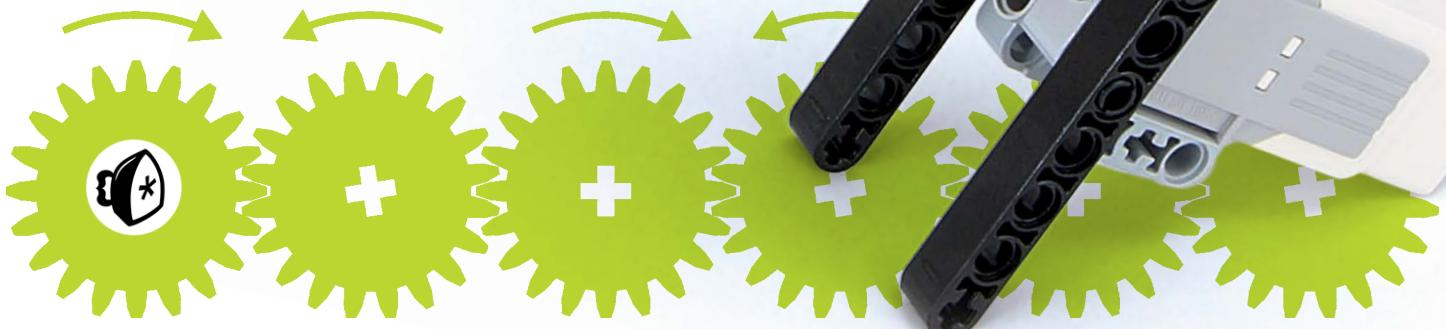


THE LEGO® MINDSTORMS® EV3 IDEA BOOK



YOSHIHITO ISOGAWA



181 Simple Machines and Clever Contraptions

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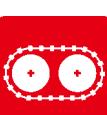
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Introduction

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?

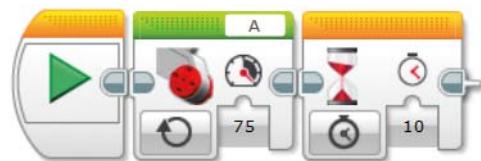
Other than this brief introduction and the table of contents, this book has almost no words. Instead, you'll find a series of photographs of increasingly complex models, each designed to demonstrate a mechanical principle or building technique.

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.

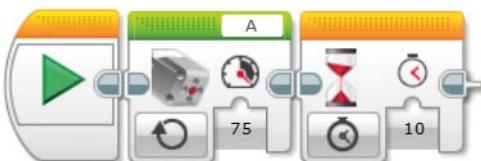
This is an idea book; it's about imagination. Rather than tell you what to see or think when you study the models, I encourage you to interpret them in your own way. Your interpretations will lead you to invent your very own models or use my mechanisms in entirely new ways!

What About Programs?

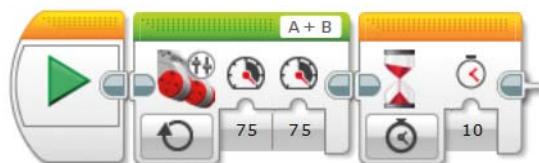
This book is about exploring the mechanical side of EV3 and robotics, rather than programming. You'll need only a few simple programs to test out your mechanical creations. Prepare these three simple programs in advance.



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.

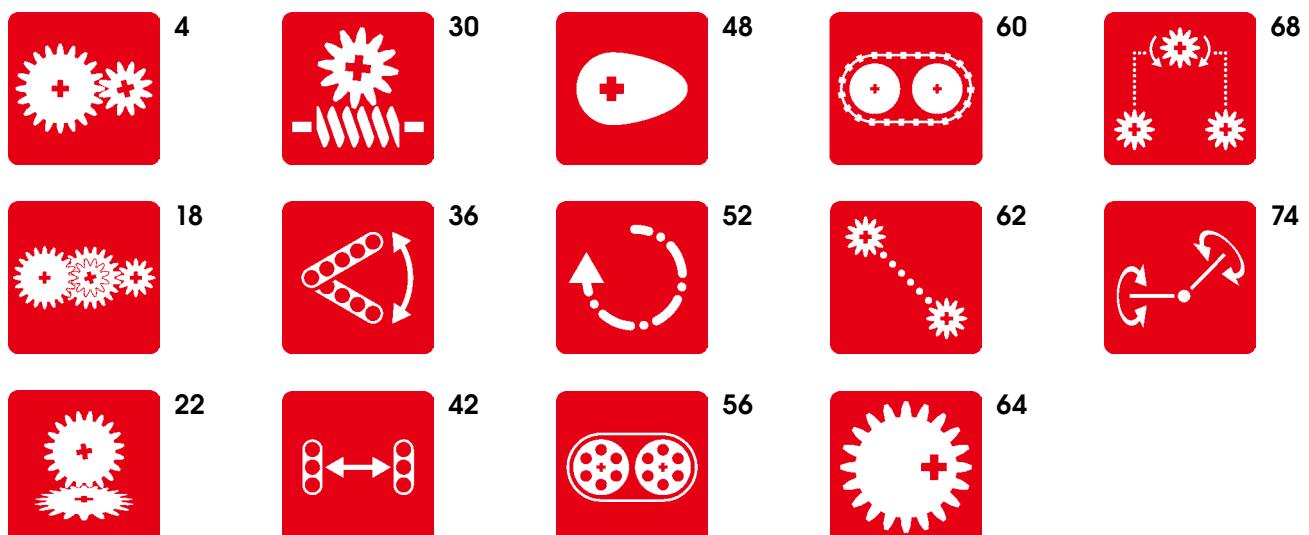
A few of the models in this book require special programs. Take note of these programs, as they are written to avoid damaging parts by overextending a mechanism's range of motion.

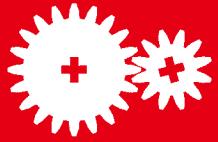


PART 1



Basic Mechanisms





Gear ratios

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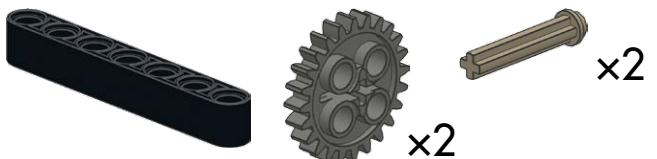
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#2

24:24 = 1:1



x2

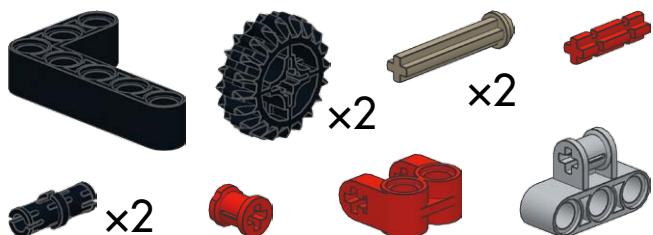


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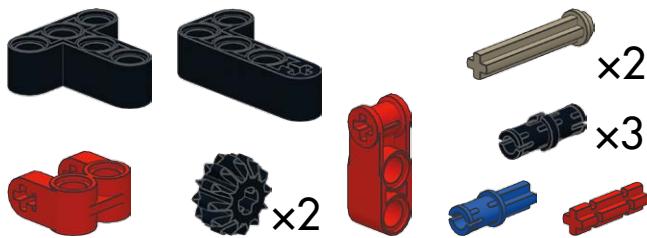


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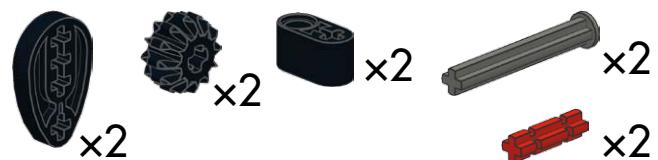
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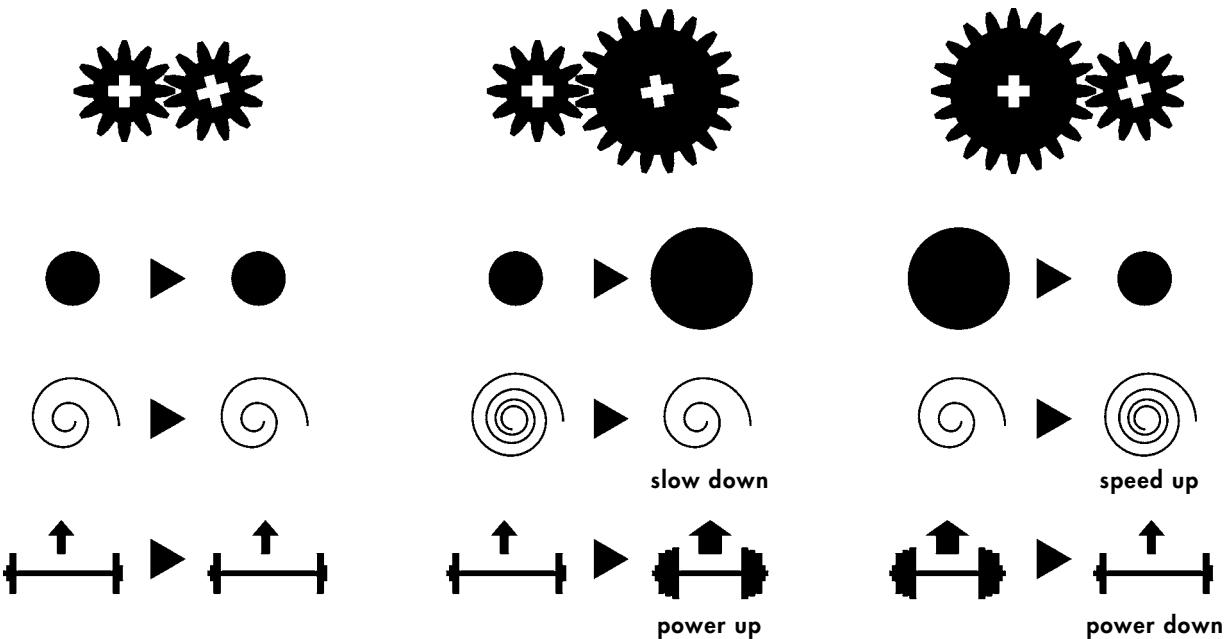


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#6



$12:12 = 1:1$



#7

$$12:20 = 3:5$$



#8

$$12:24=1:2$$



#9



$$12:36=1:3$$



#10



$$20:36 = 5:9$$

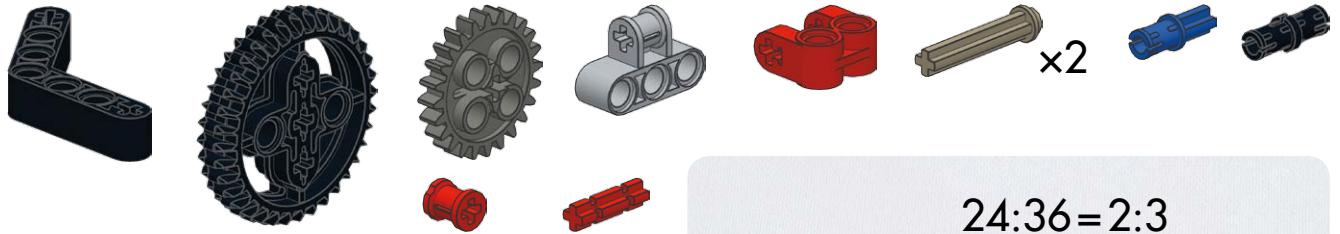


#11

$$20:24 = 5:6$$



#12



$$24:36 = 2:3$$



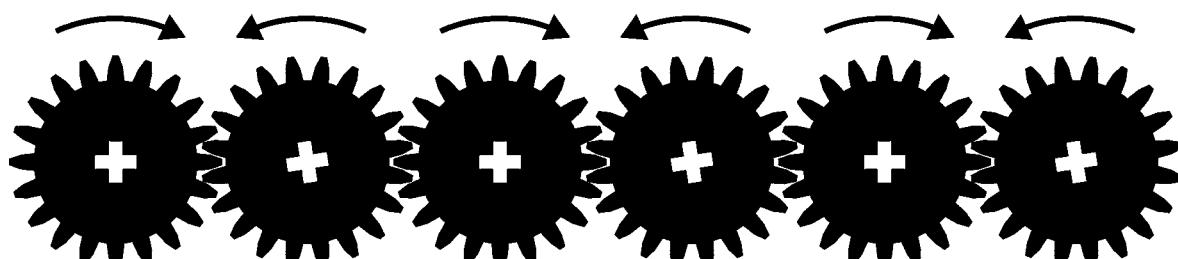
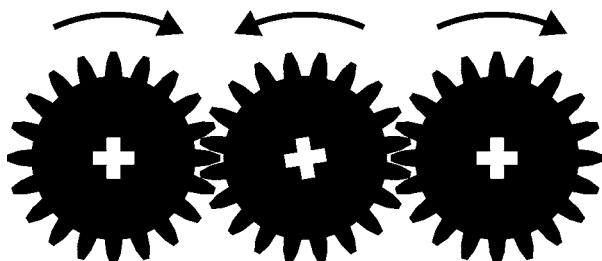
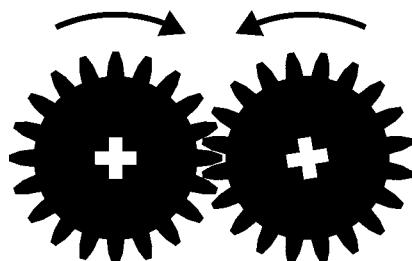
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$$12:20:12 = 3:5:3$$



#14

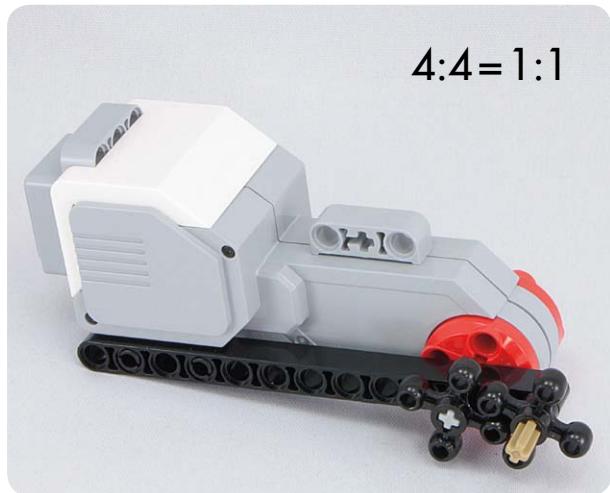
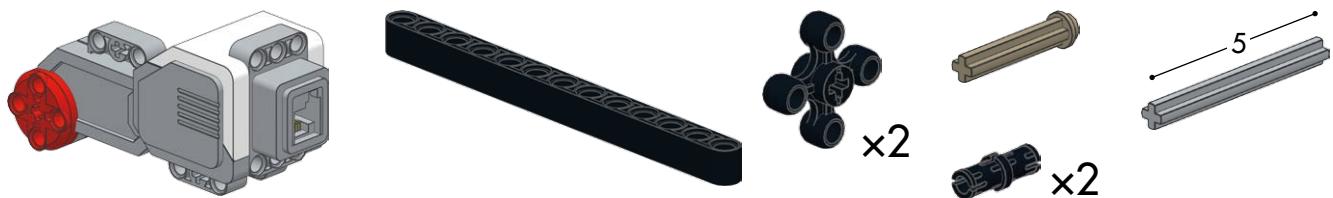
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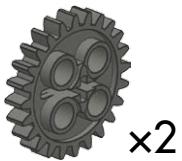
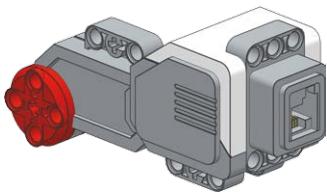
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#16



#17



×2



×2

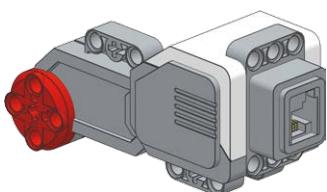


×2

$$24:24 = 1:1$$



#18



×2

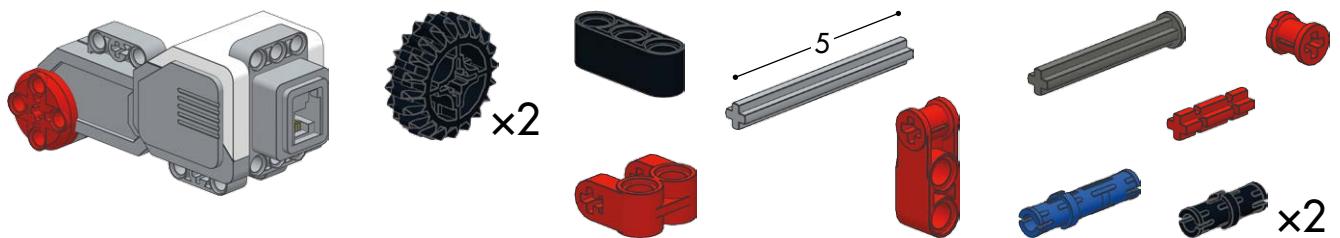


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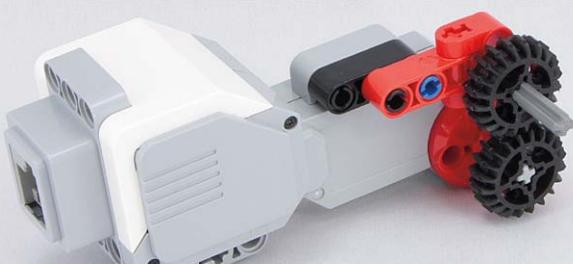
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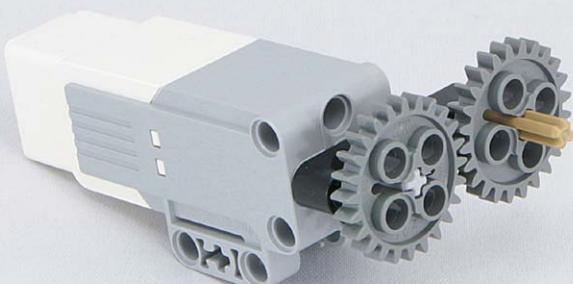
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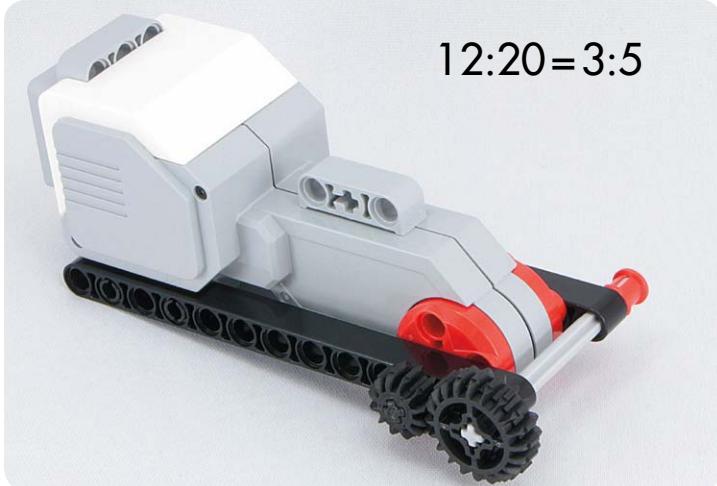
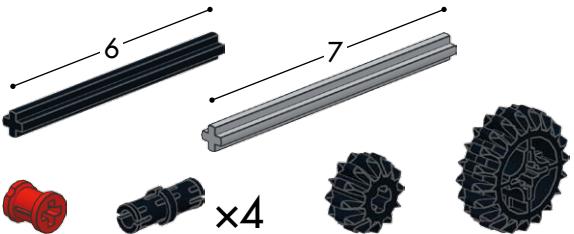
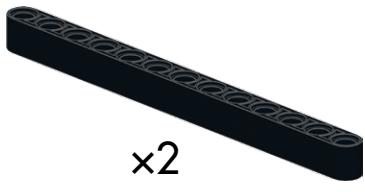
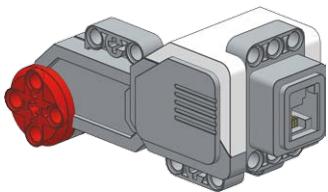
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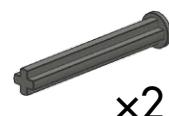
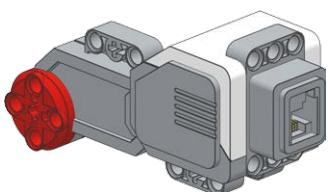
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$$12:20 = 3:5$$



#22

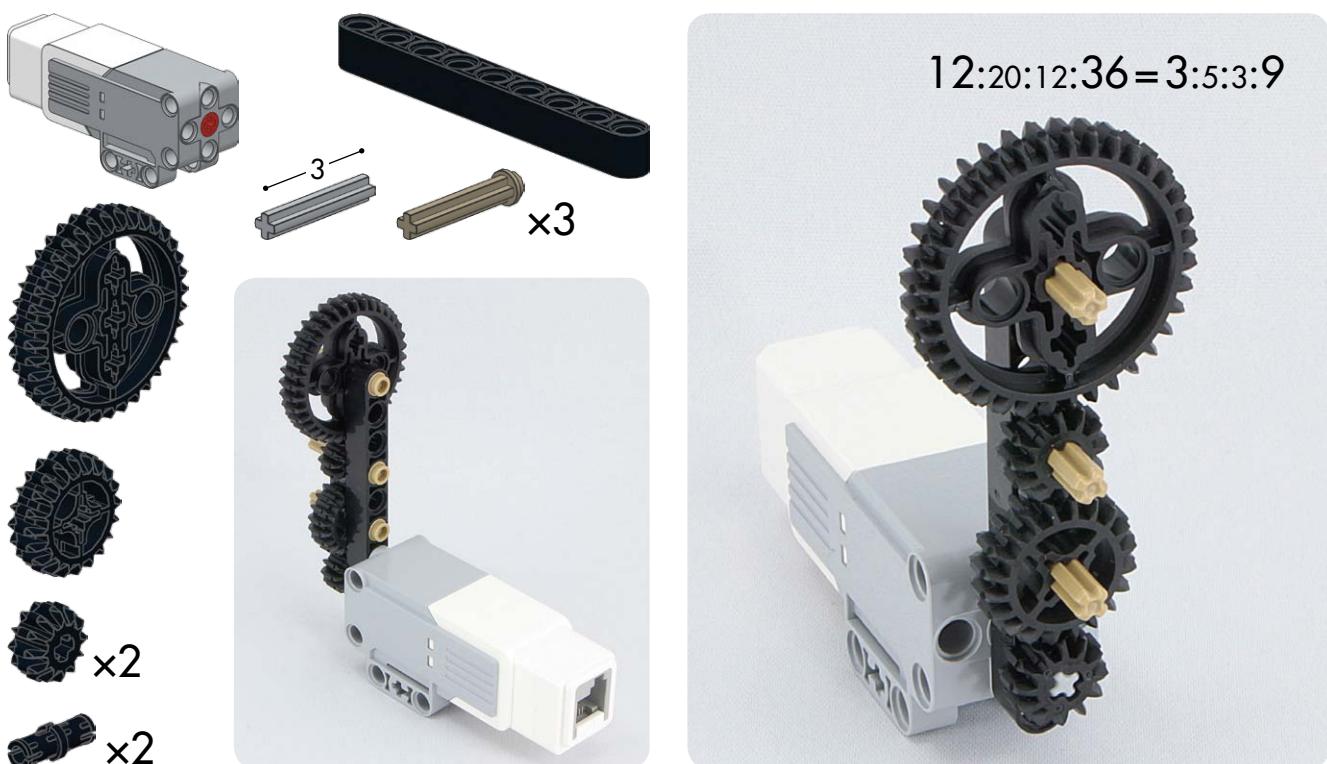


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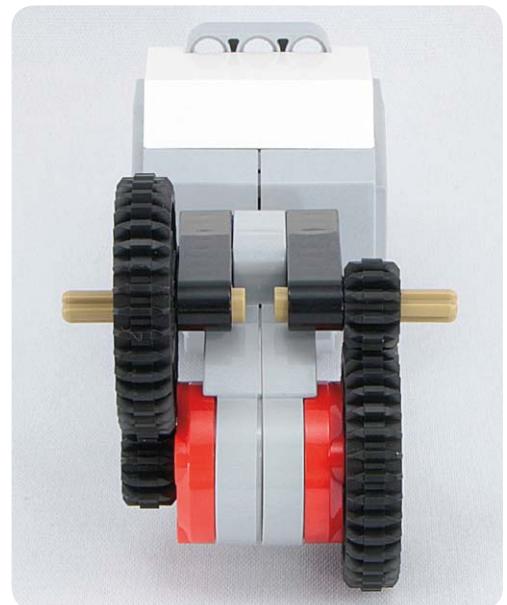
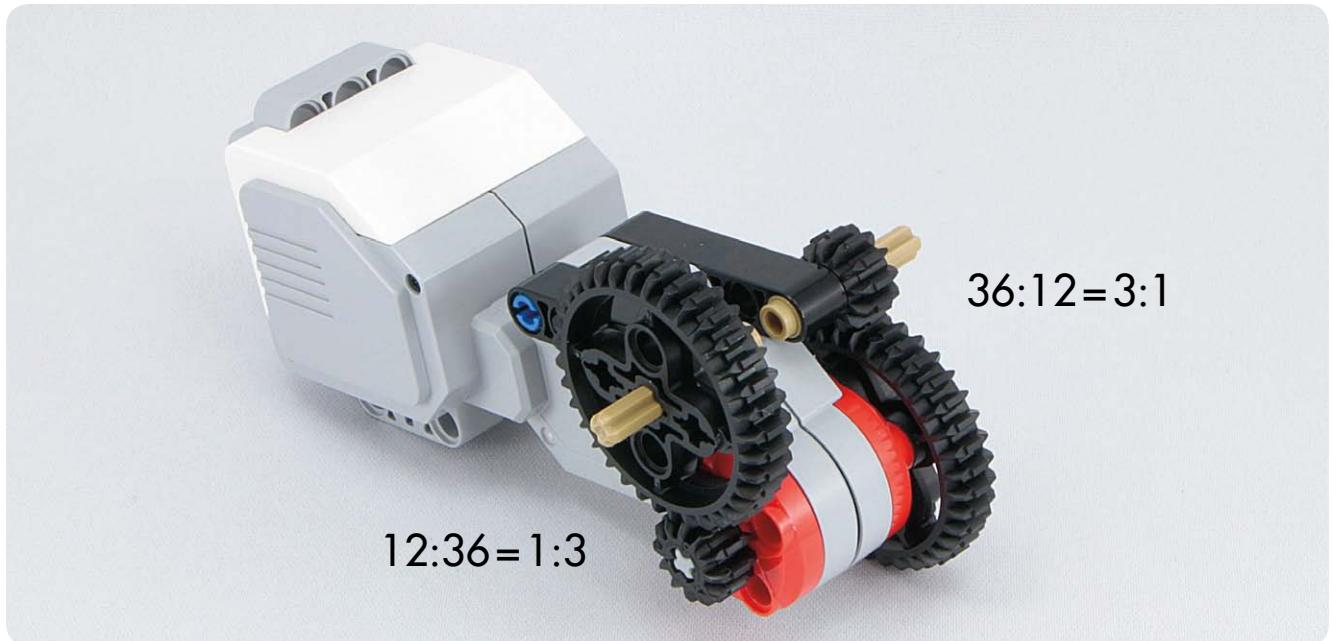
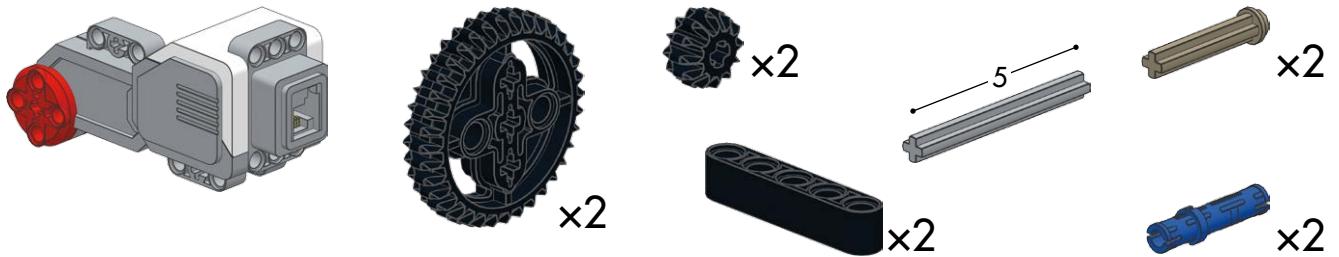
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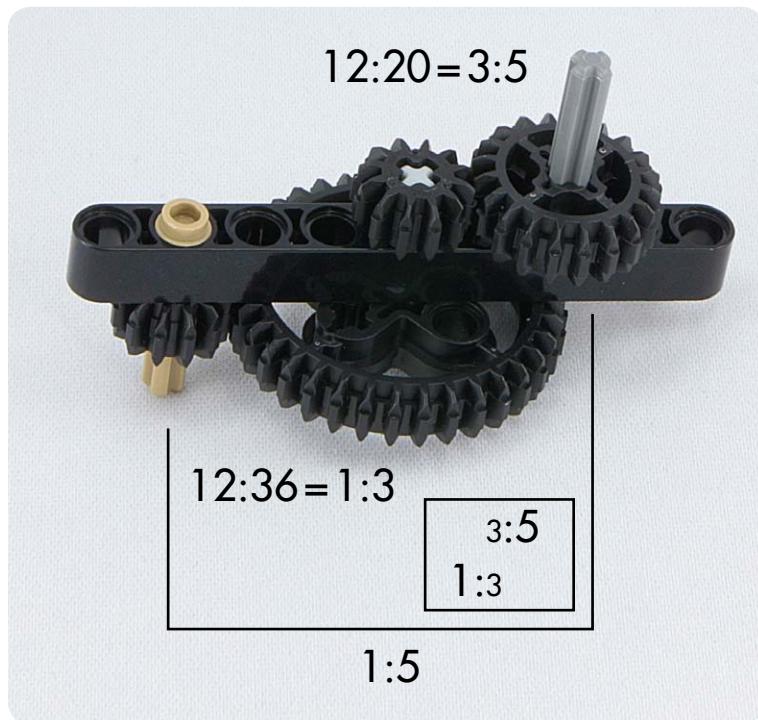


Compound gear systems

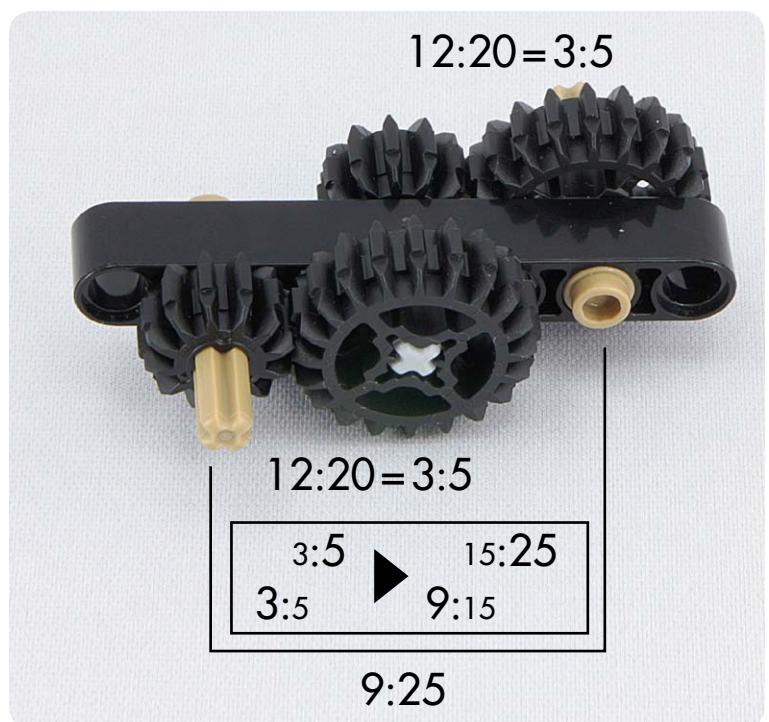
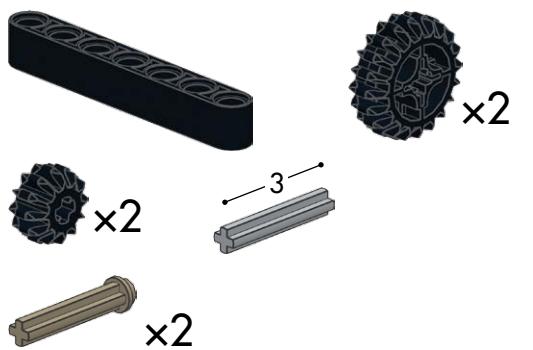
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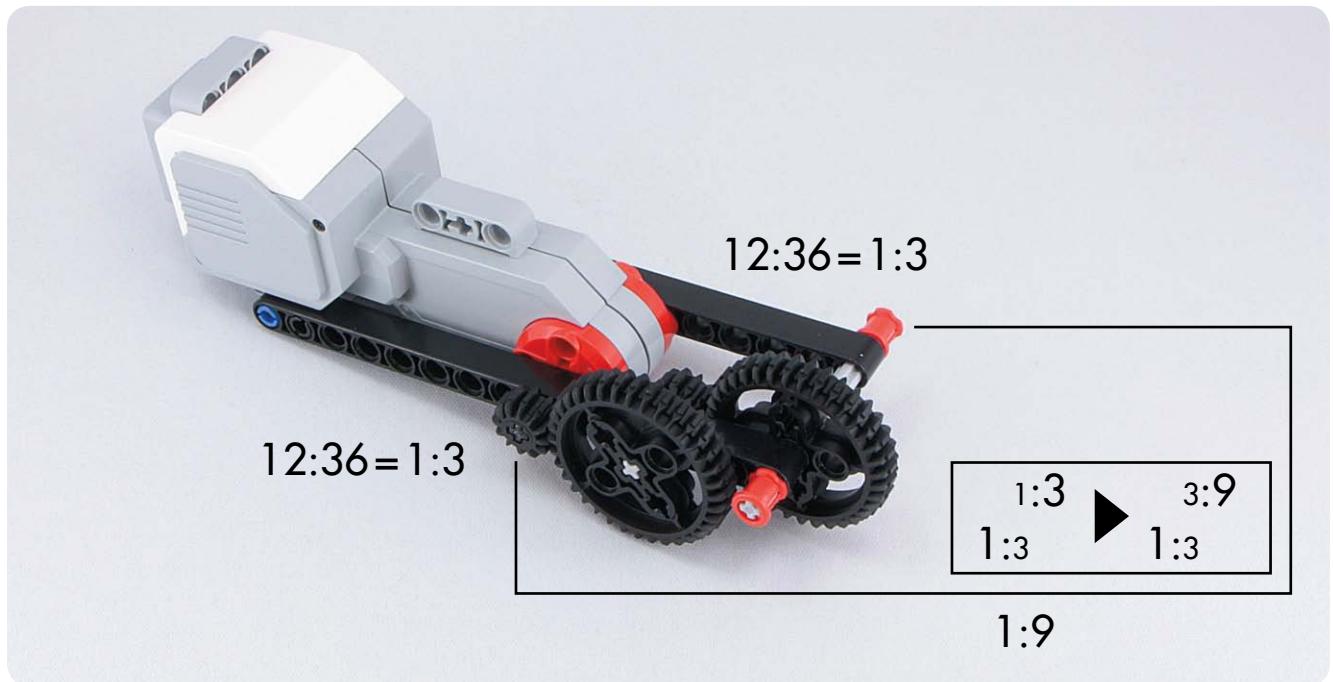
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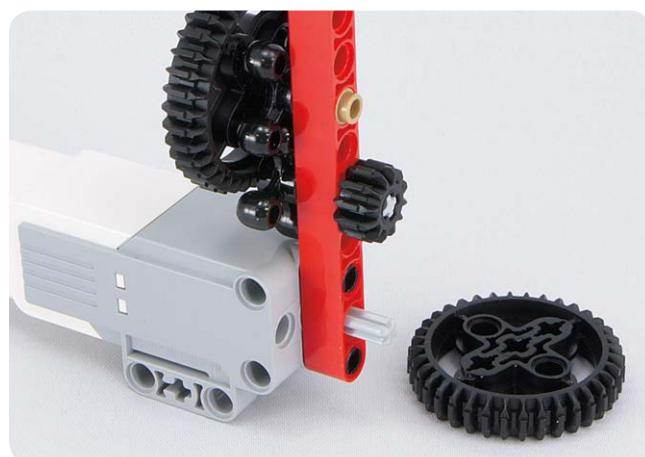
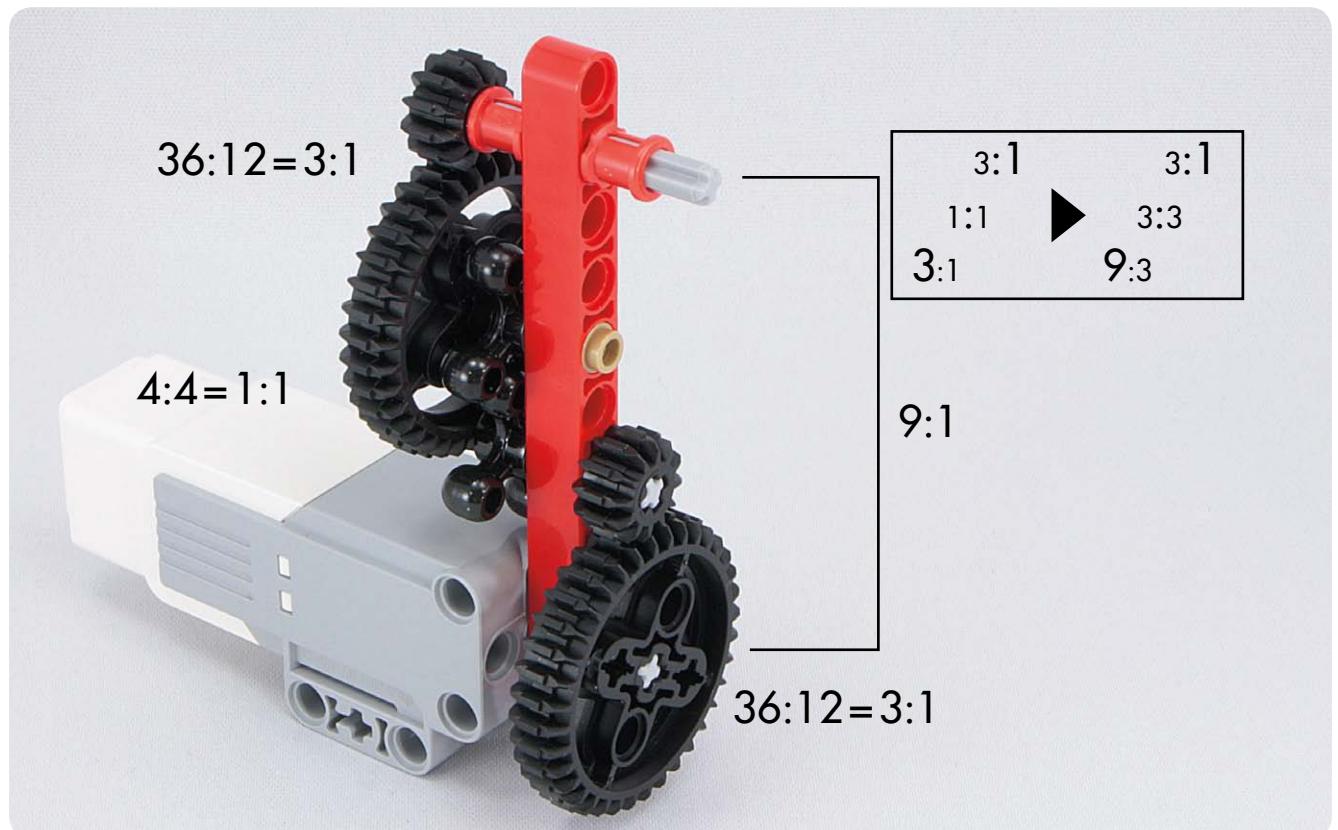
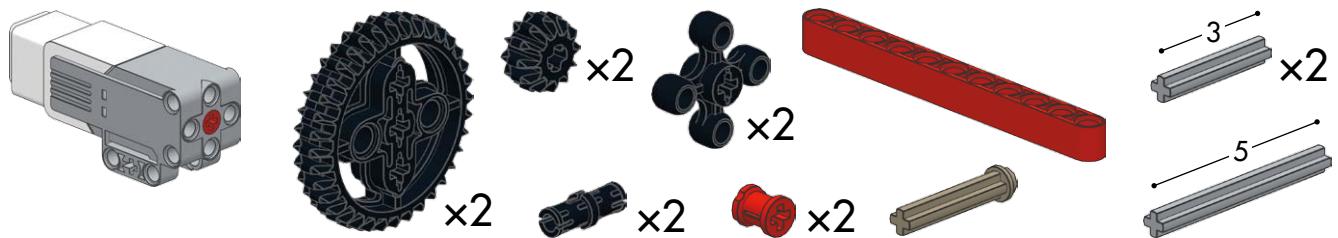
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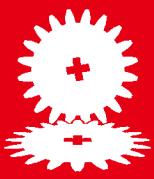


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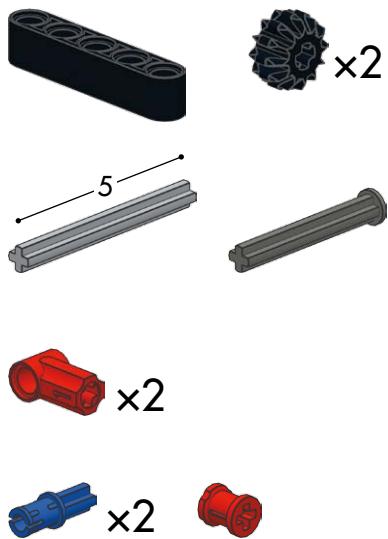
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Changing the angle of rotation

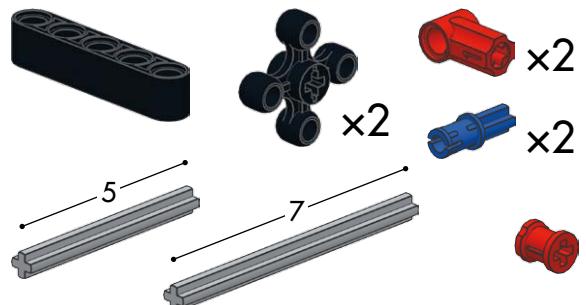
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$12:20 = 3:5$

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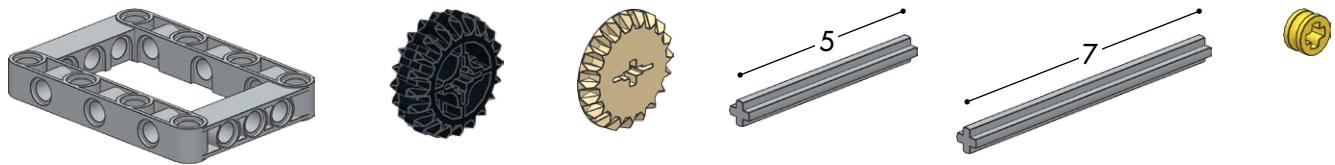
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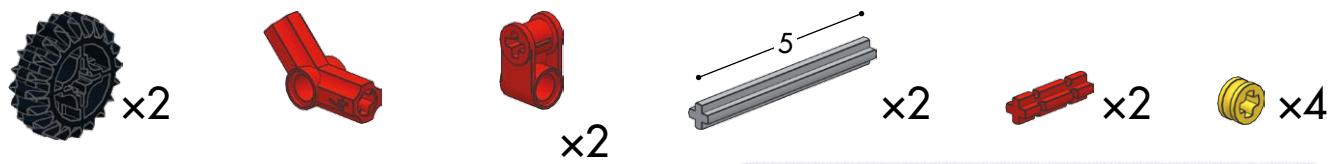
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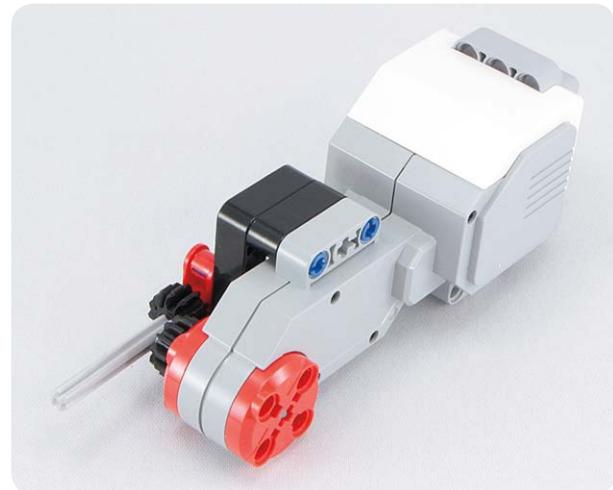
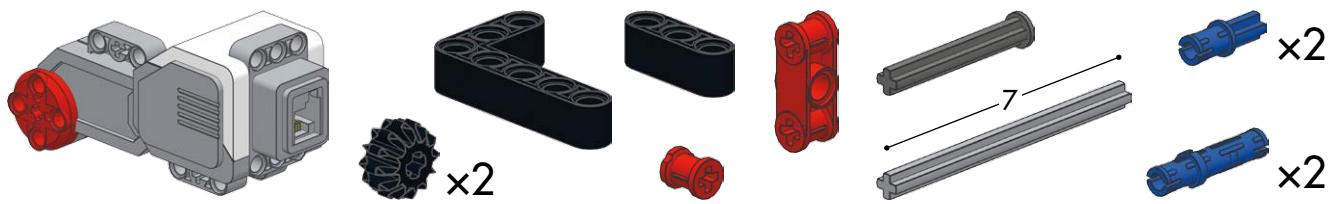
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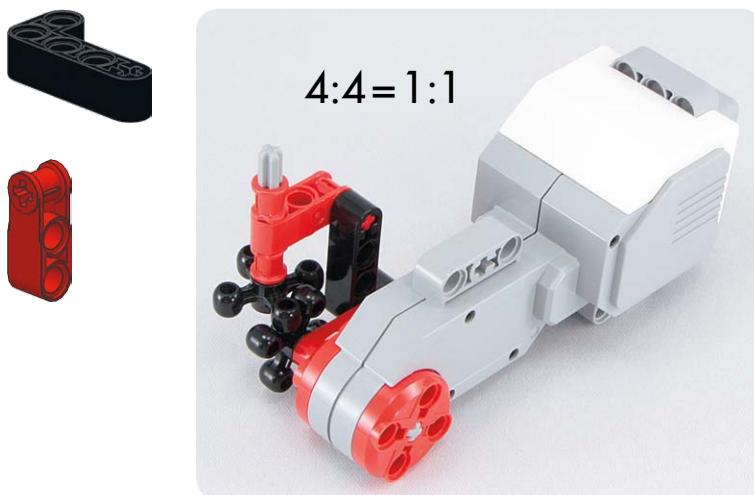
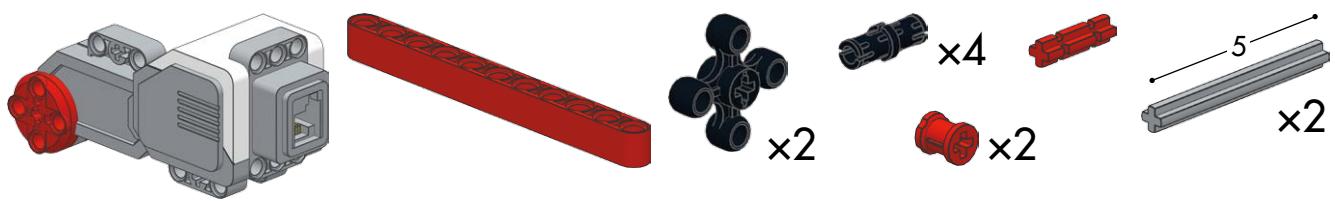
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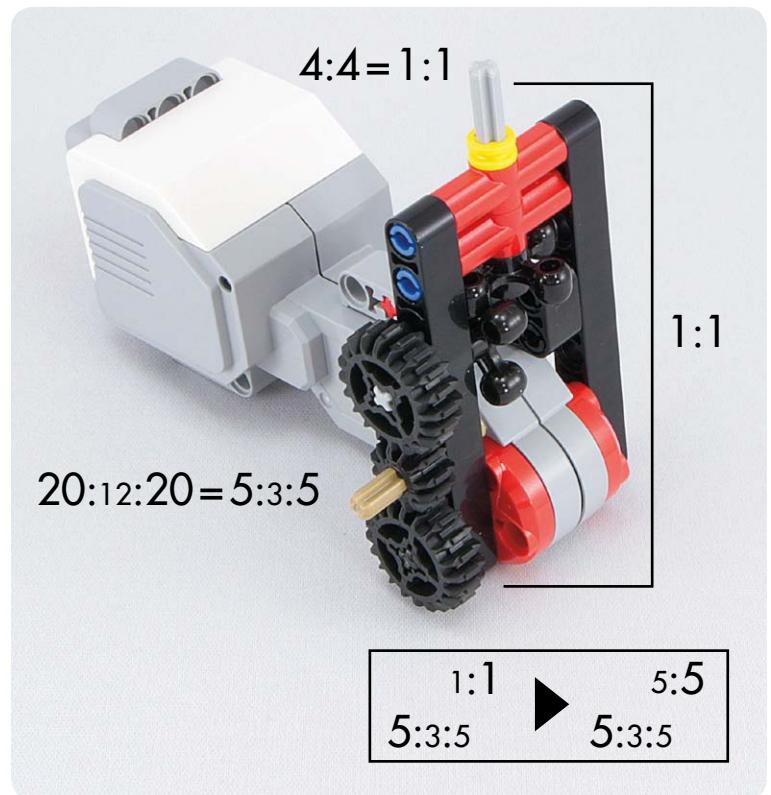
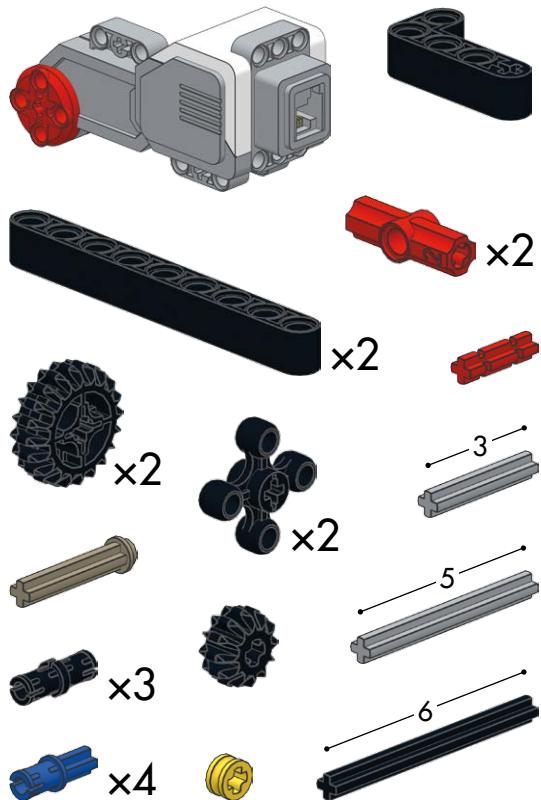
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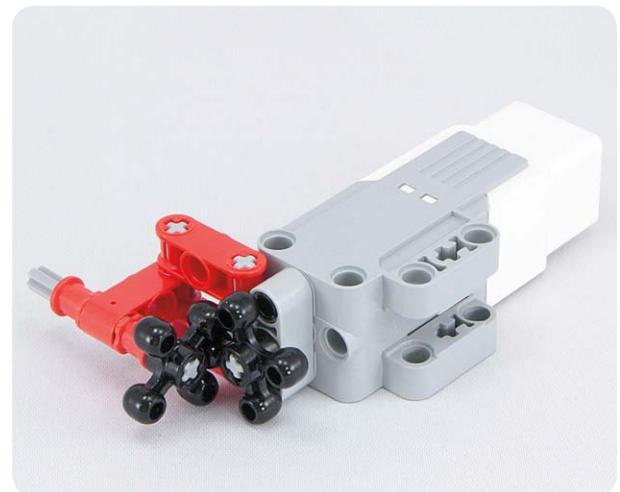
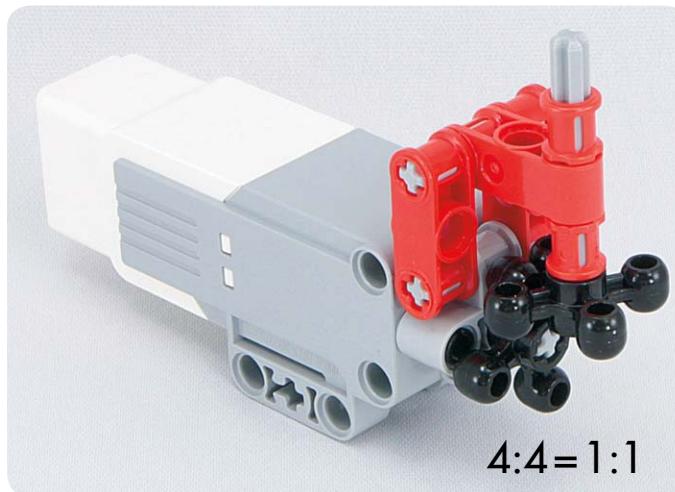
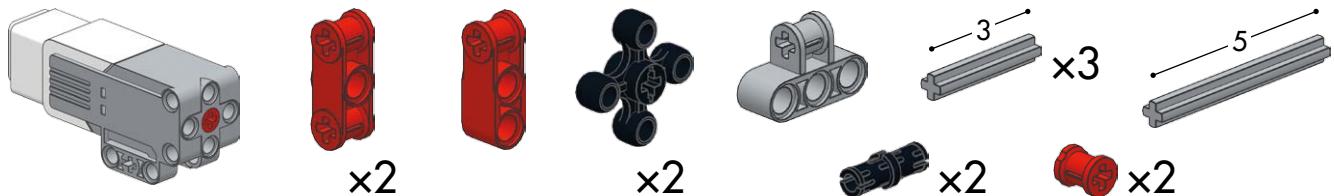
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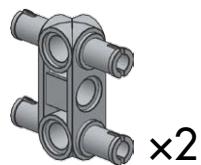
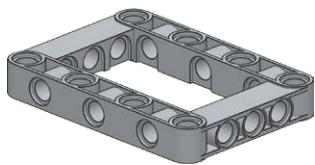
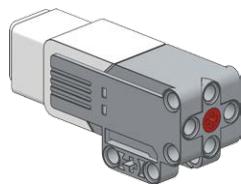
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#43



#44



x2



x2



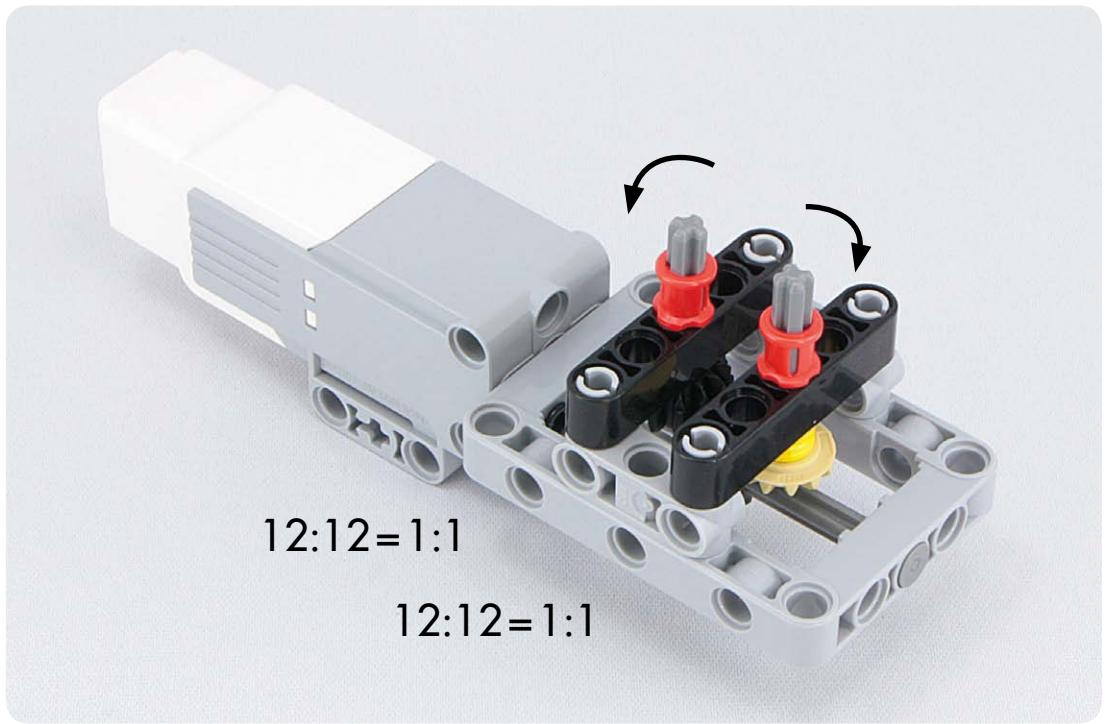
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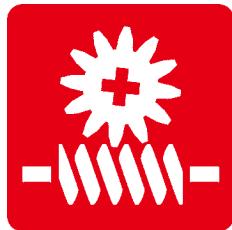


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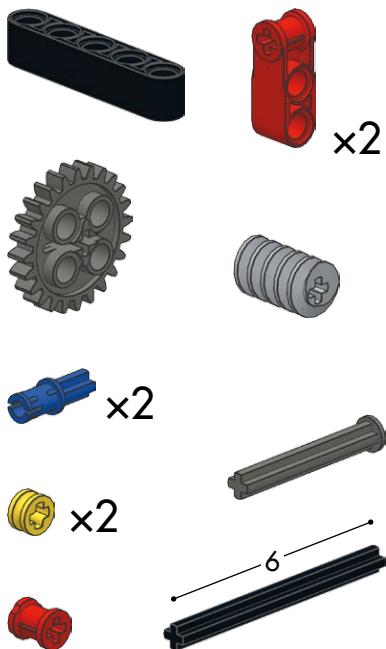
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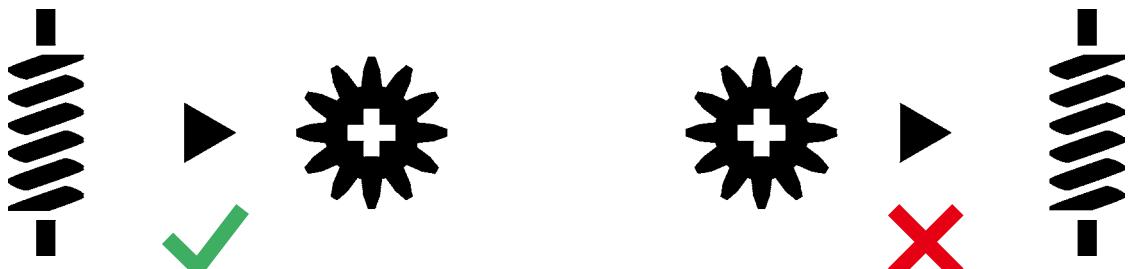




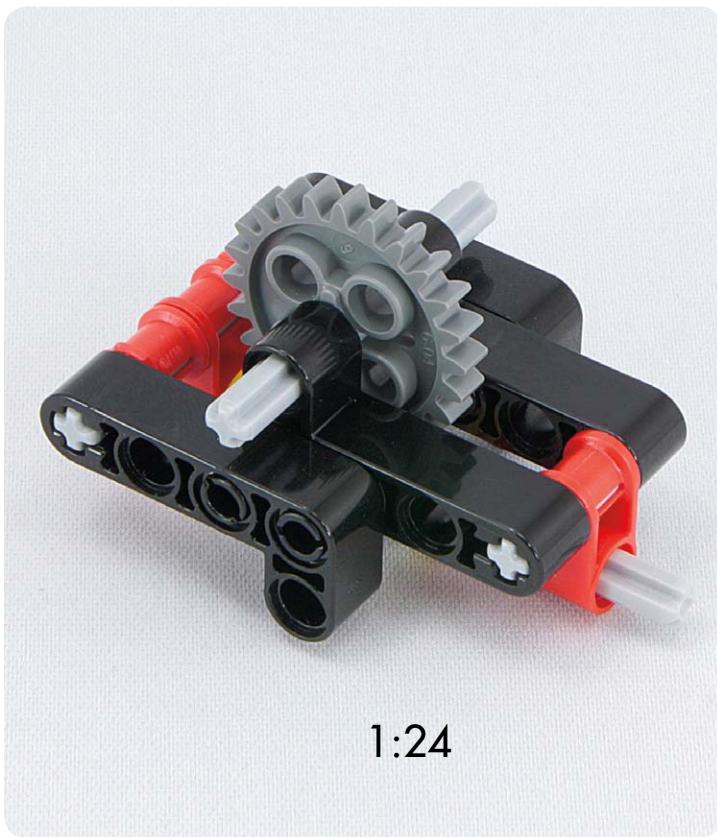
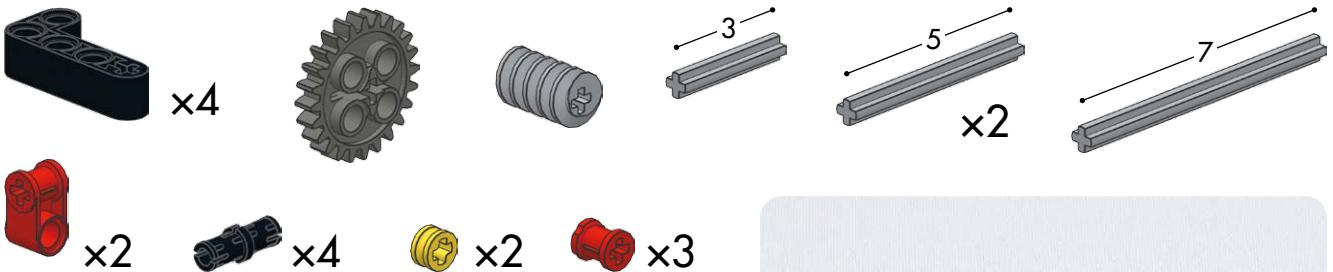
Using worm drives

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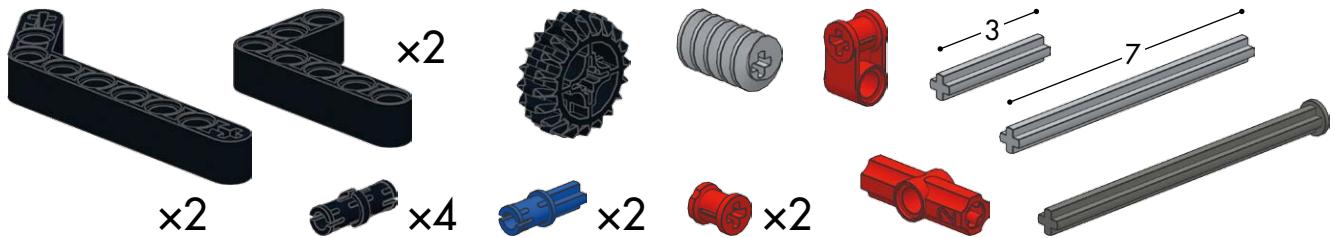




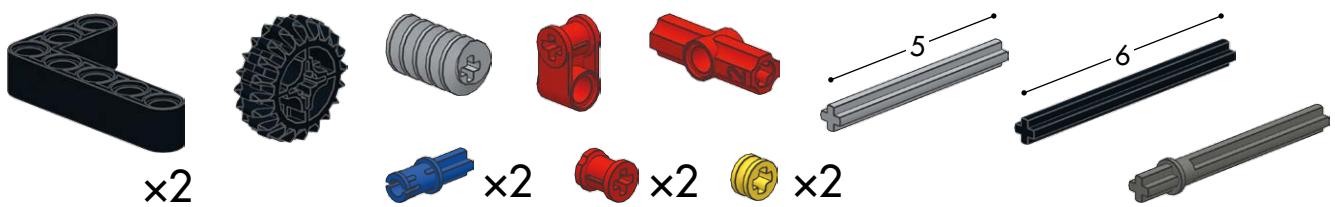
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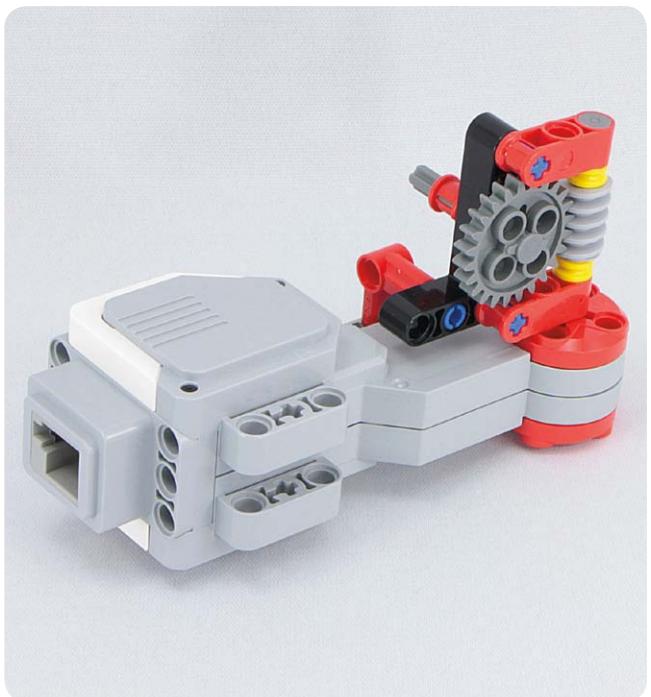
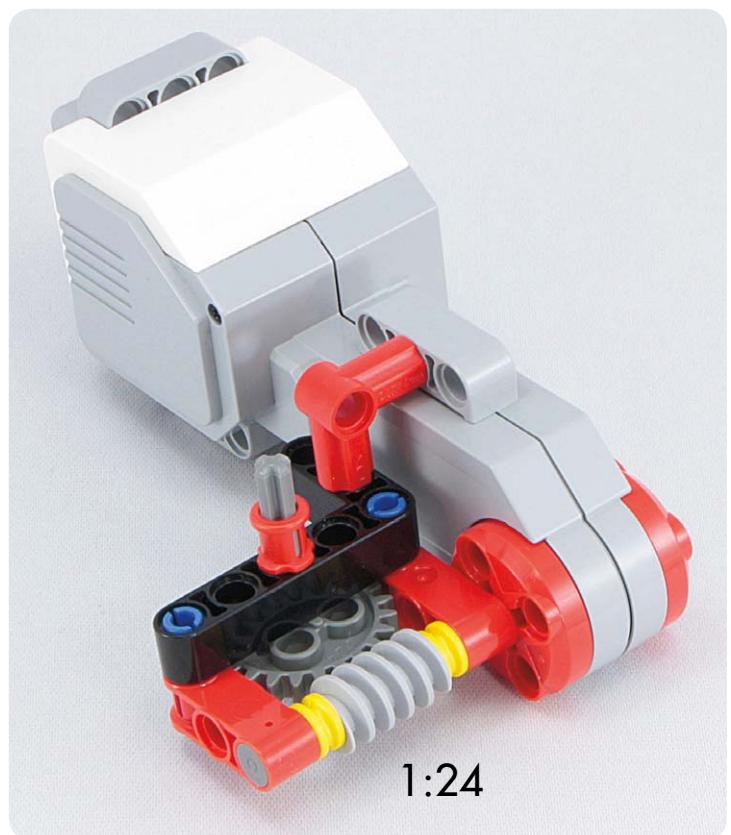
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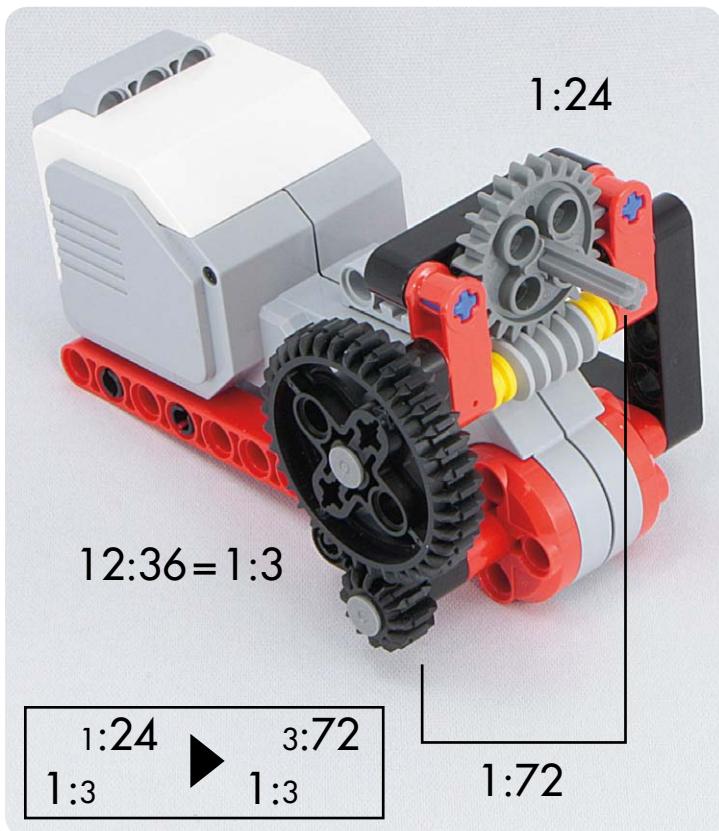
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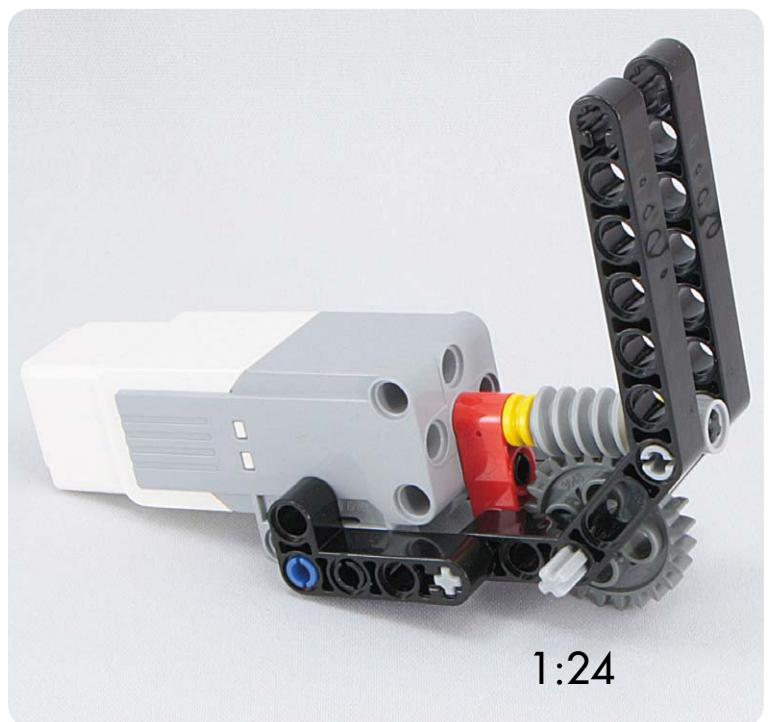
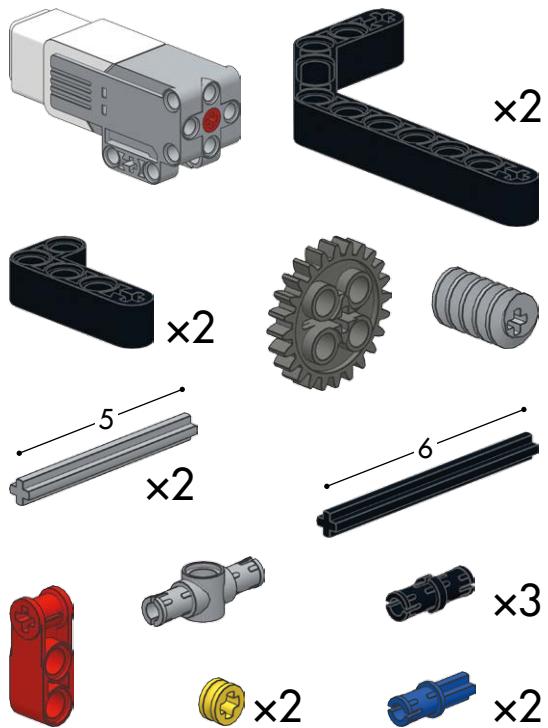
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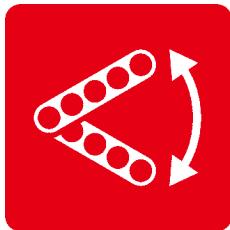


