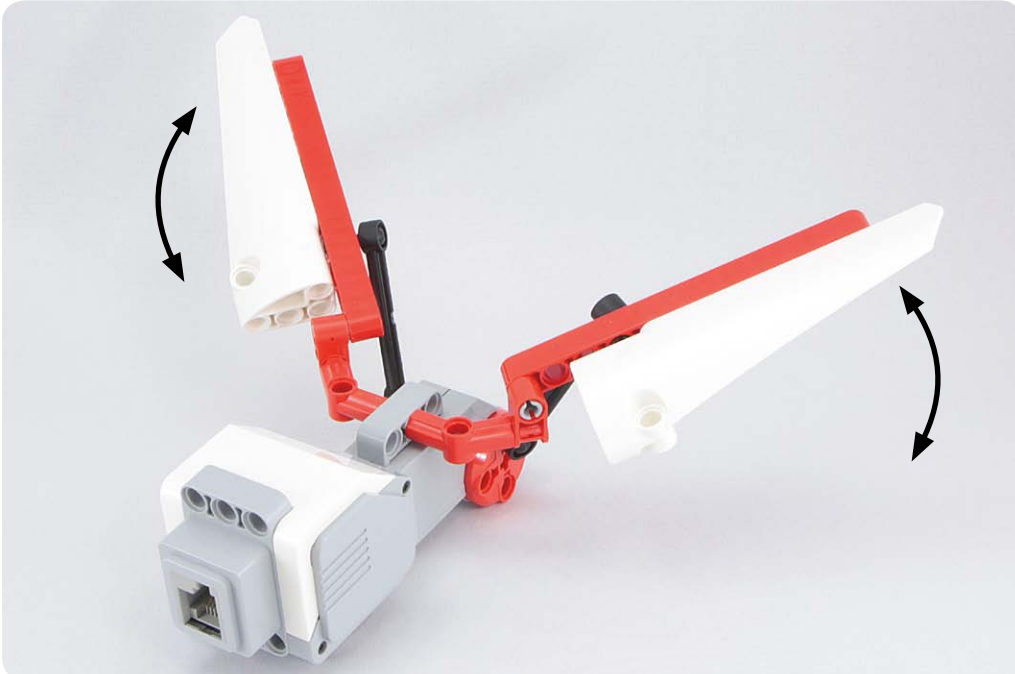
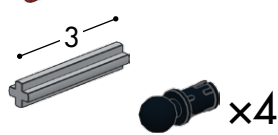
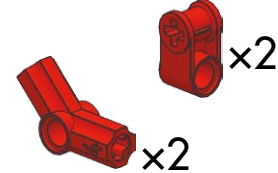
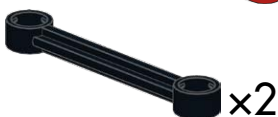
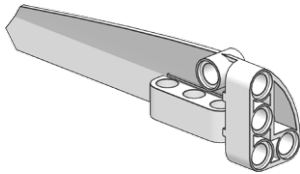
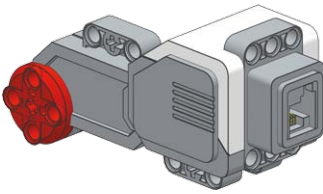
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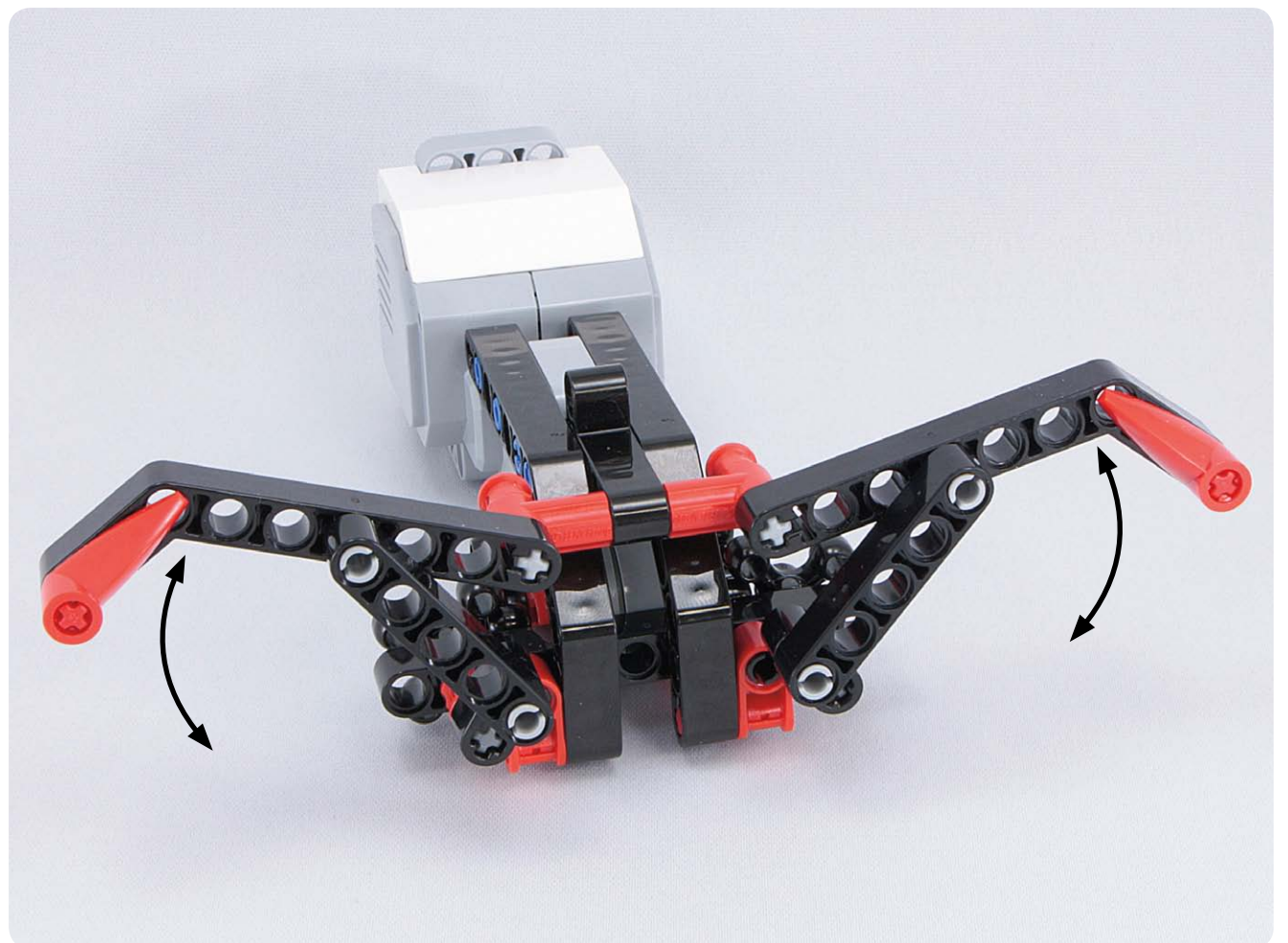
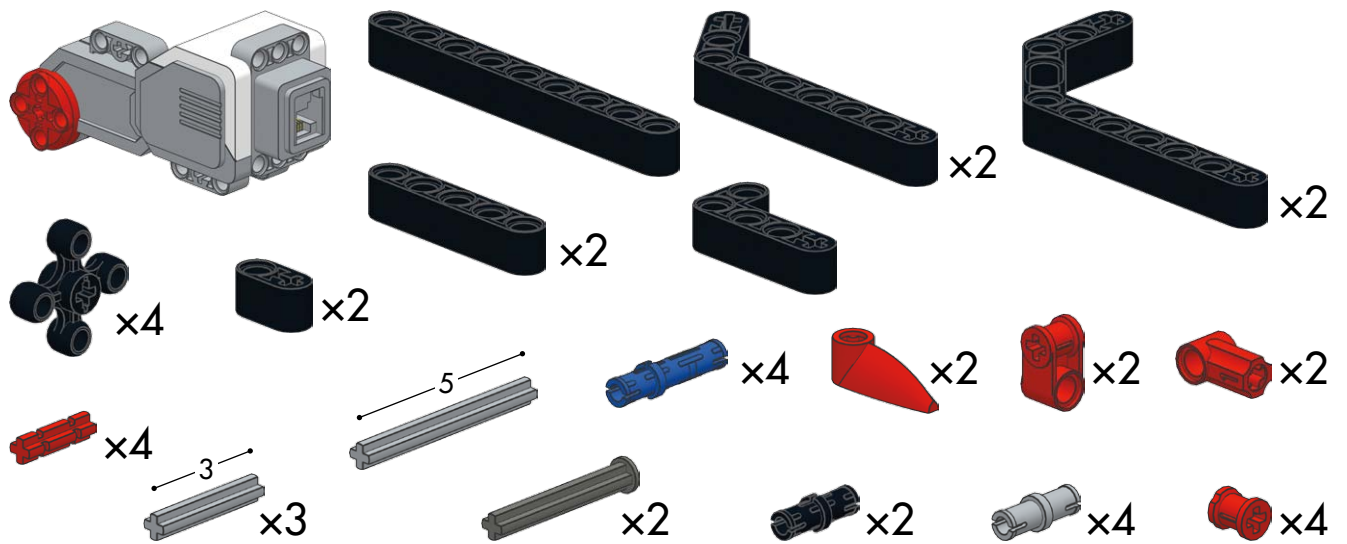


Flapping wings

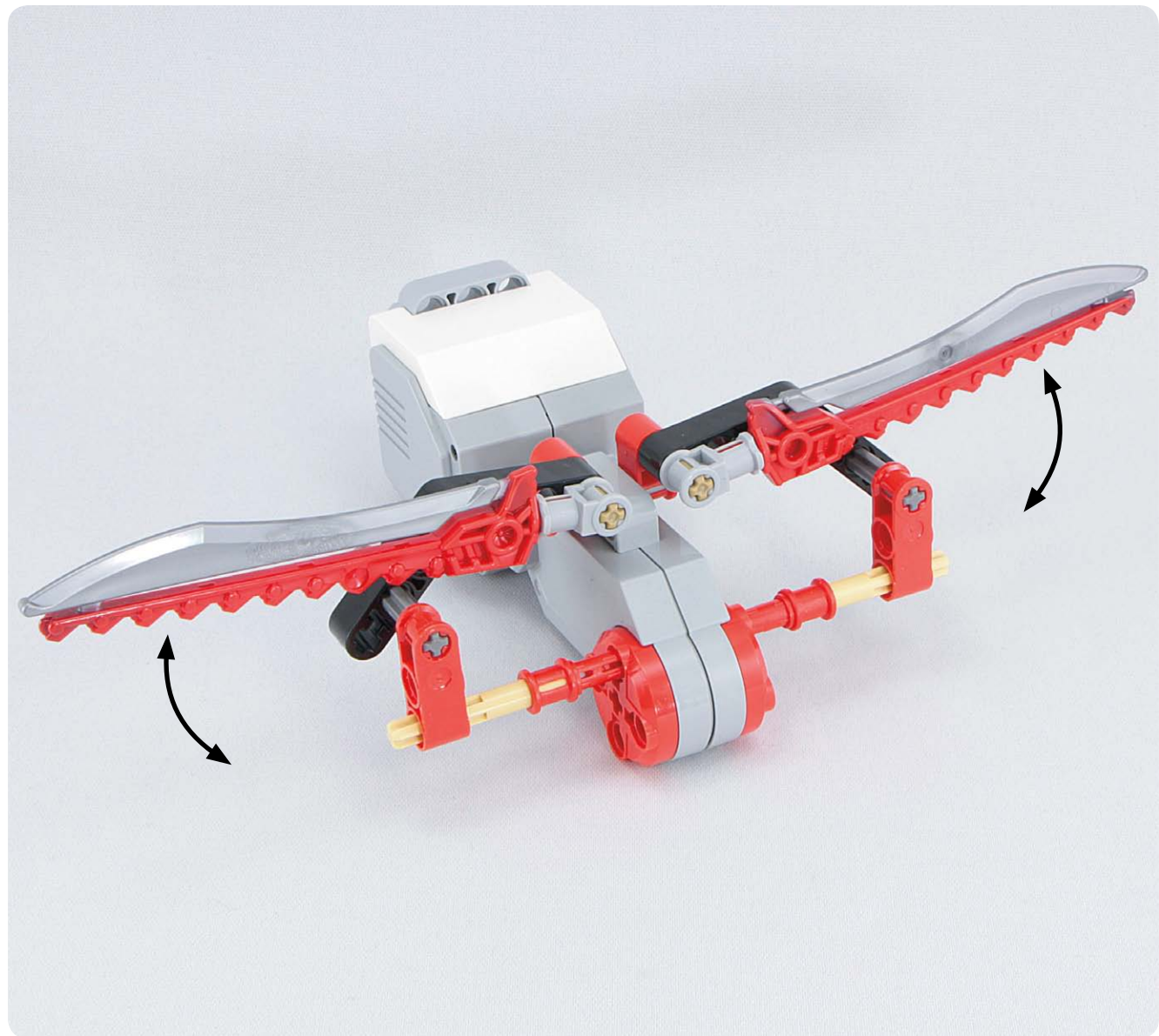
#129

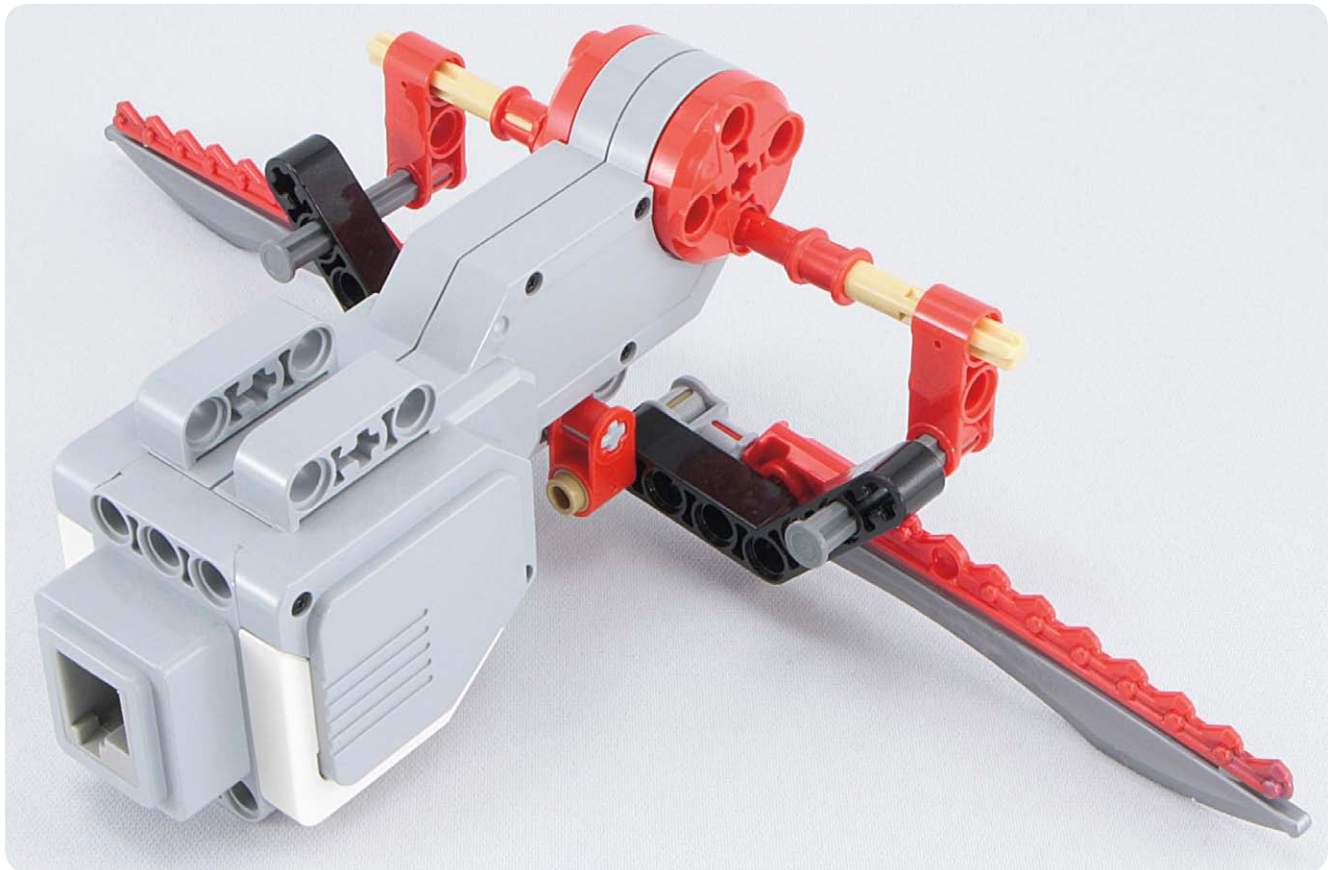




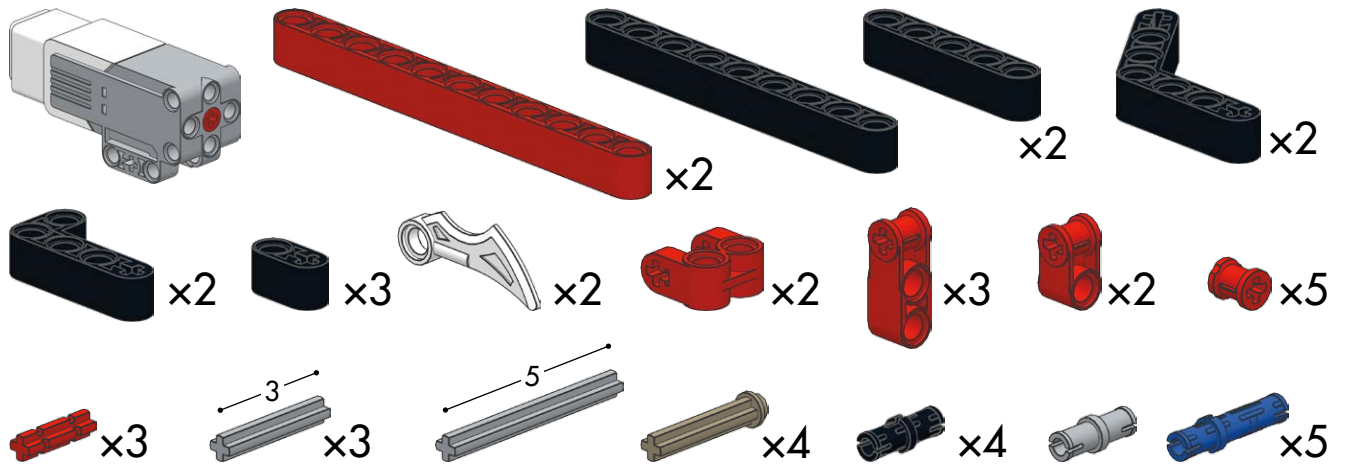


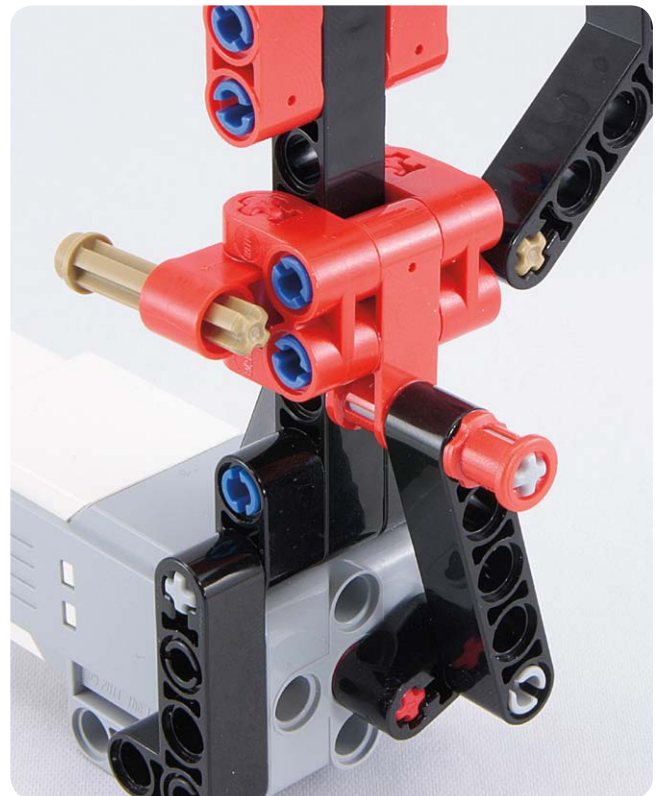
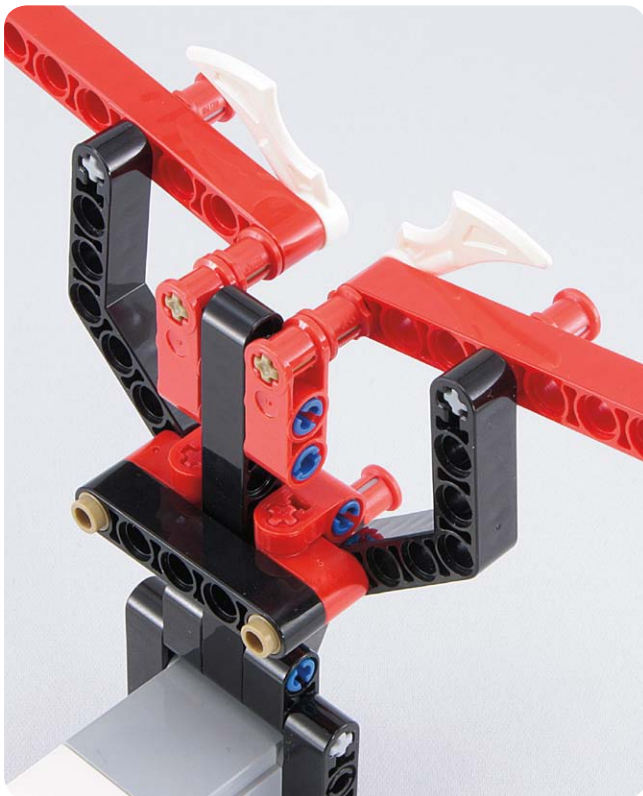


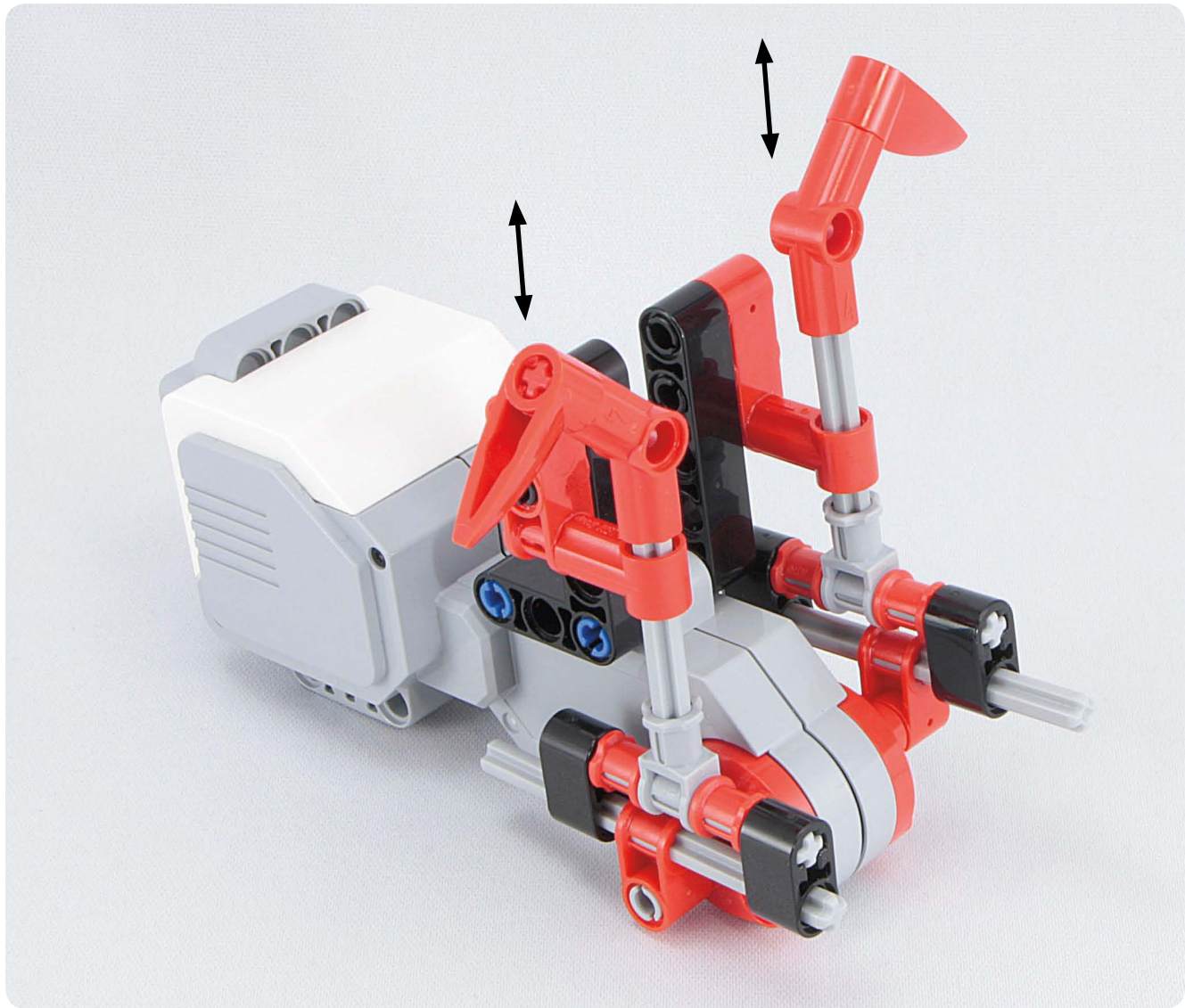


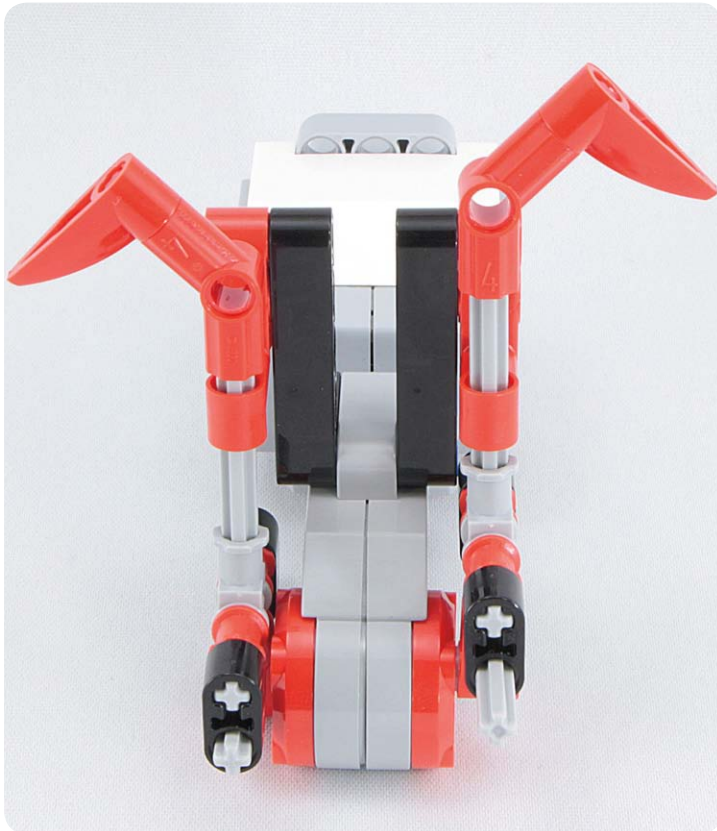
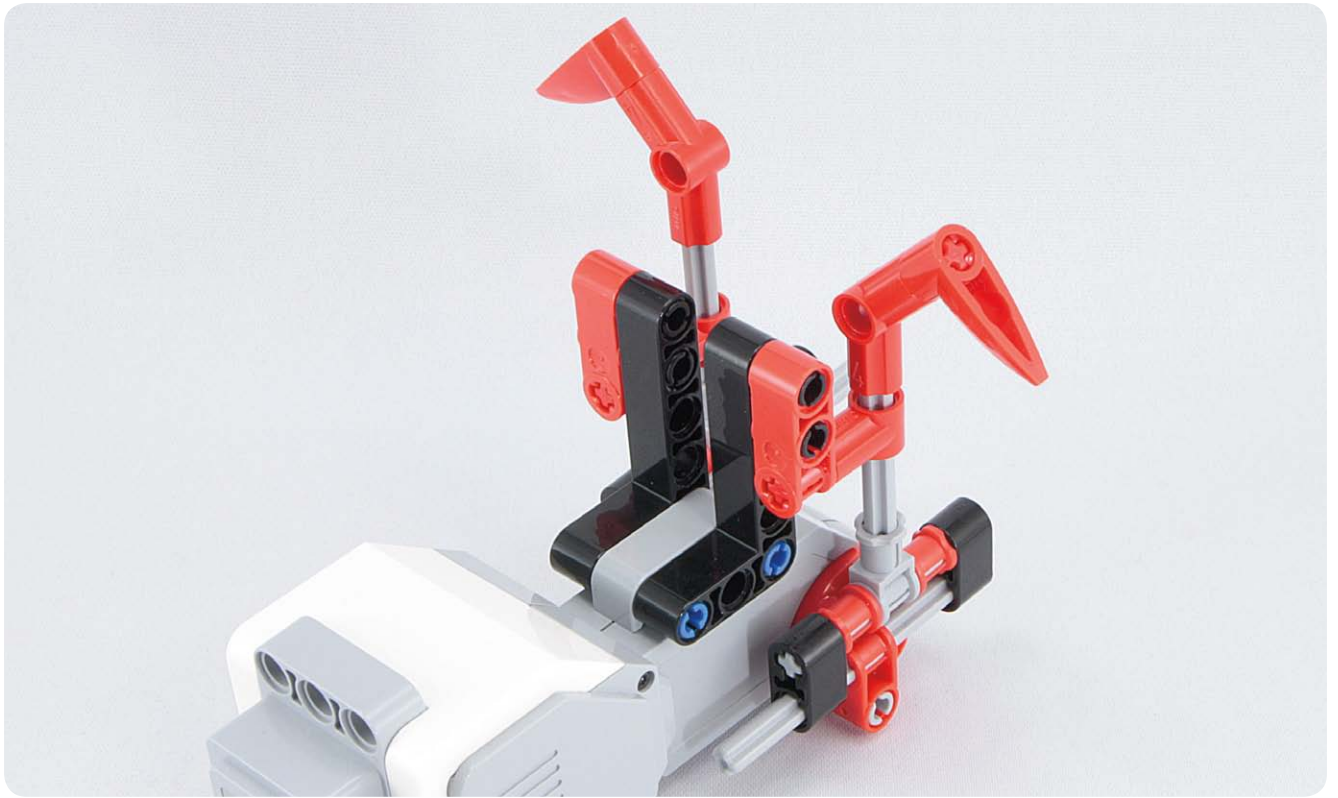


#133





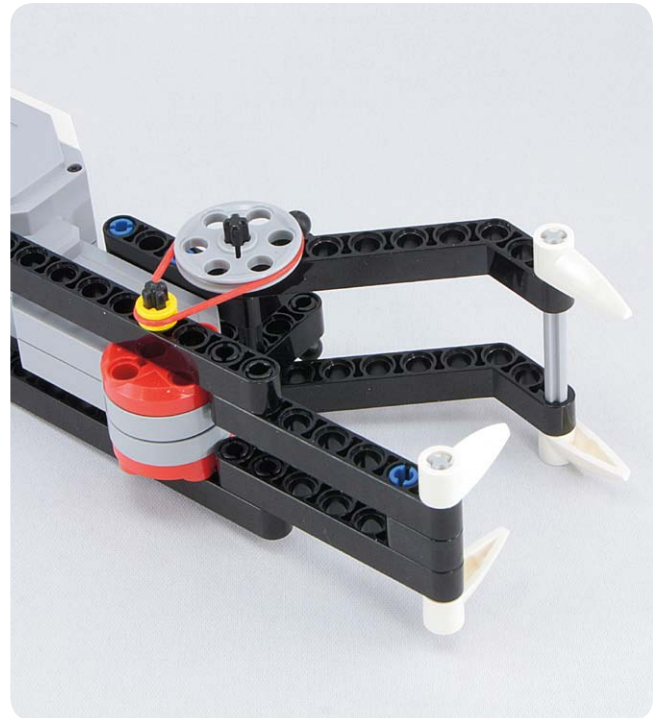
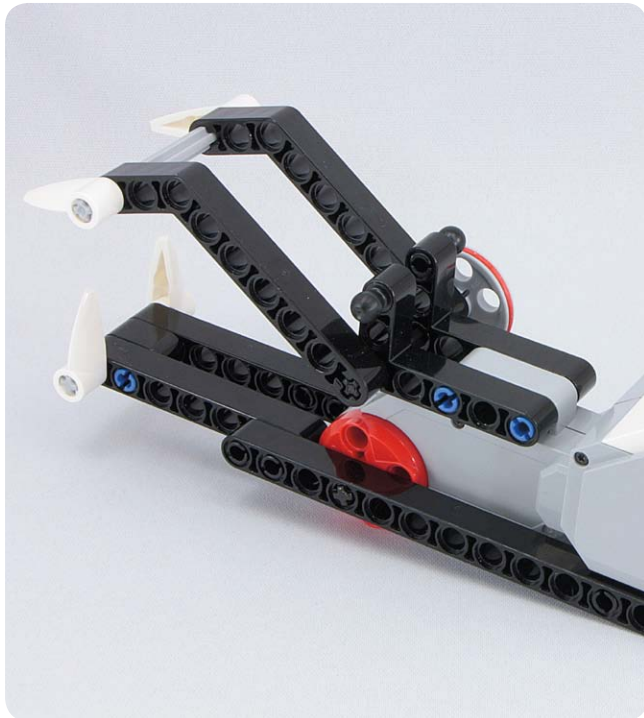
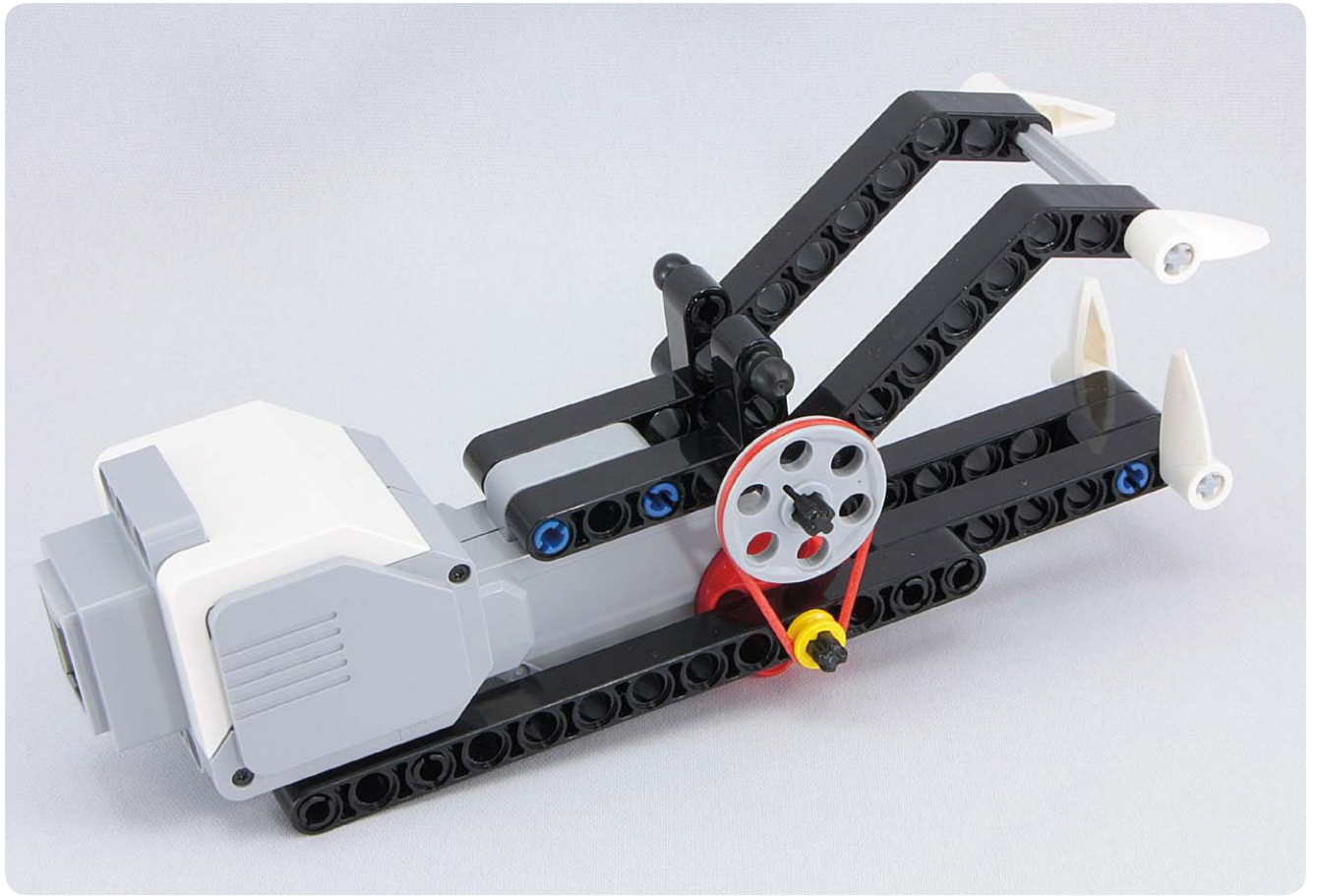