#50



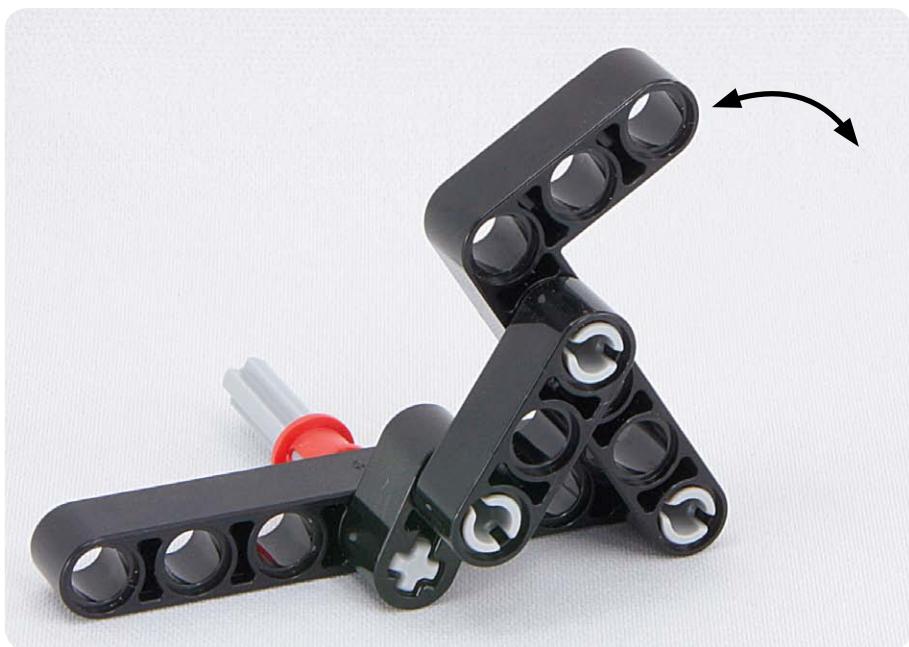
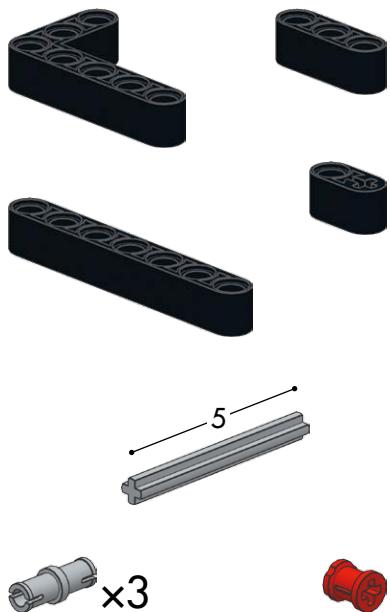
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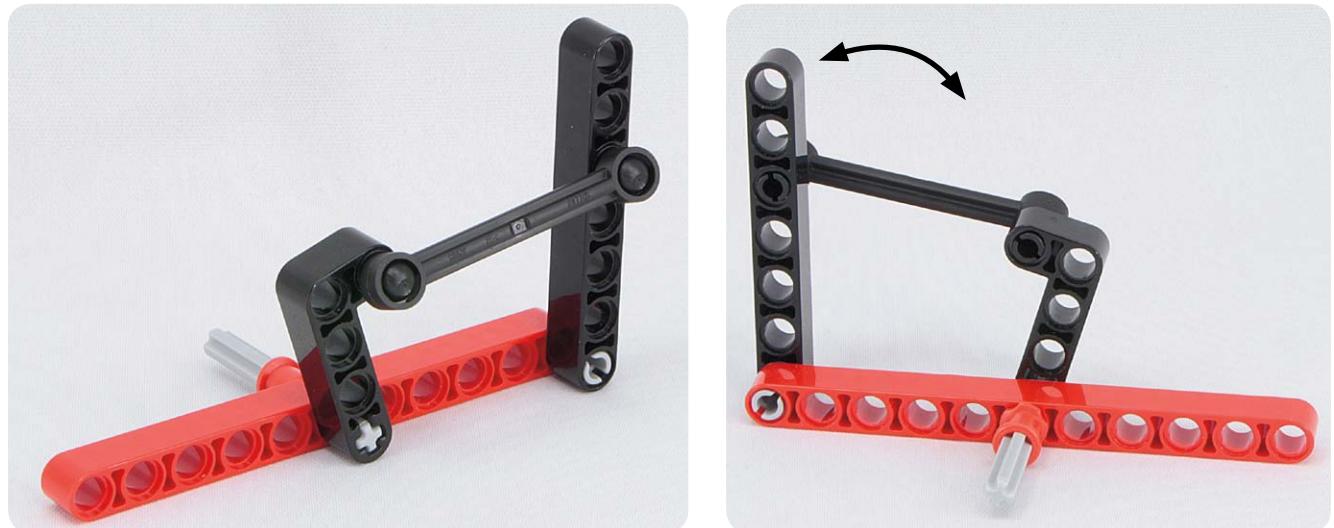


Swinging mechanisms

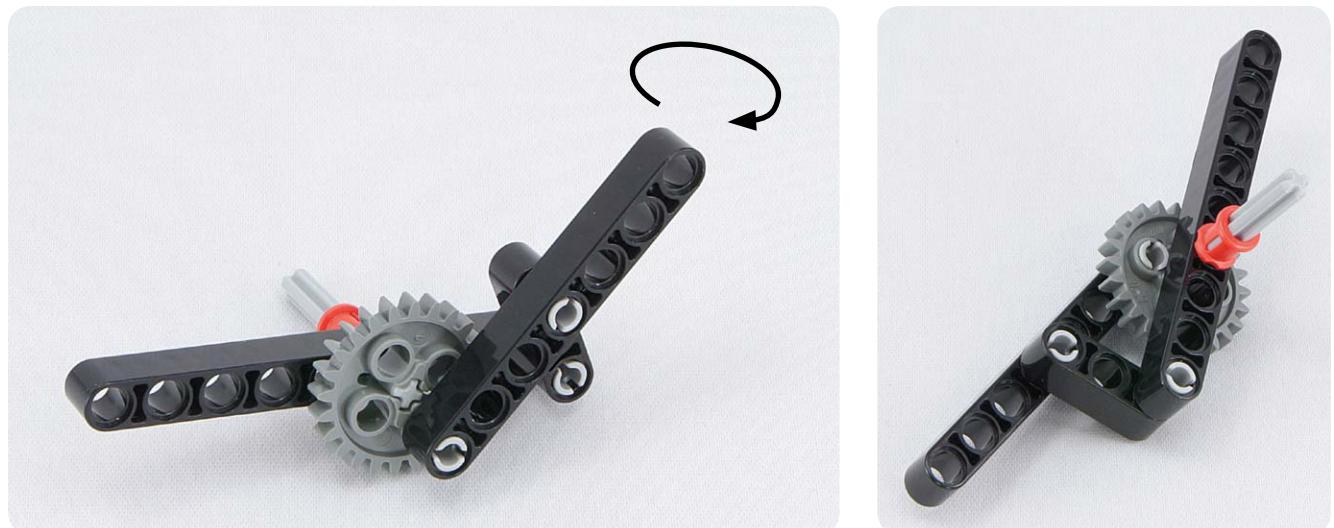
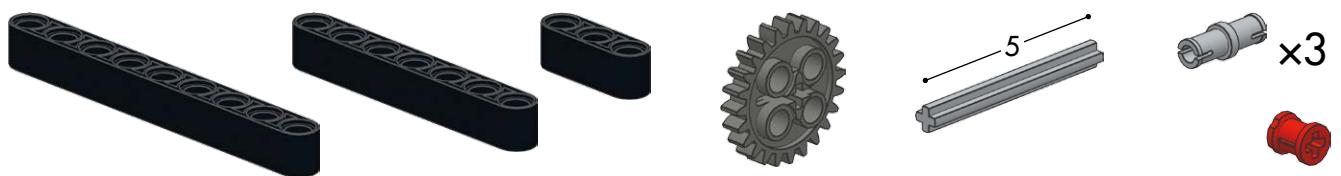
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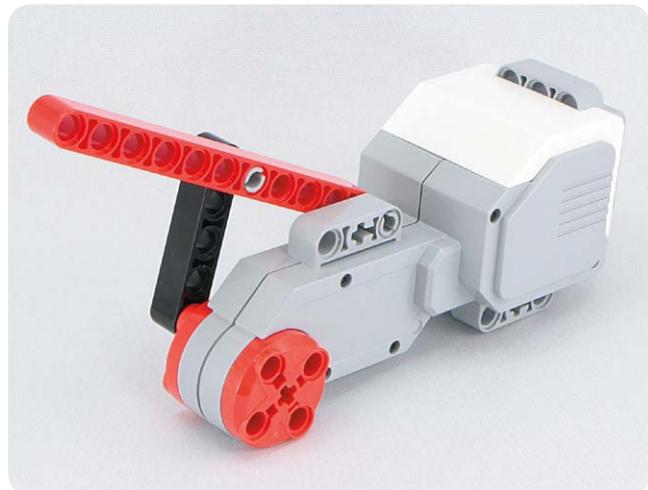
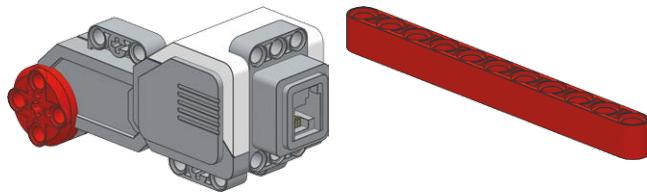
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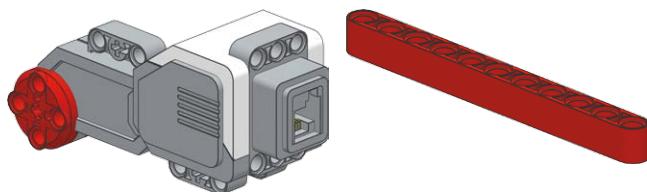
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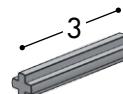
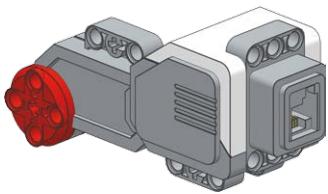
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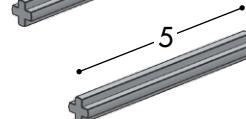
#56



#57



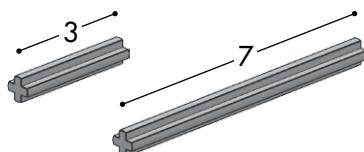
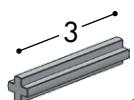
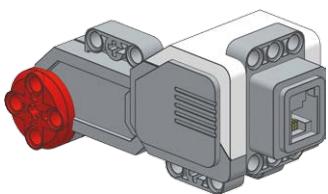
x2



x2



#58



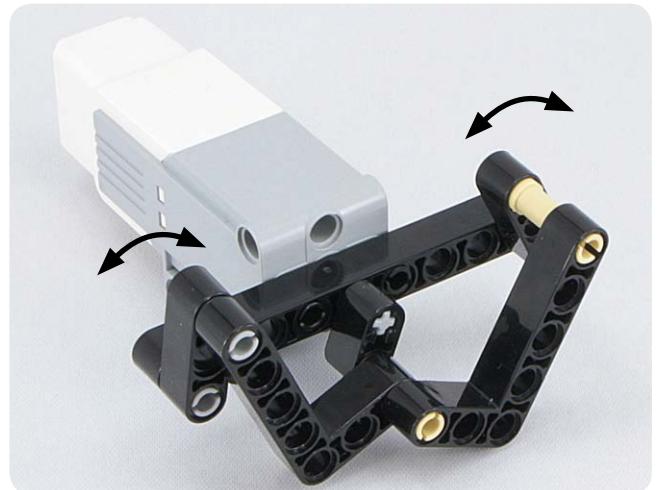
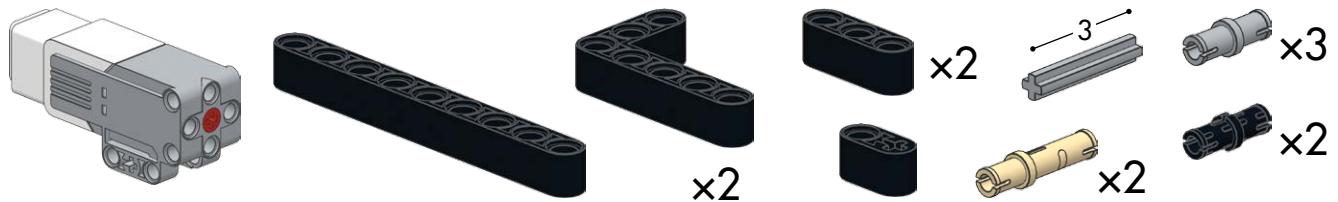
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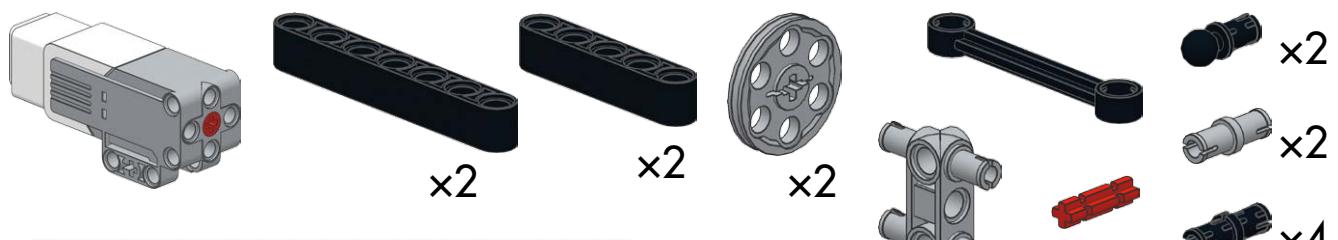
#60



#61



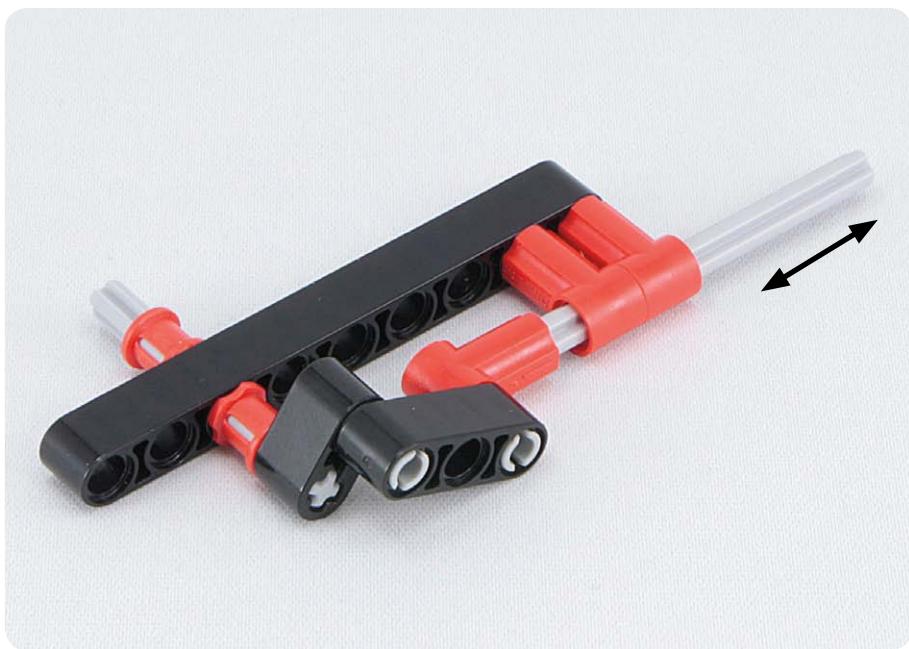
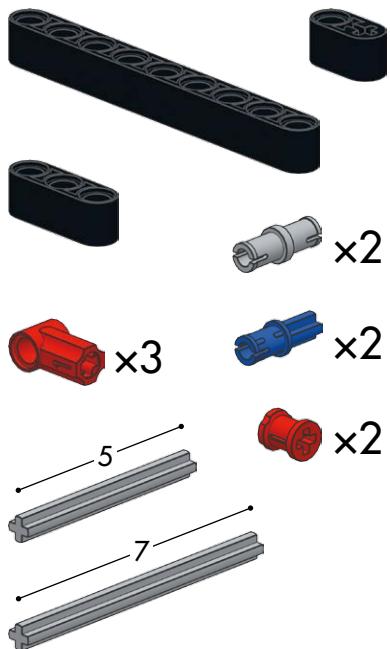
#62



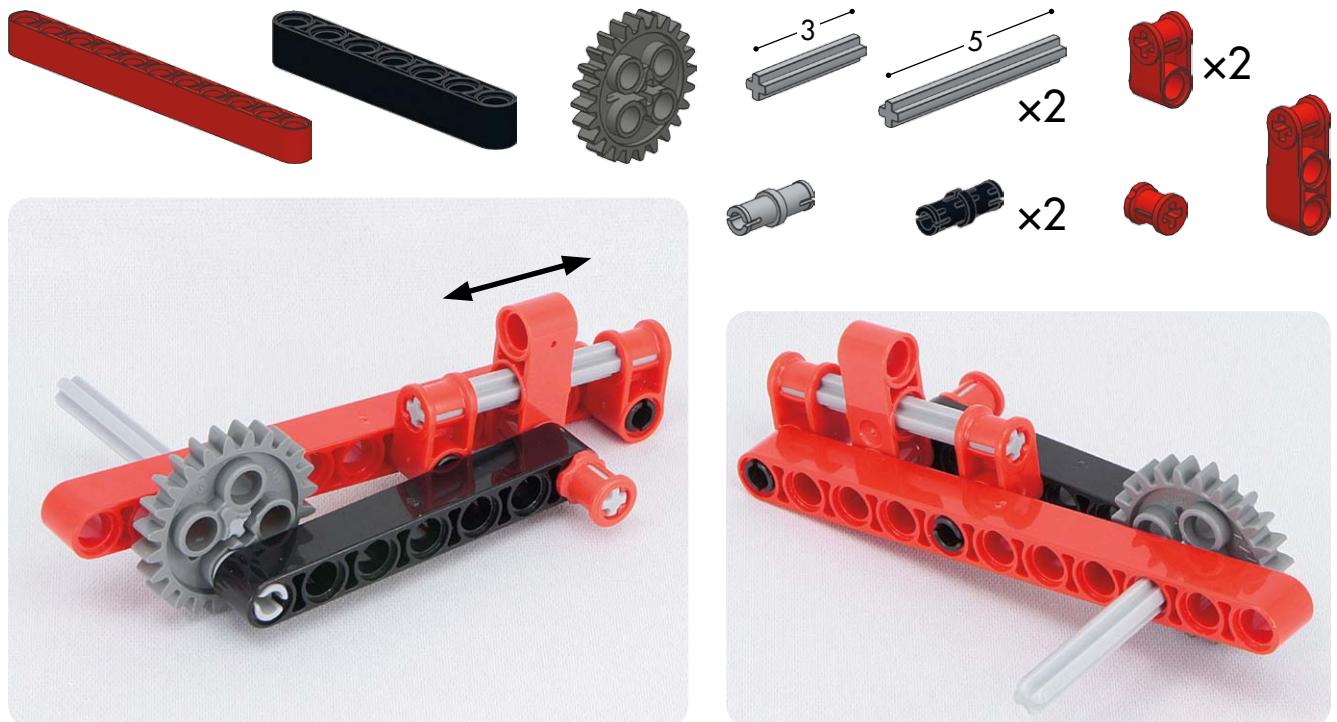


Reciprocating mechanisms

#63



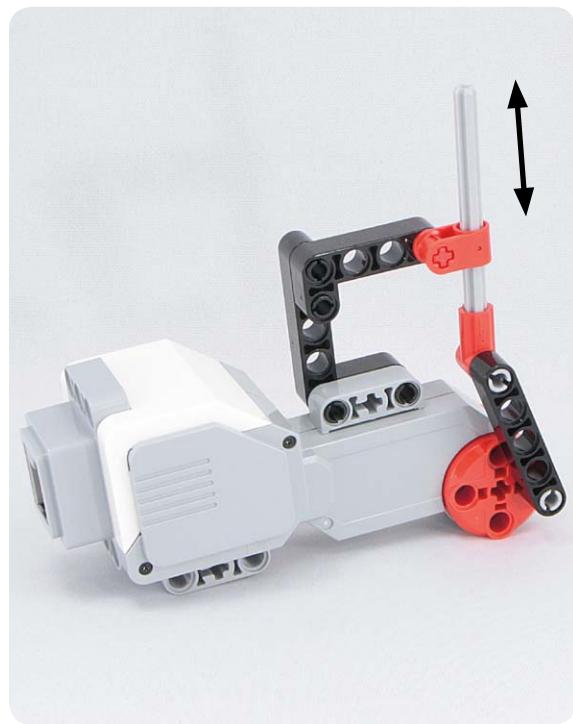
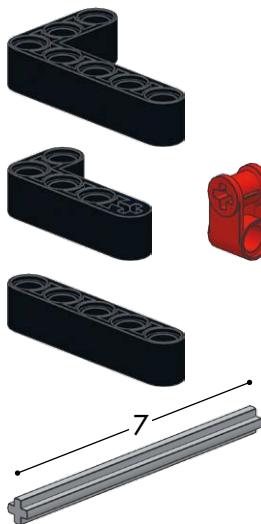
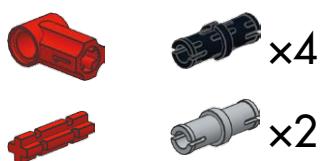
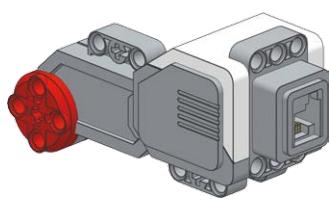
#64



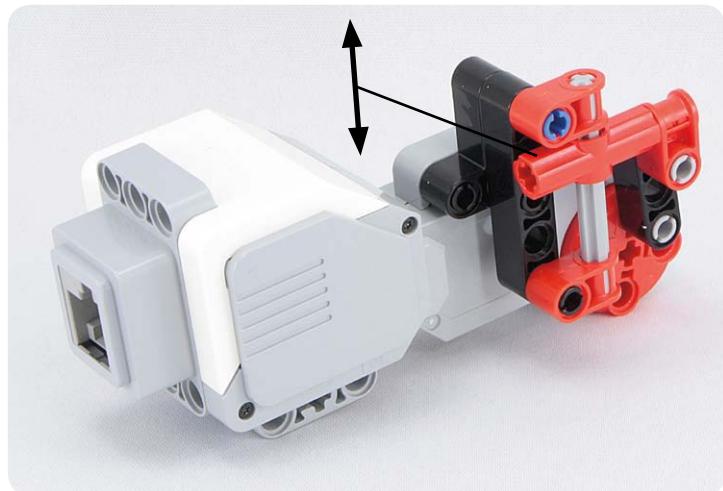
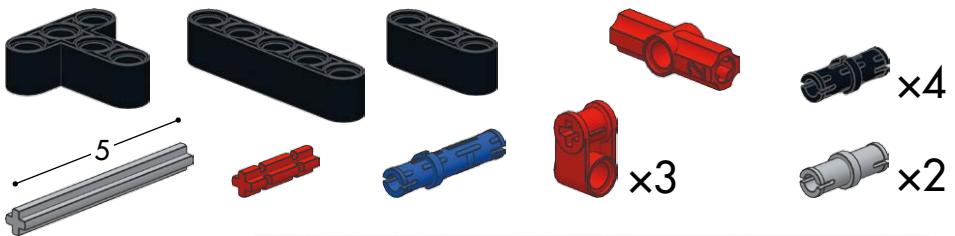
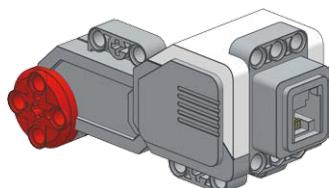
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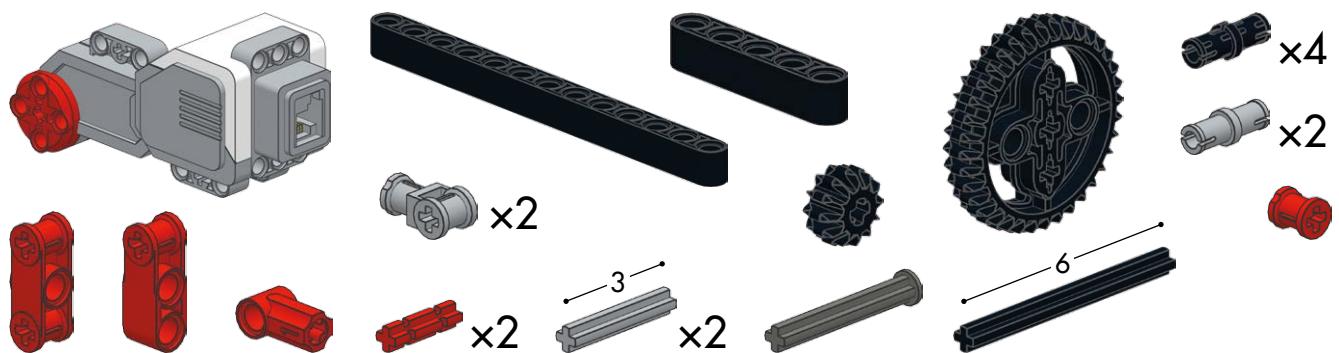
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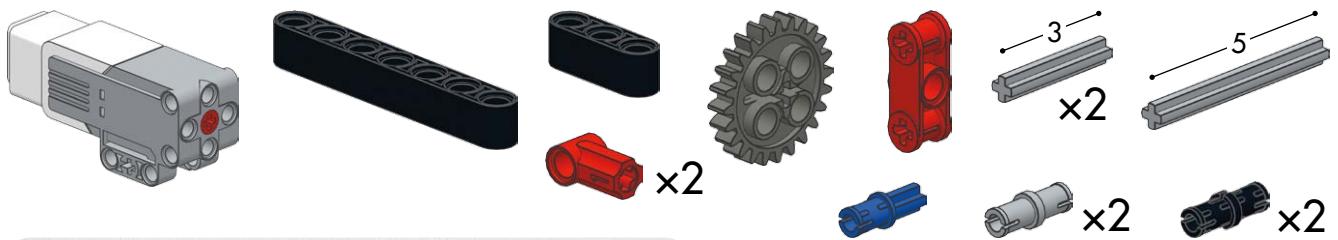
#67



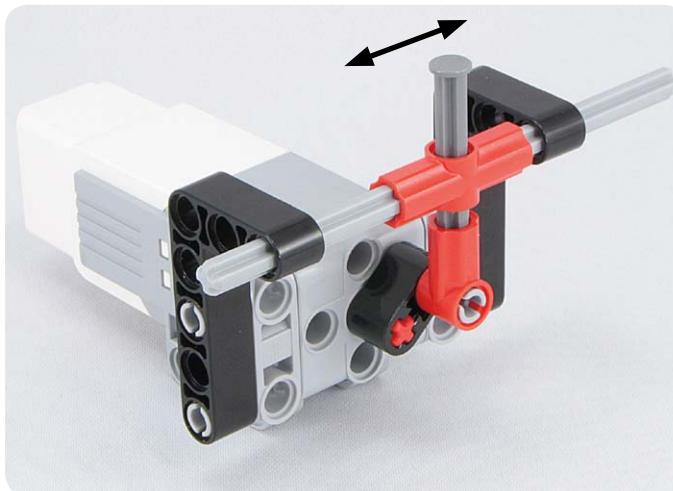
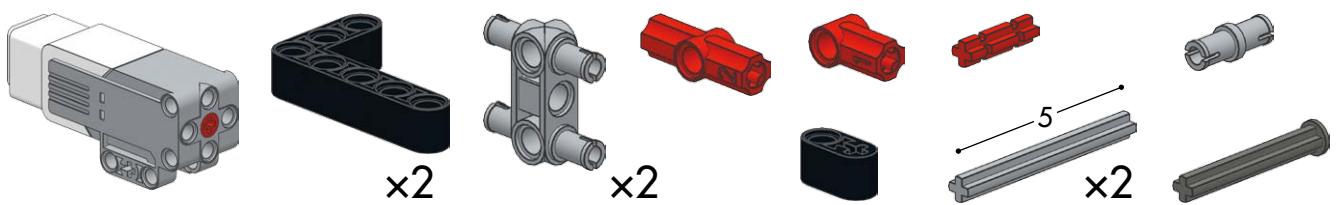
#68



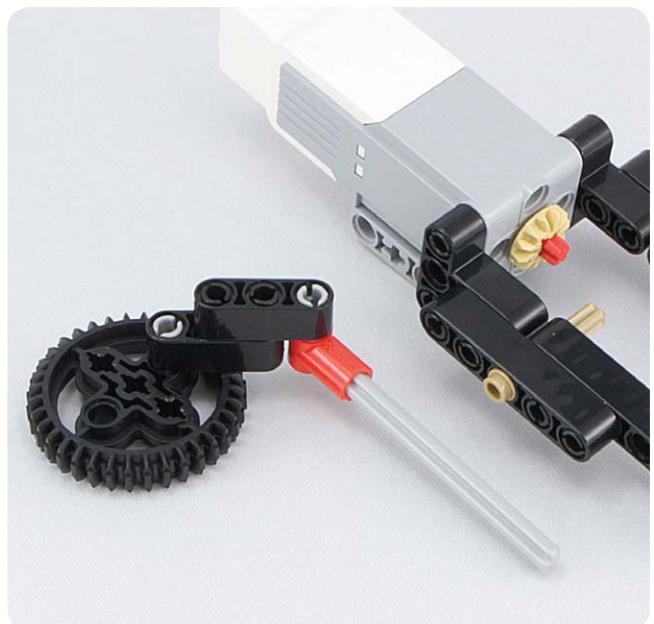
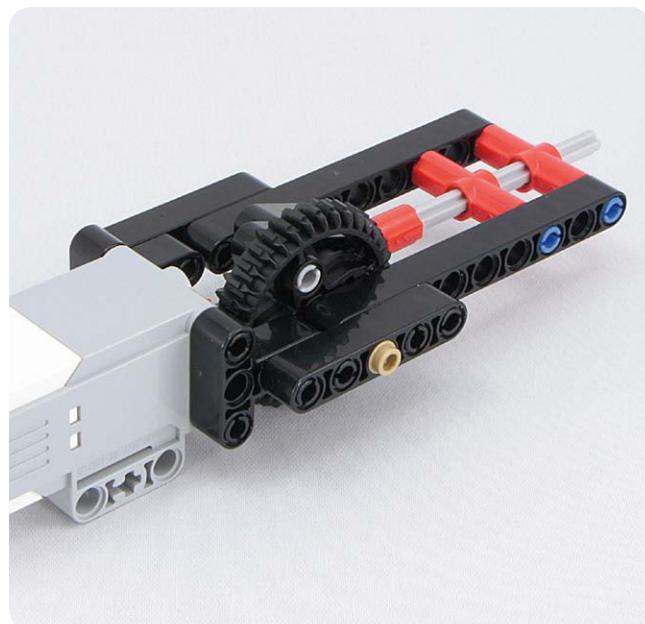
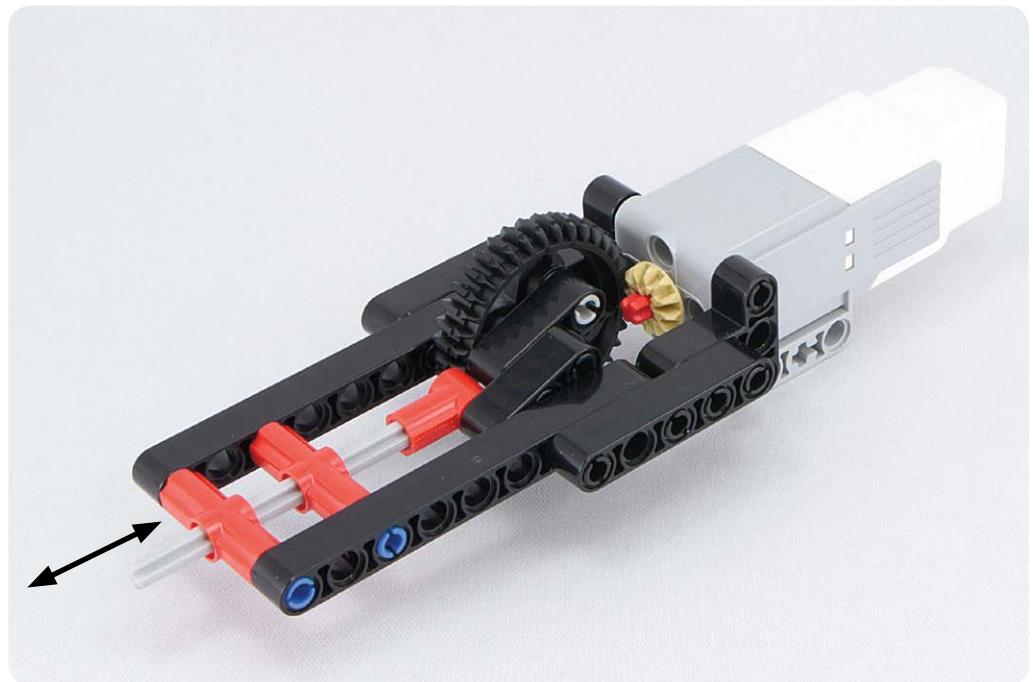
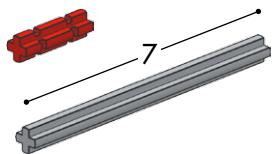
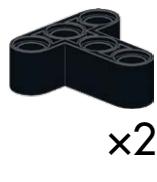
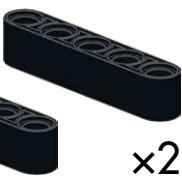
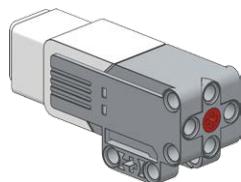
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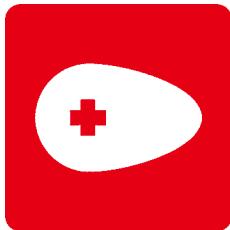


#70



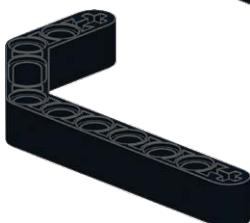
#71





Cam mechanisms

#72



x2



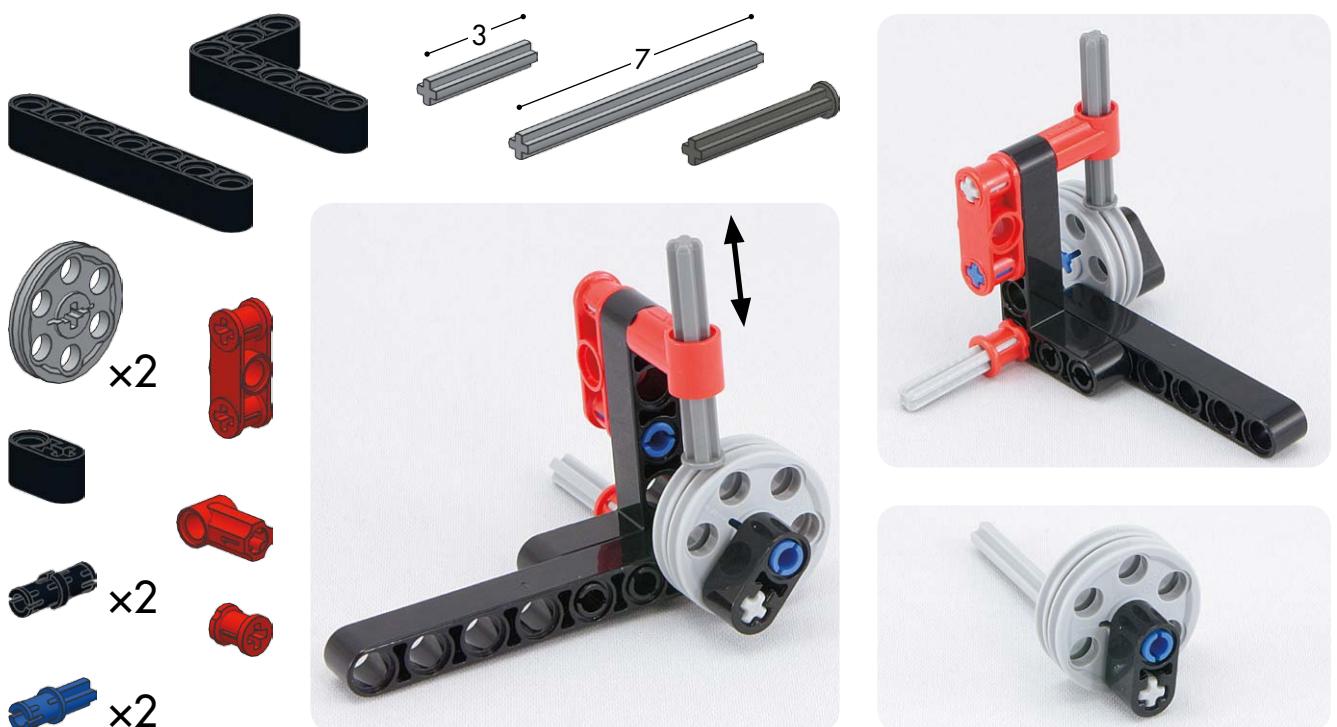
— 5 —



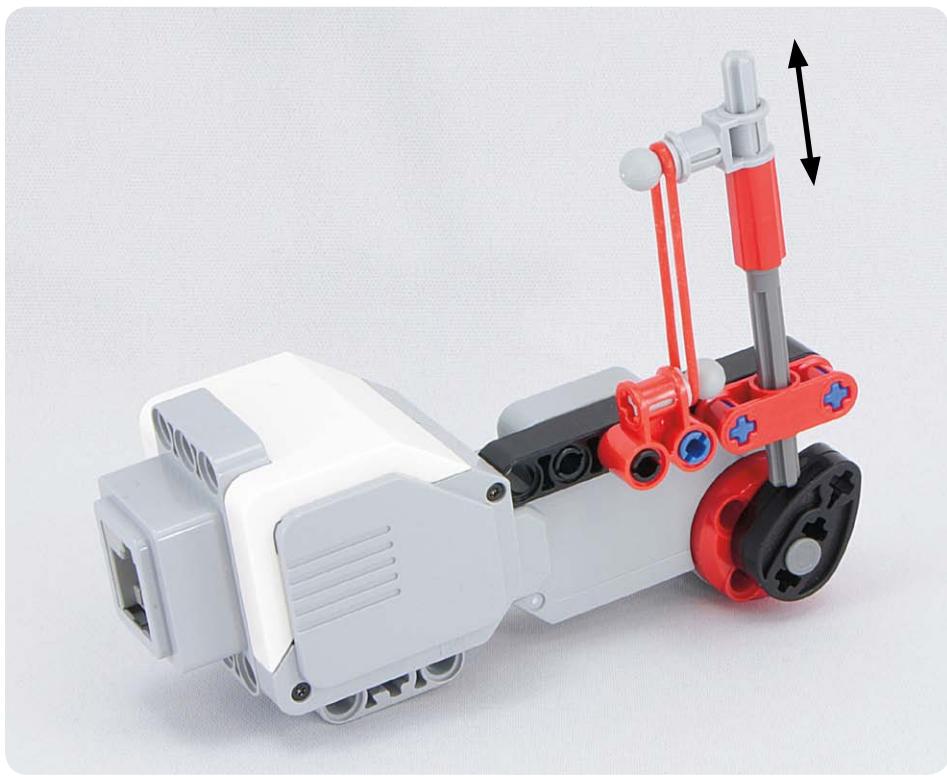
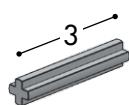
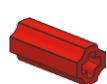
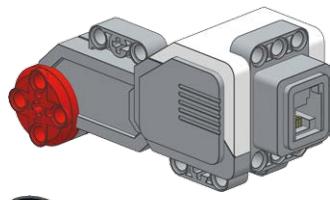
#73



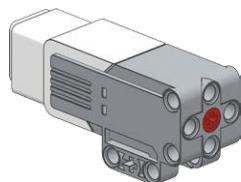
#74



#75



#76



x2



x2

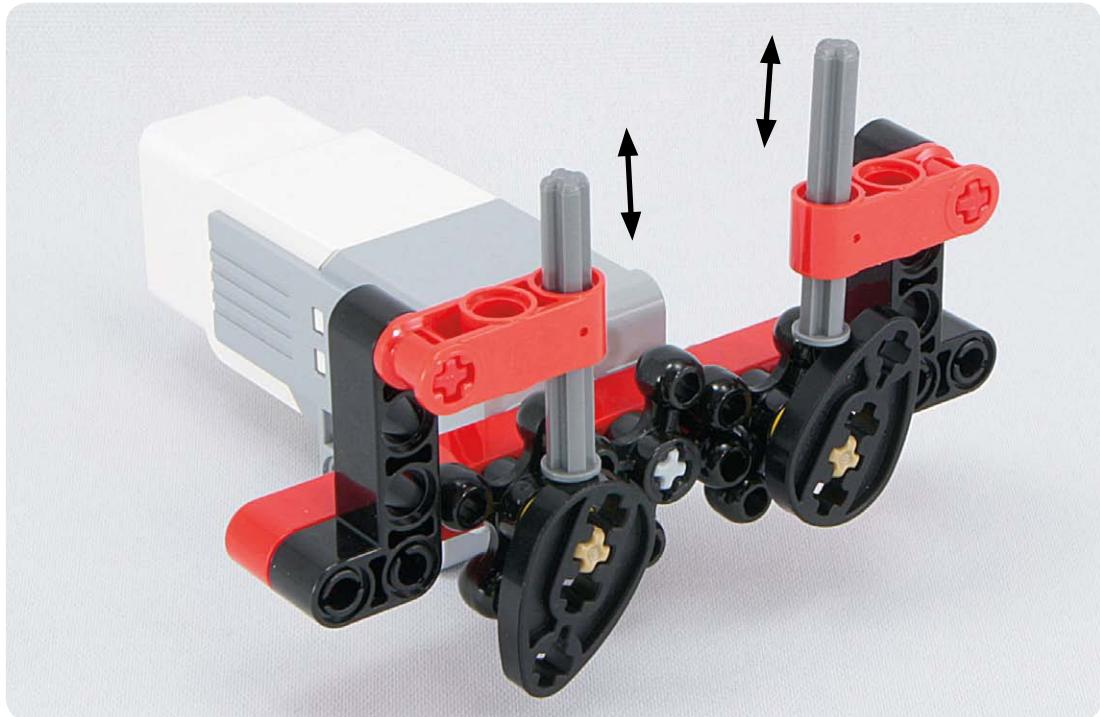
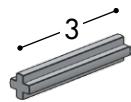


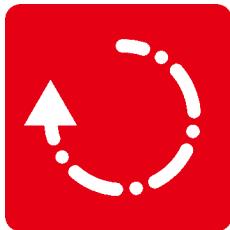
x3



x2

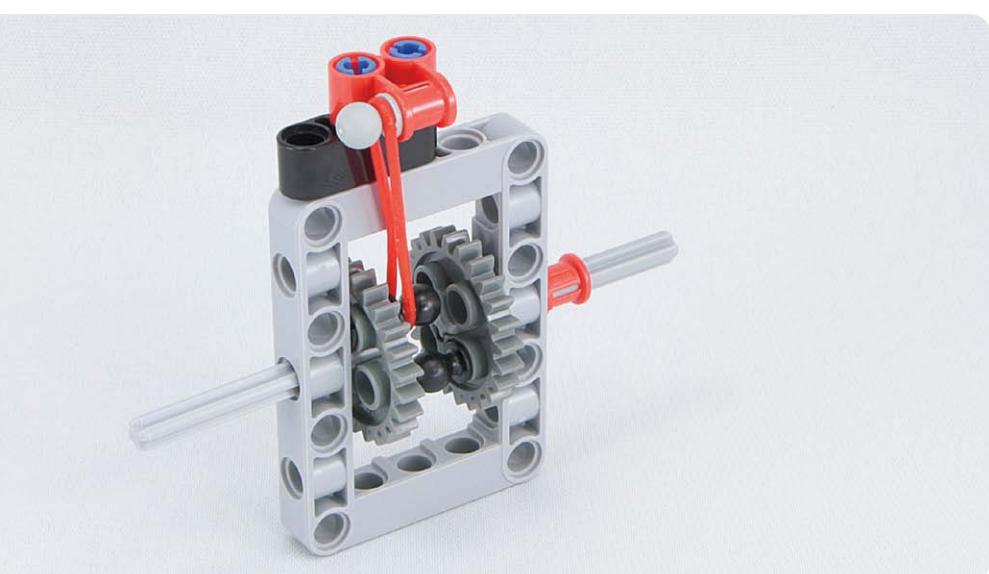
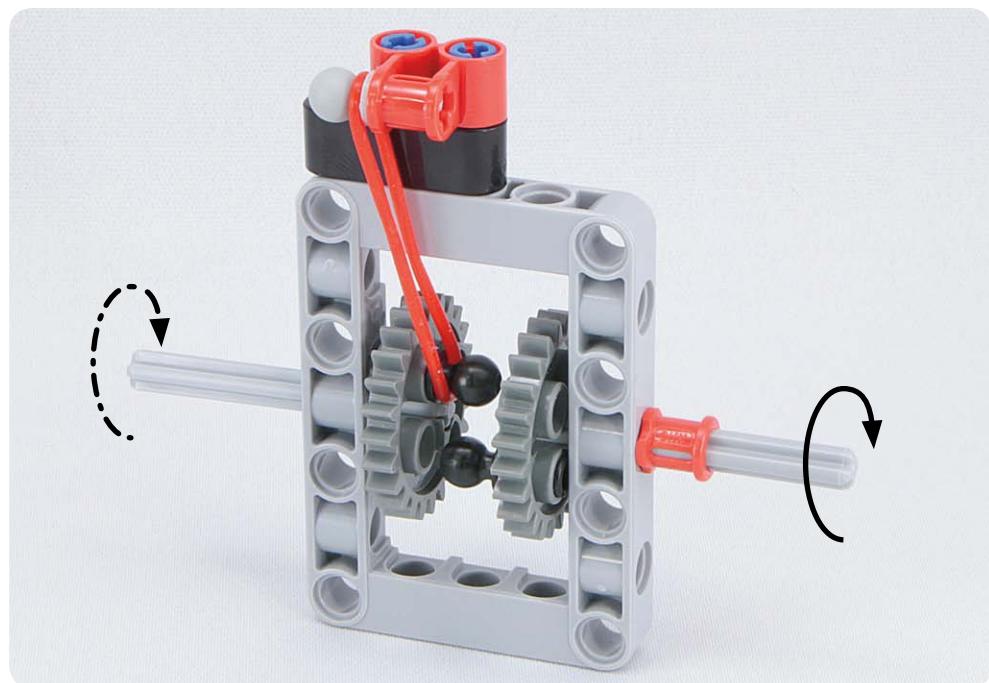
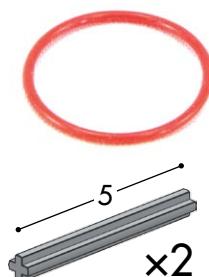
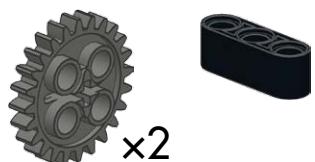
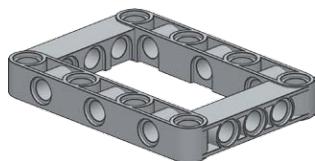
red Technic beam (x2)



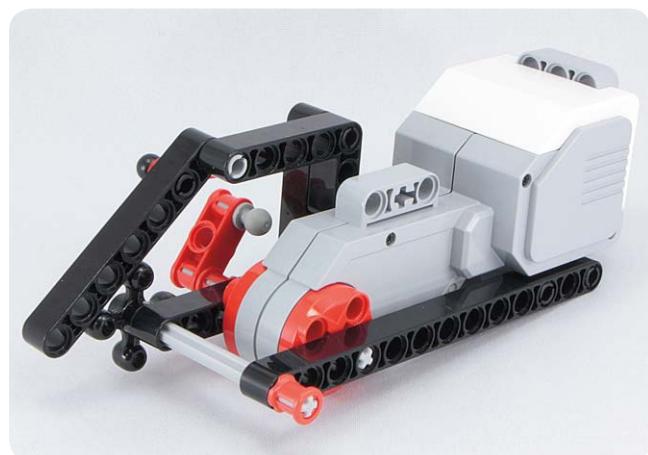
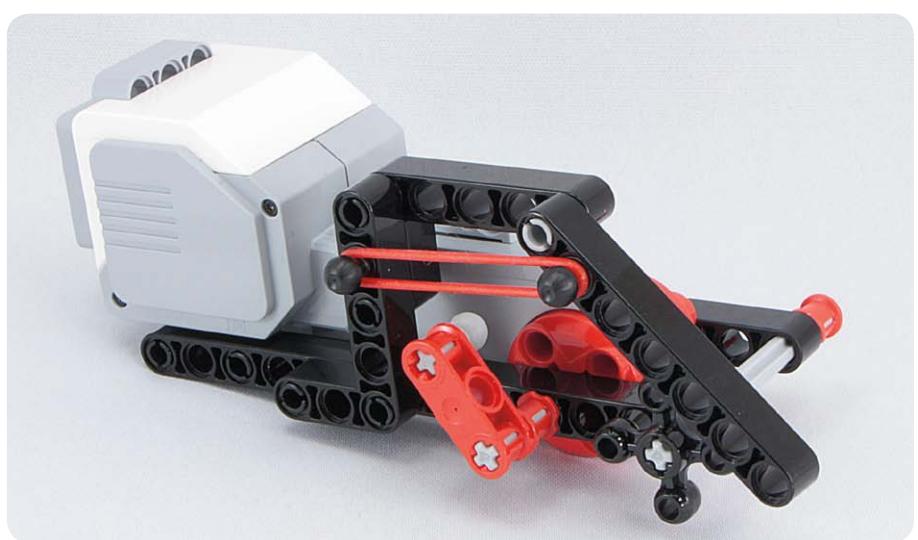
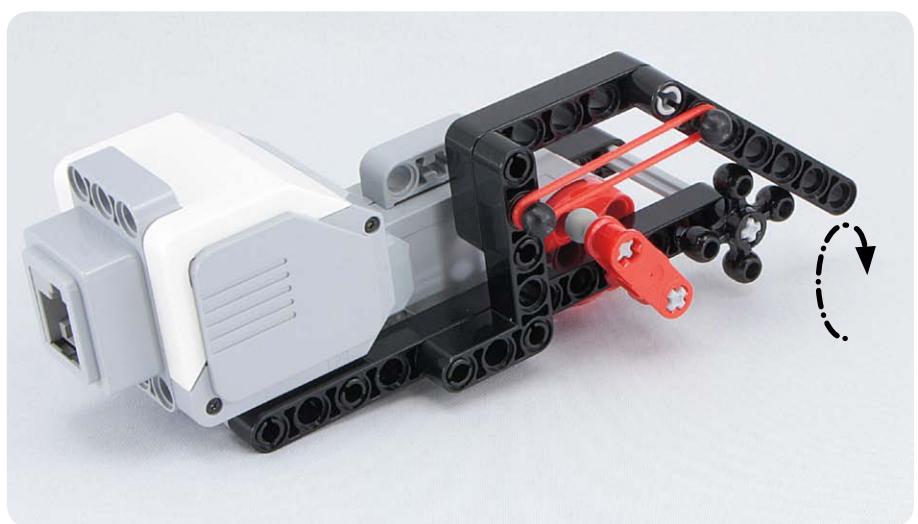
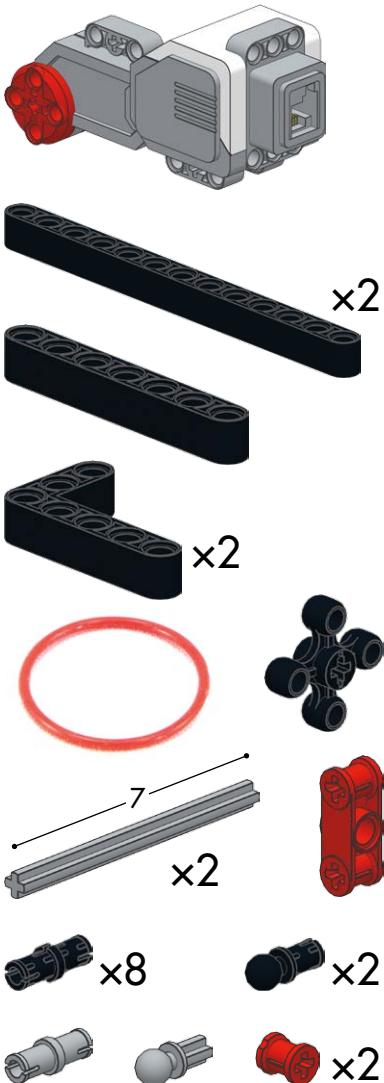


Intermittent motion

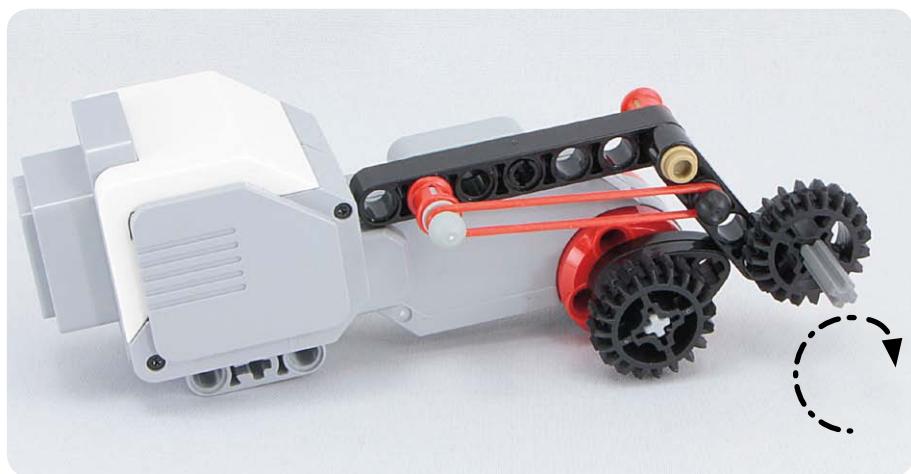
#77



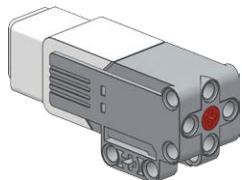
#78



#79



#80



x2



x3



x2



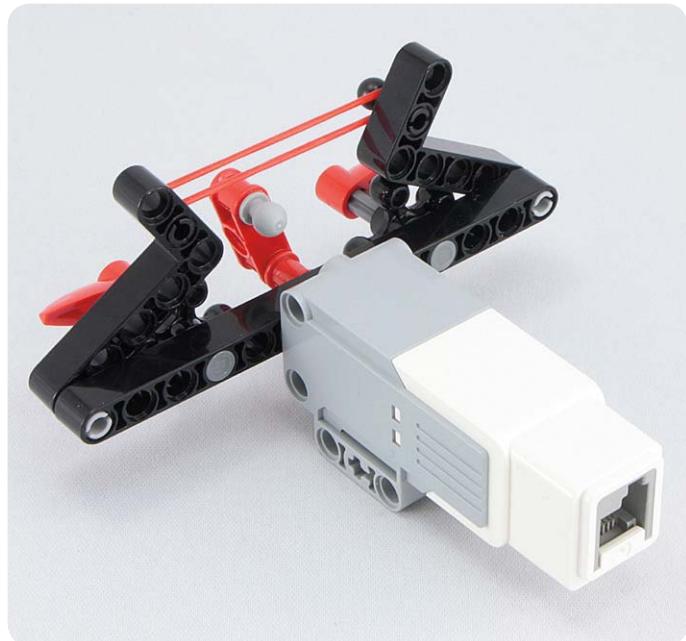
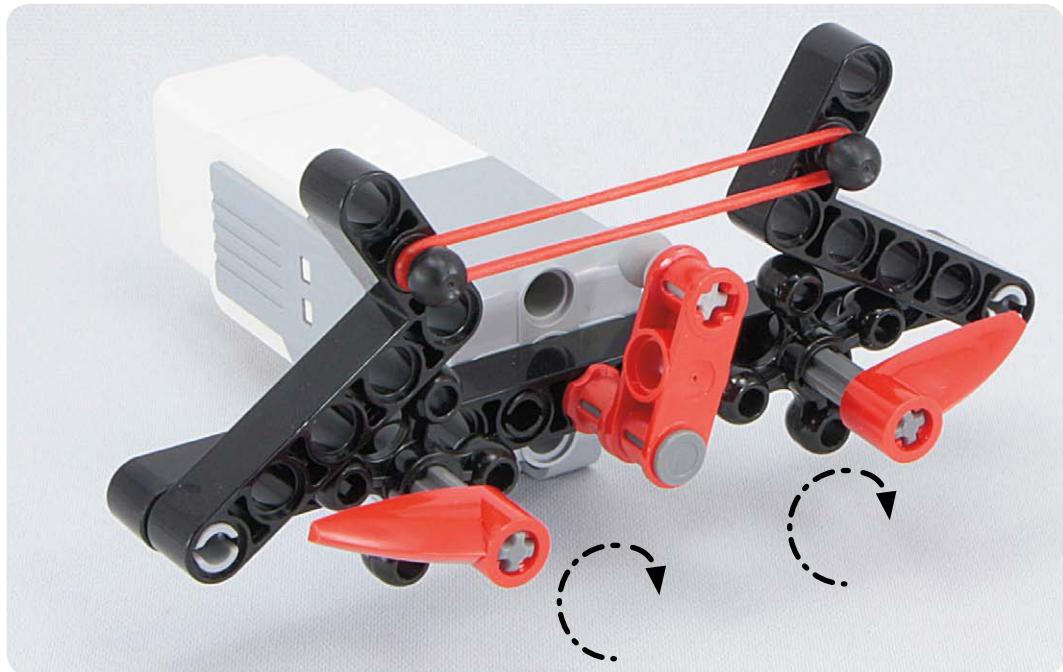
x2

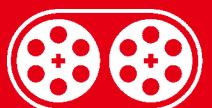


x2



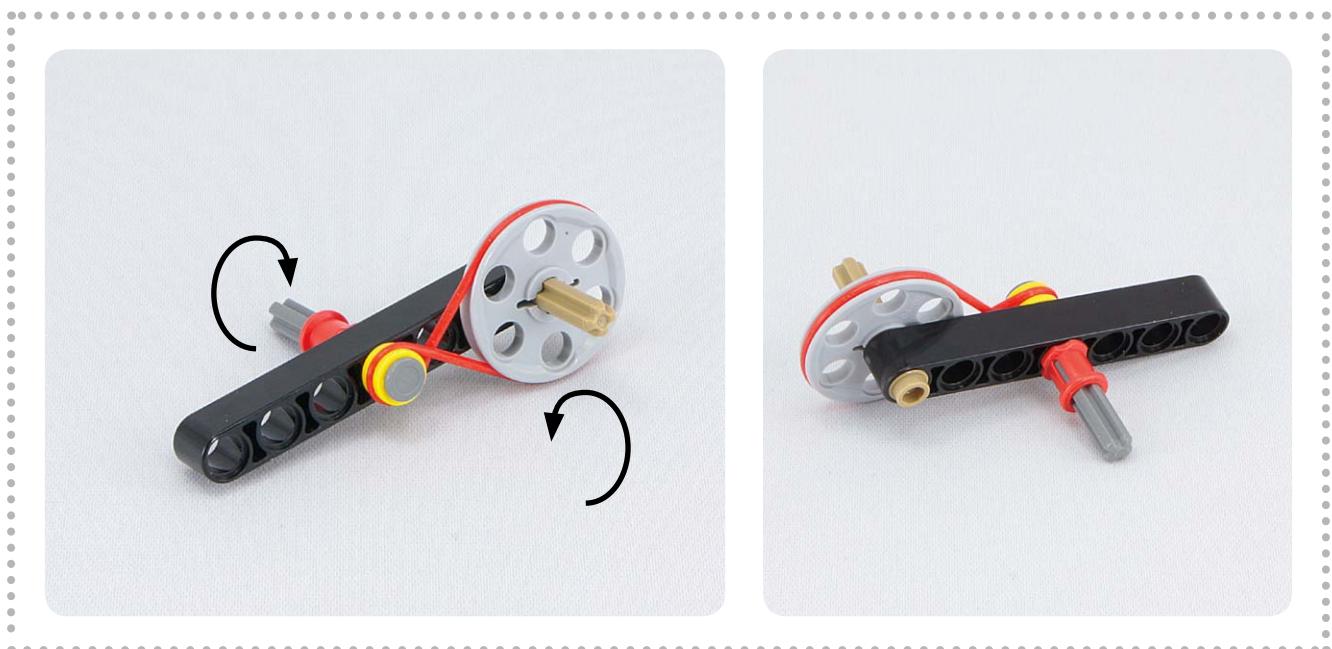
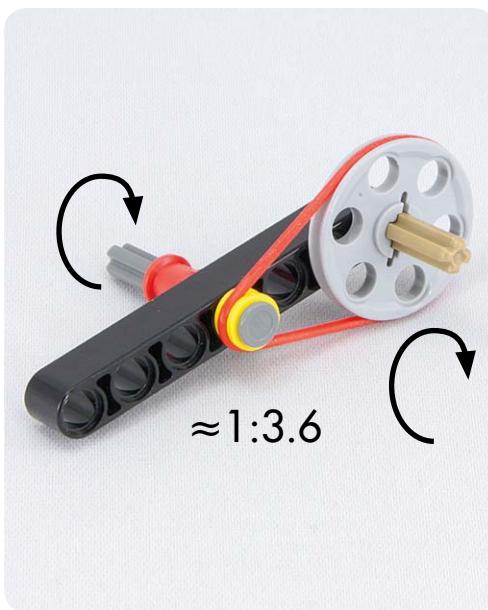
x2





Transmitting rotation with rubber bands

#81



#82

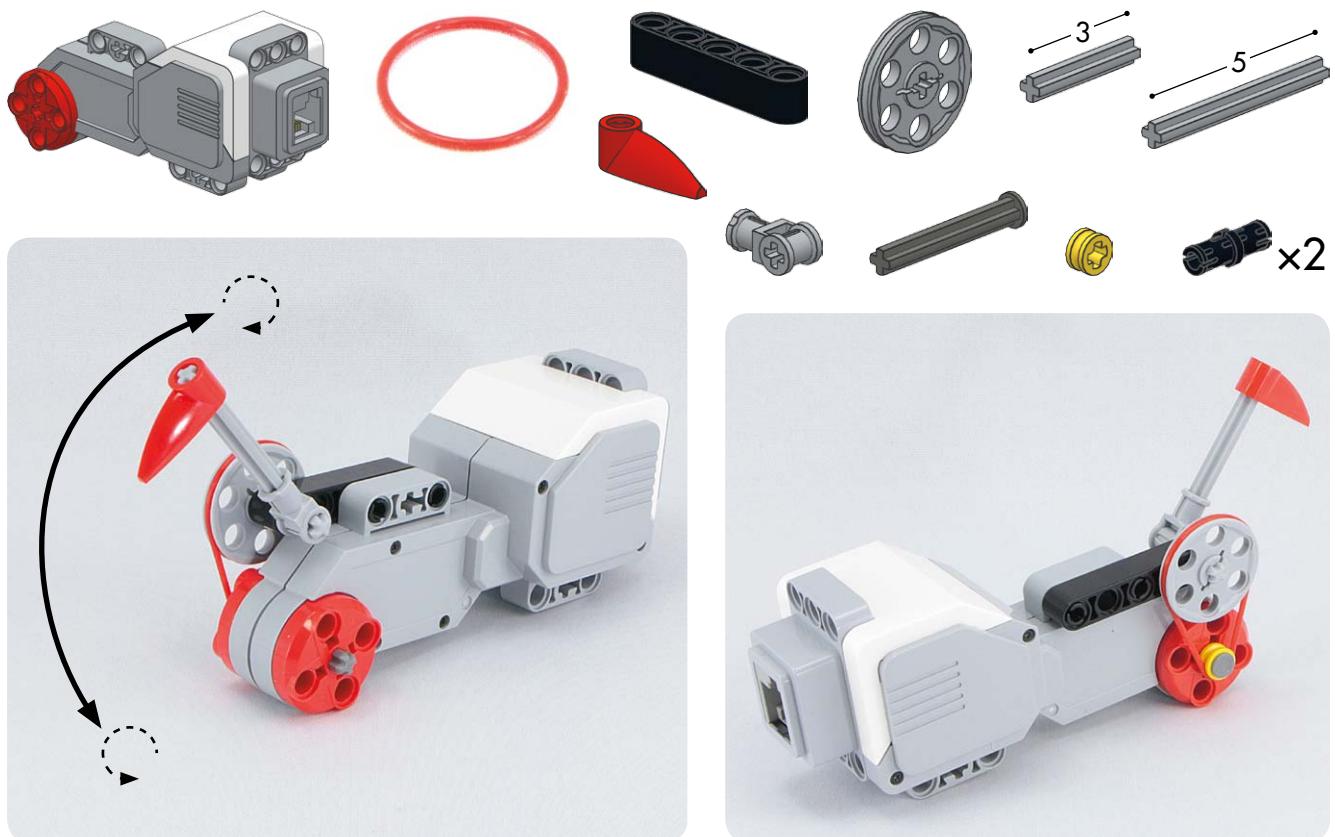


1:1

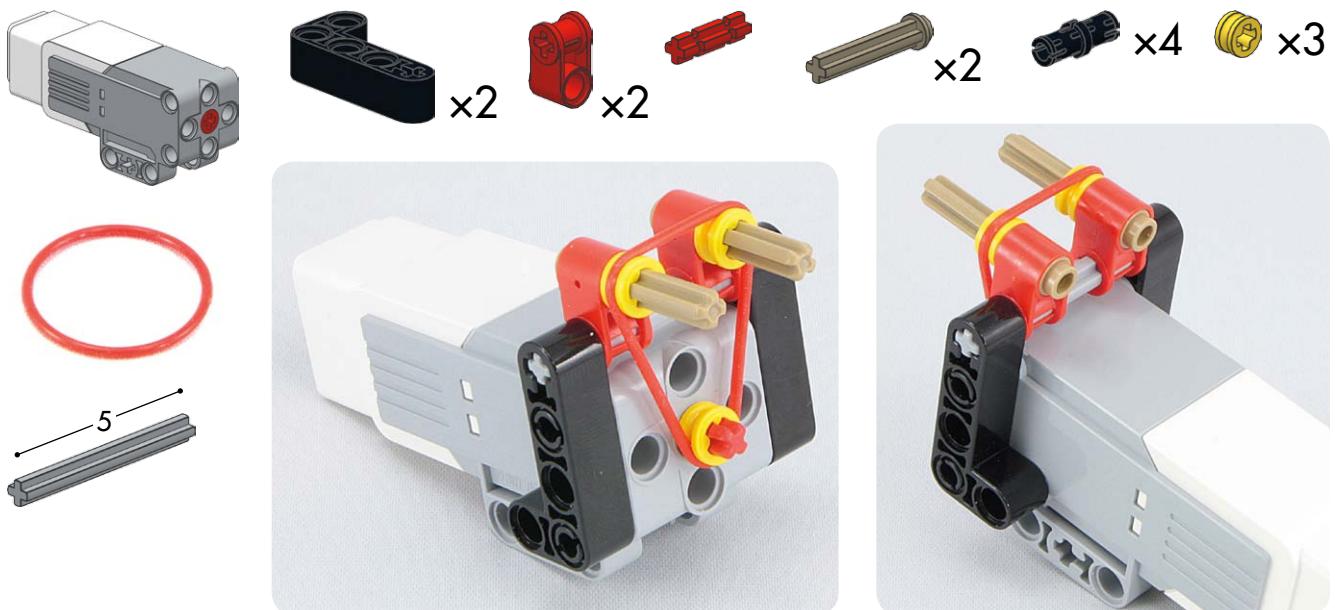
#83



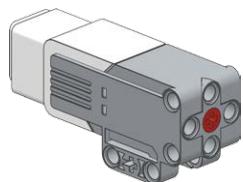
#84



#85



#86



×2



×2



×2



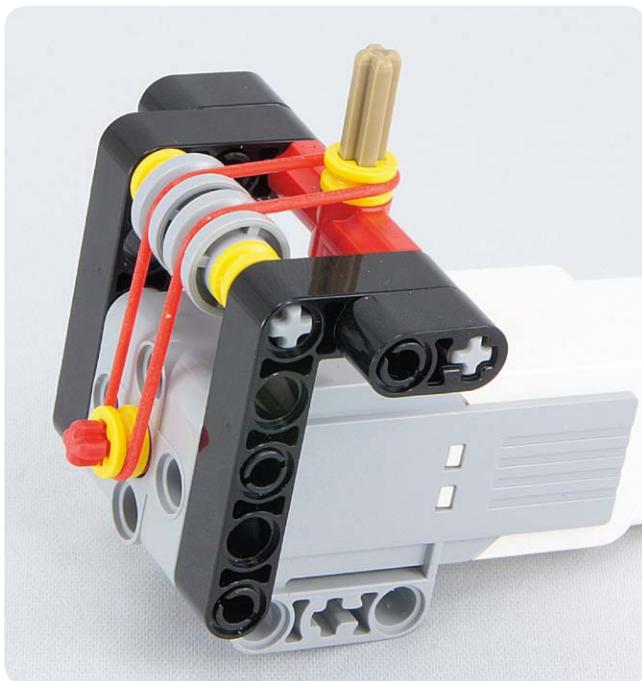
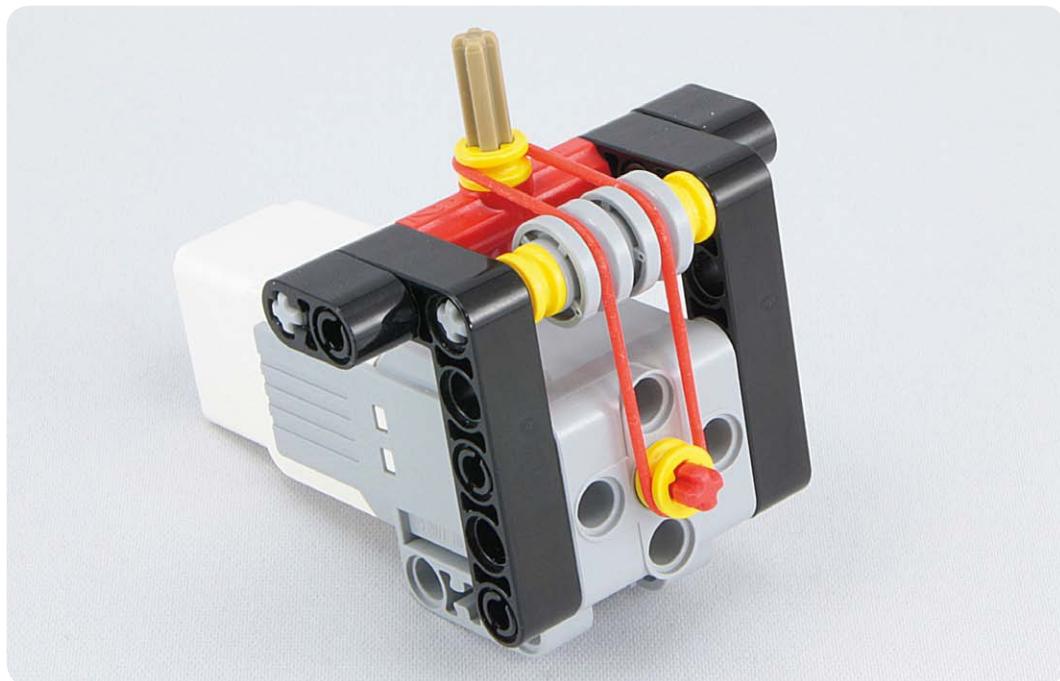
×2