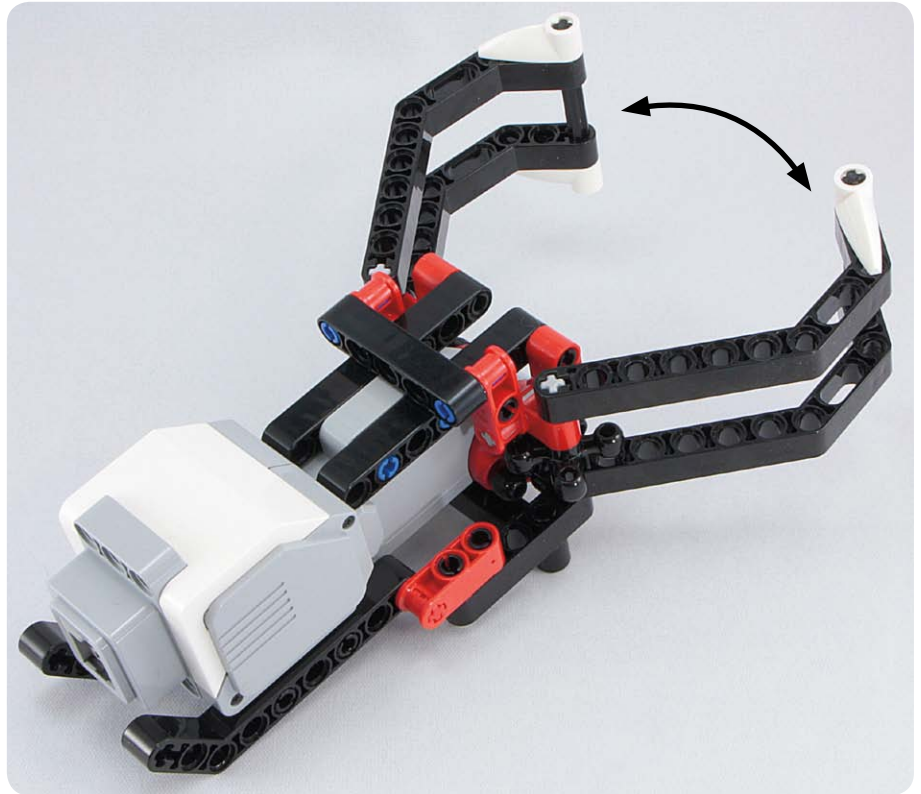
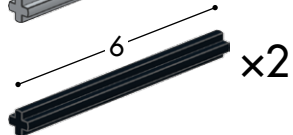
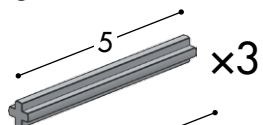
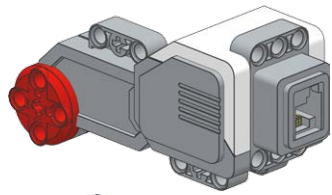


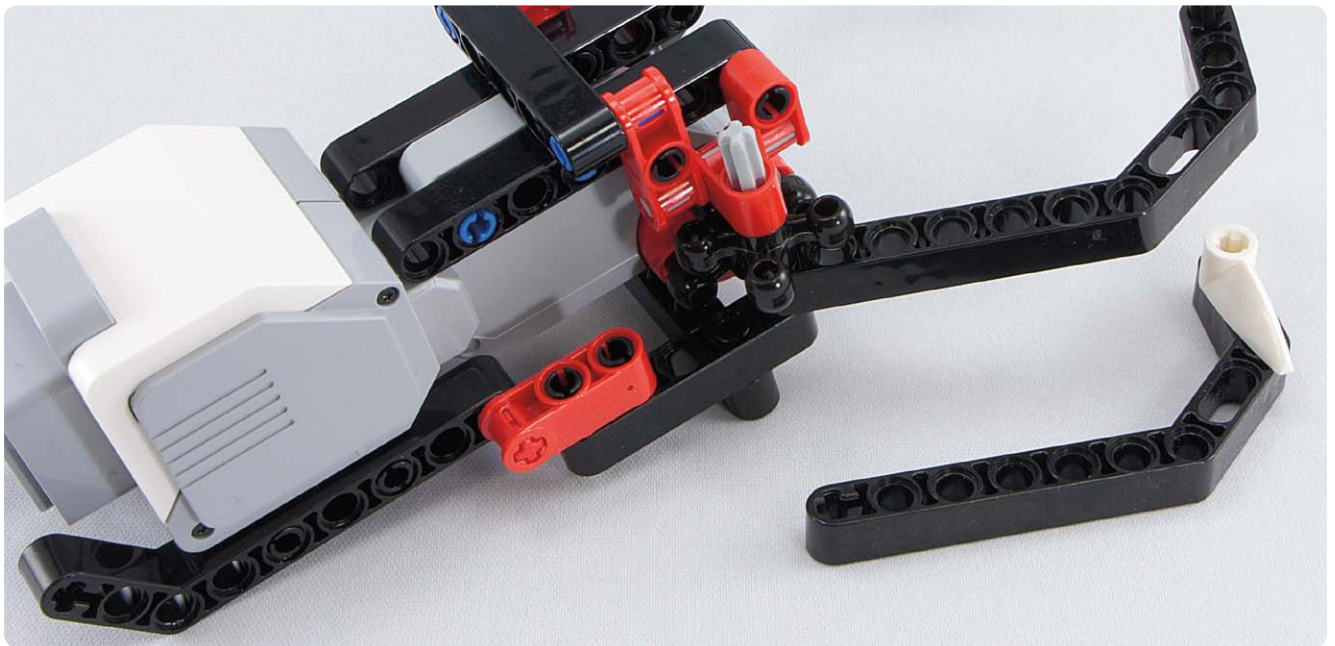
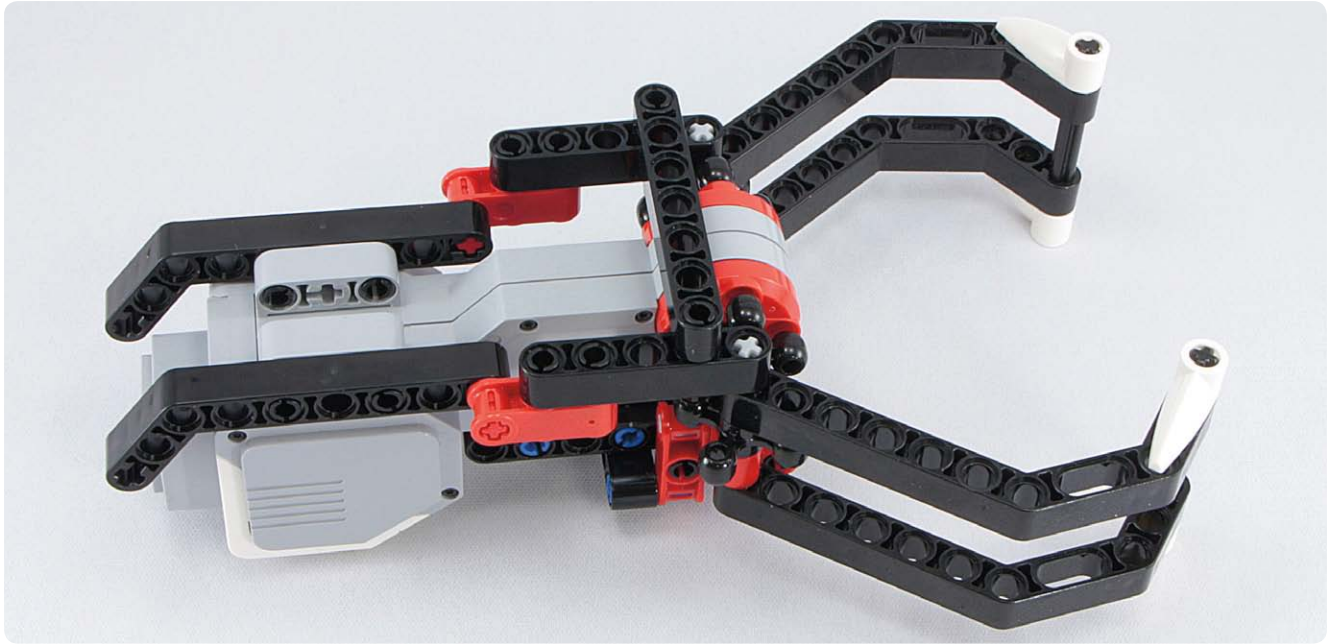


1x Motor (grey and white)
 2x Black 1x Technic Beam
 2x Black 2x Technic Beam
 2x Black L-shaped 1x3 Technic Beam
 1x Red Rubber Band
 2x Black L-shaped 1x3 Technic Beam
 1x Yellow Pin
 1x Grey Wheel
 4x White Funnel
 5x Grey 1x Technic Axle
 3x Blue Pin
 6x Black 1x Technic Axle
 2x Black Pin
 7x Grey 1x Technic Axle
 2x Black Pin
 8x Black Pin

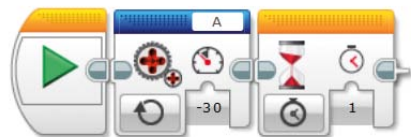


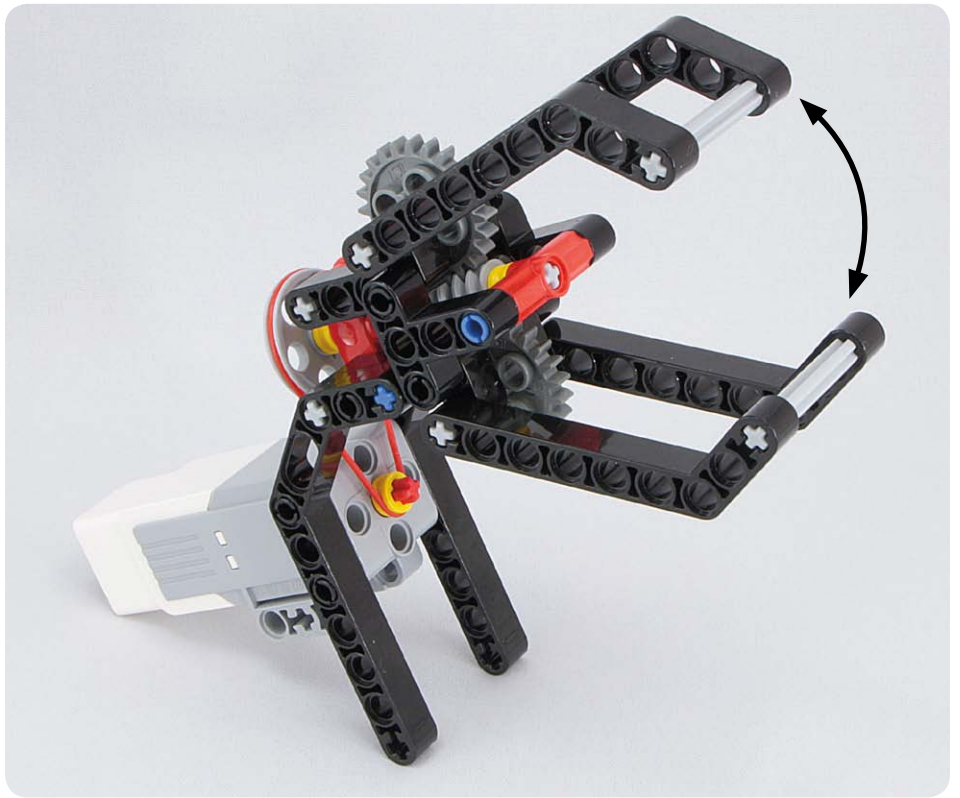
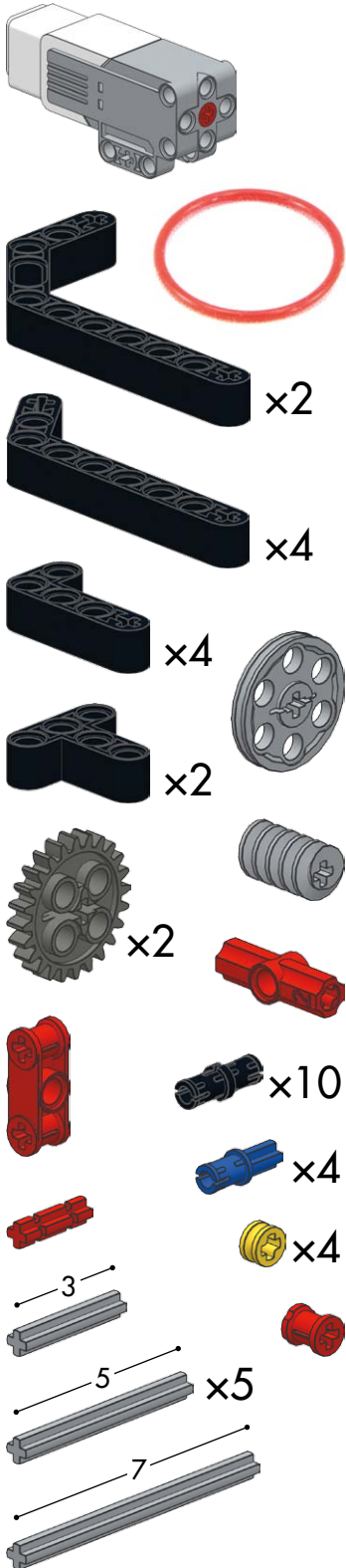


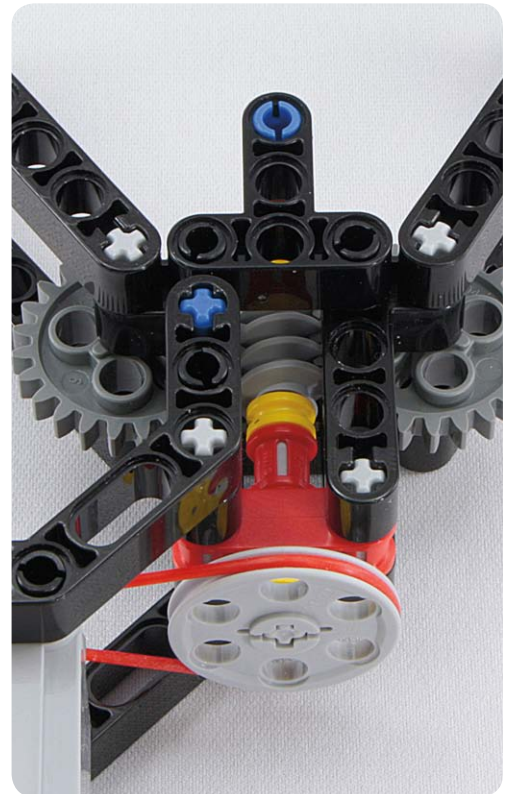


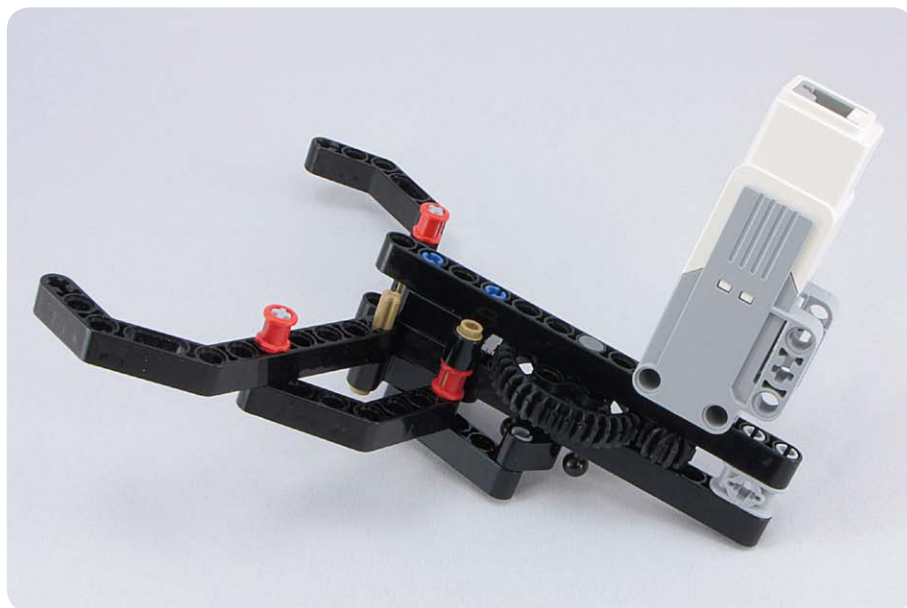
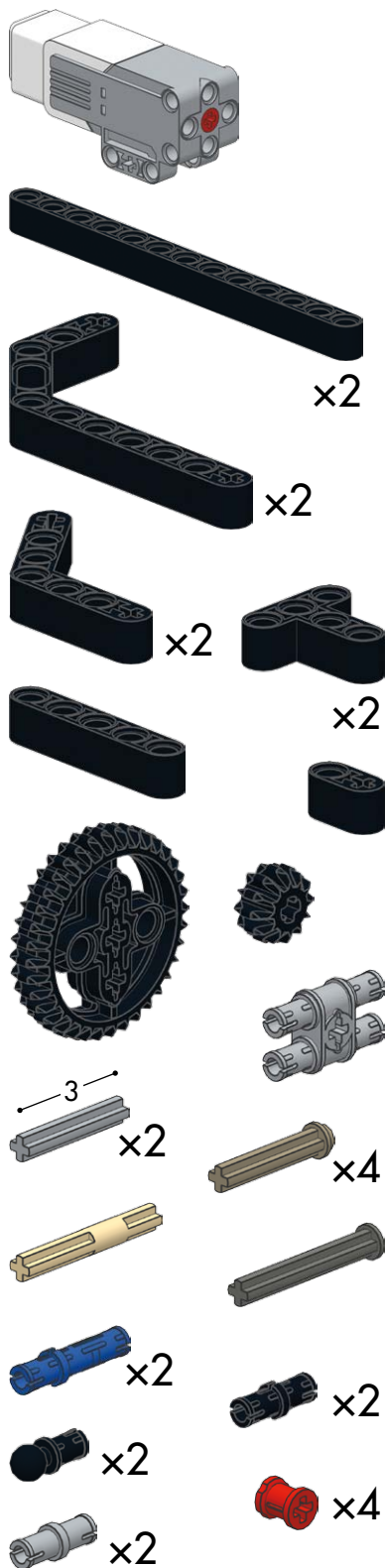


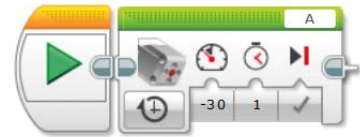
To avoid overextending the mechanism,
use this program instead of the standard one.



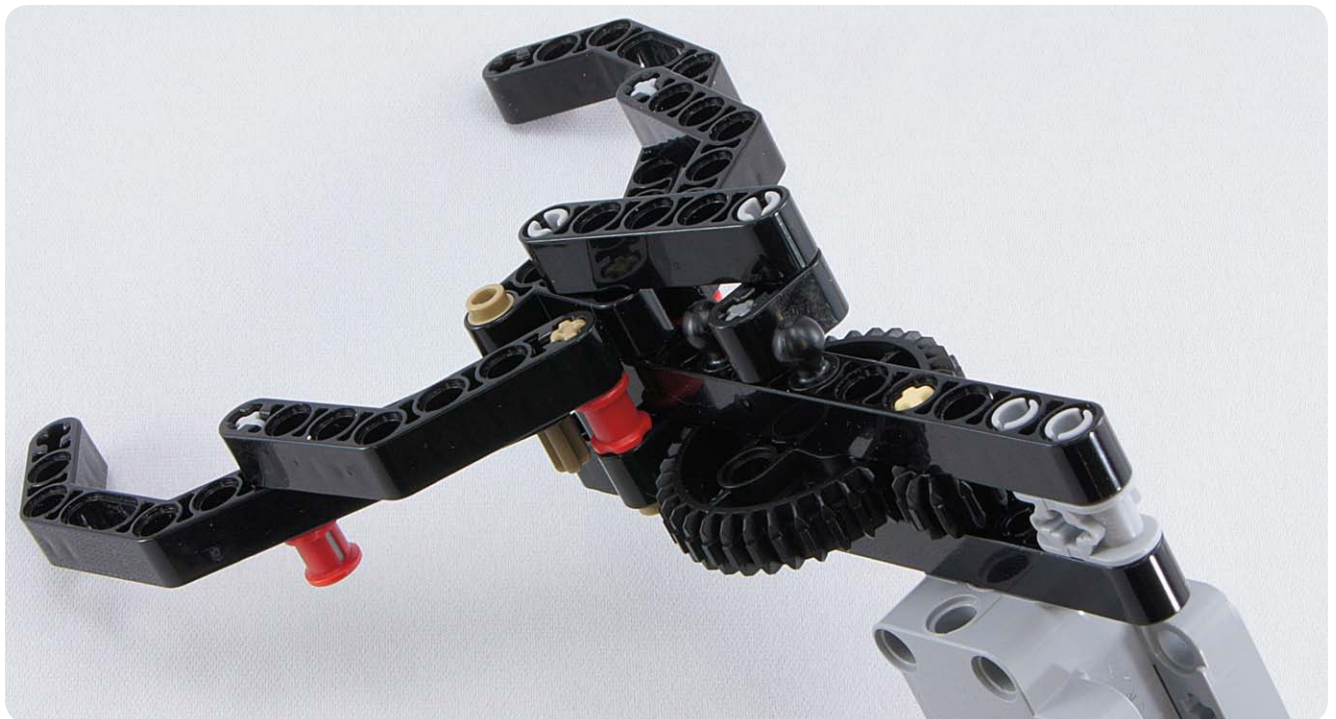
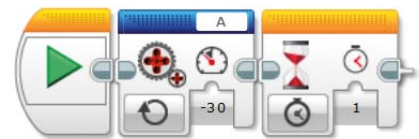


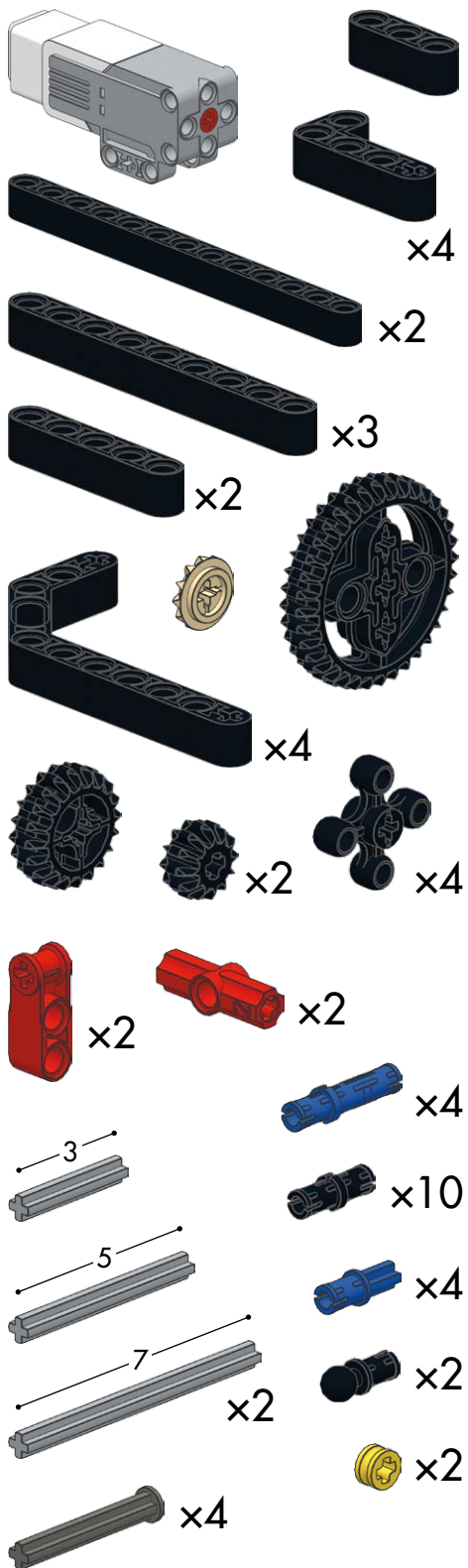


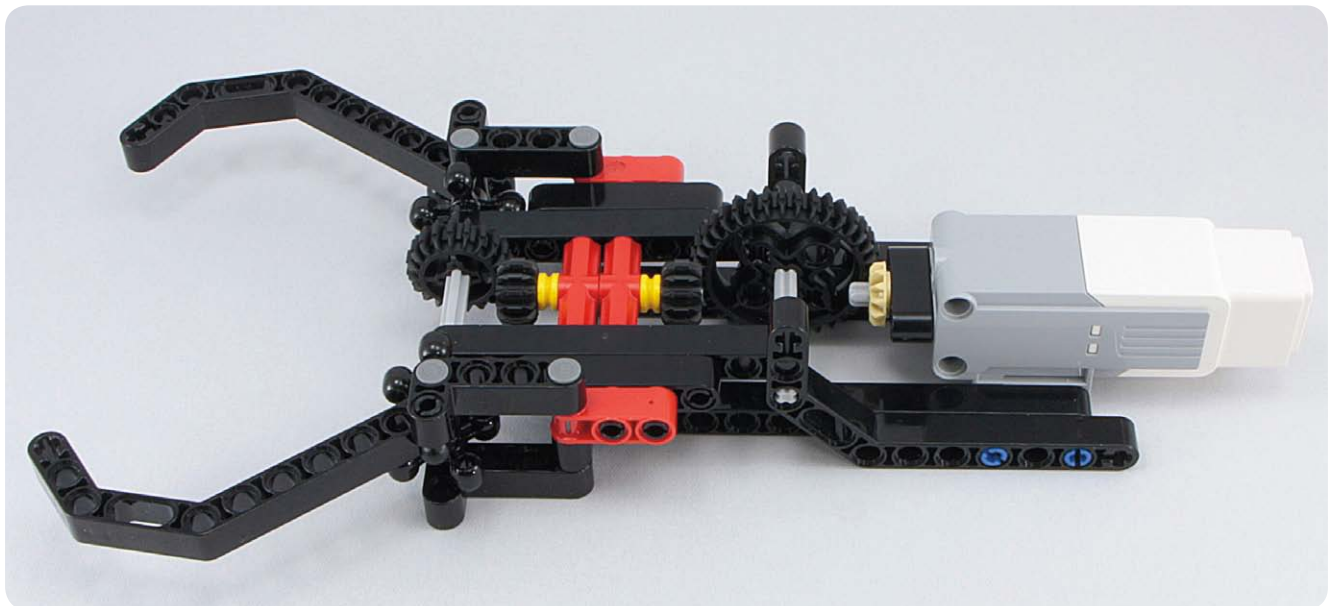
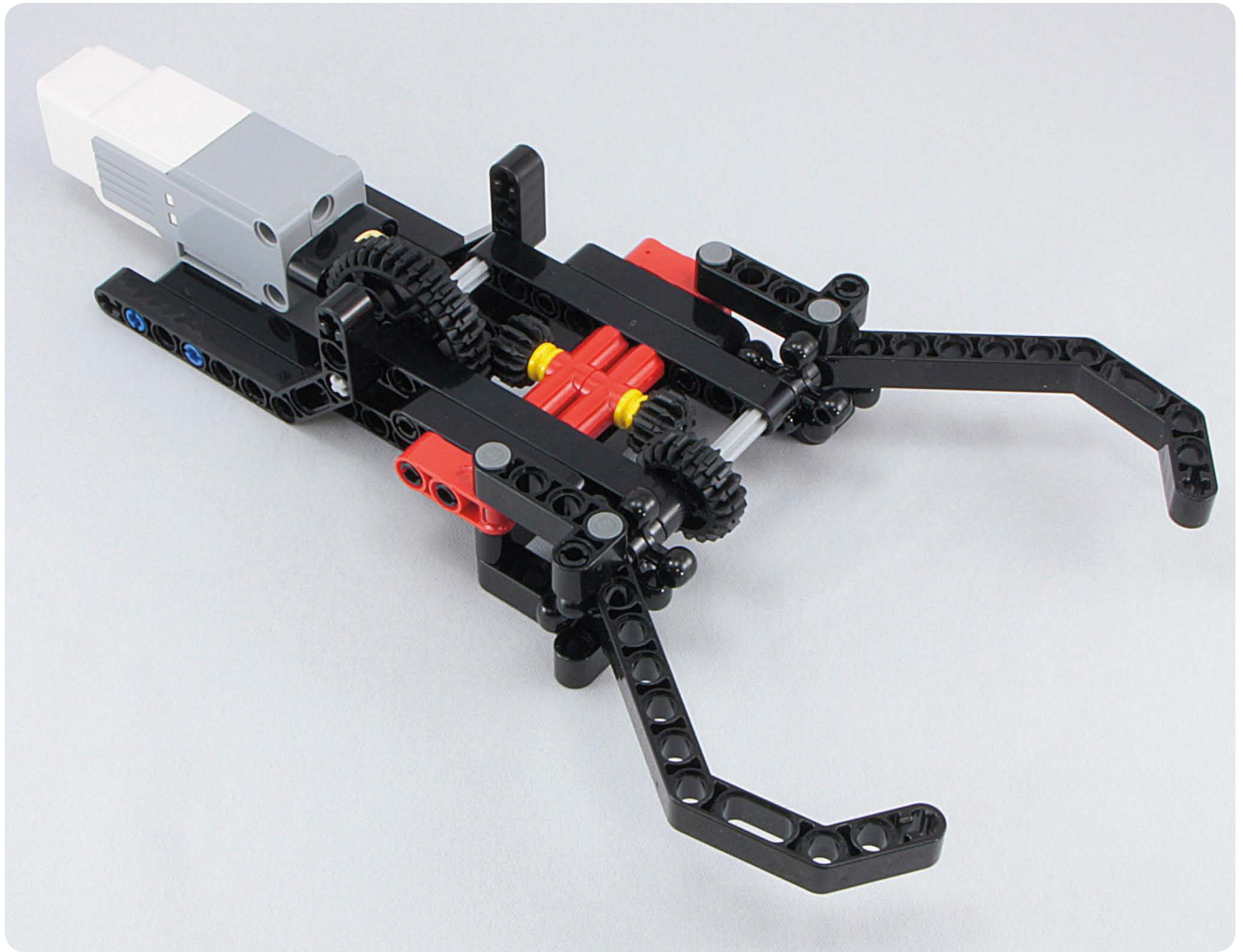




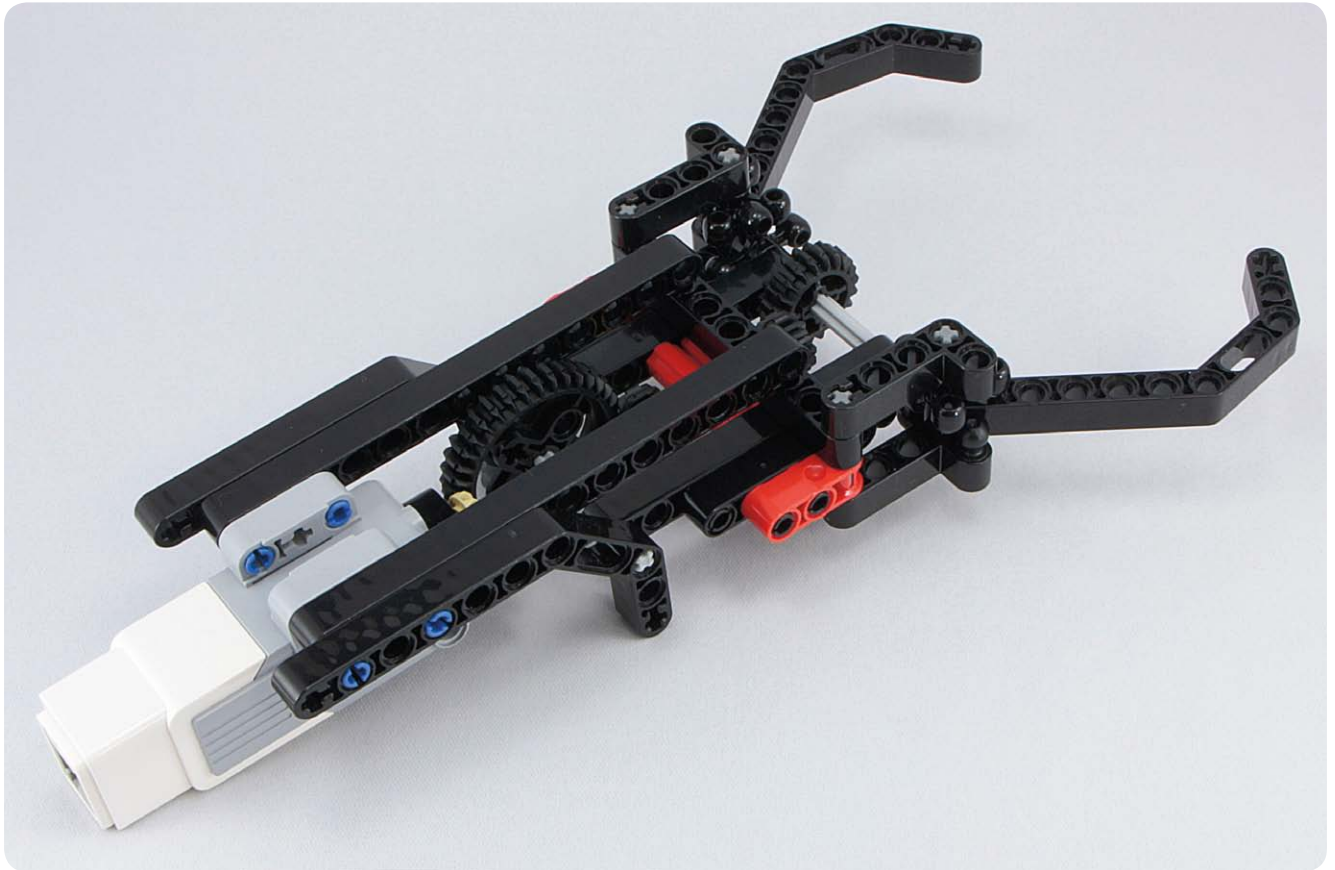
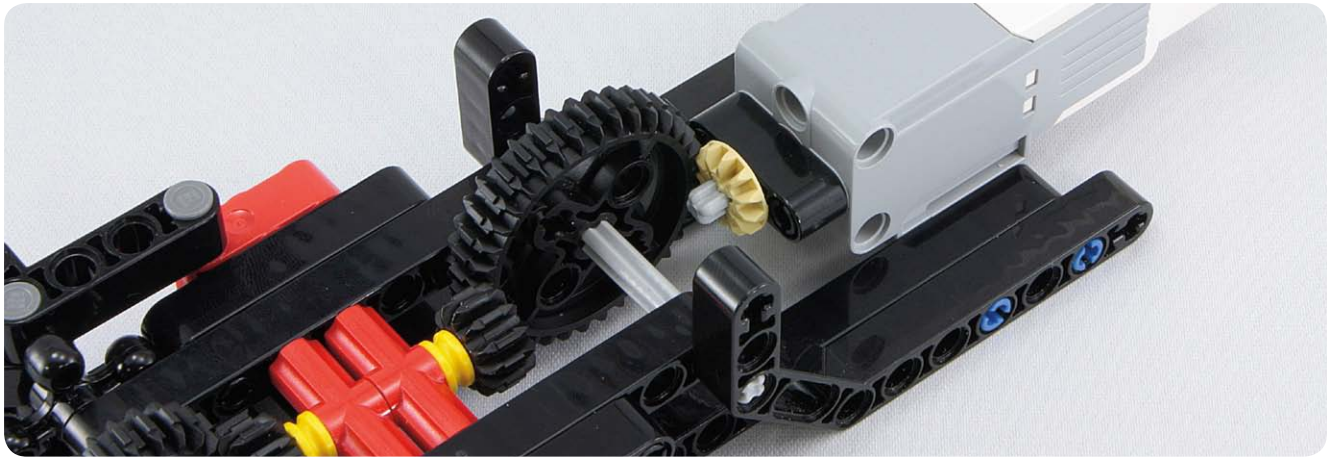
To avoid overextending the mechanism, use this program instead of the standard one.





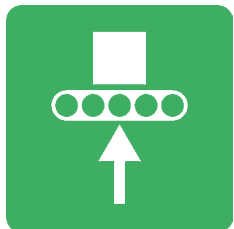






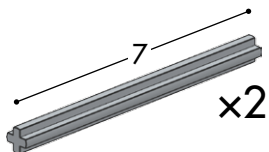
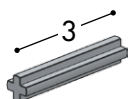
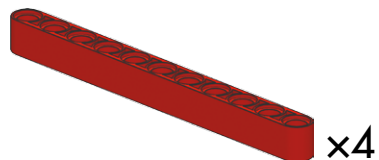
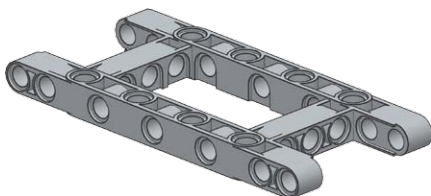
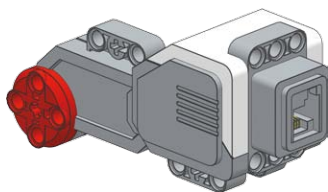
Here's a program
for this arm.