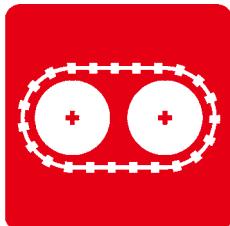


×6



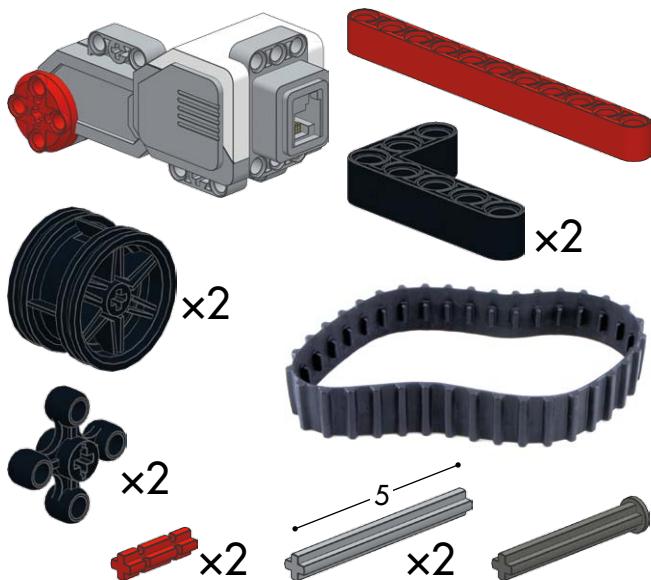
×4



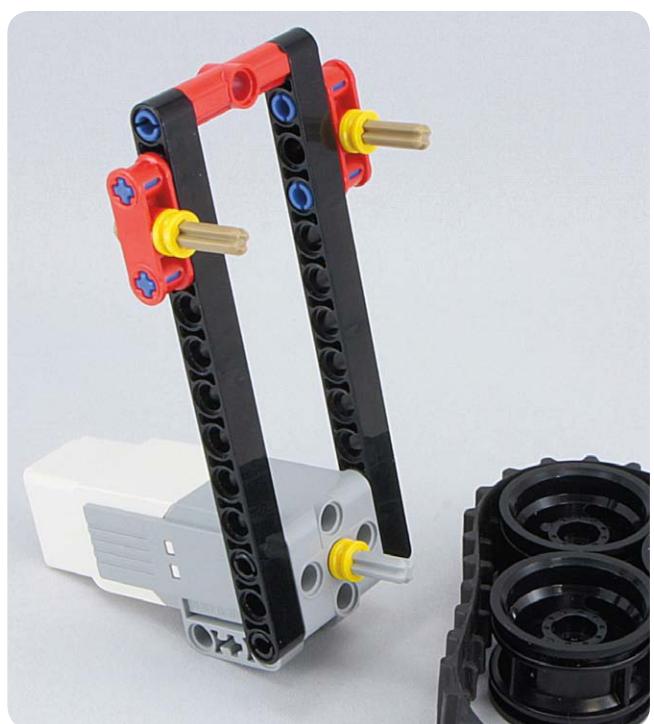
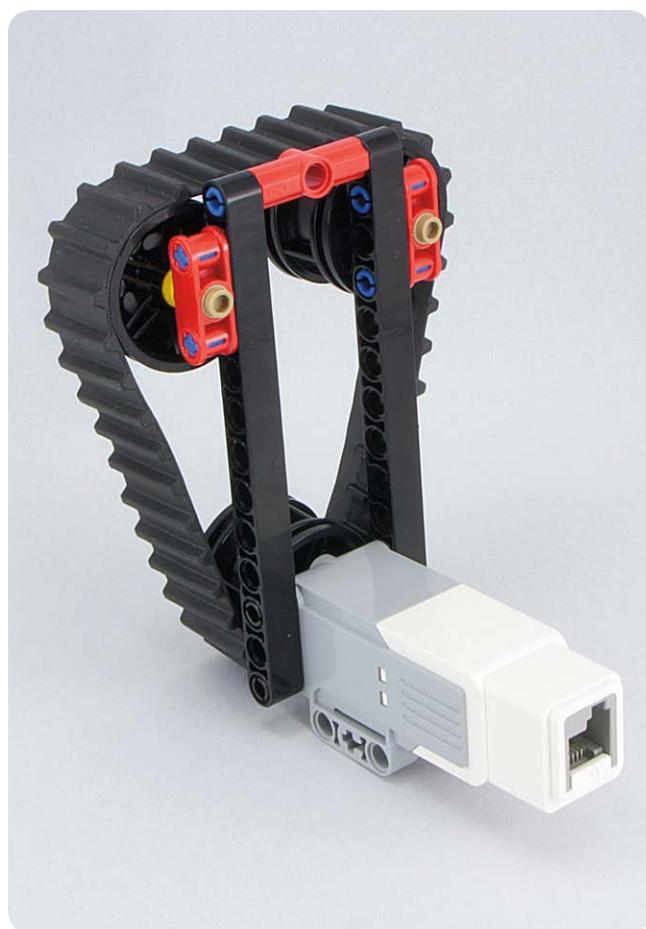
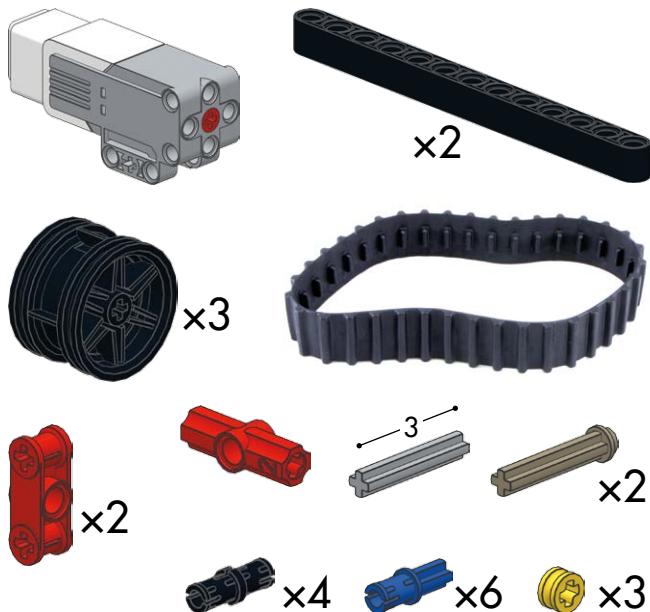


Transmitting rotation with caterpillar treads

#87



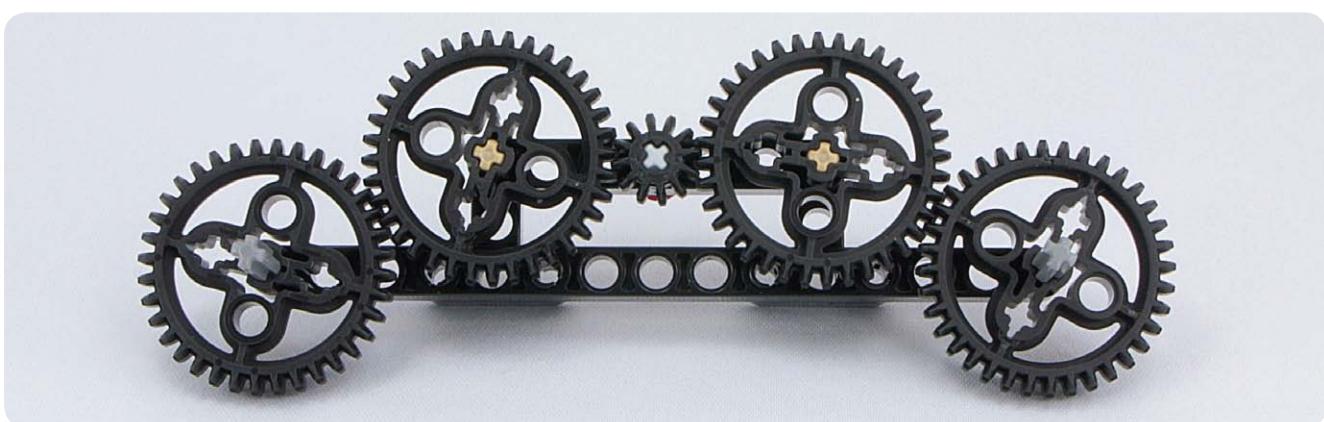
#88



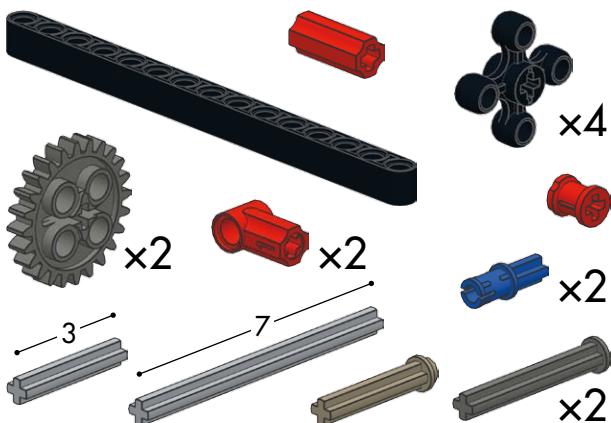


Transmitting rotation over a long distance

#89

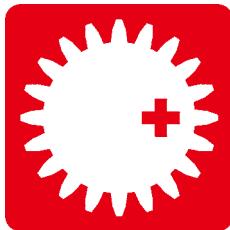


#90



#91



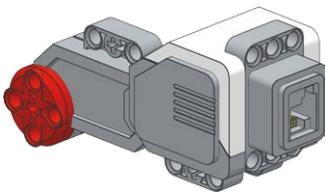


Off-center axes of rotation

#92

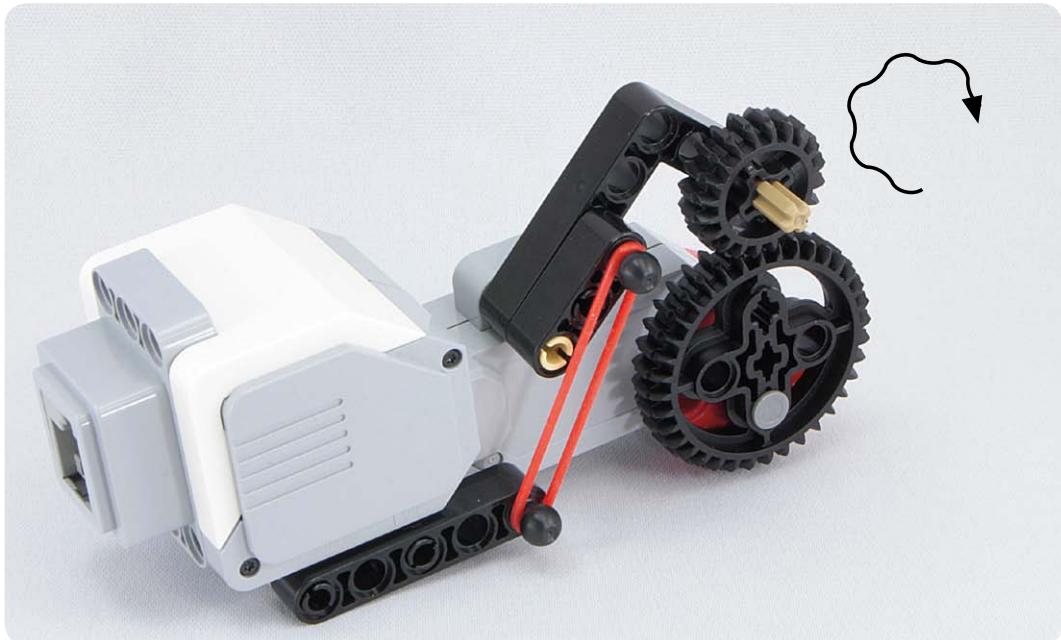


#93

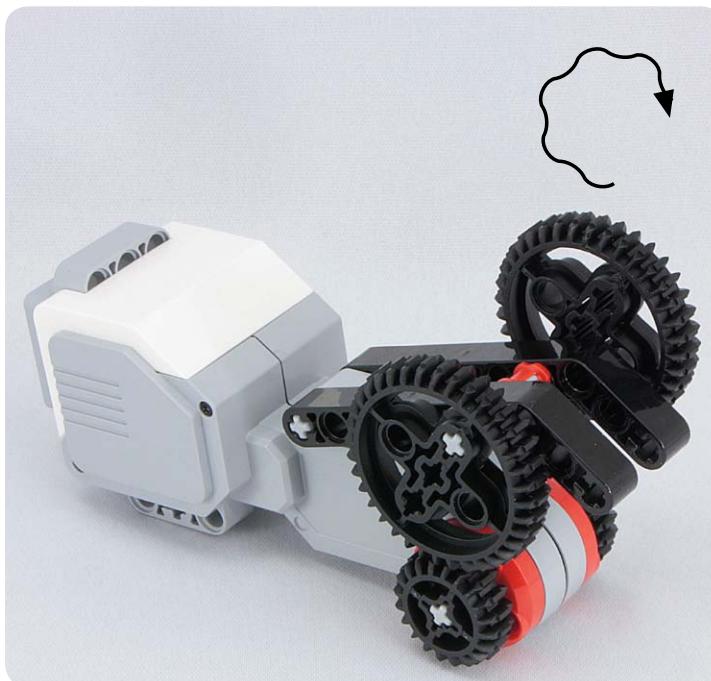


x2

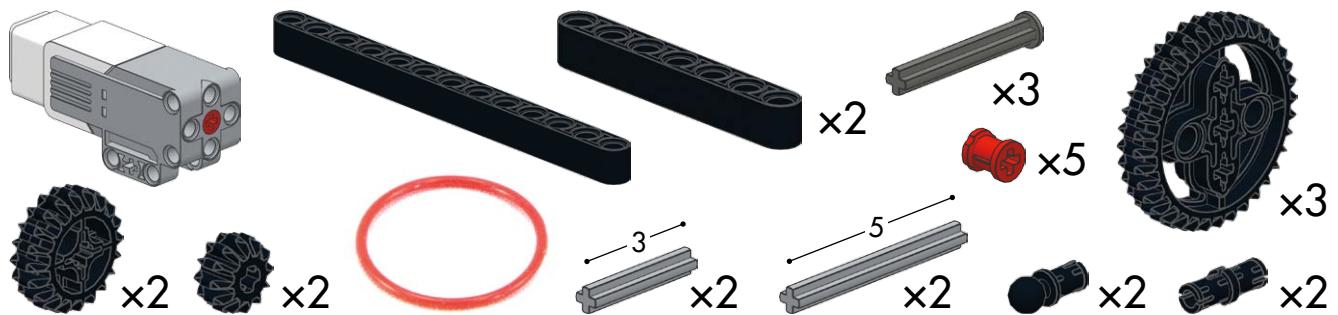
x3

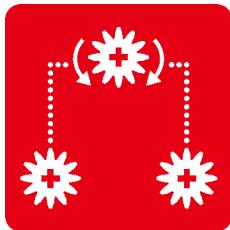


#94



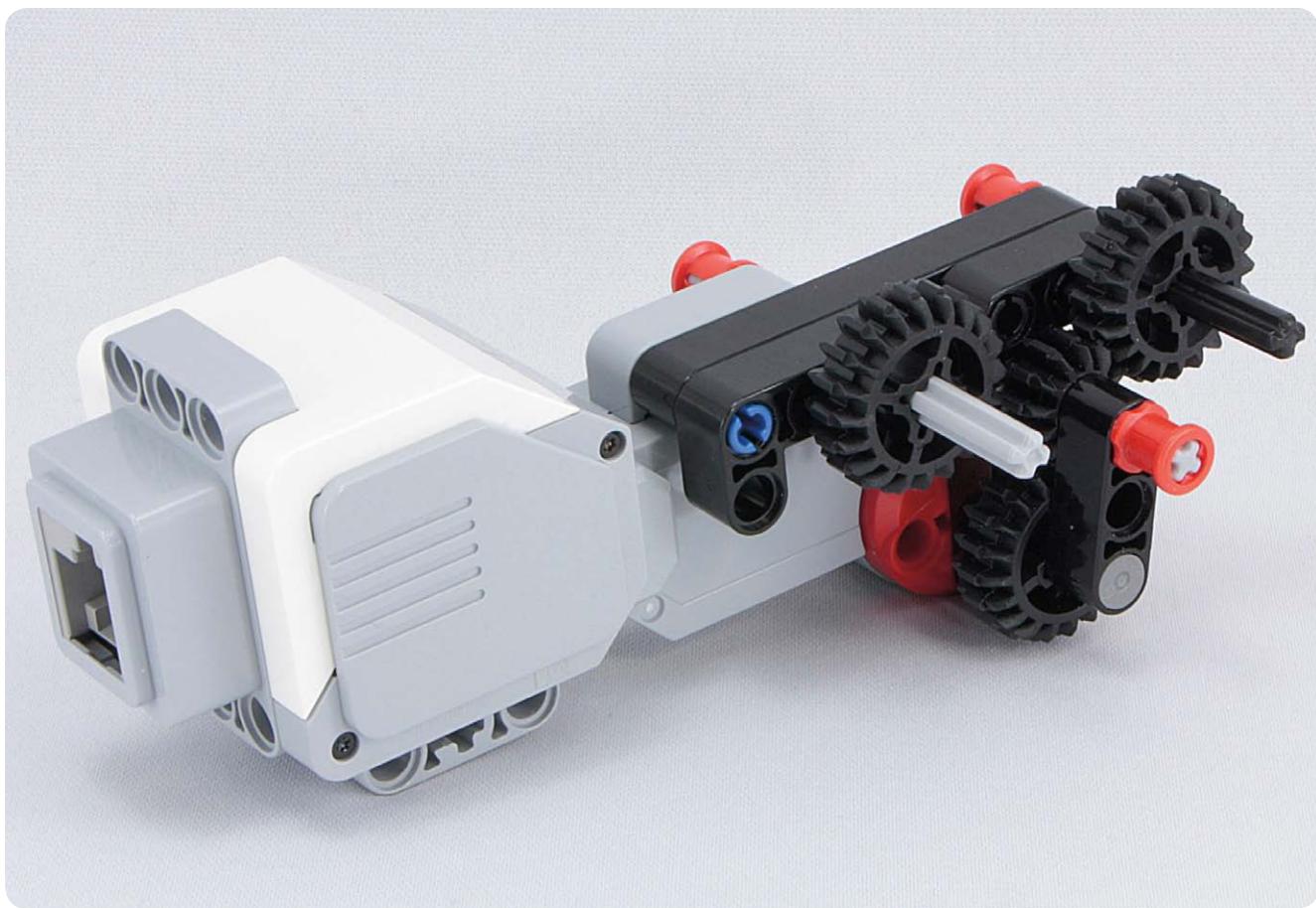
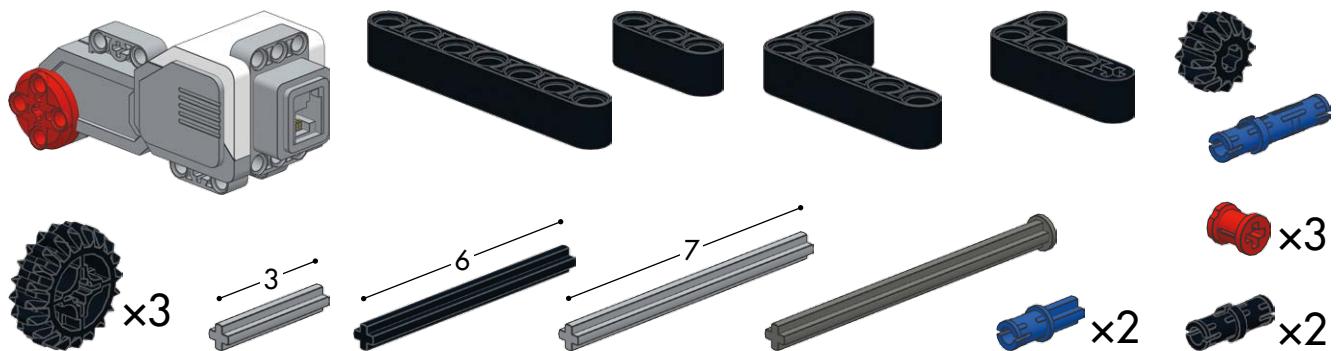
#95





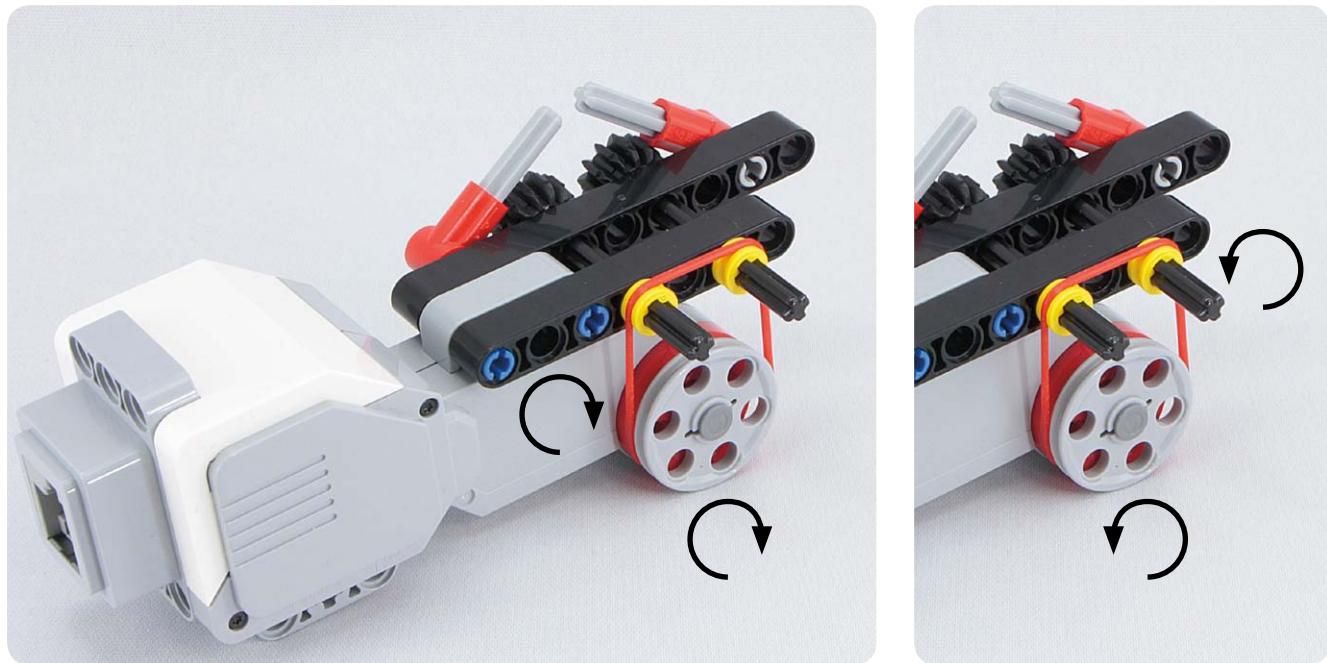
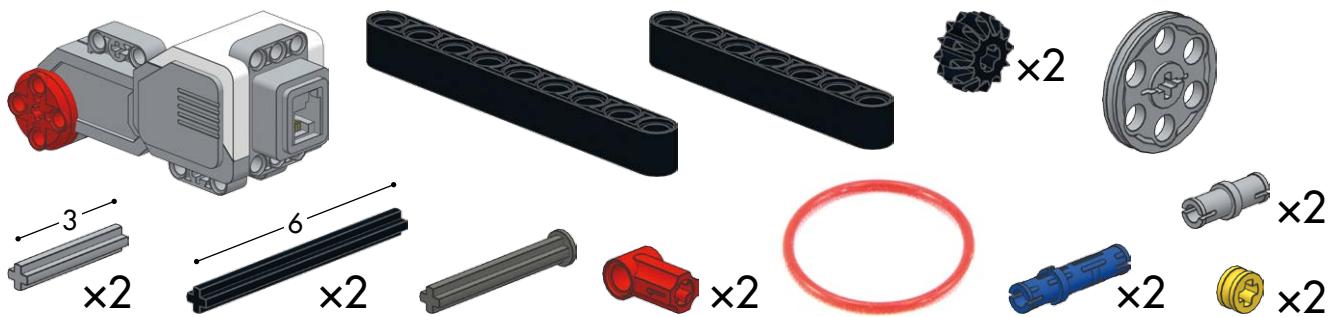
Changeover mechanisms using rotational direction

#96

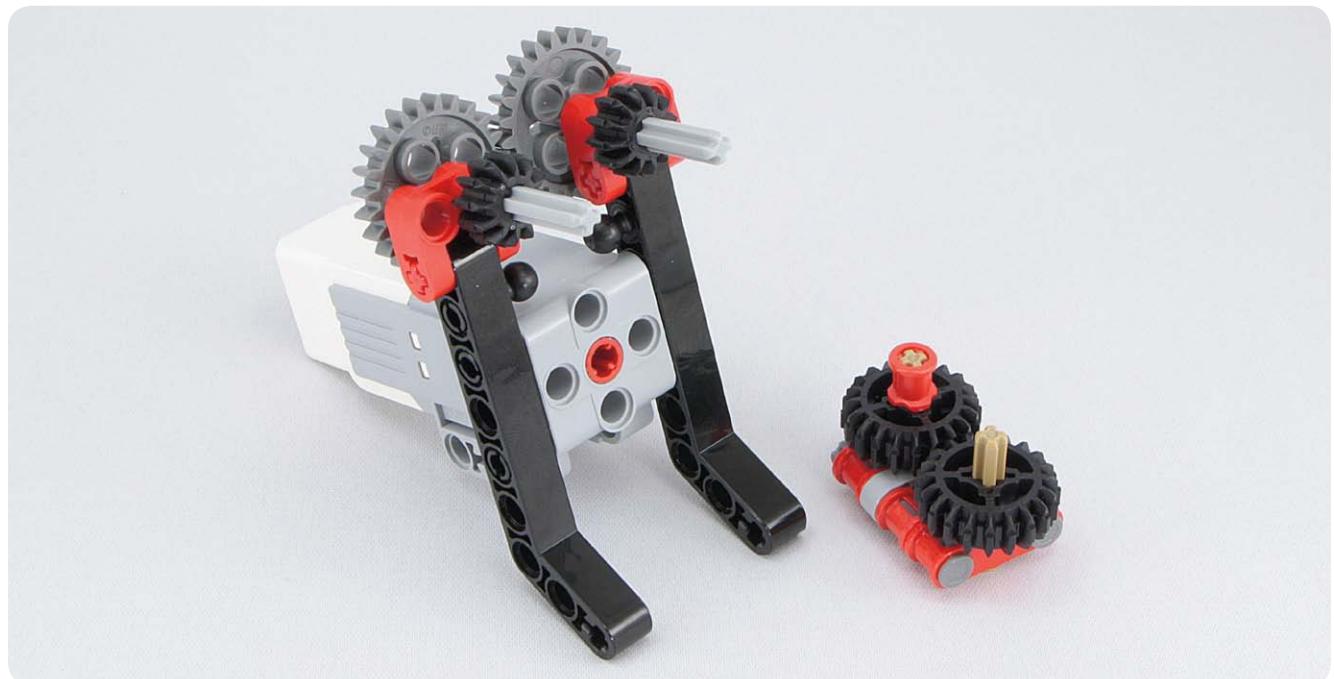
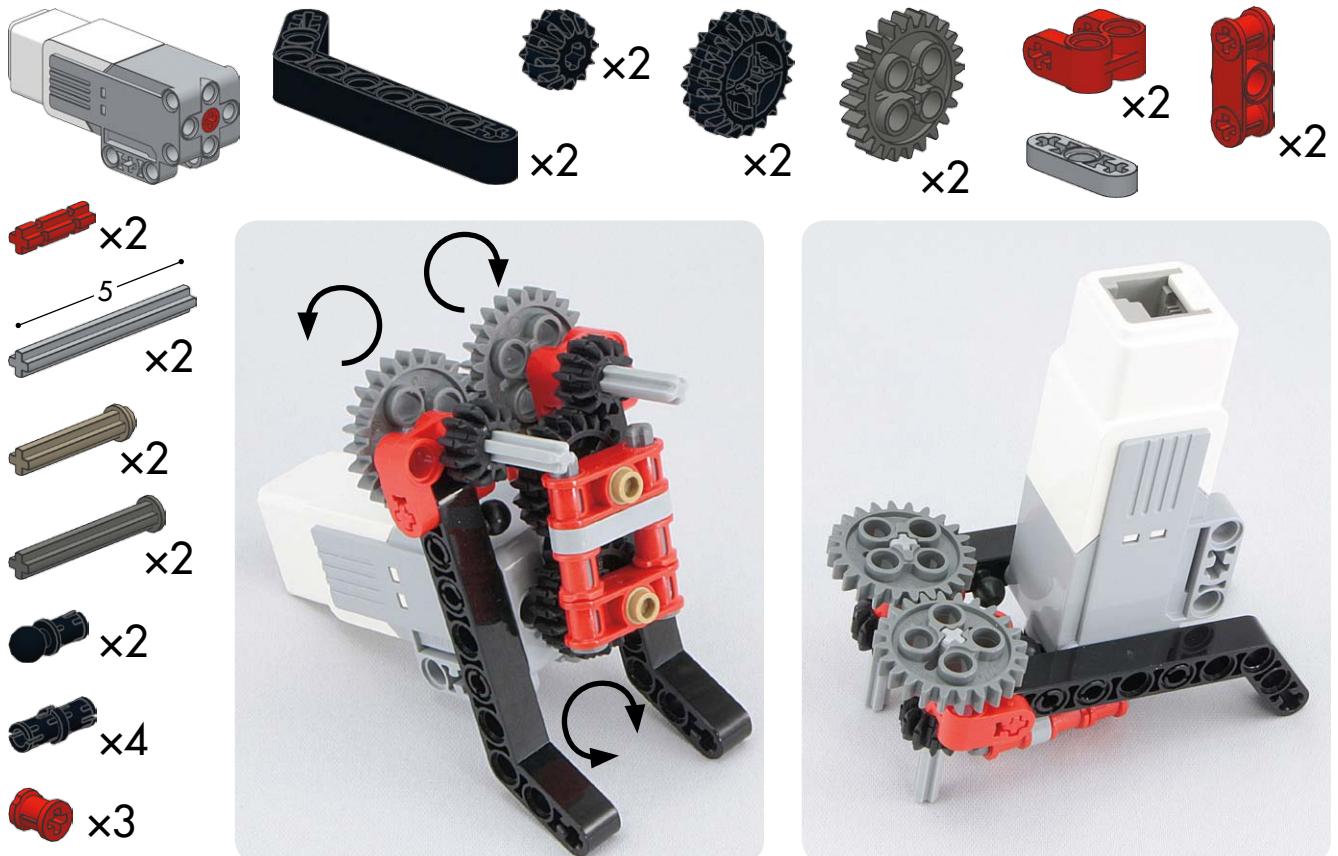




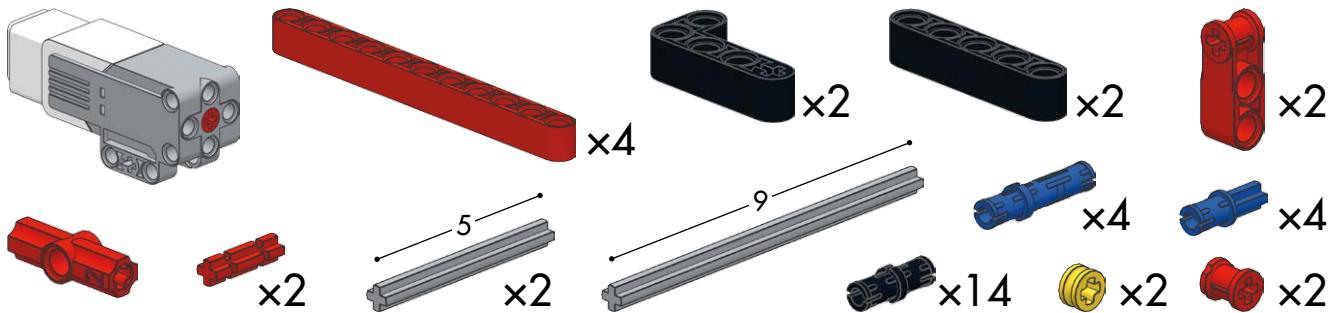
#97



#98



#99

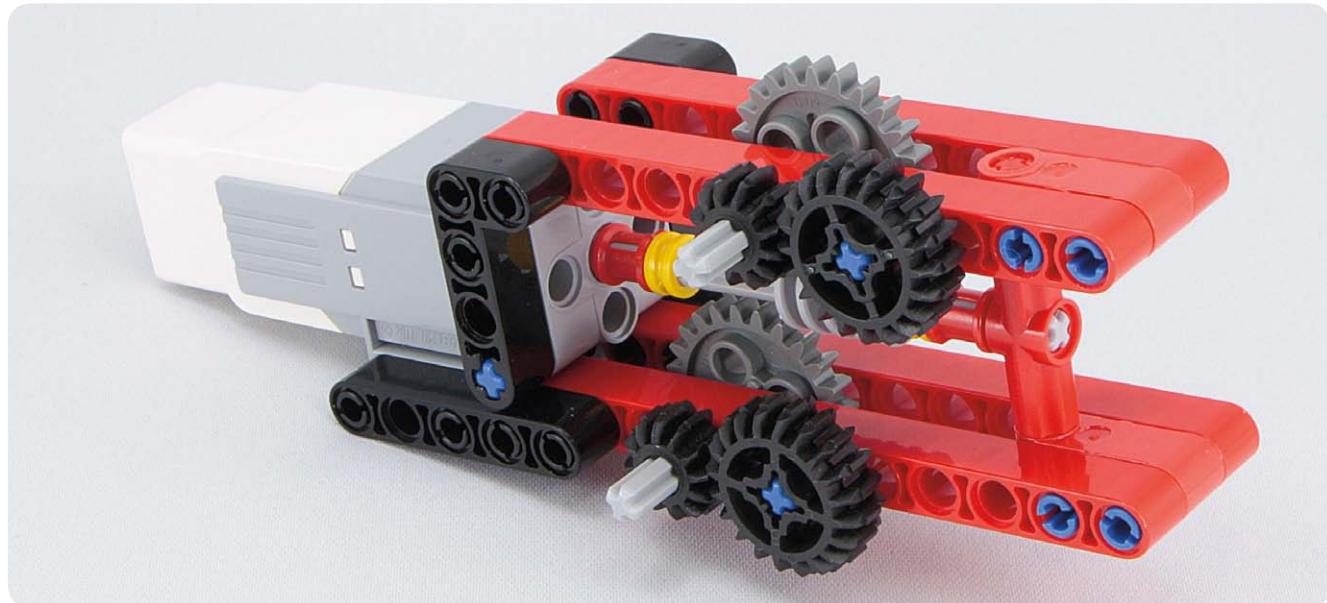
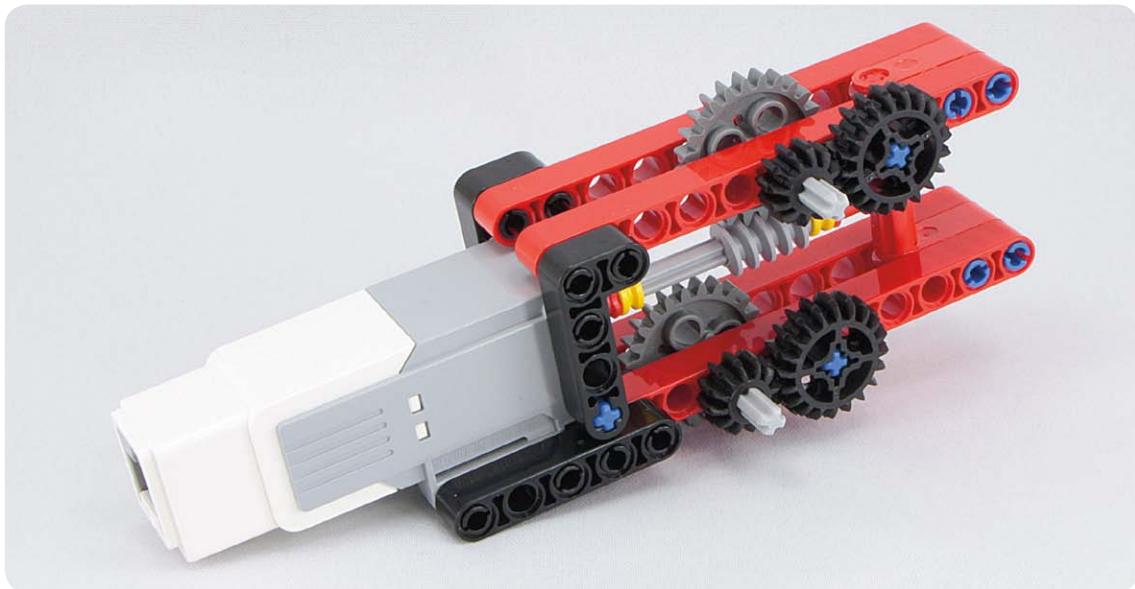


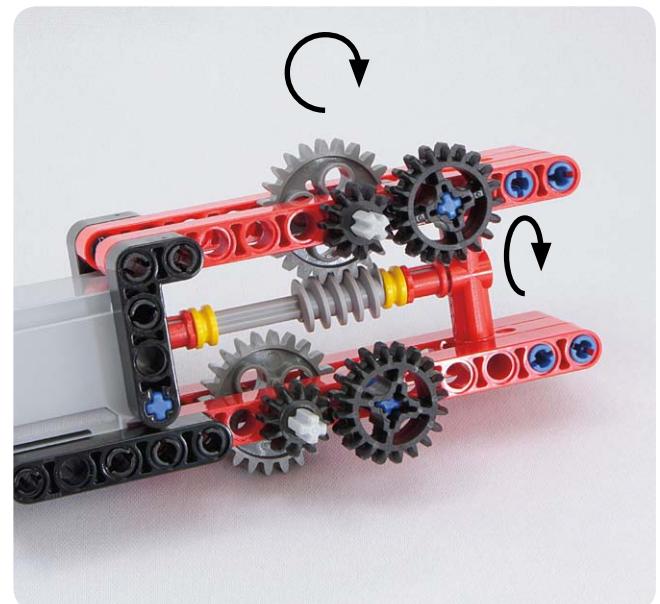
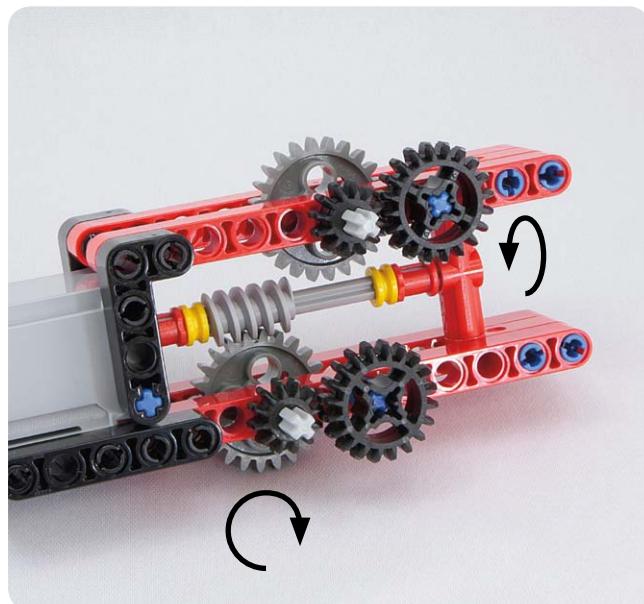
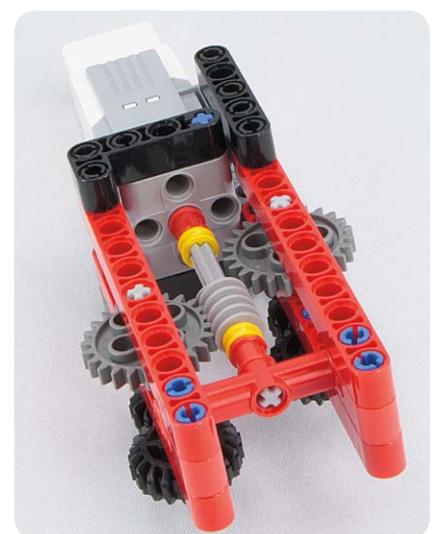
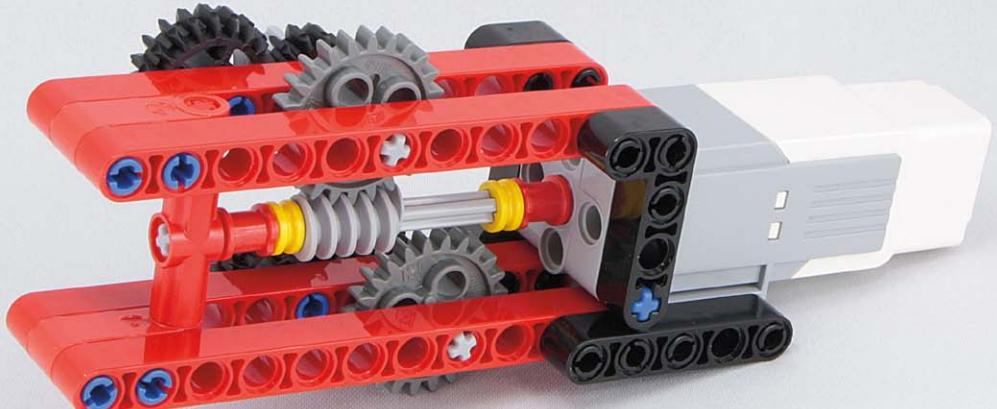
2L gear: 2

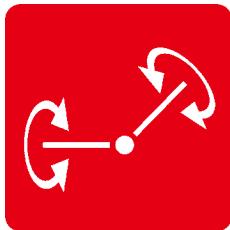
3L gear: 2

4L gear: 2

Shaft: 1

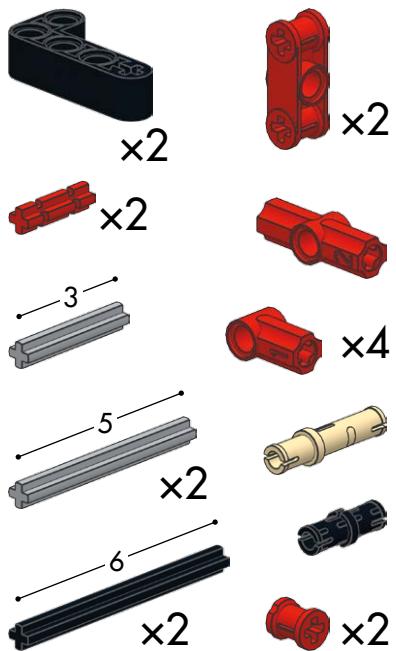




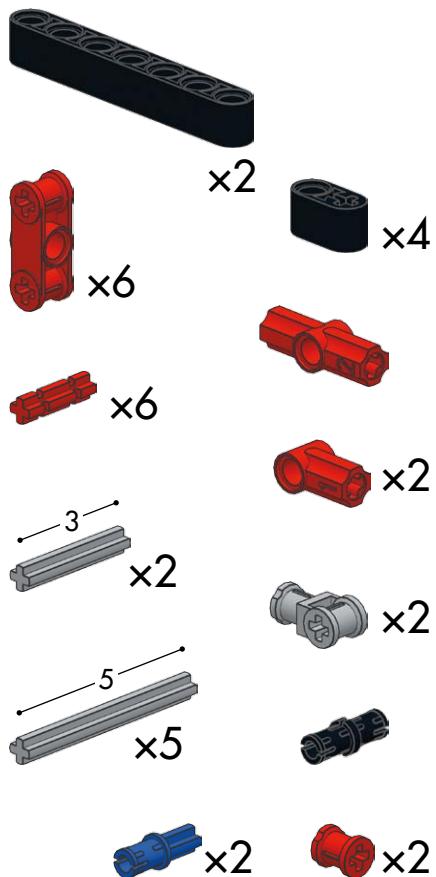


Universal joints

#100



#101





PART 2



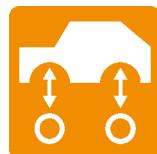
Vehicles



78



90



100



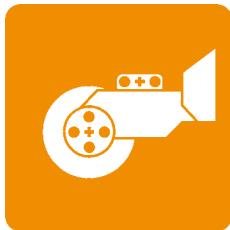
82



94

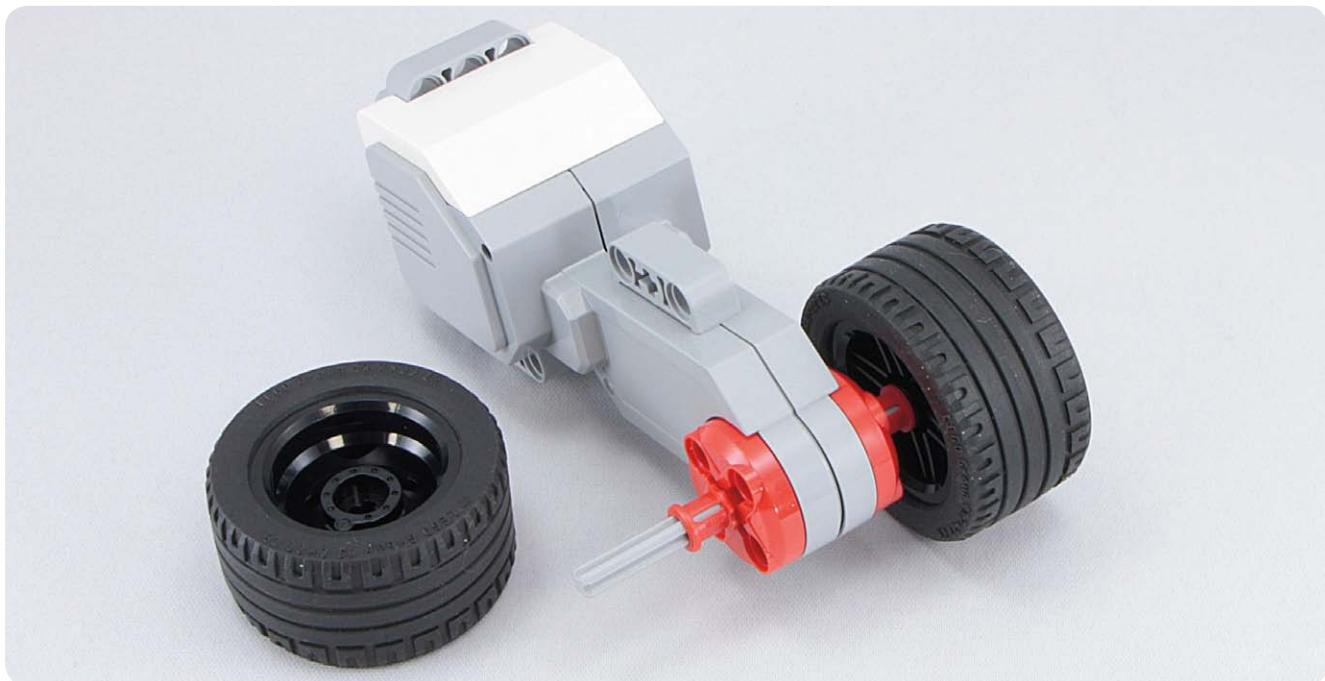
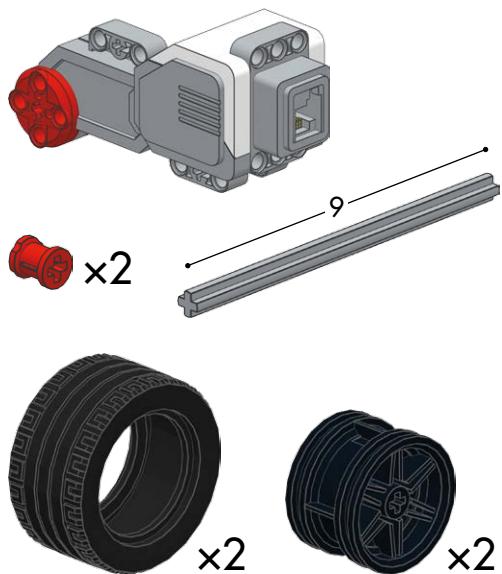


104

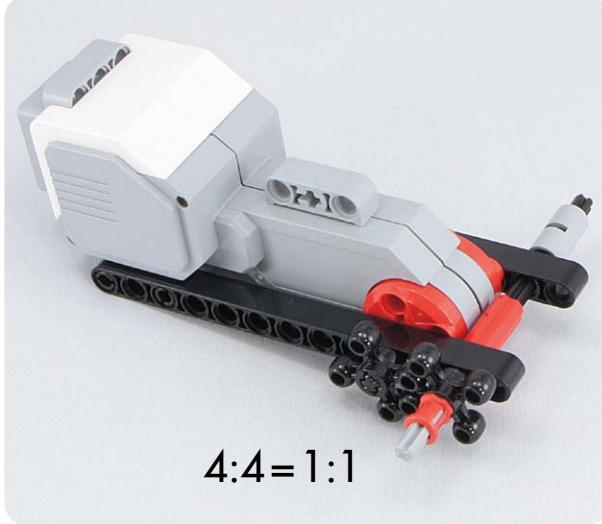
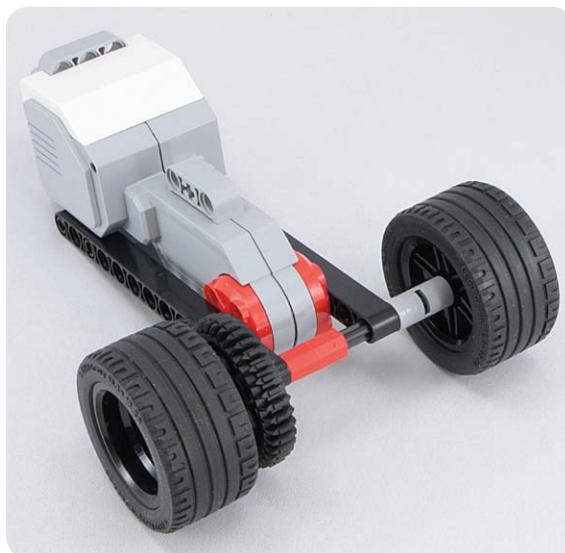


Driving wheels with a motor

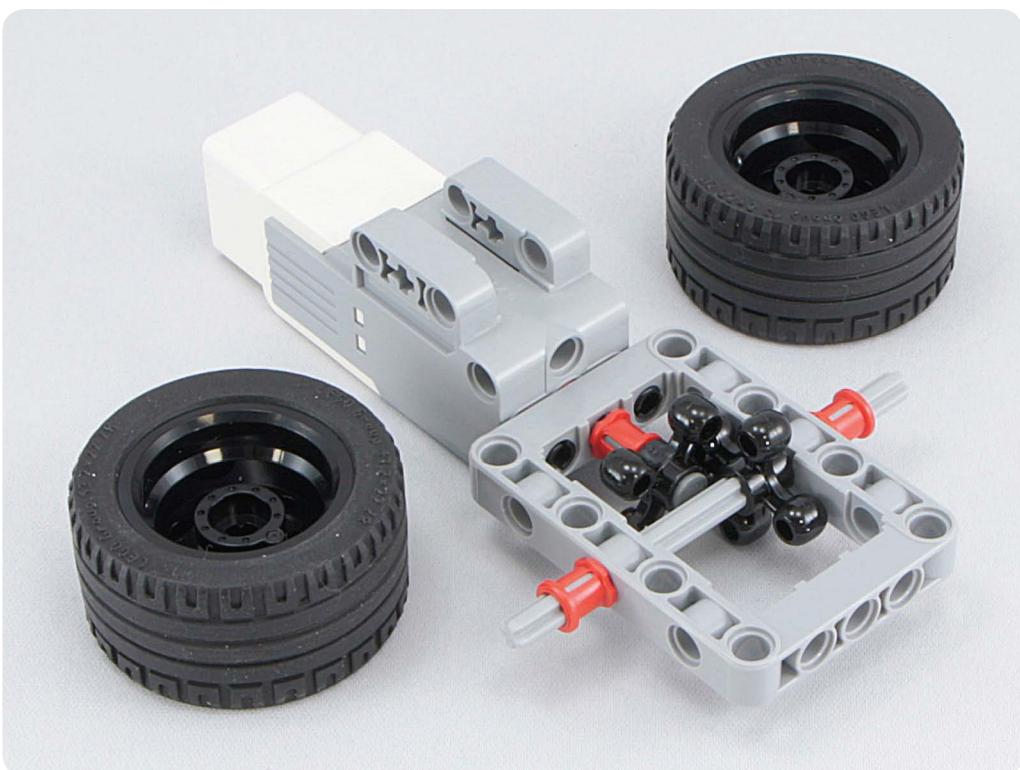
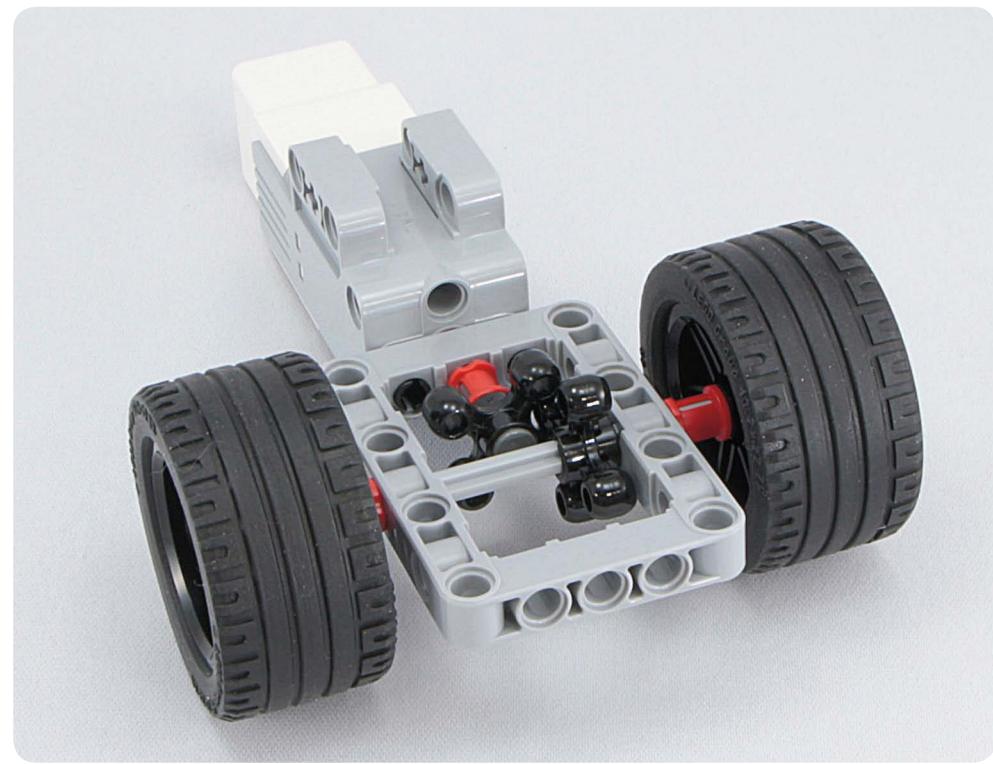
#102



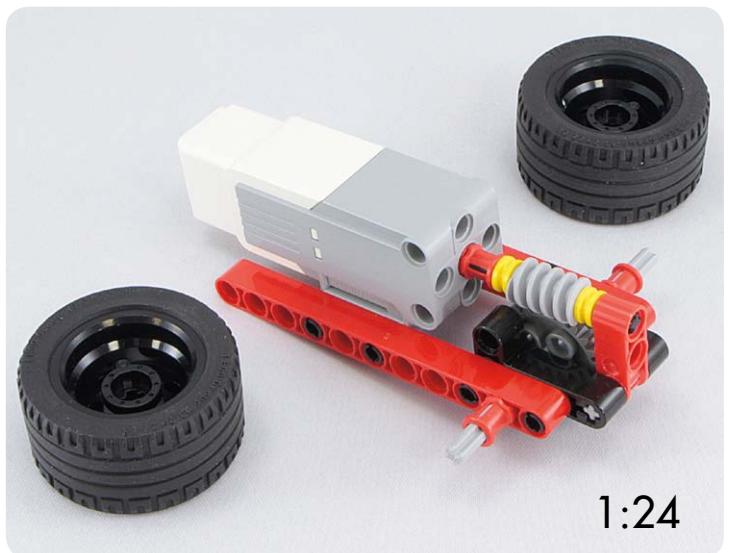
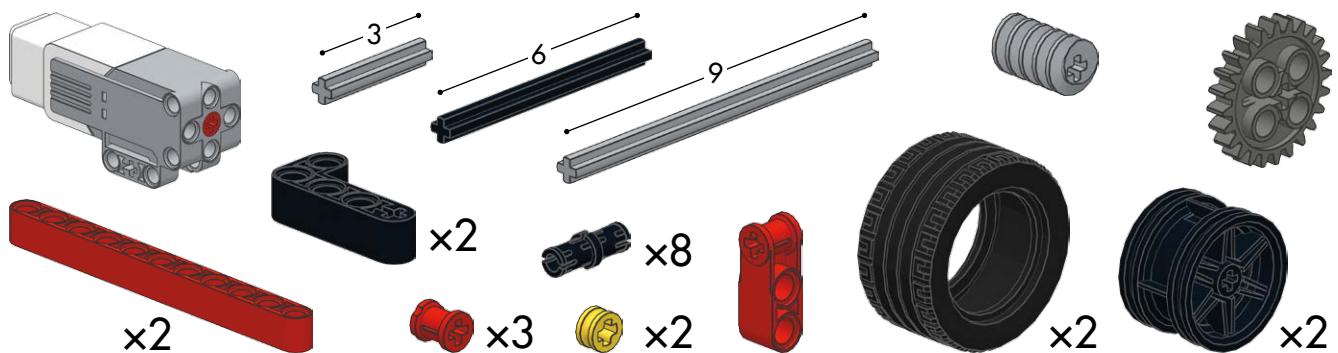
#103



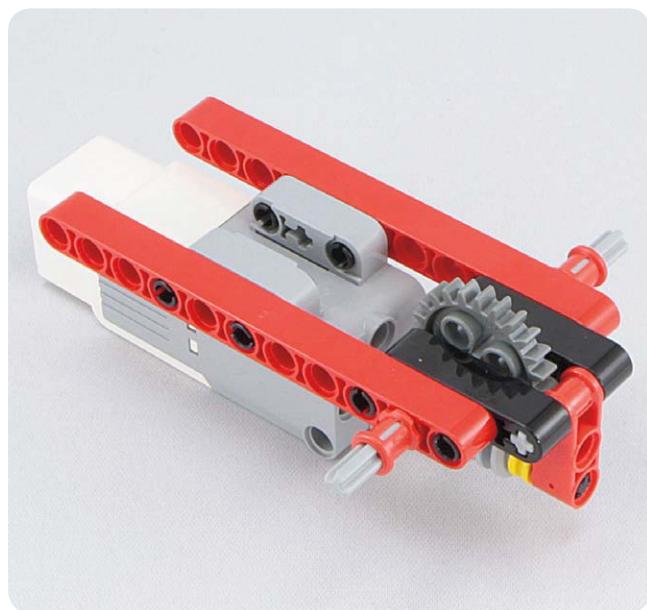
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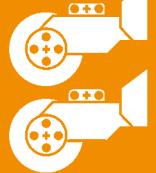


#105



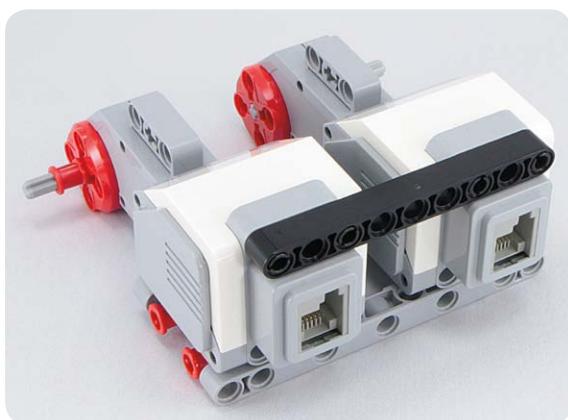
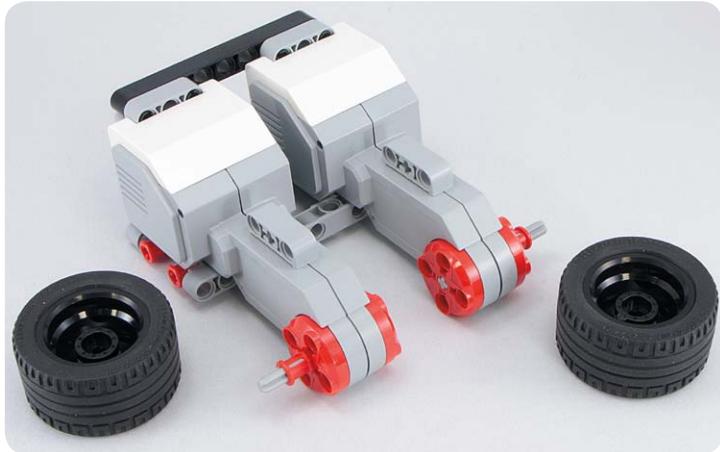
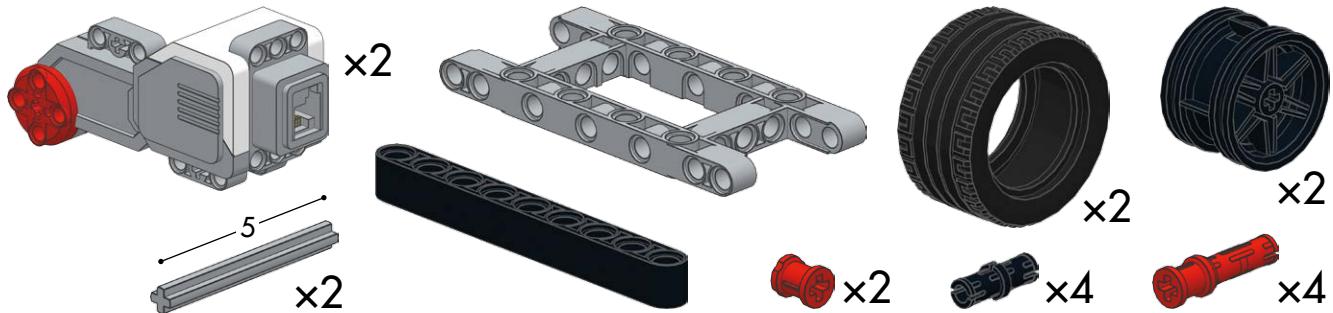
1:24



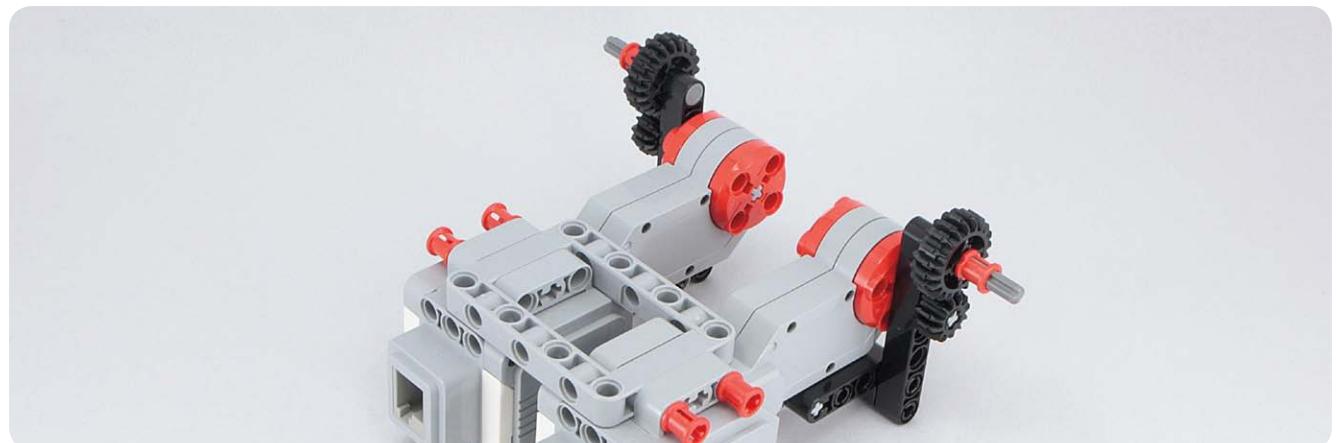
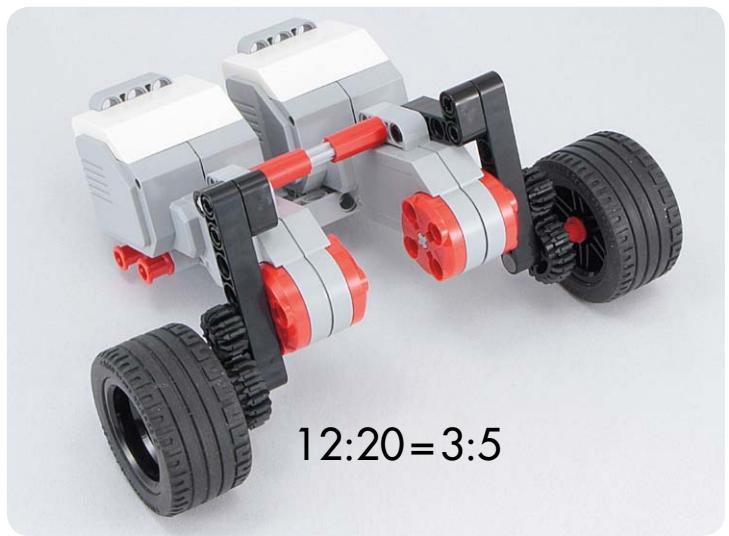


Driving wheels with two motors

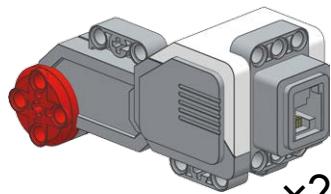
#106



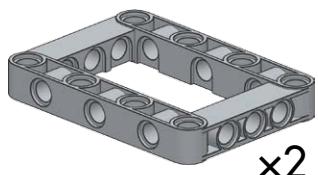
#107



#108



4x

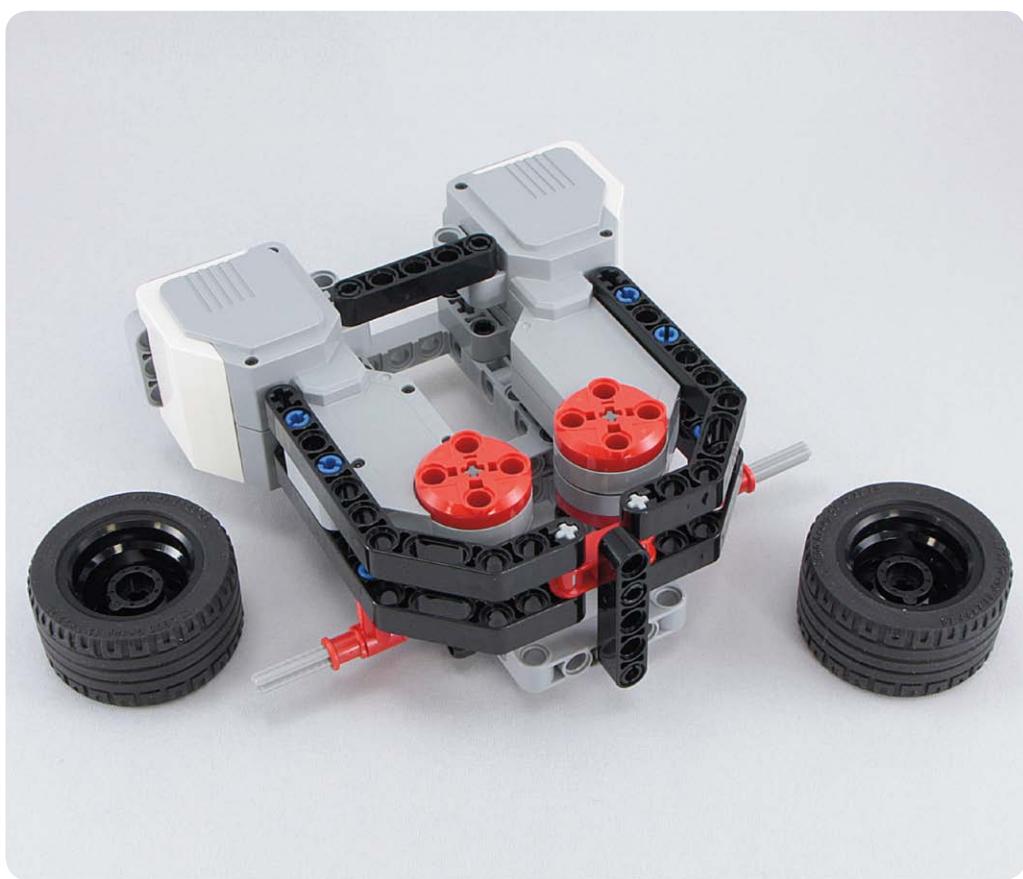
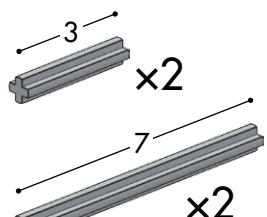
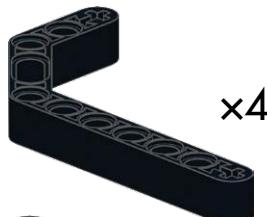


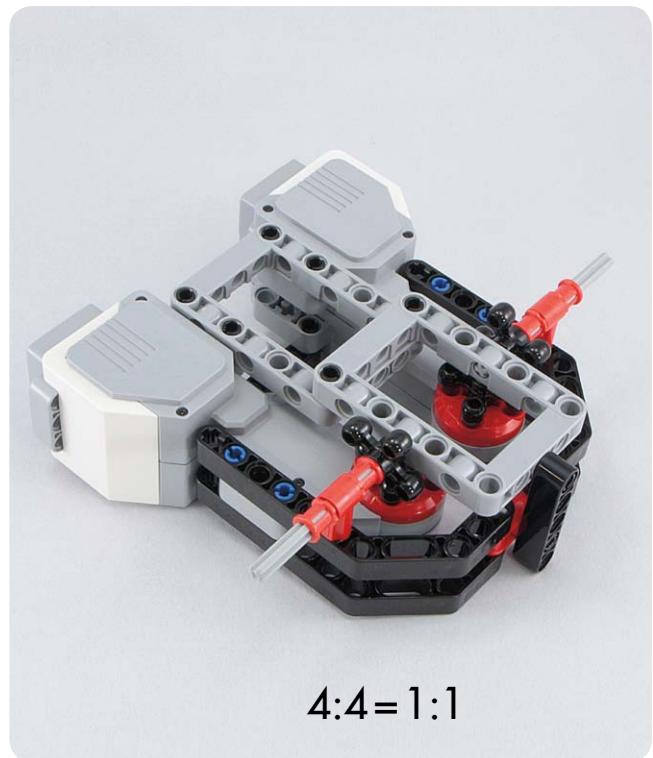
10x

4x

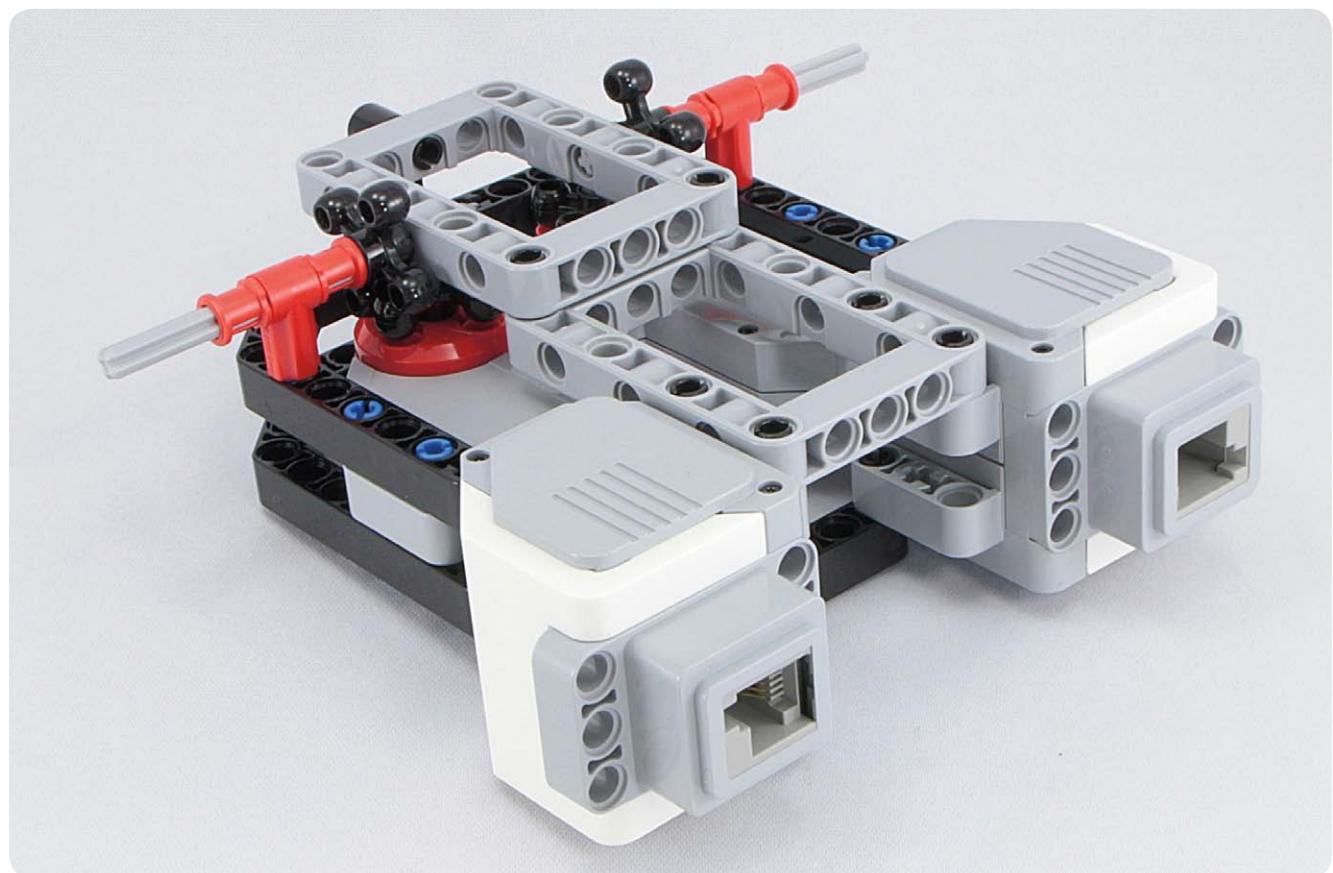
2x

2x

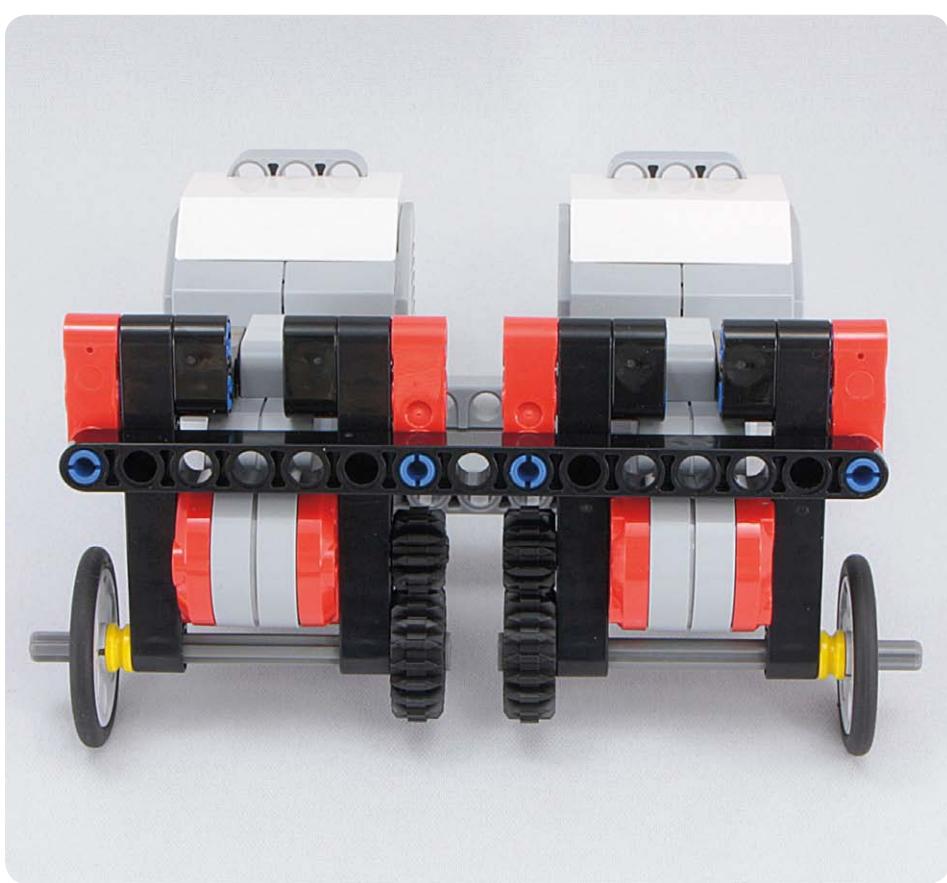
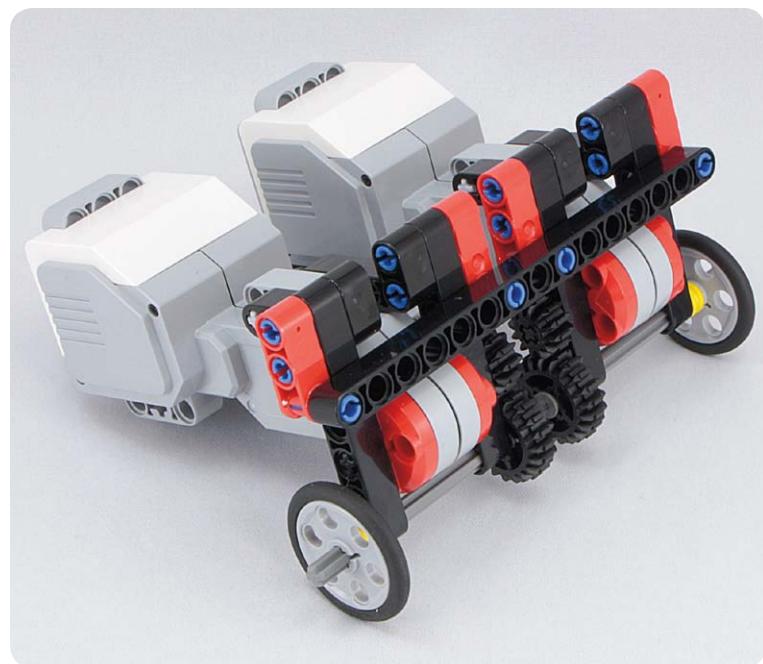