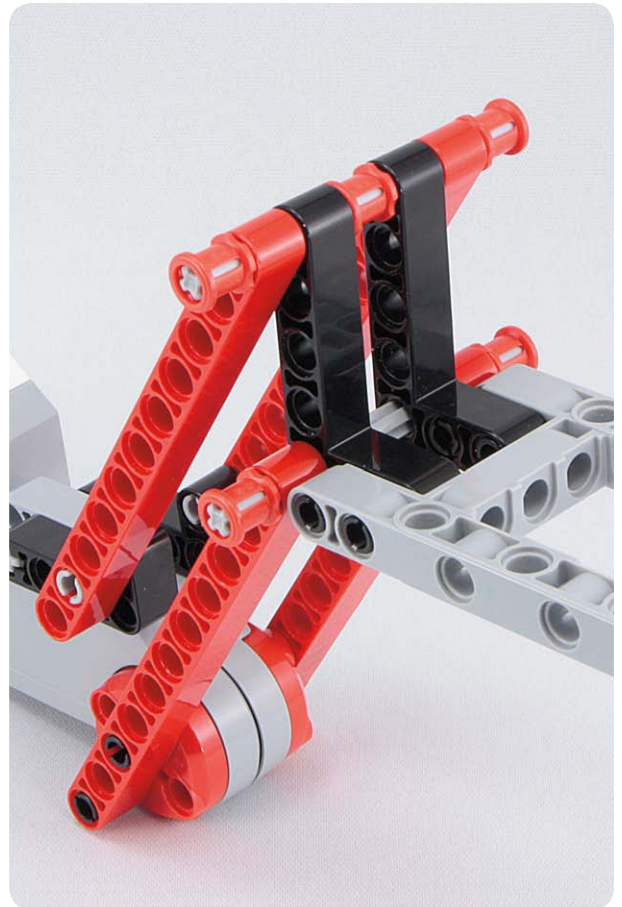
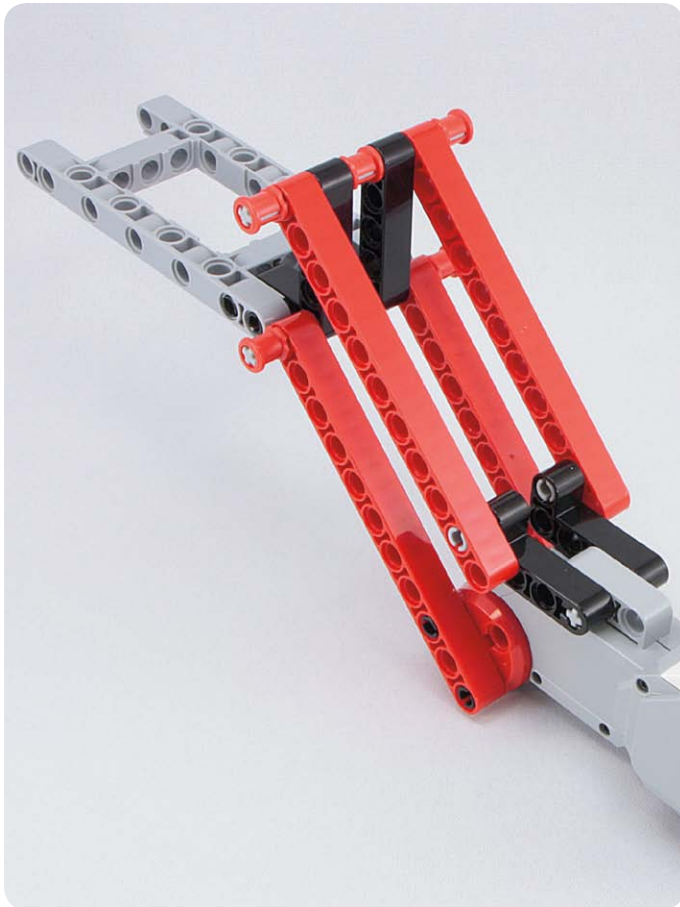
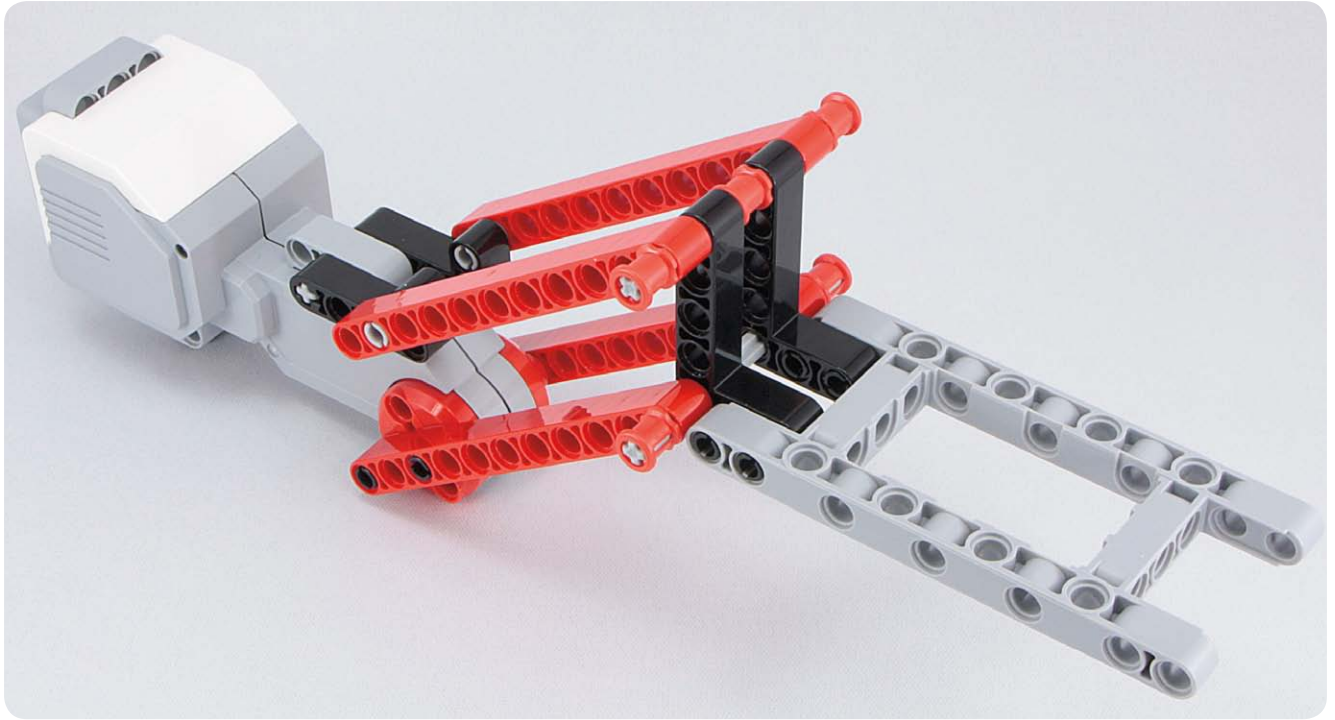


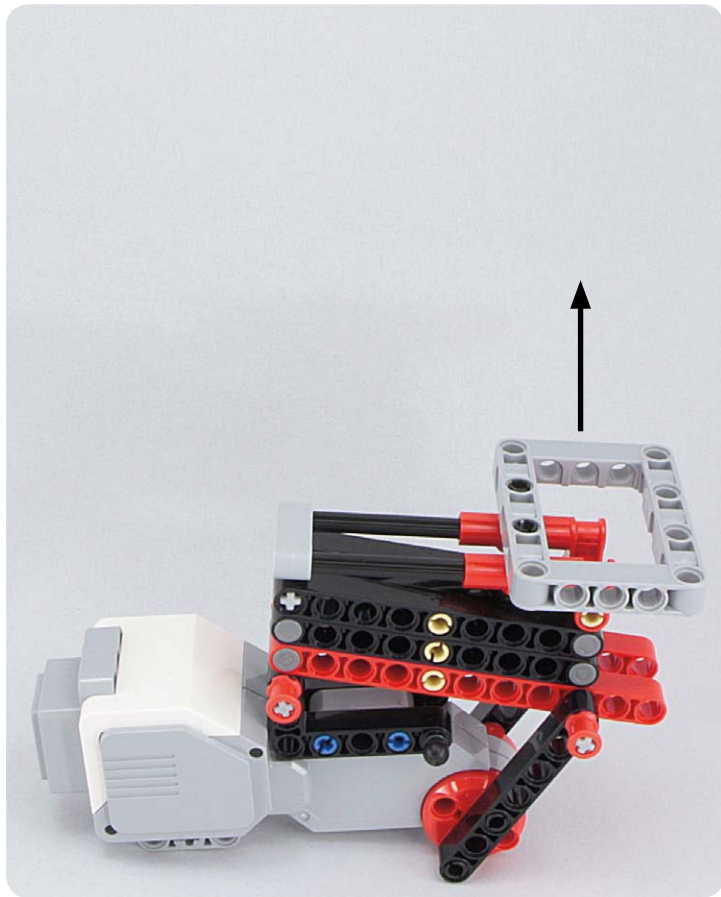


Lifting things

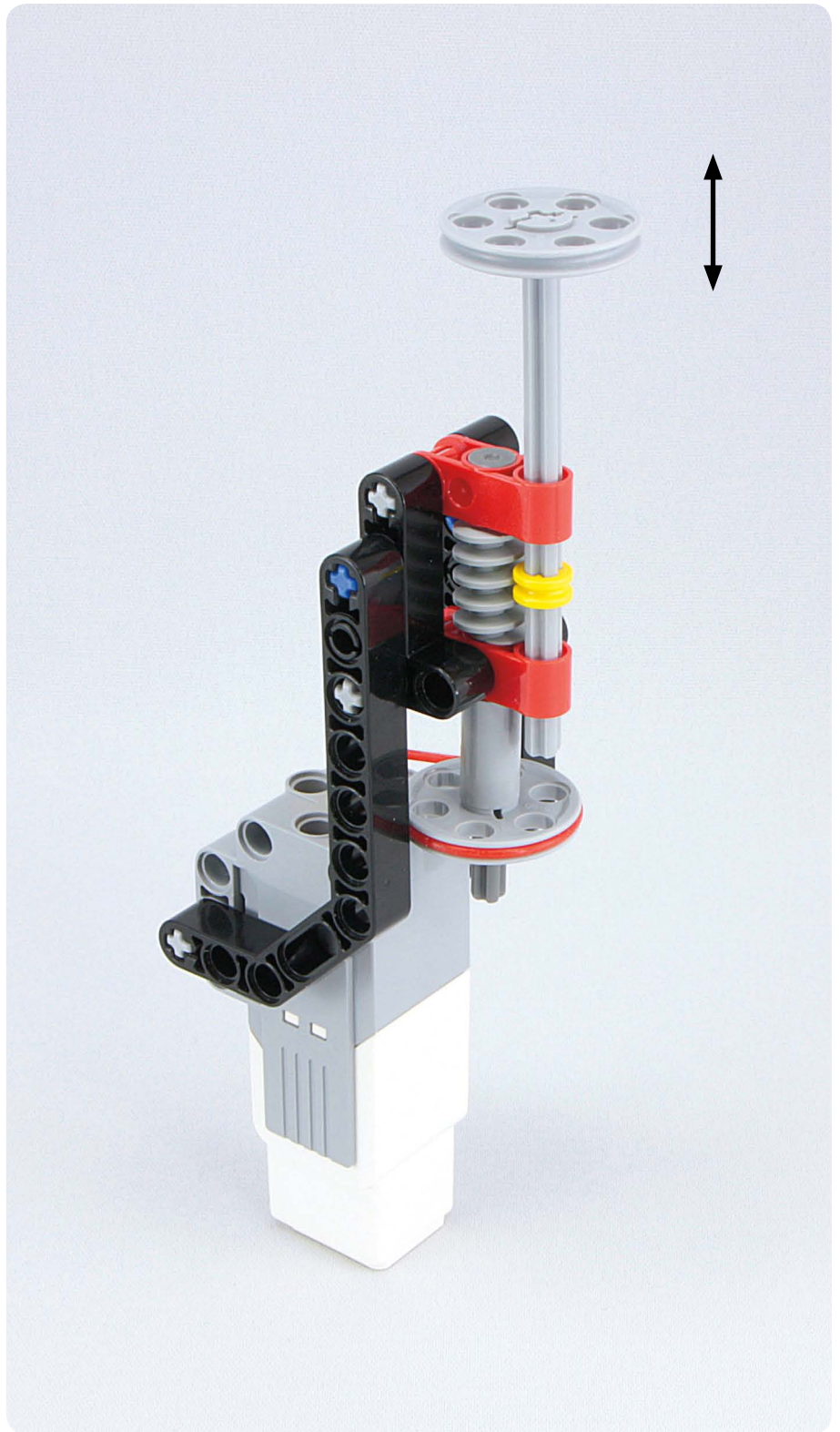
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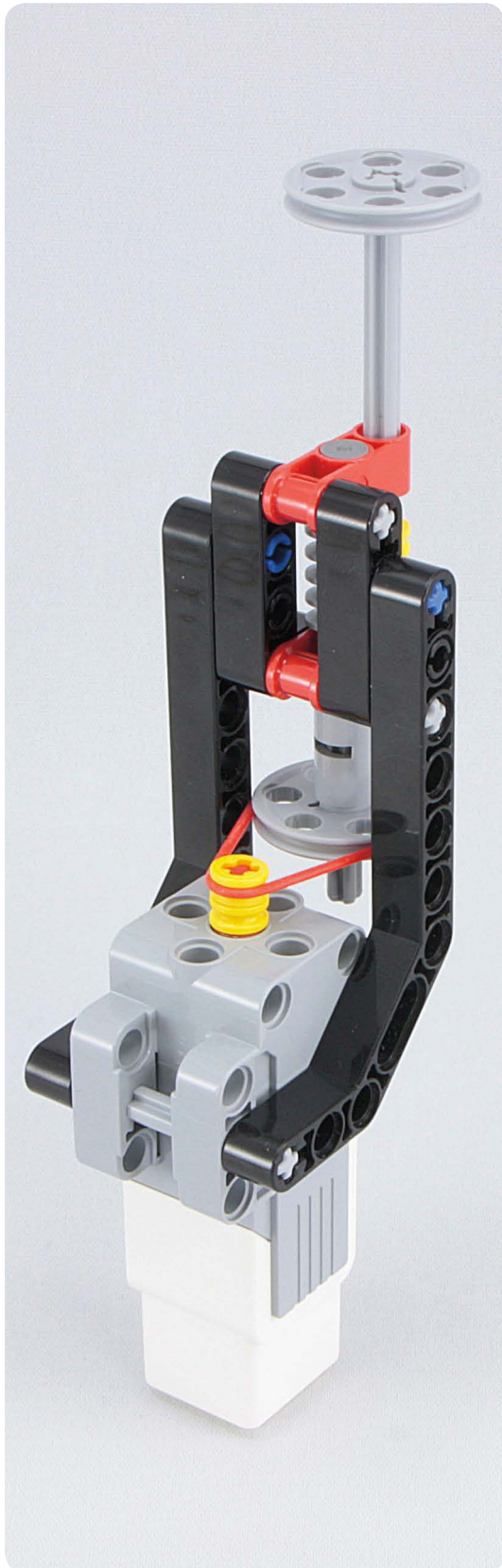




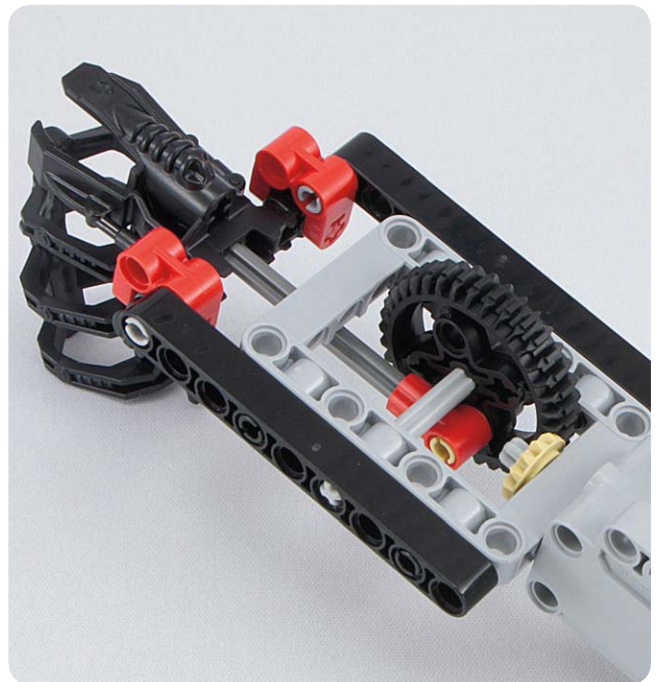
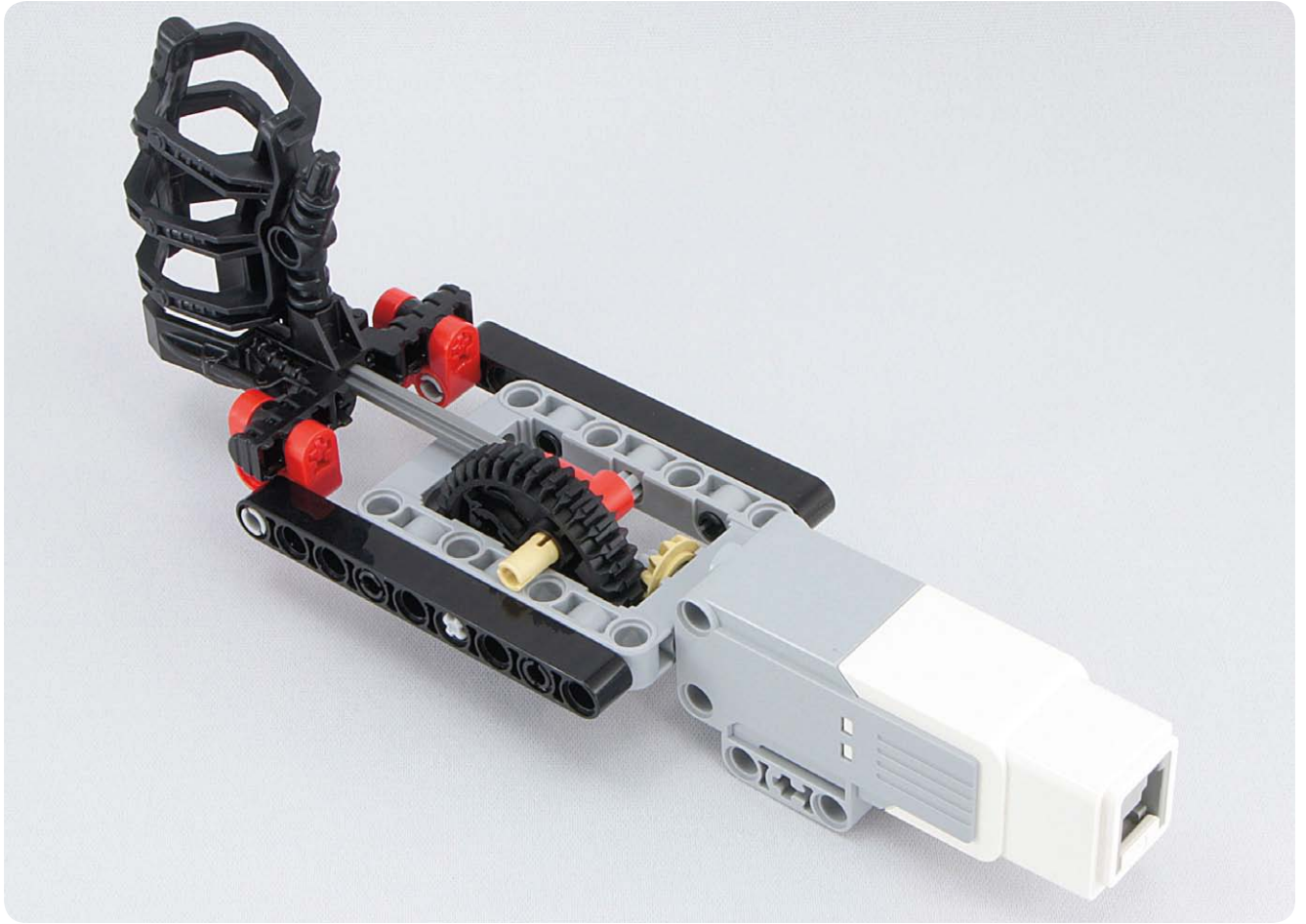


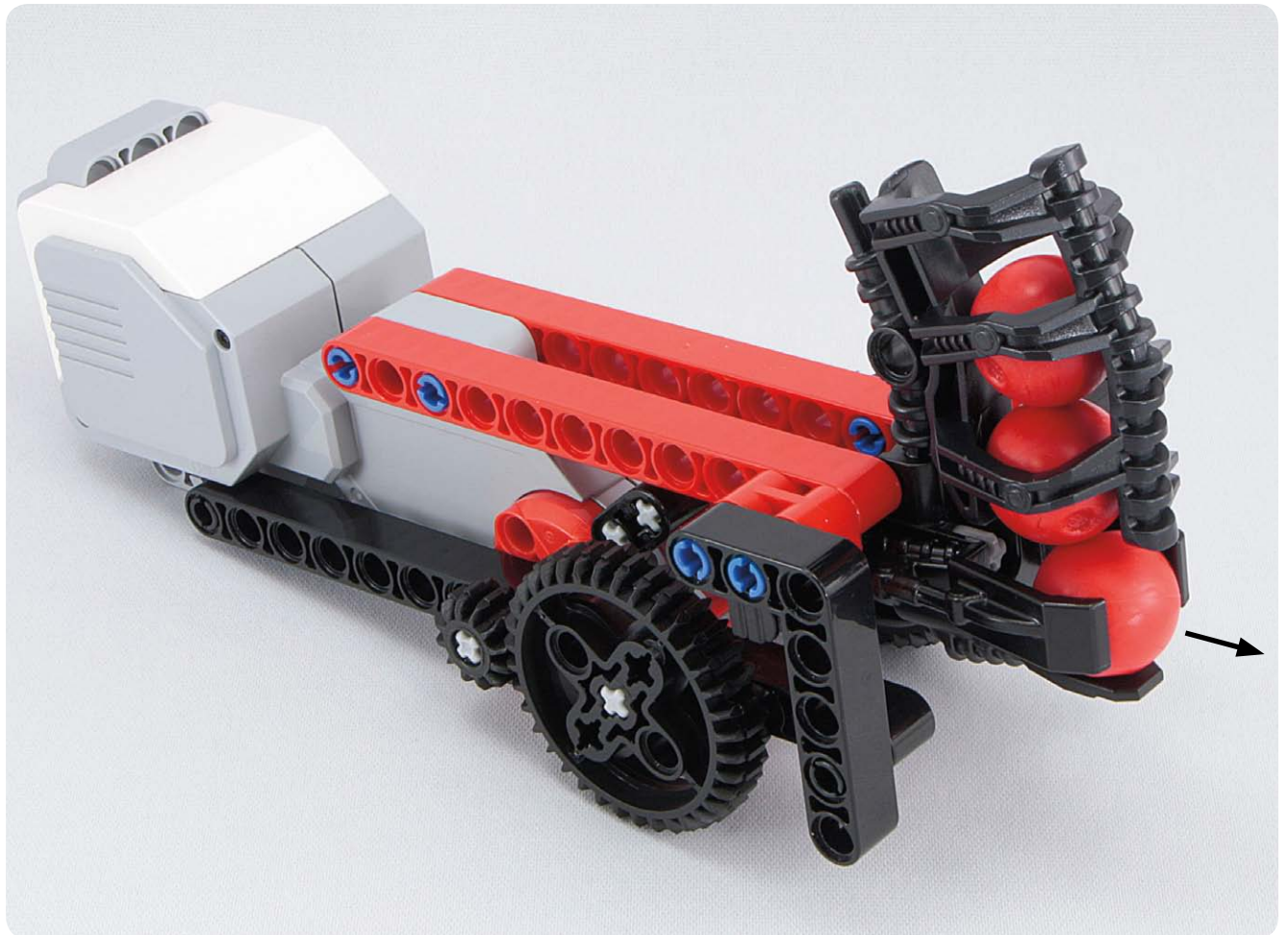
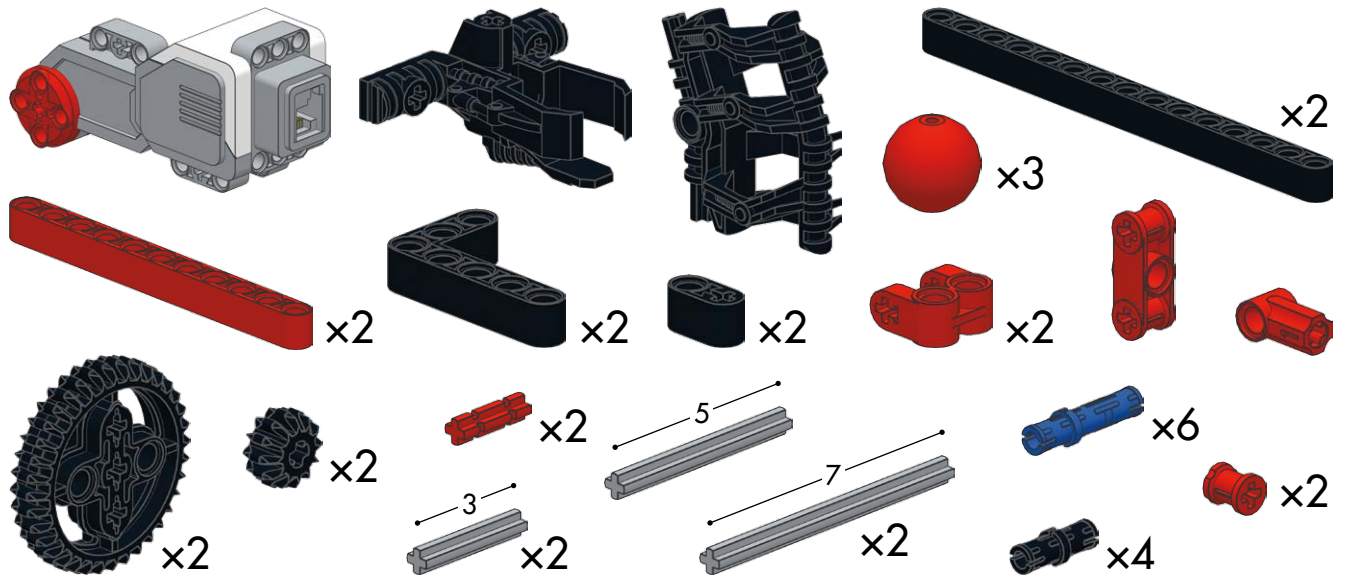


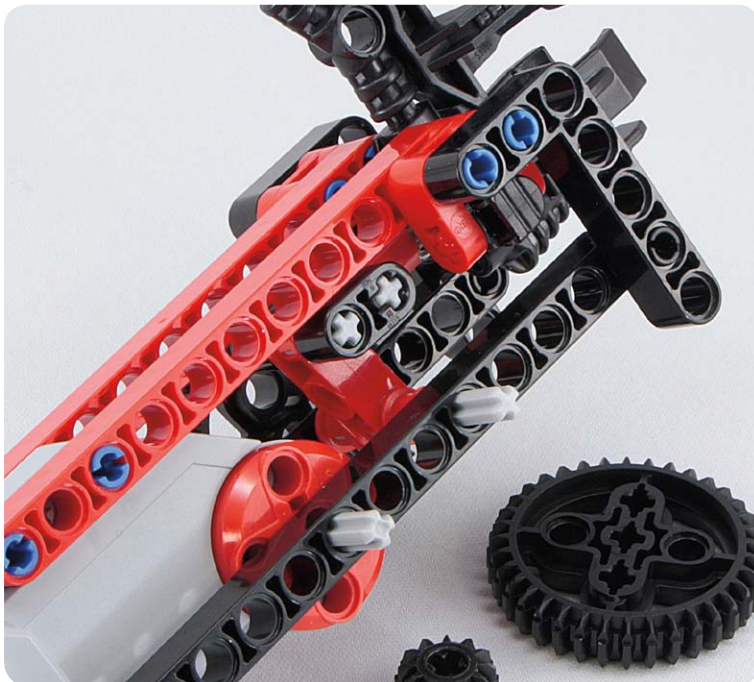
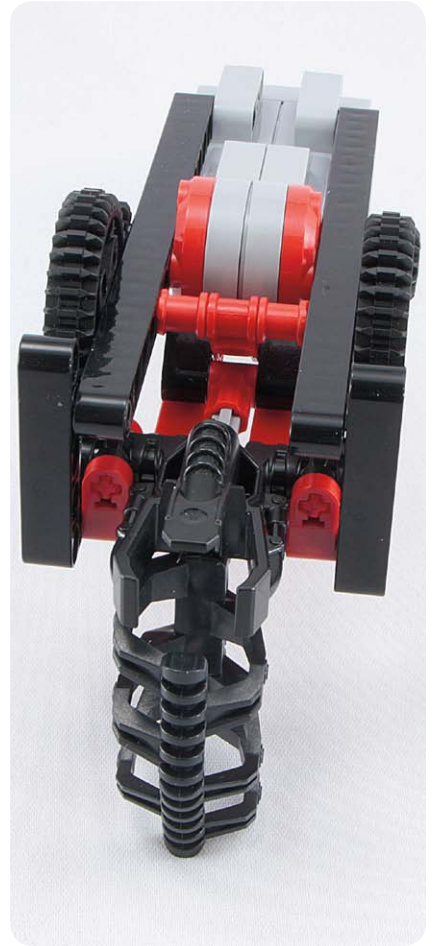
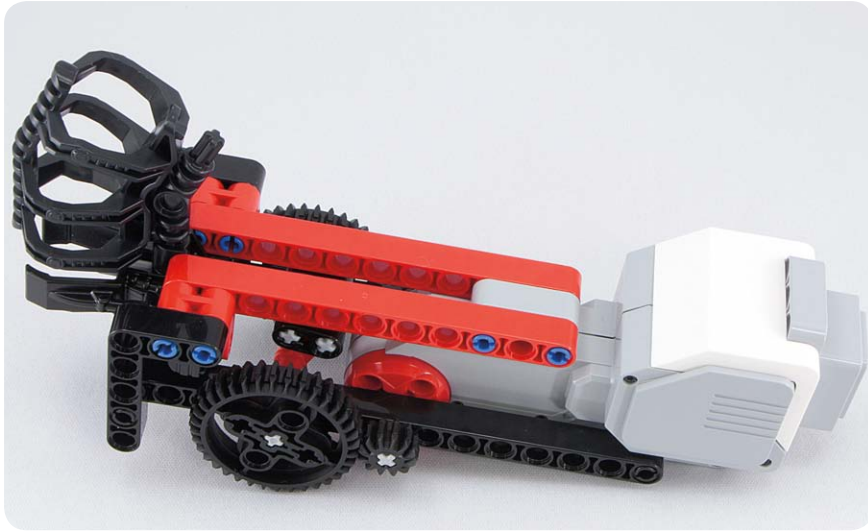


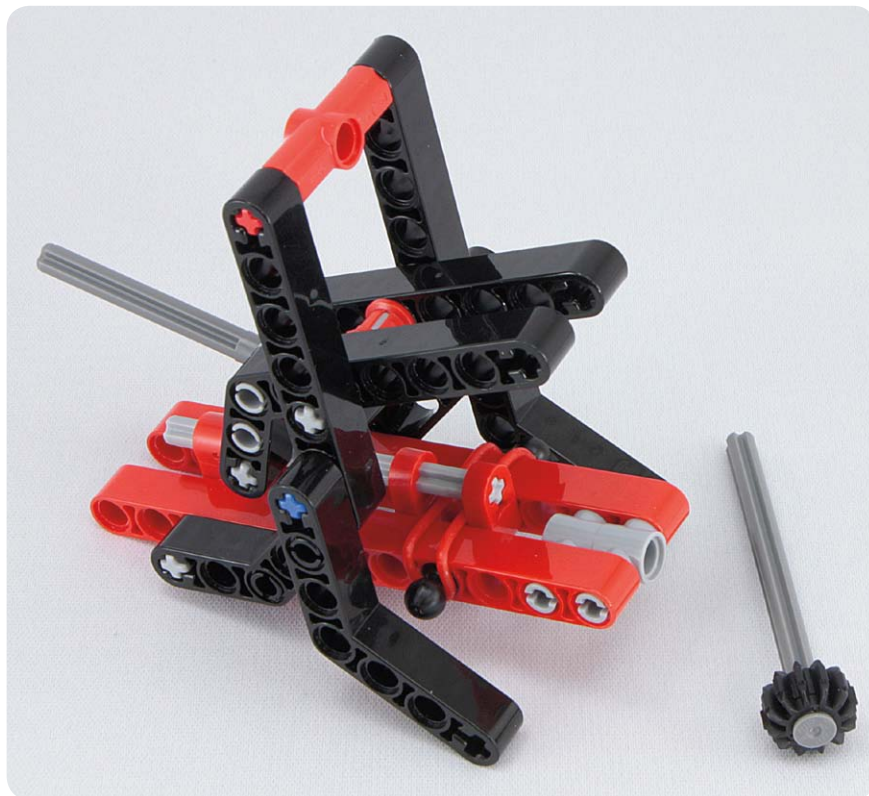
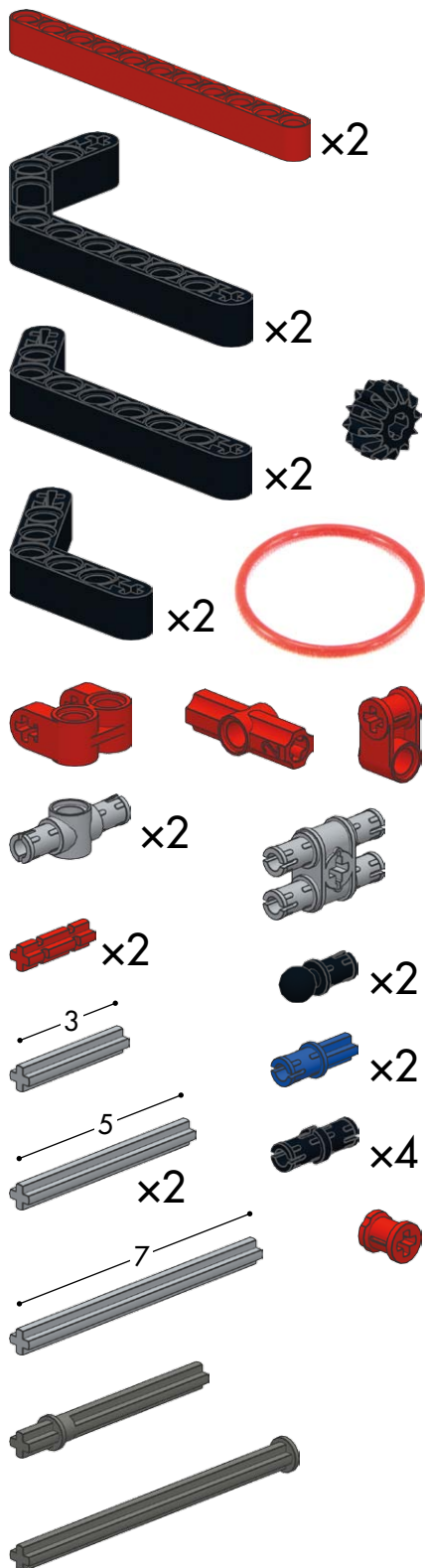


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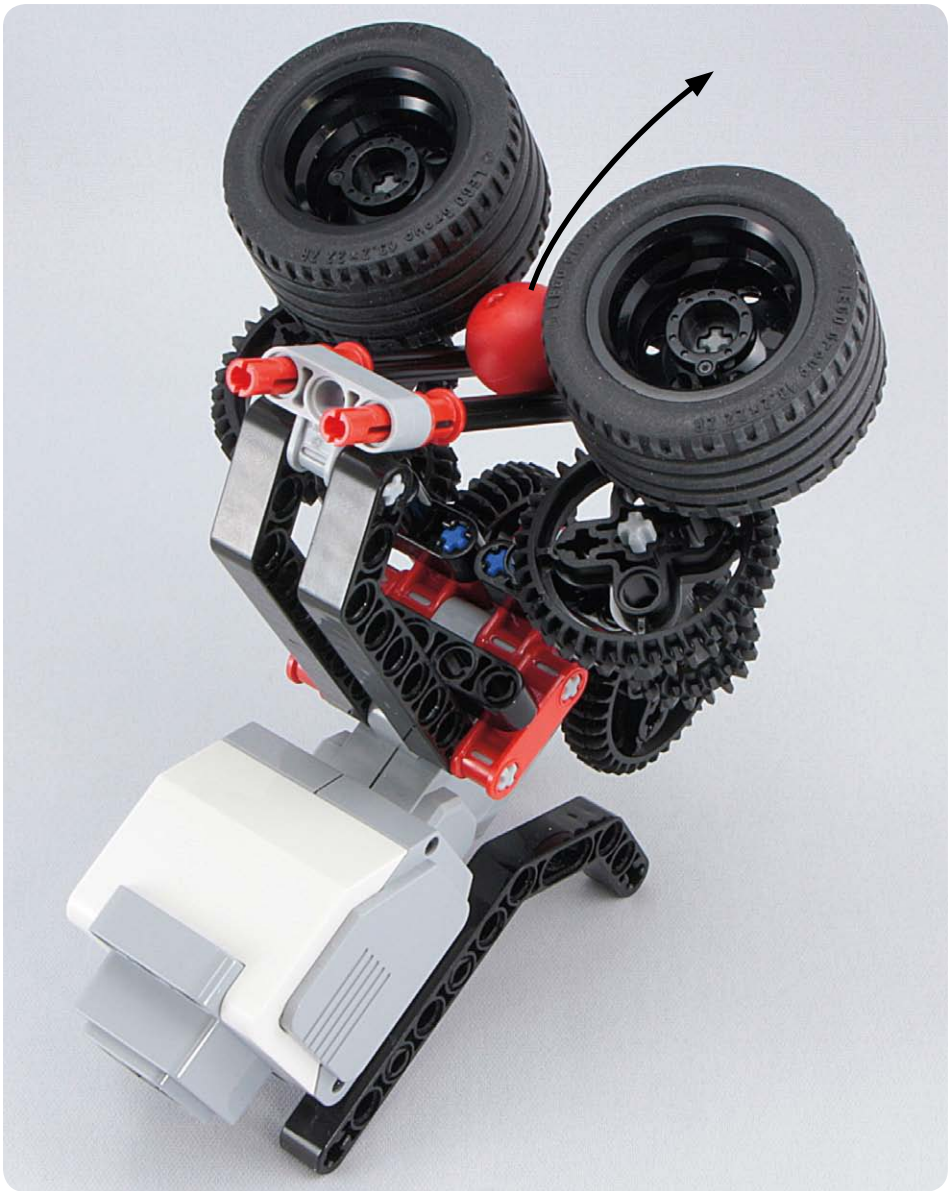
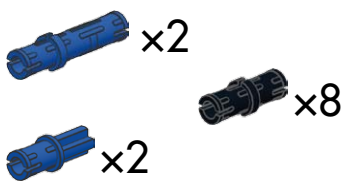
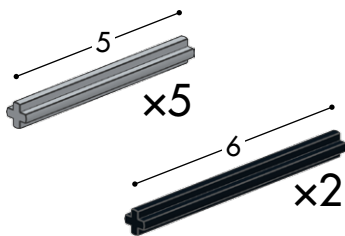
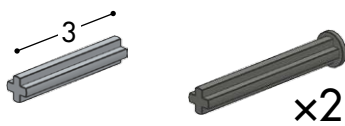
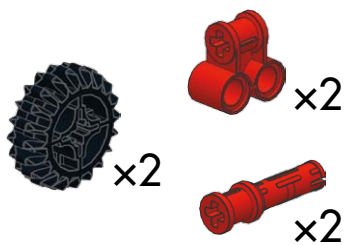
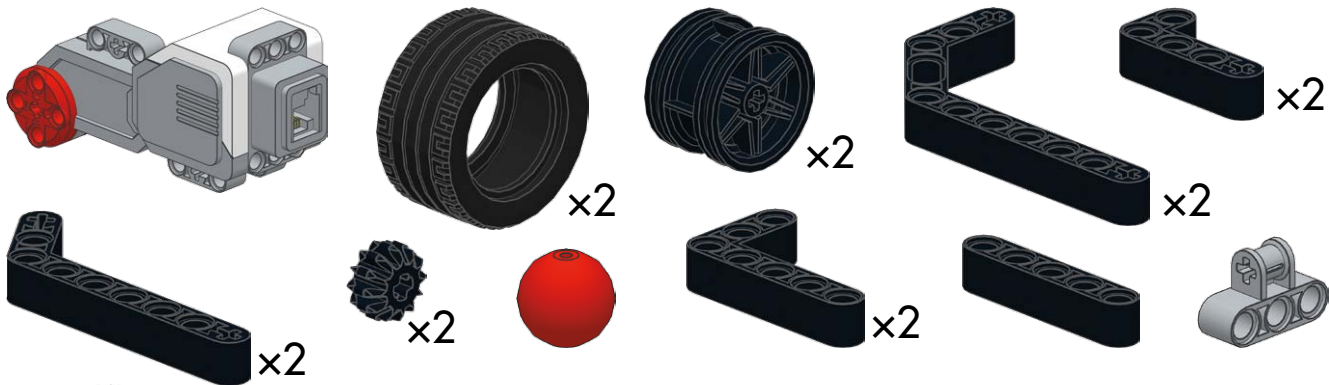


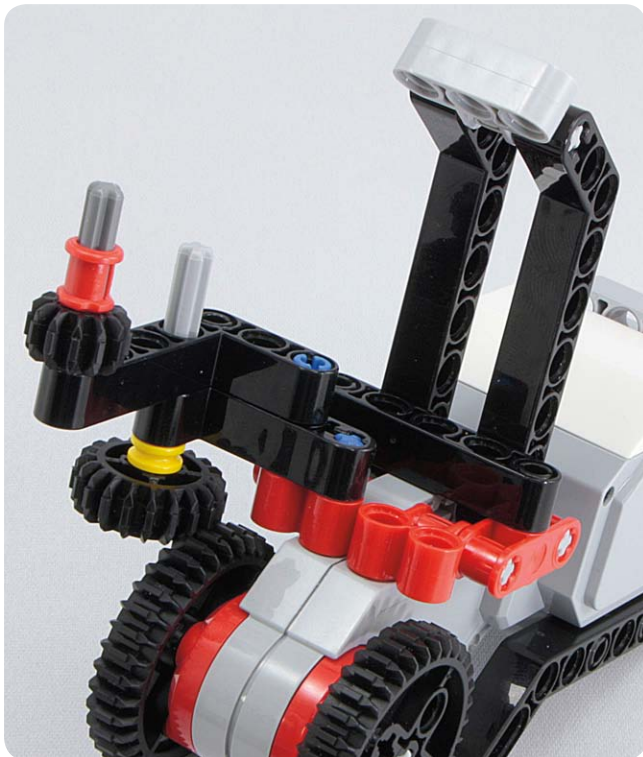


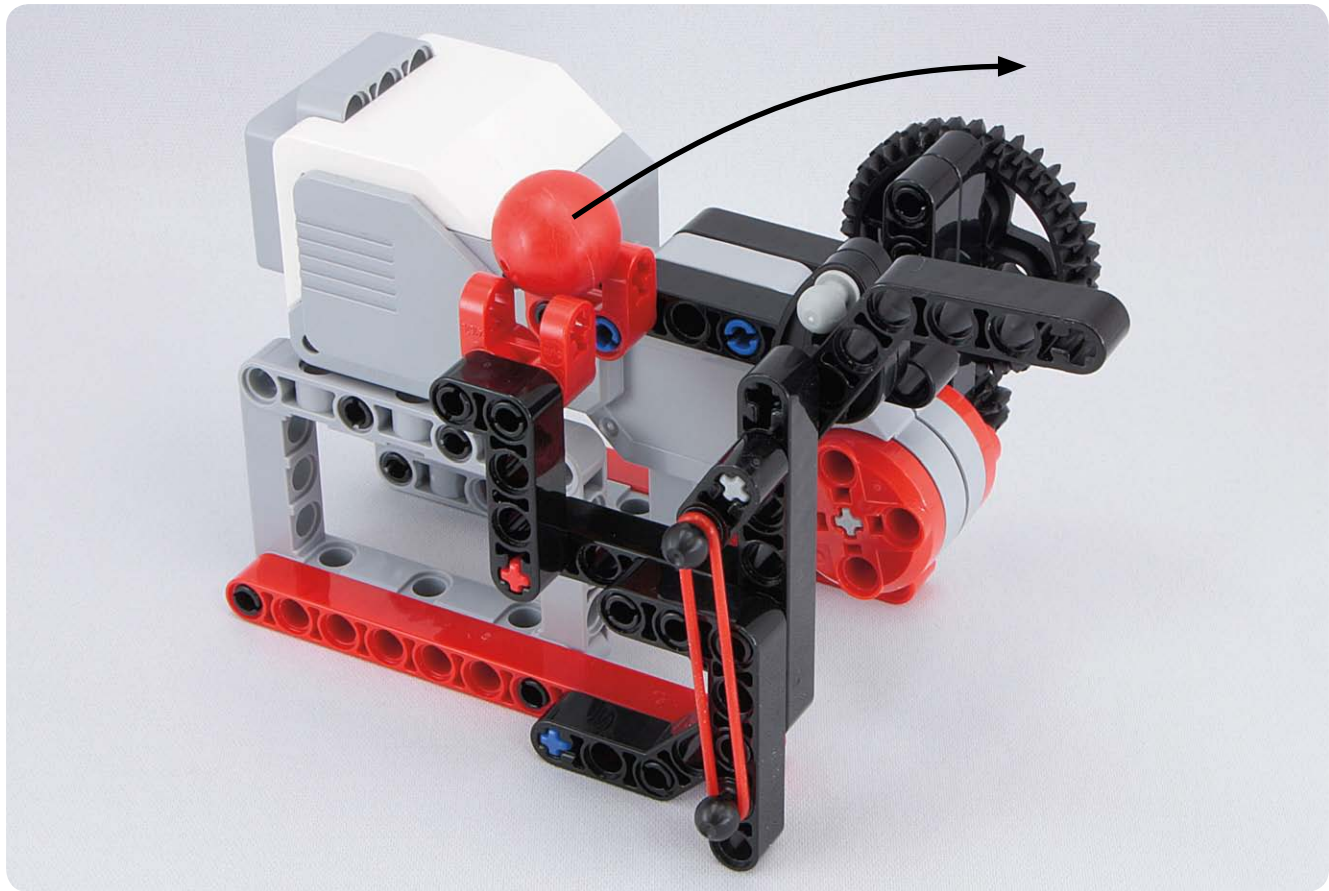


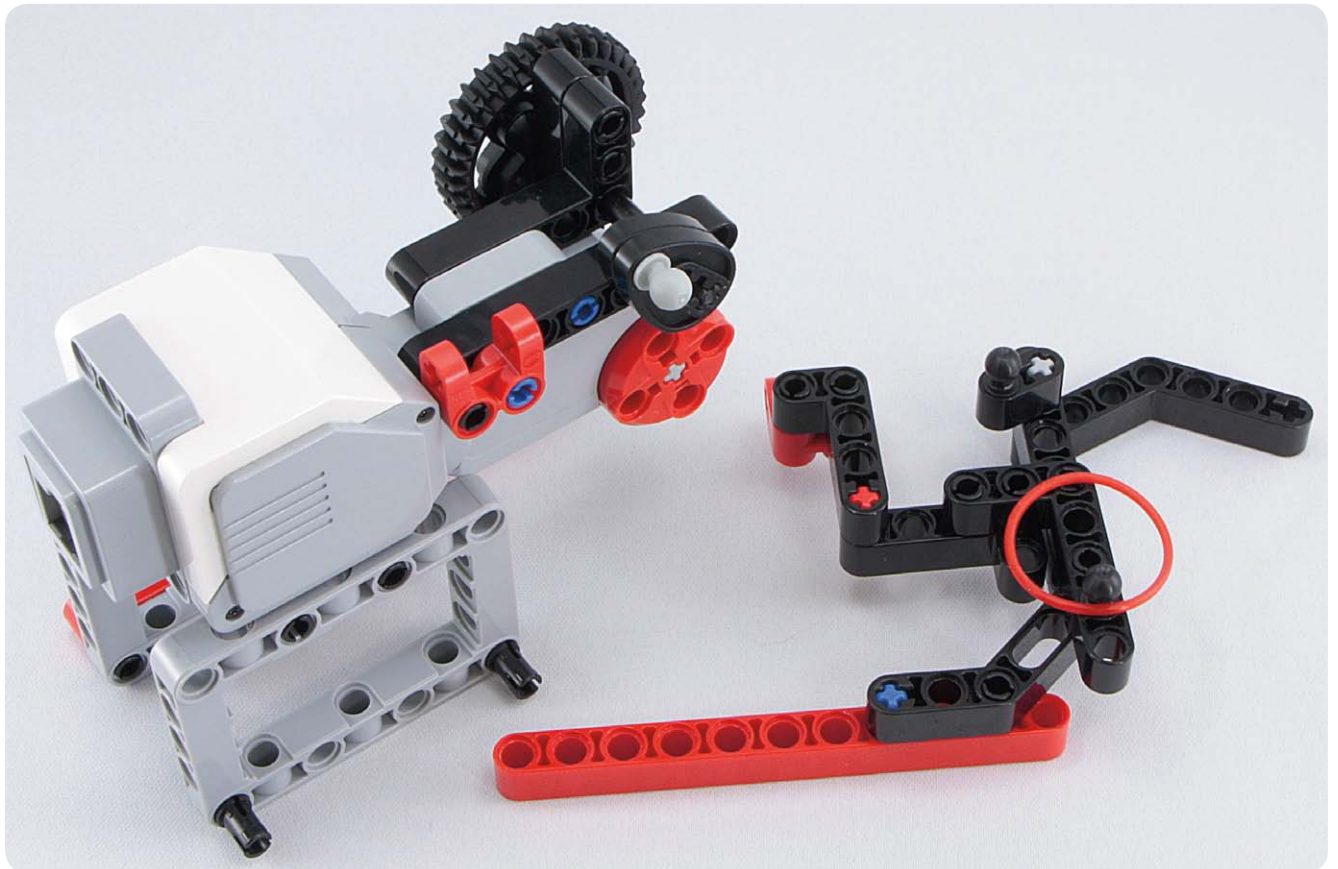
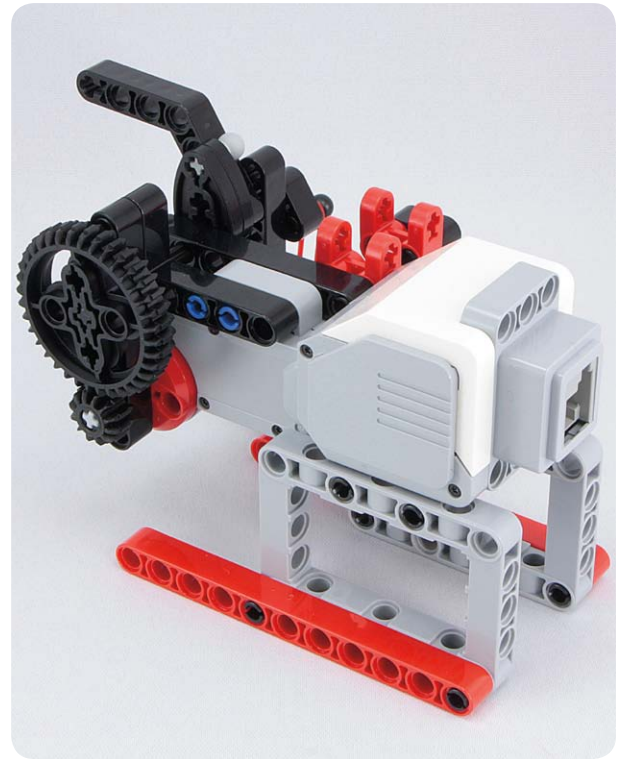
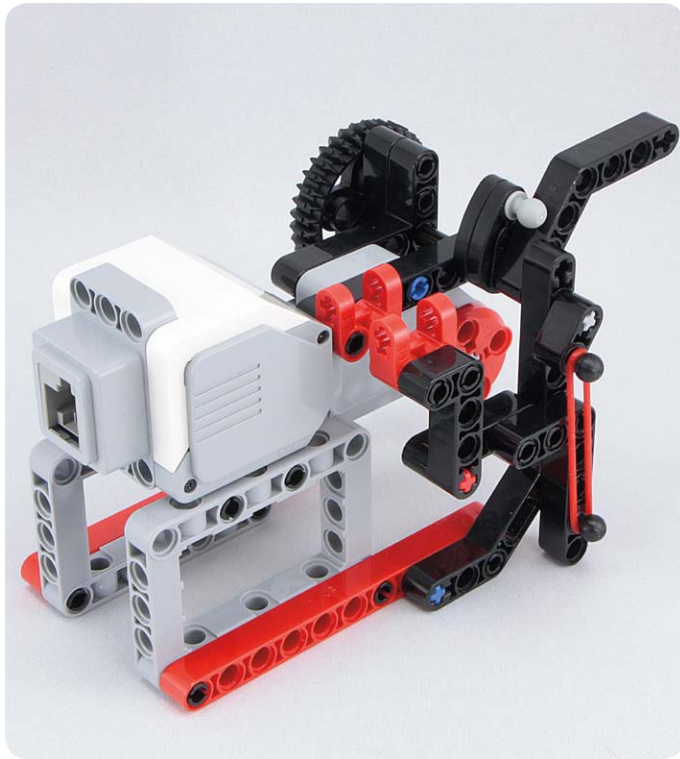




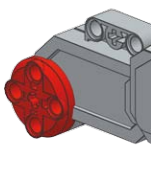
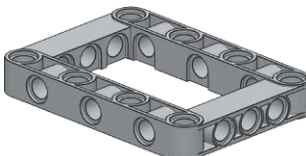




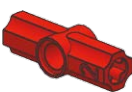
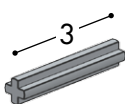


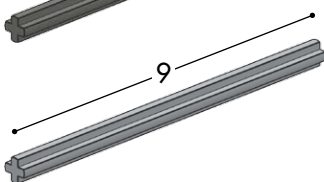




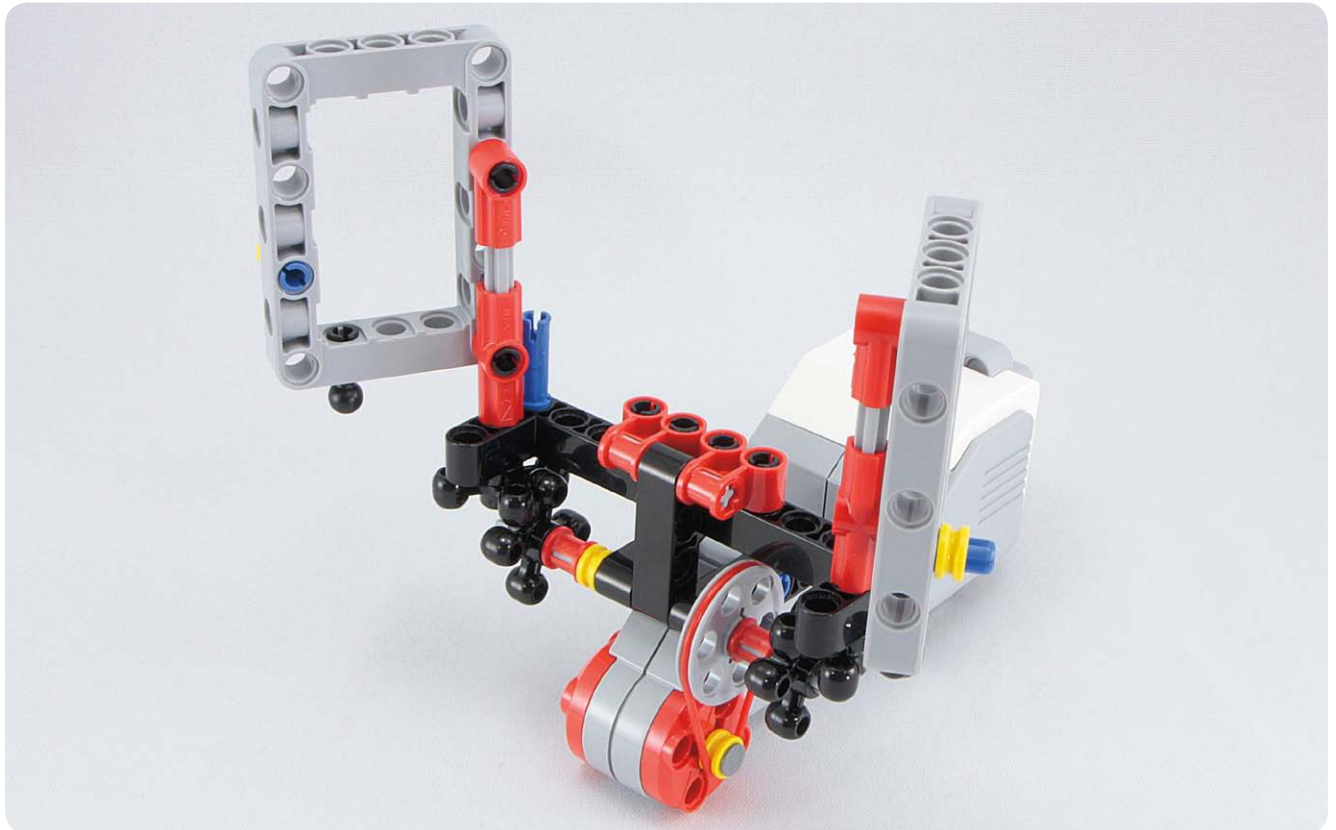
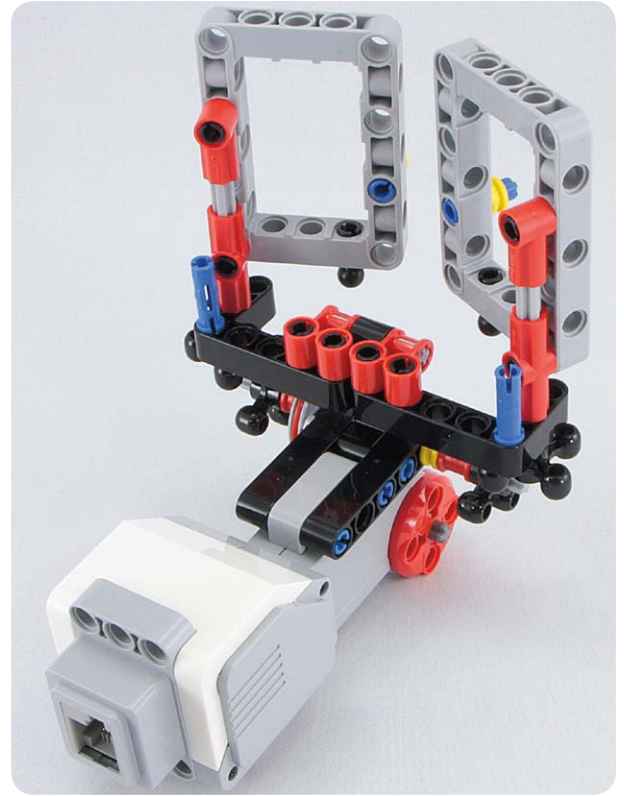
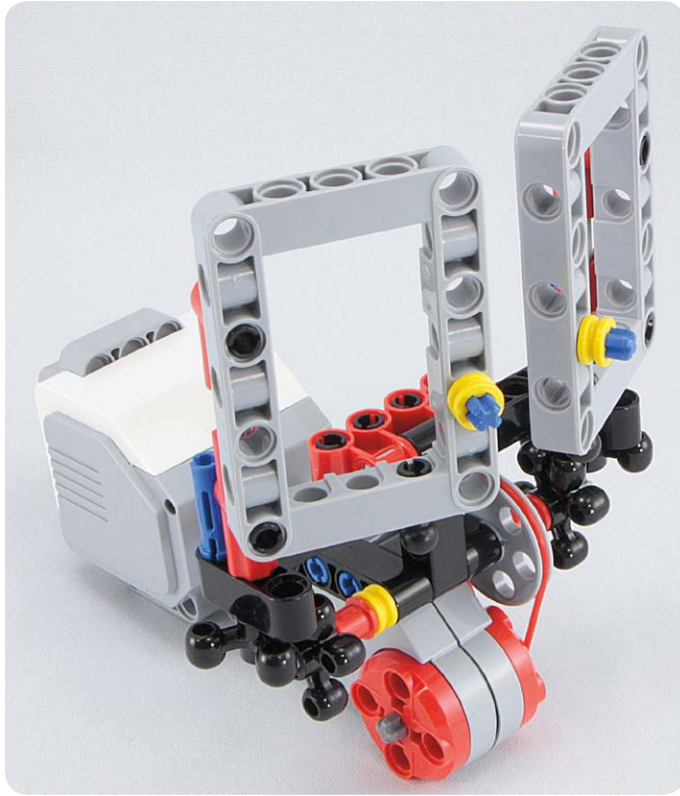

 x2
 x2
 x2

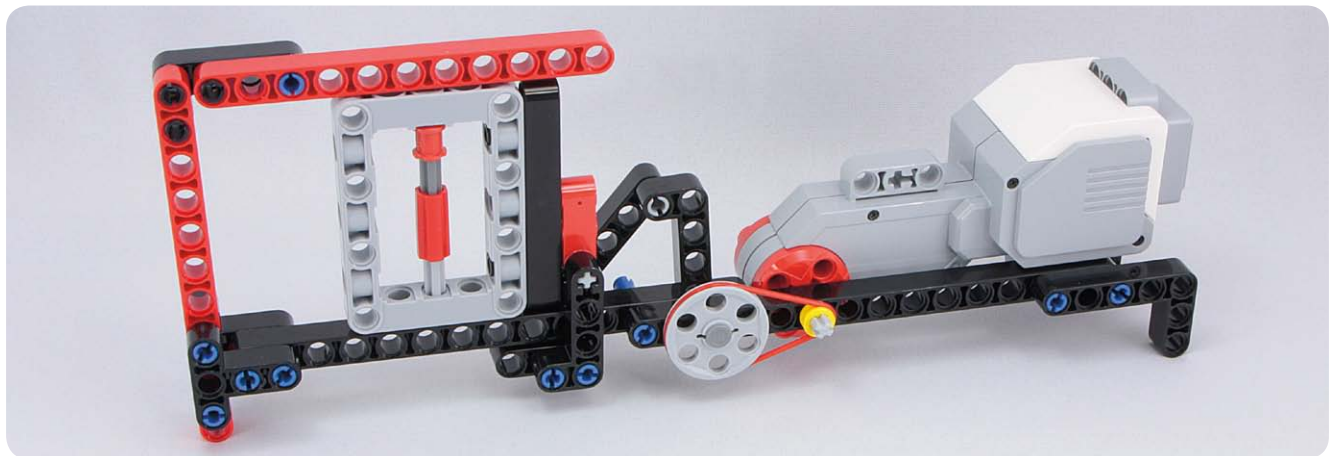
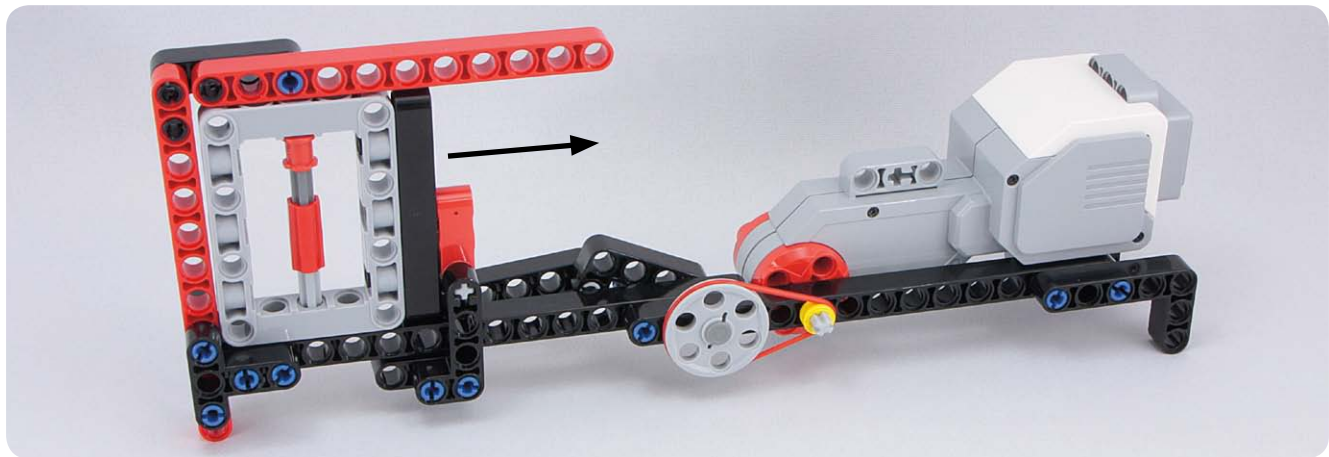
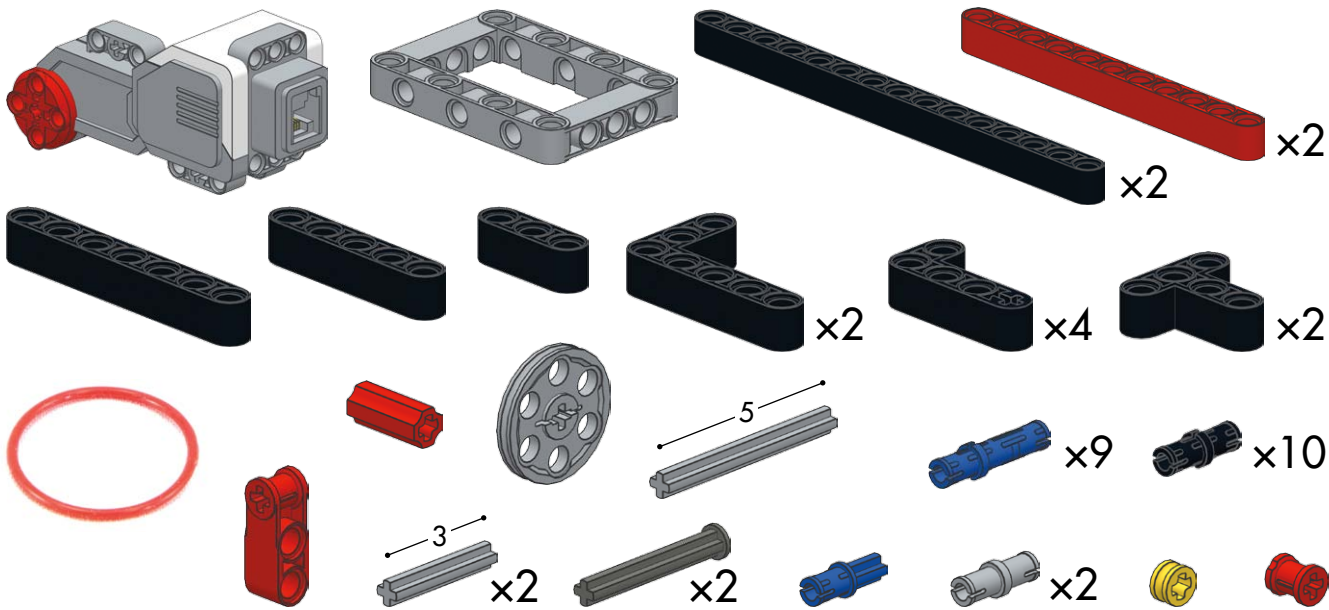

 x4

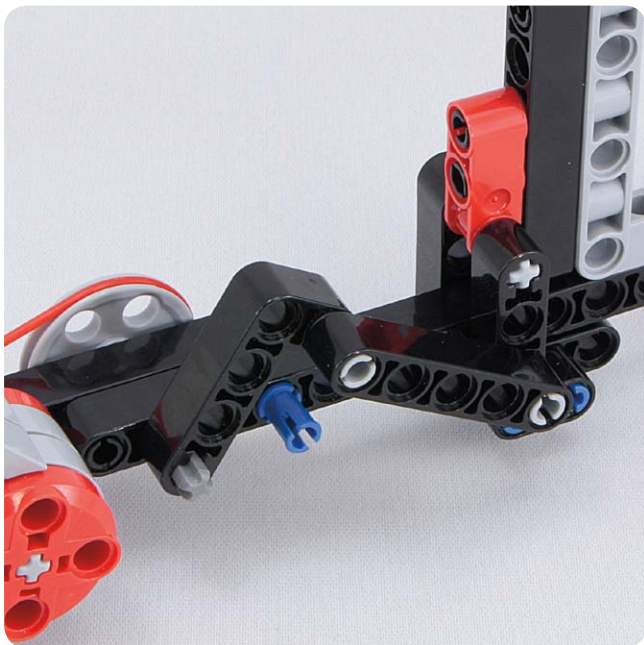
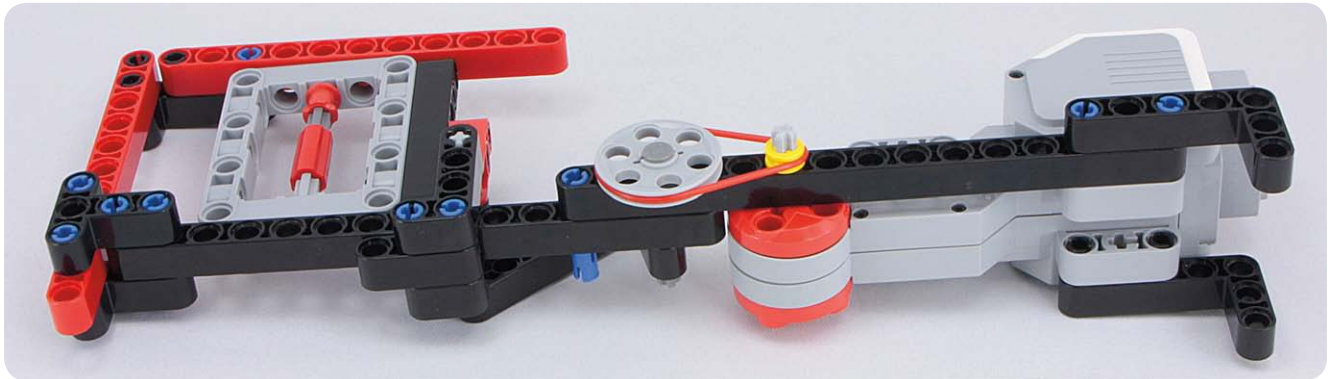
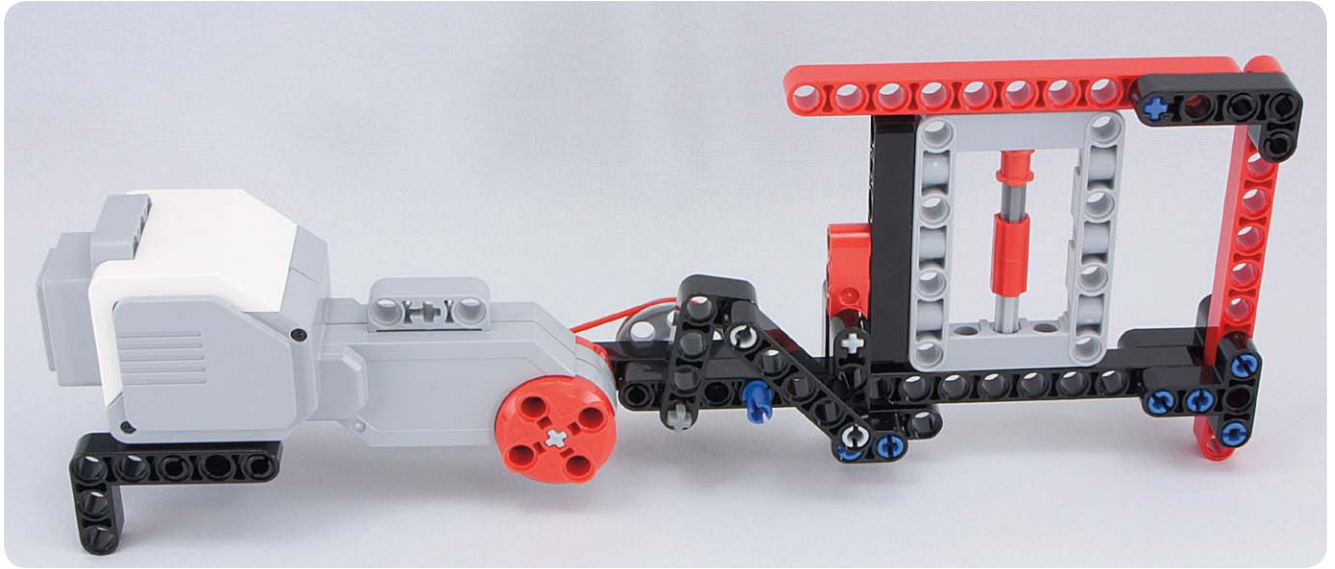
 x2
 x2
 (3) x5

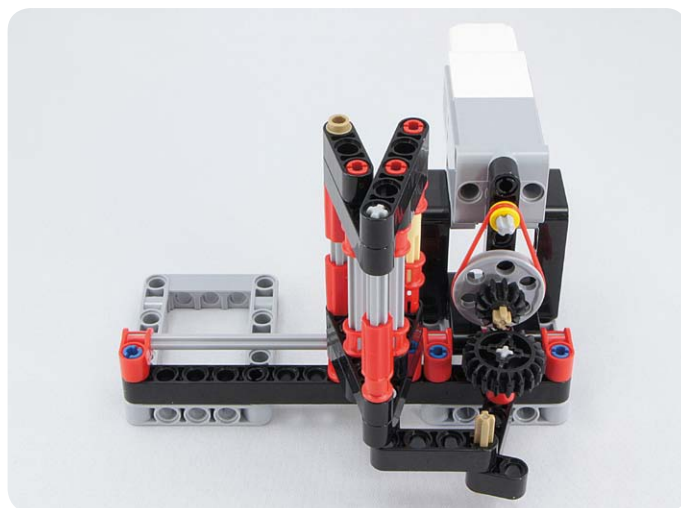
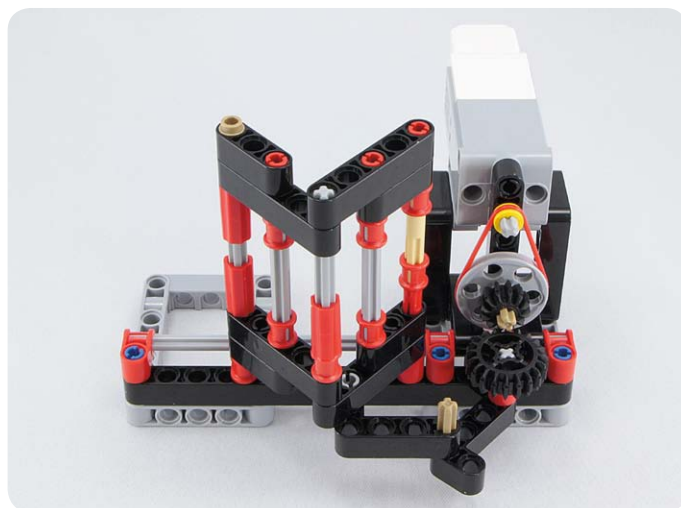
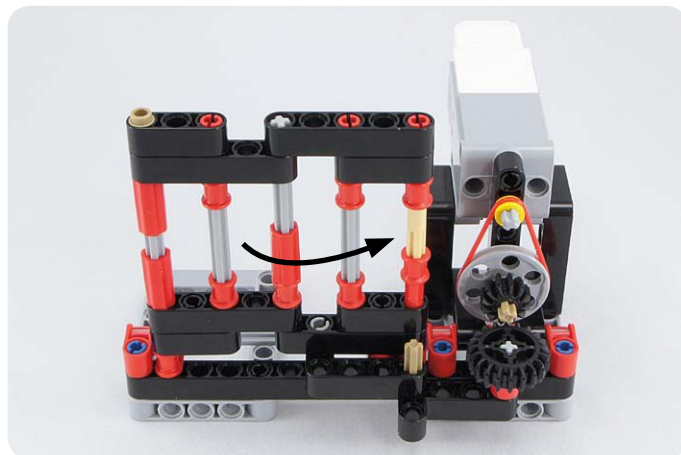
 (9)
 (Blue) x5
 (Black) x2
 (Blue) x2
 (Black) x8
 (Yellow) x4
 (Red) x2

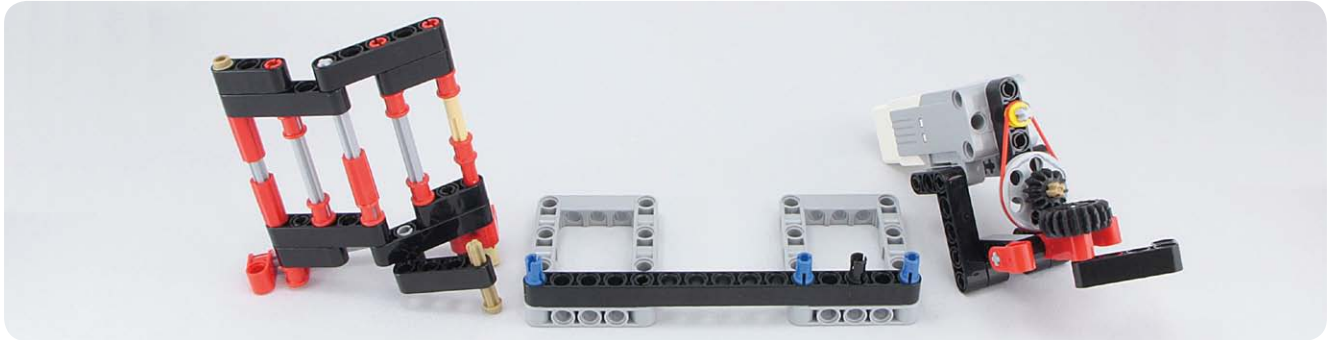
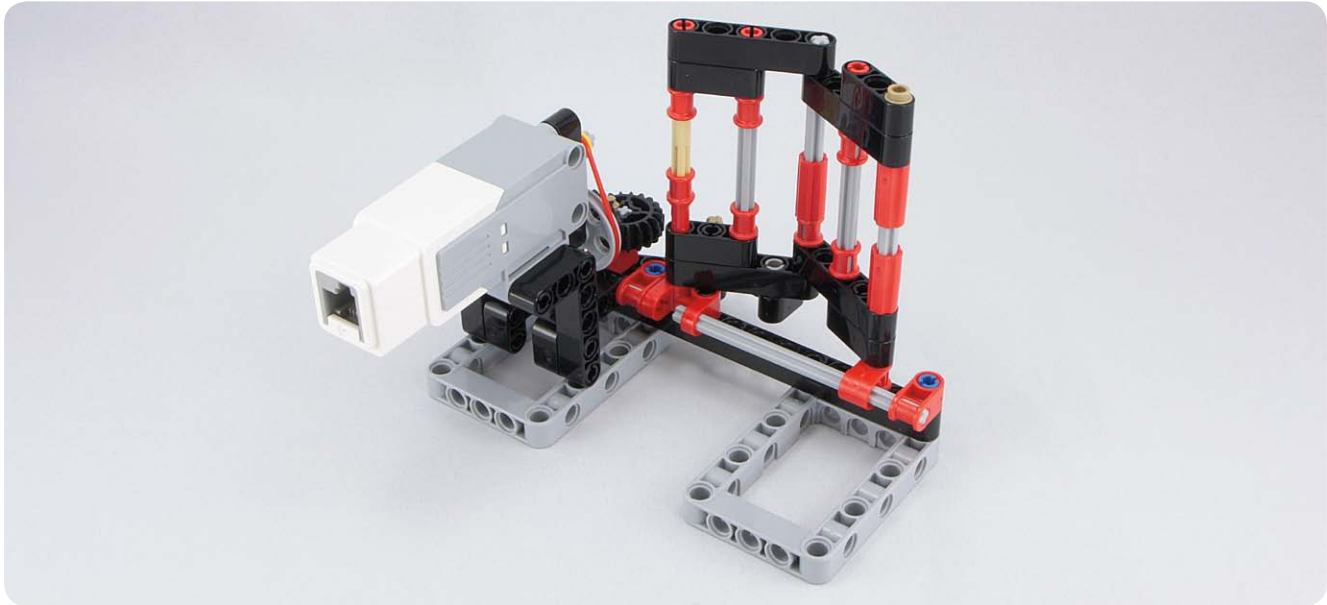
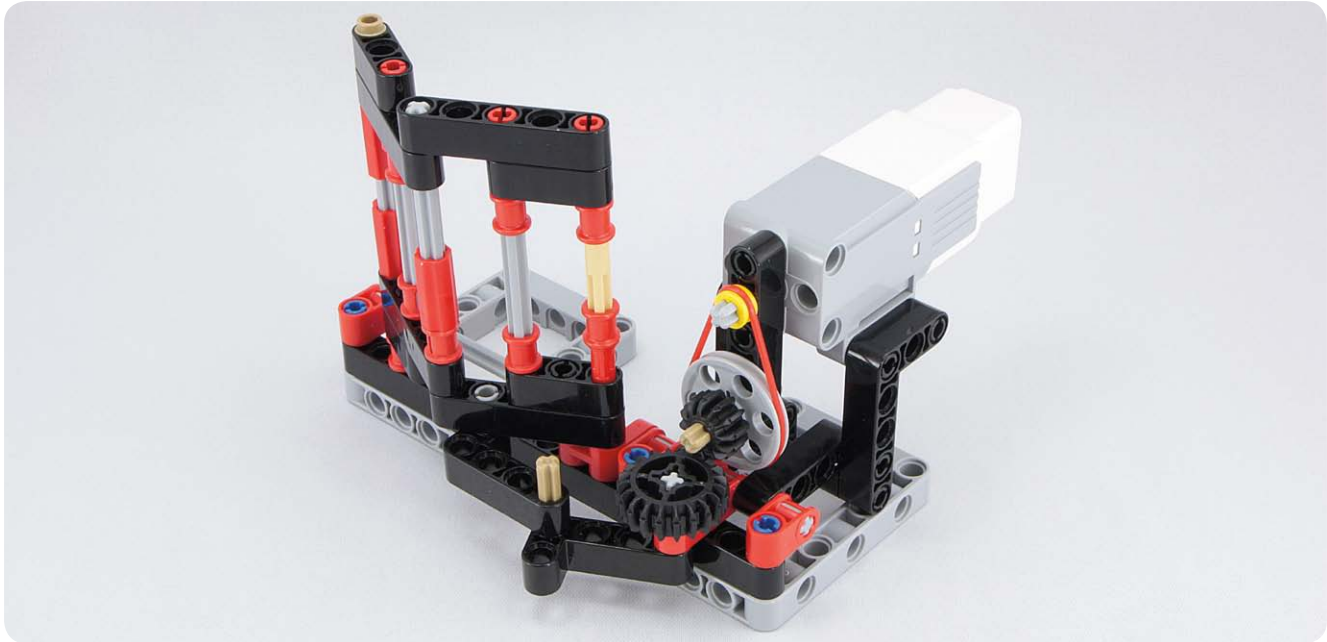