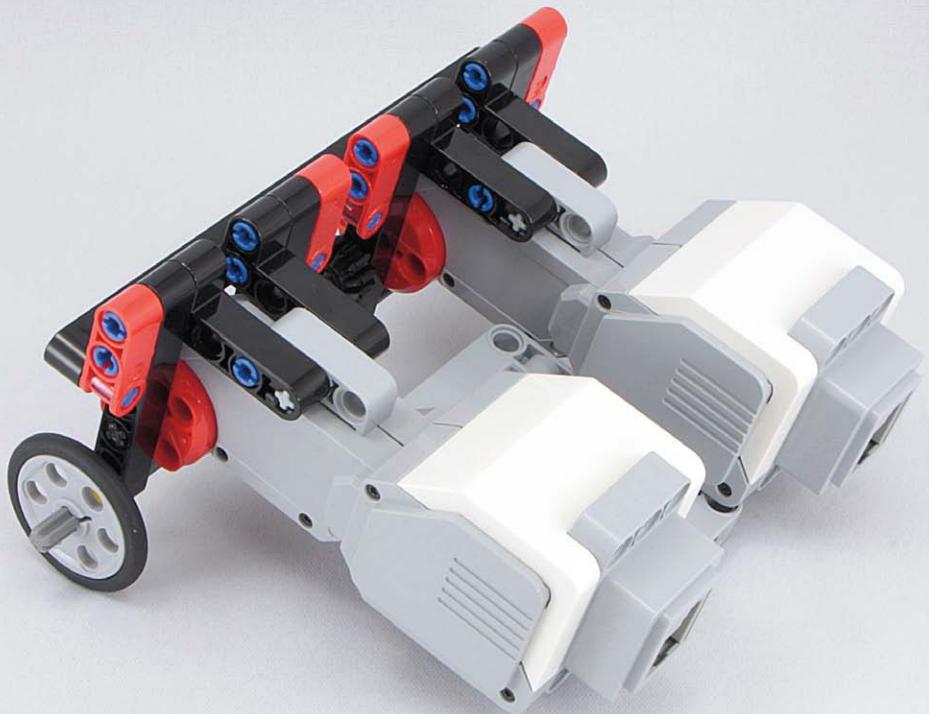


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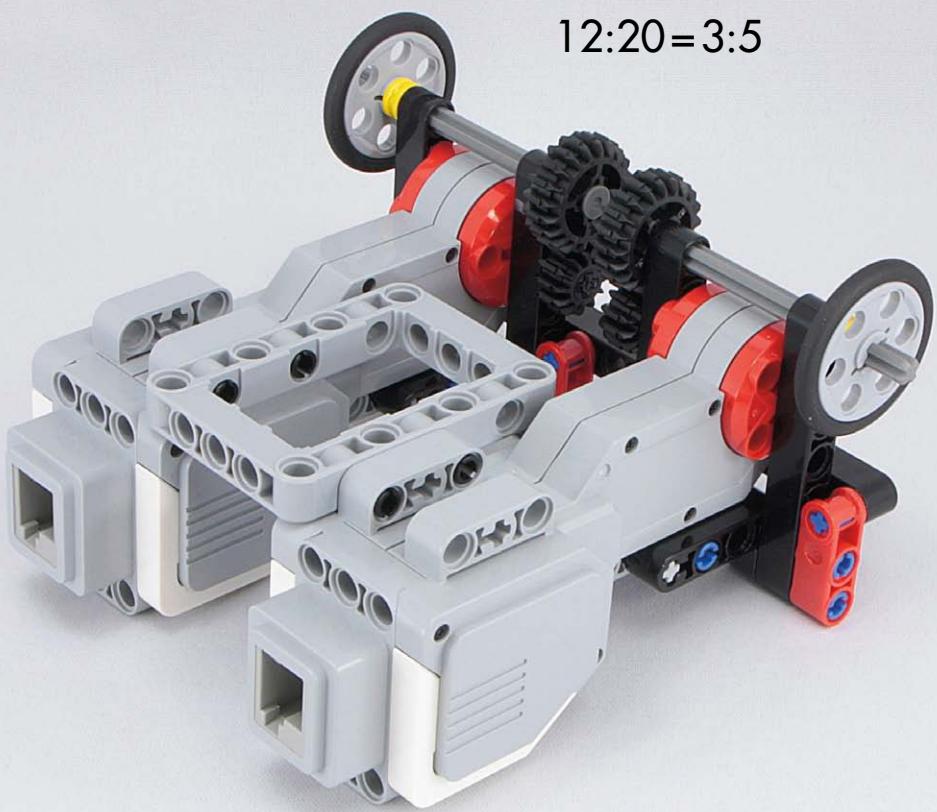


#109

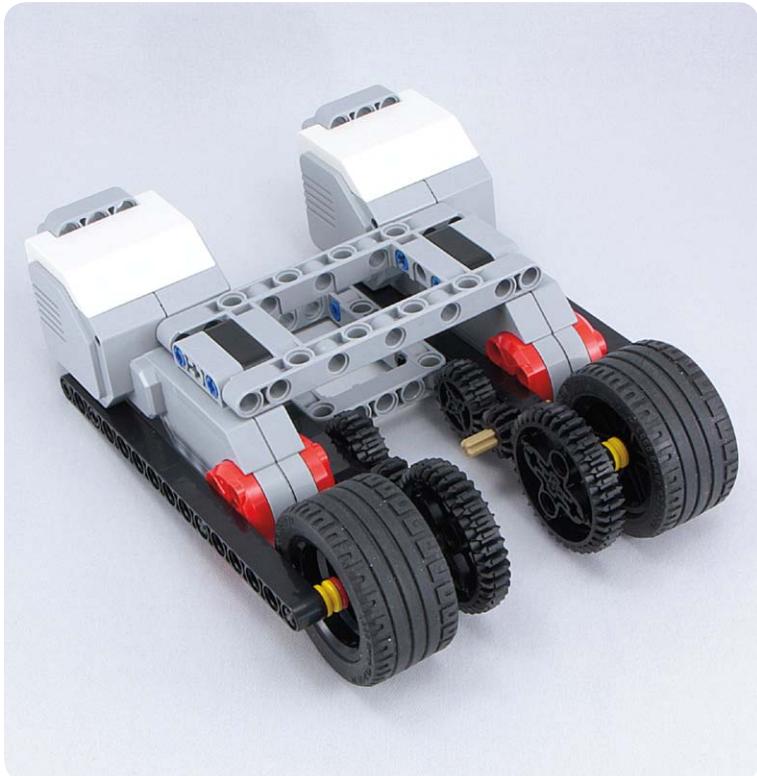
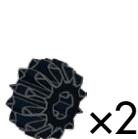
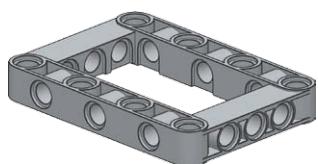
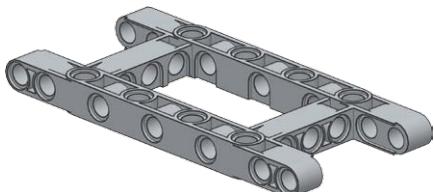
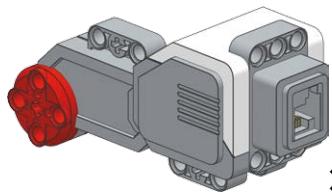


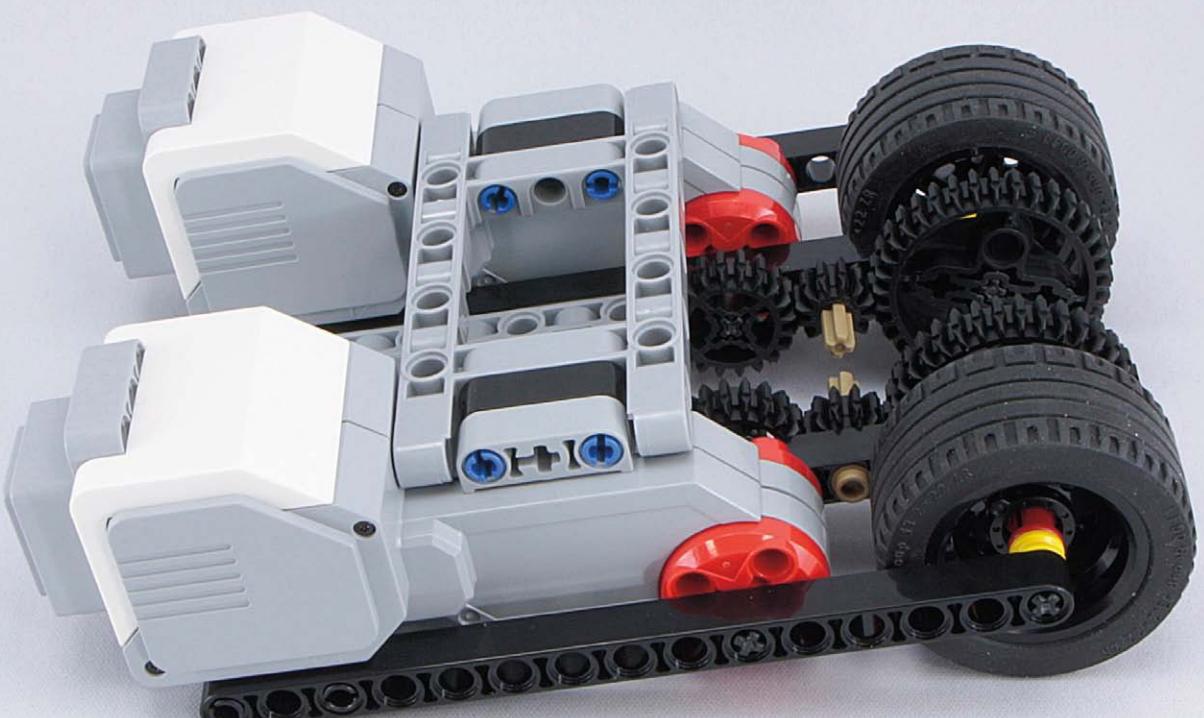


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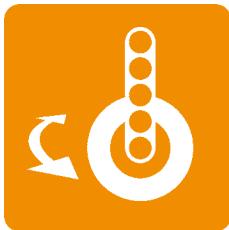


#110





20:36 = 5:9



Caster wheels

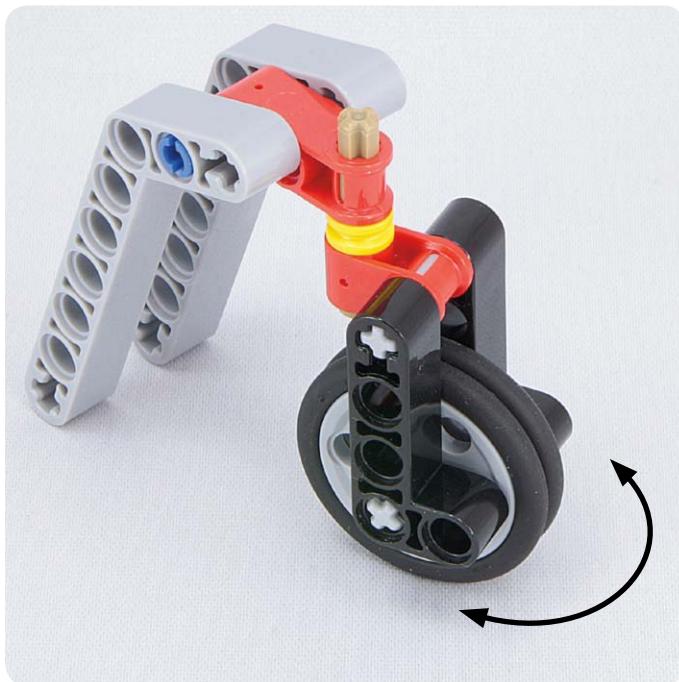
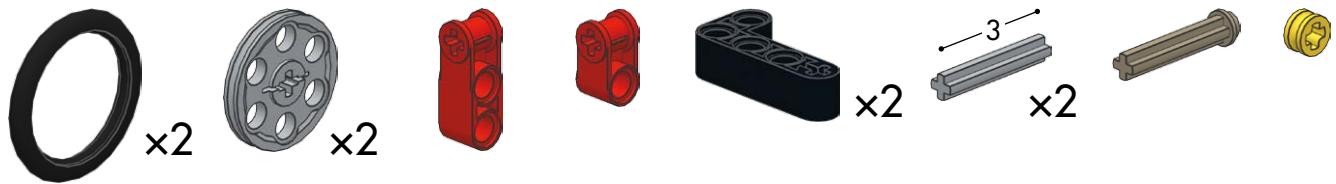
#111



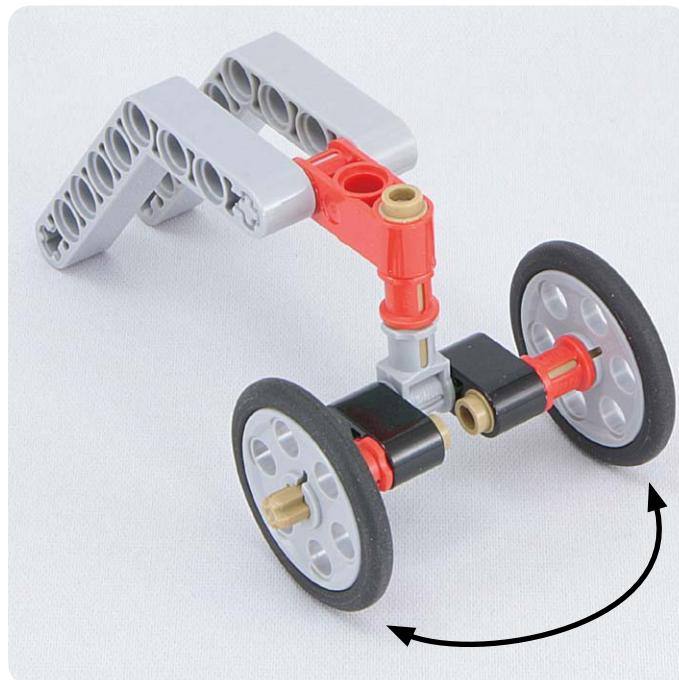
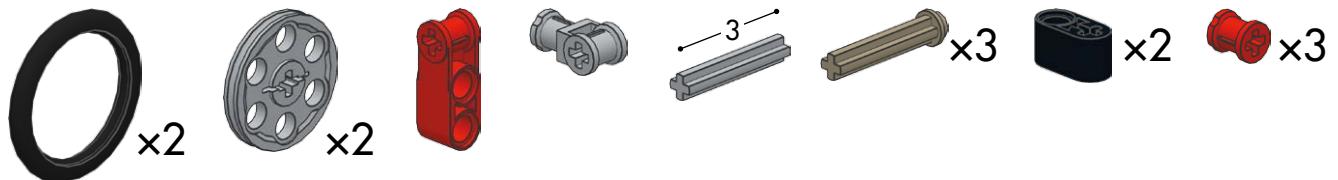
#112

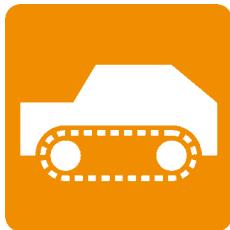


#113



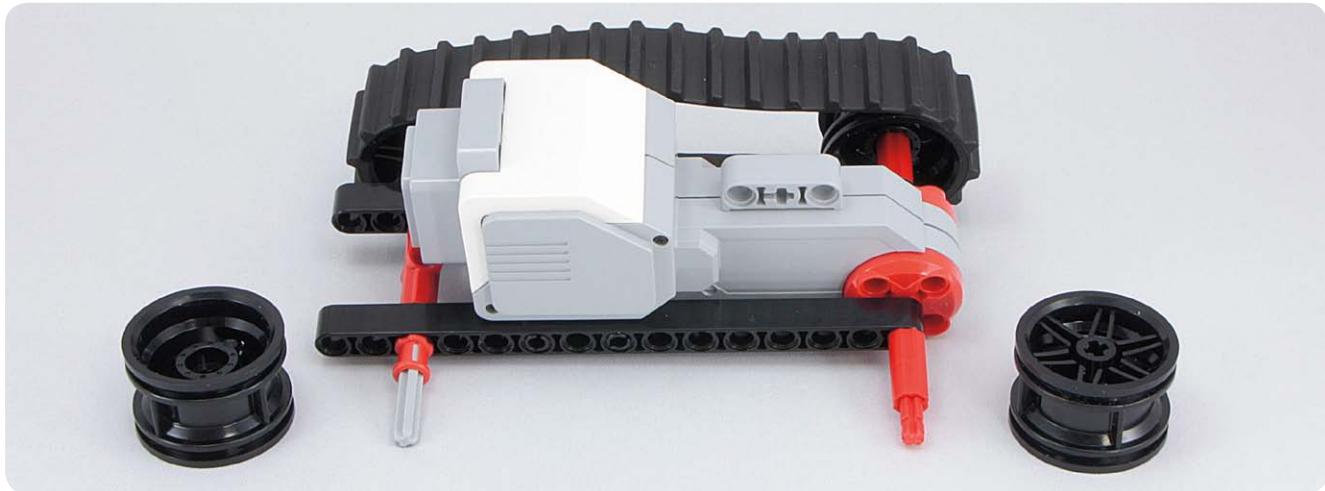
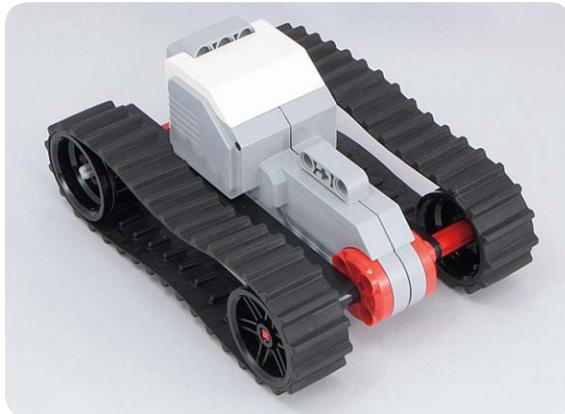
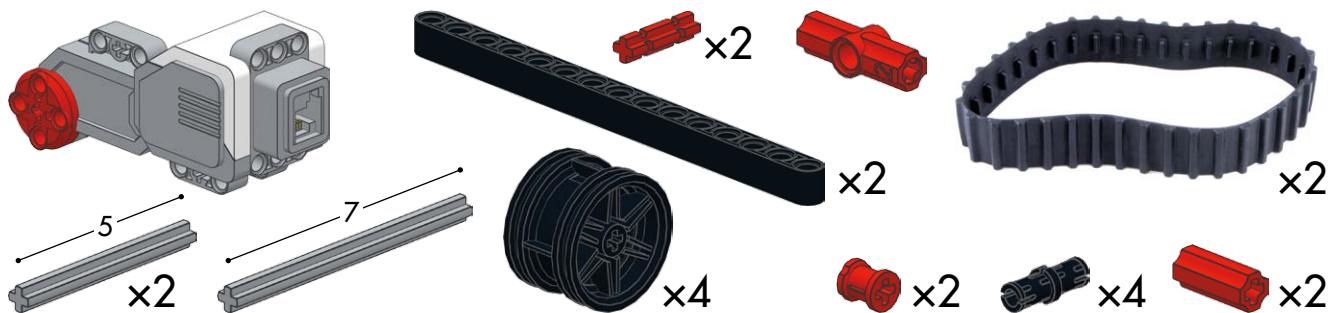
#114



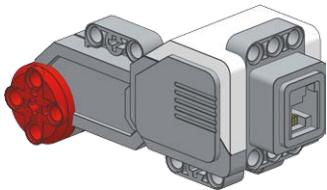


Crawlers

#115



#116



x2



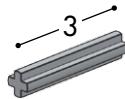
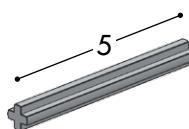
x2



x2



x2



x2



x8

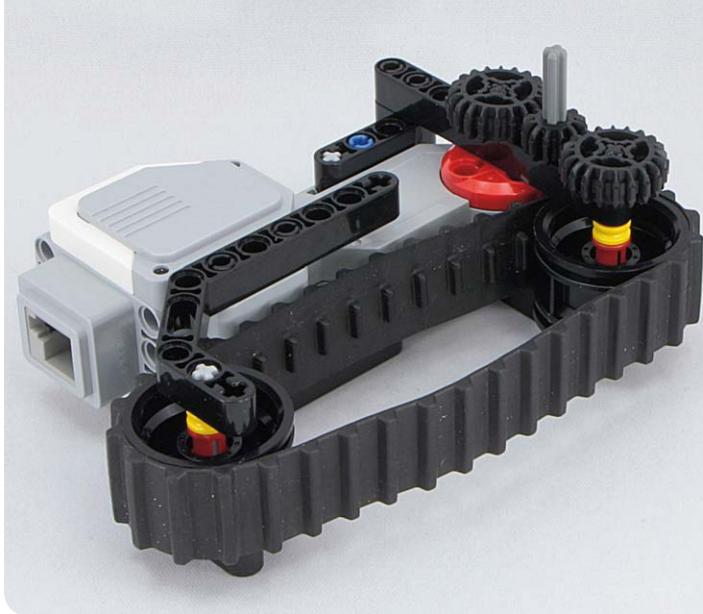


x2



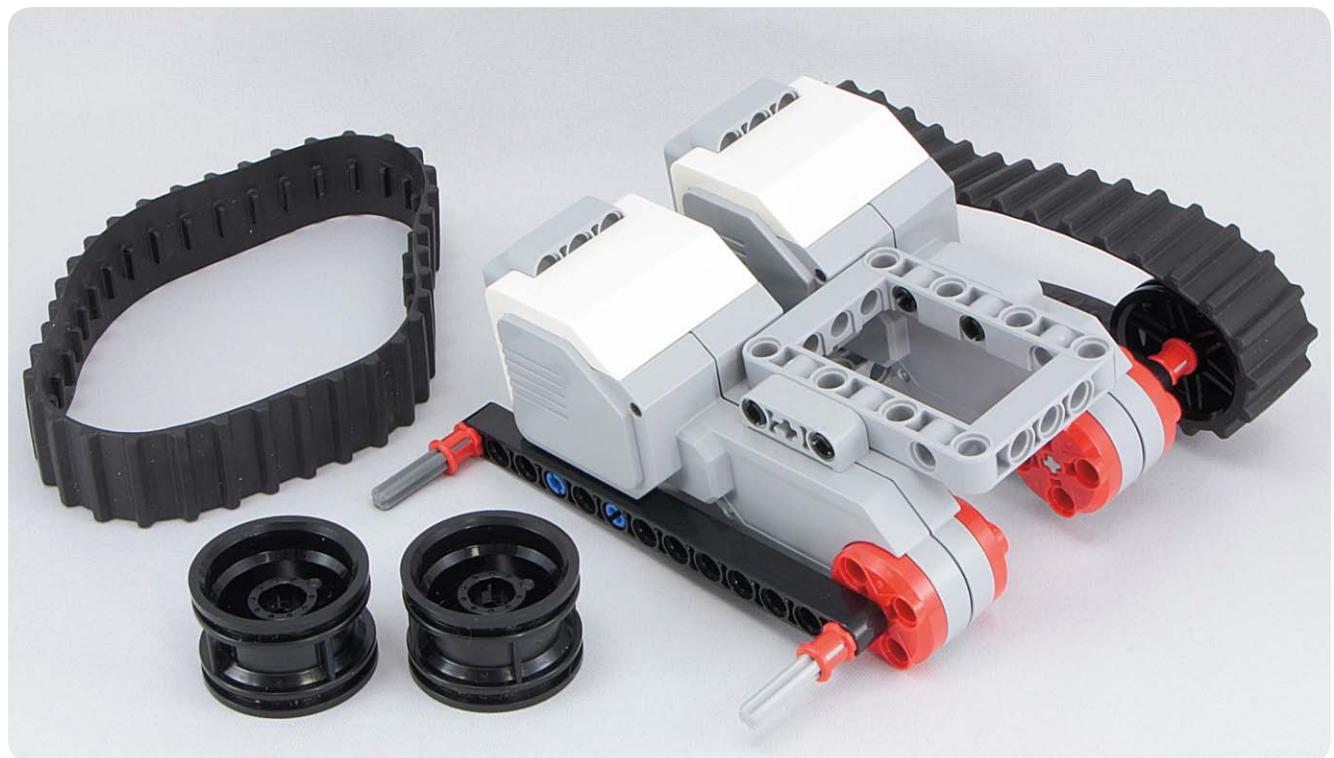
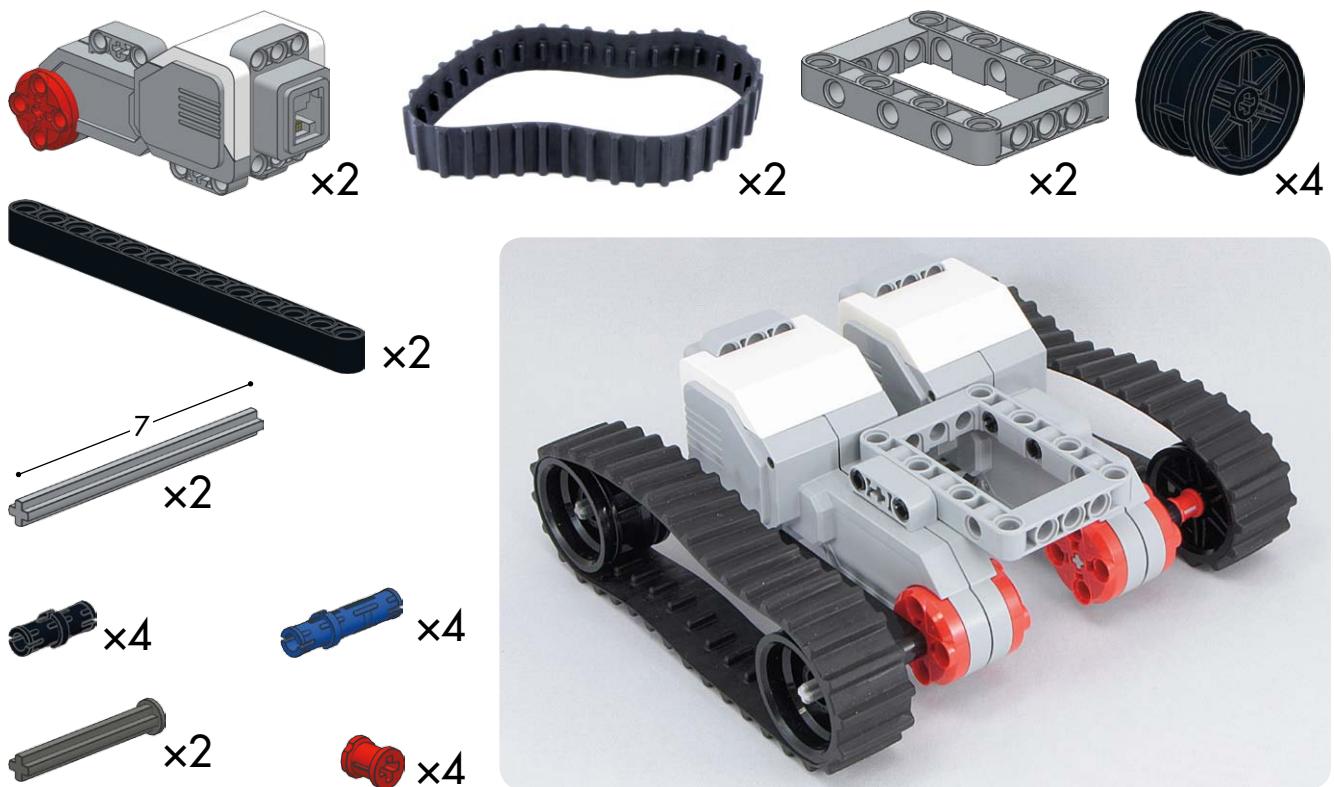
x4

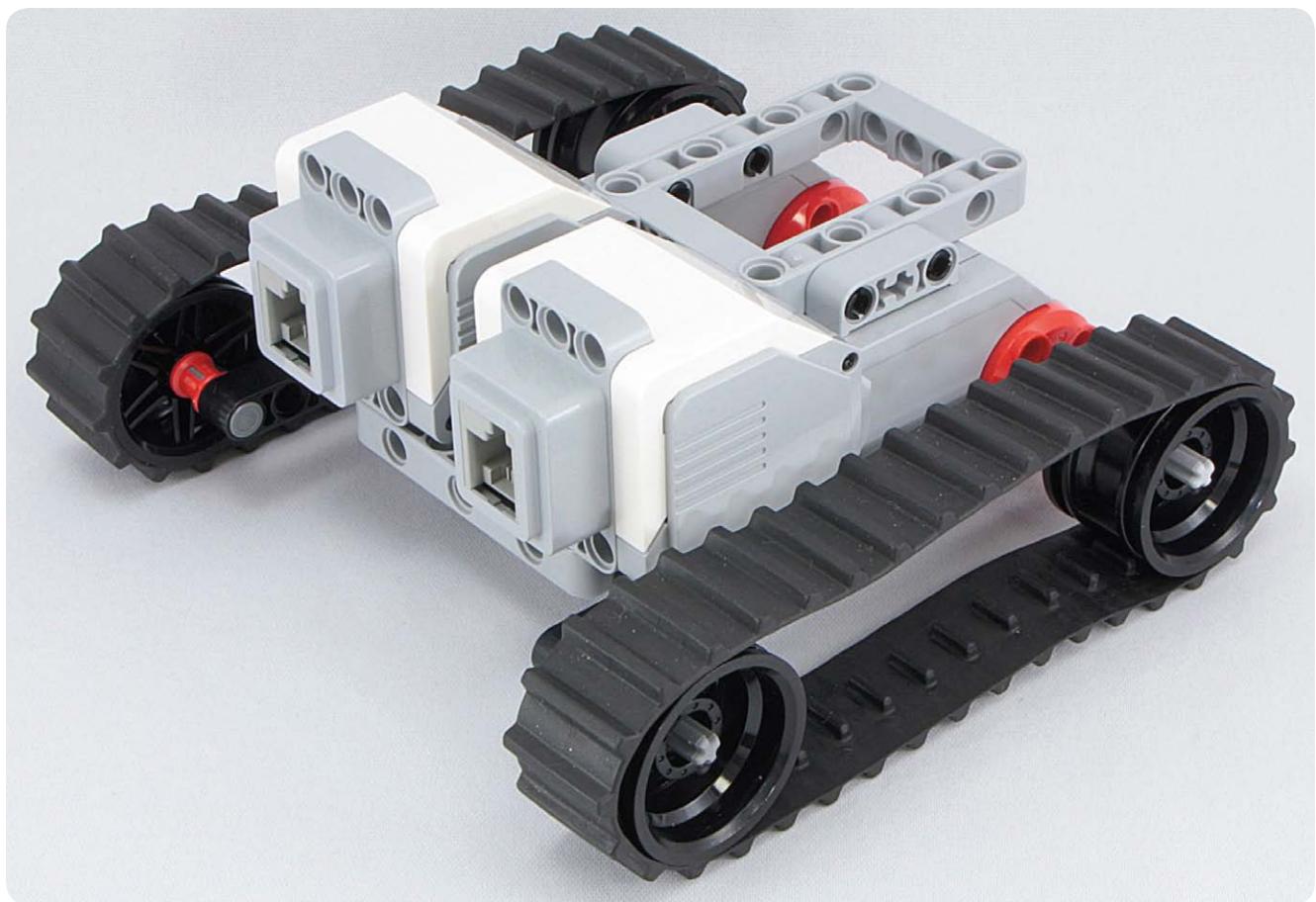
$$20:12:20 = 5:3:5$$



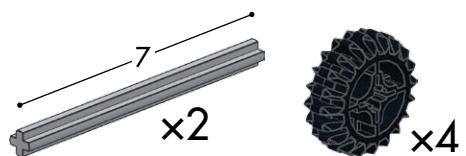
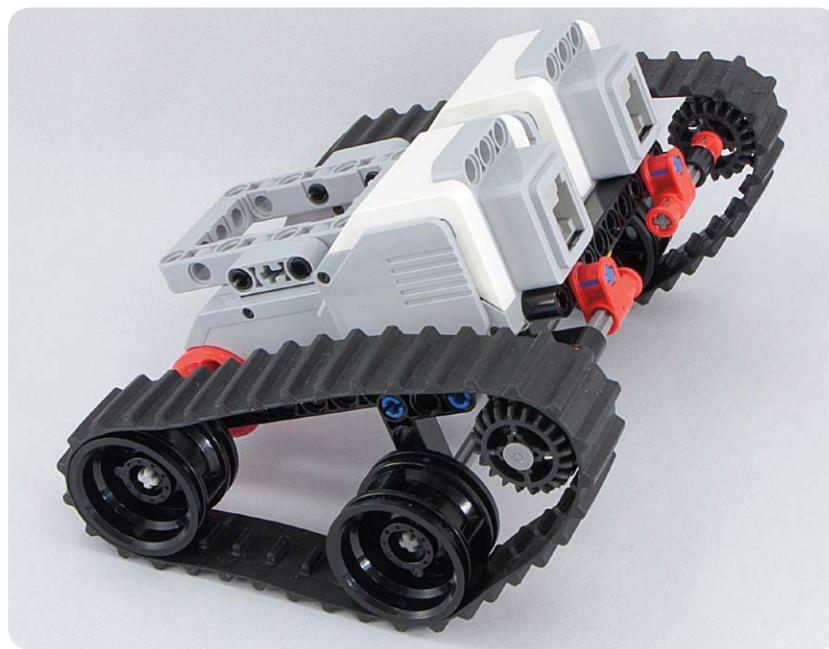
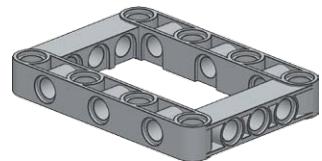
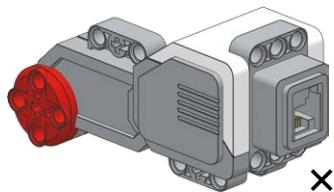
95

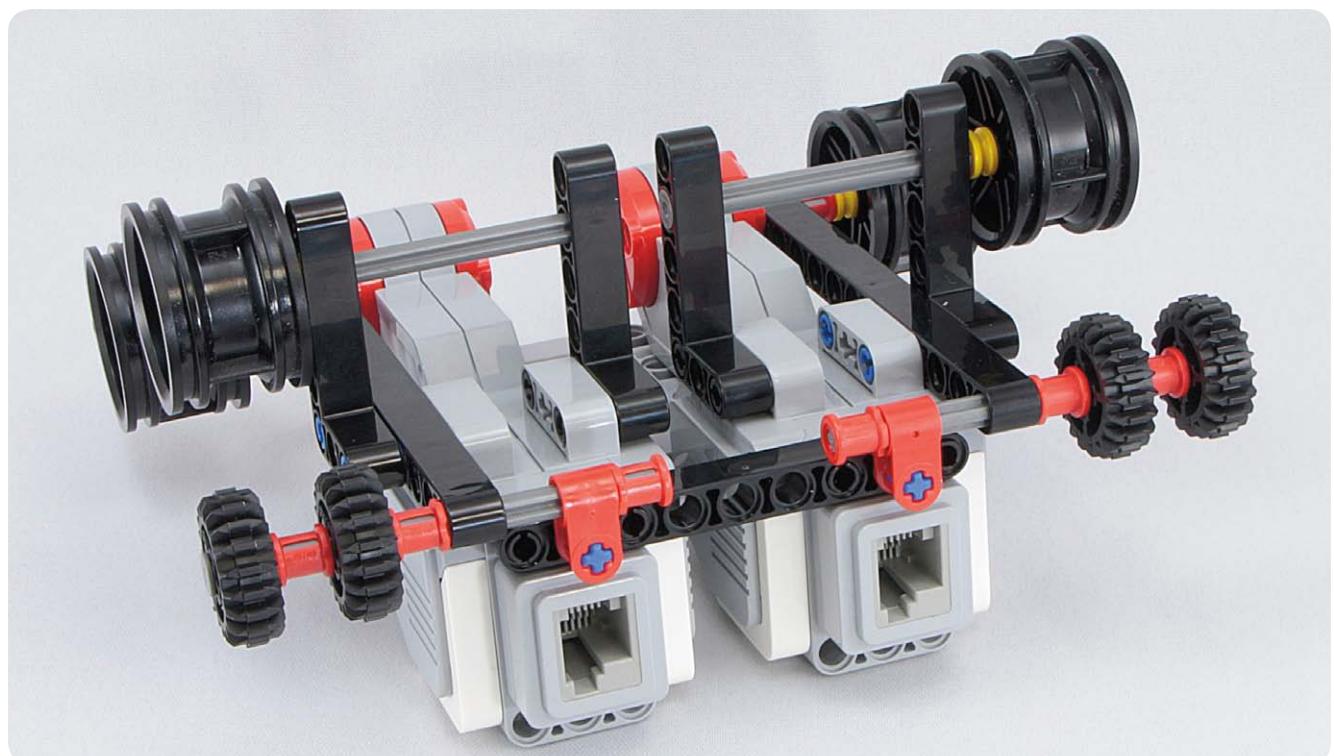
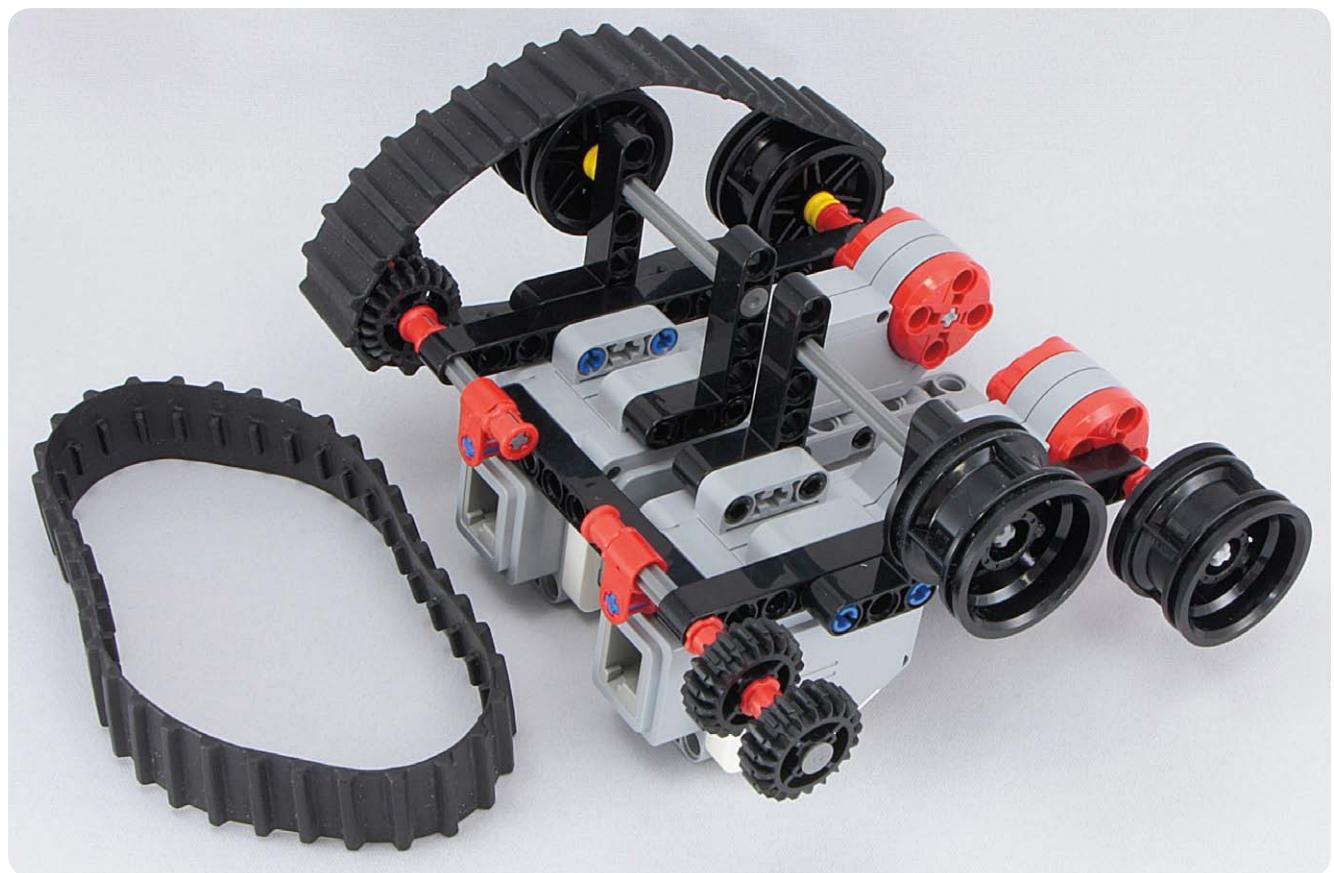
#117

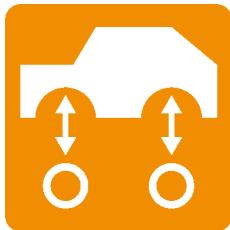




#118

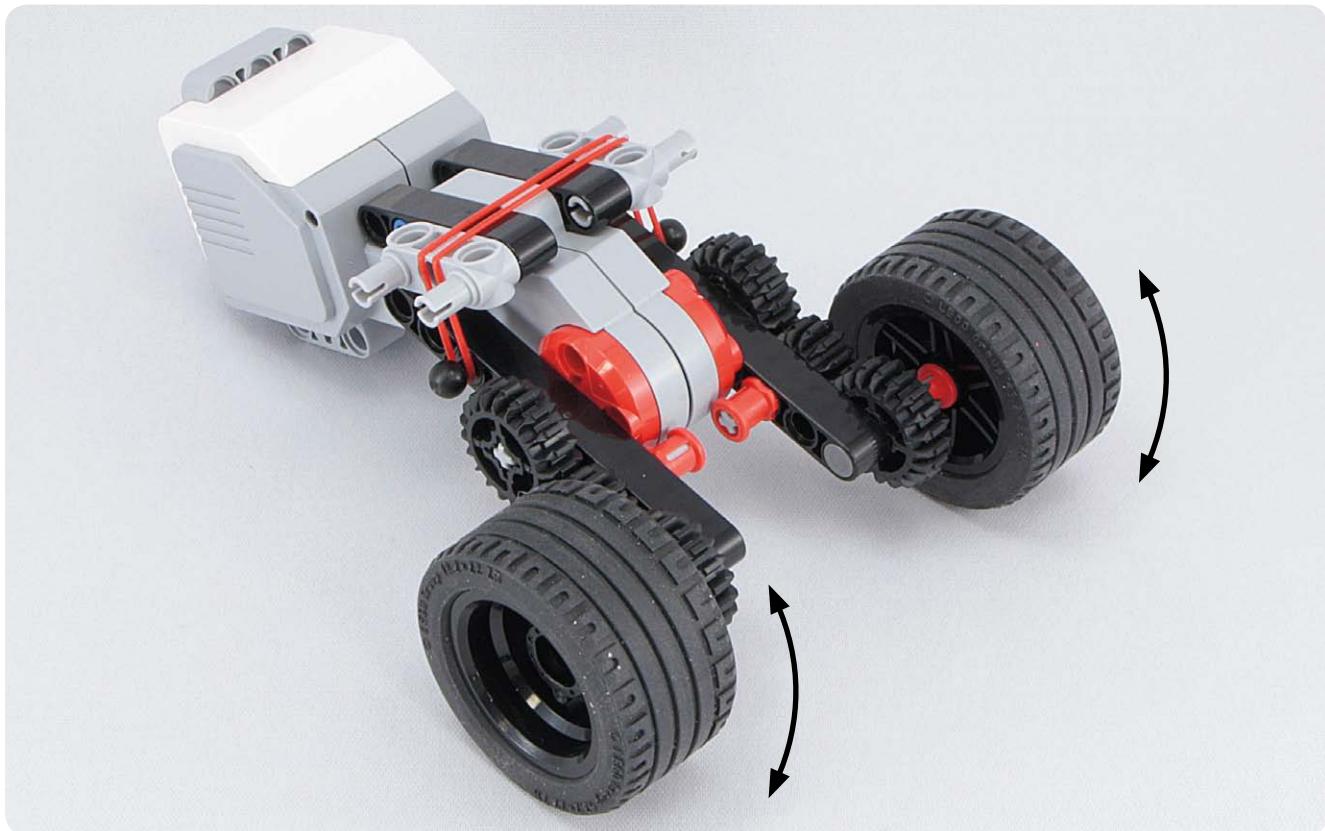


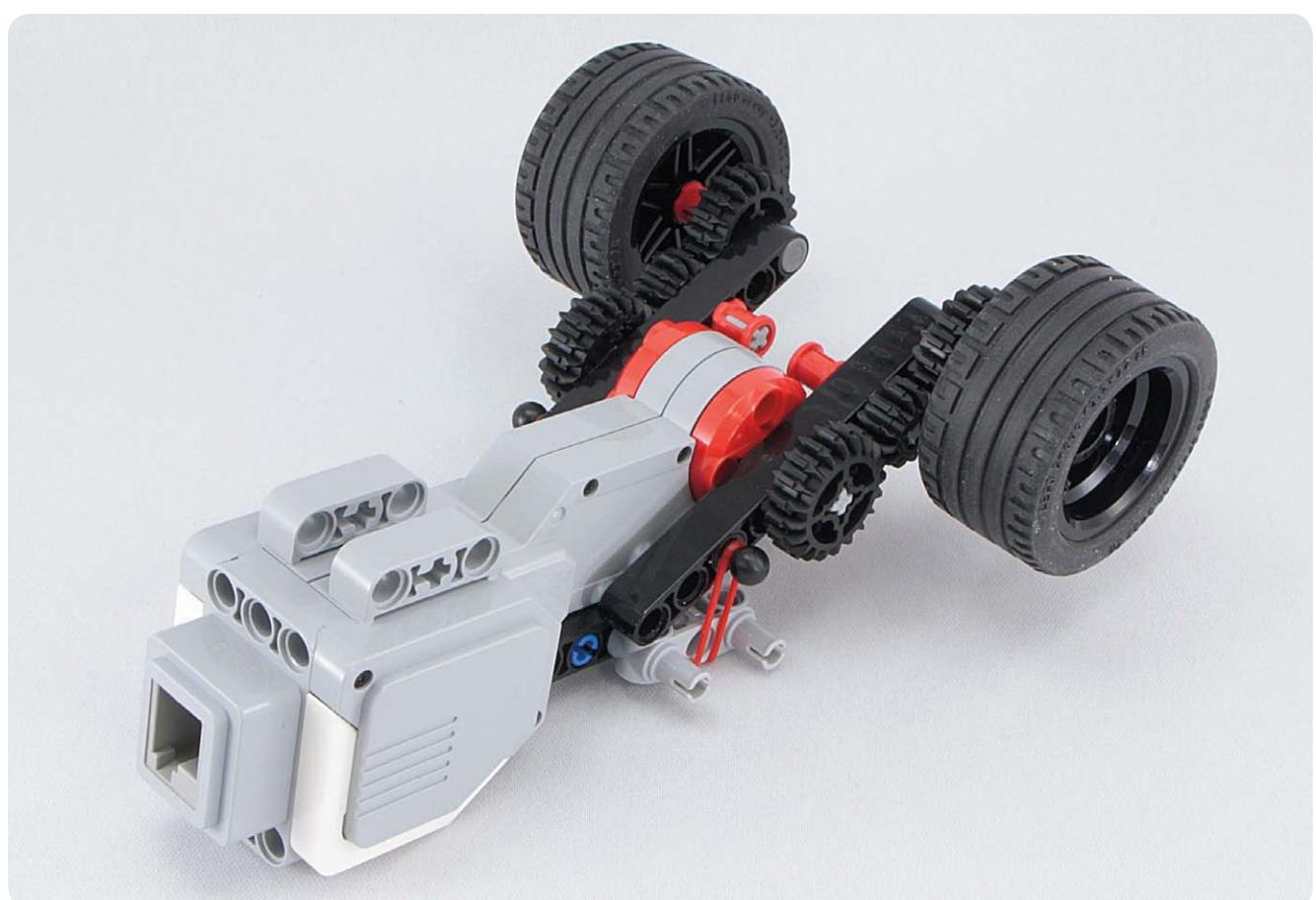
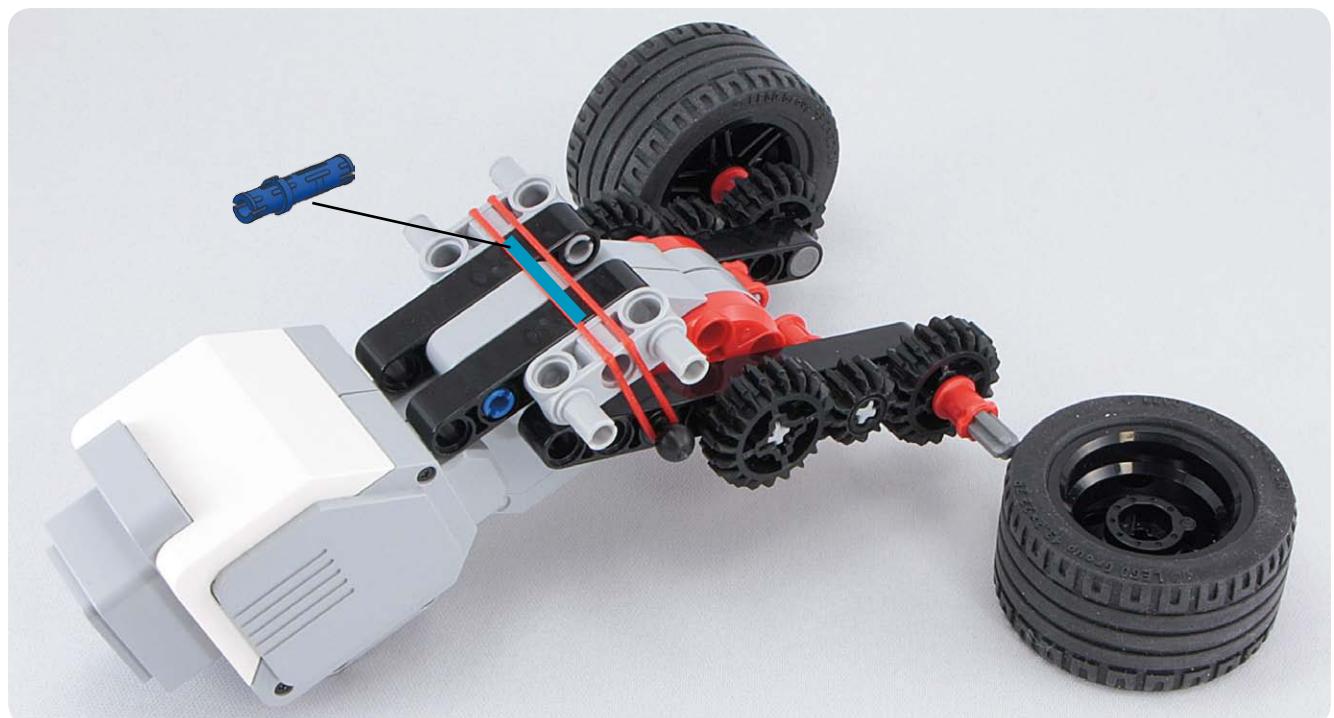




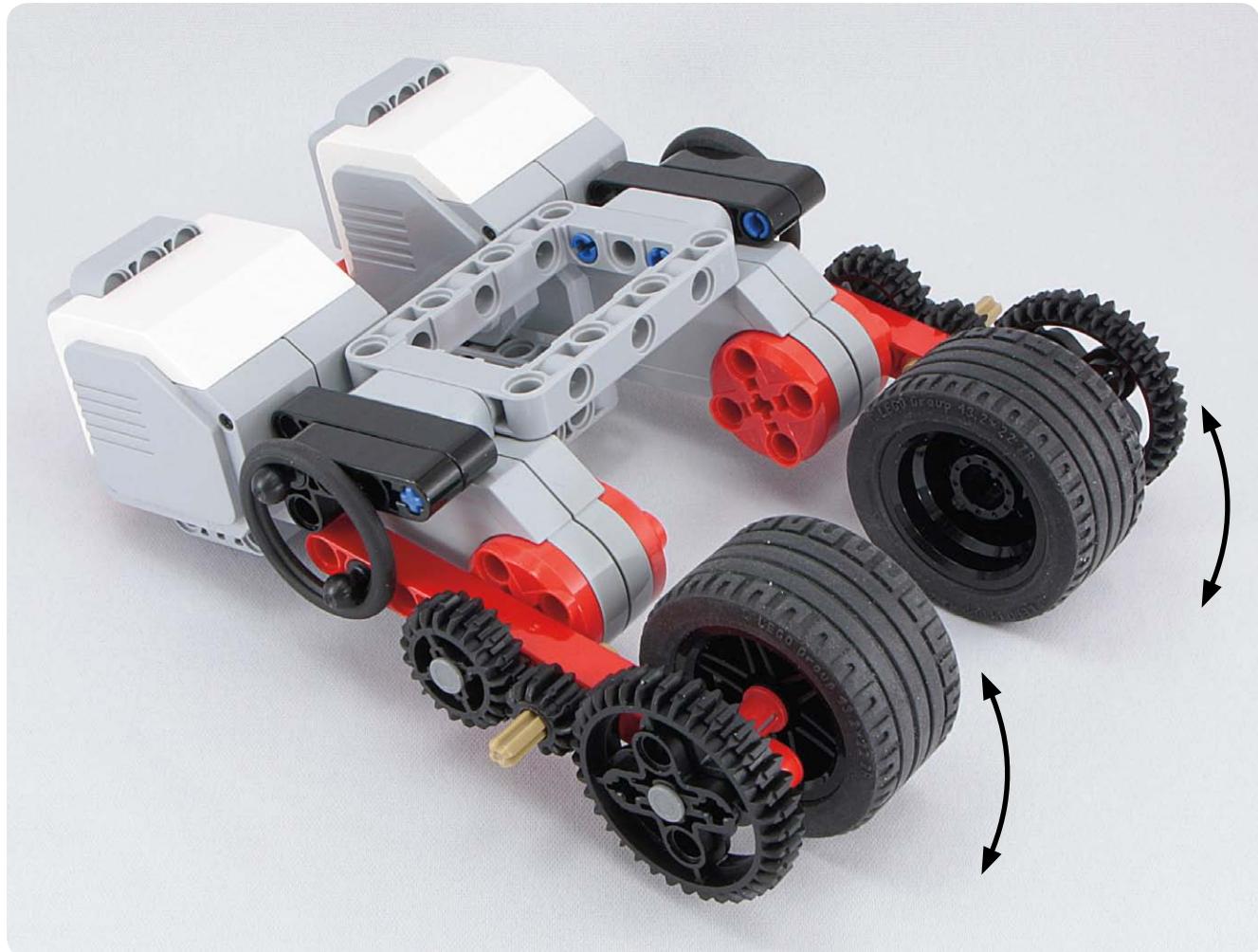
Suspended wheels

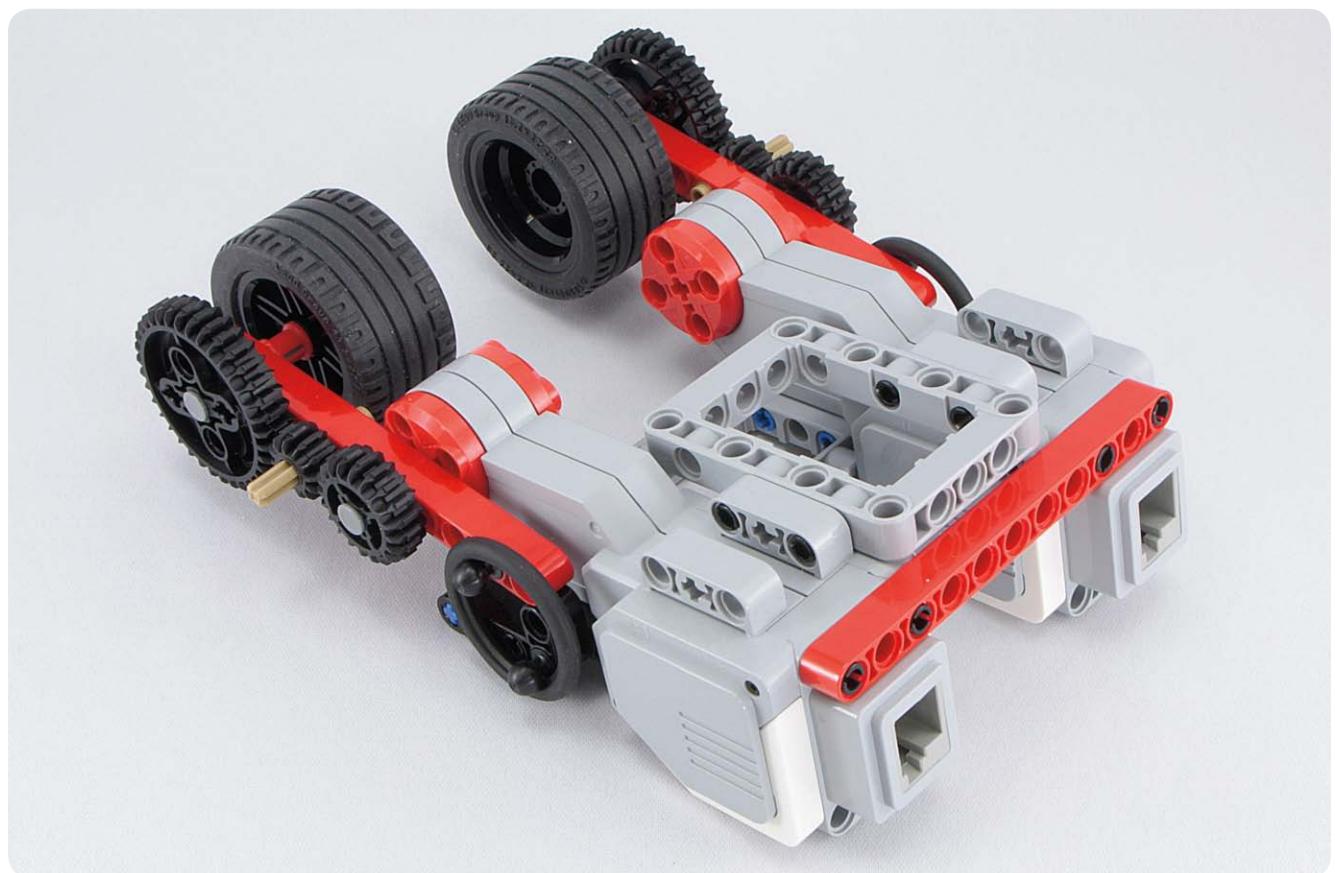
#119

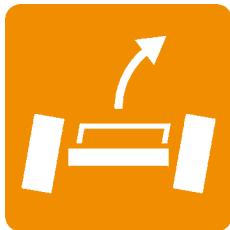




#120

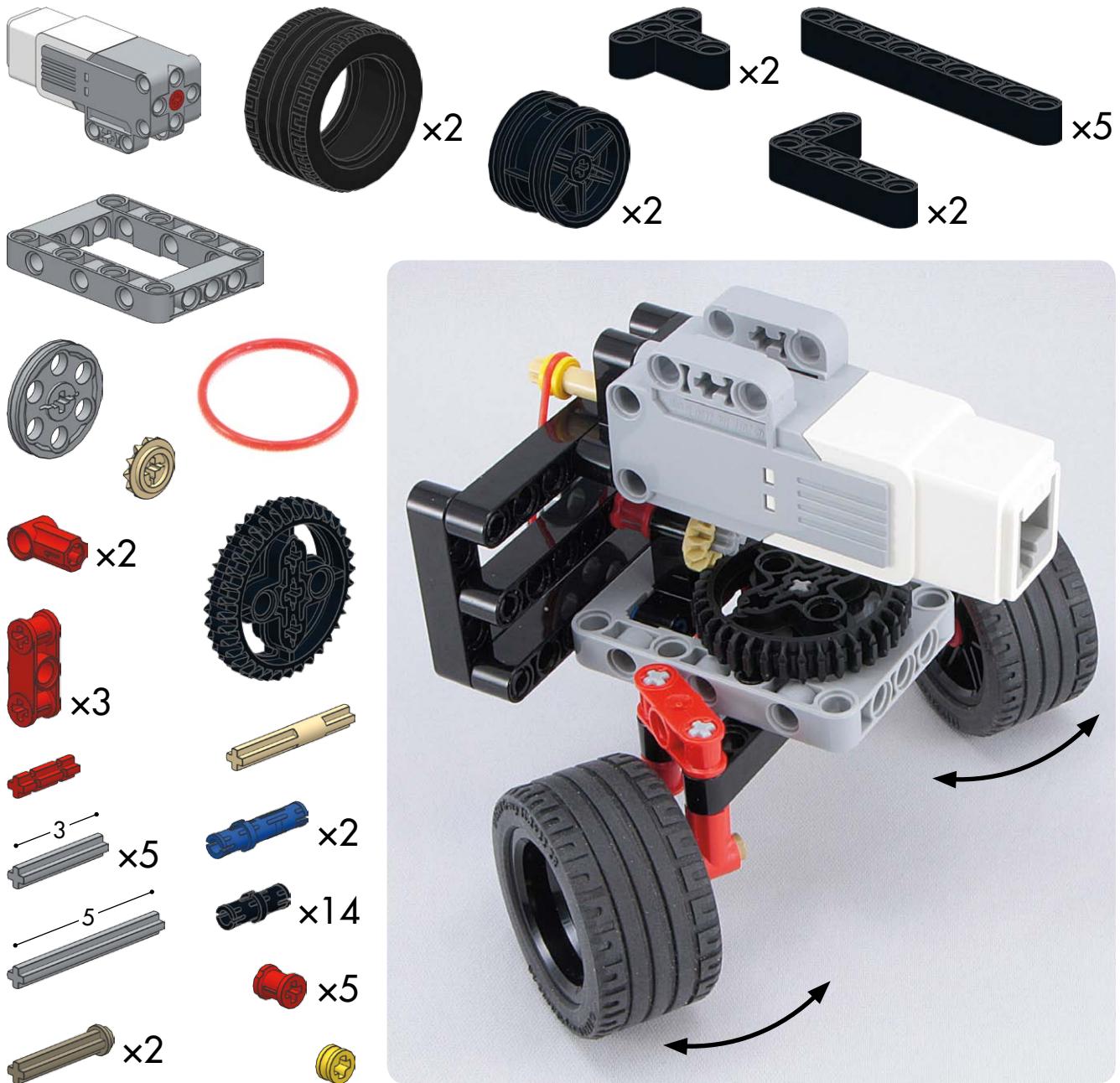


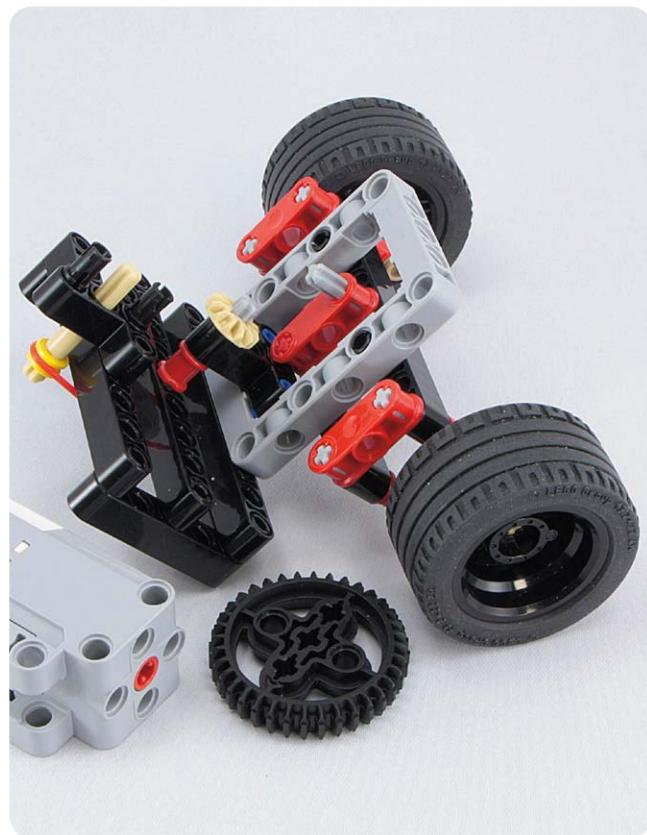
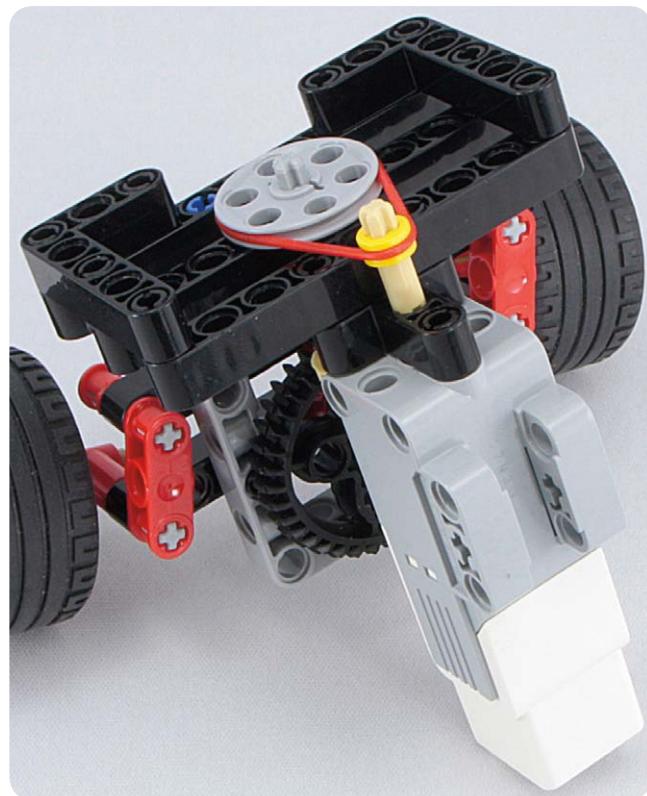
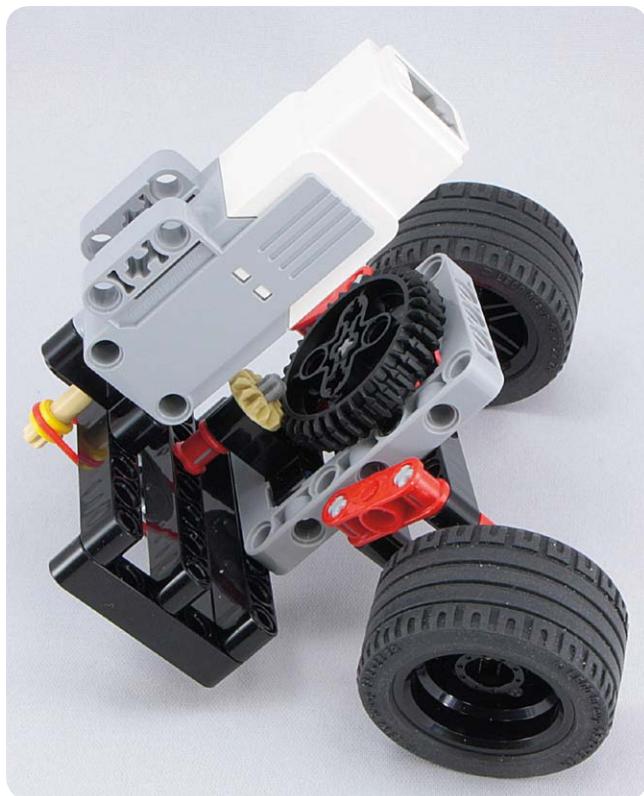




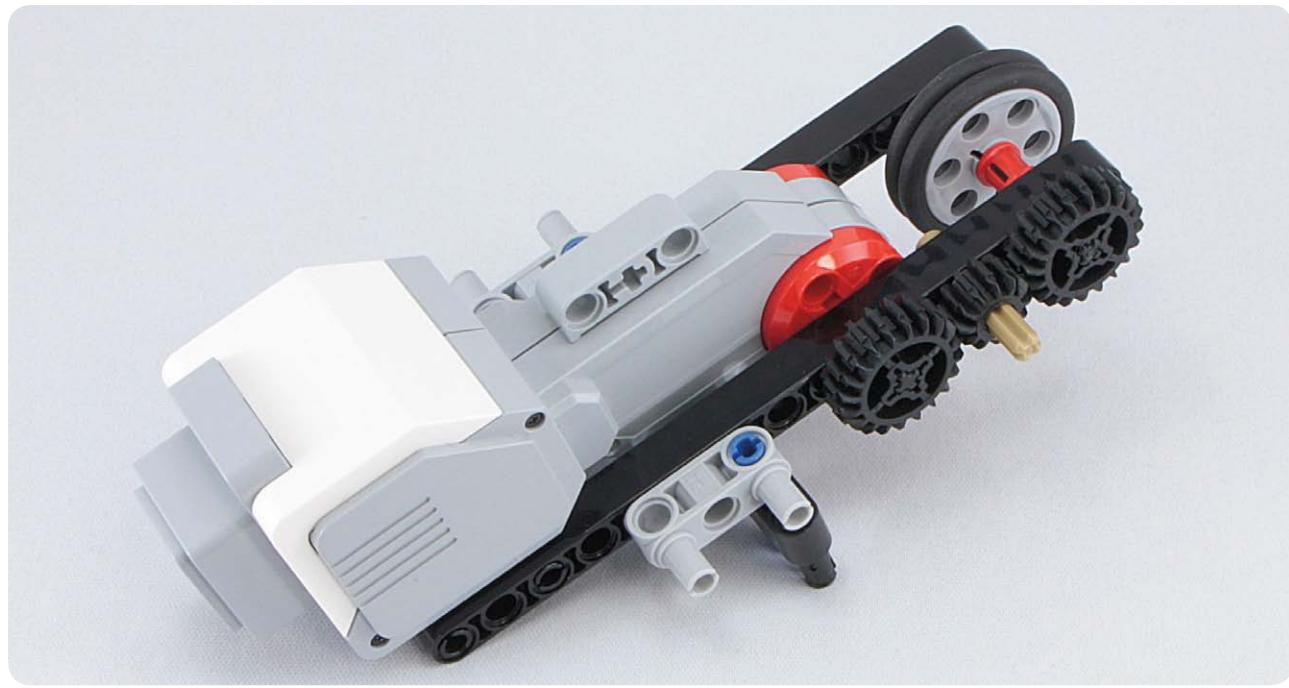
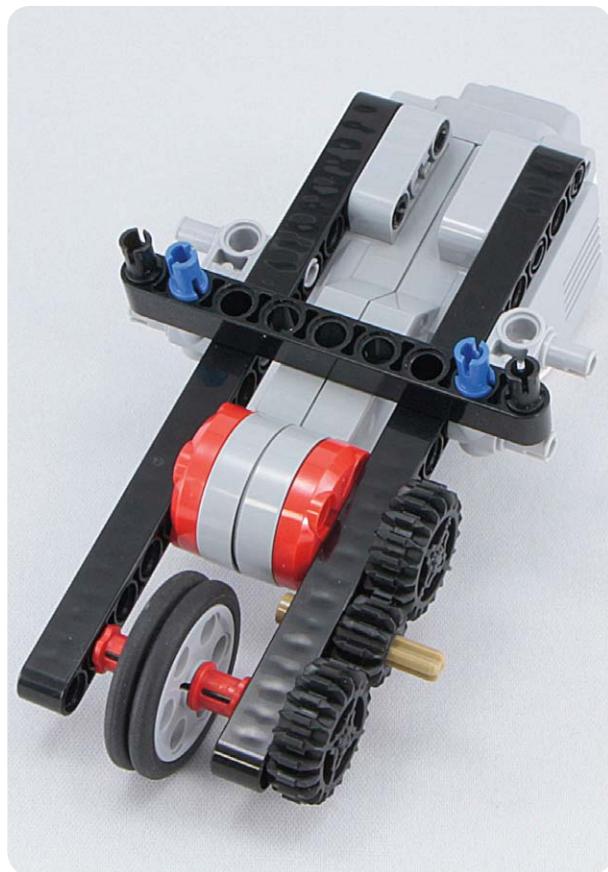
Steering

#121











PART 3



Moving Without Tires



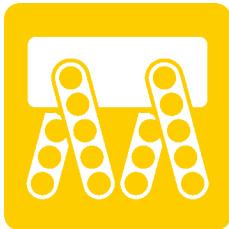
110



122

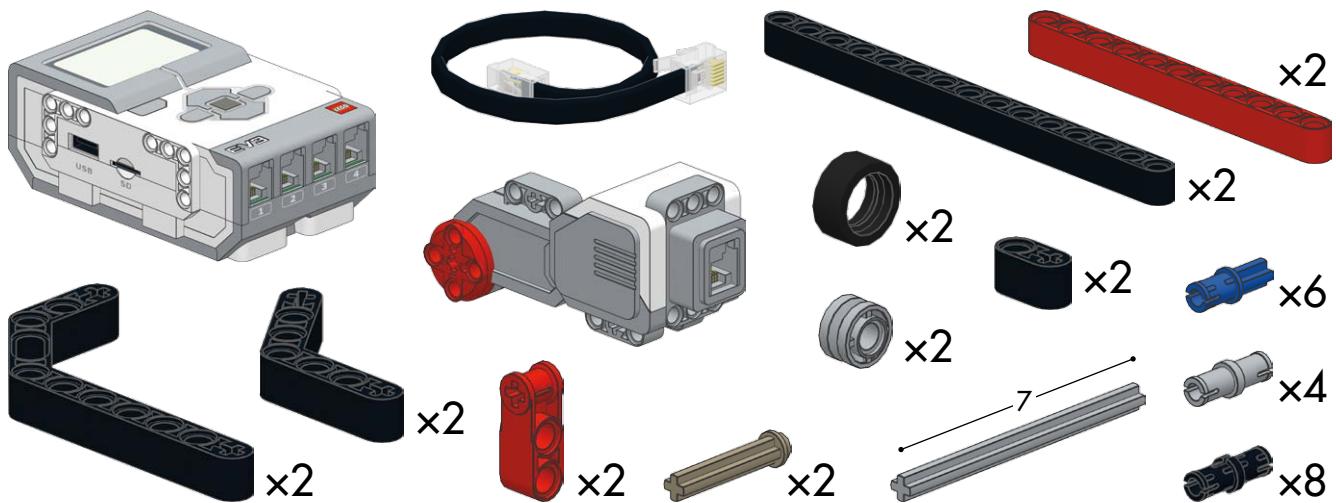


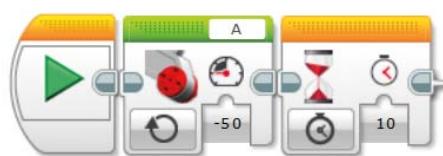
126



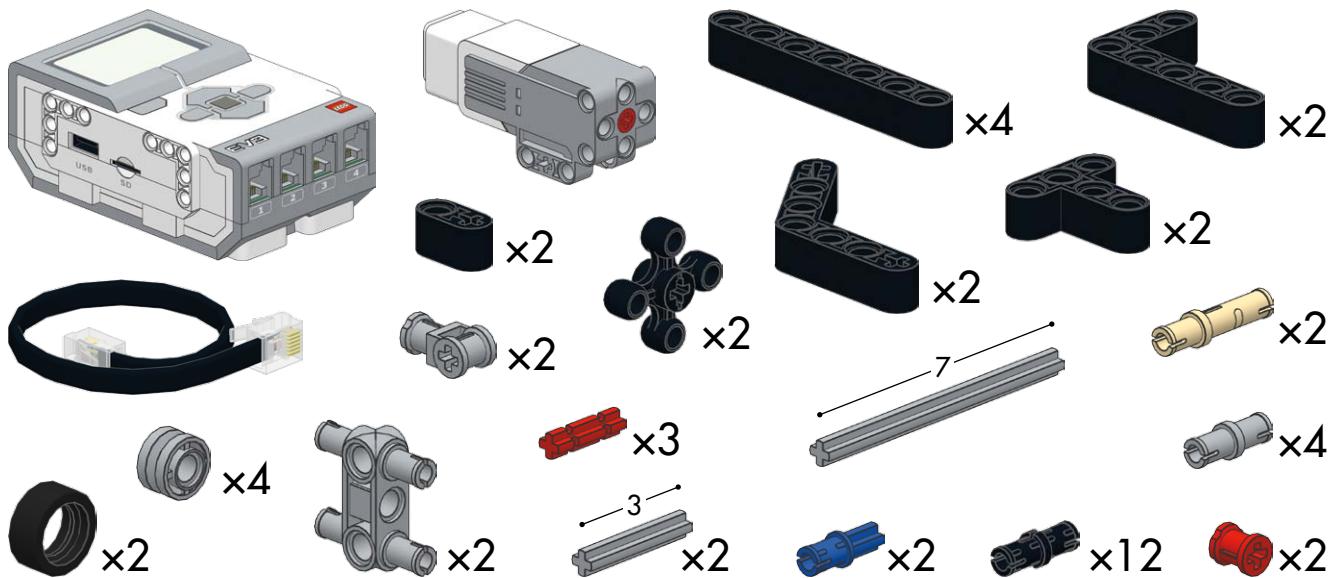
Walking machines

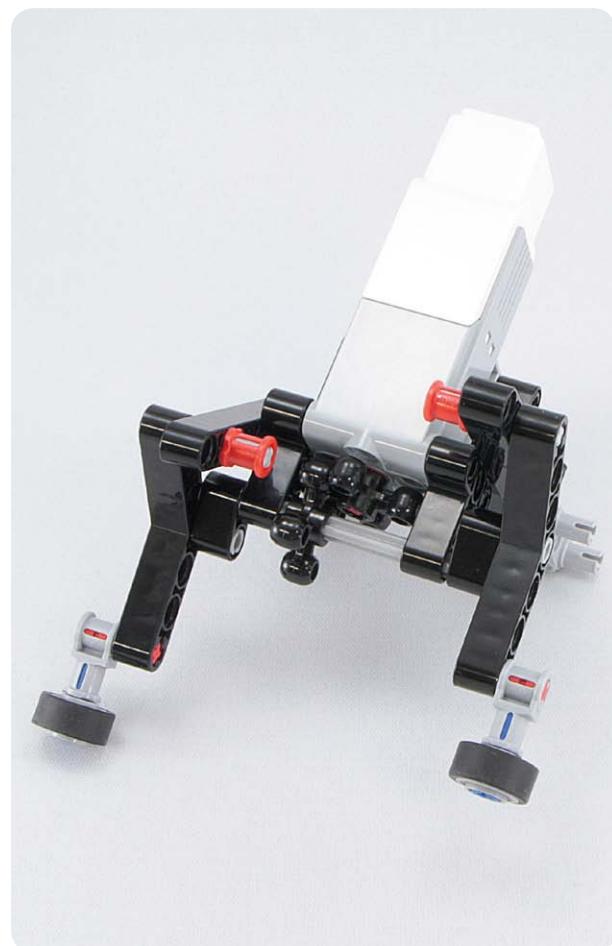
#122



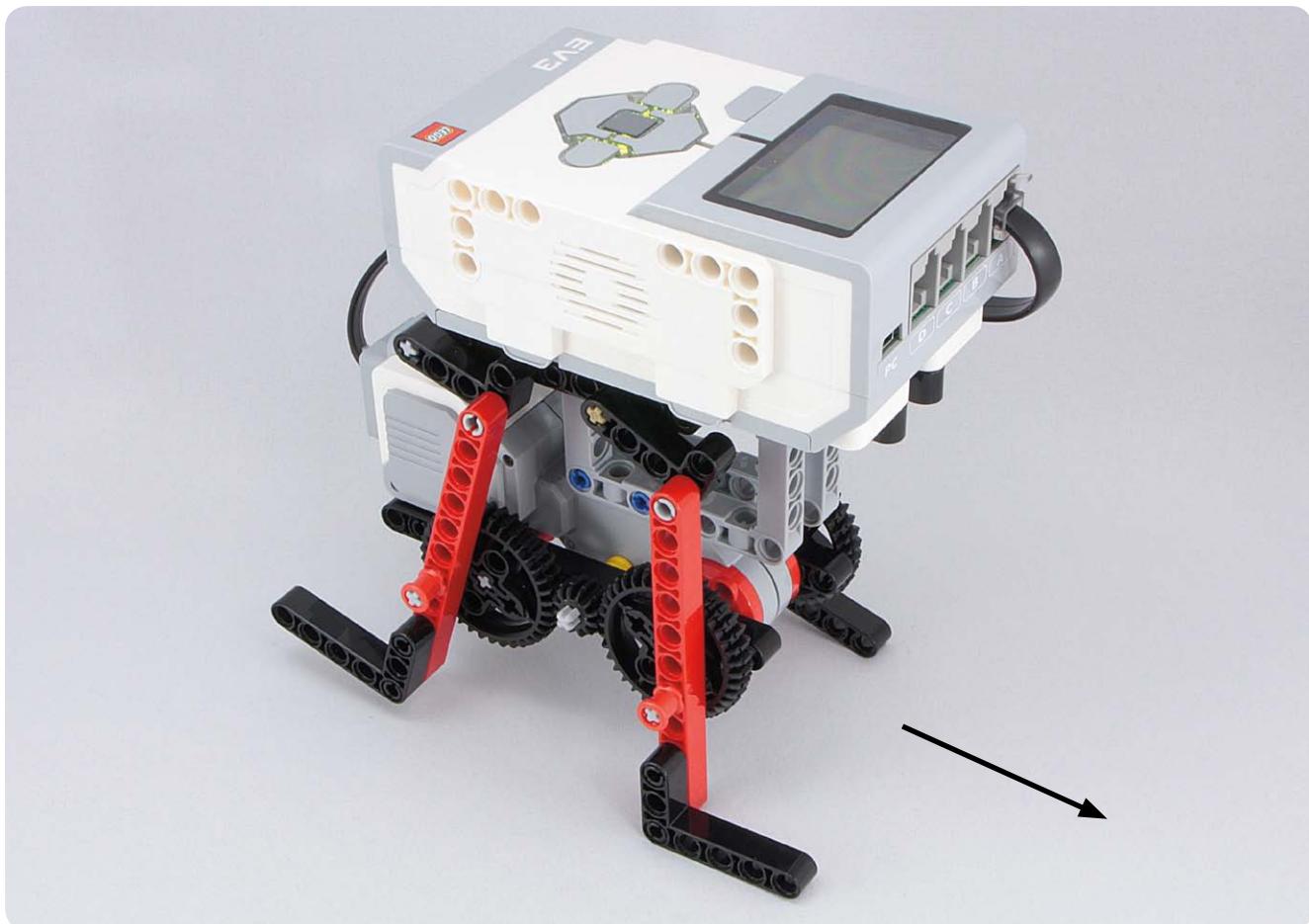
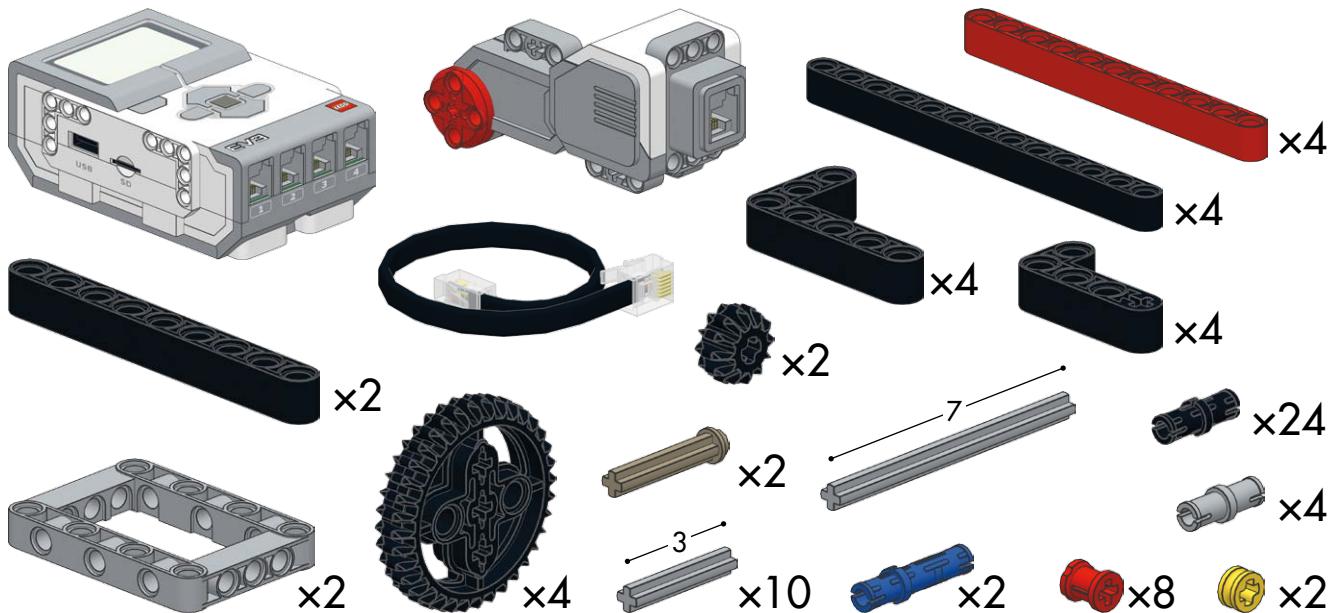


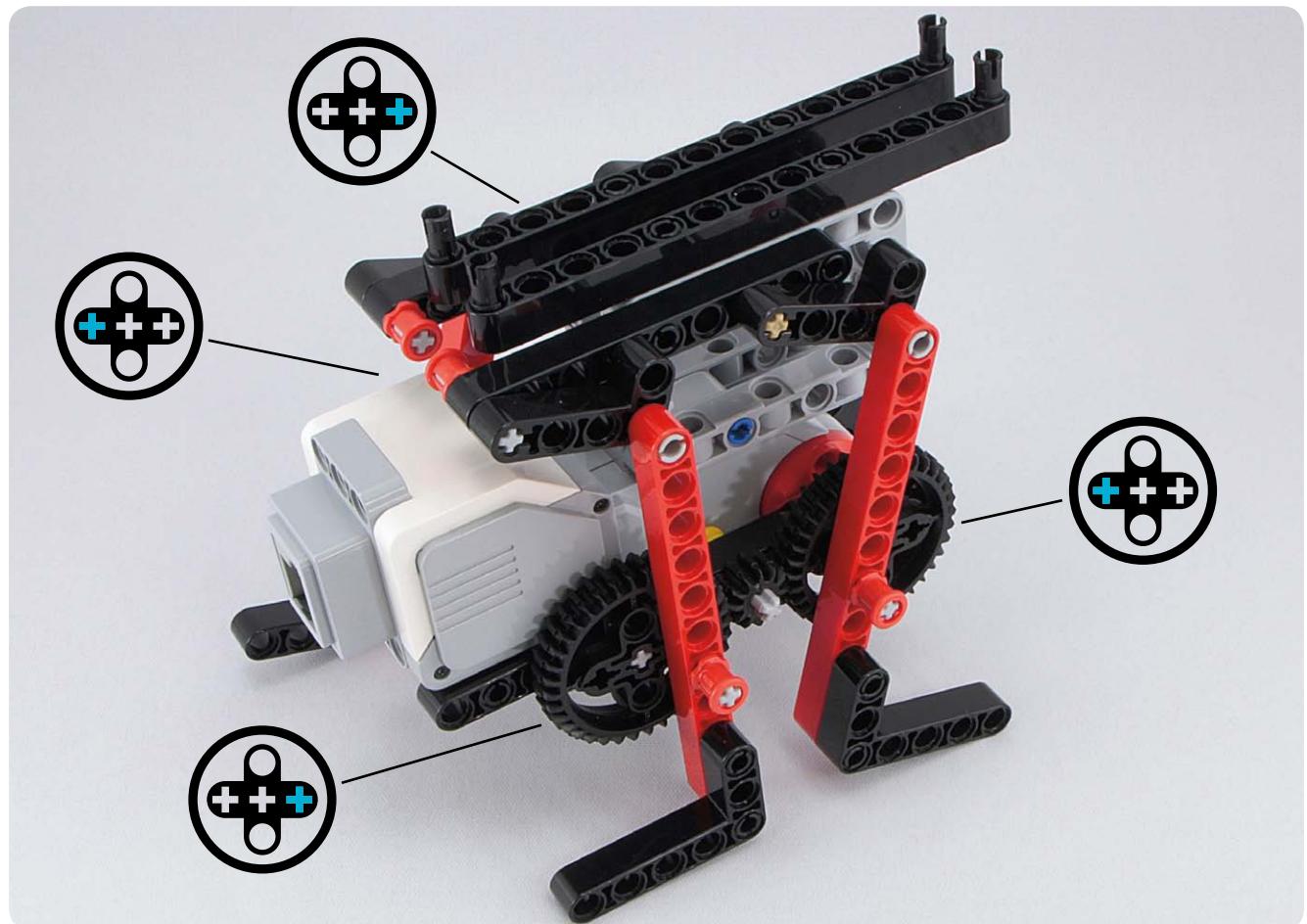
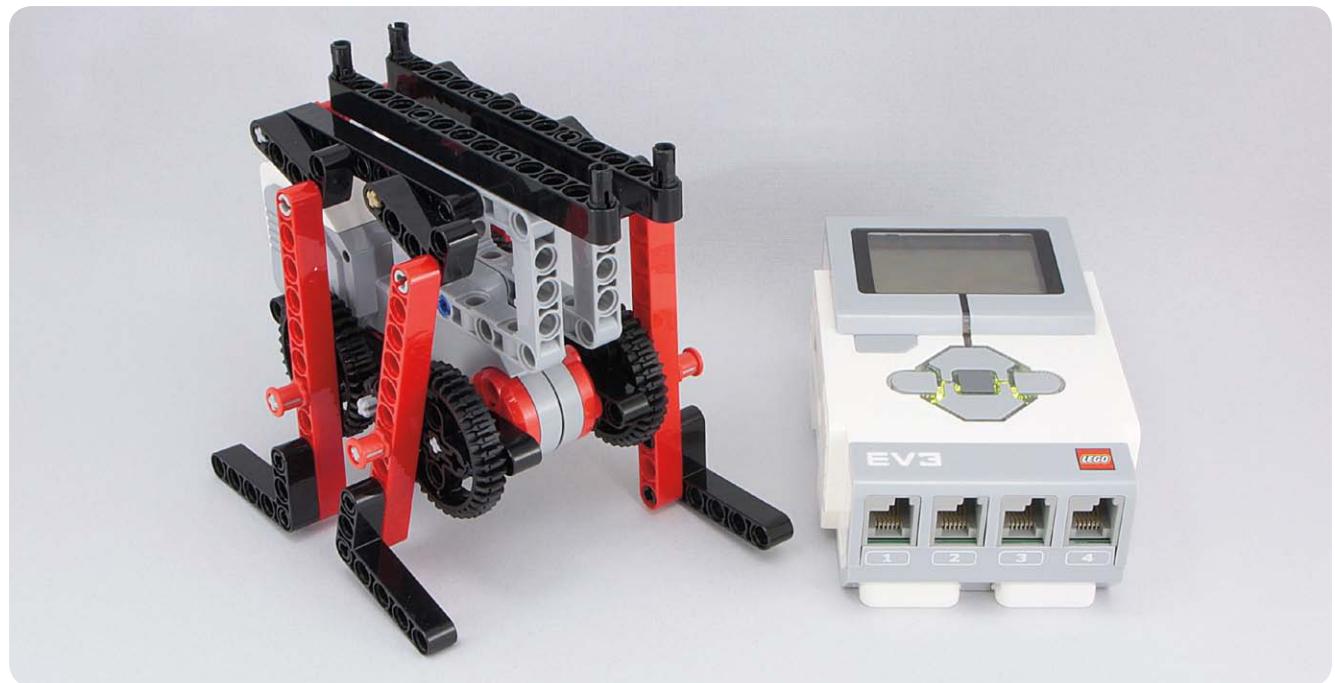
#123

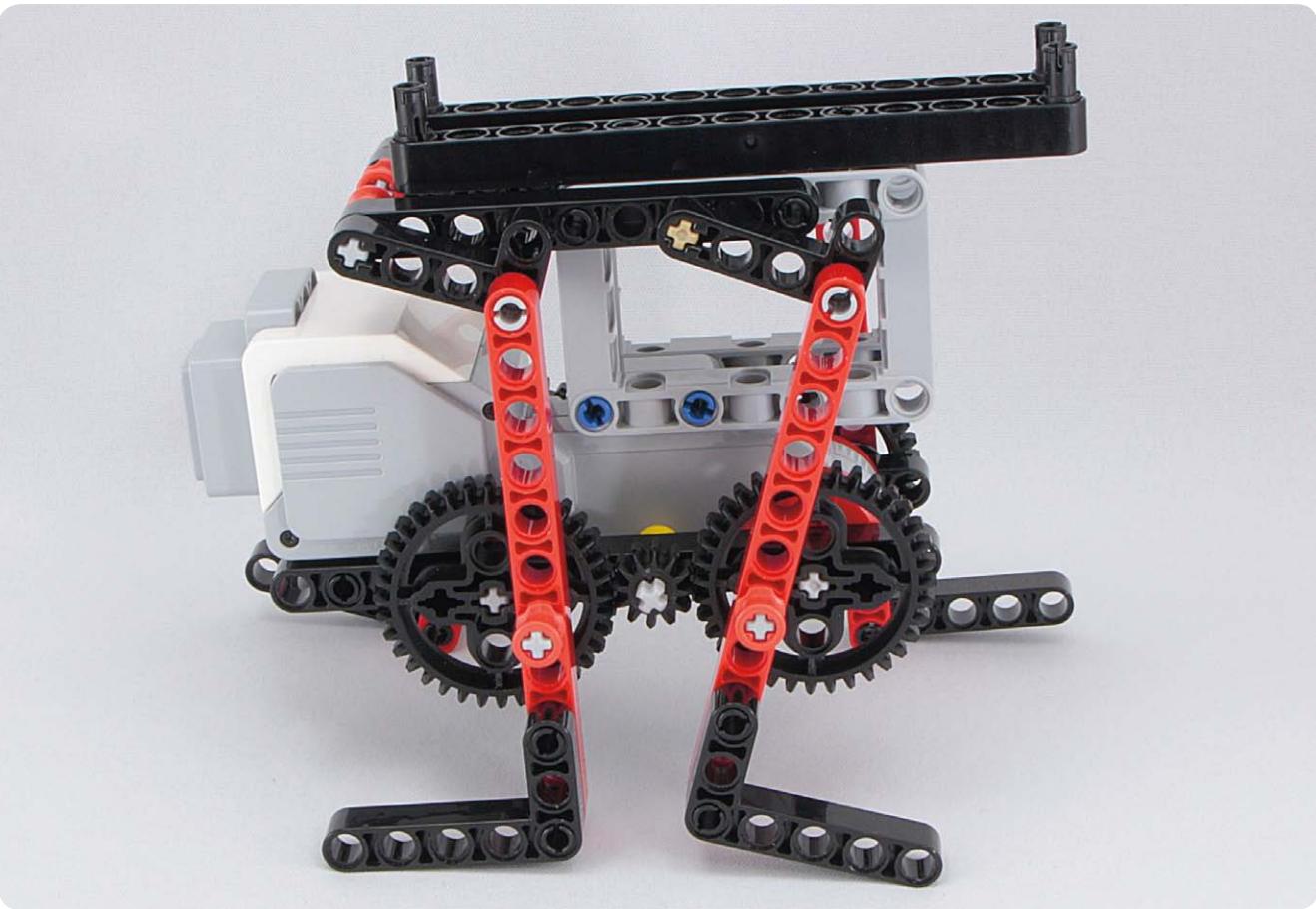




#124

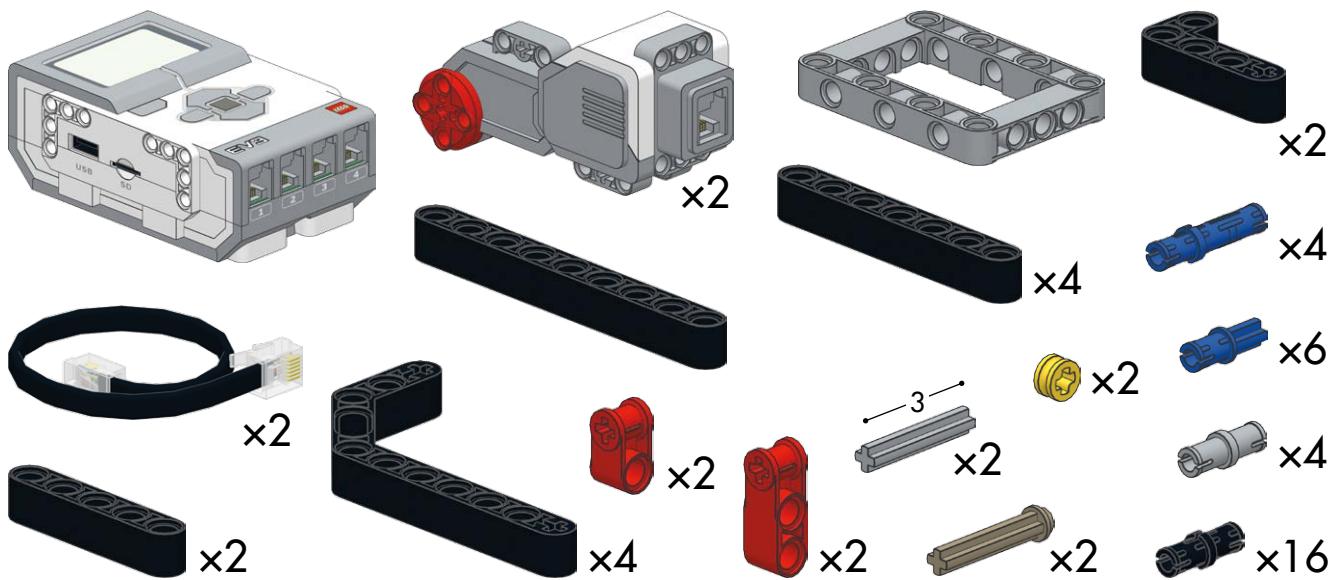


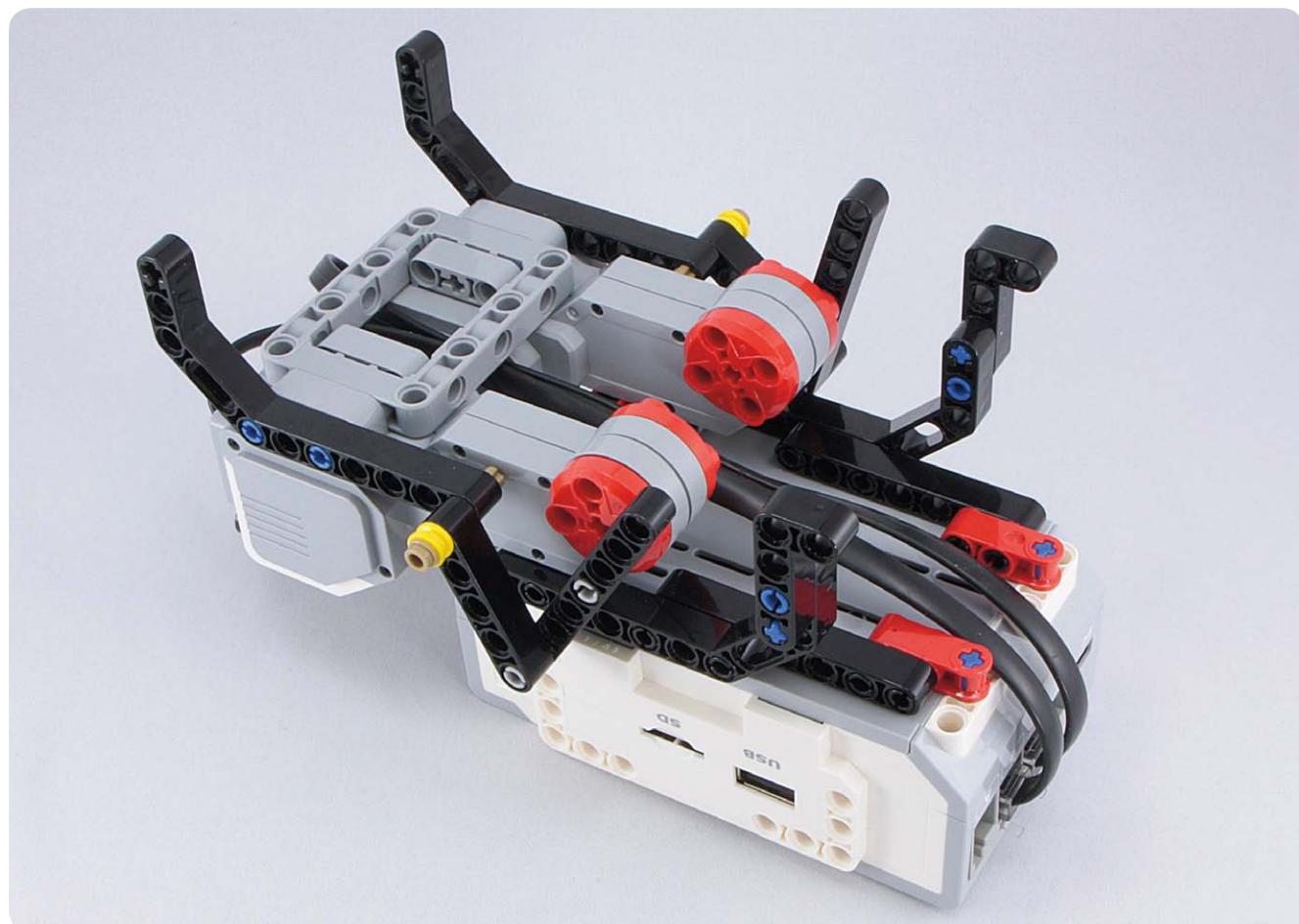




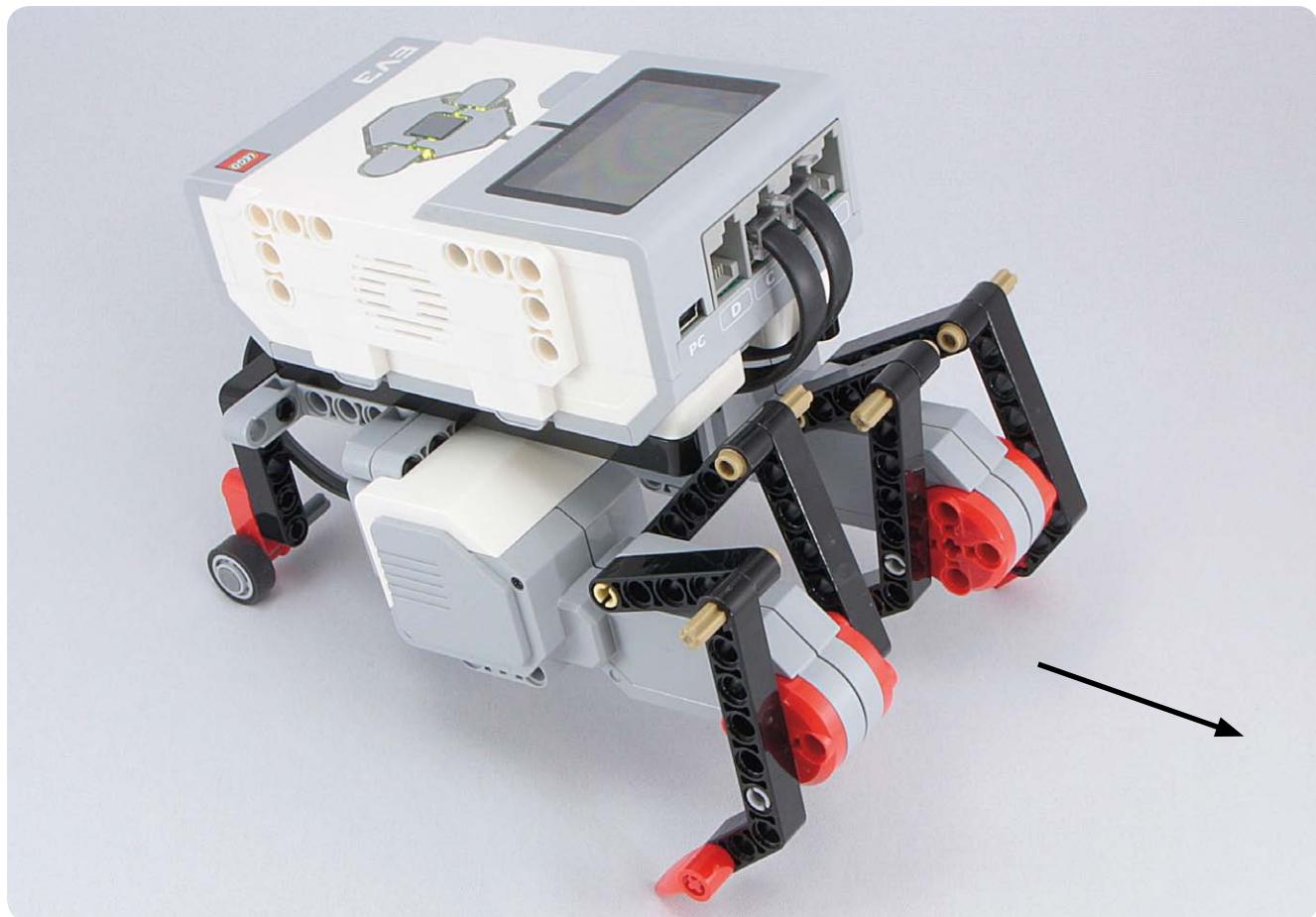
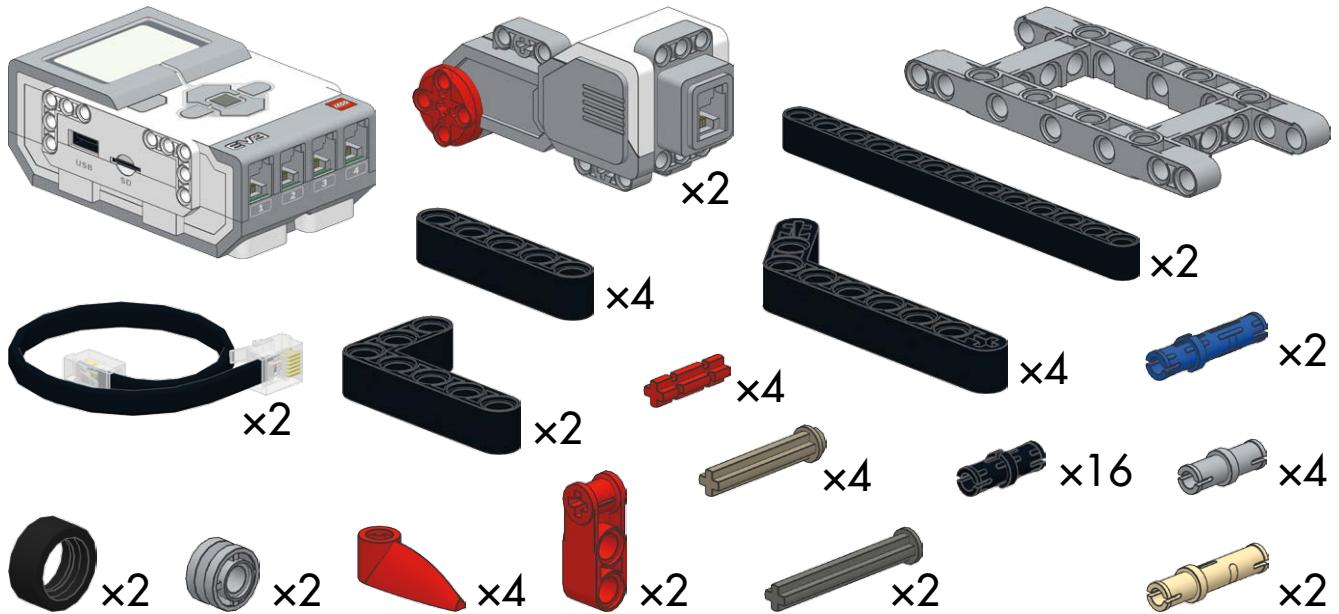


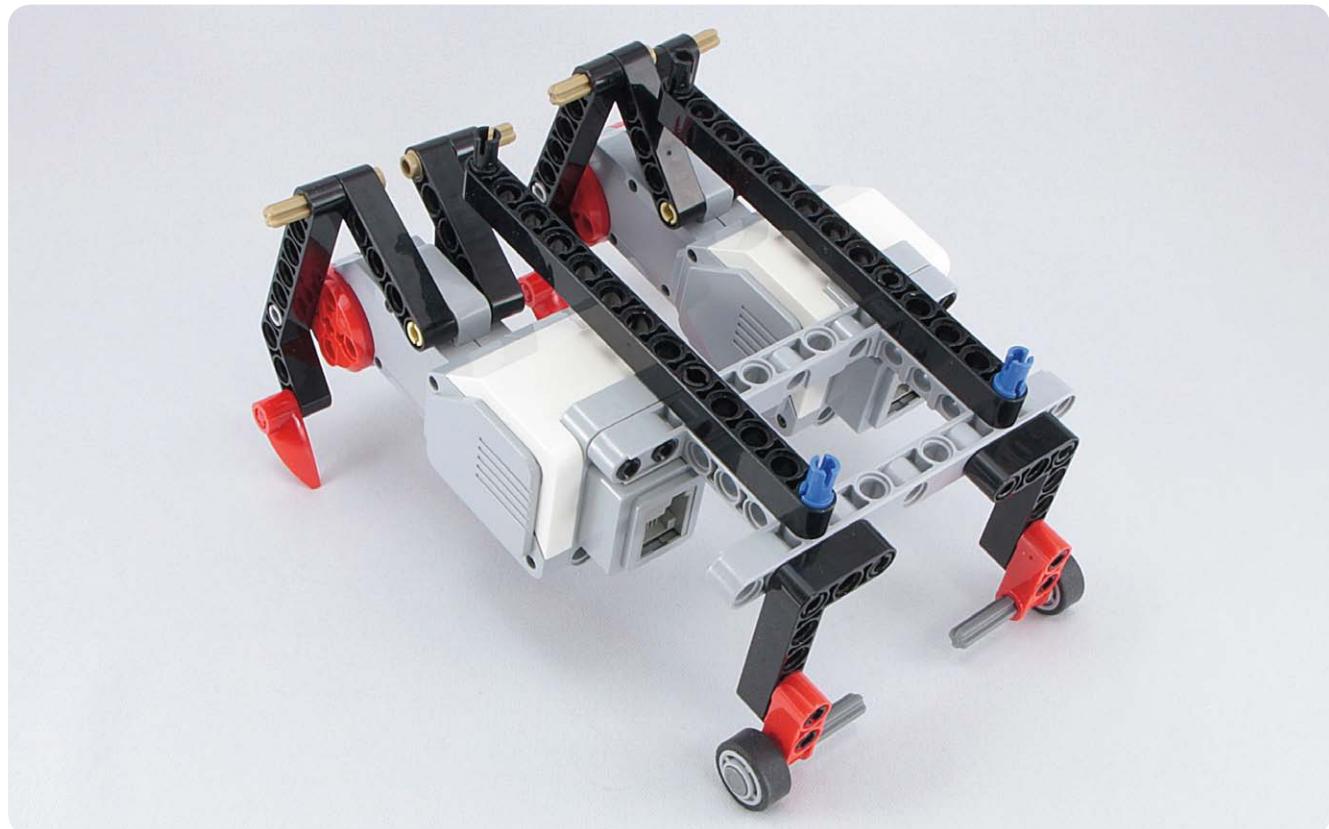
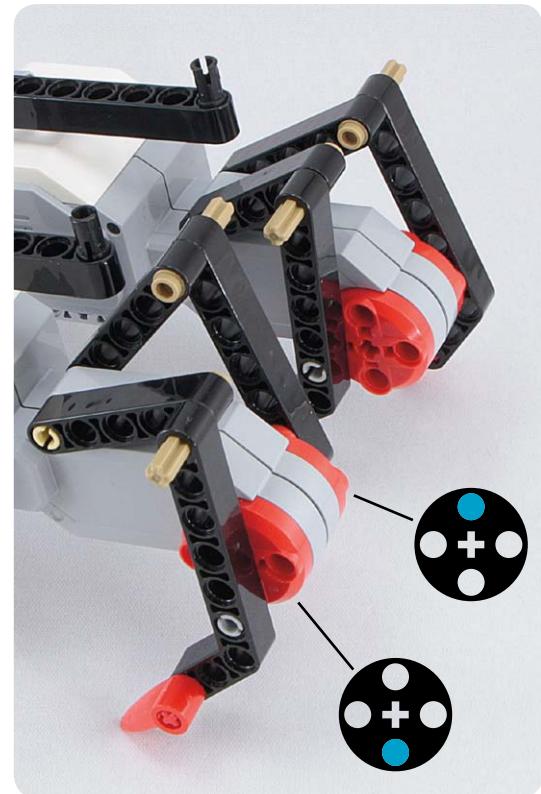
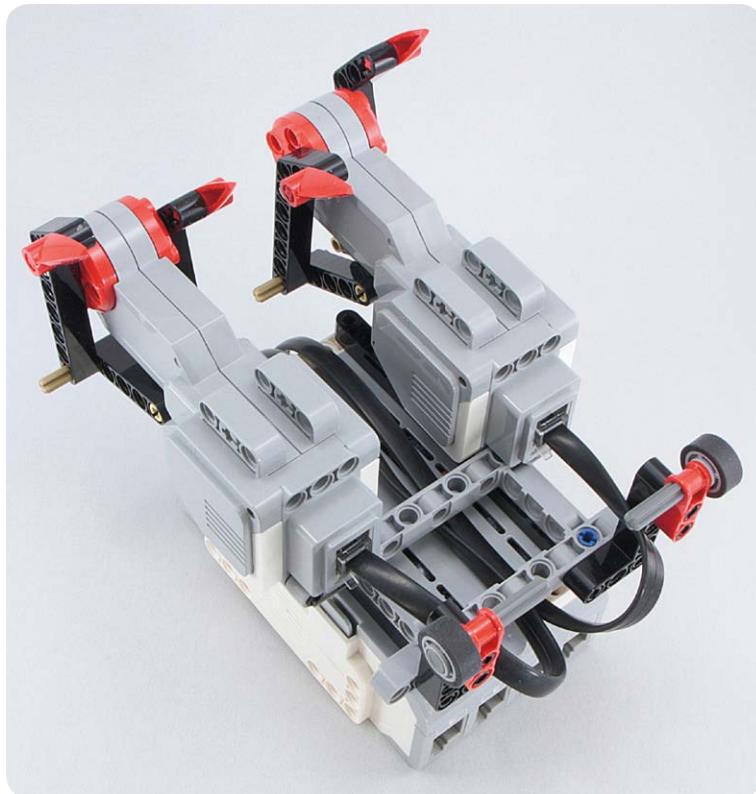
#125

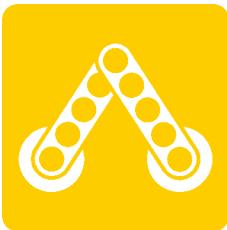




#126

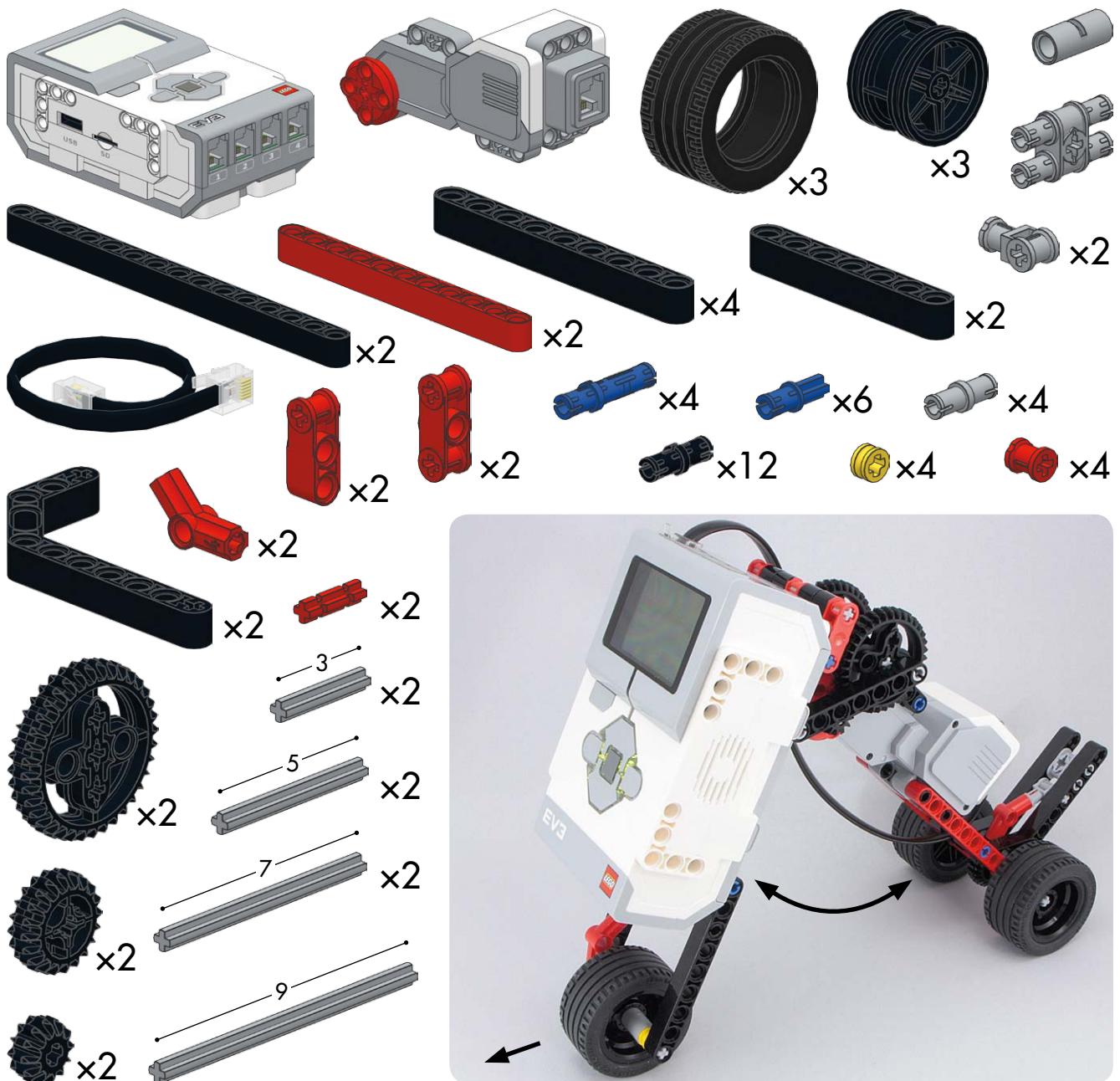


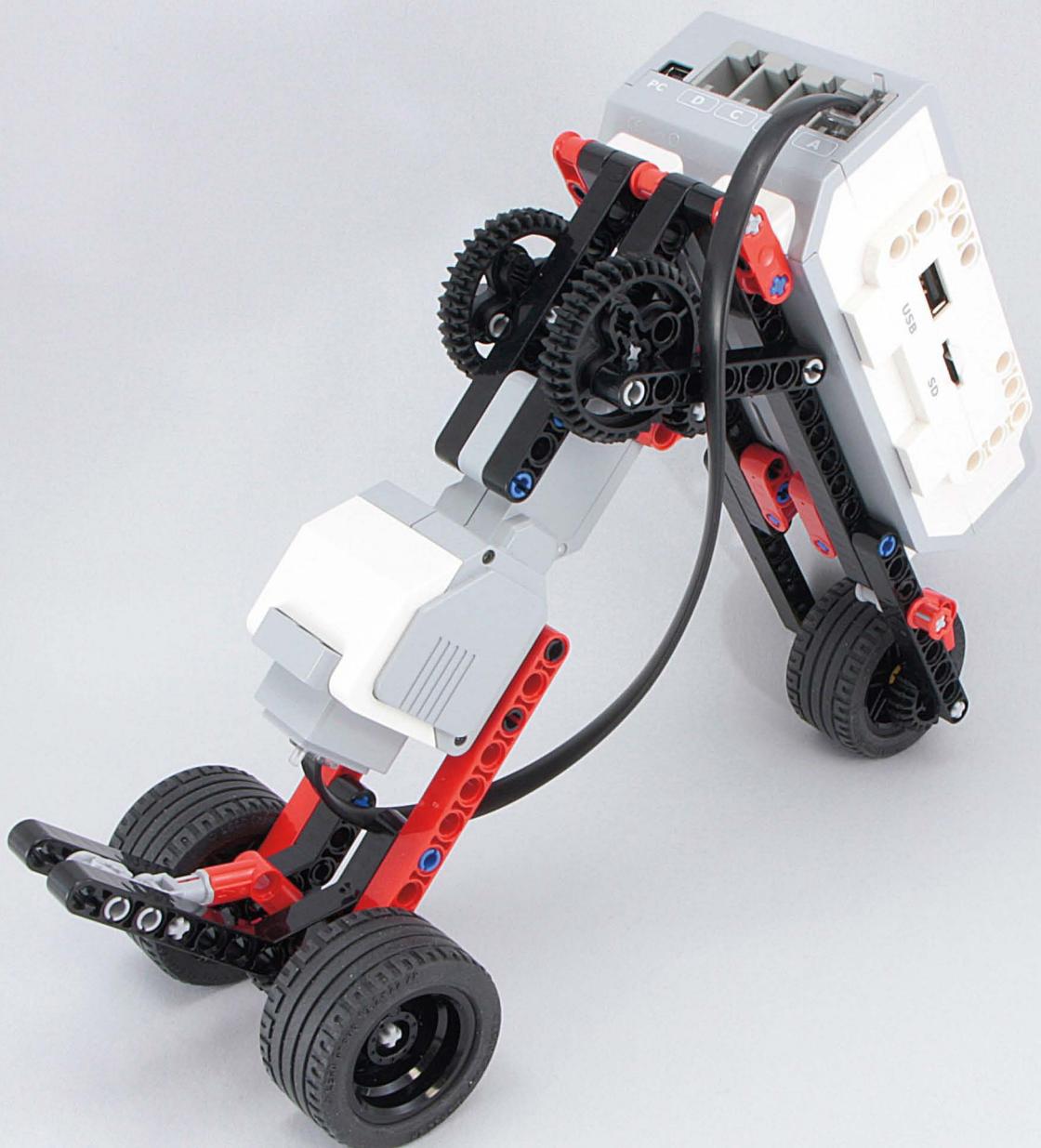


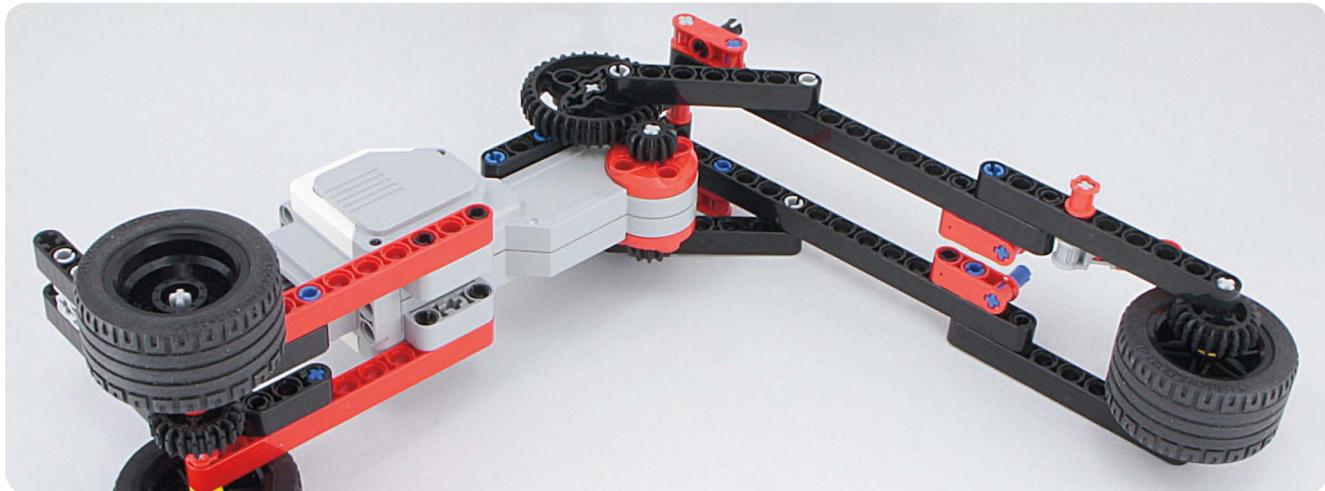
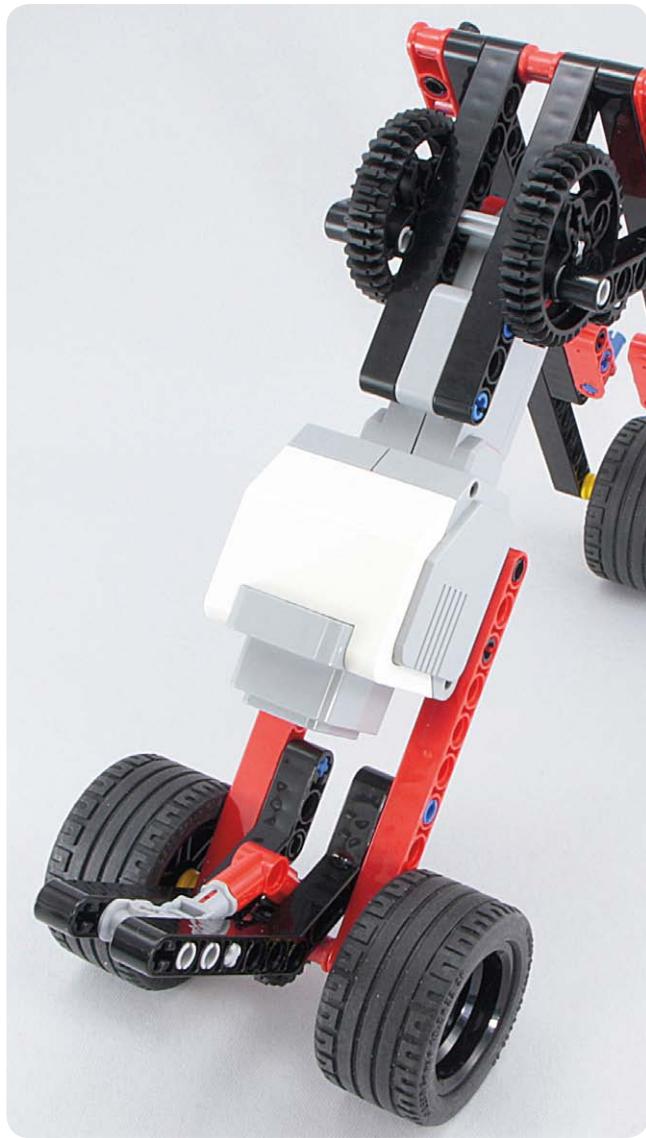
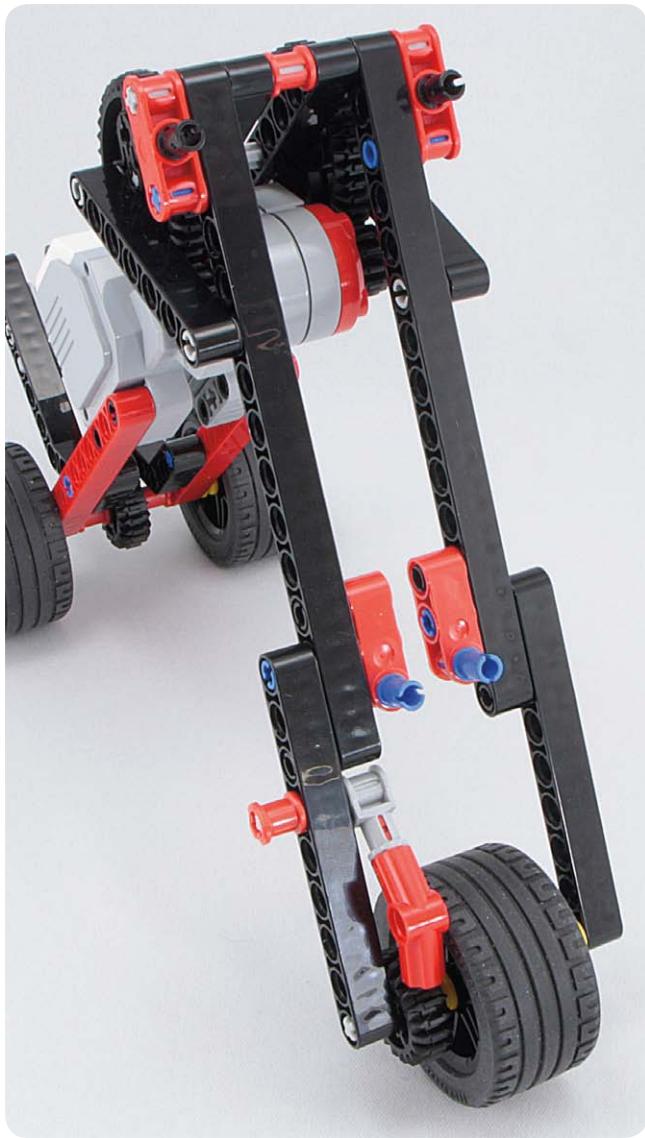


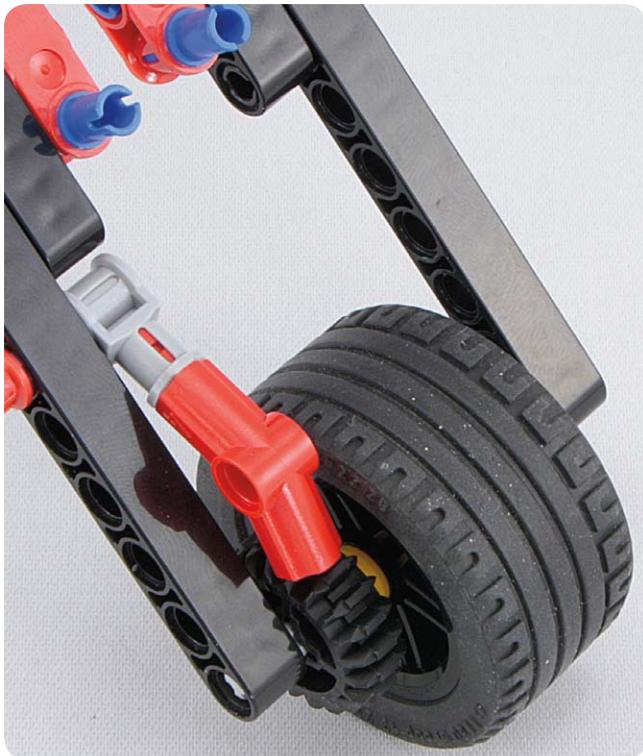
Moving like an inchworm

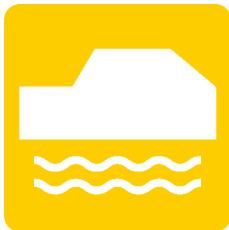
#127







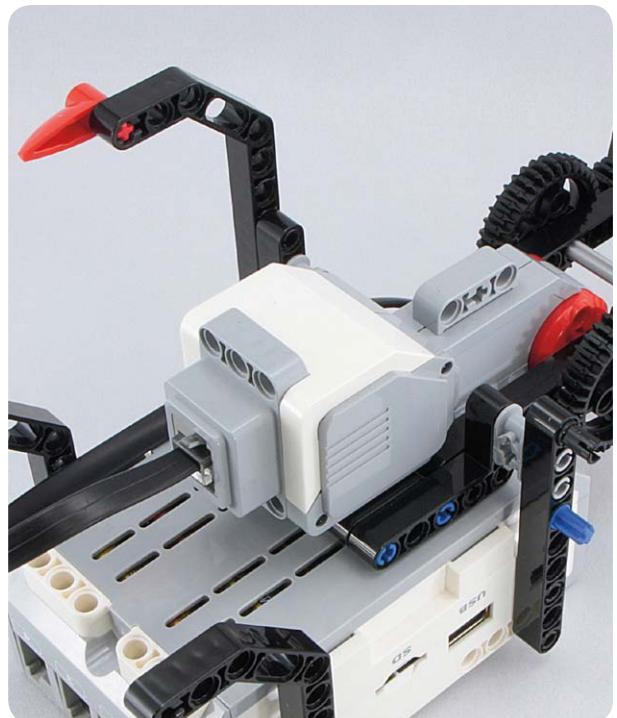
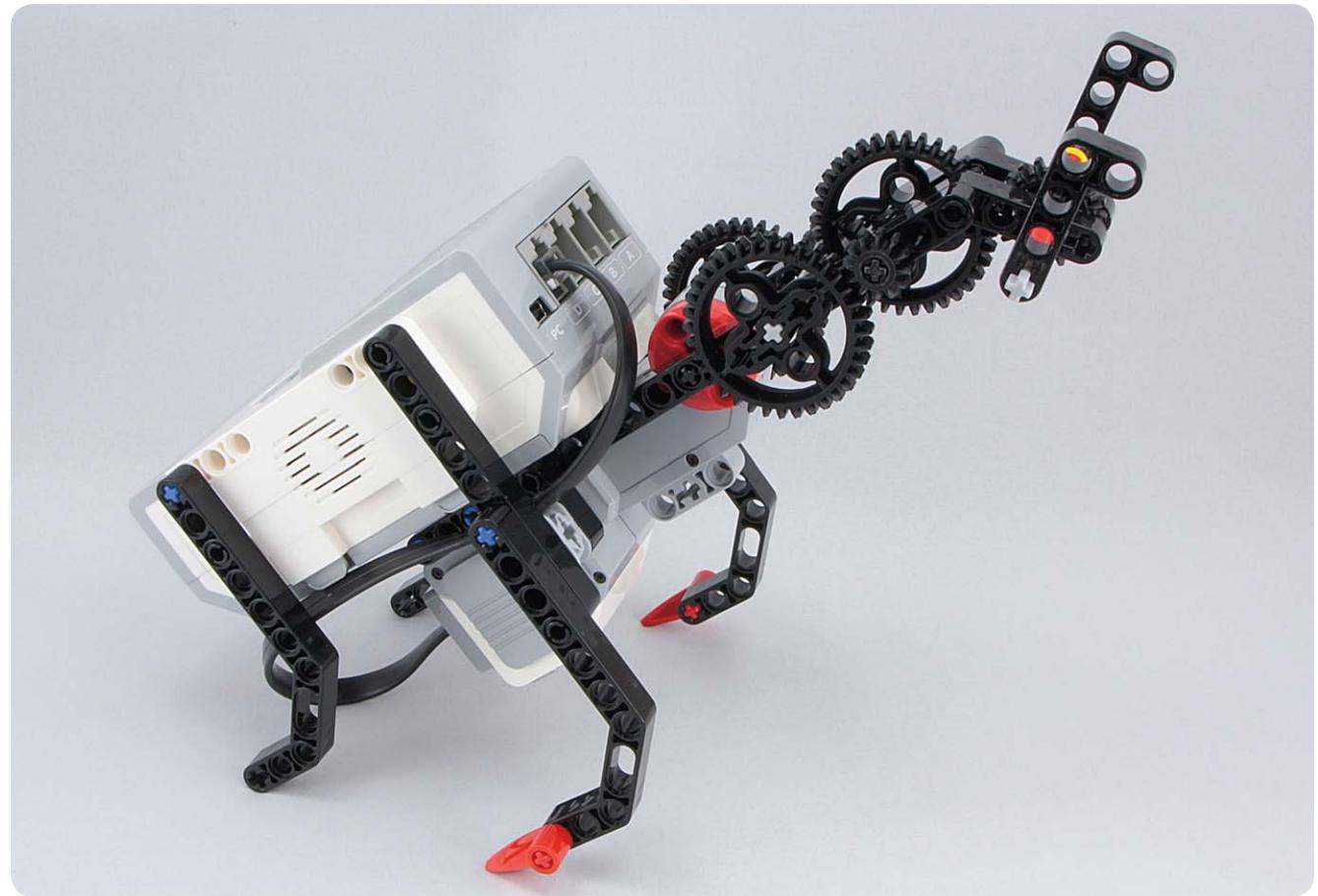




Moving through vibration

#128







PART 4



Arms, Wings, and Other Movements



130



158



180



194



140



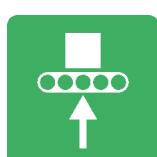
168



184



198



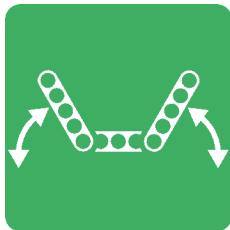
152



176

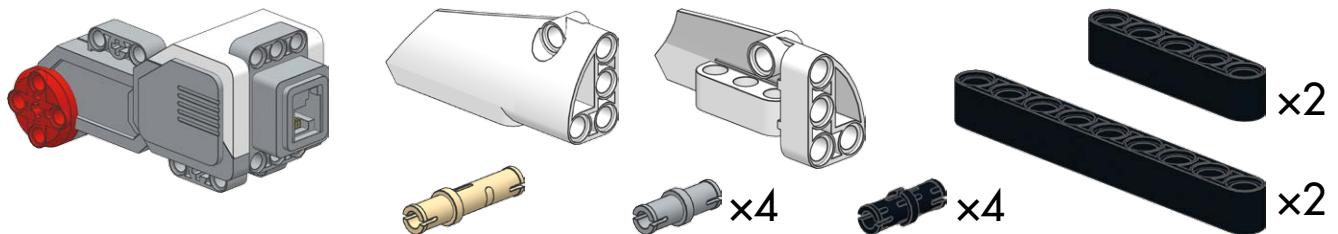


188

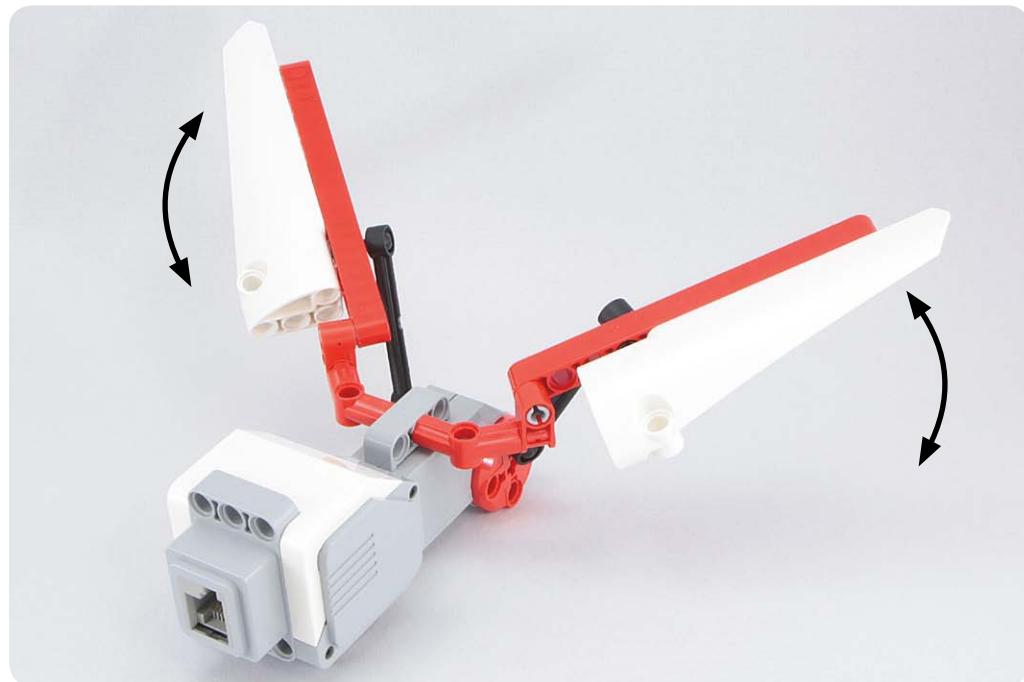
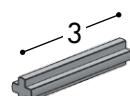
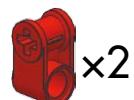
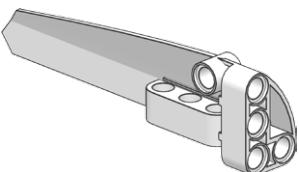
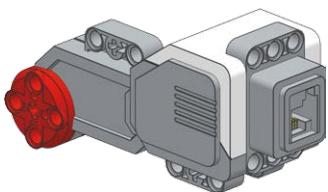


Flapping wings

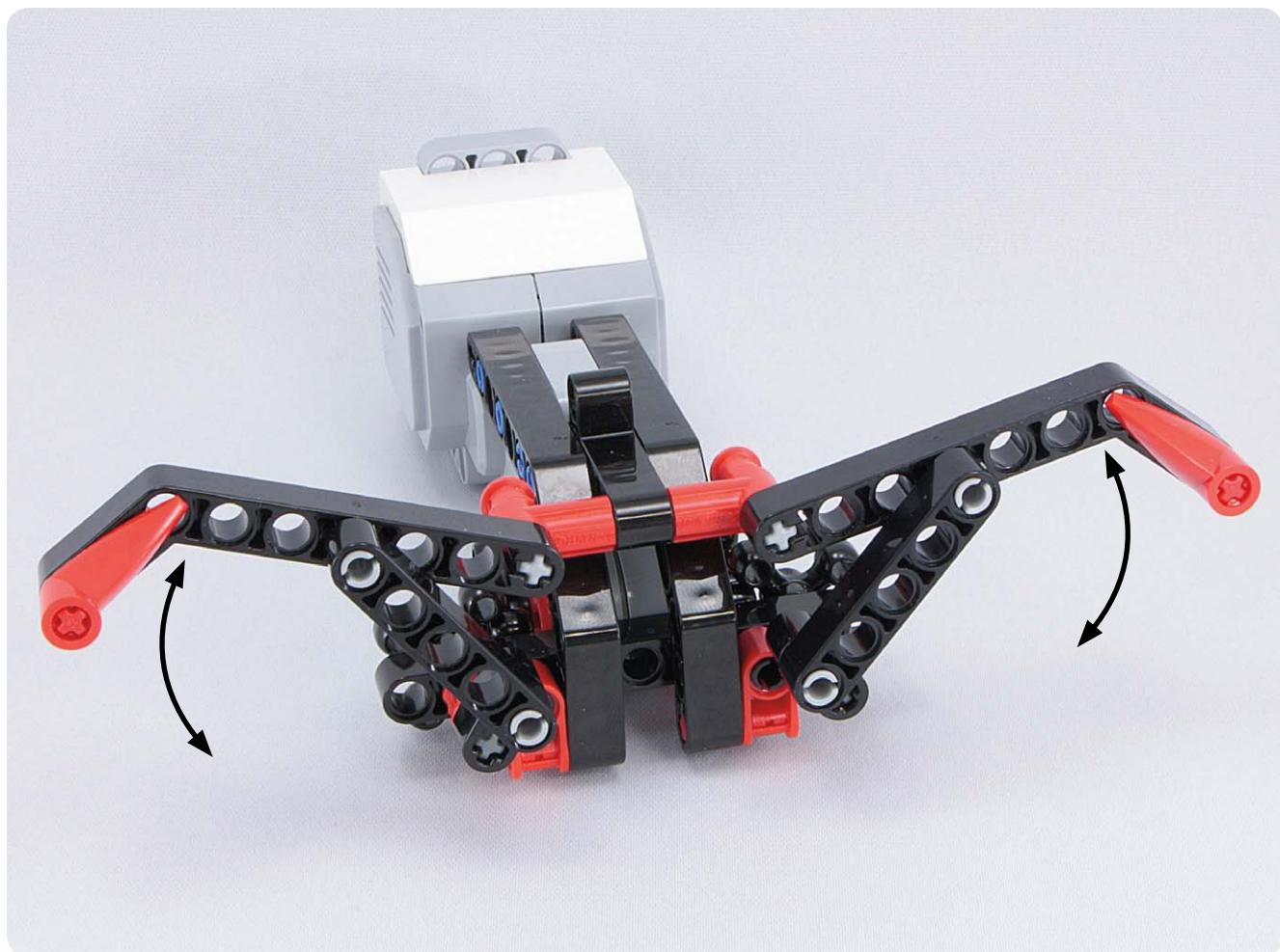
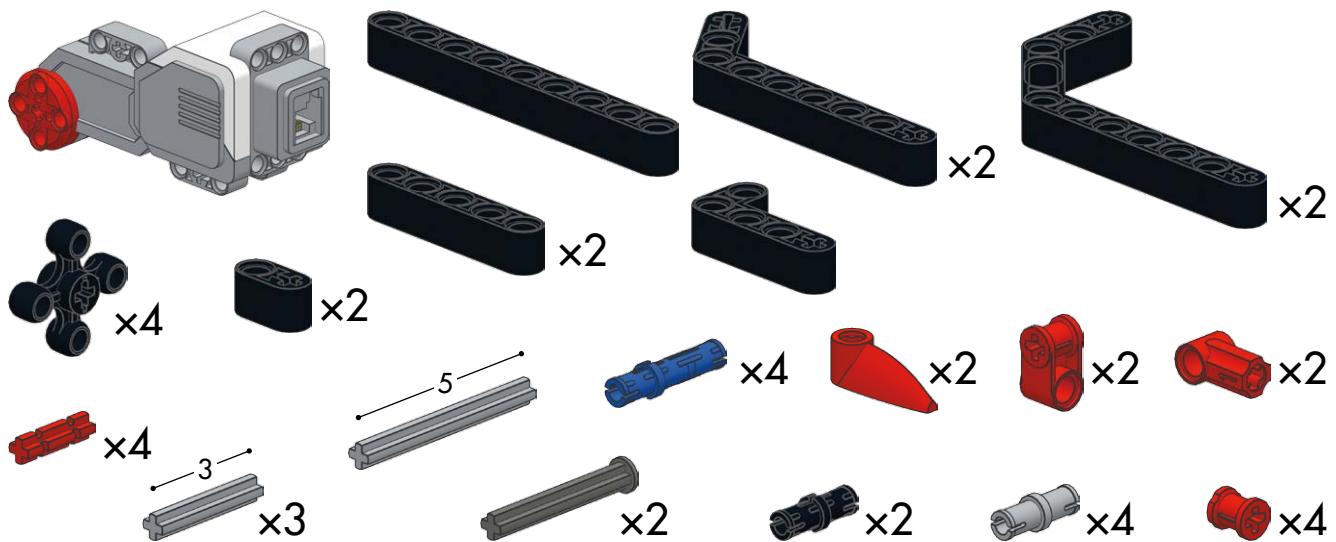
#129