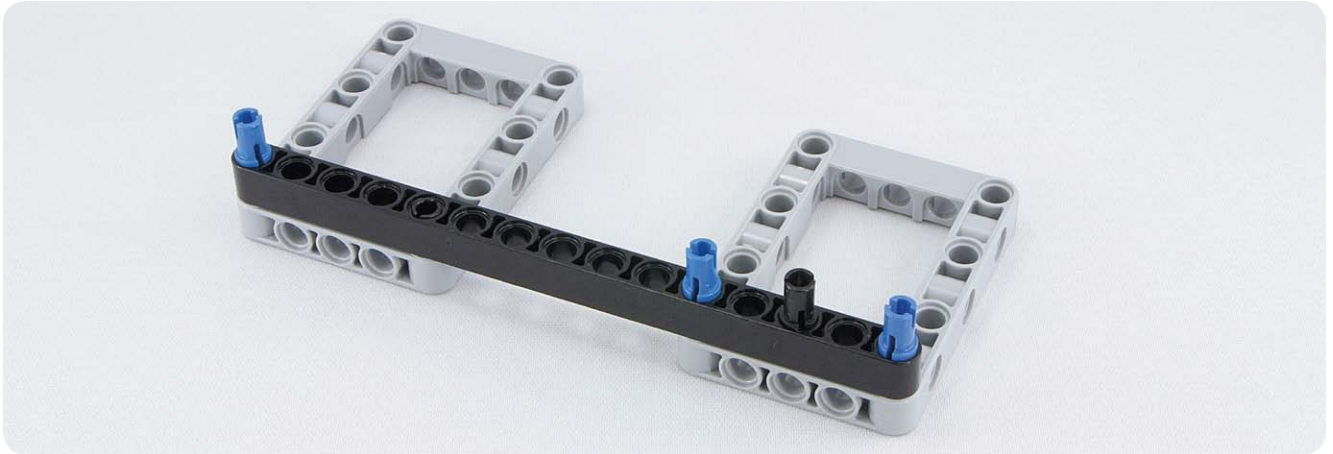


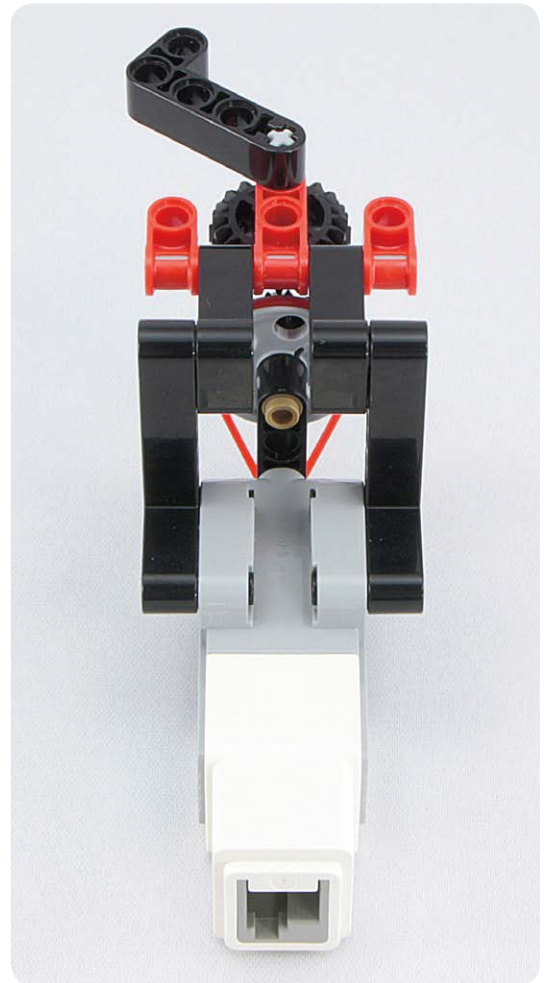




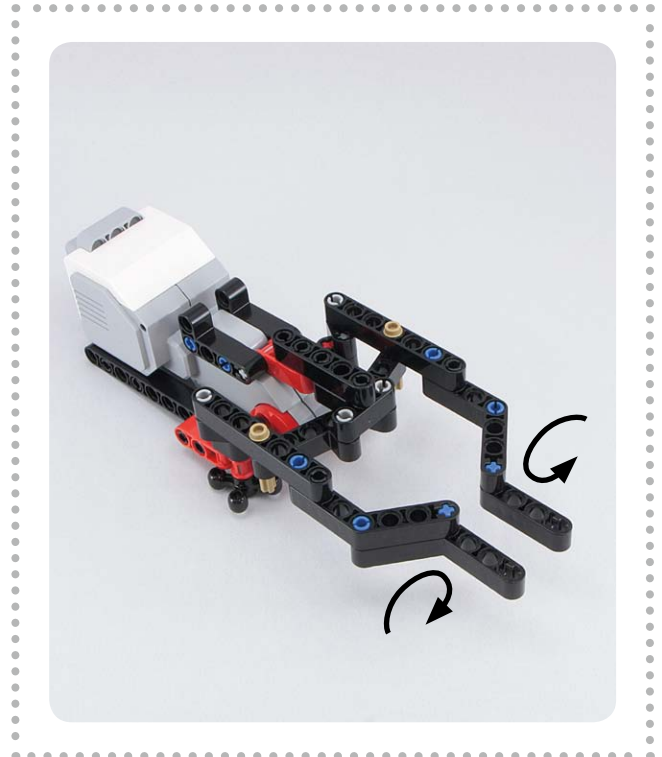
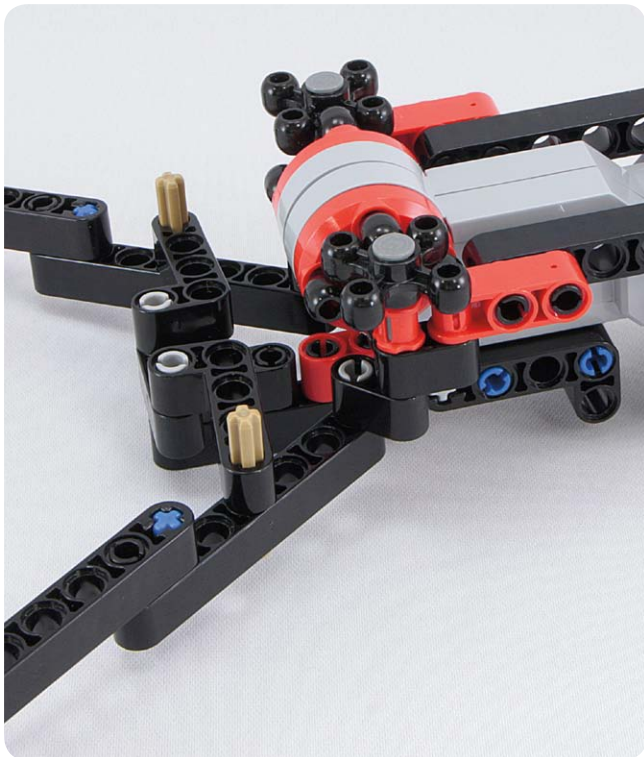
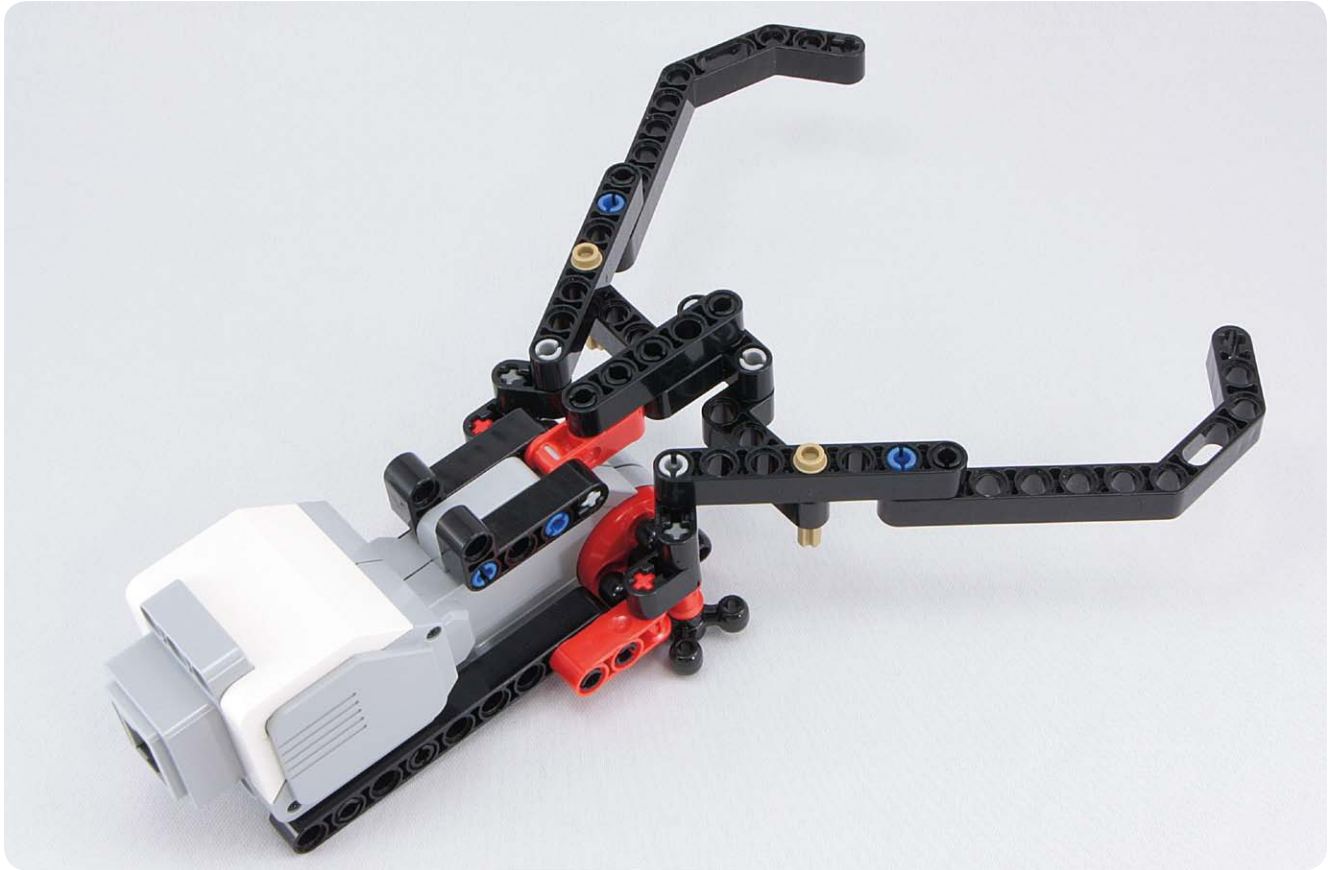


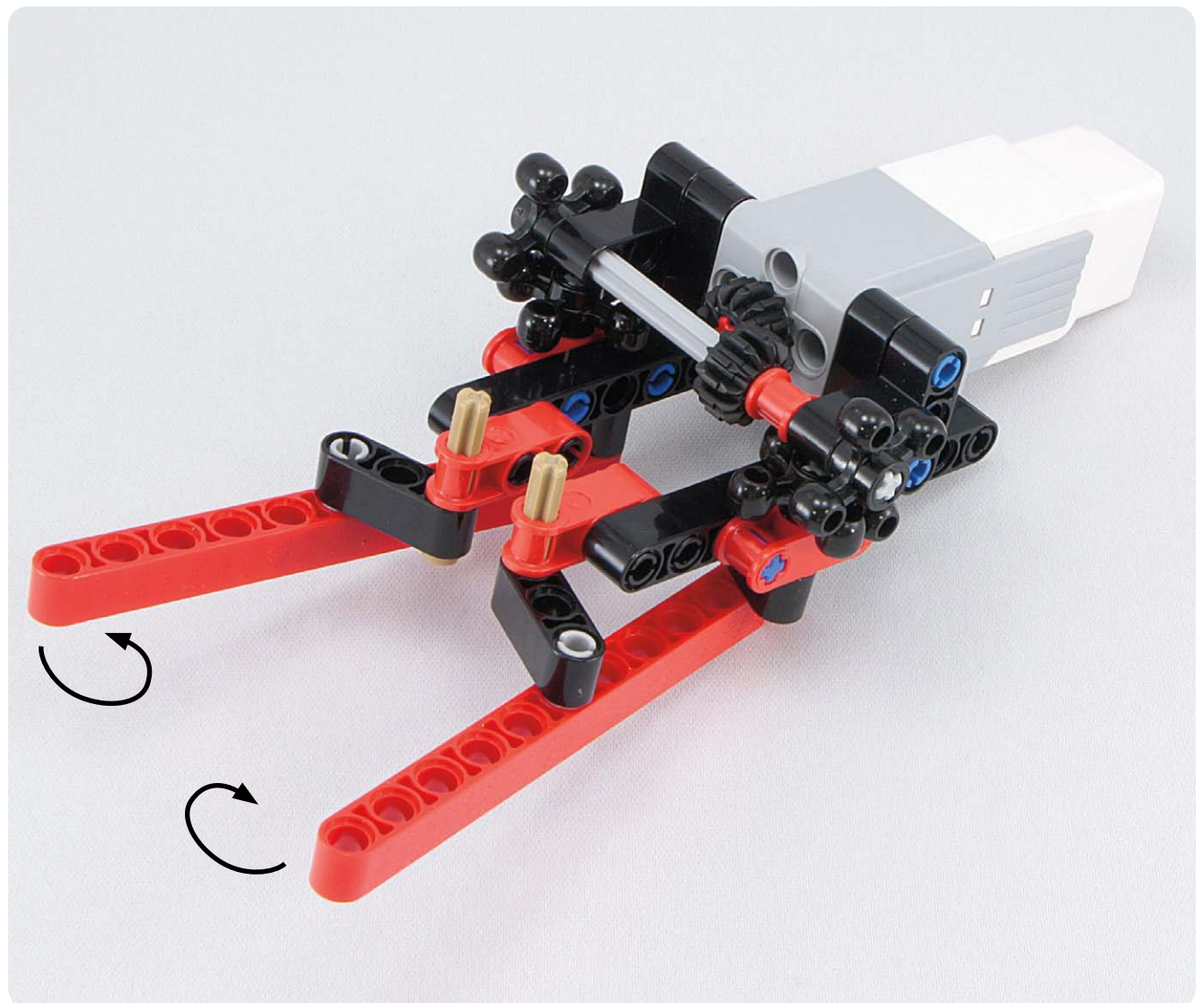
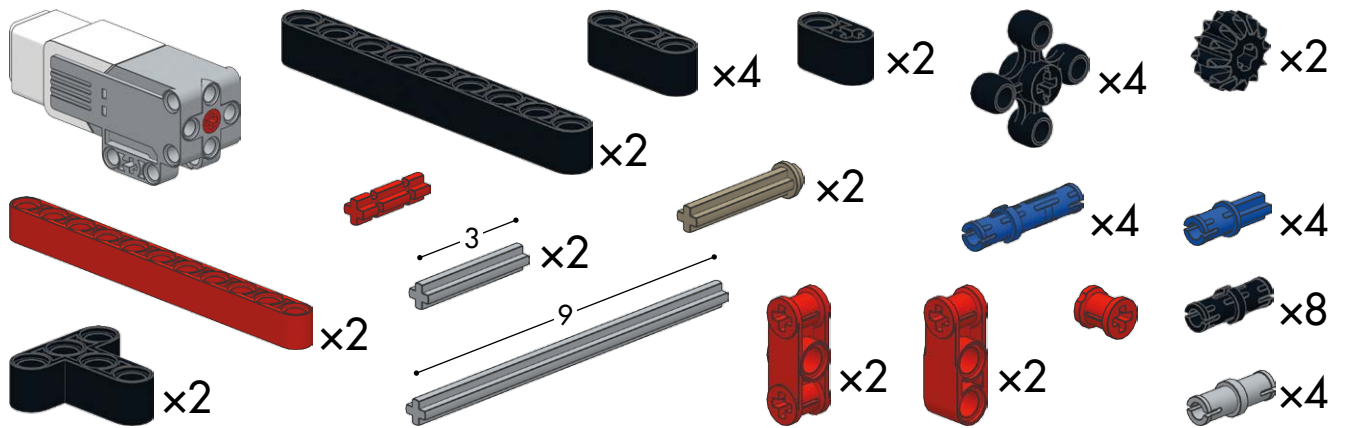


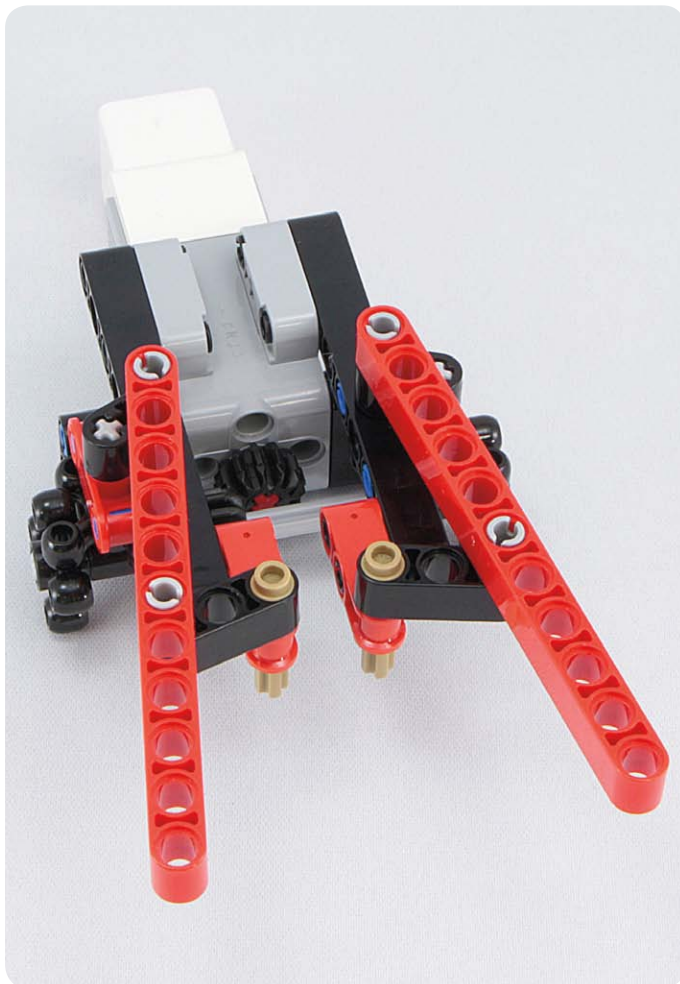
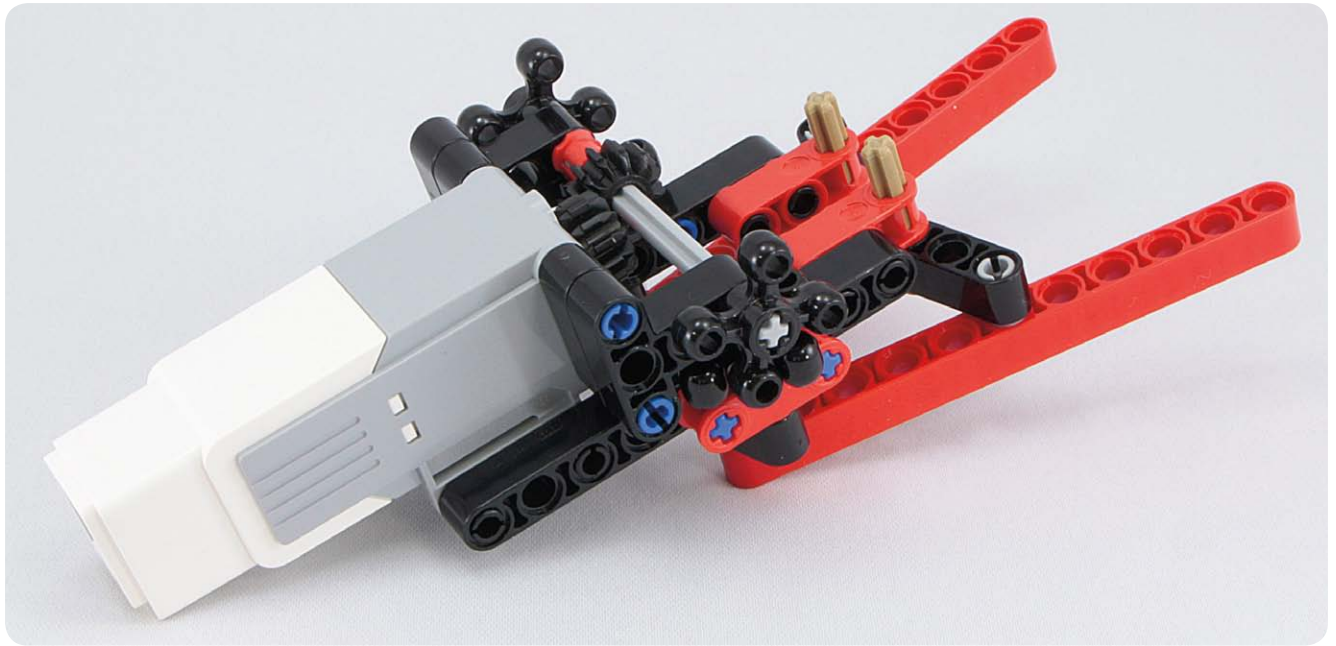




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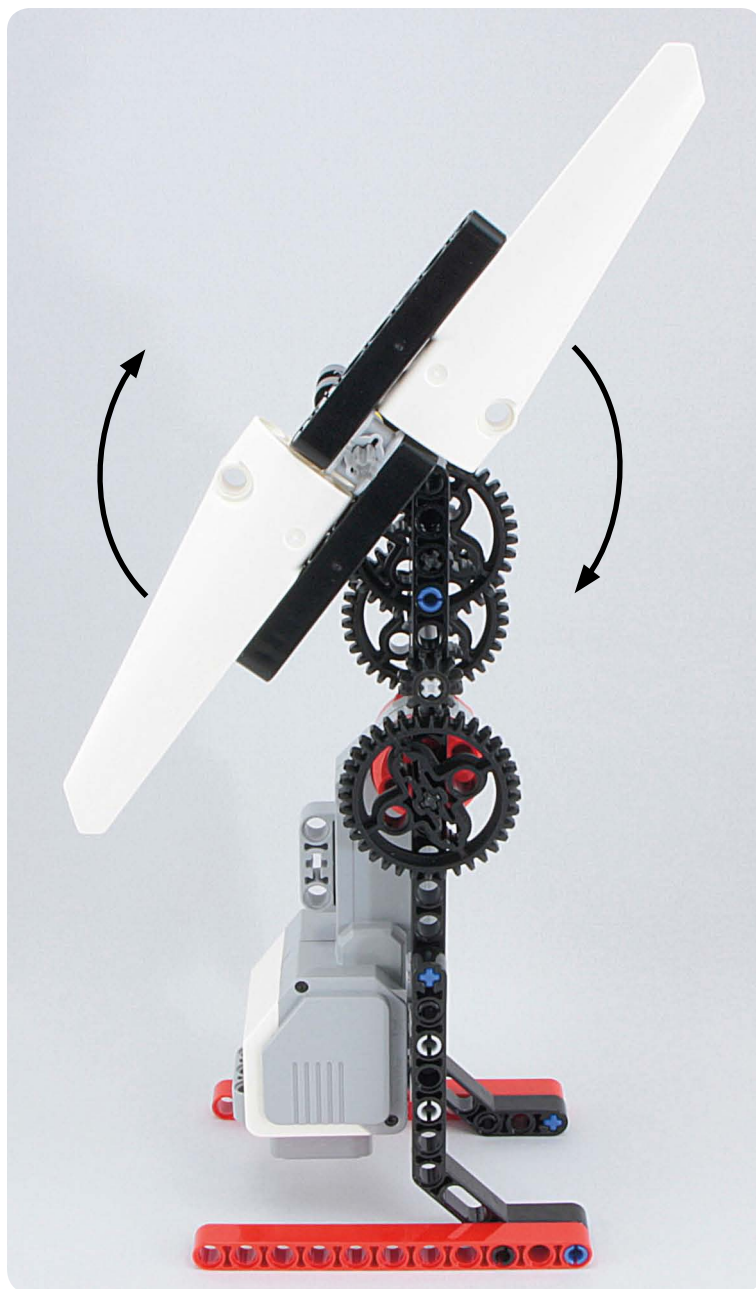




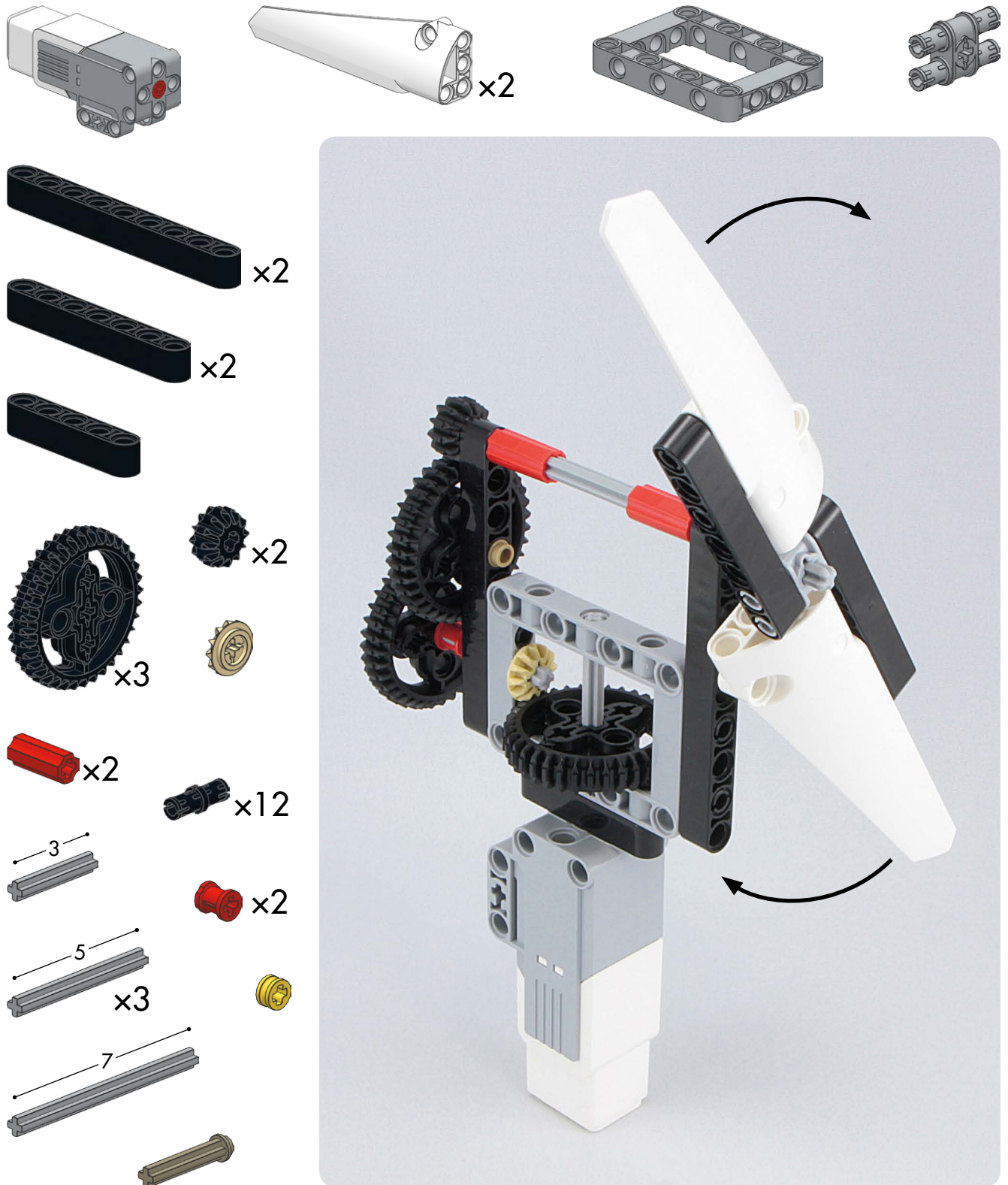


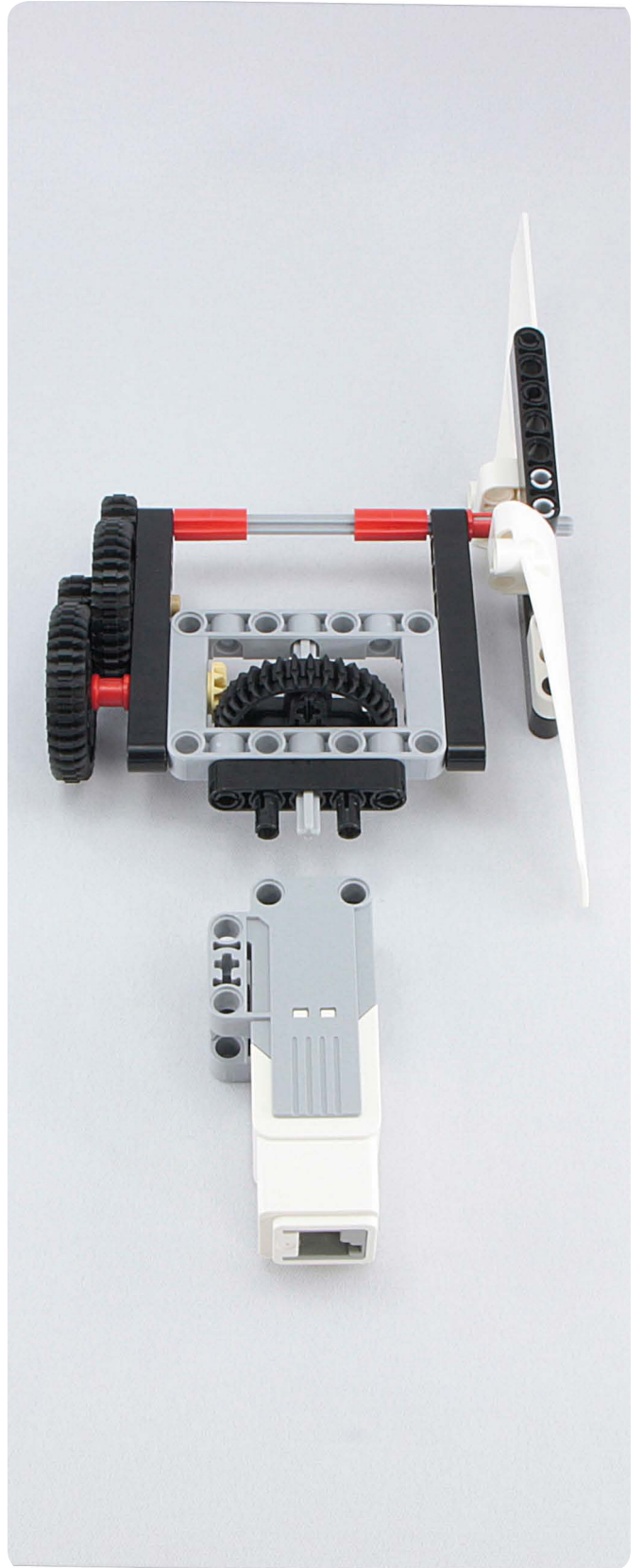
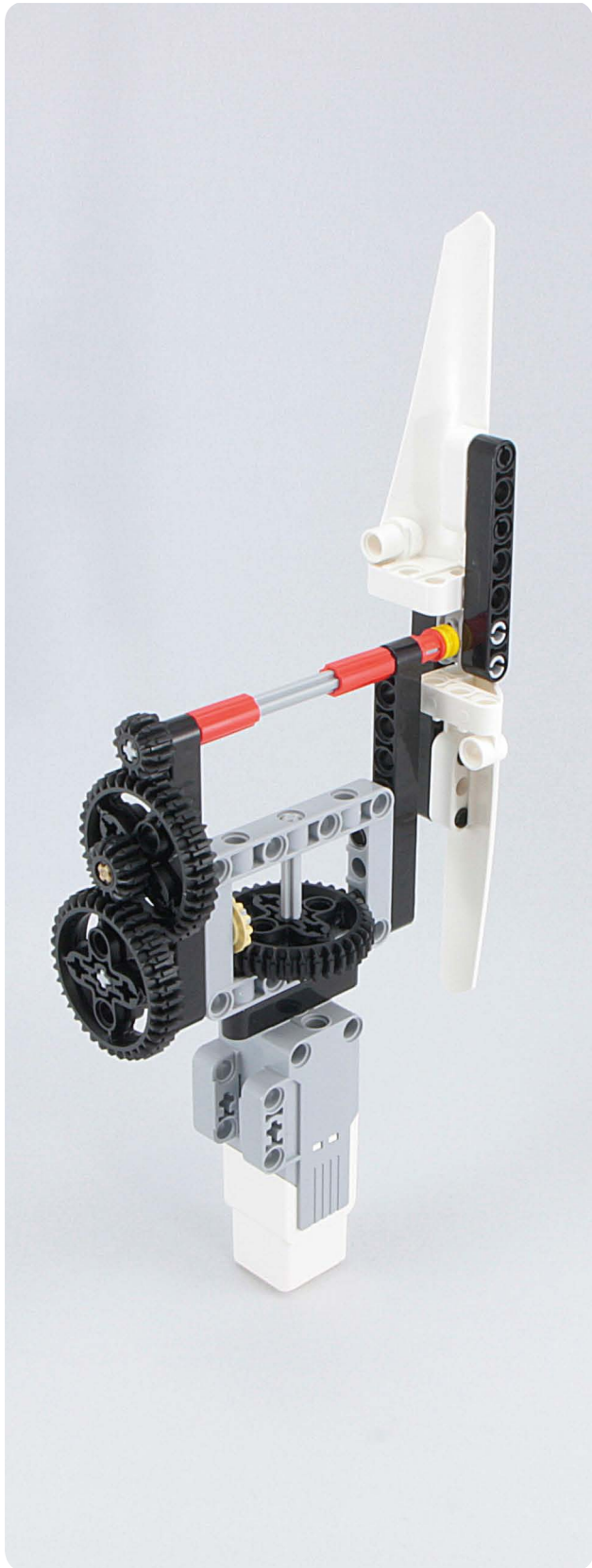


#153

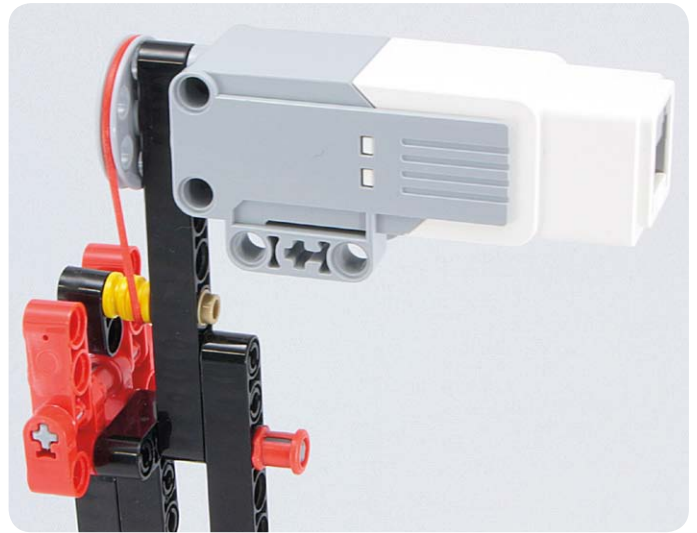




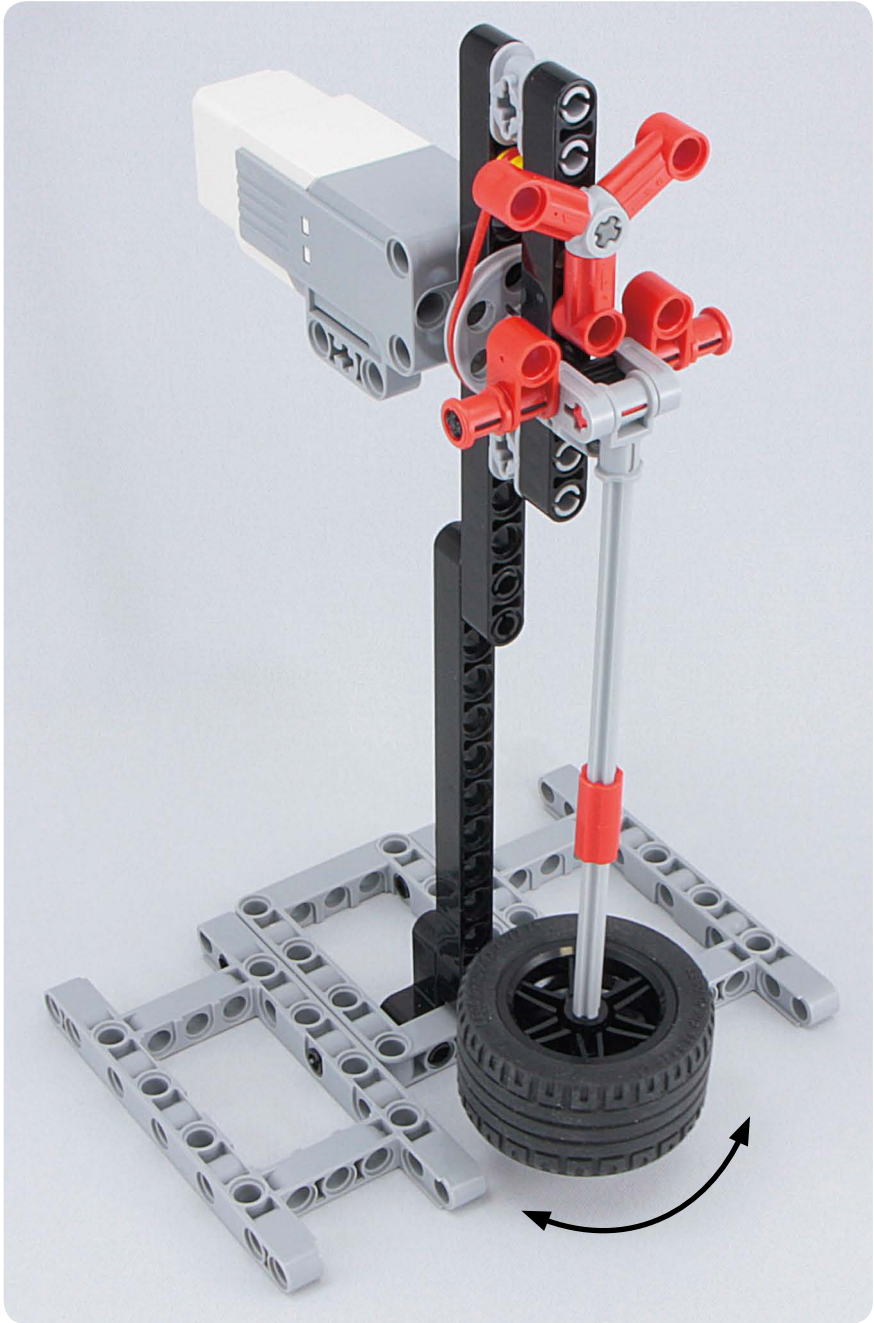


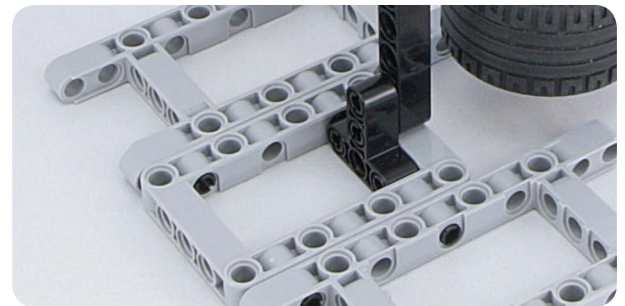
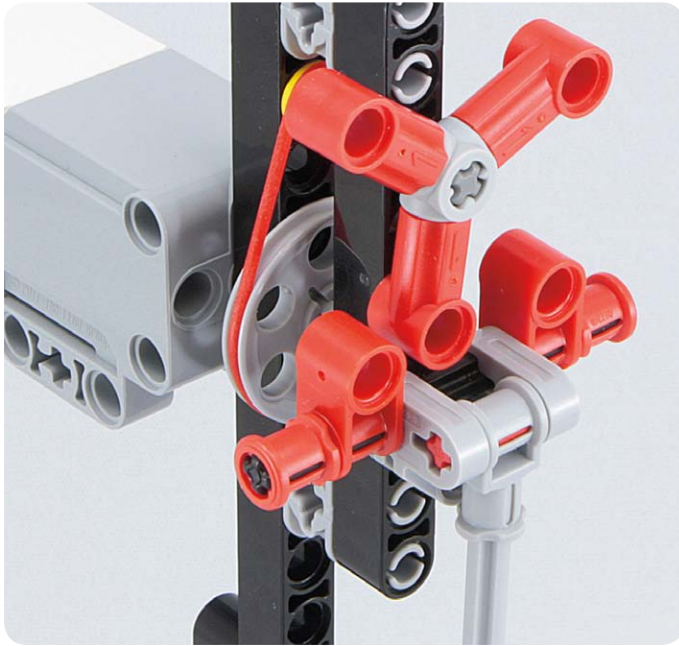
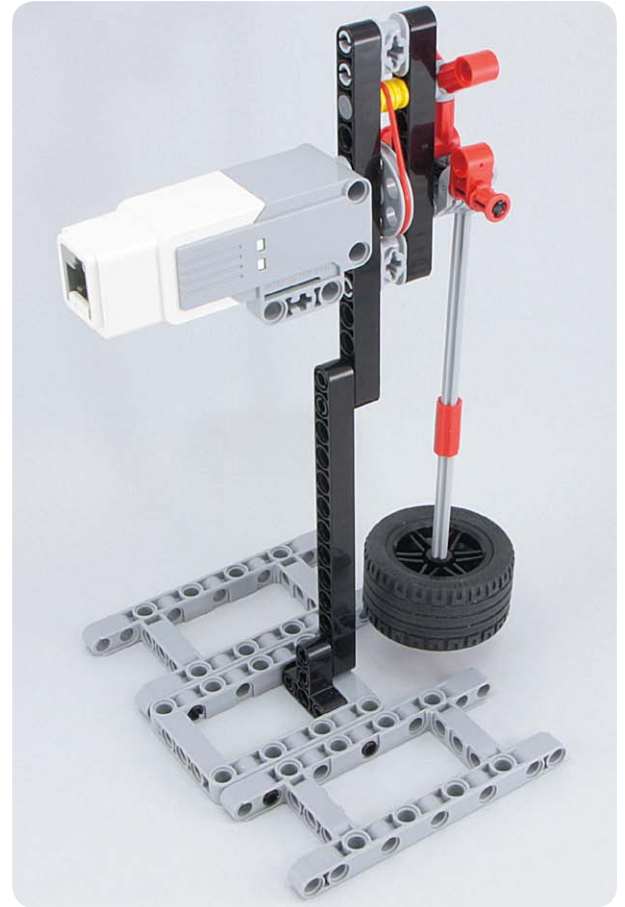


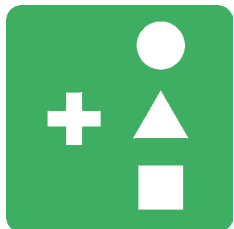




#156

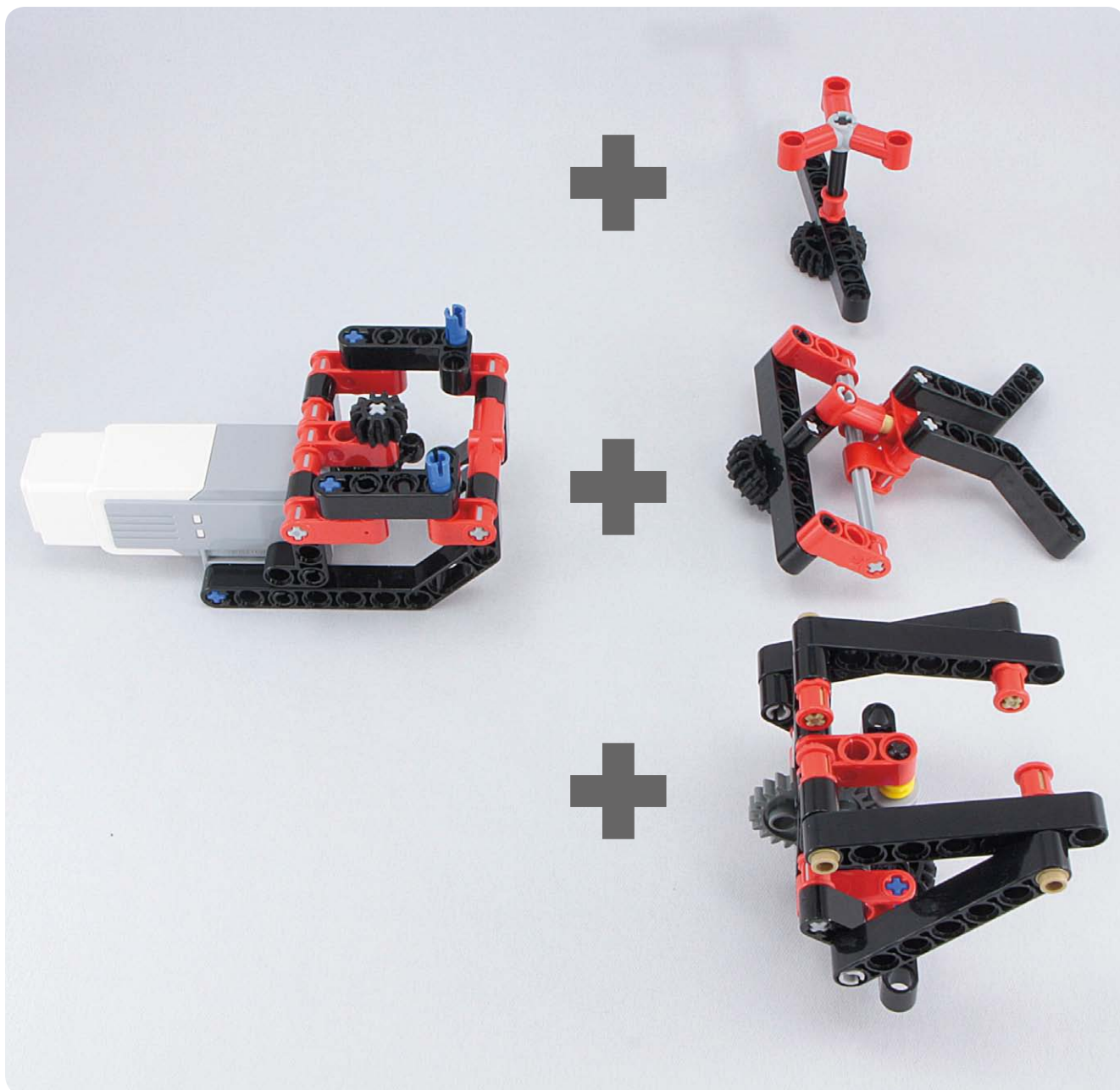


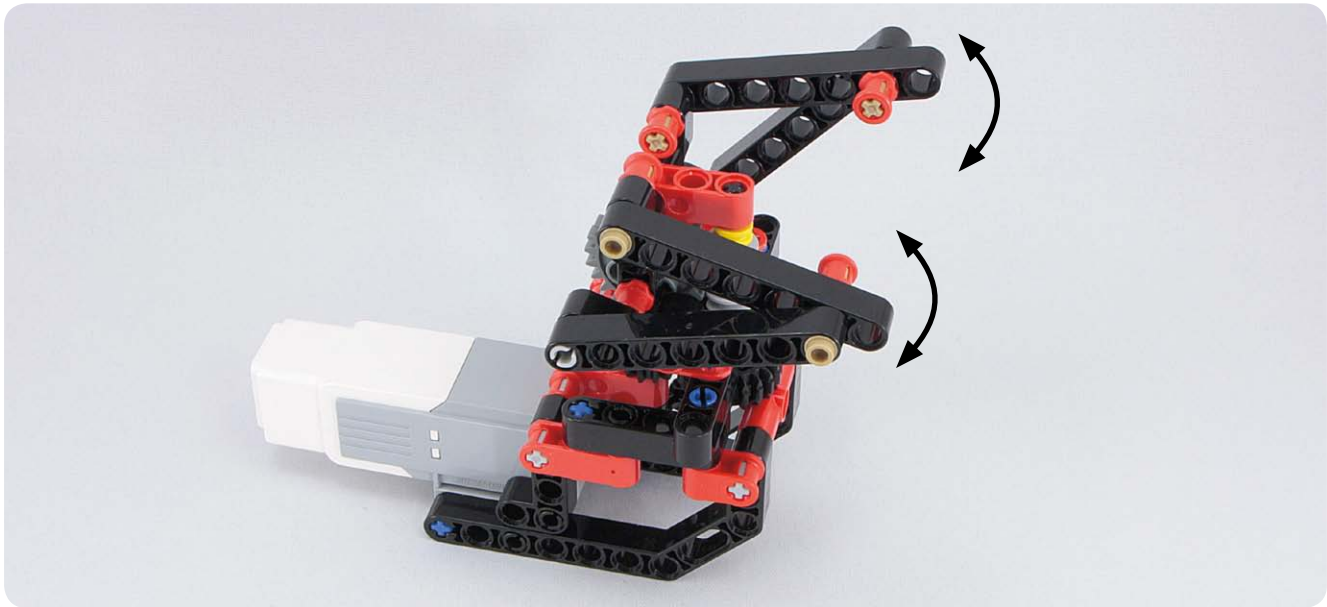
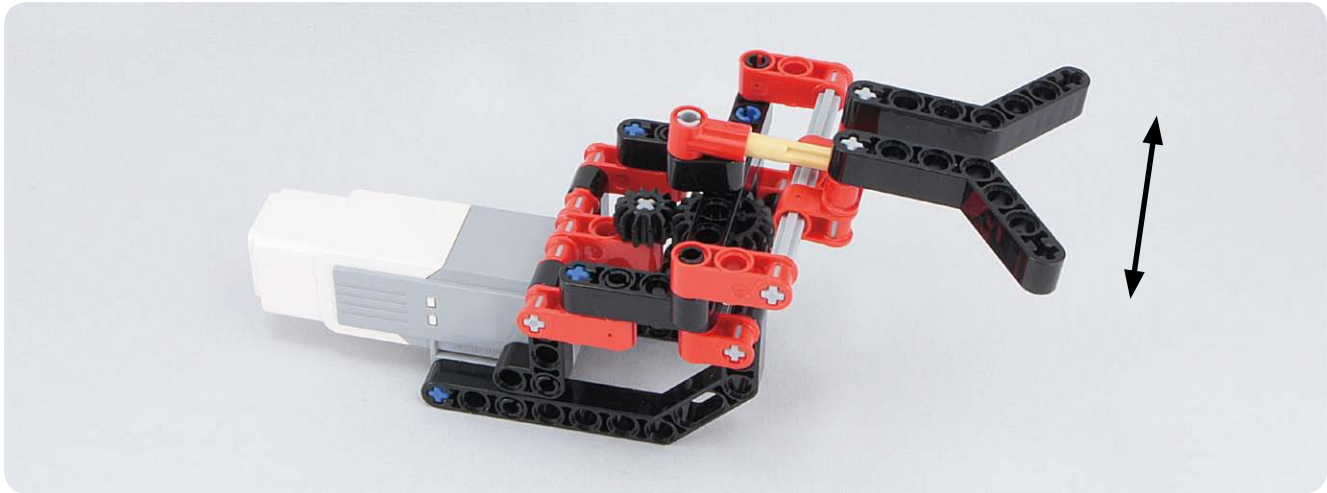
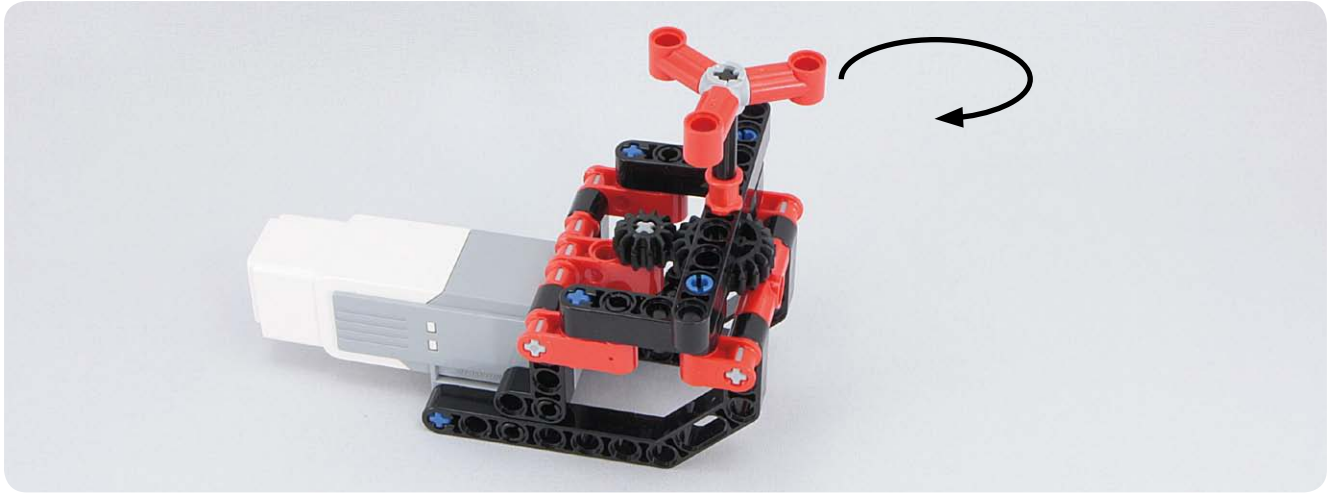


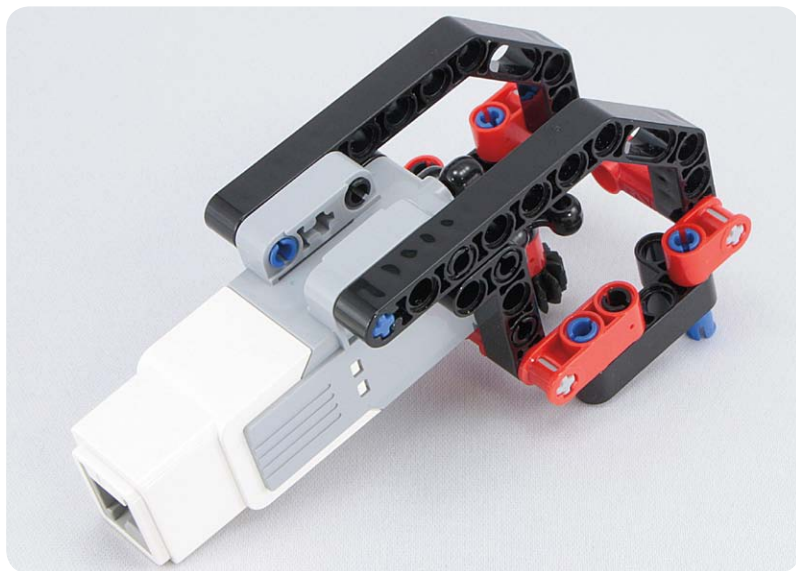
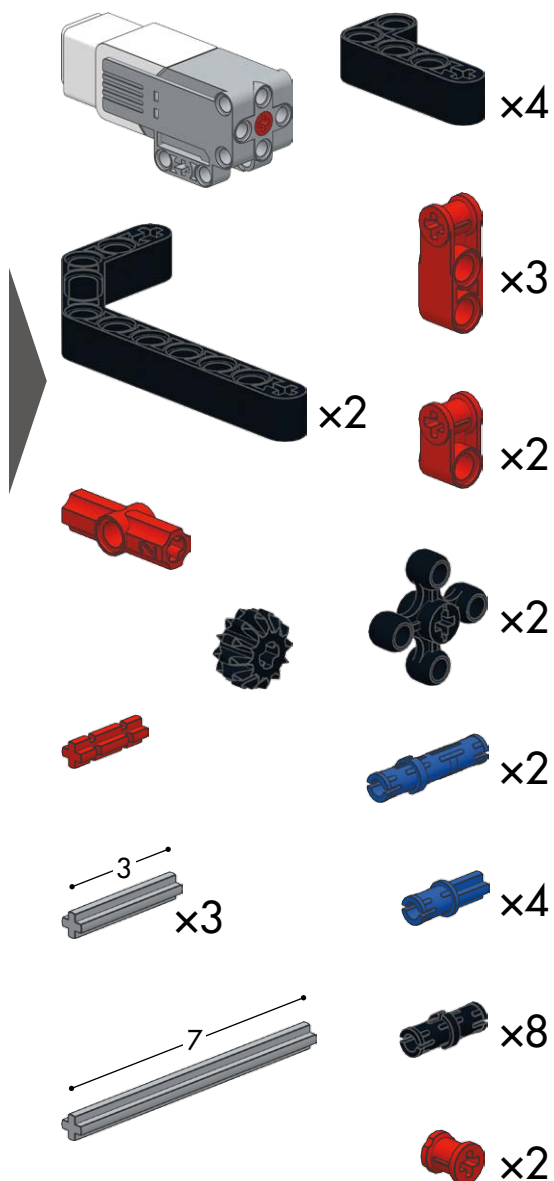
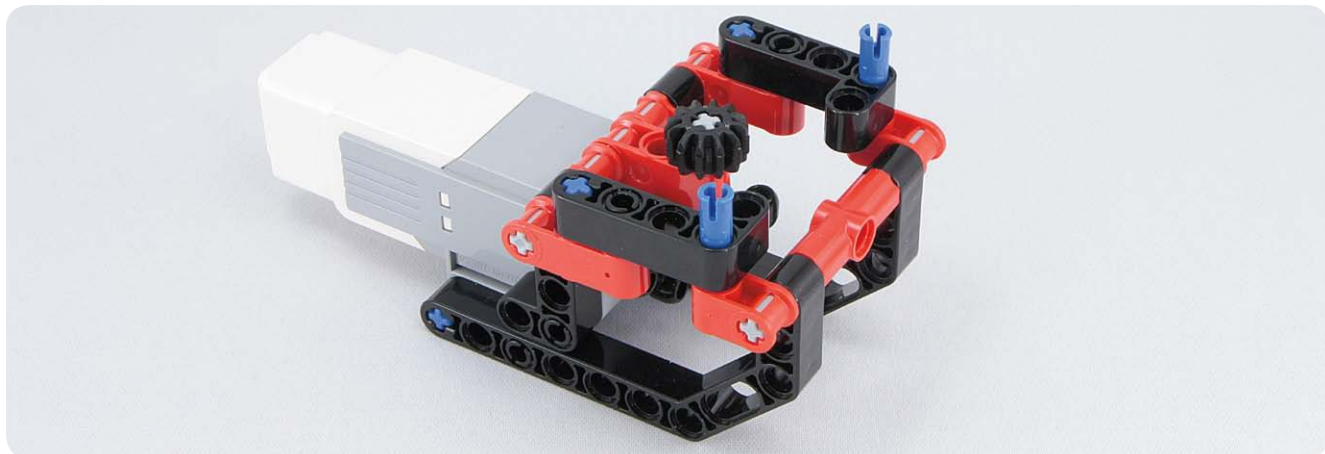


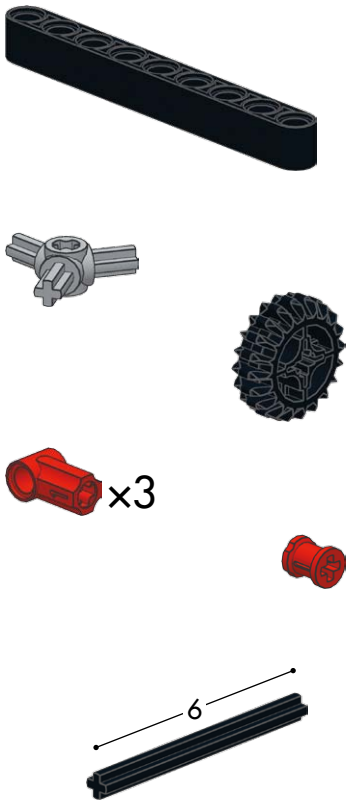
Using attachments to change motion

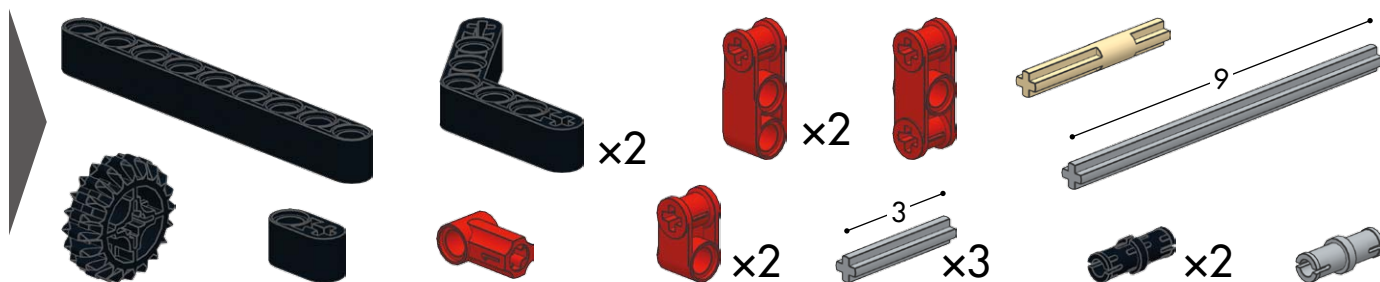
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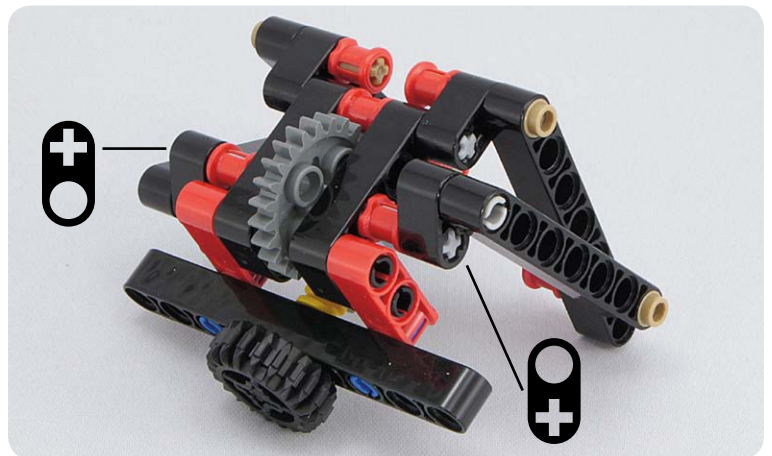
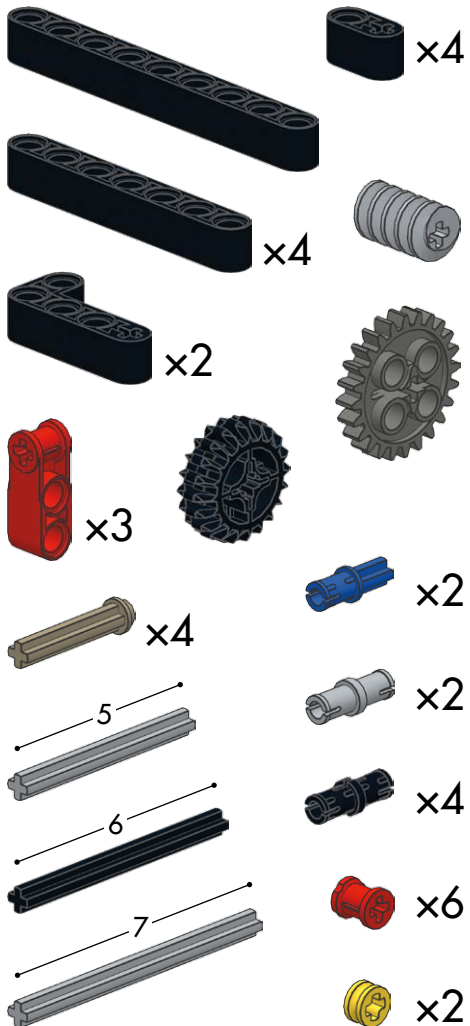
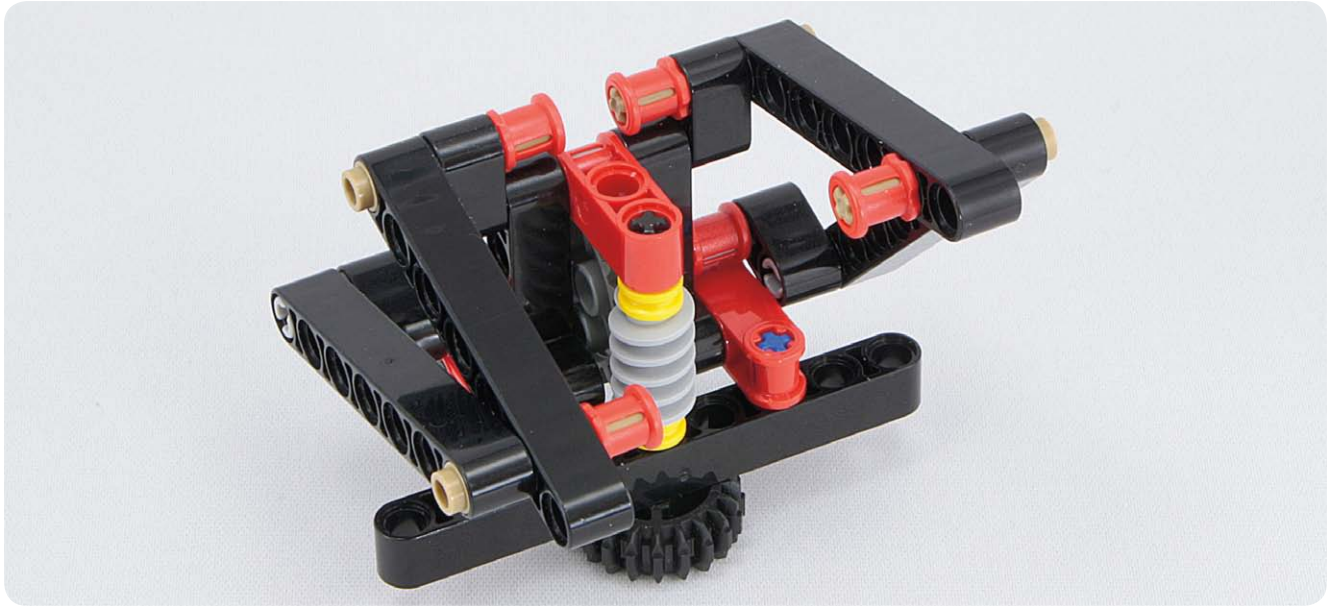


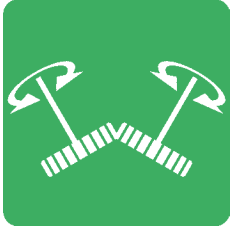






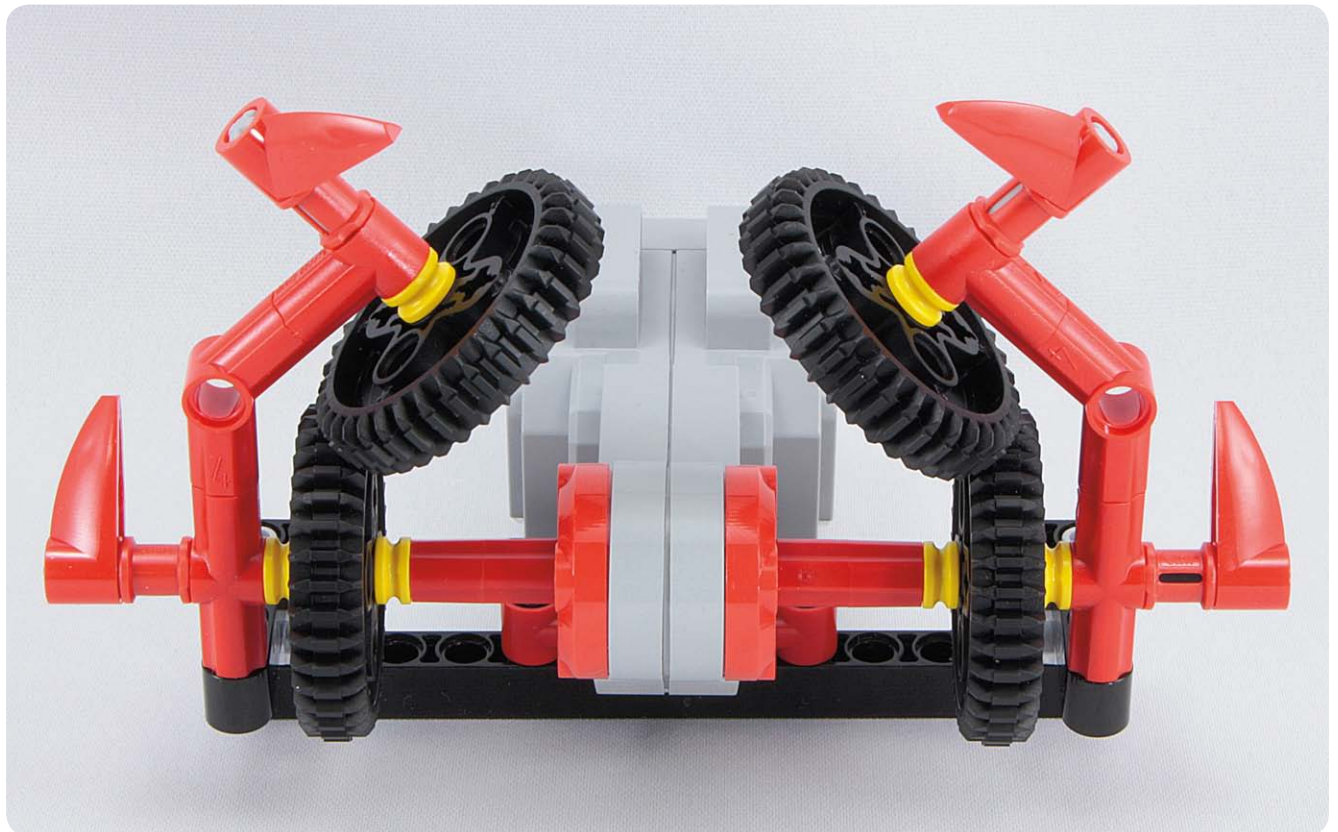
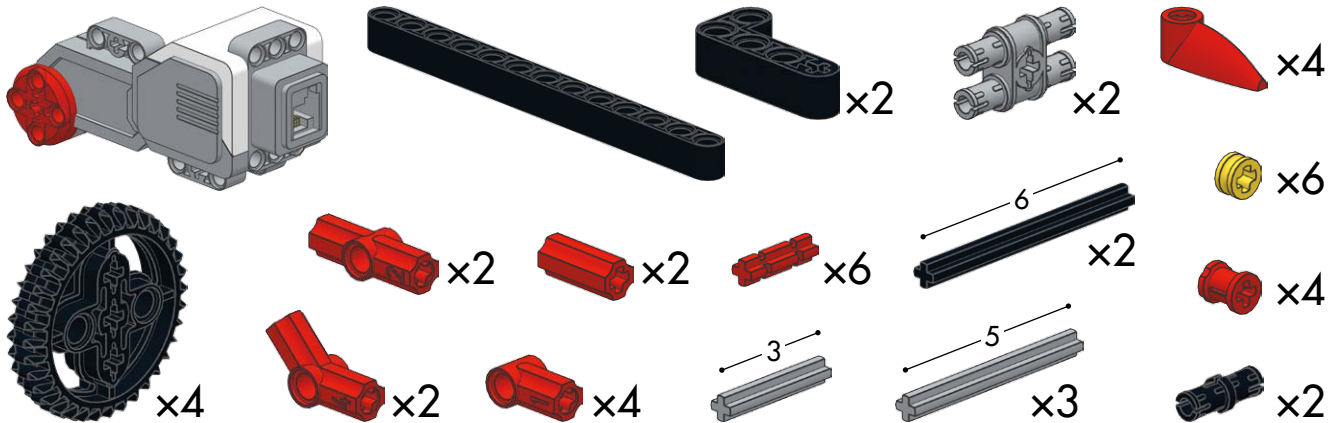


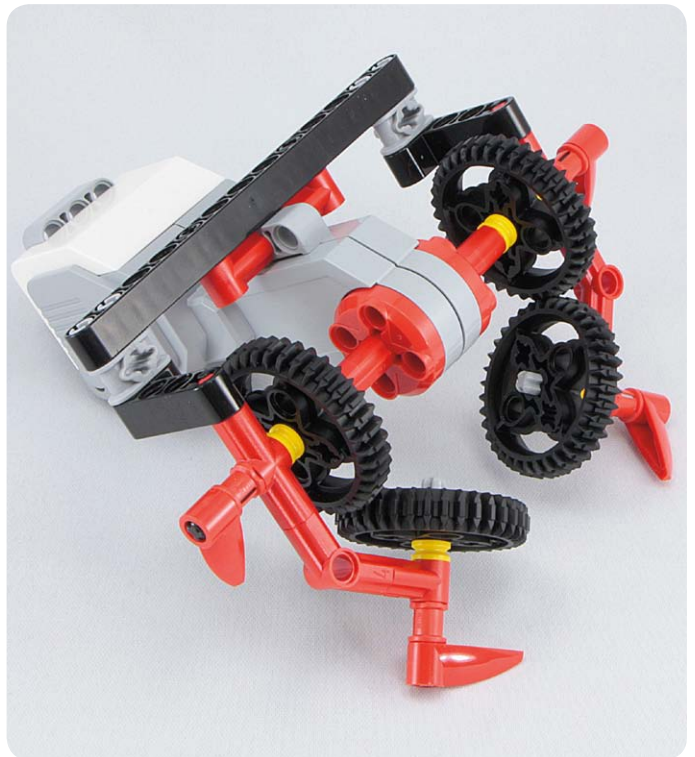


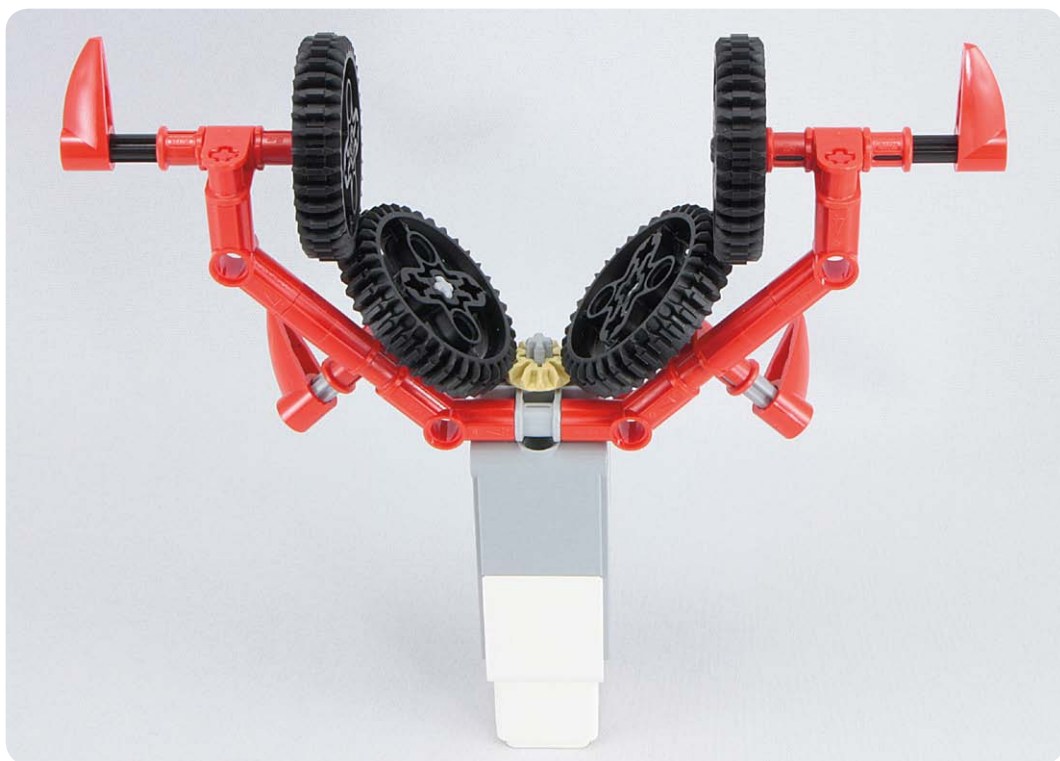
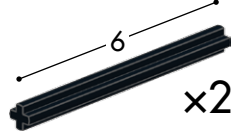
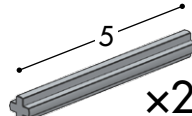
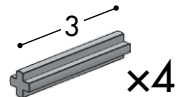
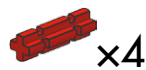
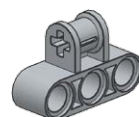
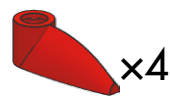
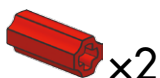
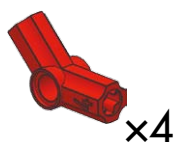
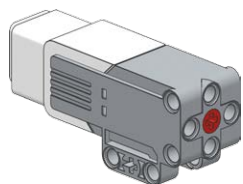