#130

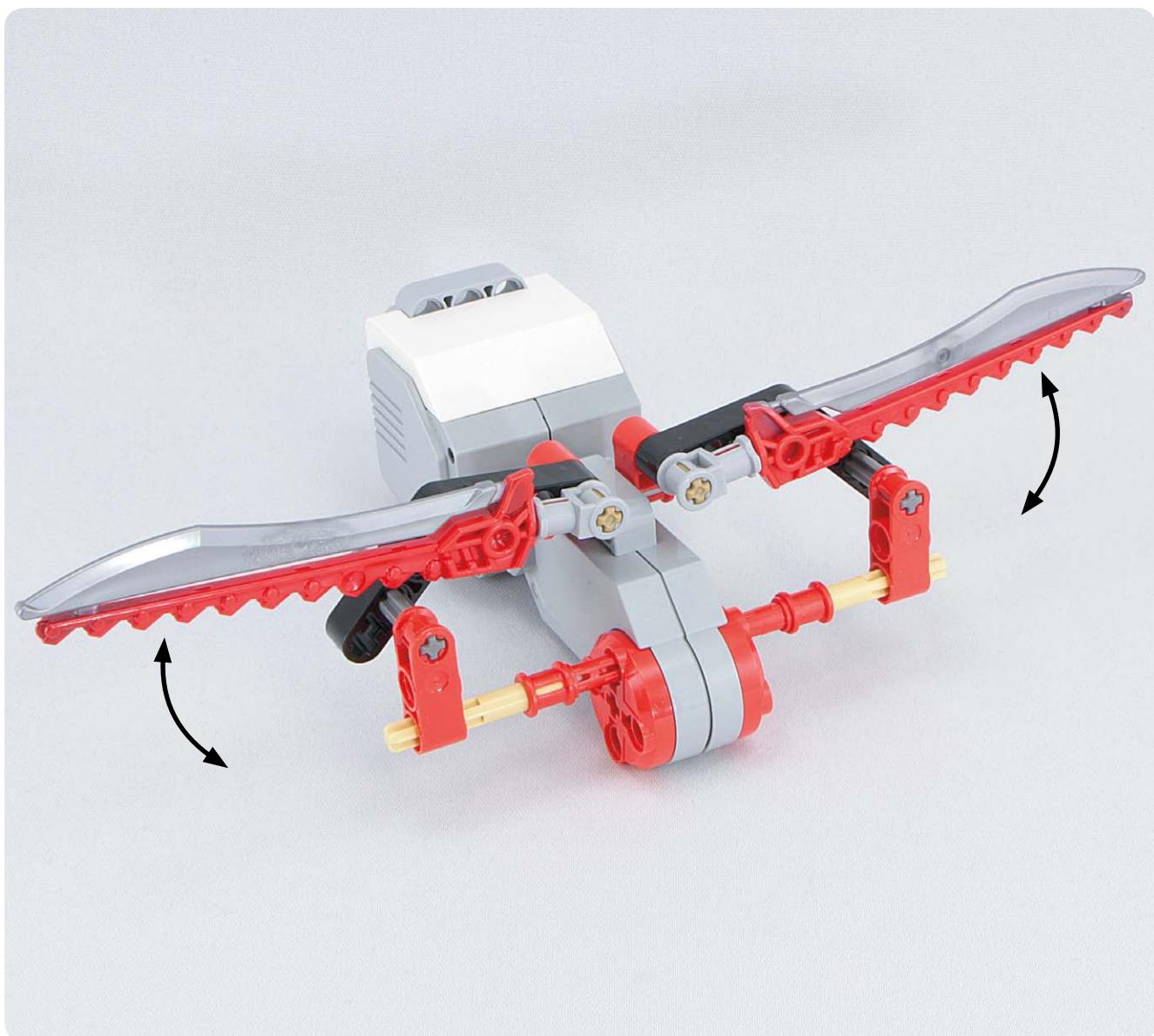
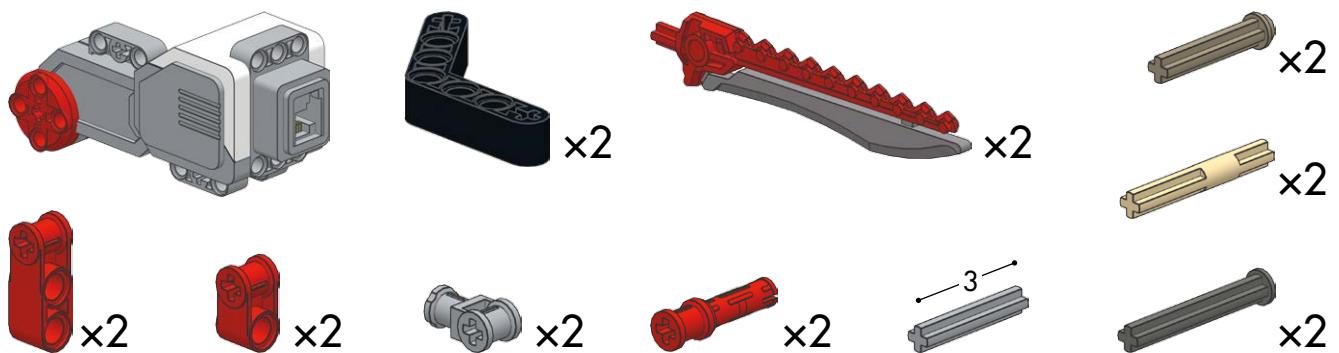


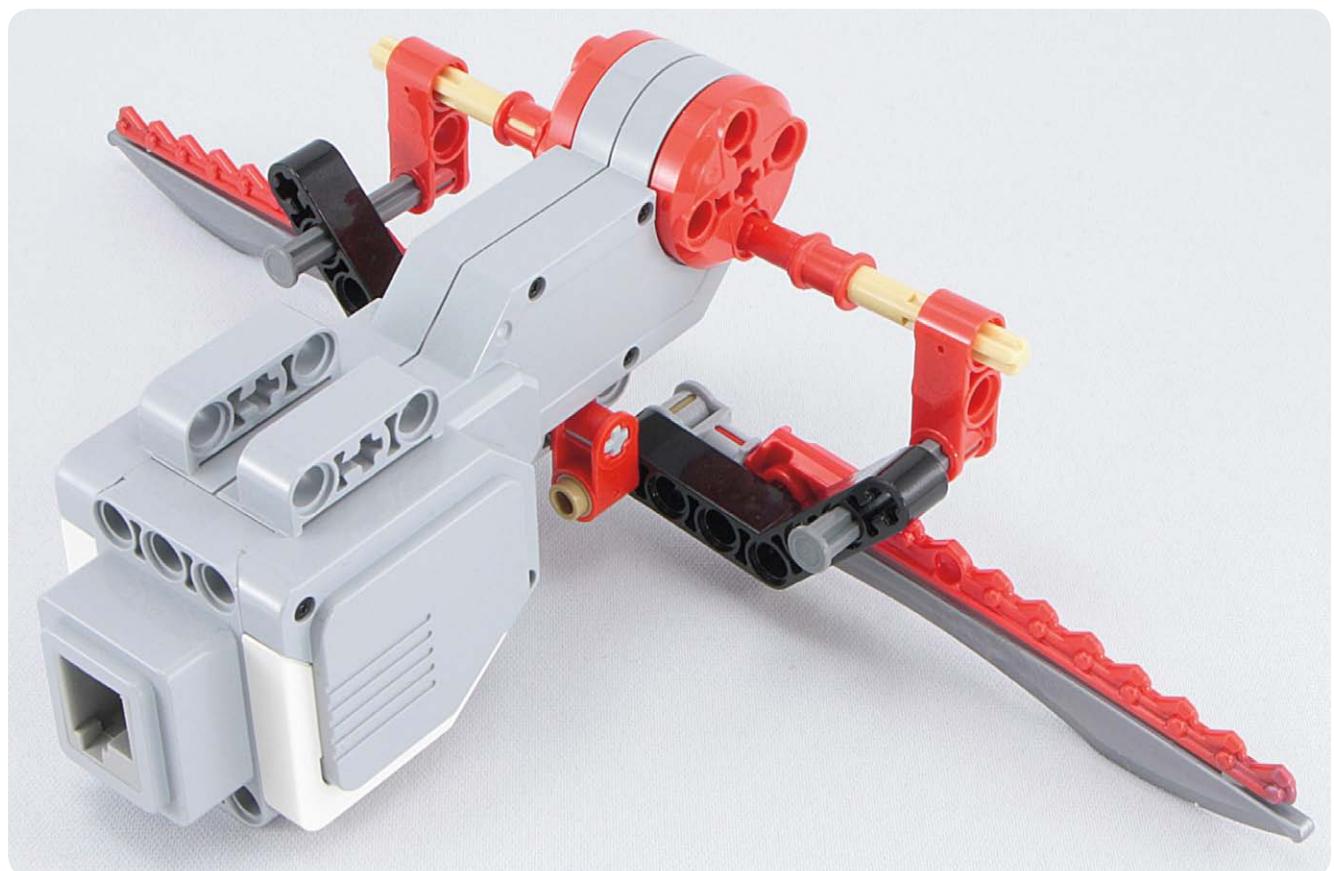
#131



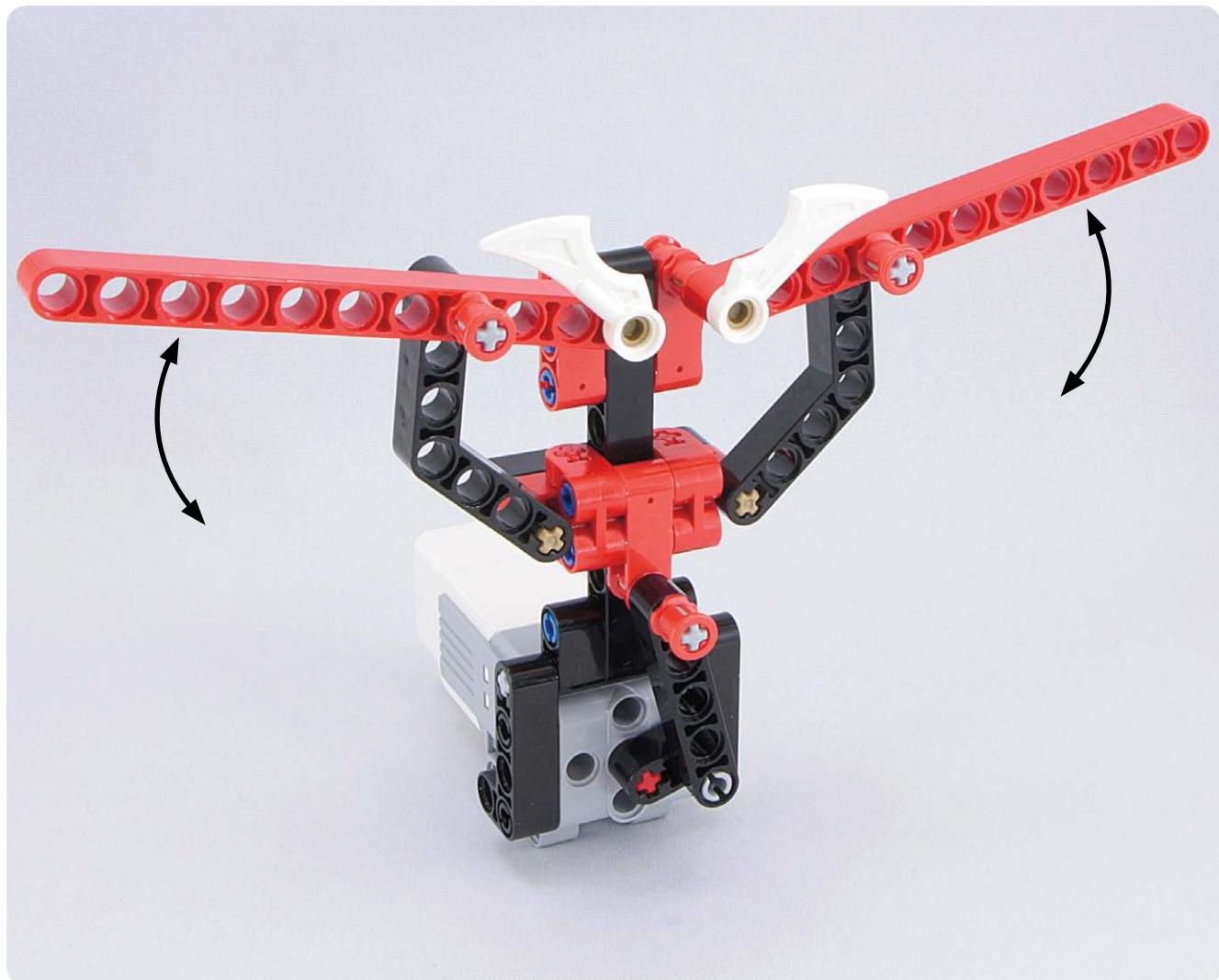
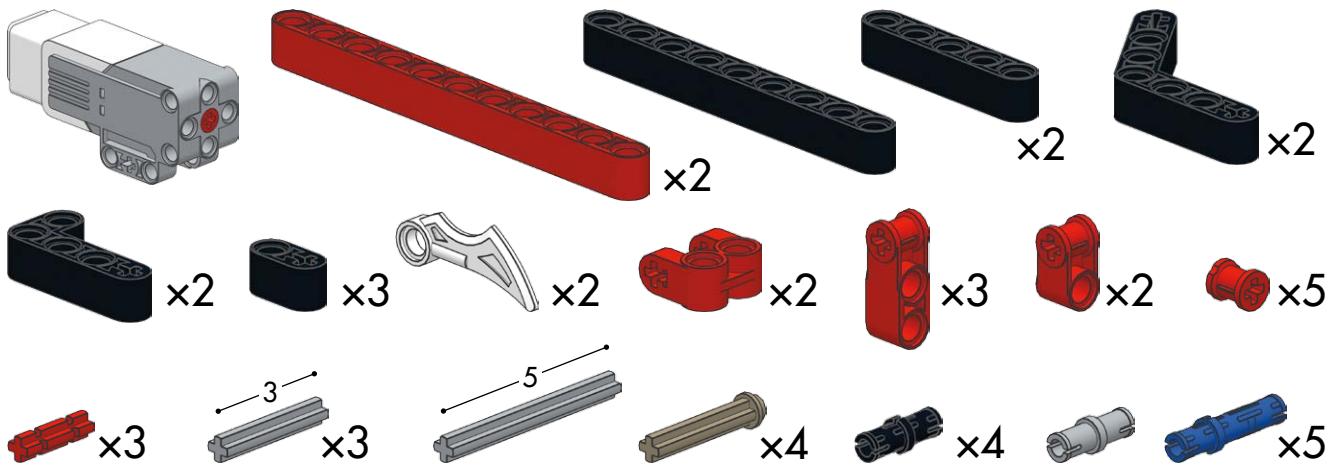


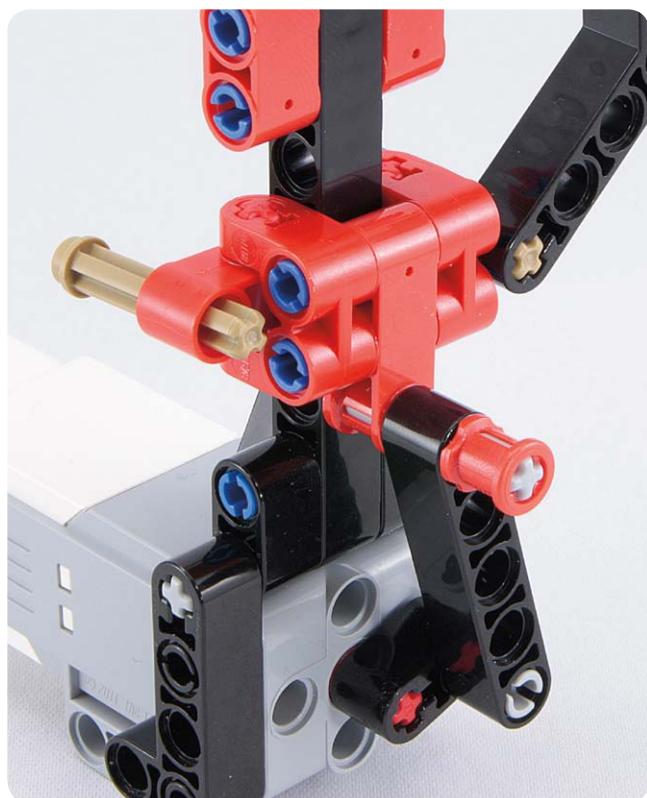
#132



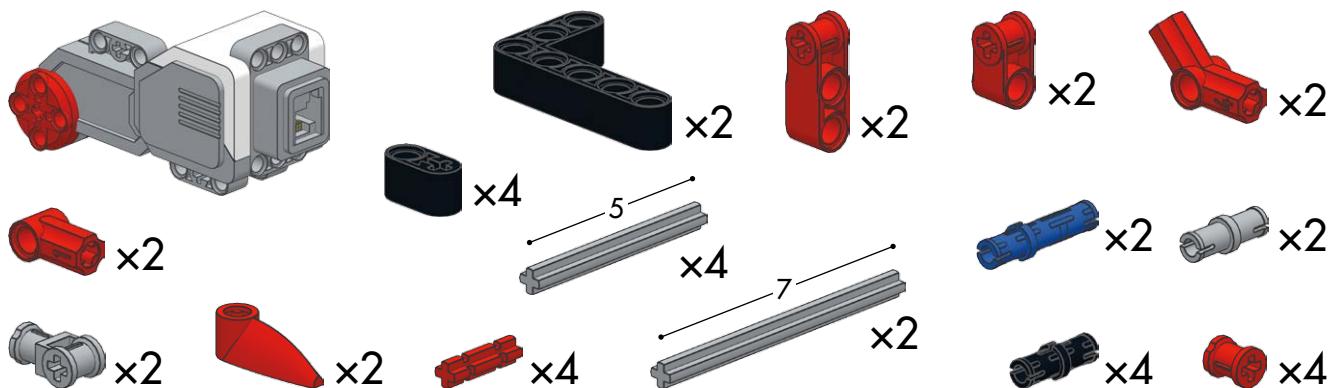


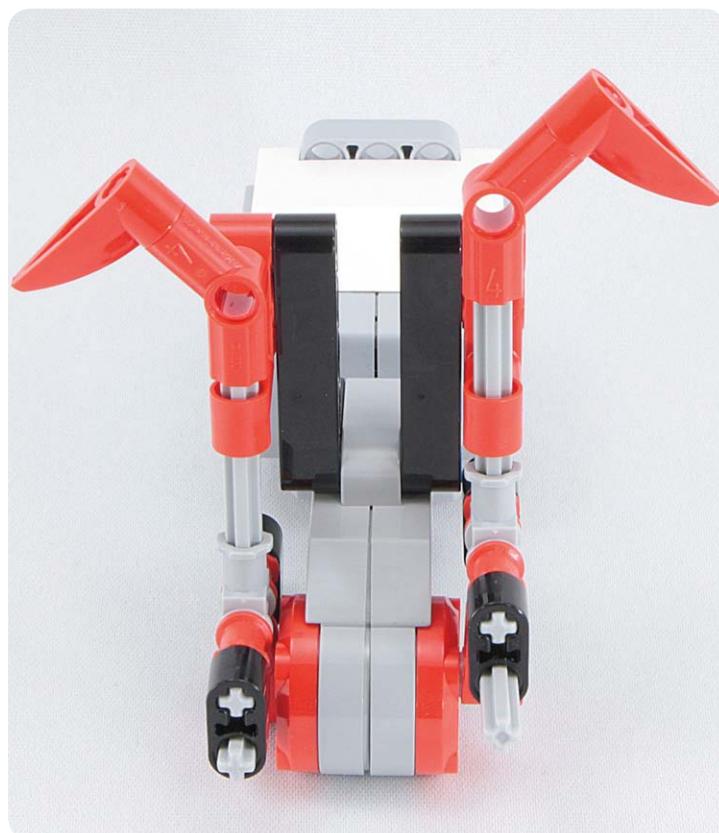
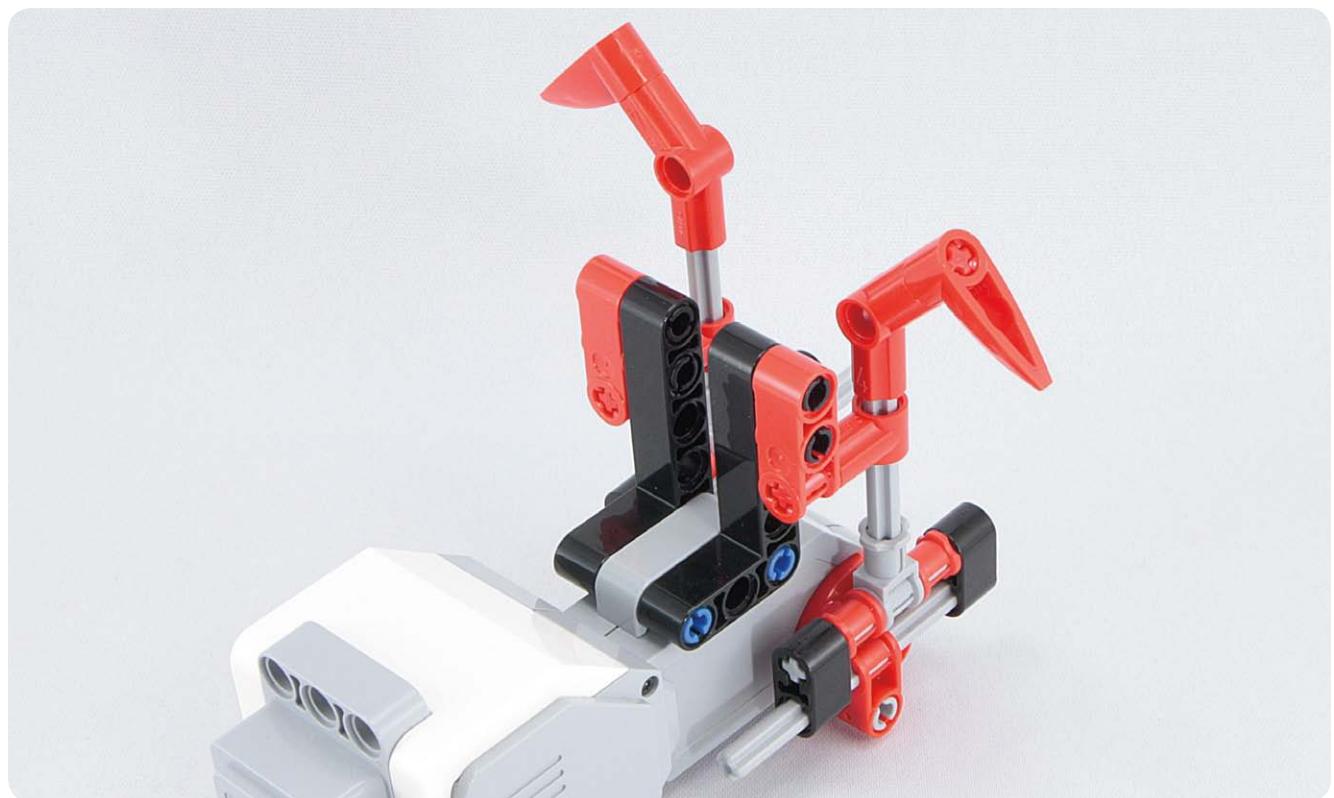
#133

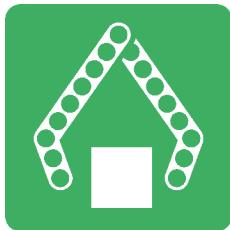




#134

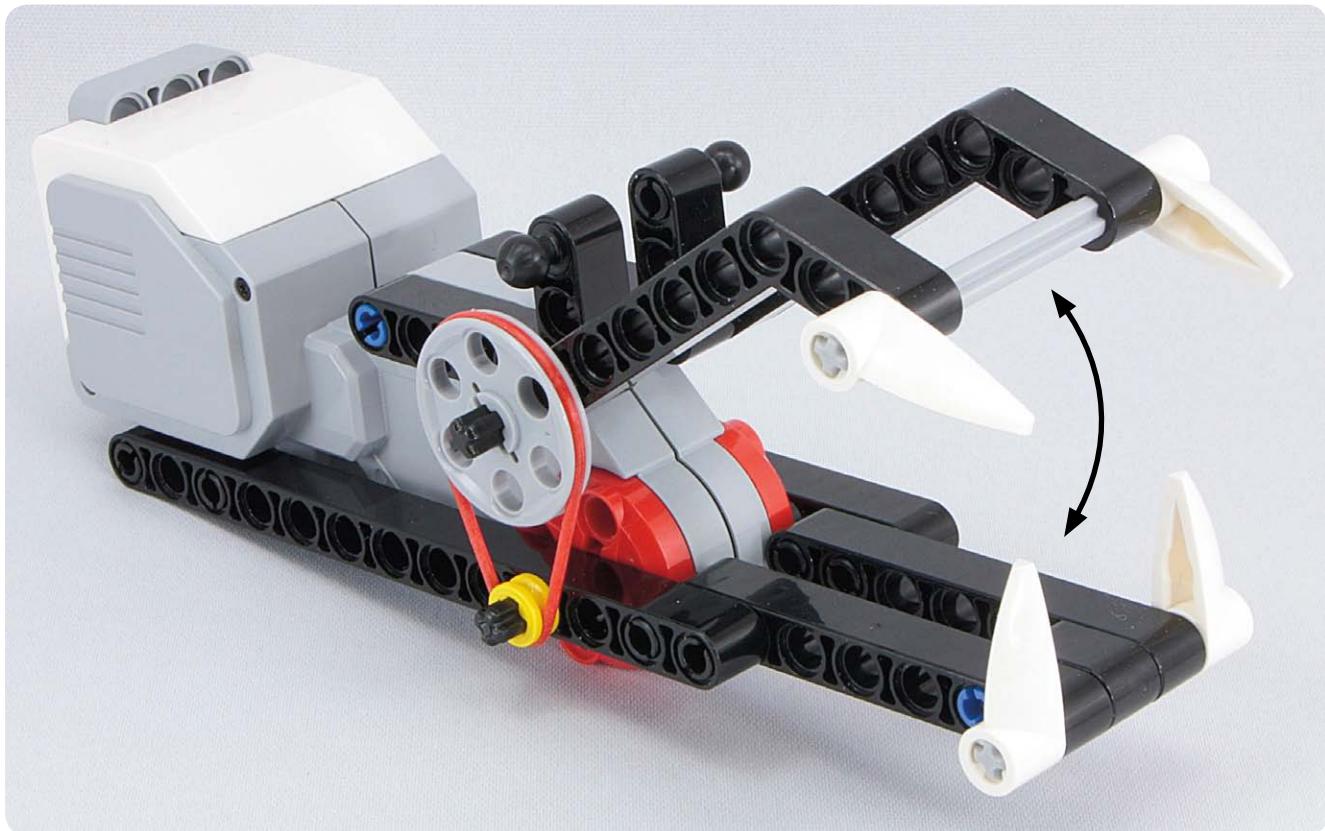
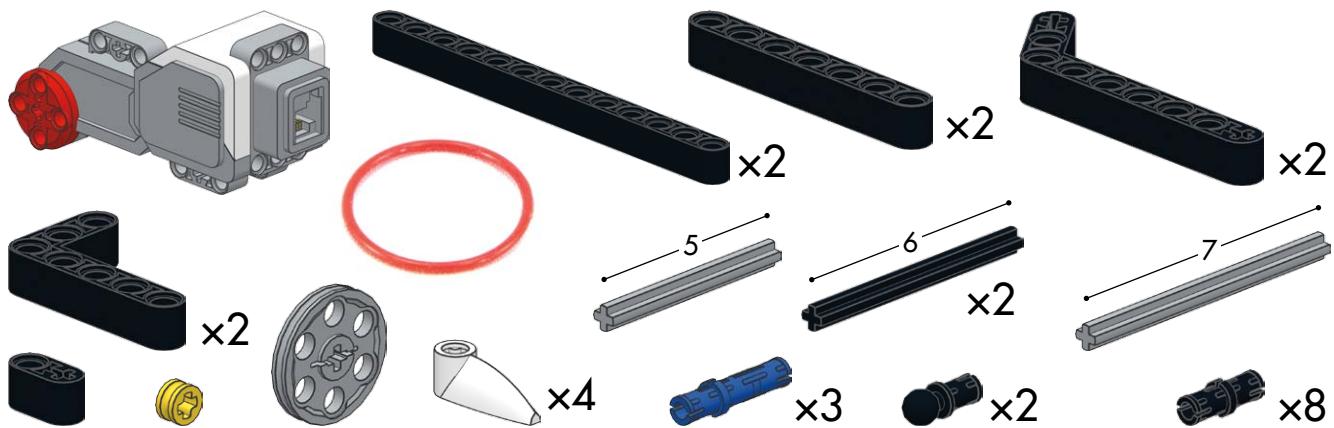


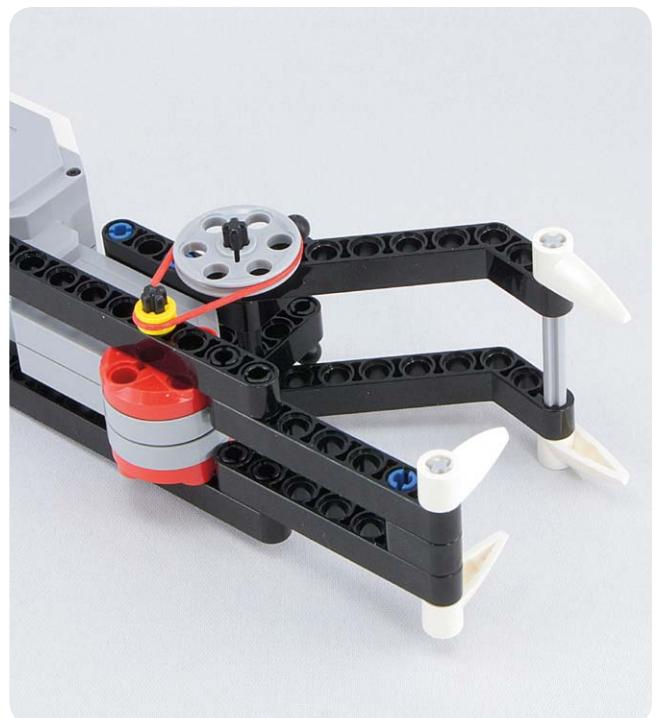
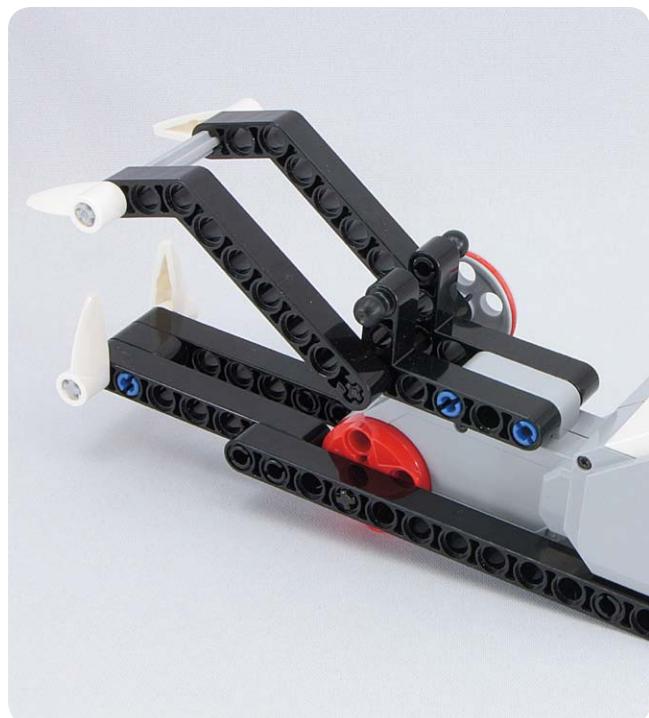
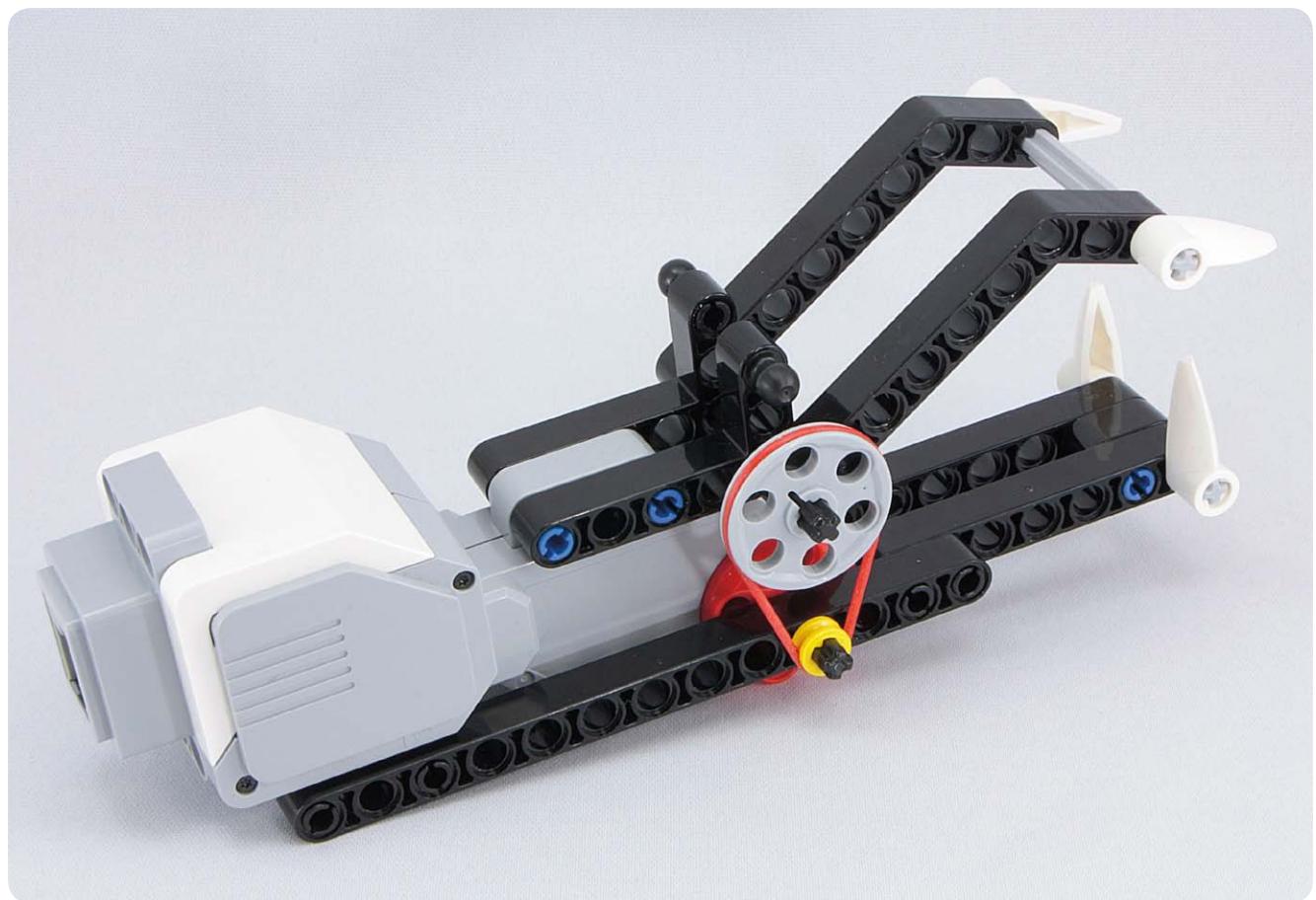




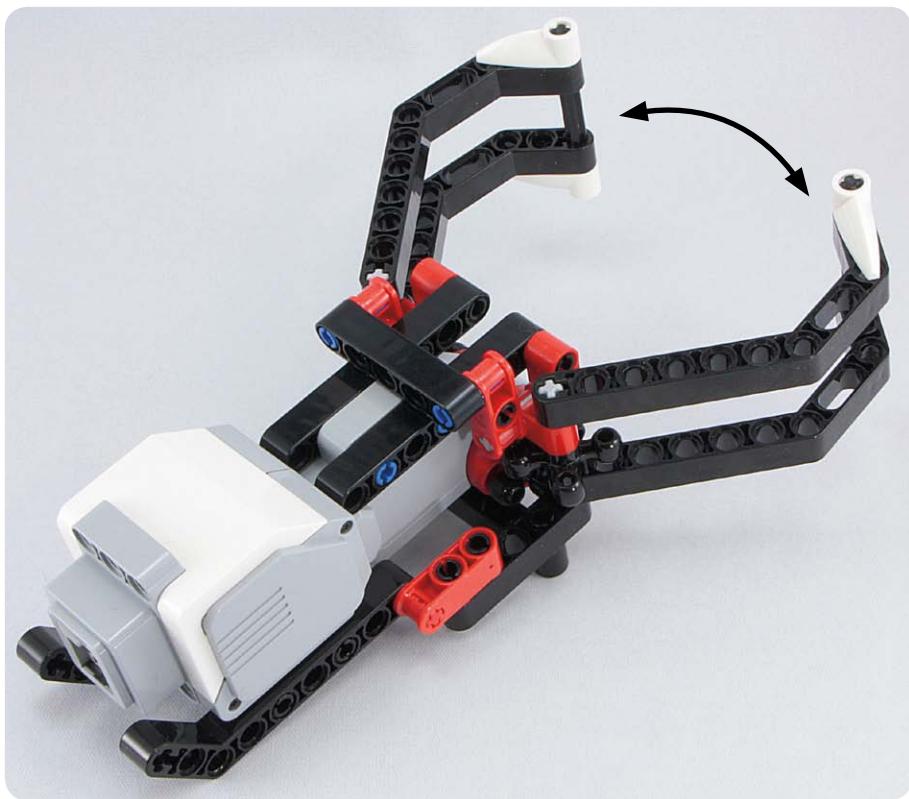
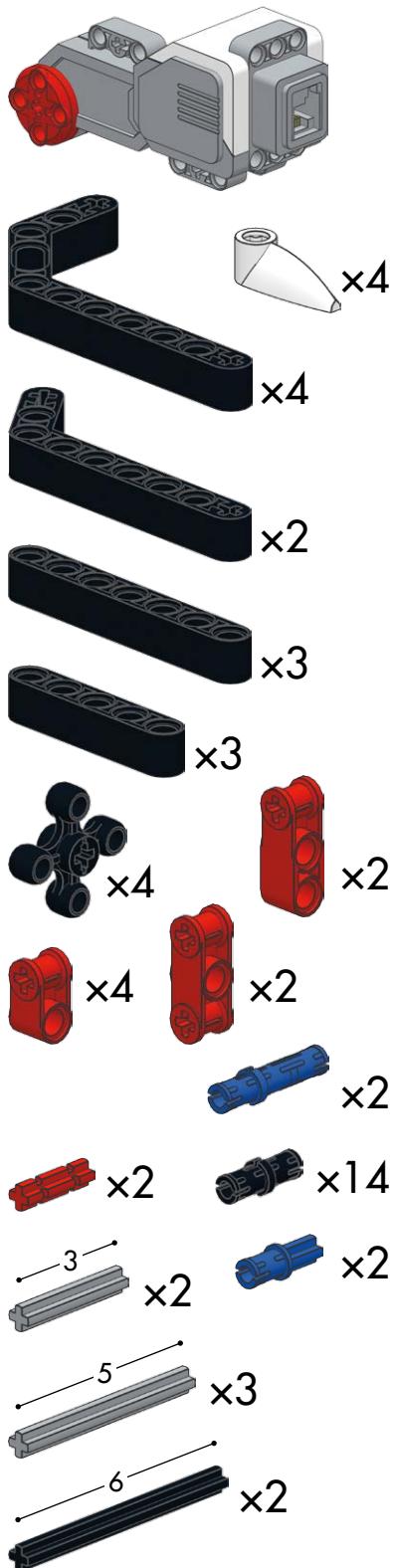
Gripping fingers

#135



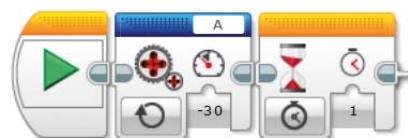


#136

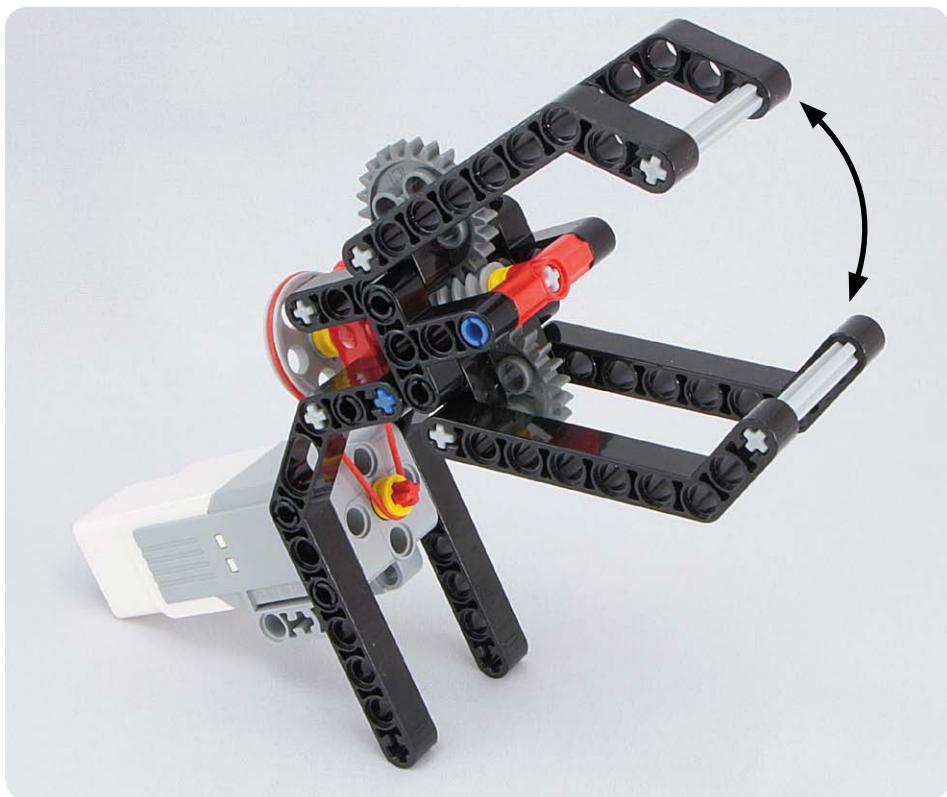
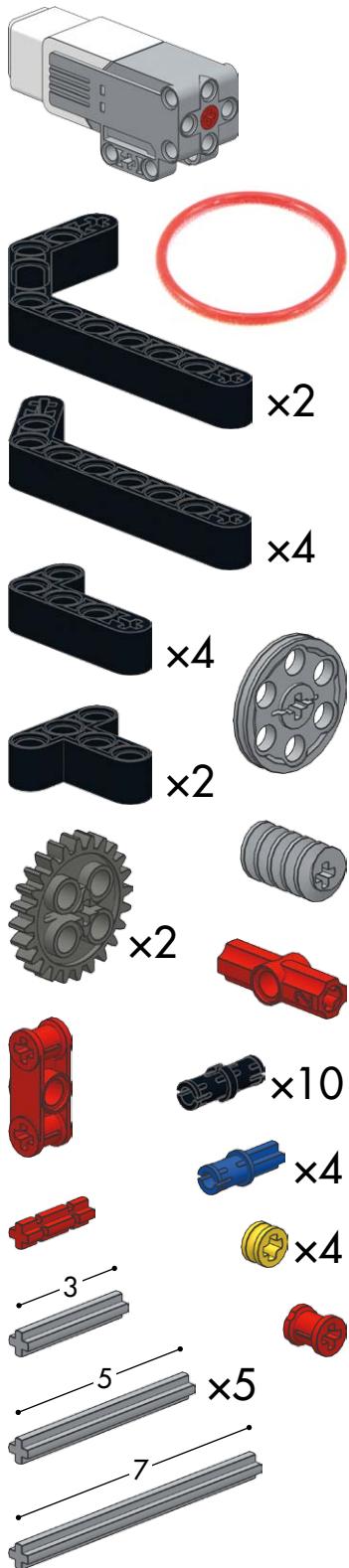


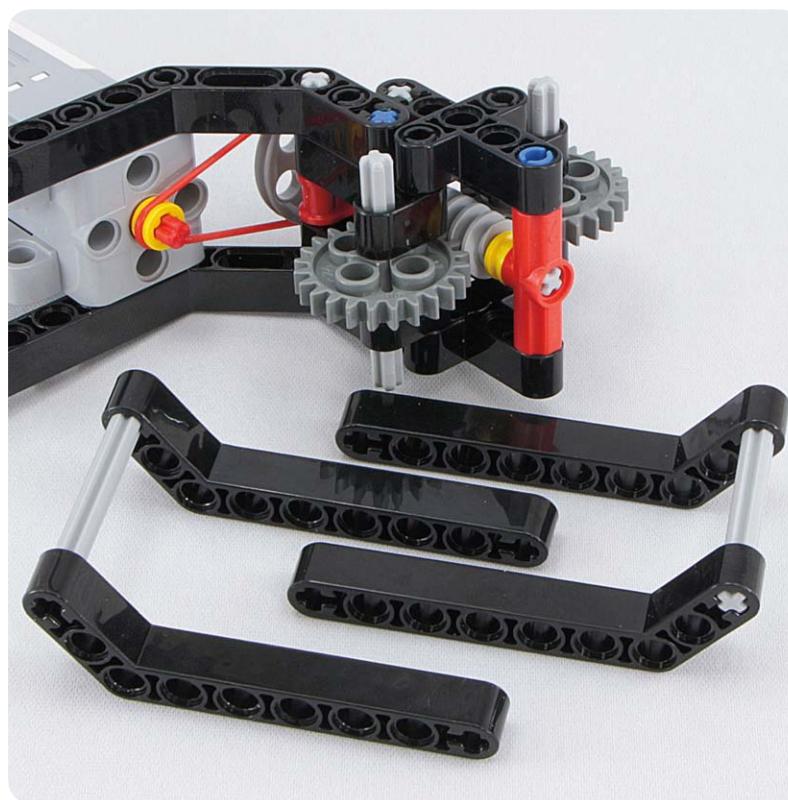


To avoid overextending the mechanism,
use this program instead of the standard one.

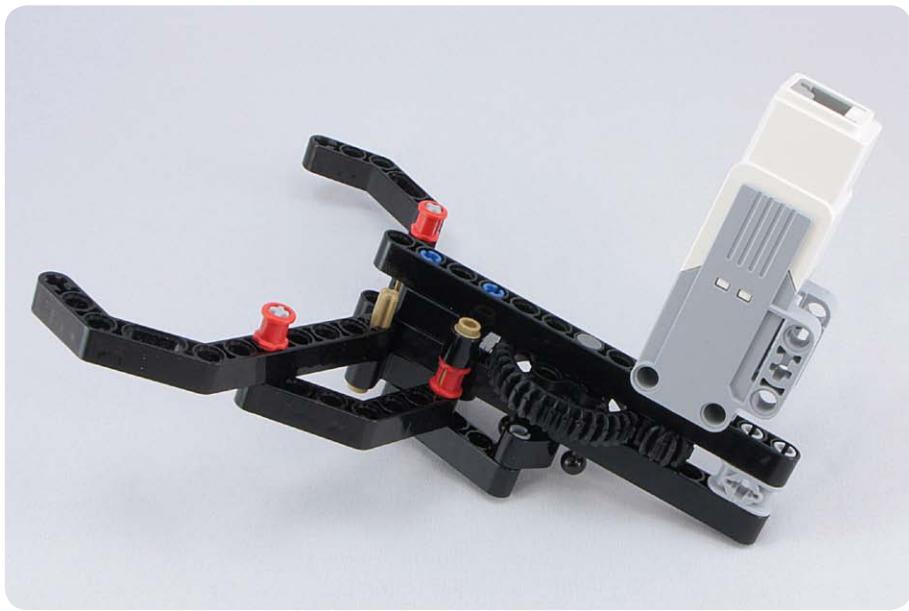
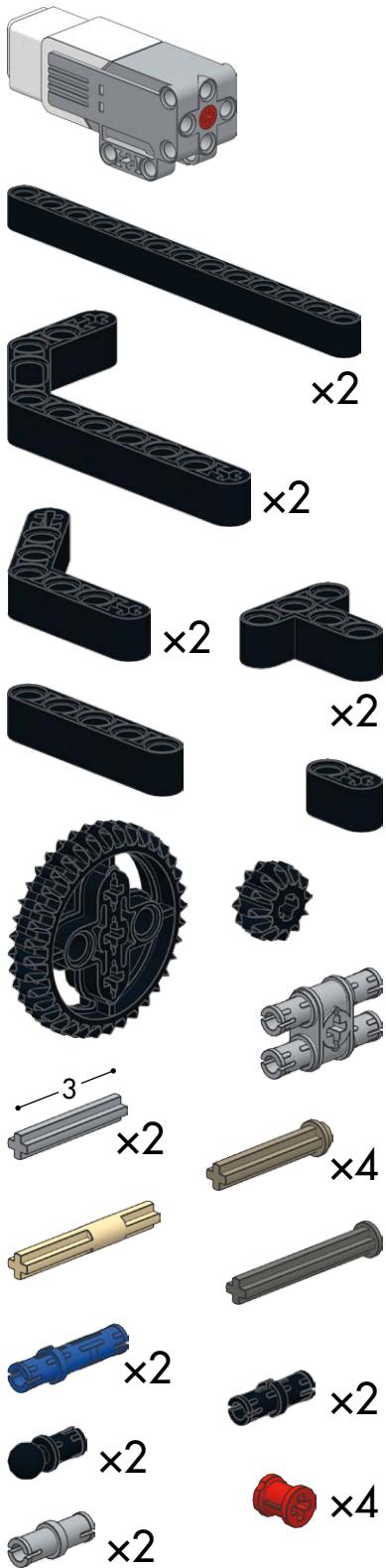


#137



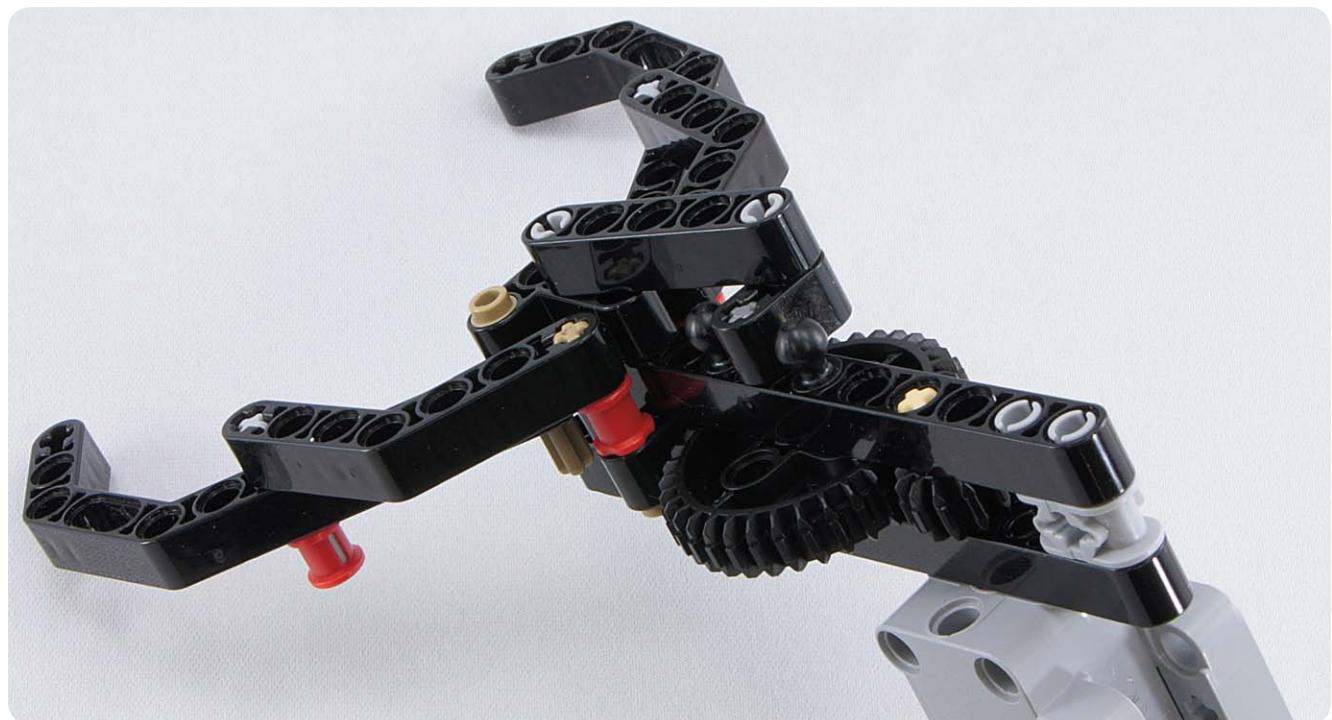
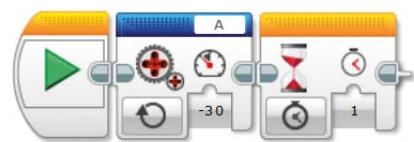


#138

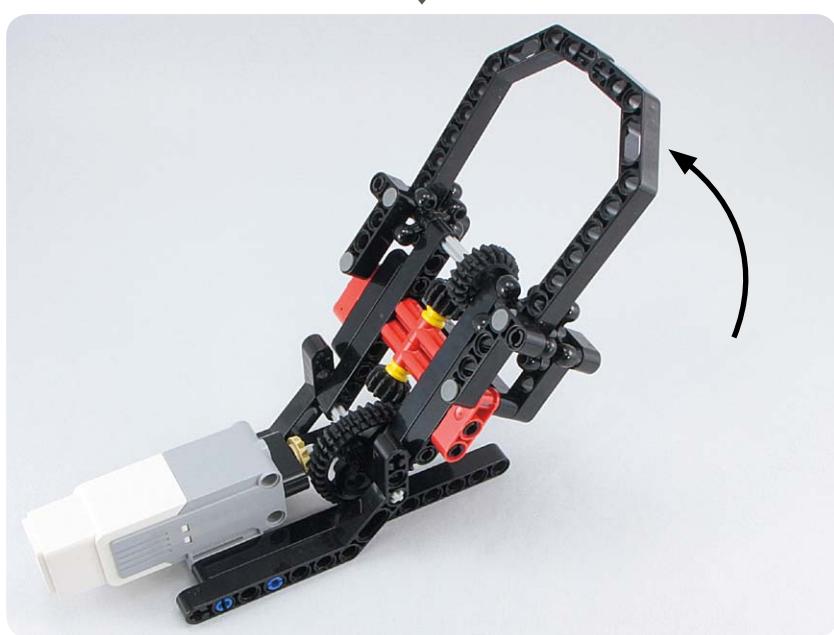
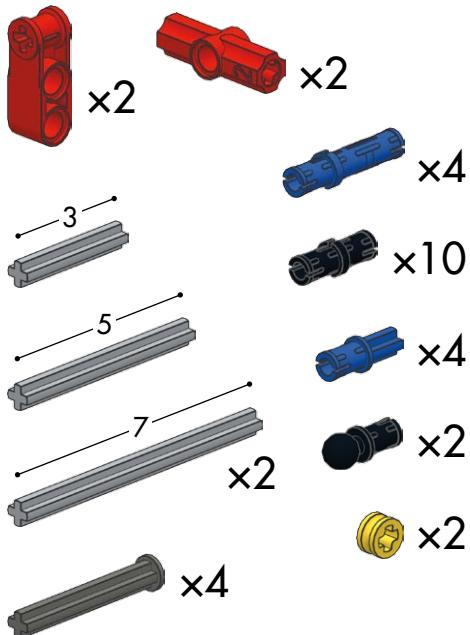
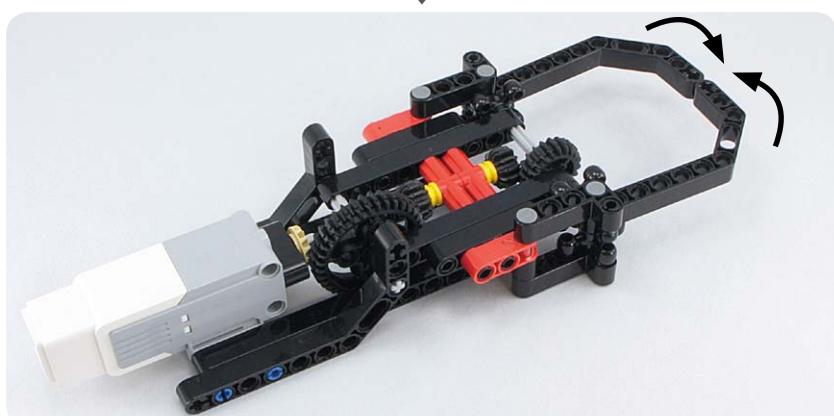
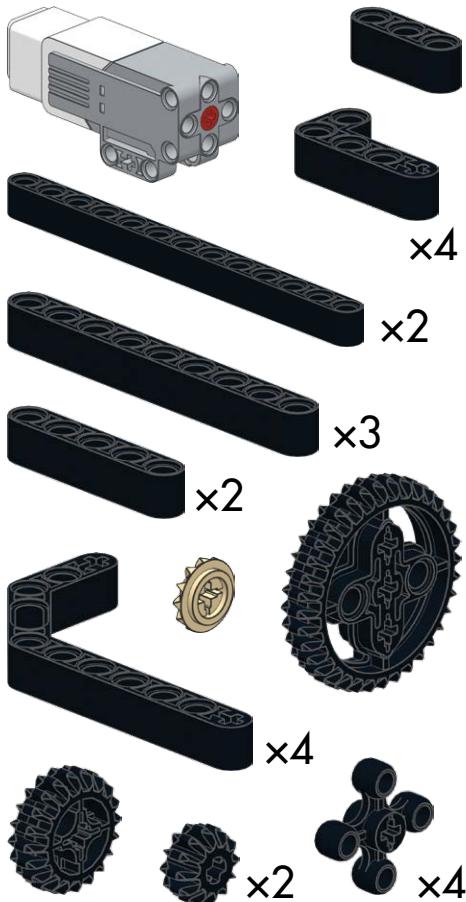


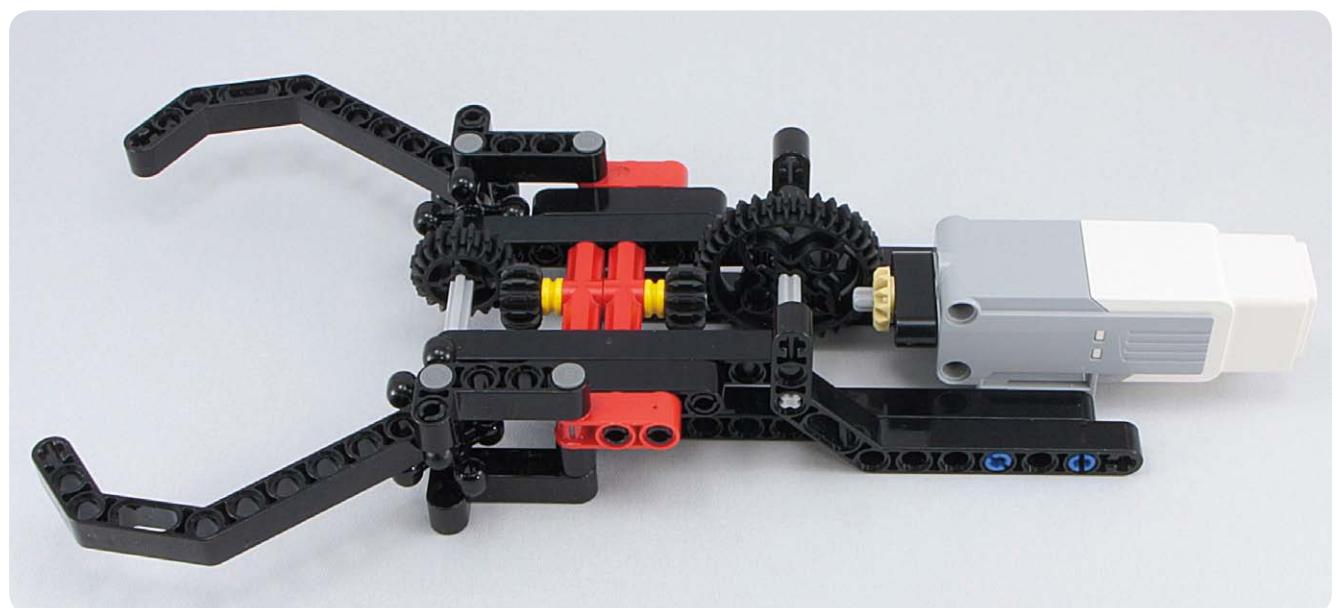
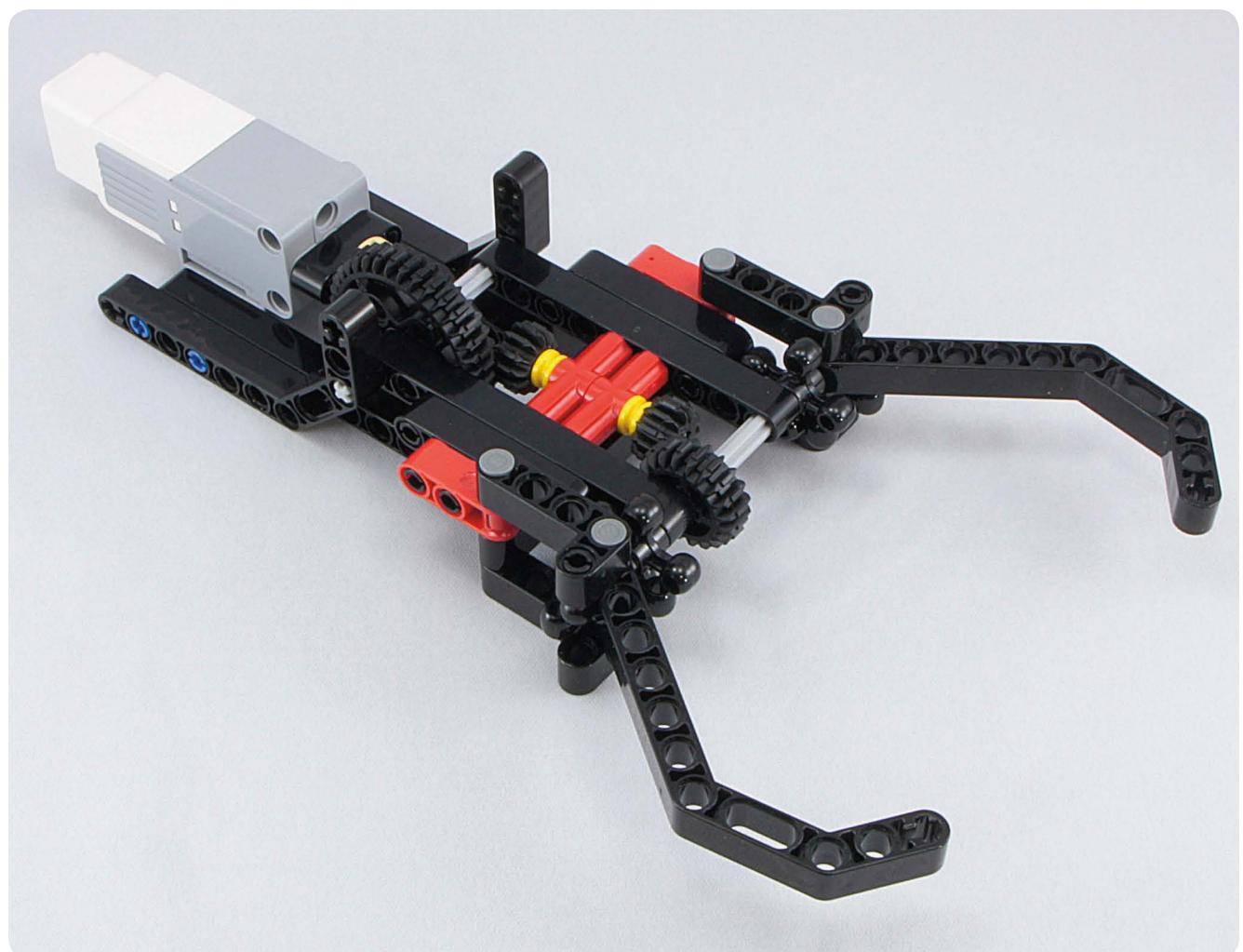


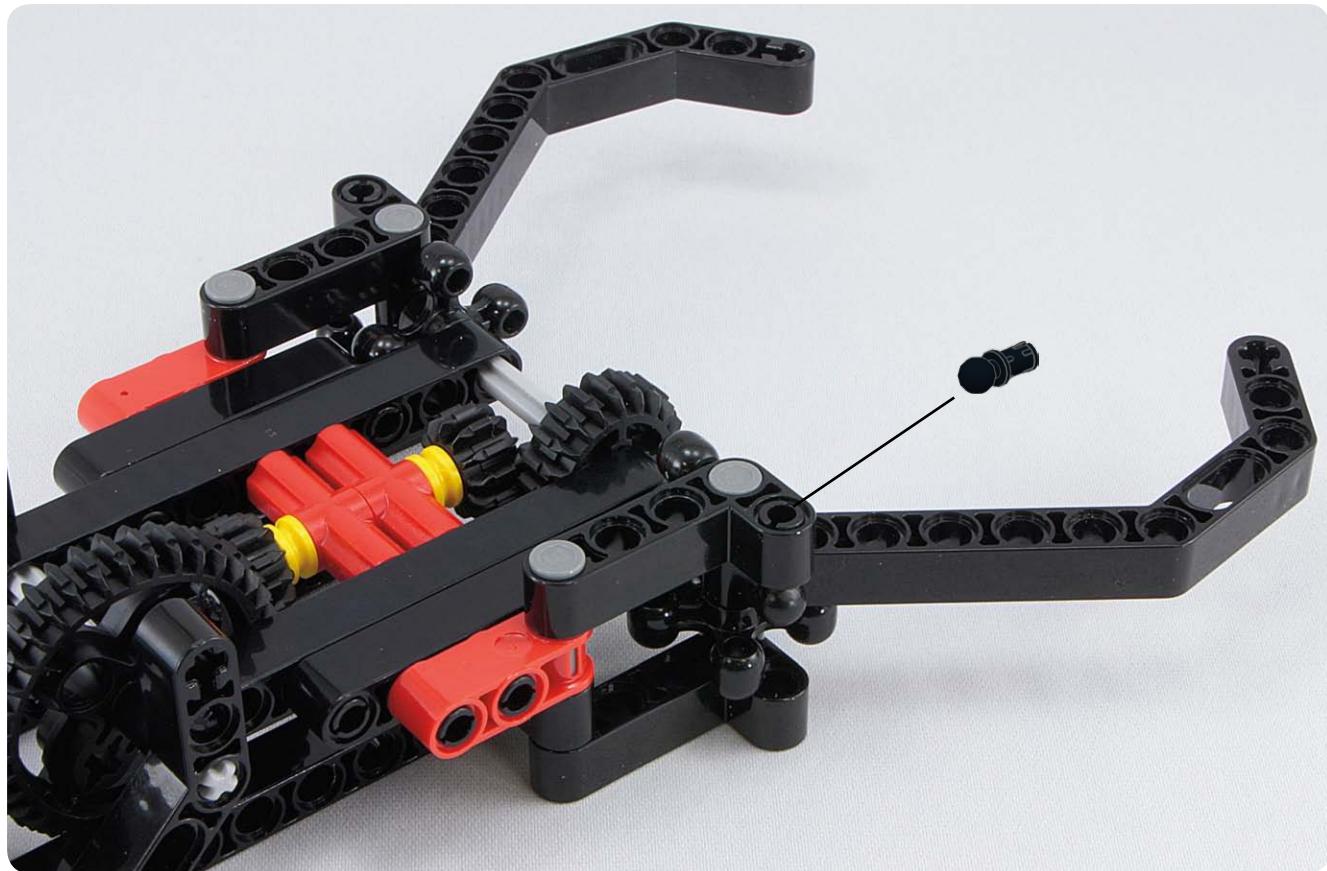
To avoid overextending the mechanism, use this program instead of the standard one.

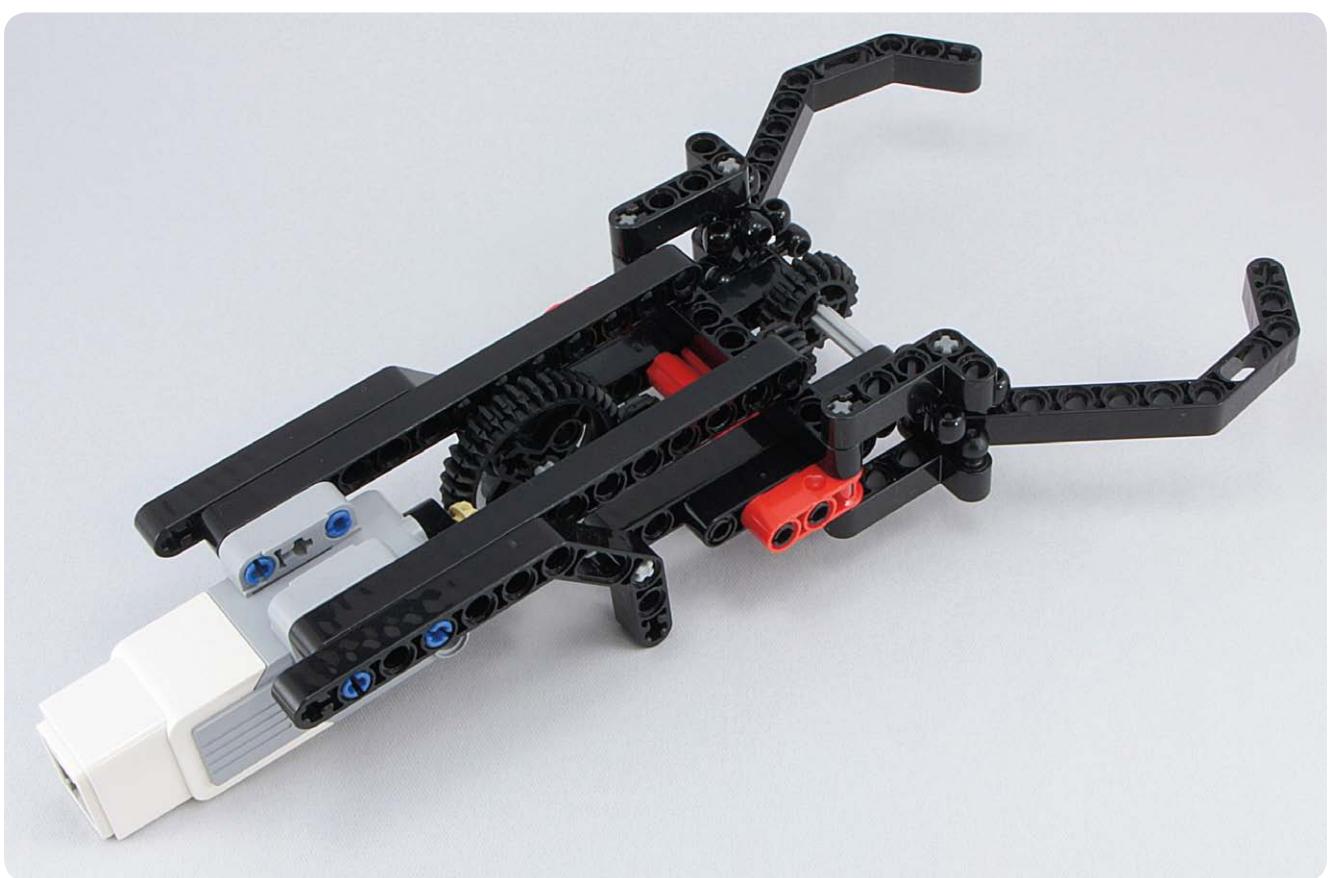
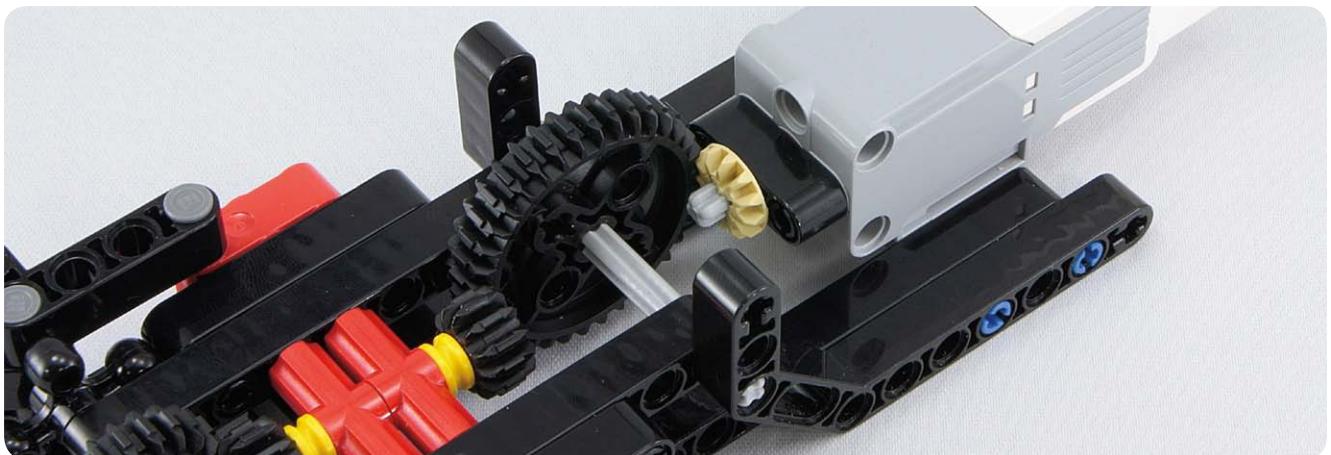


#139

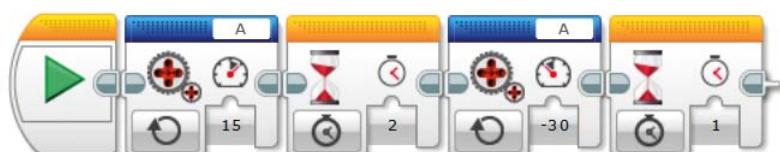


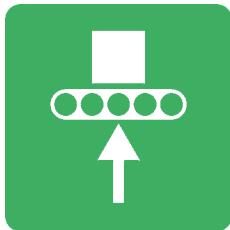






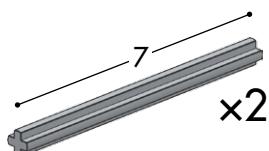
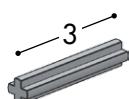
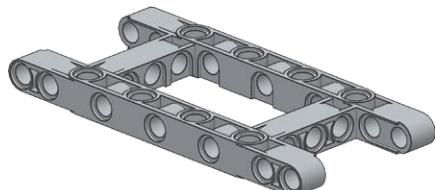
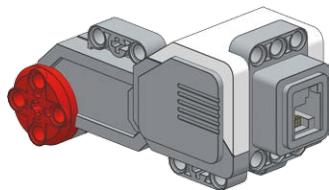
Here's a program
for this arm.

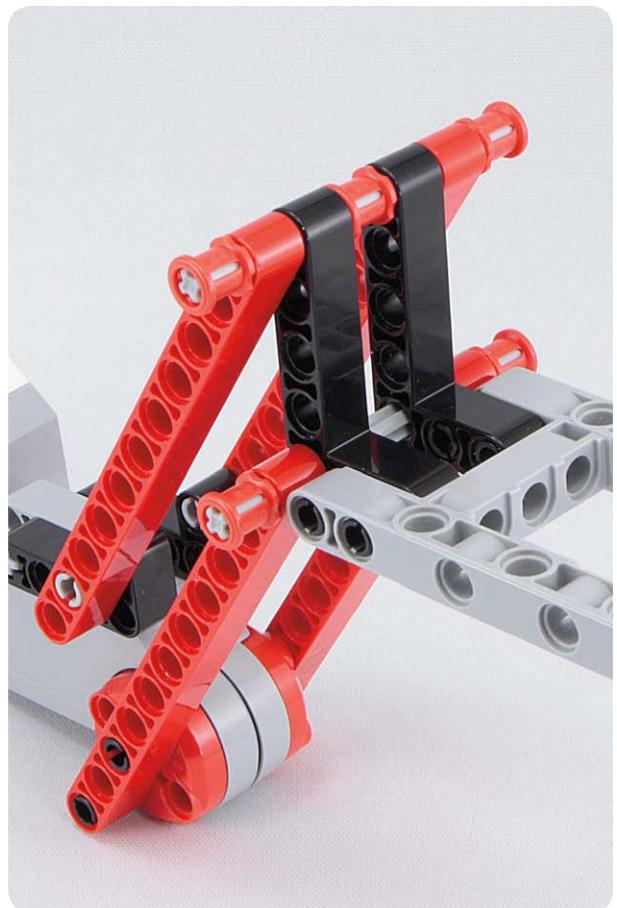
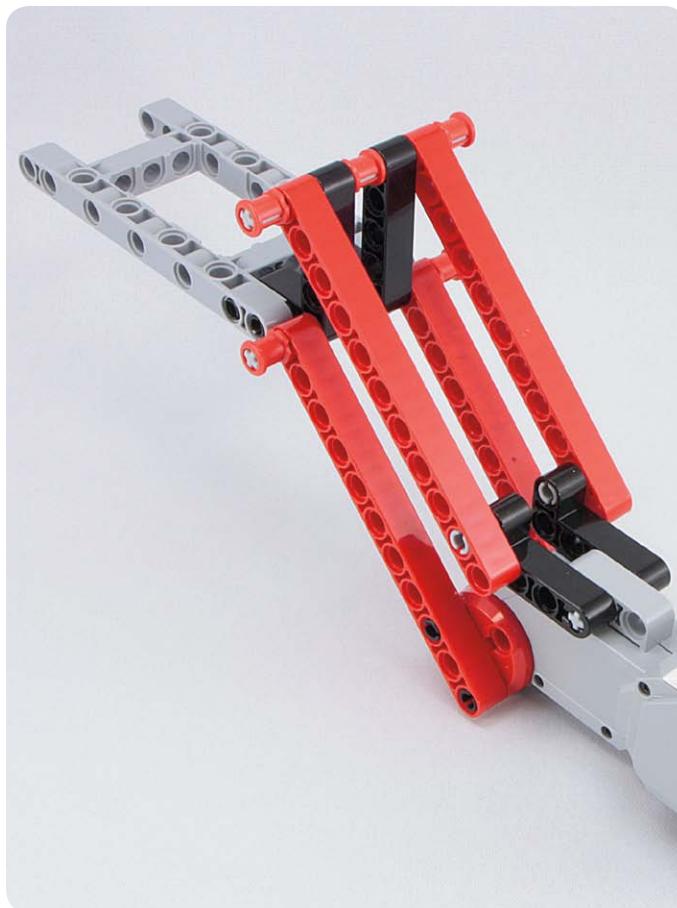
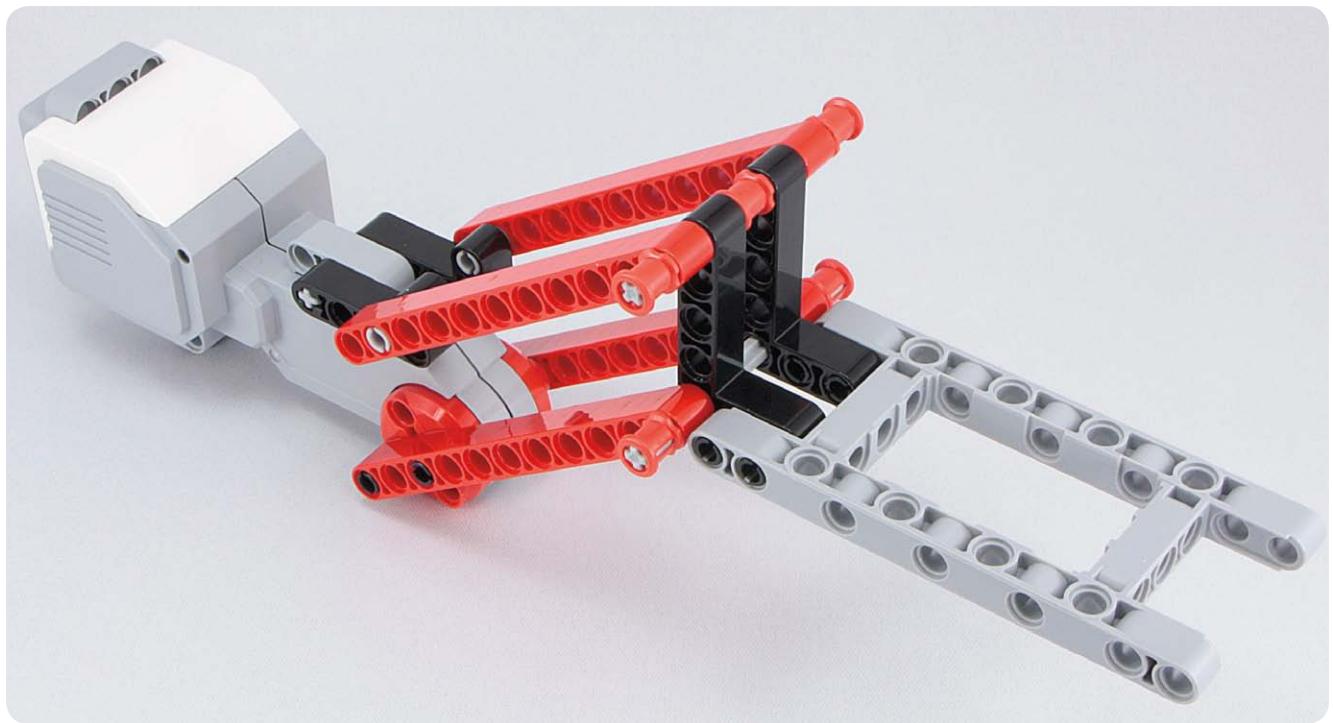




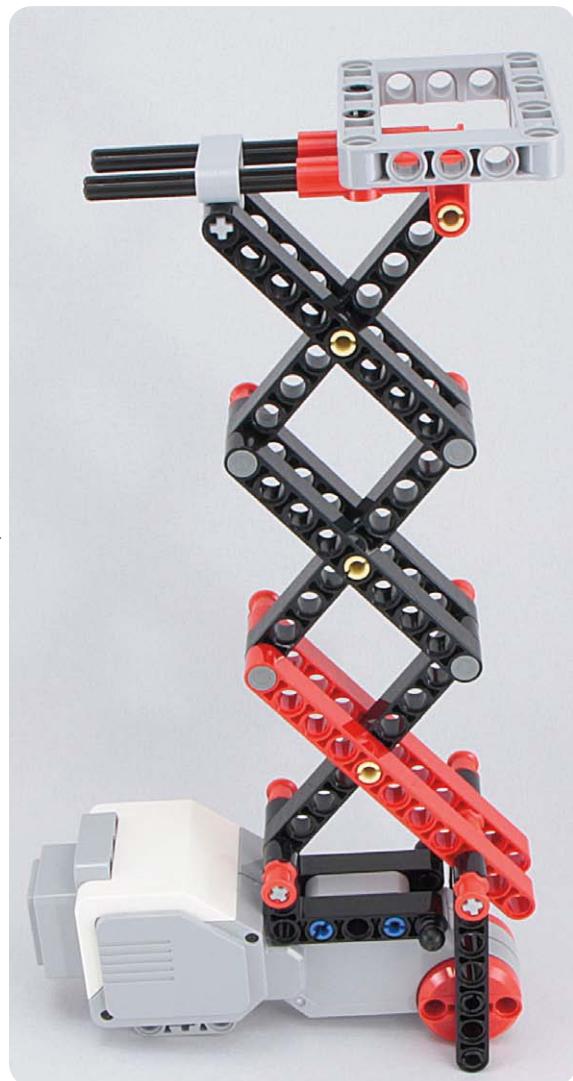
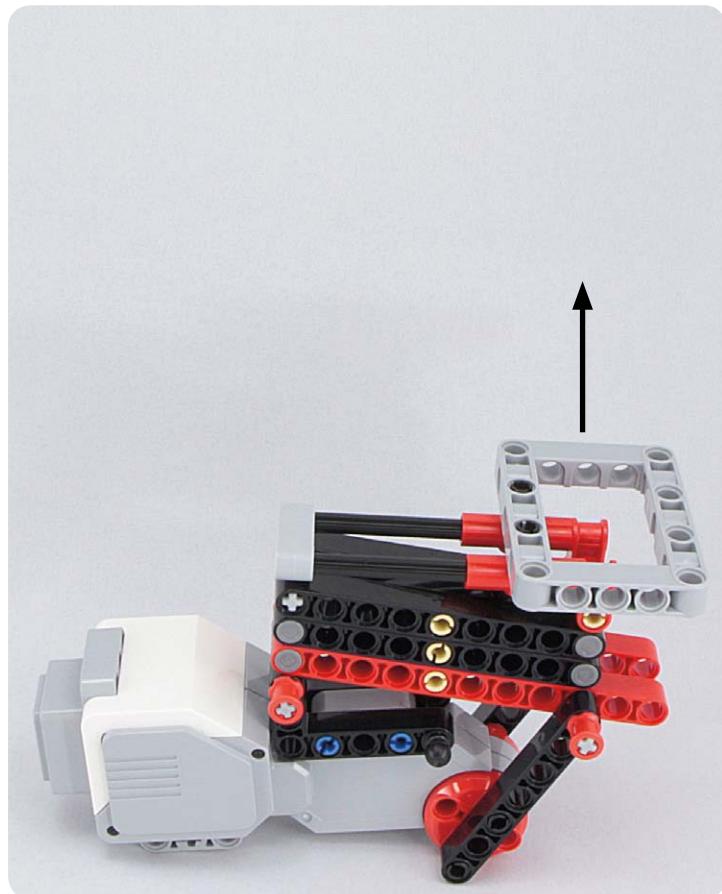
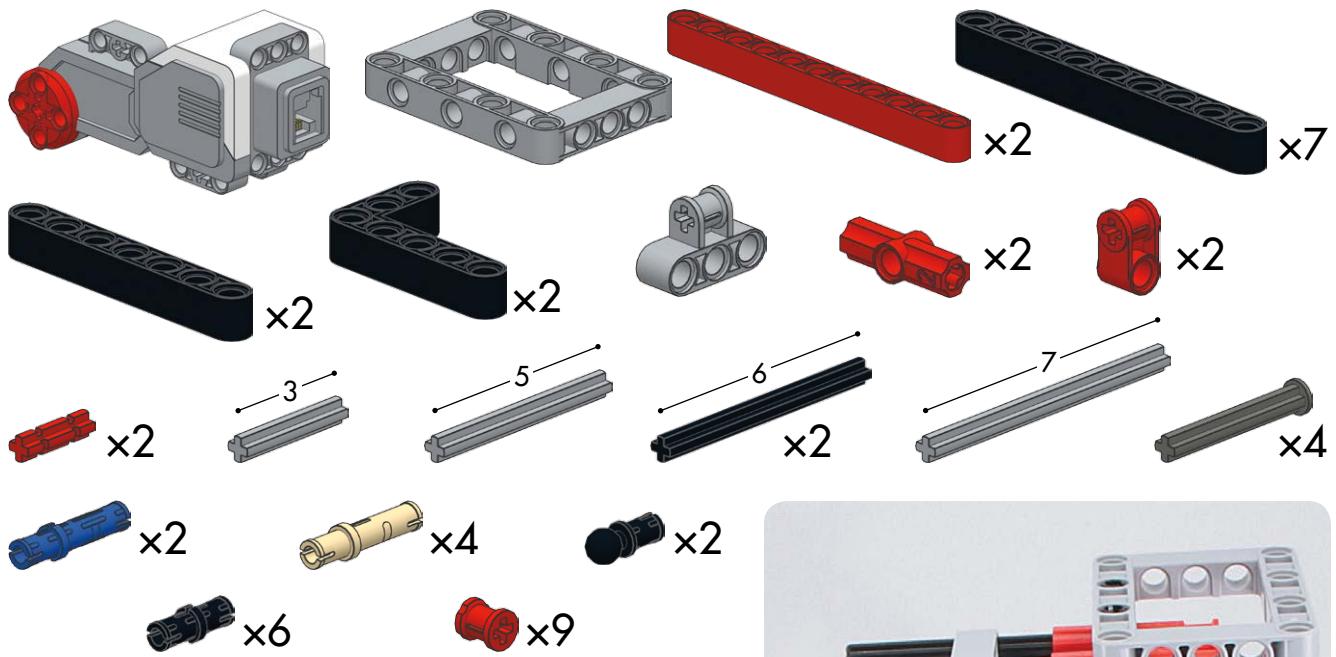
Lifting things

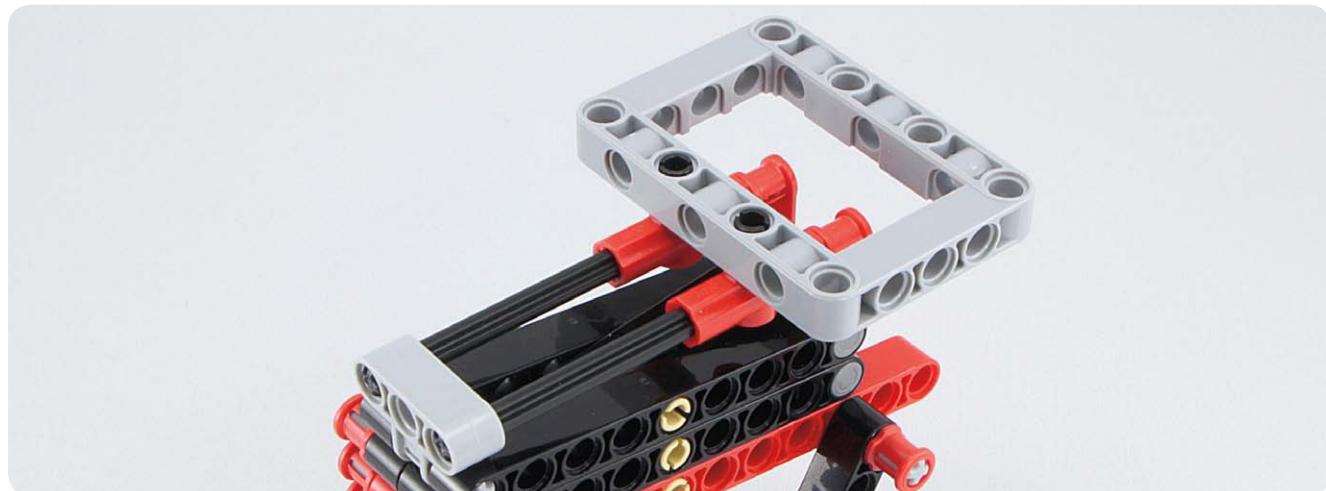
#140





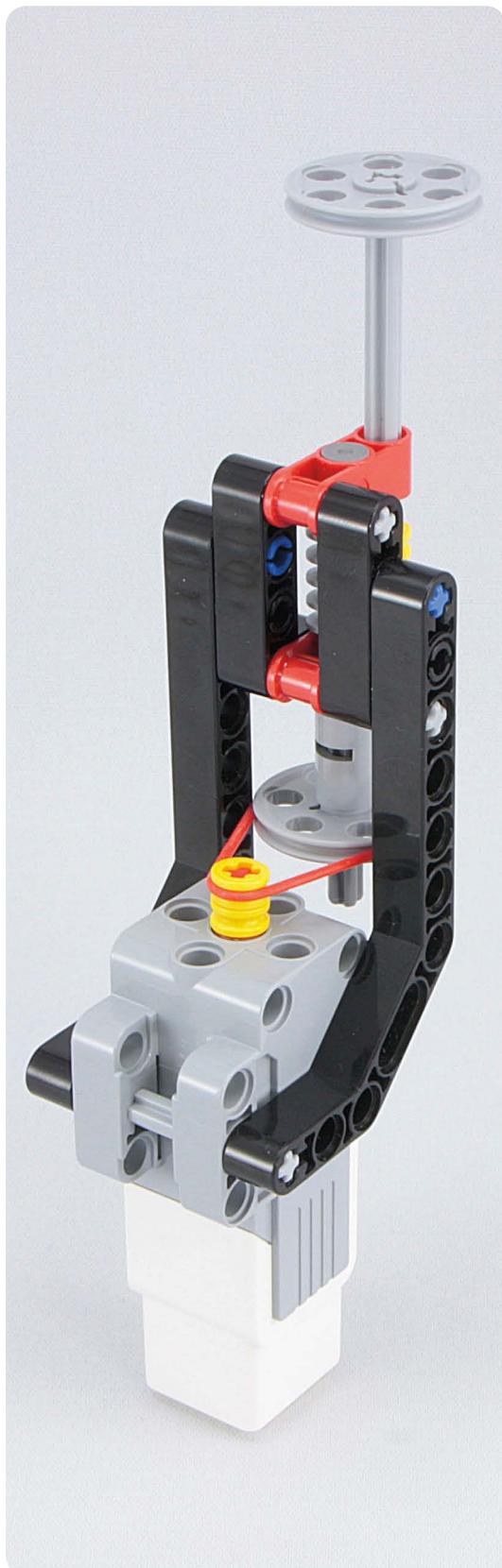
#141

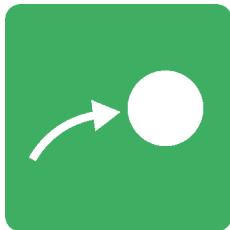




#142

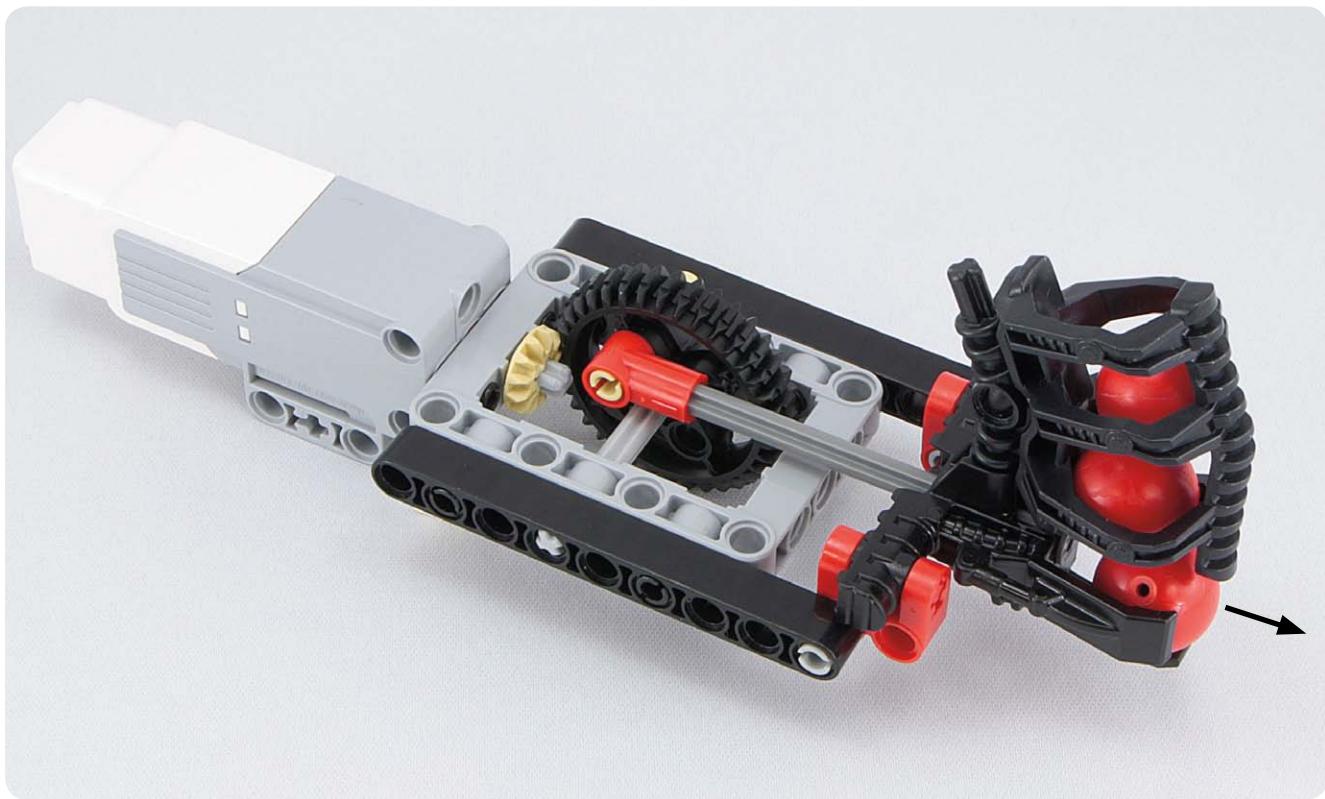
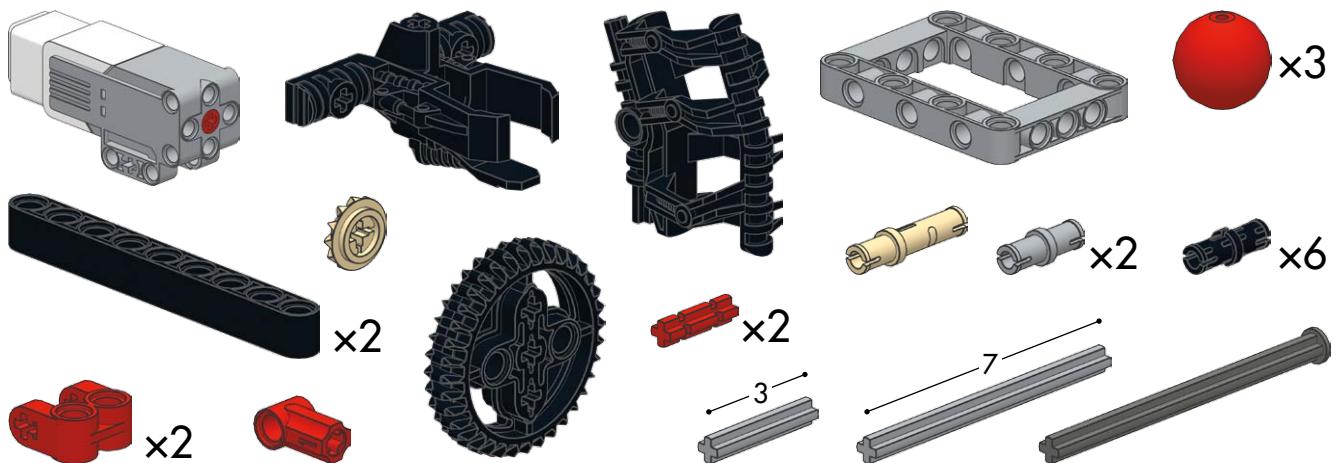


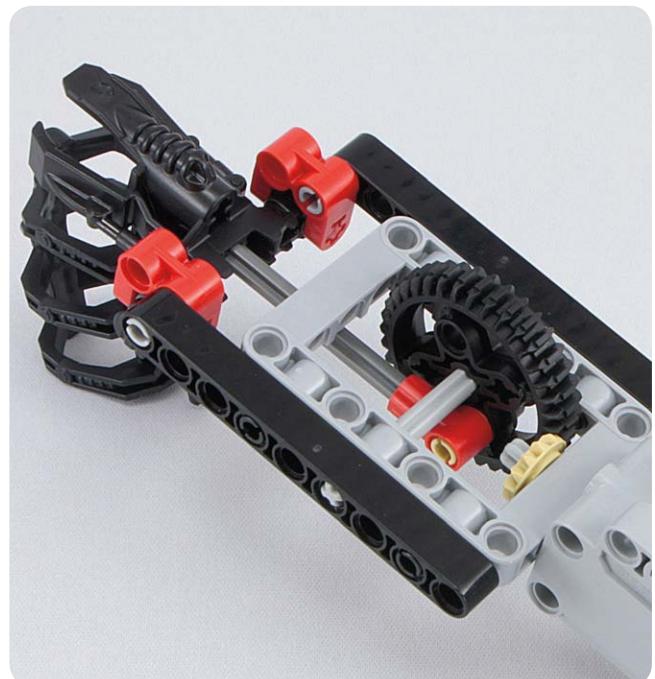
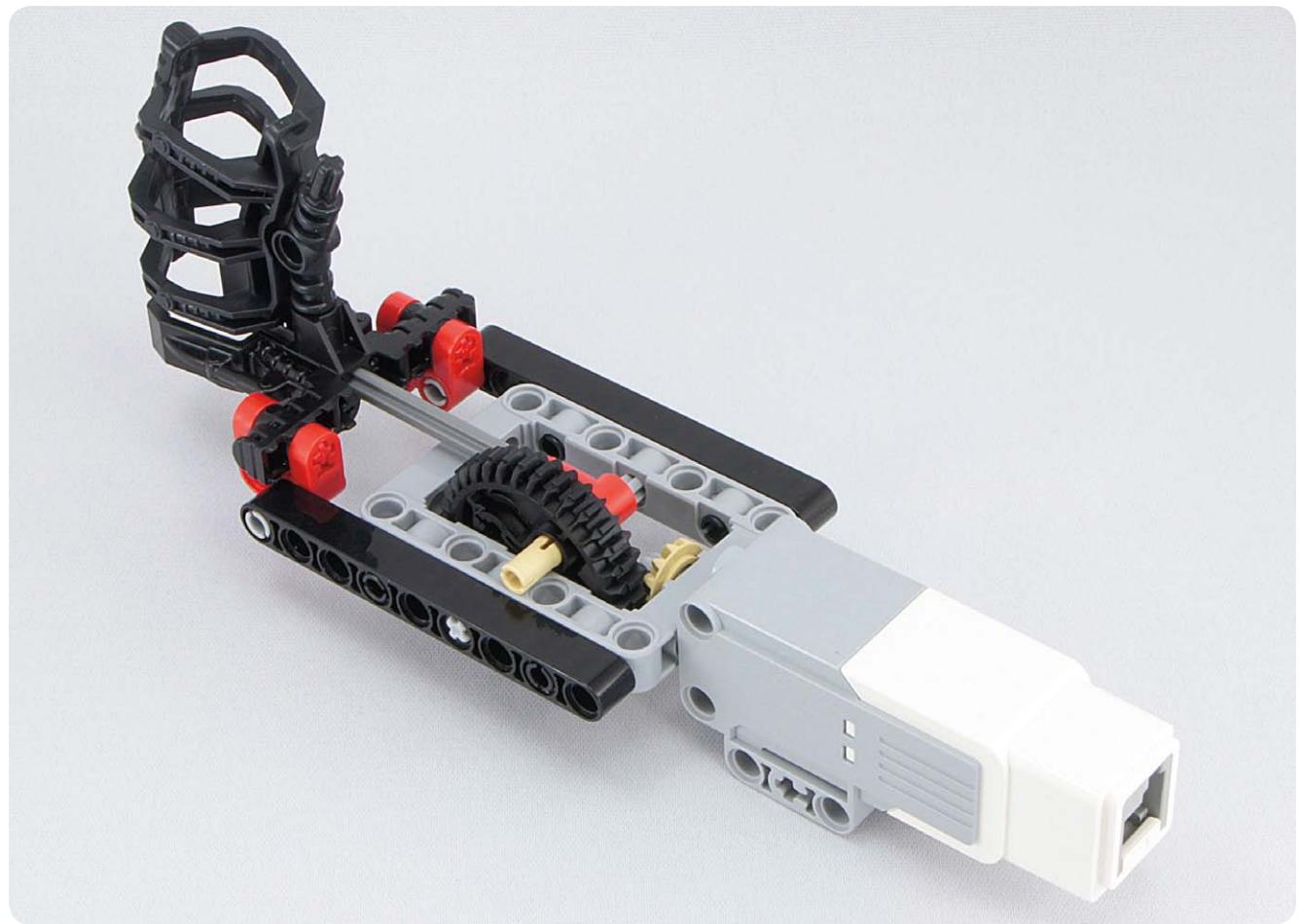




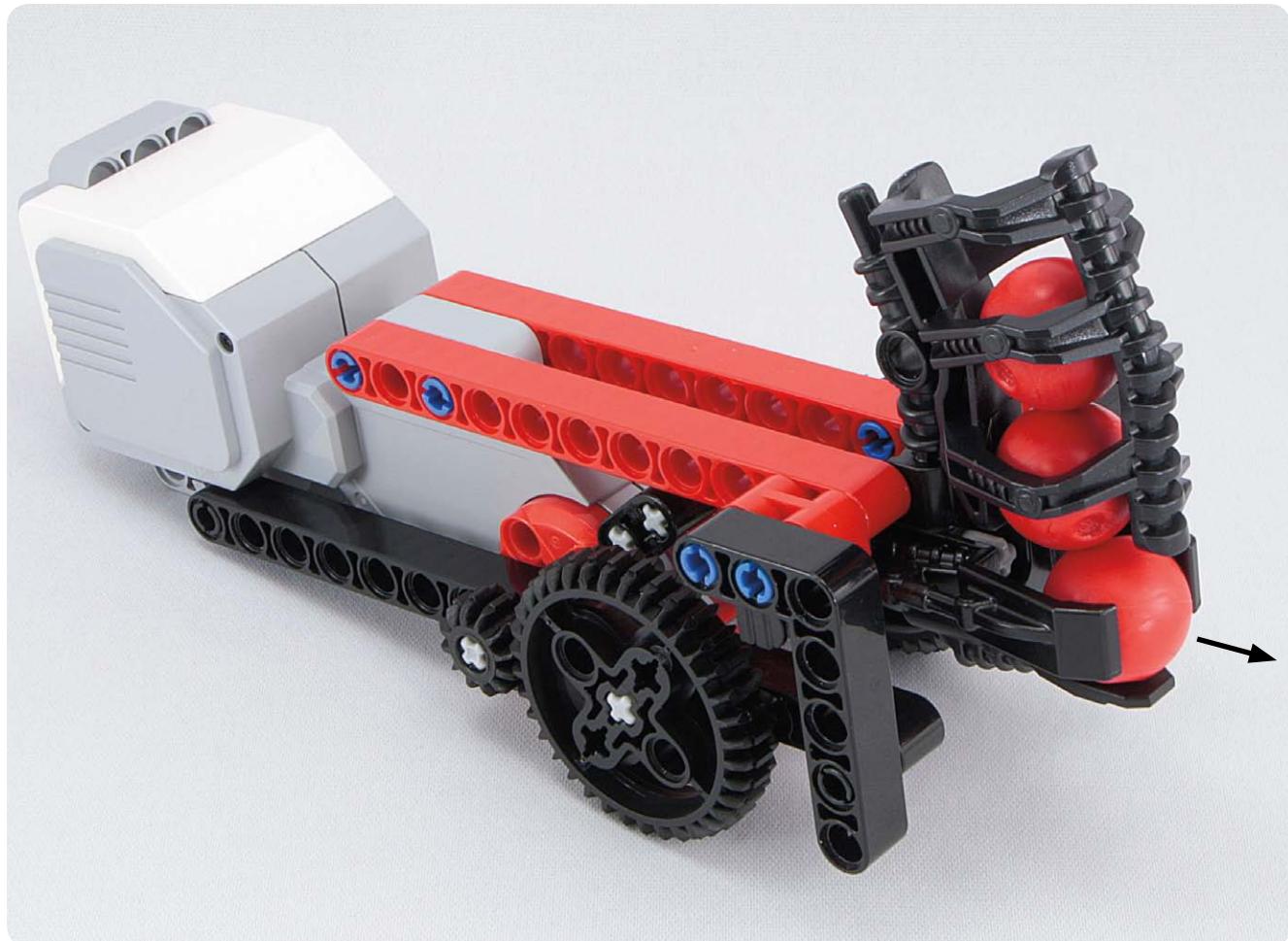
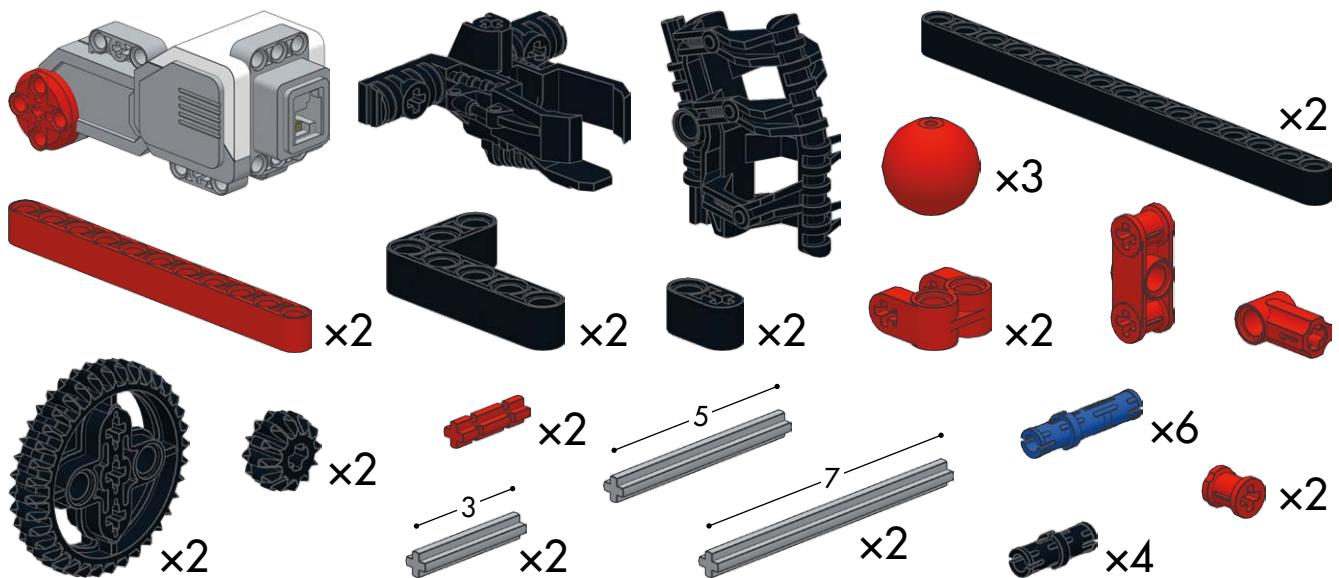
Shooting things

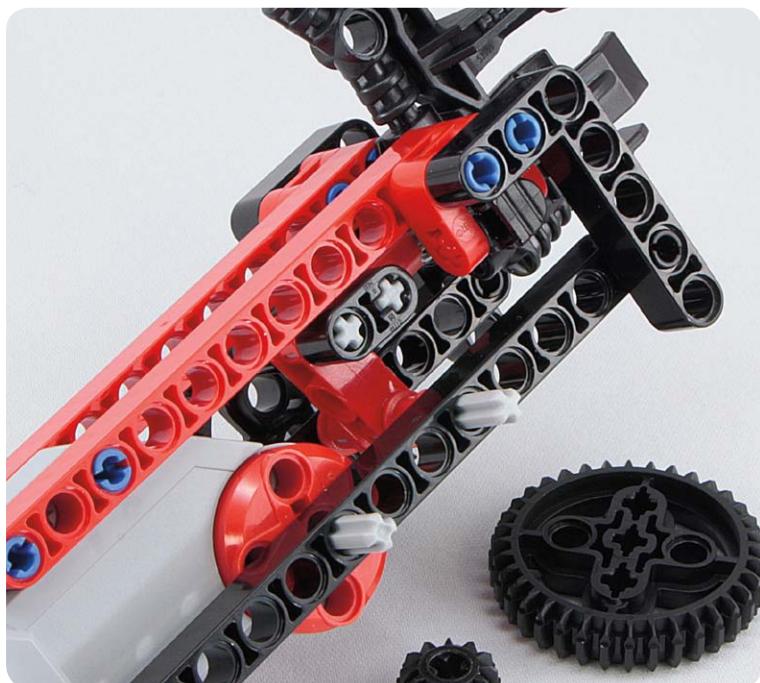
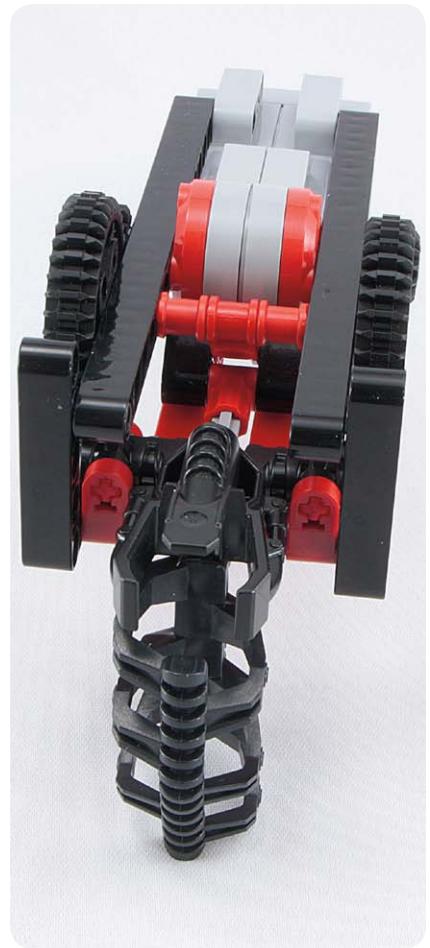
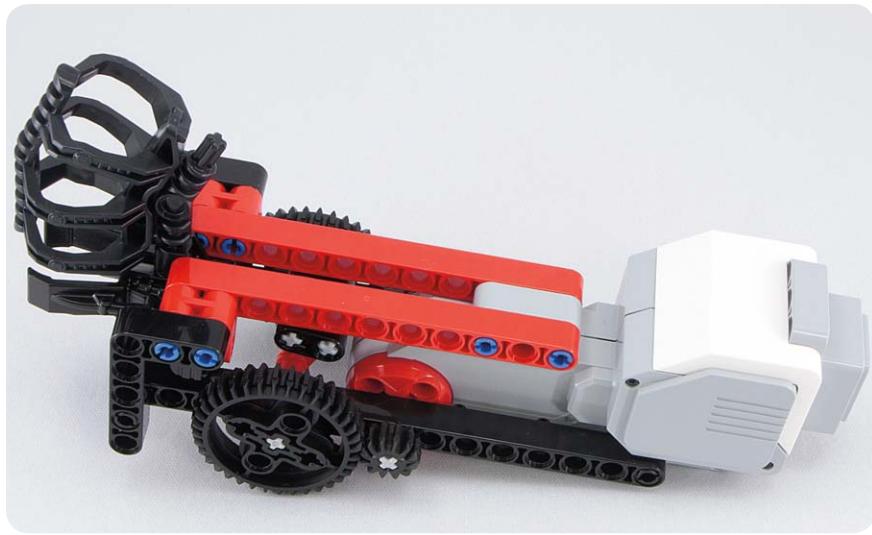
#143



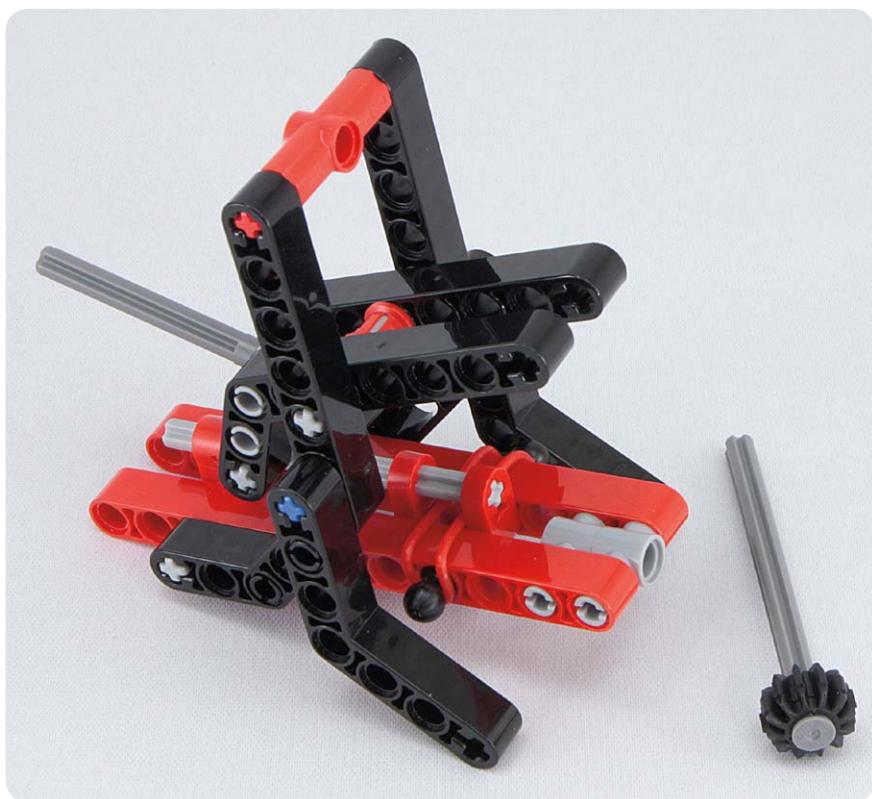
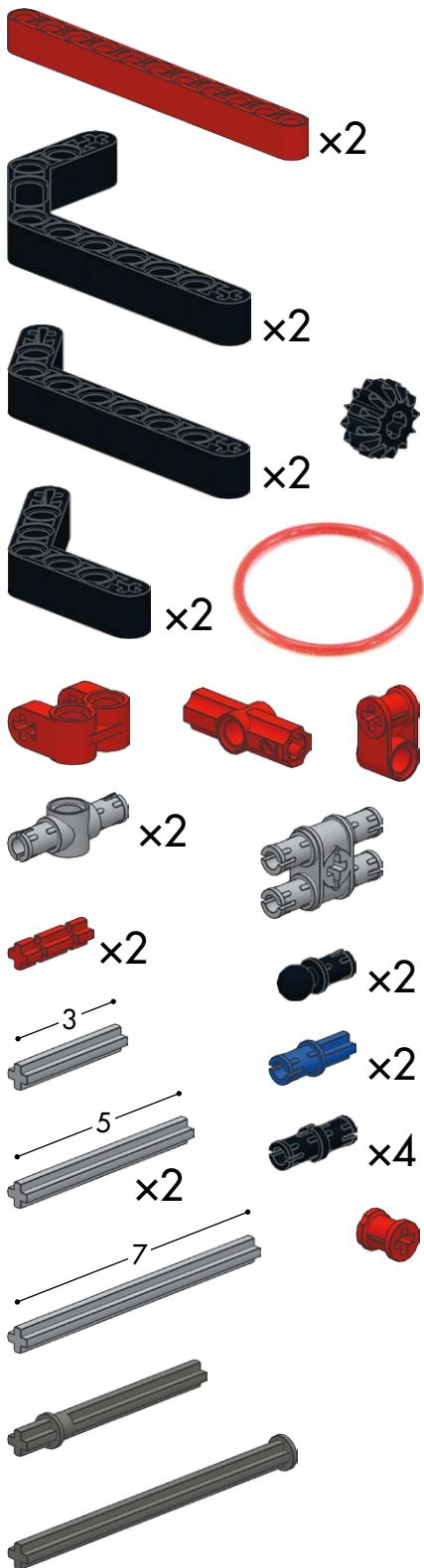


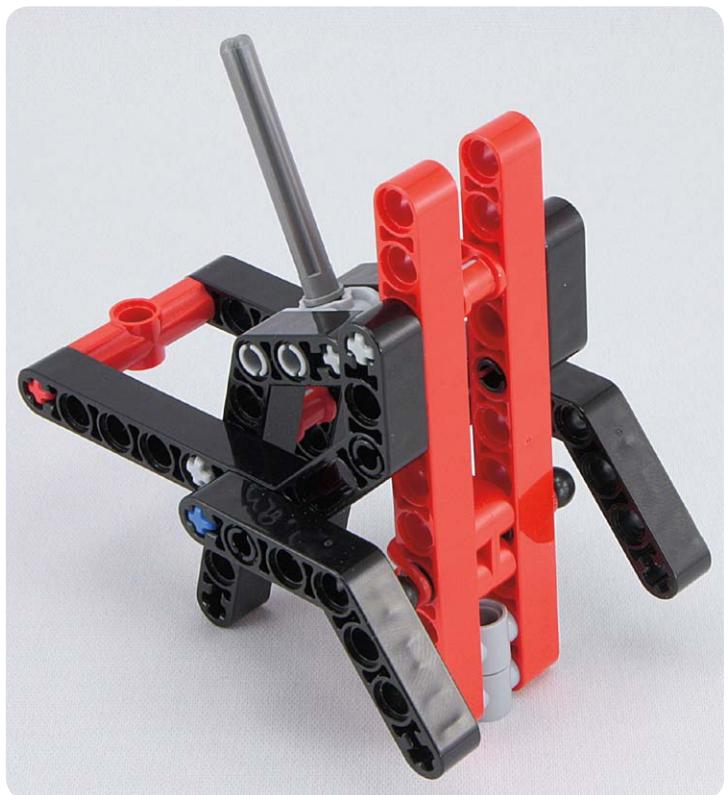
#144





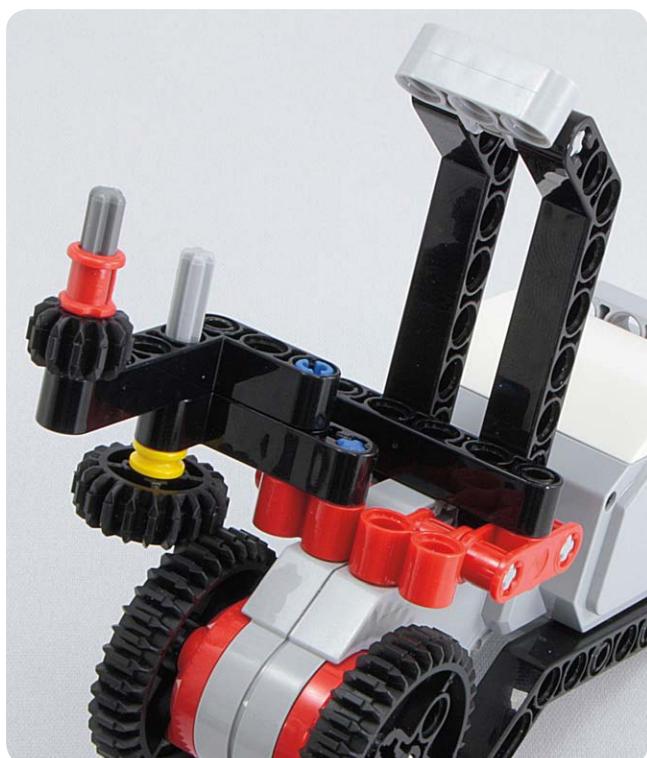
#145



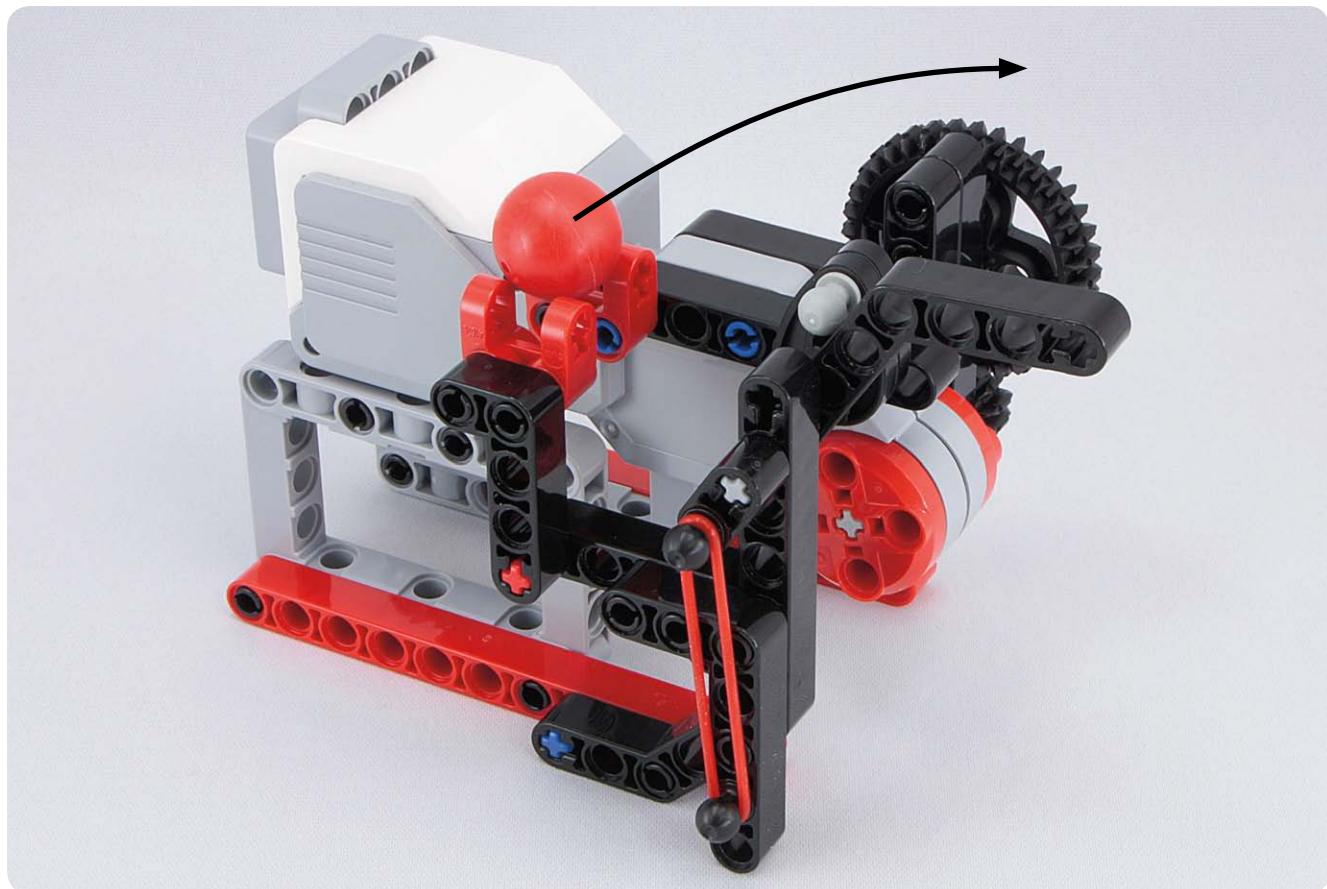
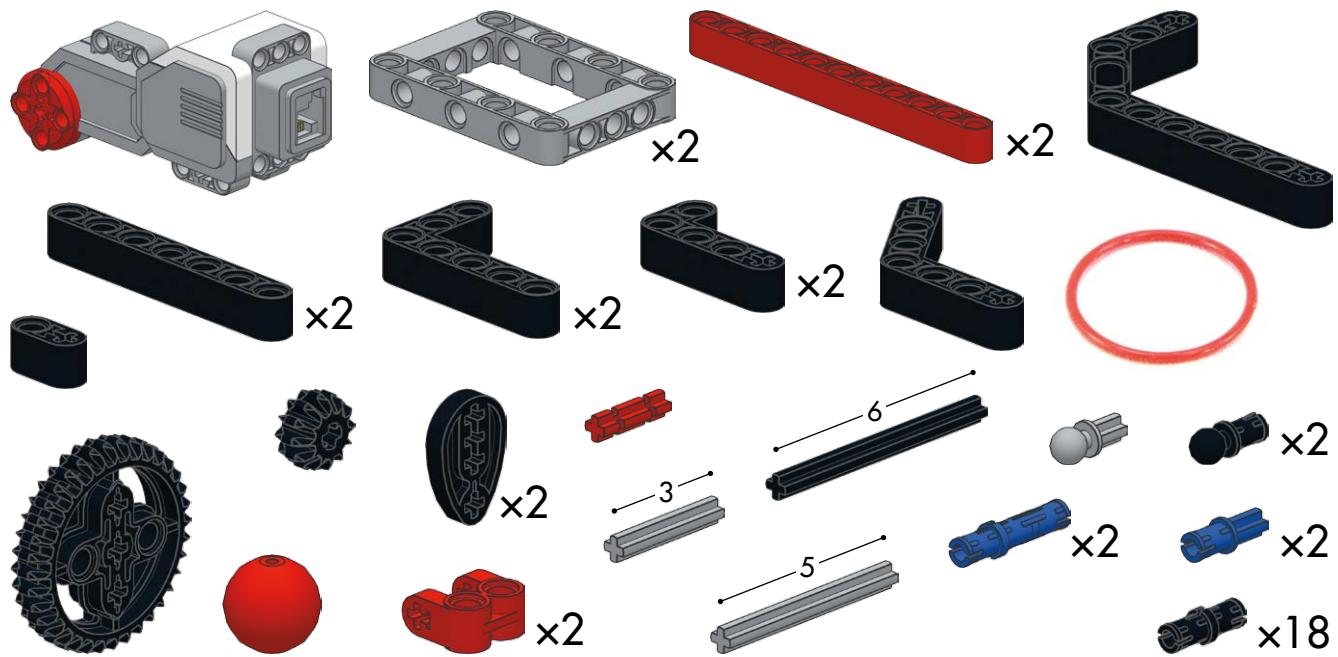


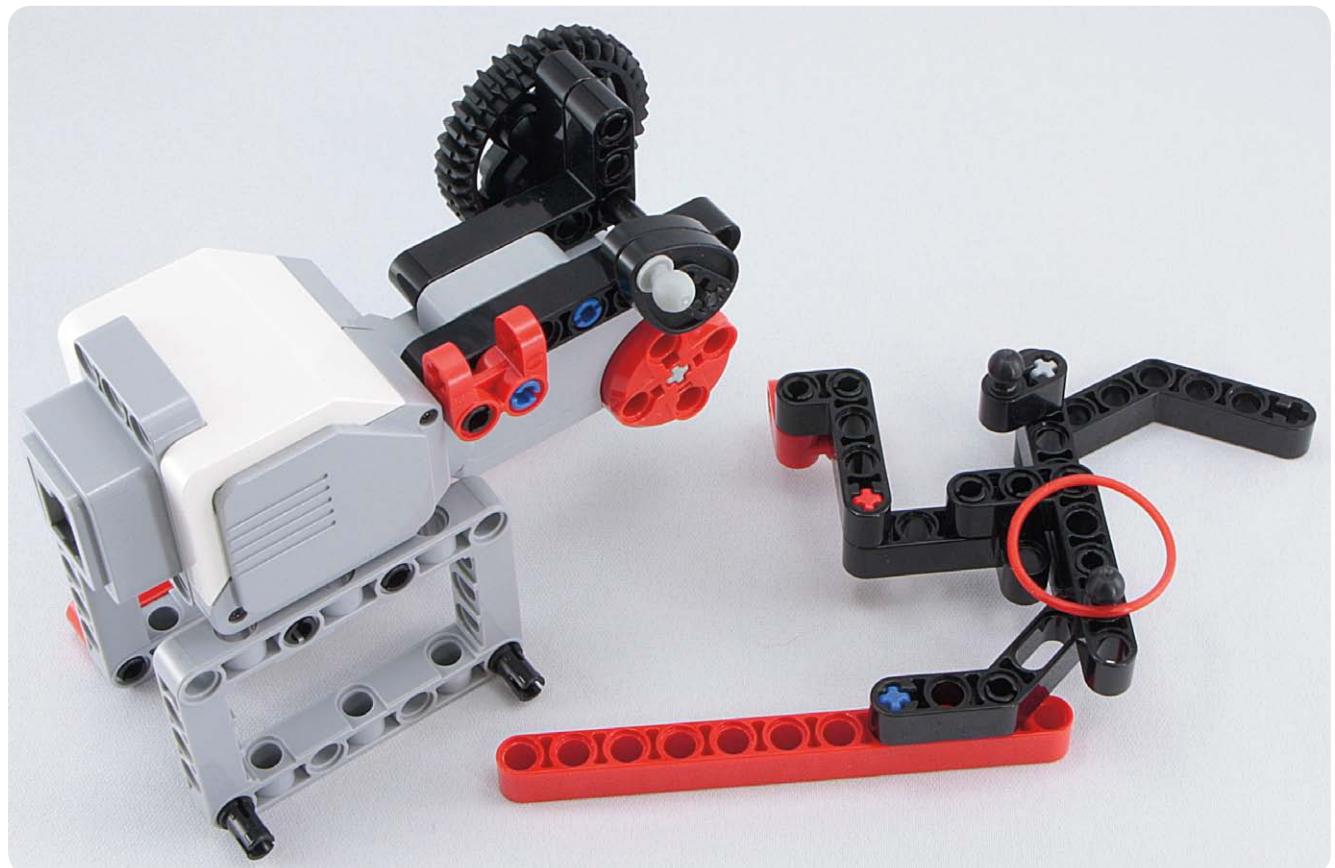
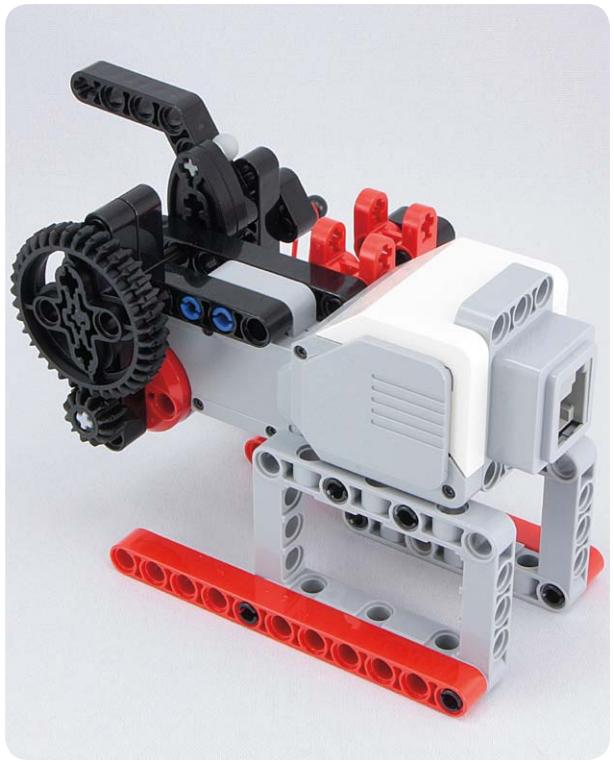
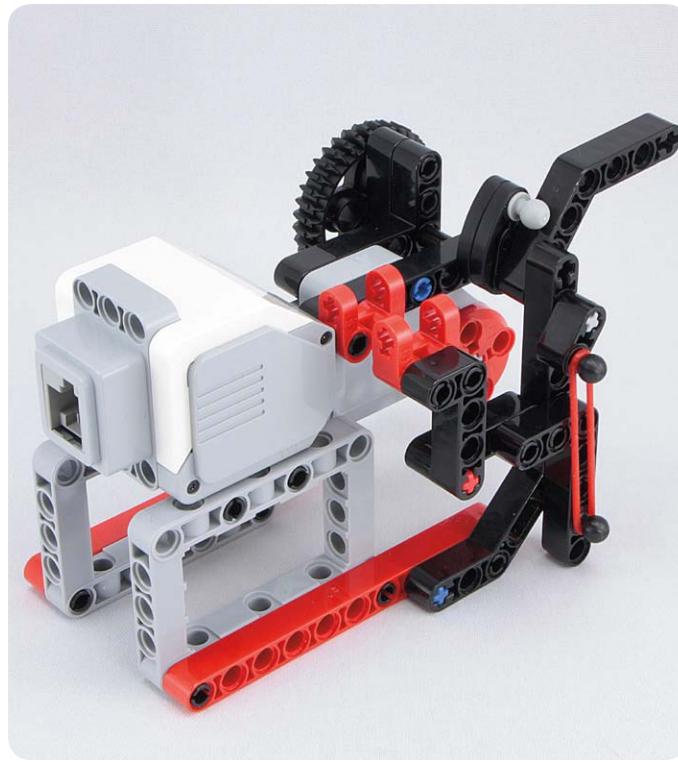
#146

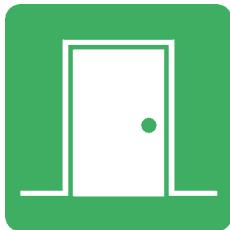




#147

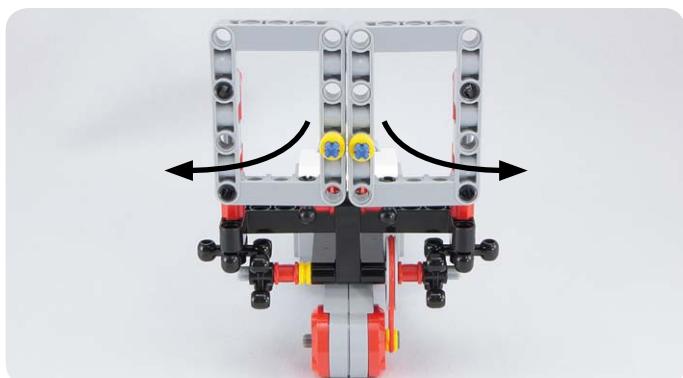
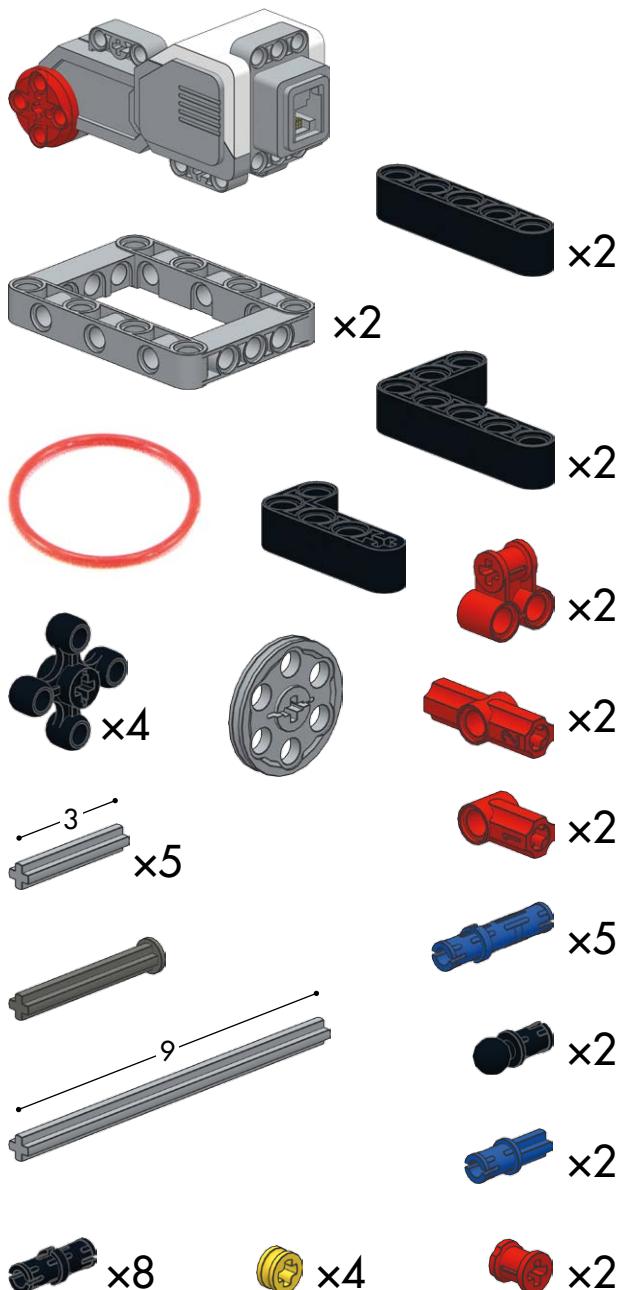


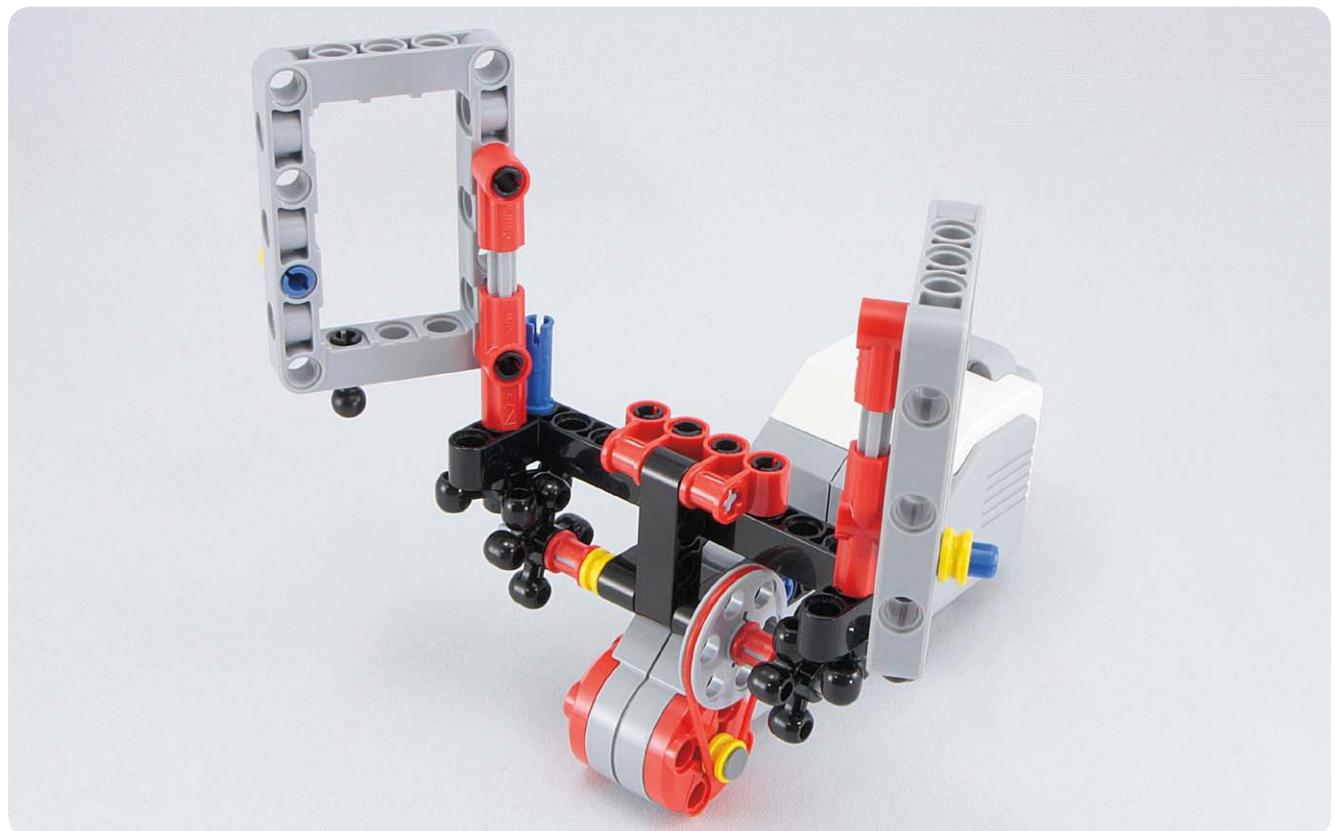
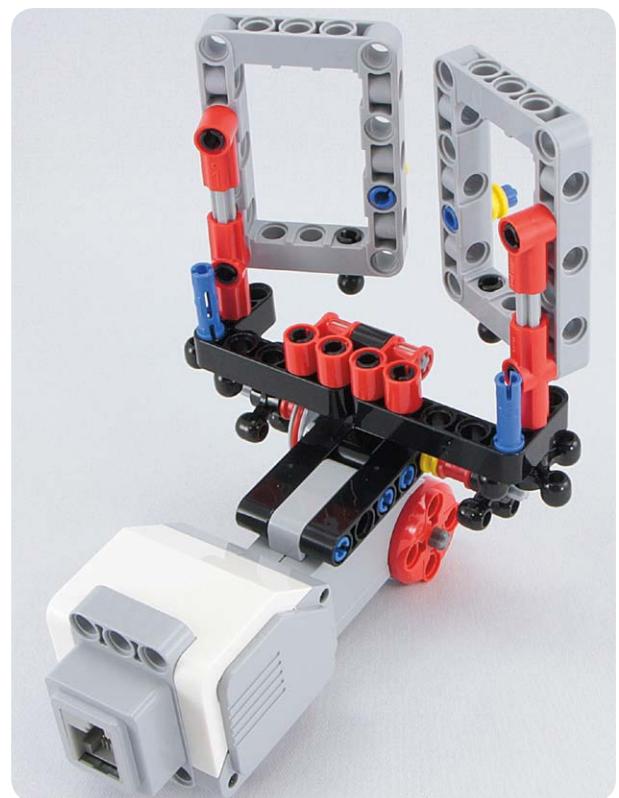
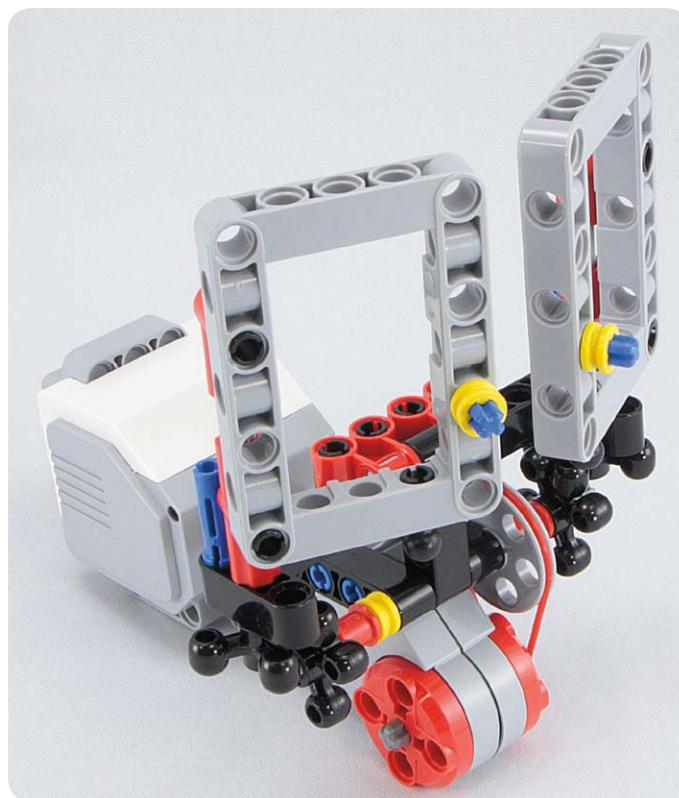