Meshing gears diagonally

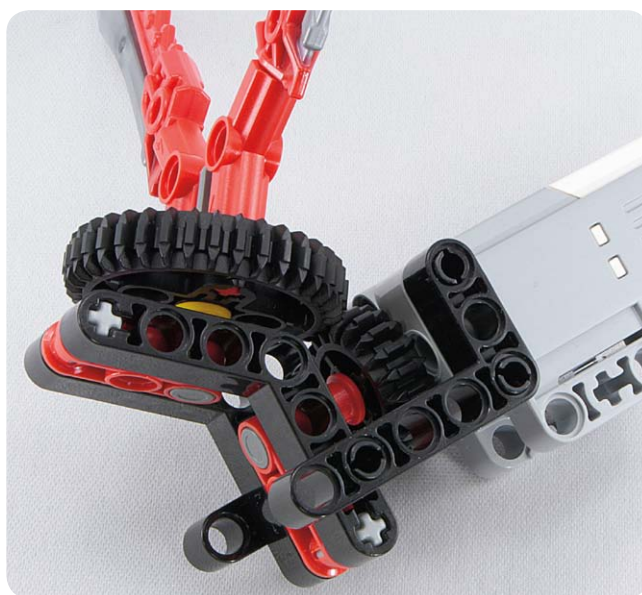
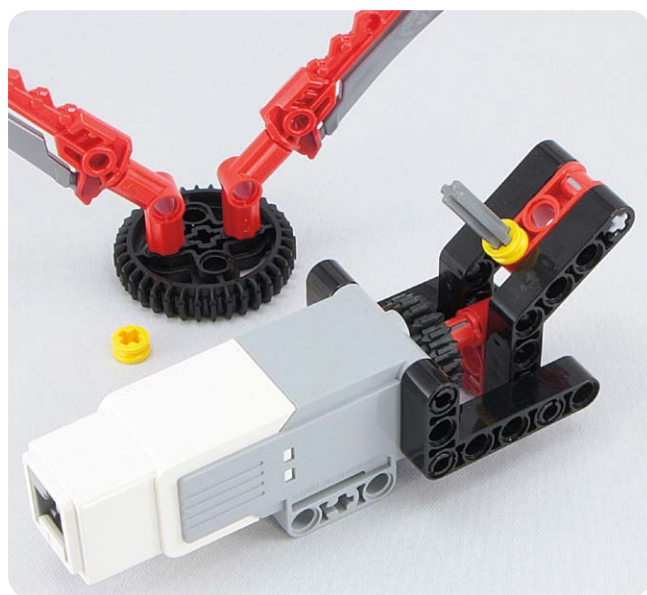
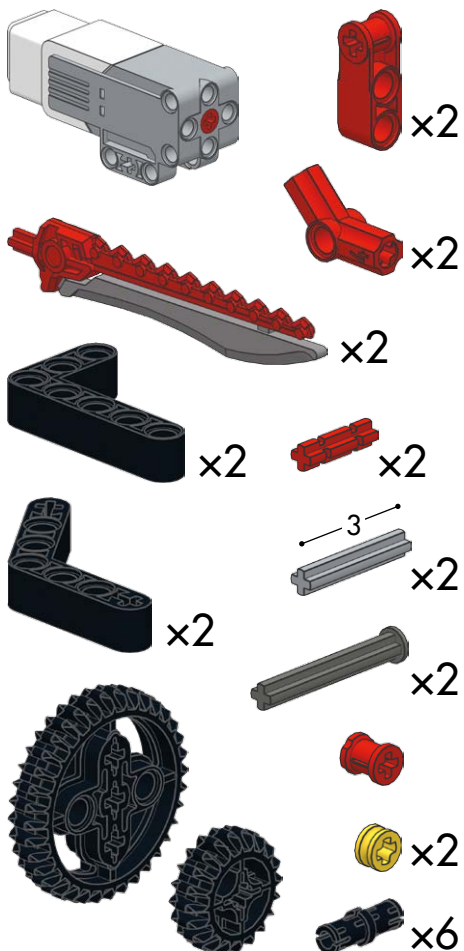
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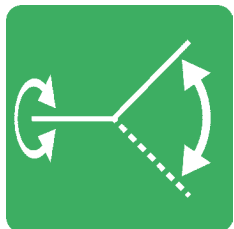






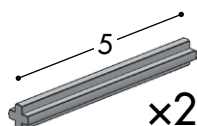
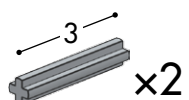
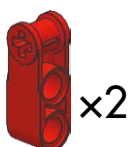
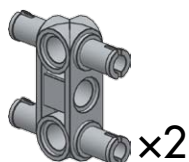
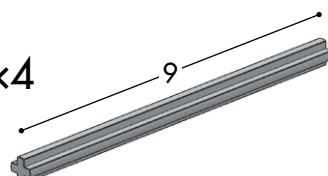
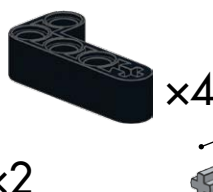
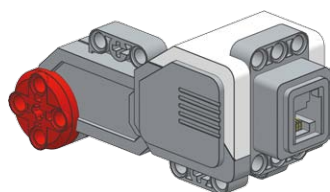
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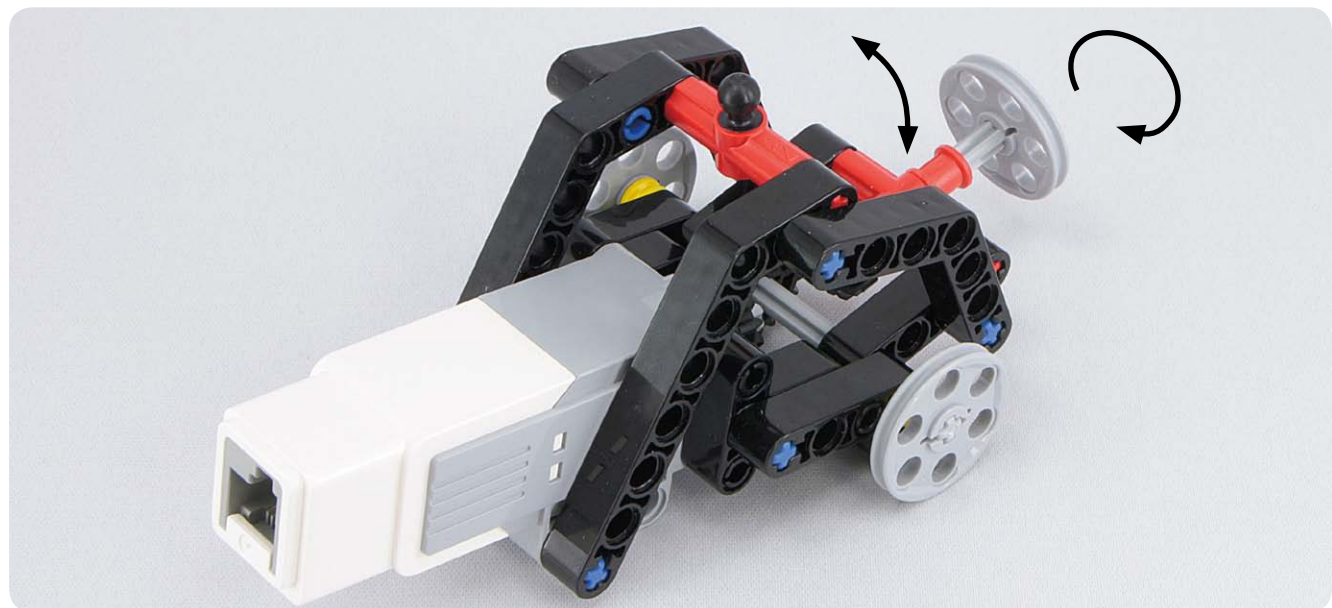
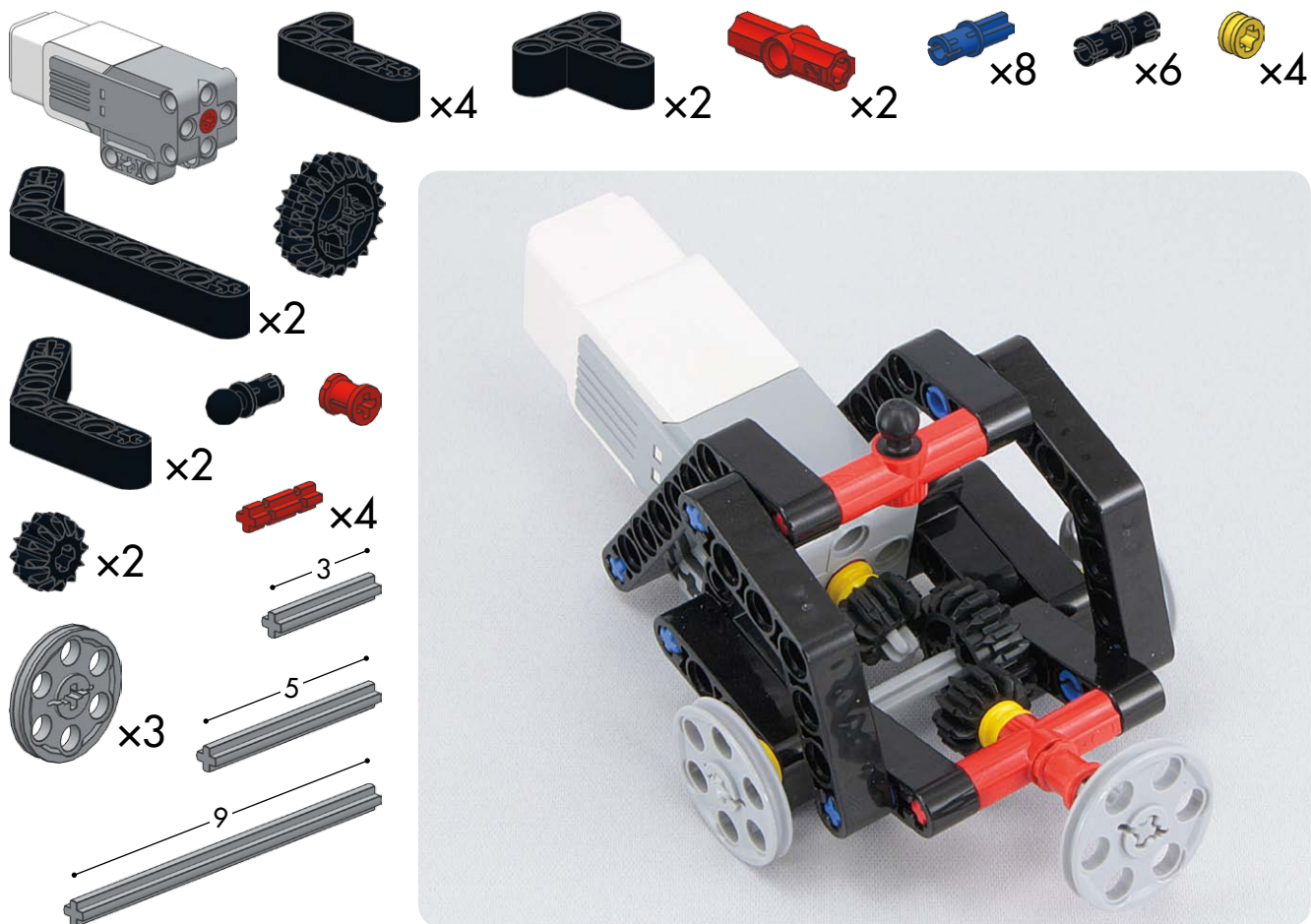


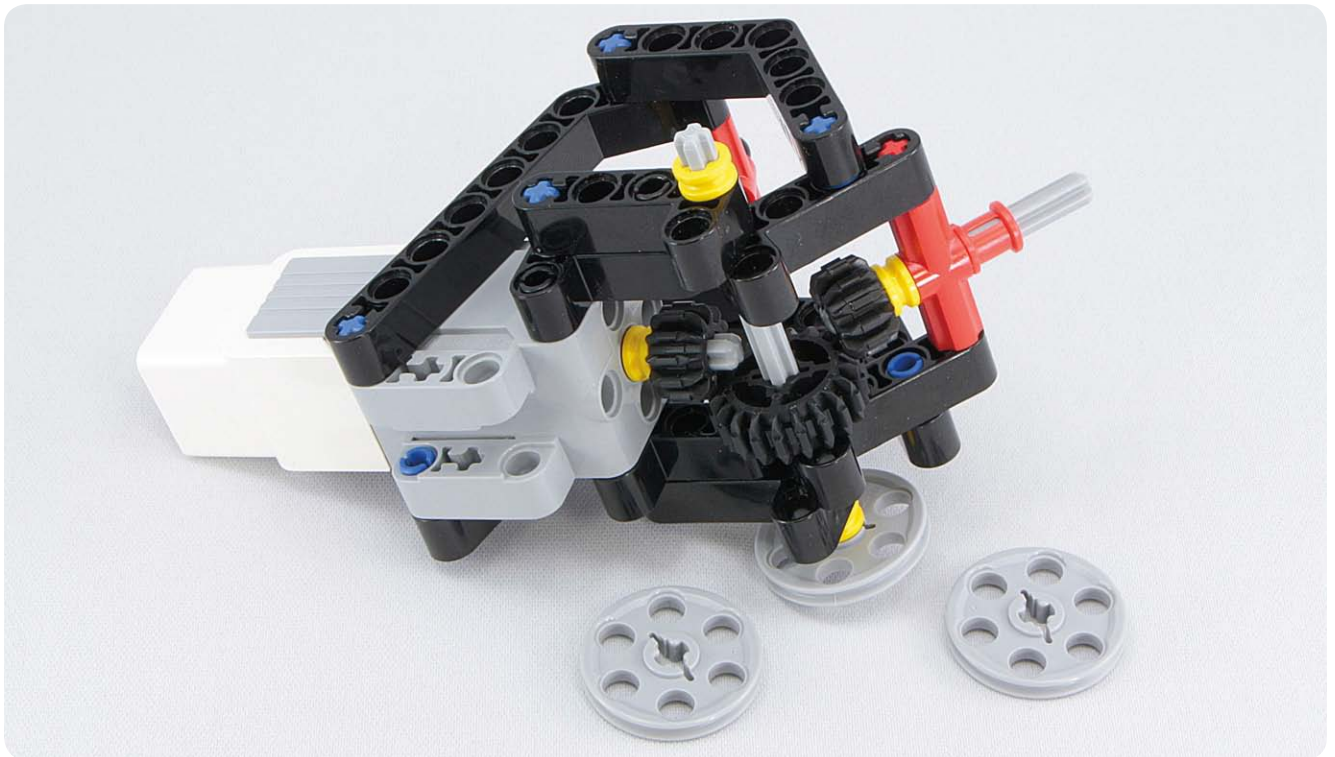
Changing the angle of rotation freely

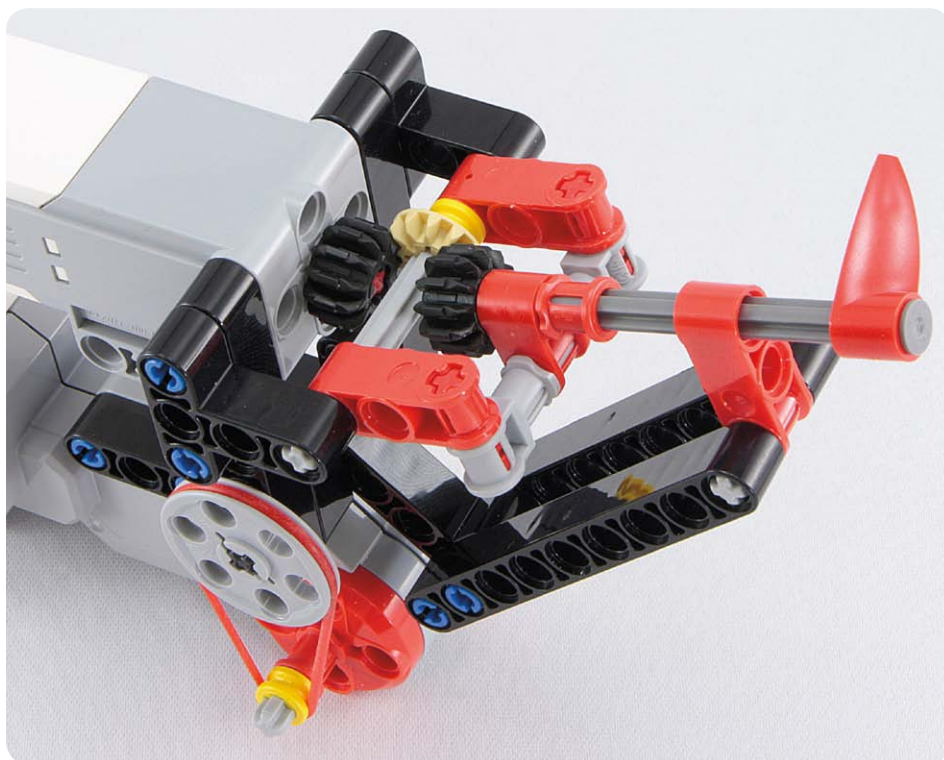
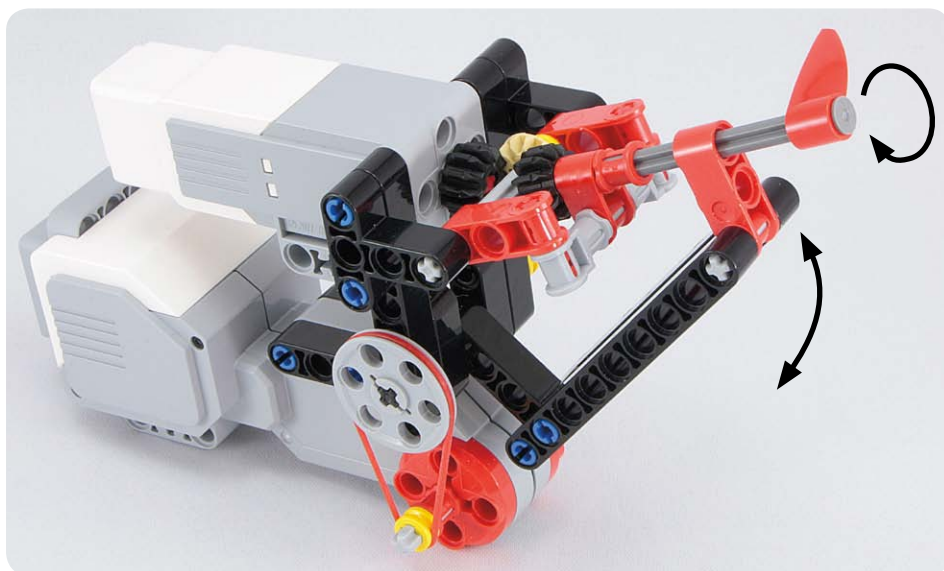
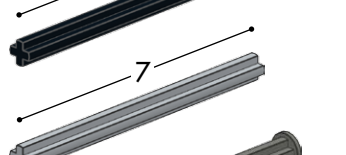
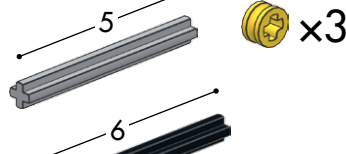
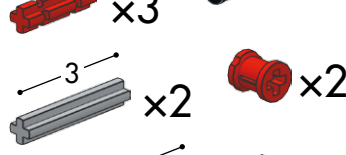
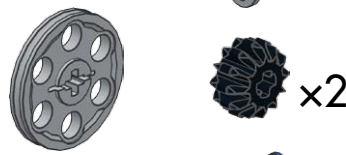
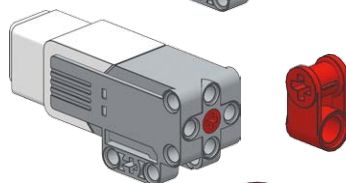
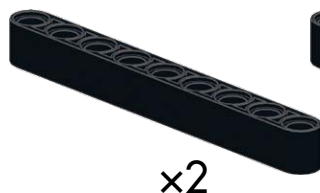
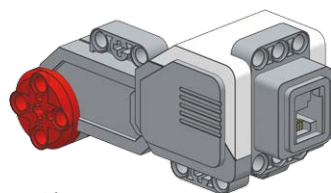
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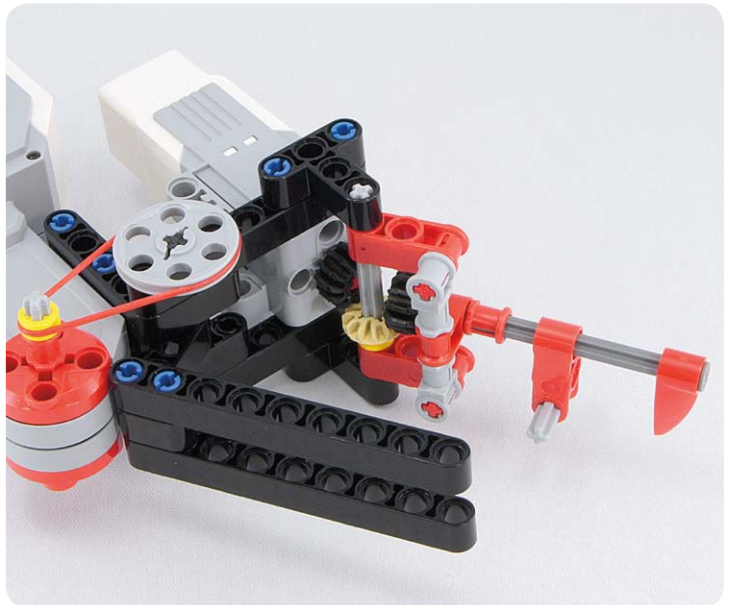
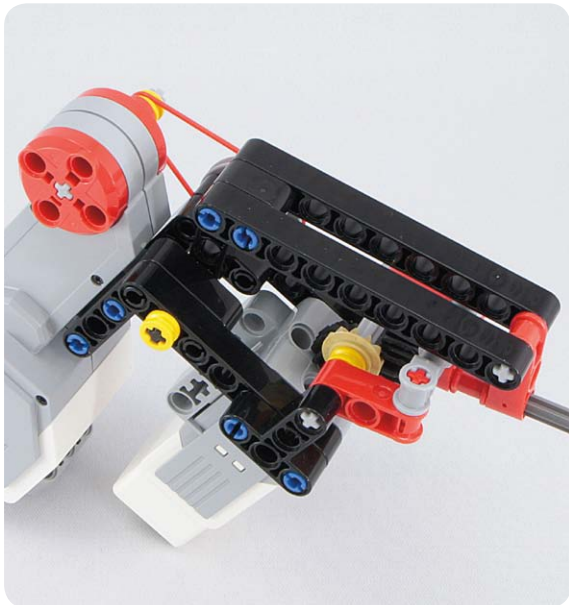
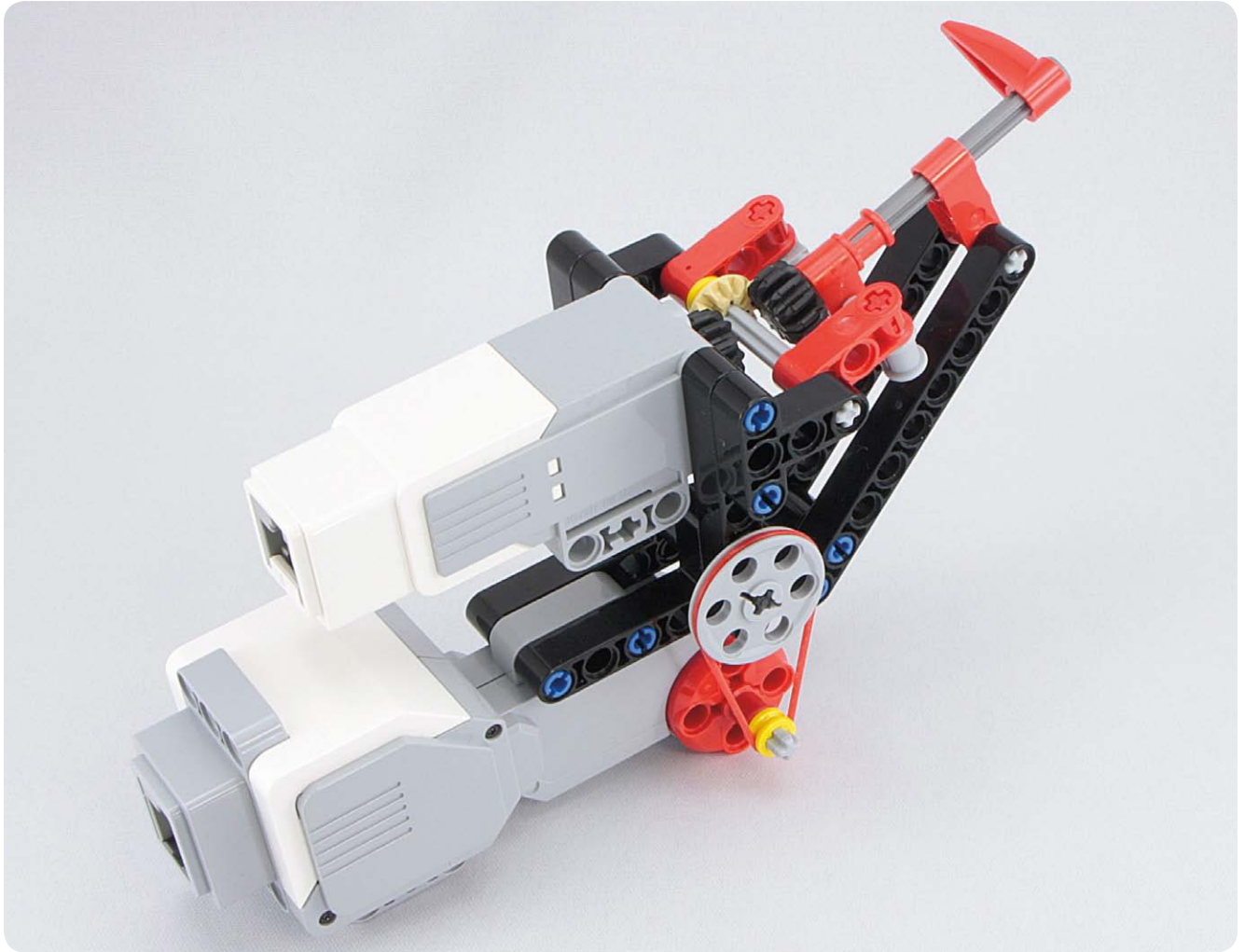






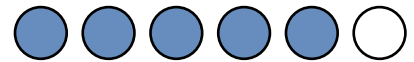








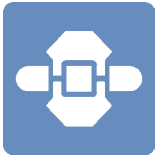
PART 5



Sensors



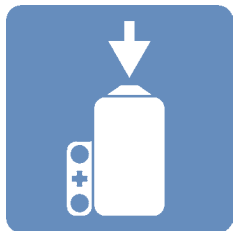
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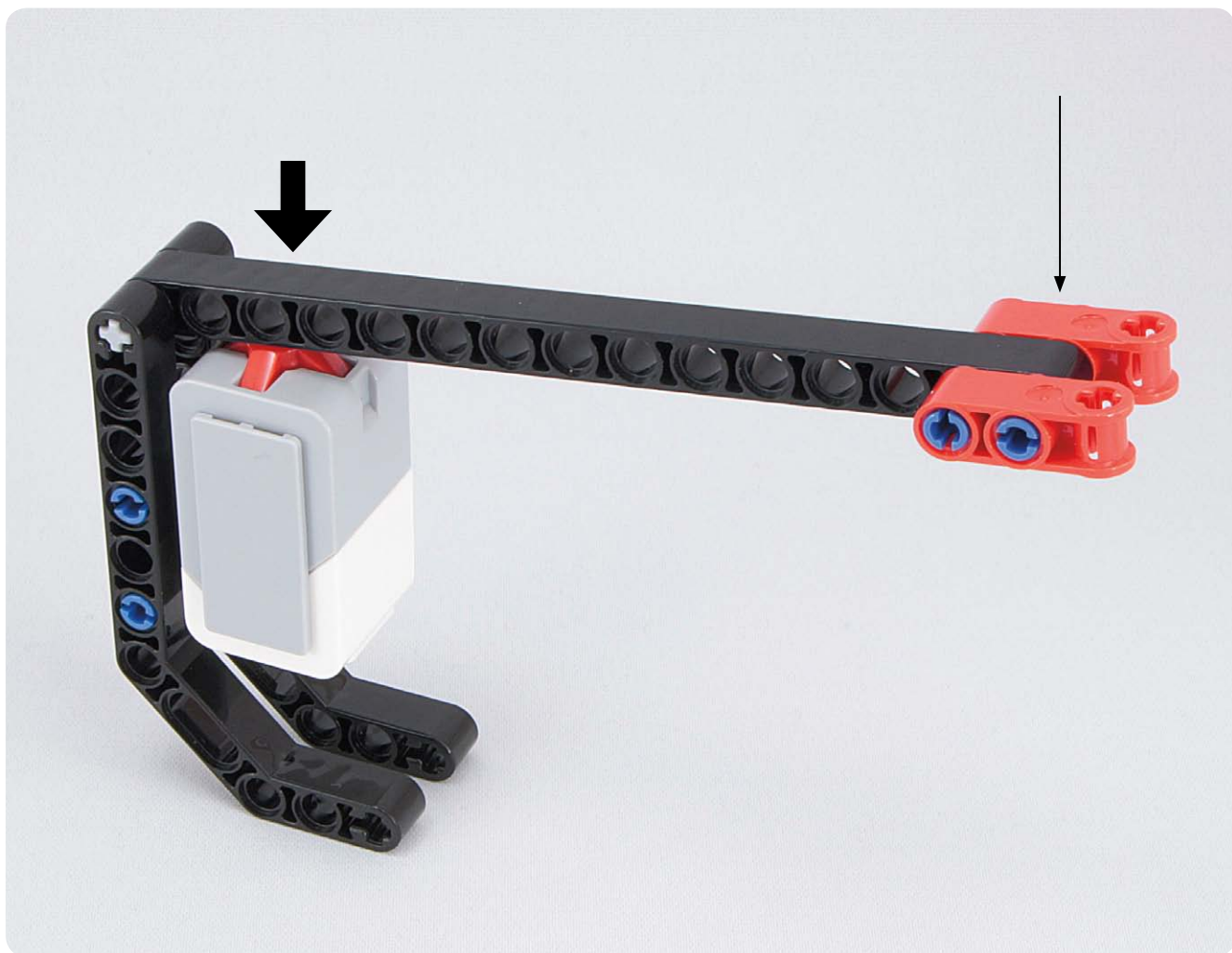
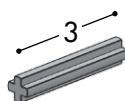
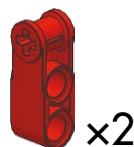
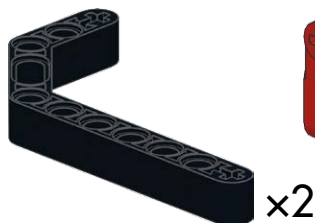
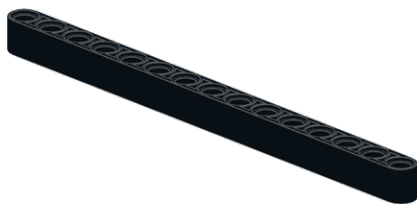
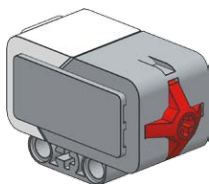


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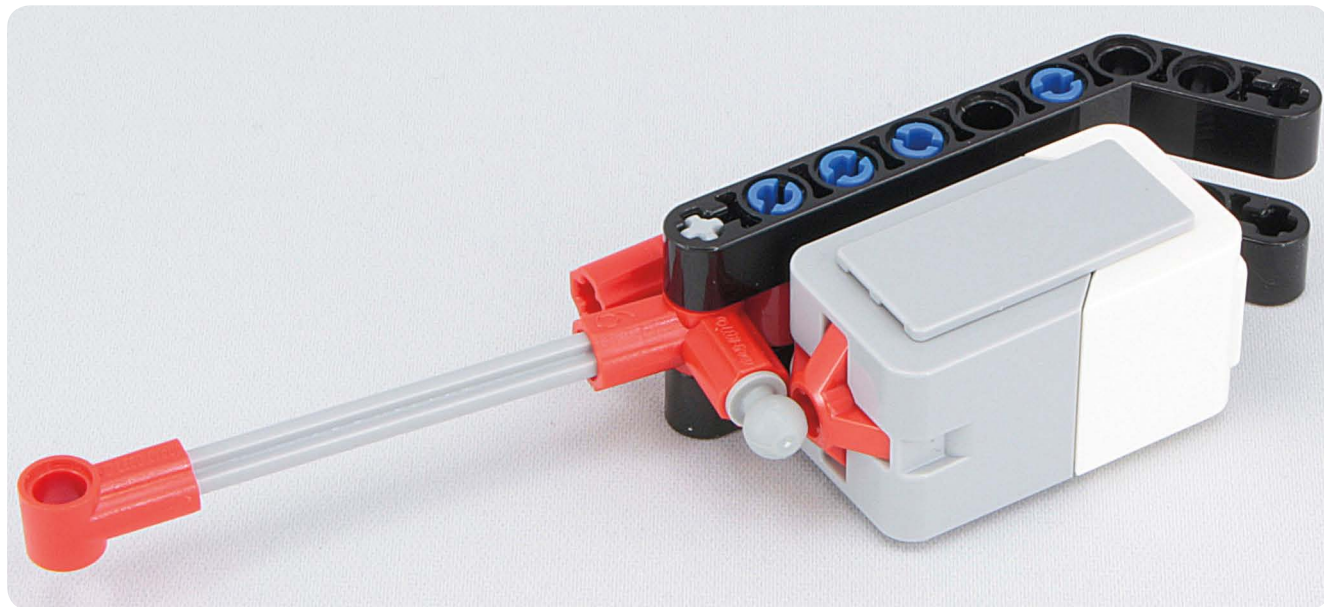
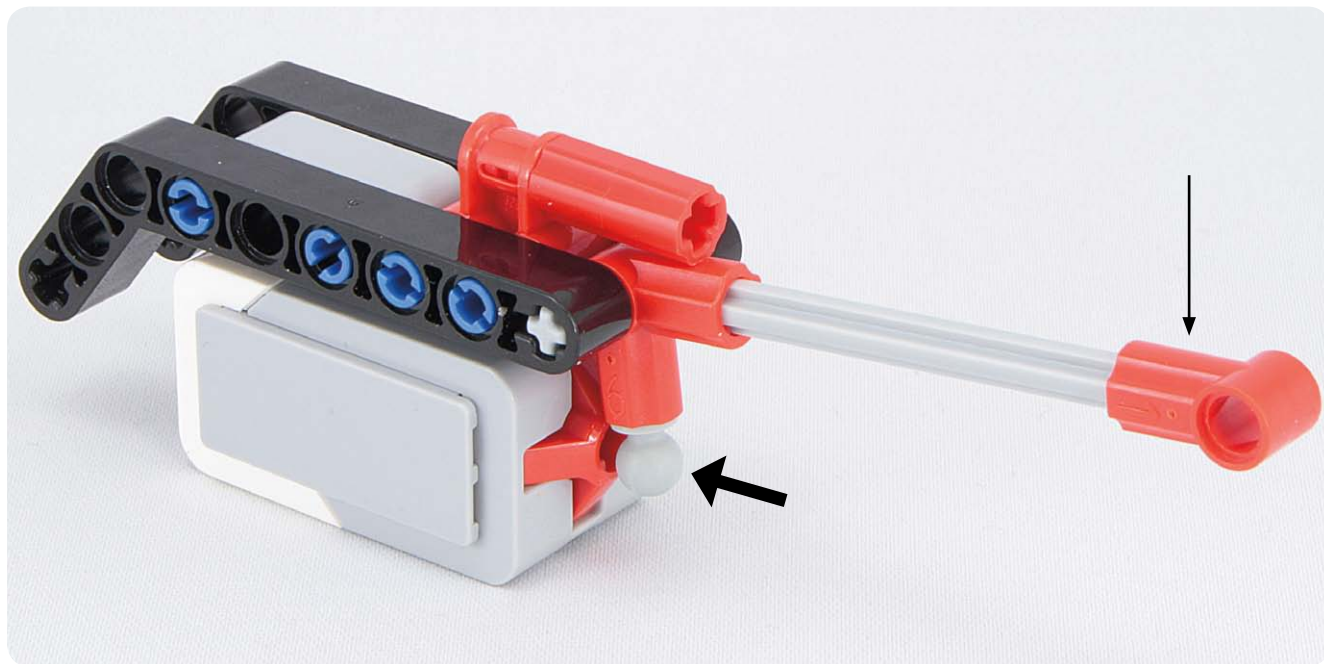
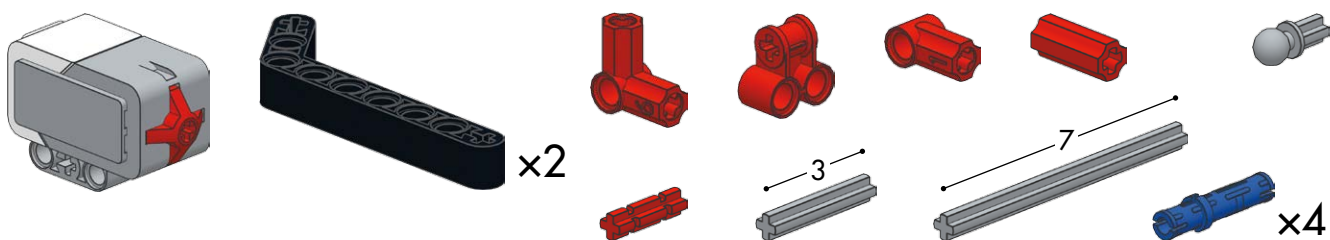


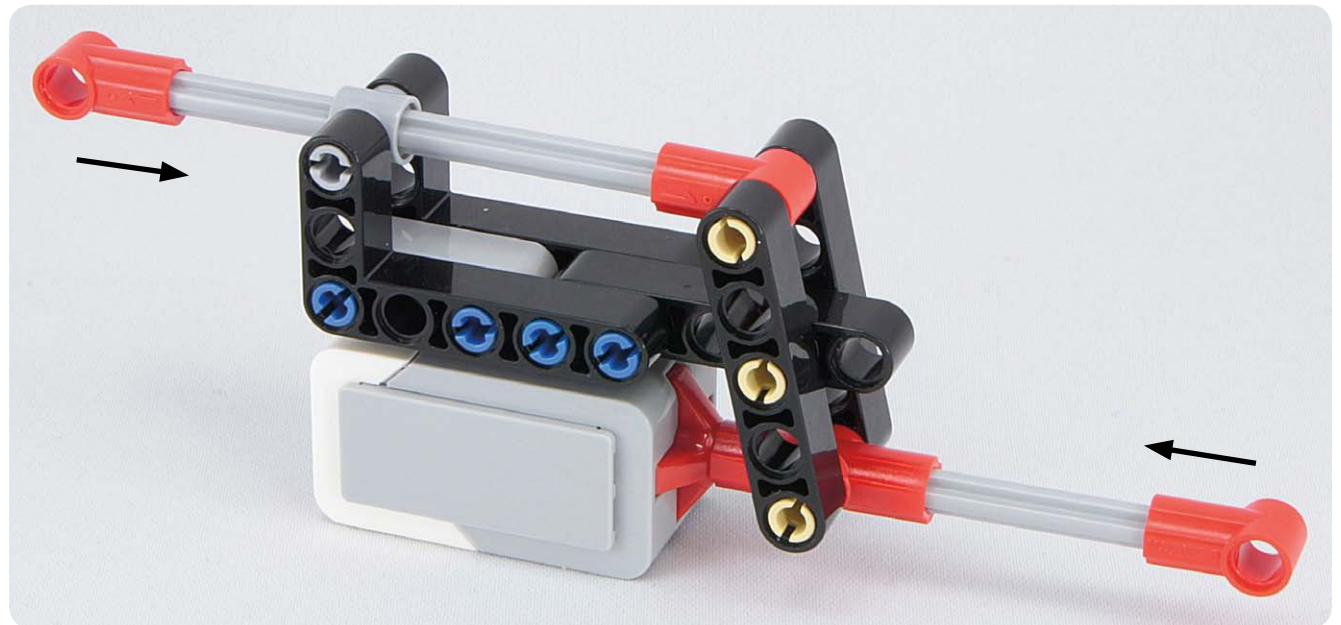
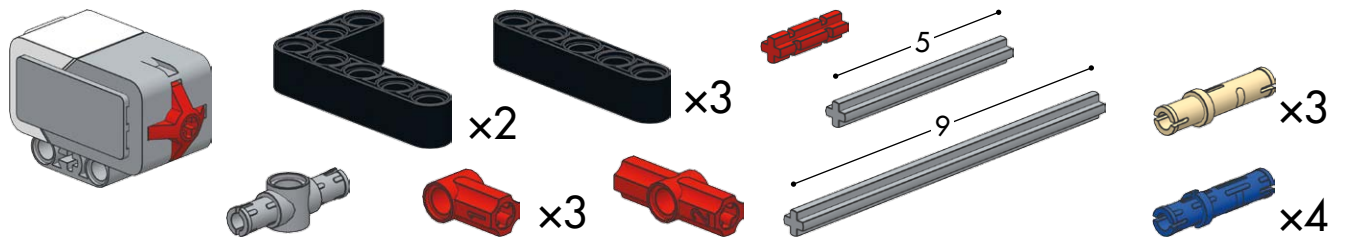
Ideas for using the touch sensor

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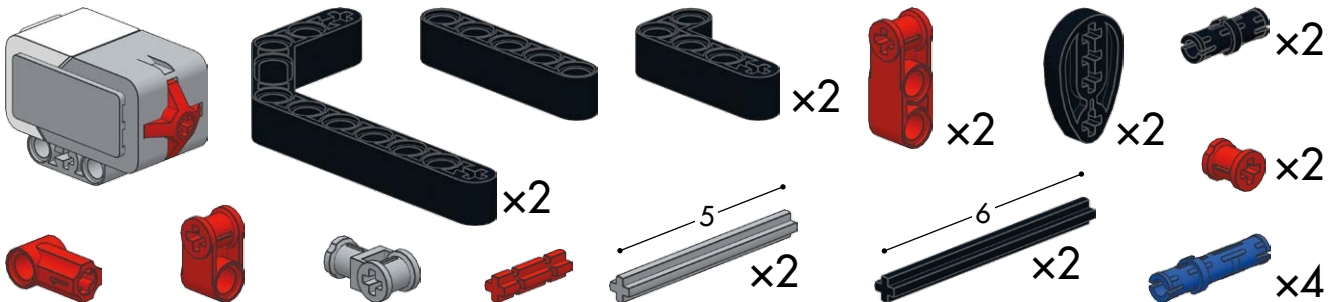


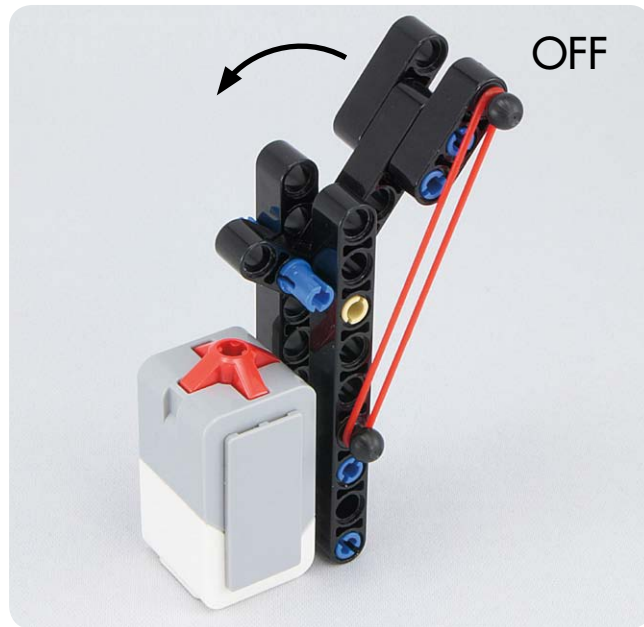
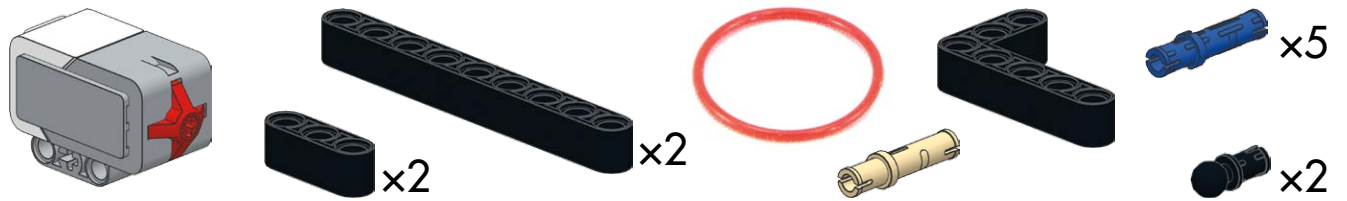
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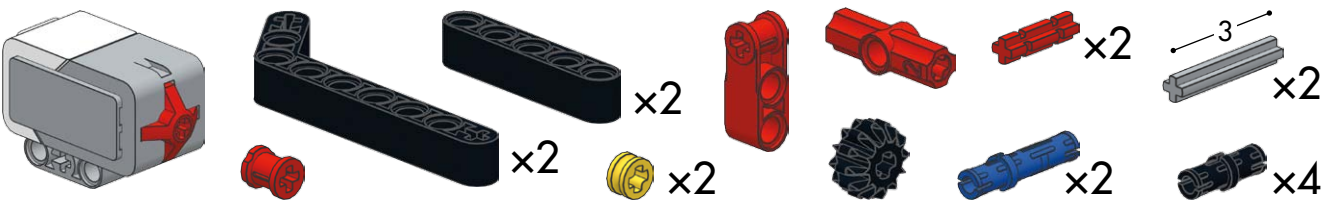


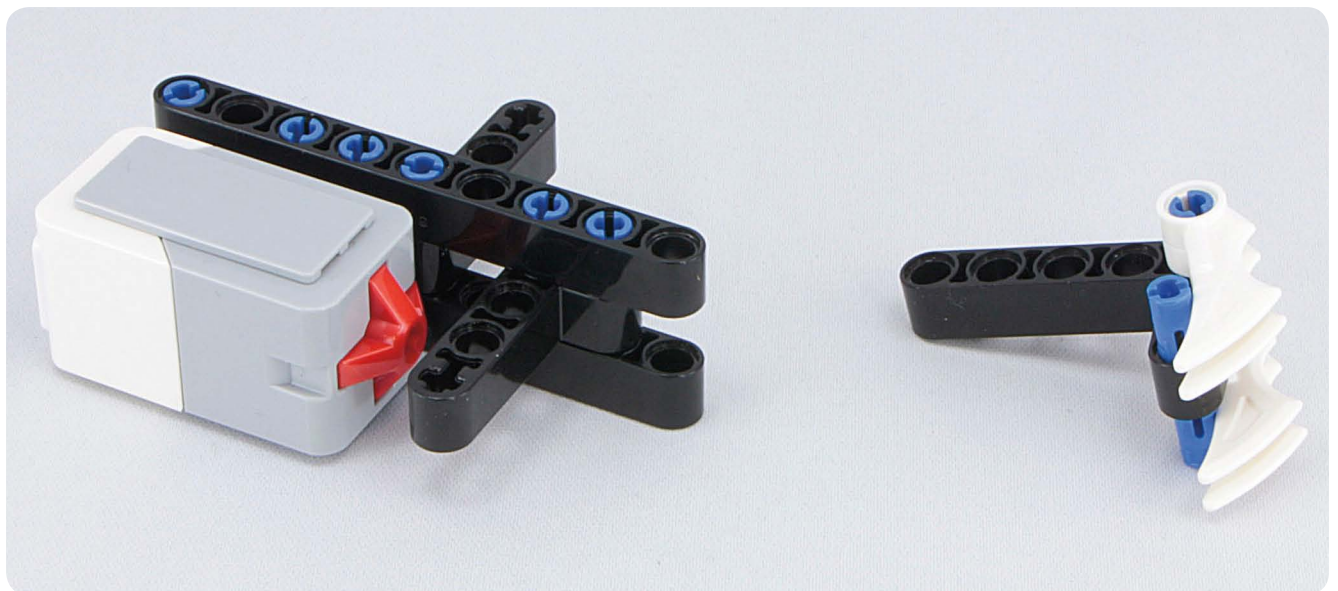
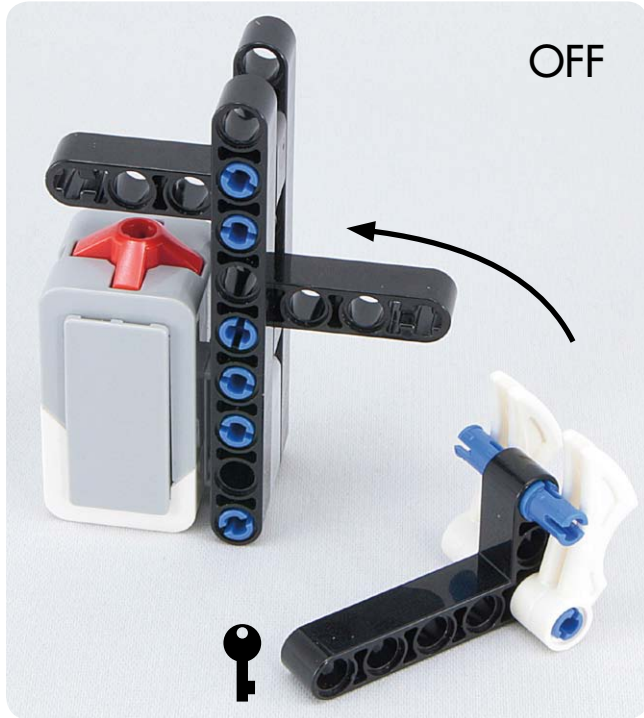
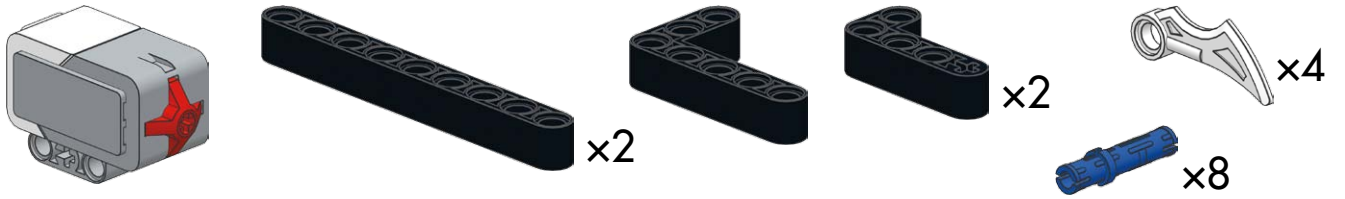


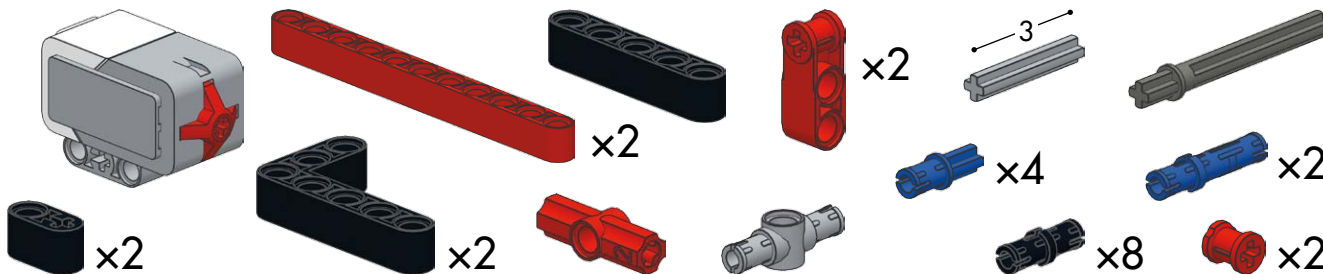
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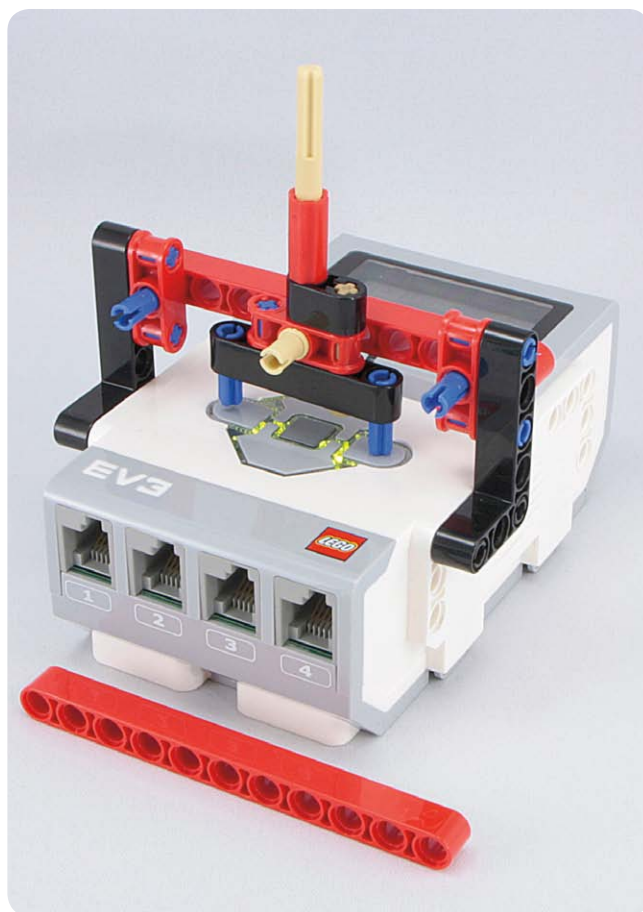




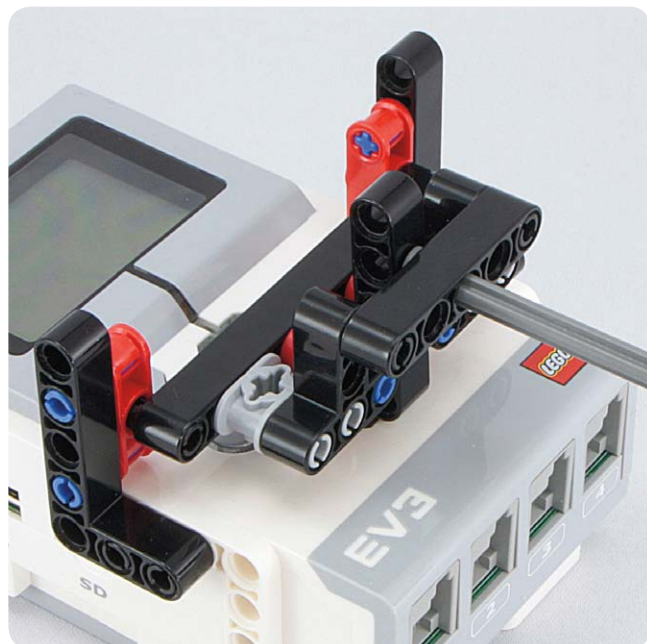
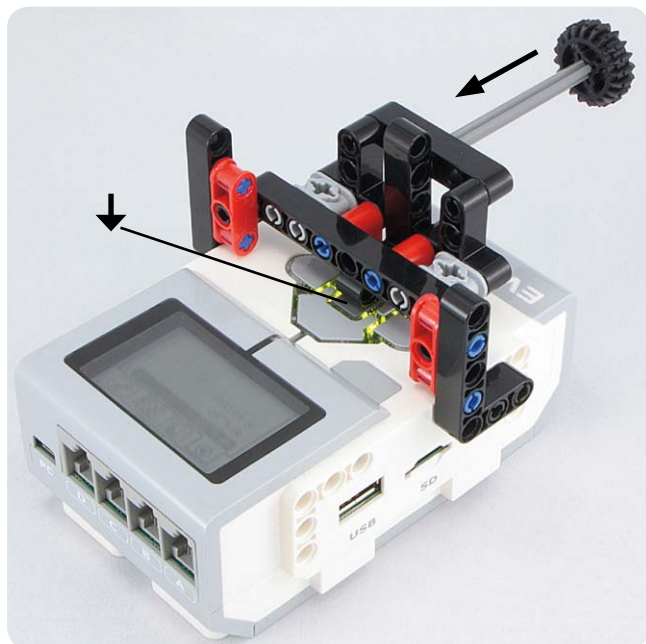
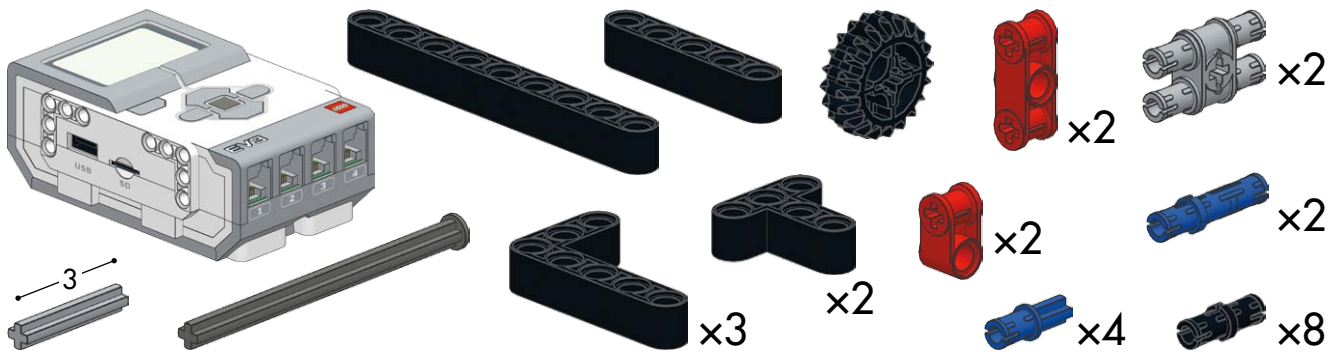


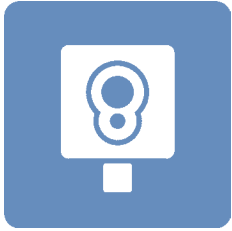




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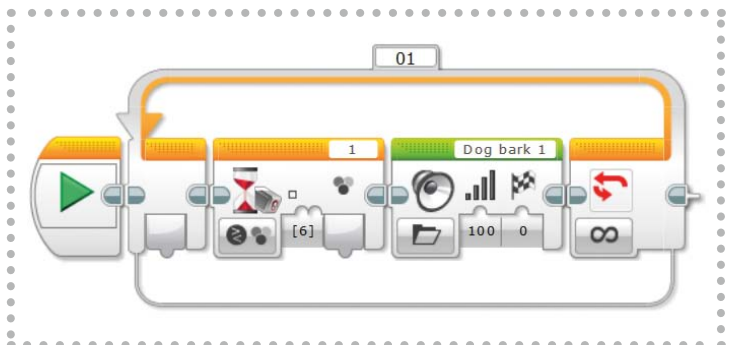
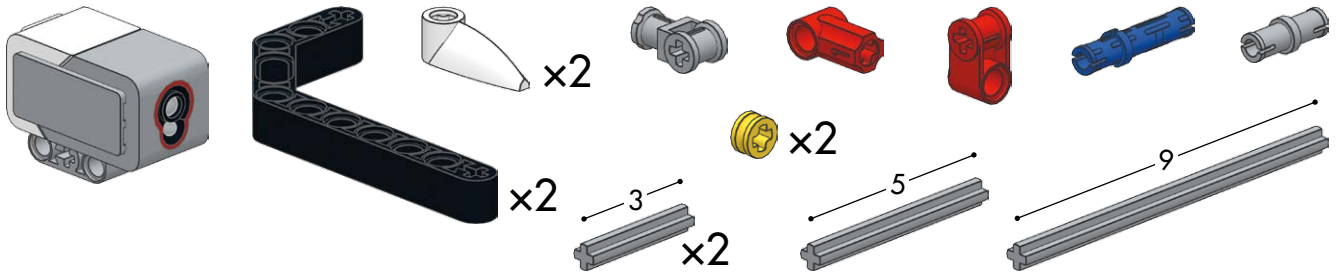
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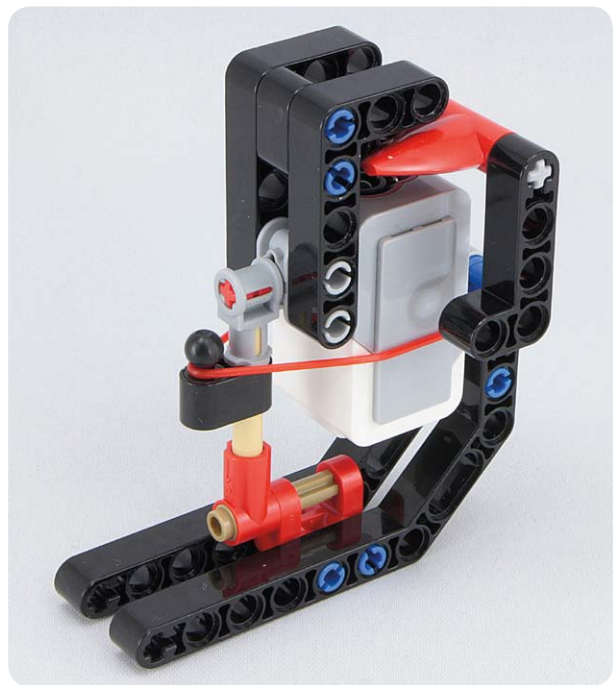
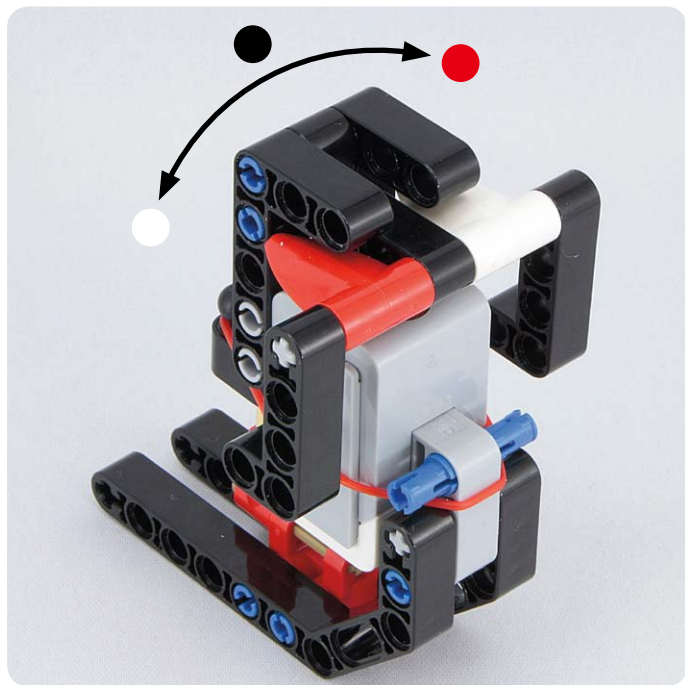
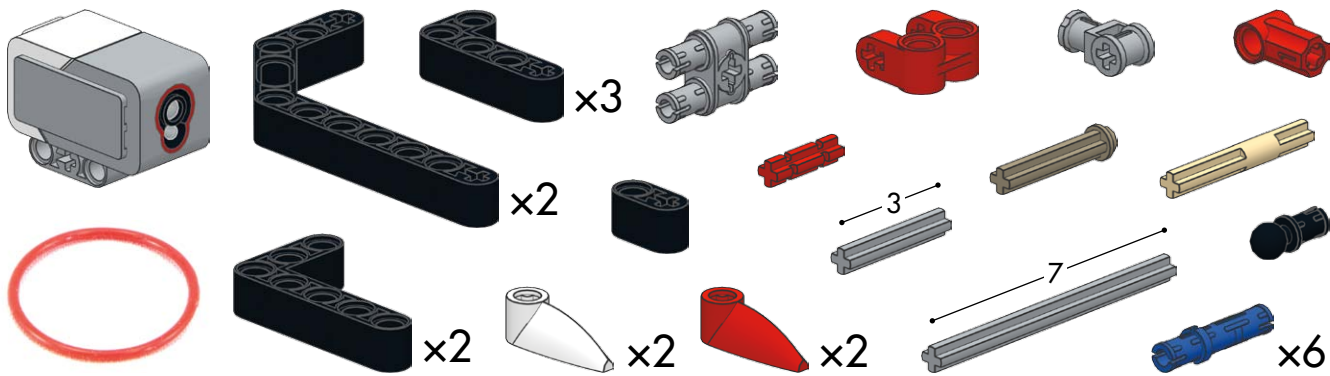


Ideas for using the color sensor

#174

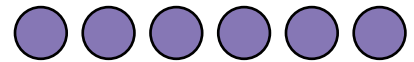


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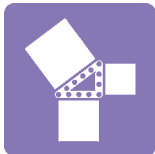




PART 6



Something Extra



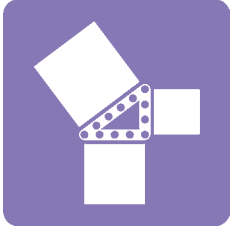
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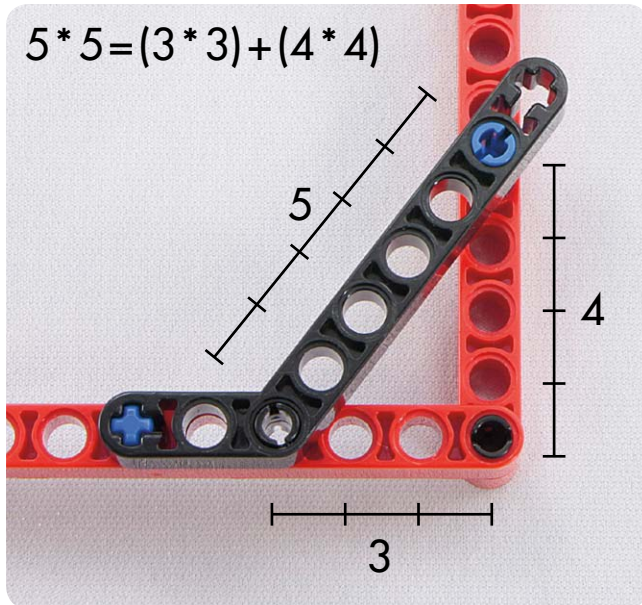


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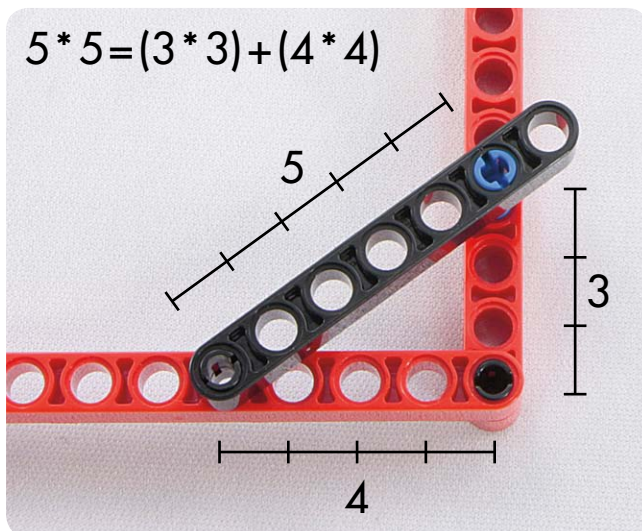


Using the Pythagorean theorem

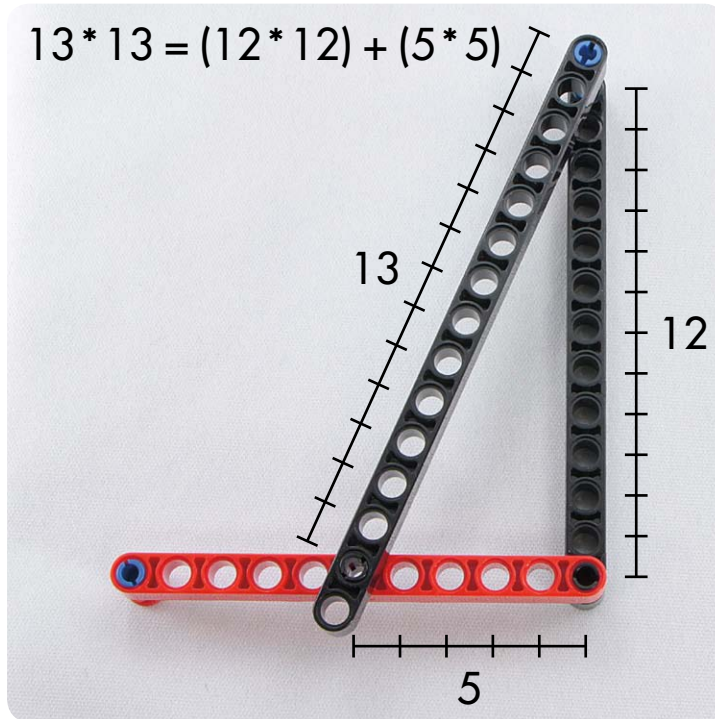
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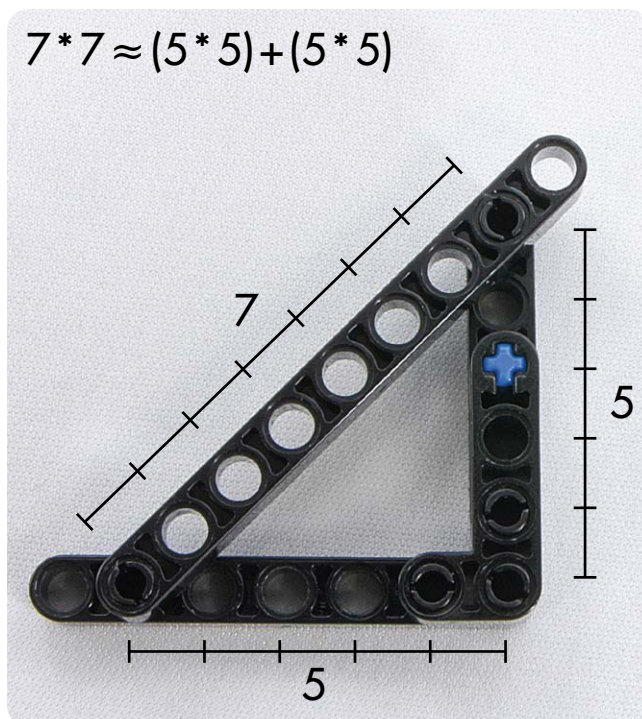
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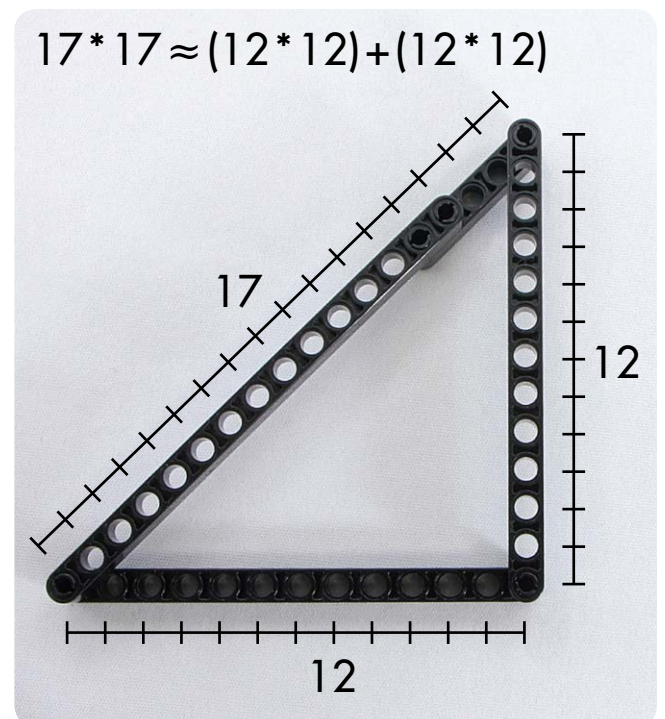
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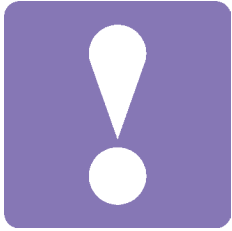


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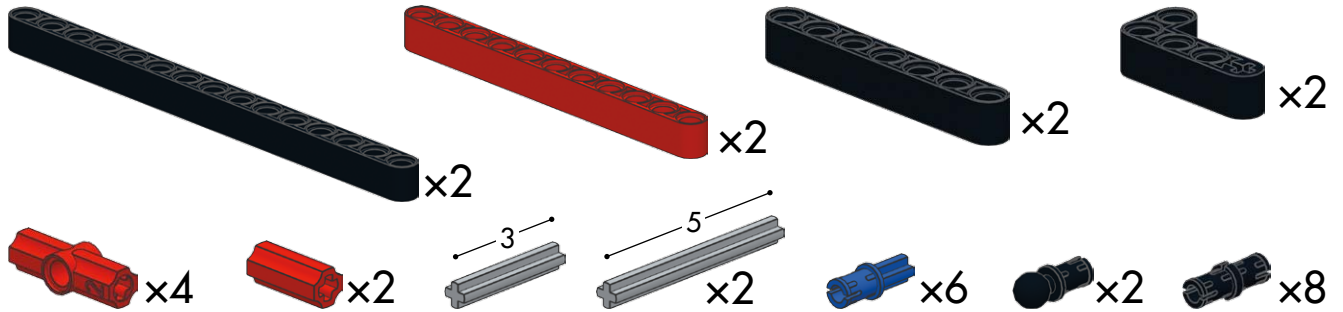




Try building something handy!

.....

#181

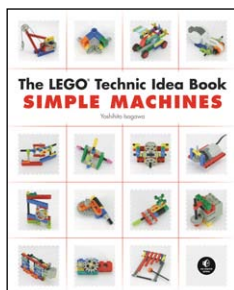




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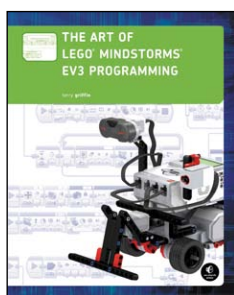
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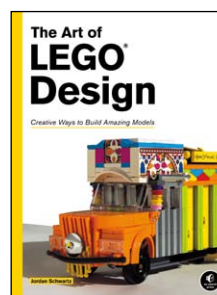
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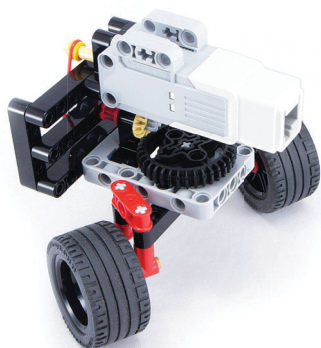
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ABOUT THE AUTHOR

Yoshihito Isogawa is a LEGO luminary with 46 years of building experience. He is the author of the *LEGO Technic Idea Book* series (No Starch Press) as well as many Japanese-language LEGO books.



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