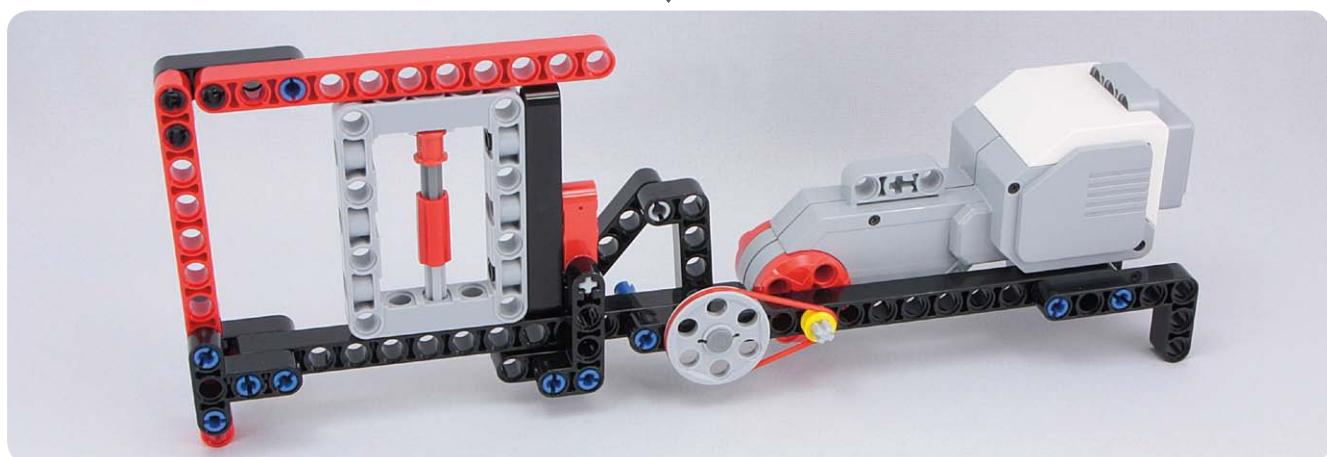
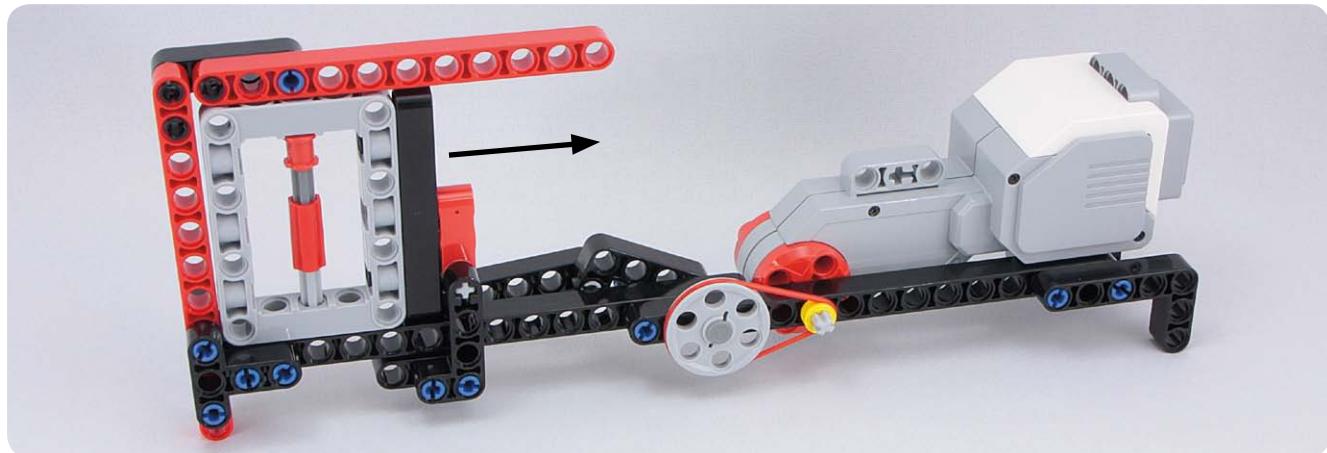
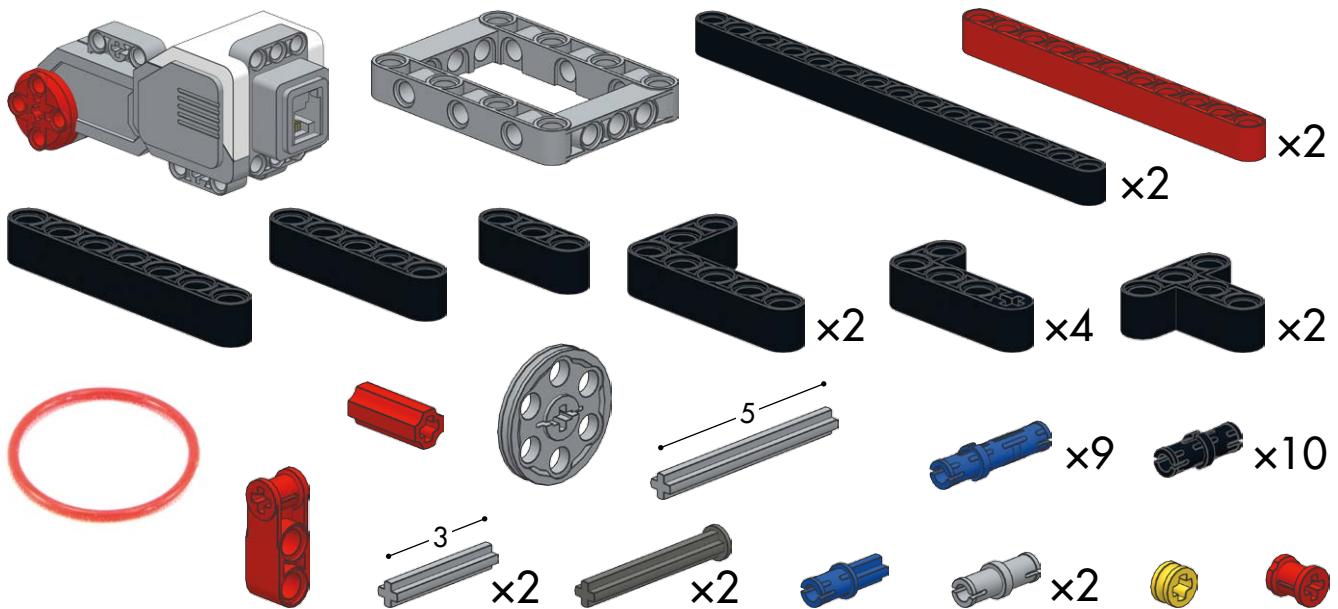
Automatic doors

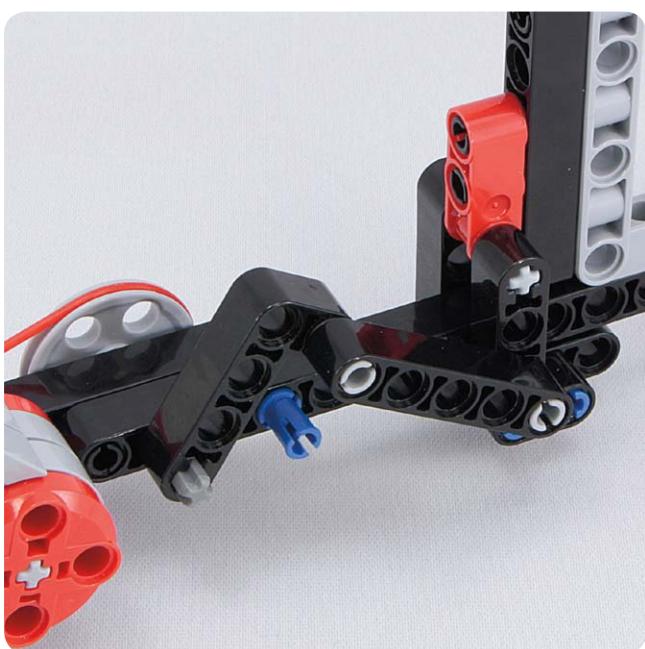
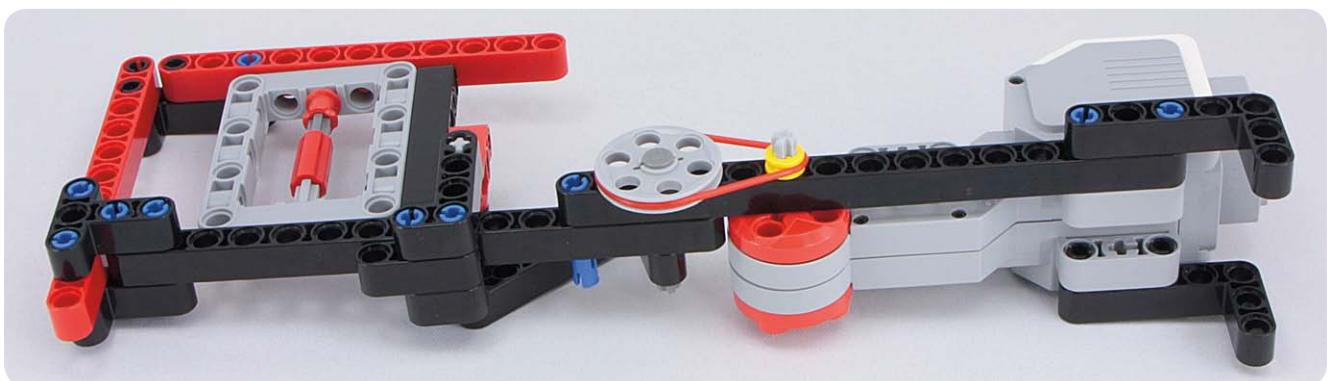
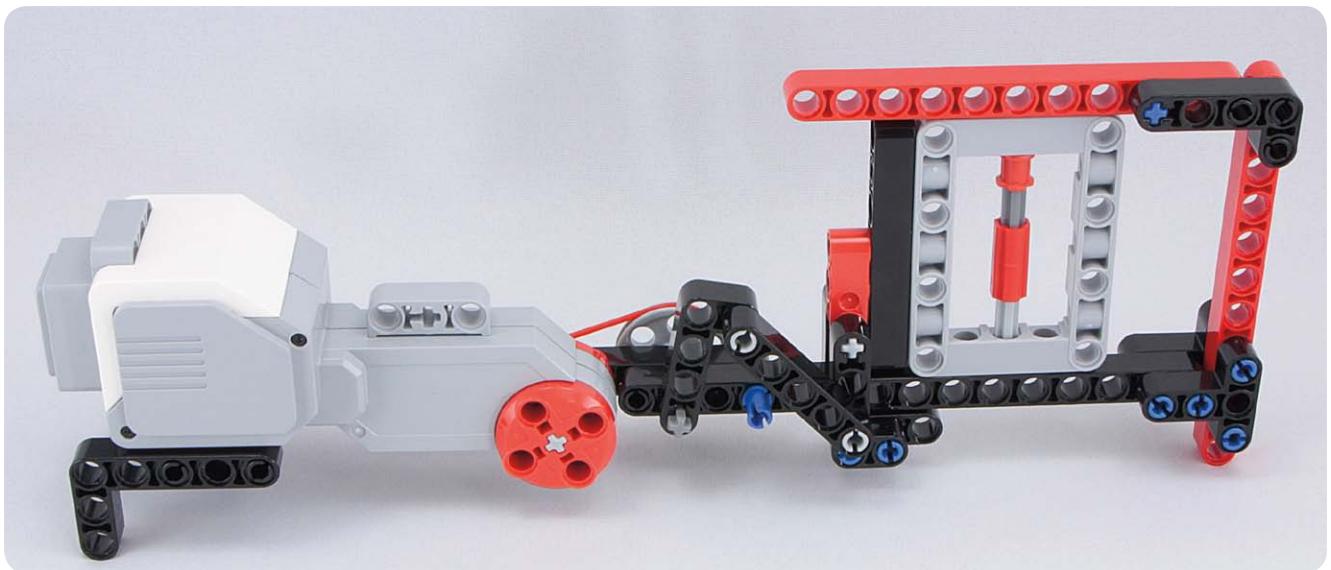
#148



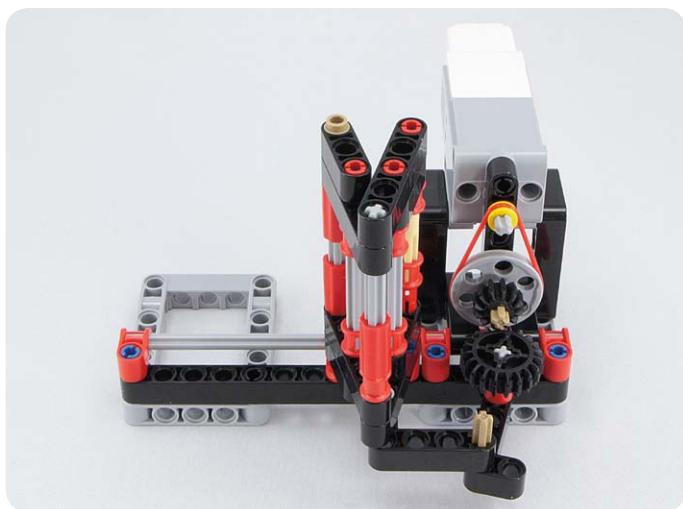
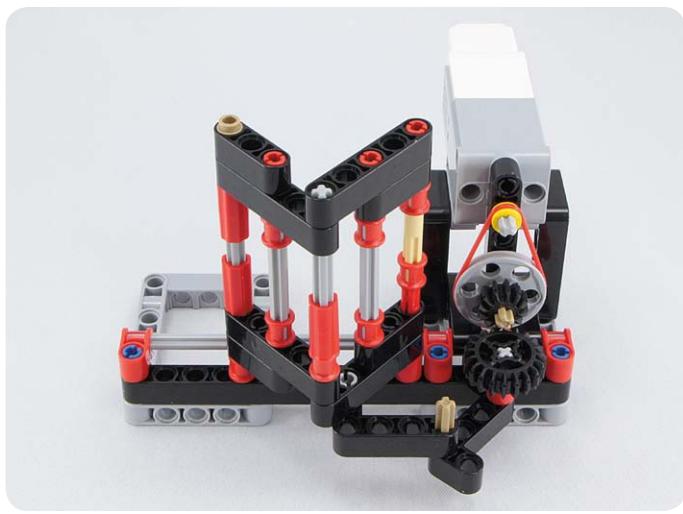
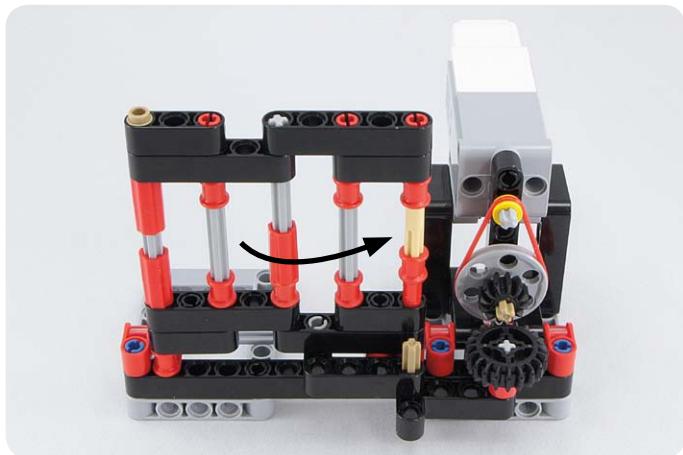


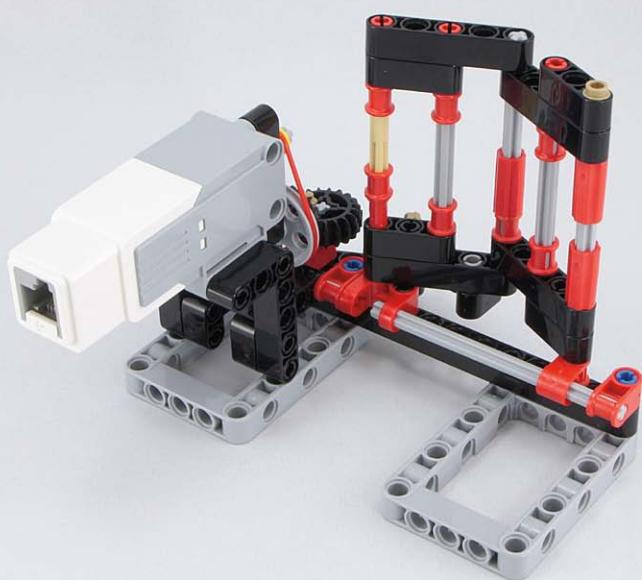
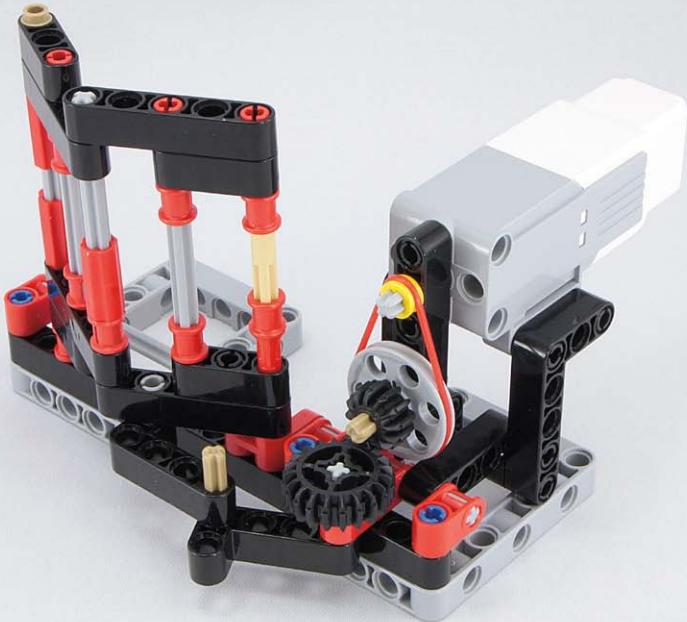
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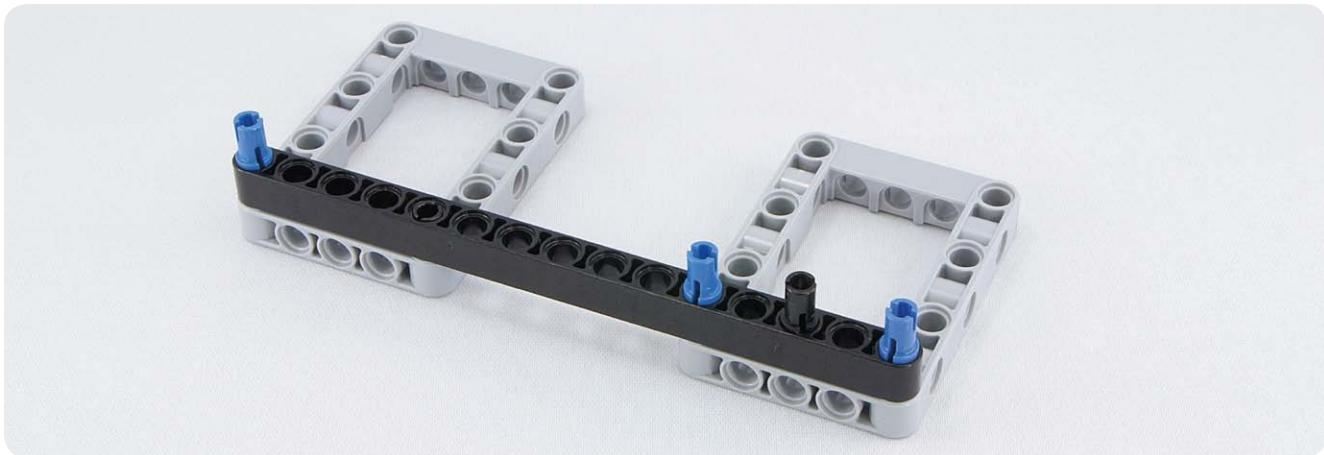


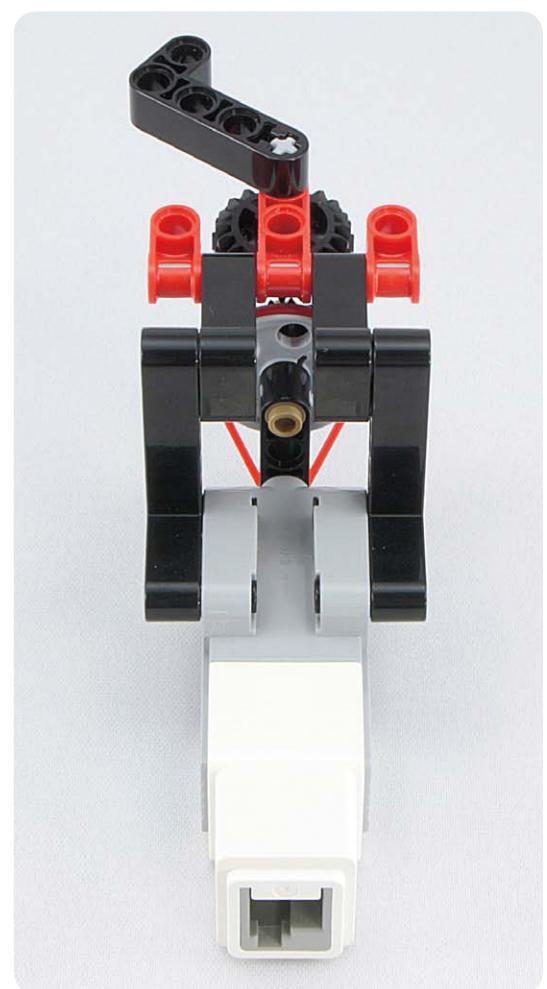


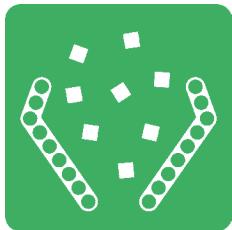
#150





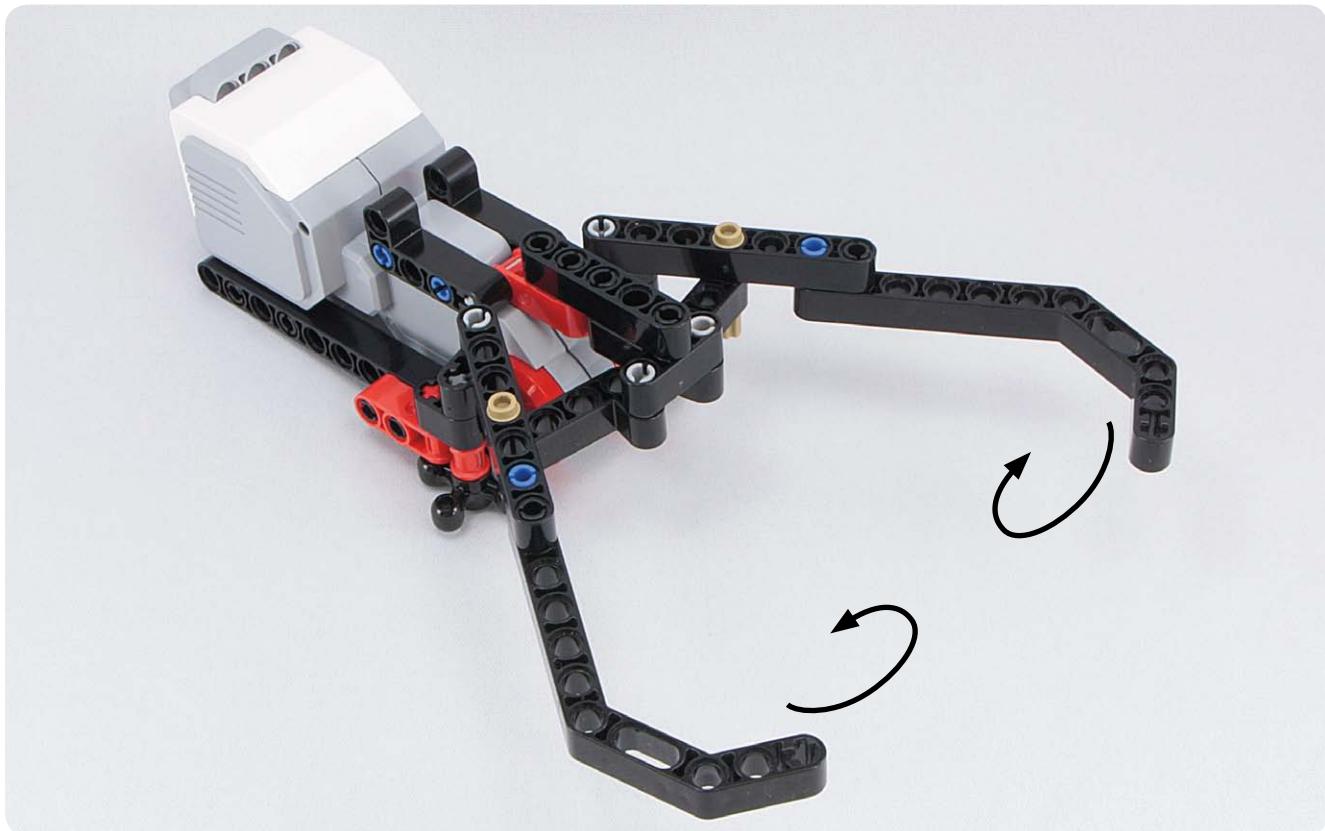
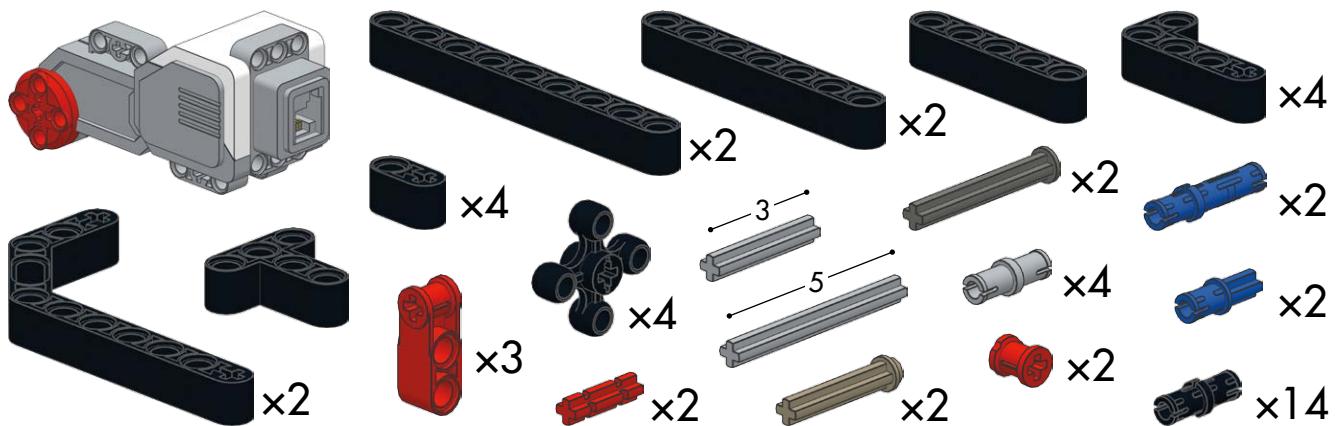


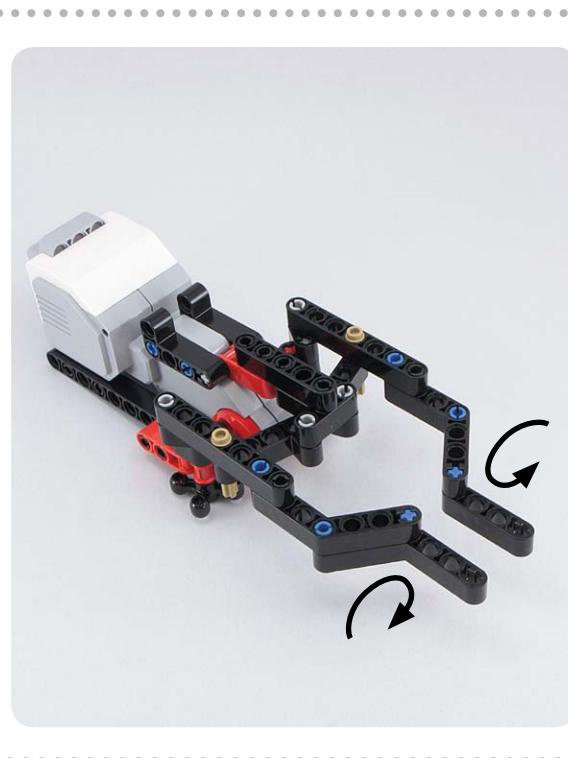
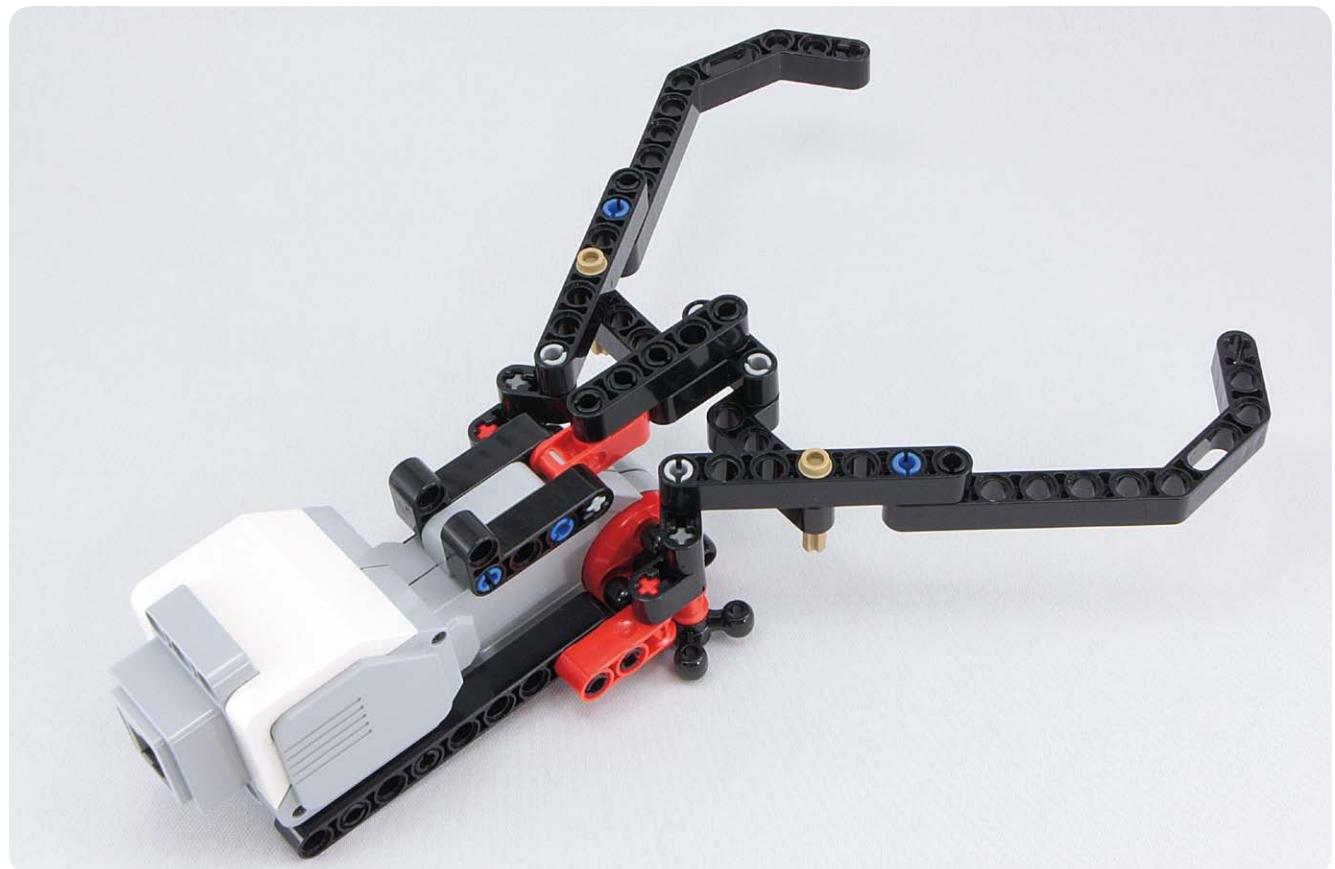




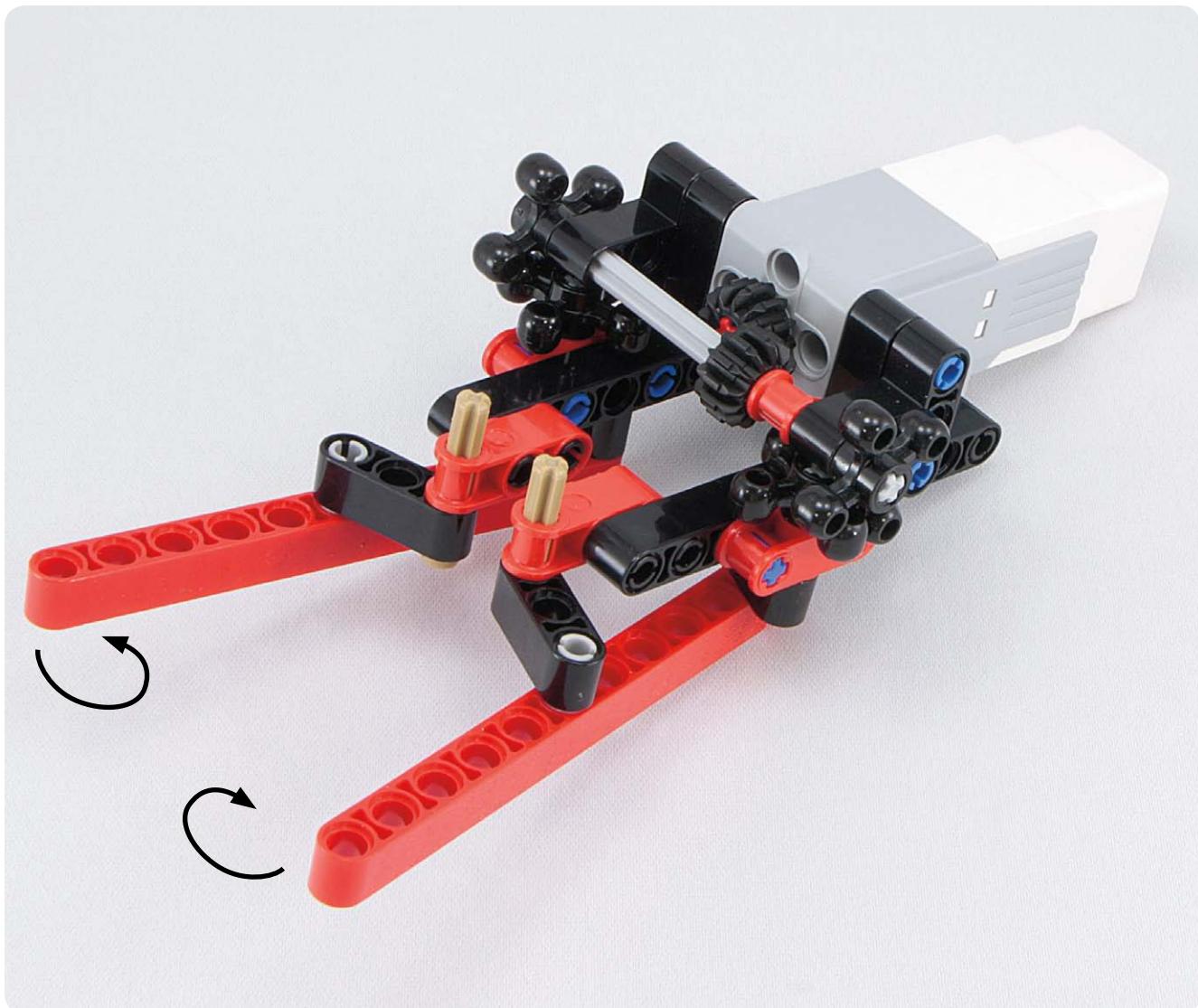
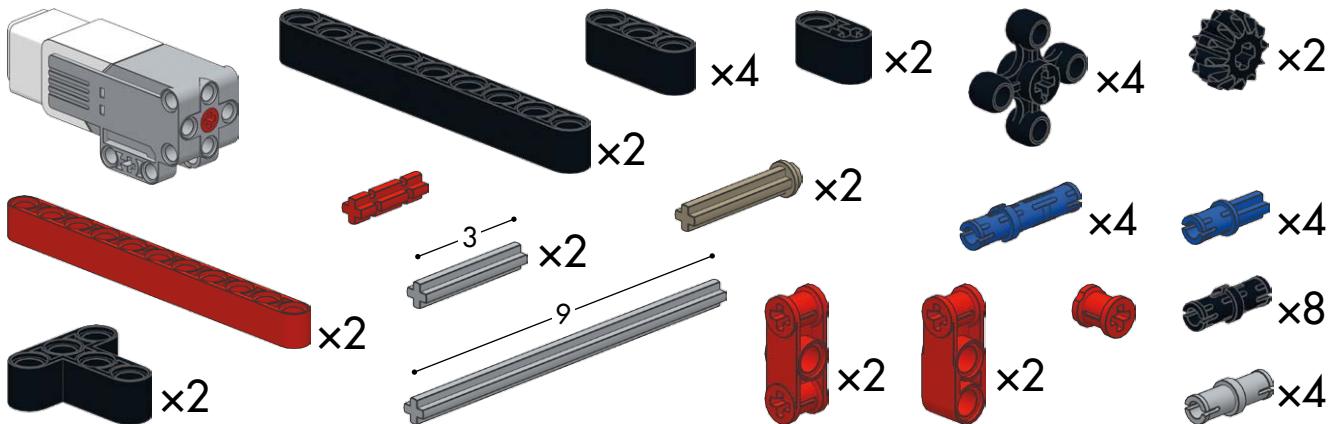
Raking up or out

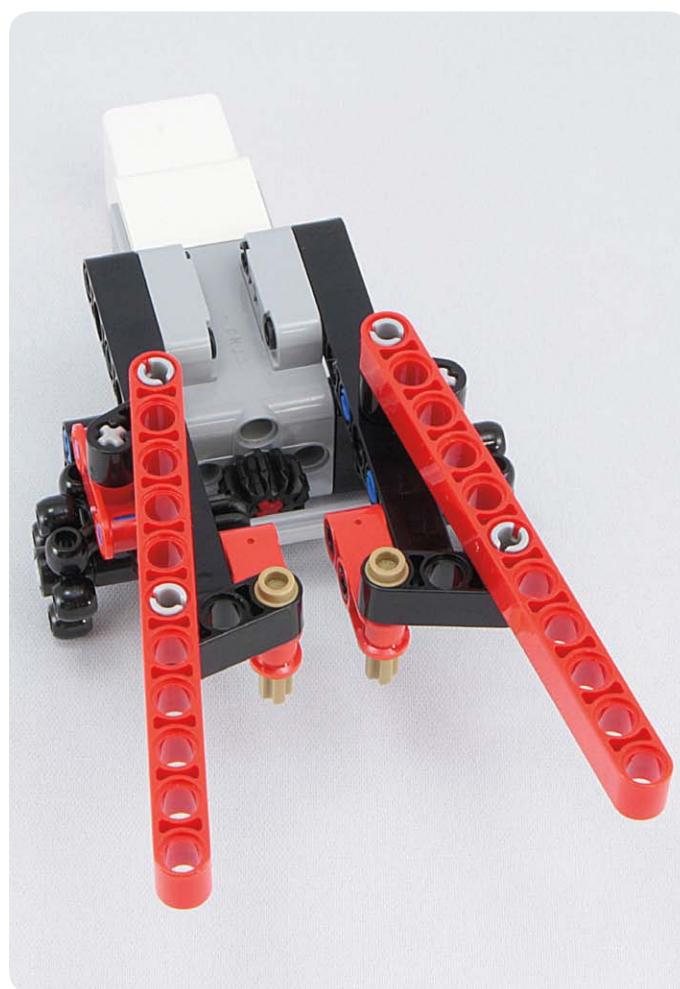
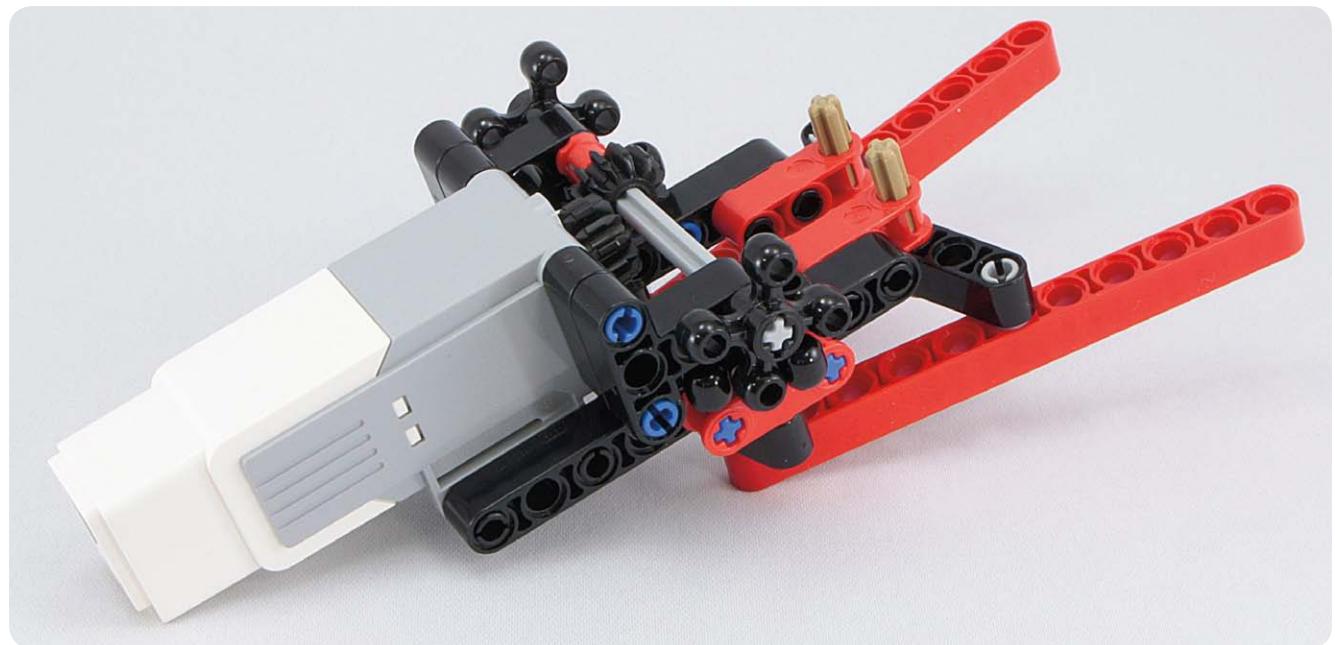
#151





#152

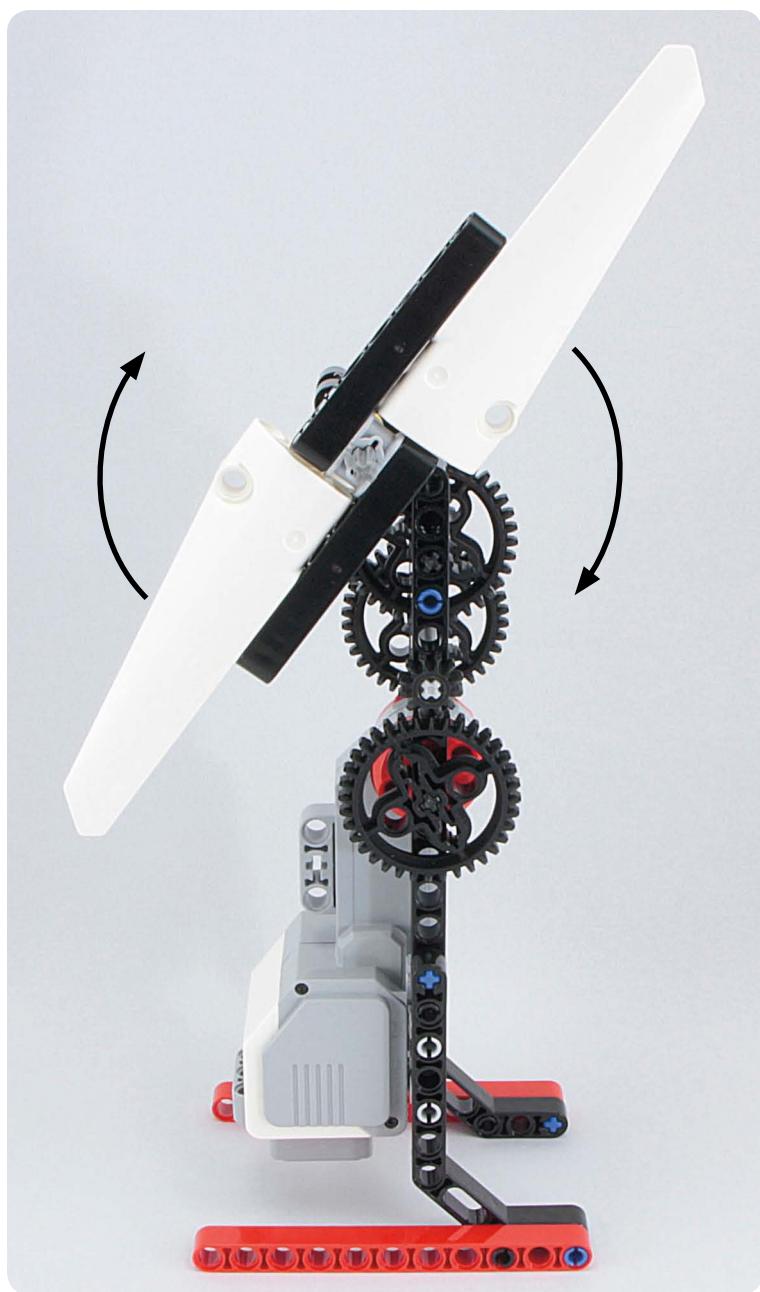


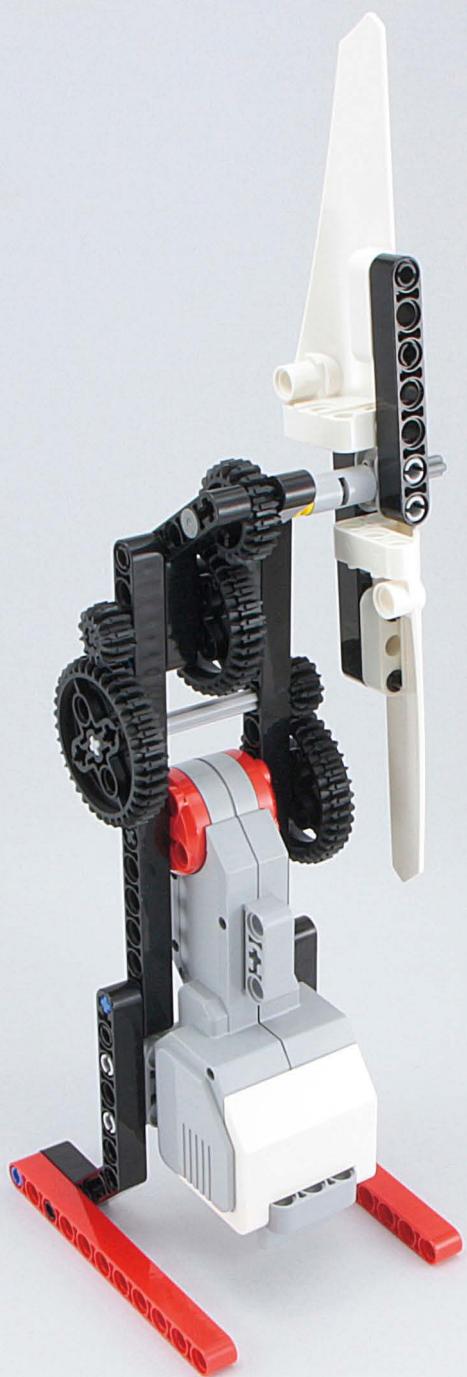
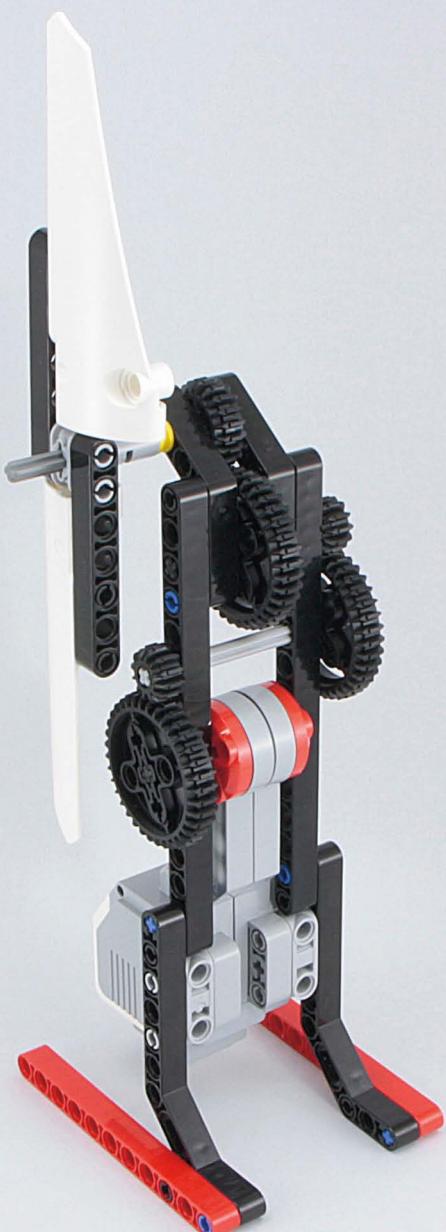




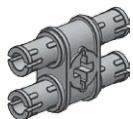
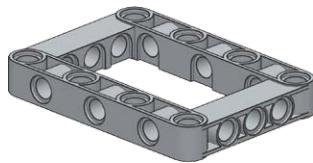
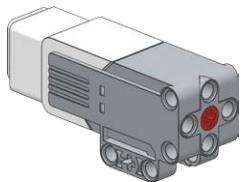
Creating wind

#153





#154



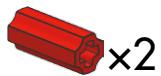
x2



x2



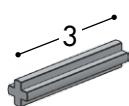
x3



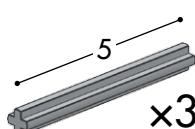
x2



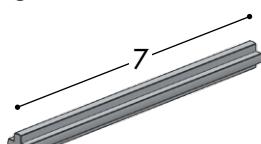
x12



3

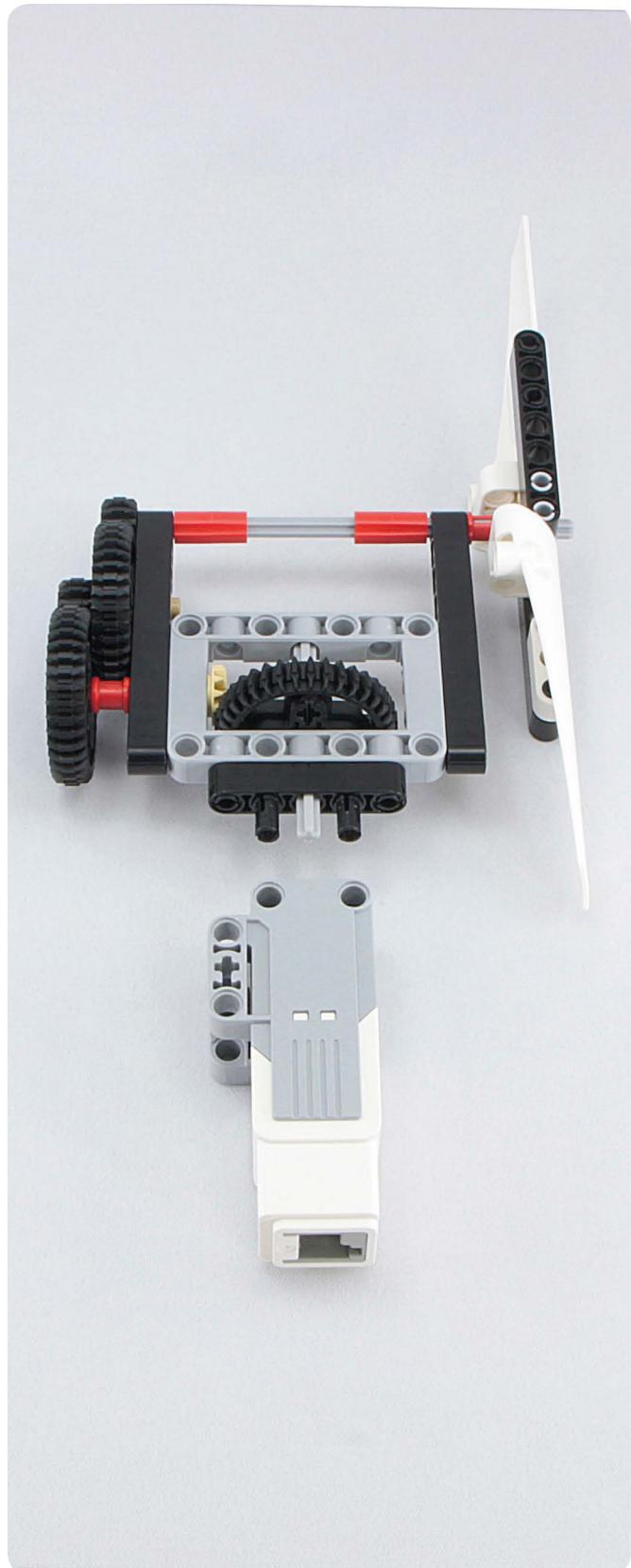
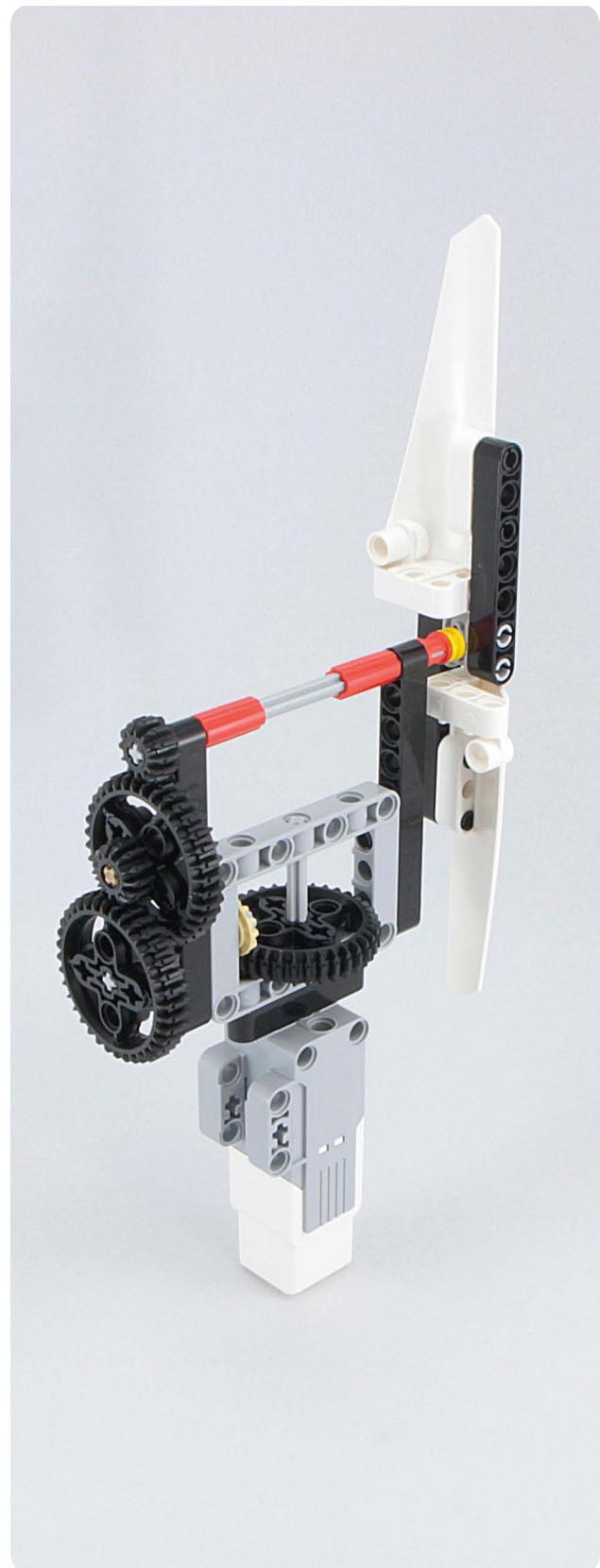


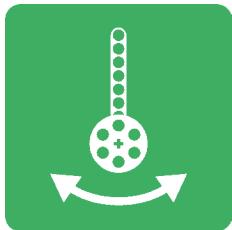
5



7

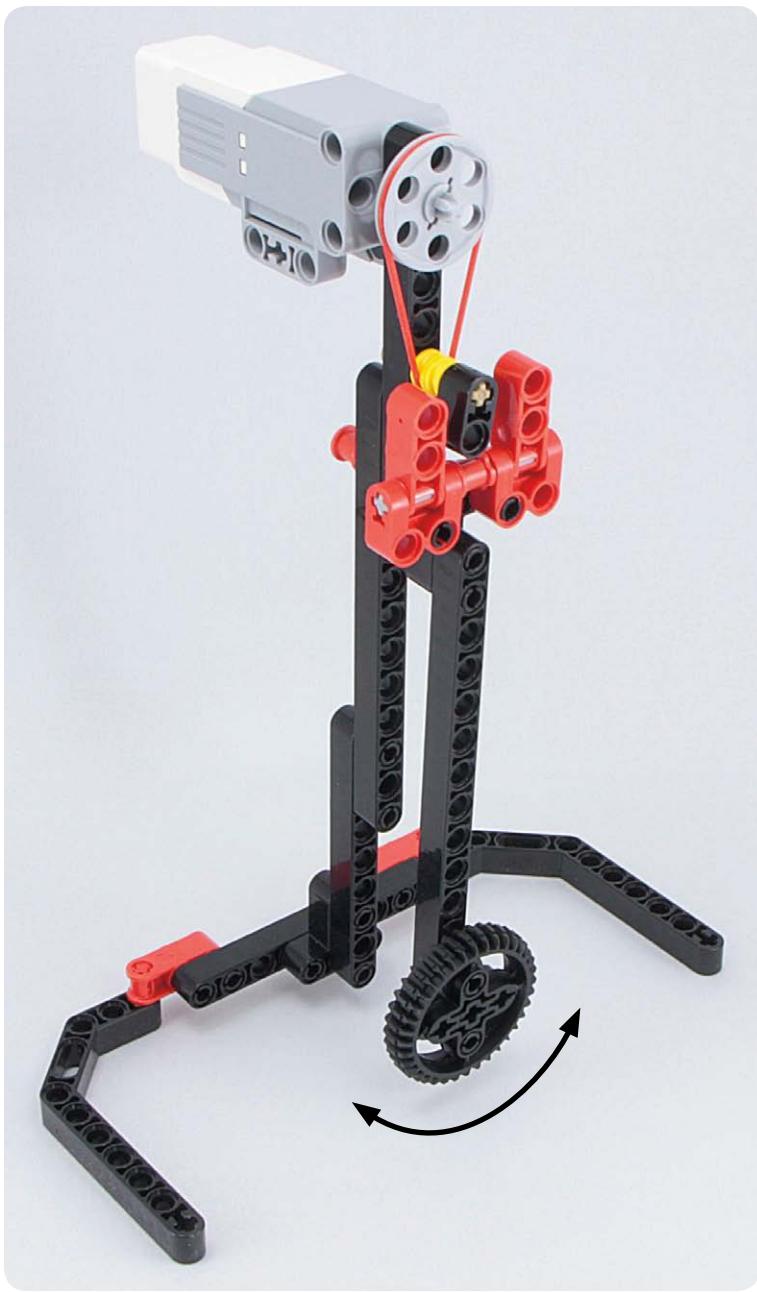
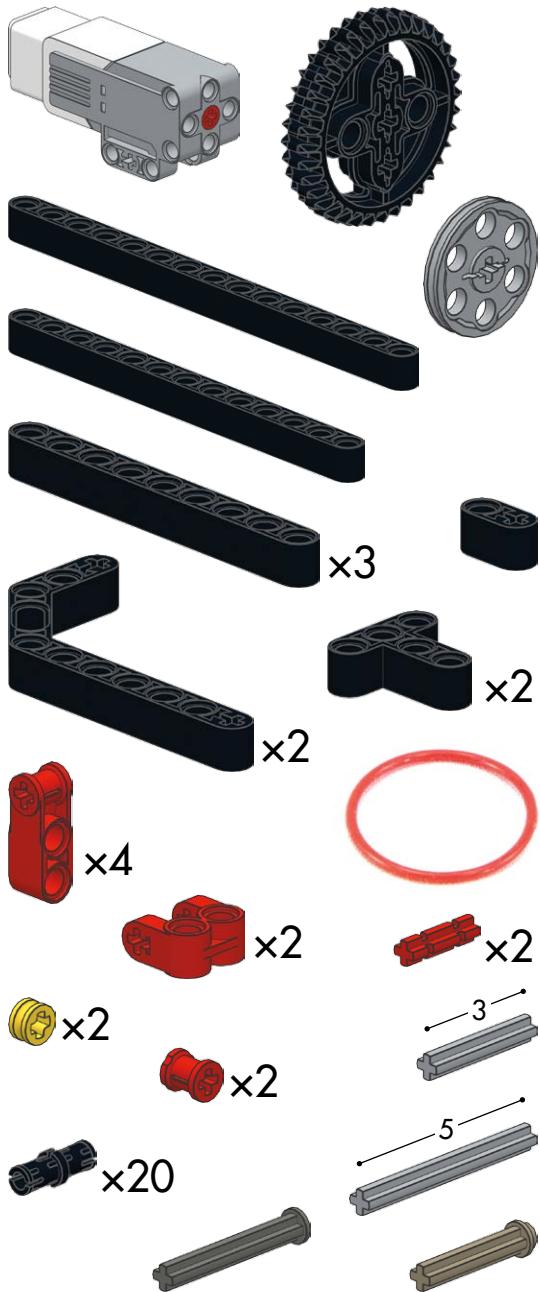


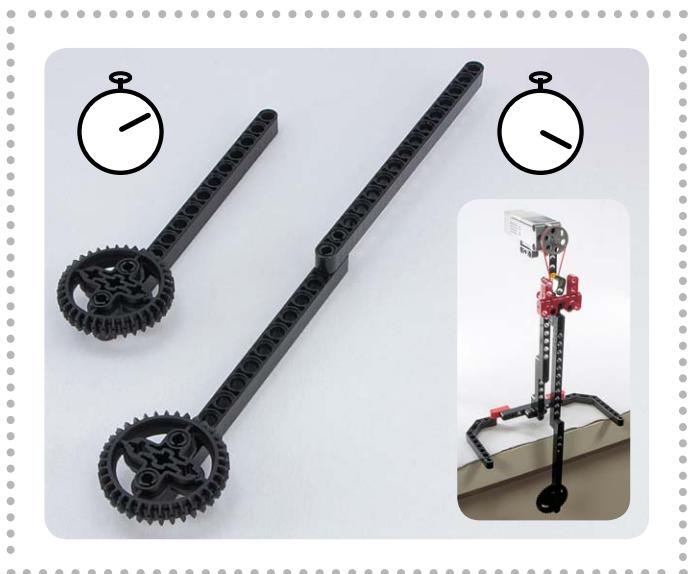
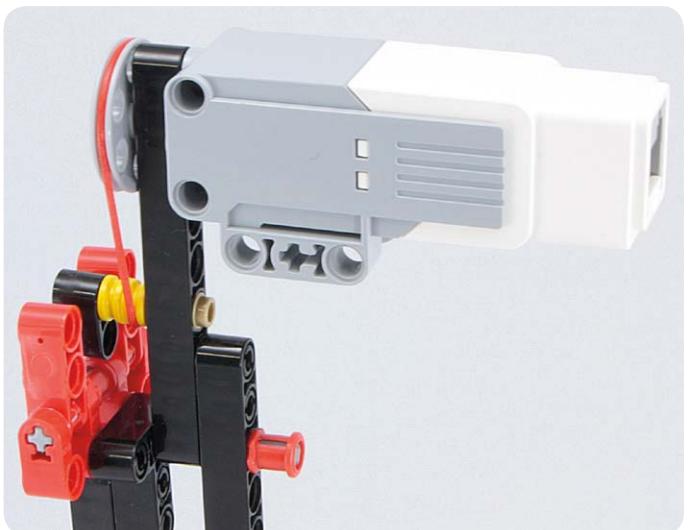




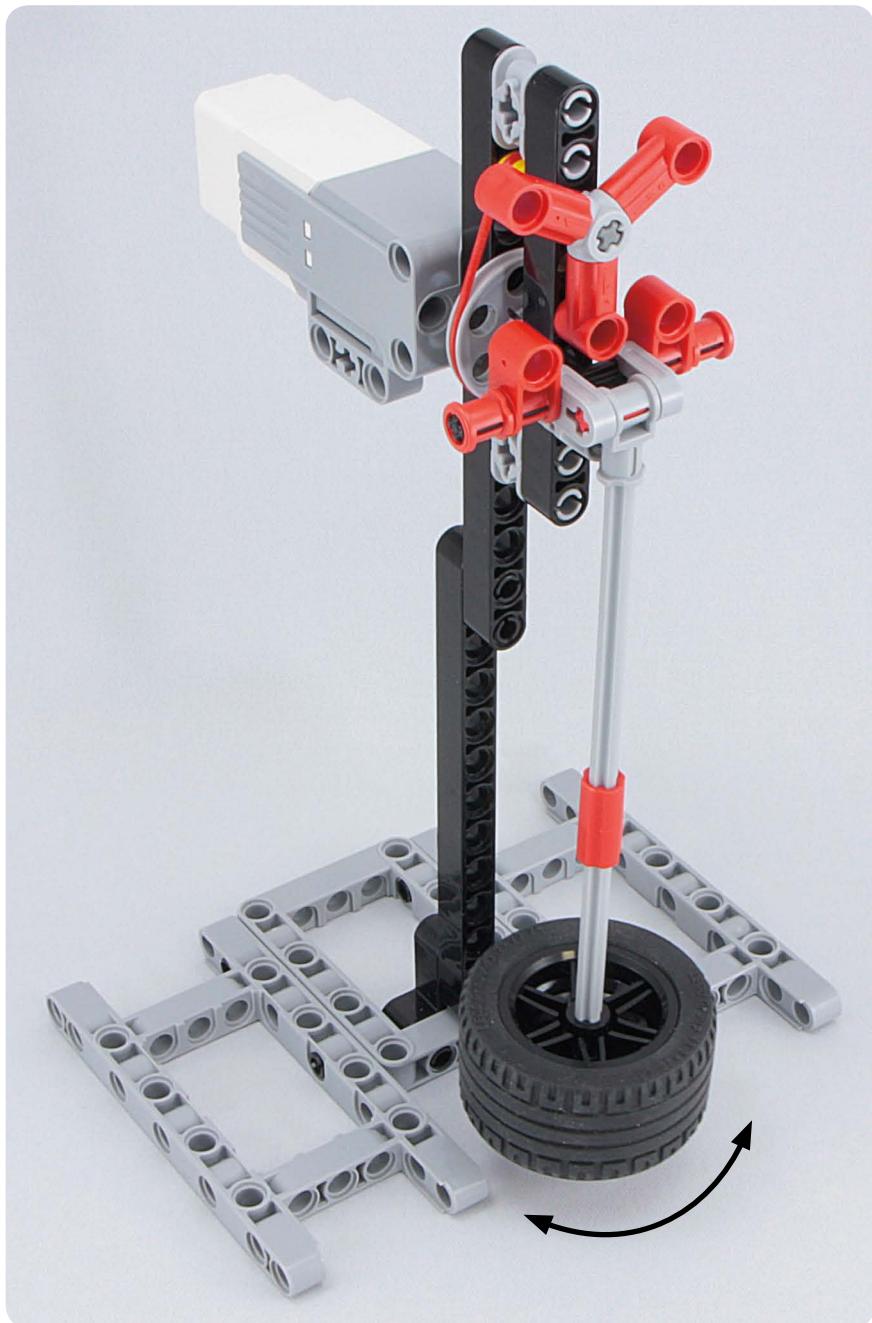
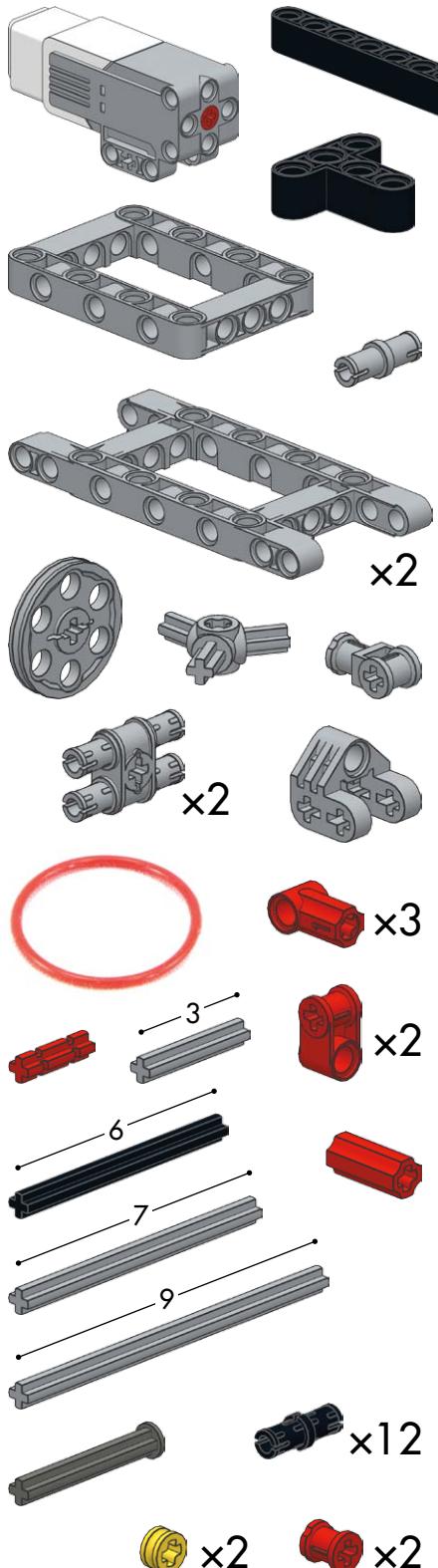
Swinging a pendulum

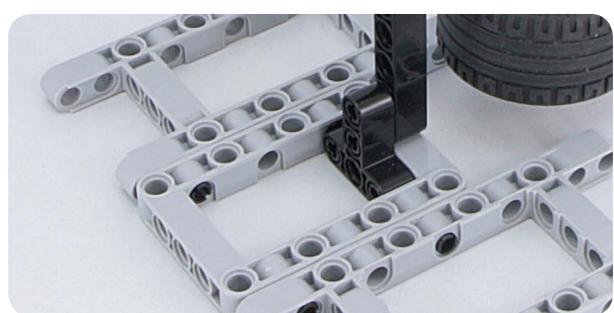
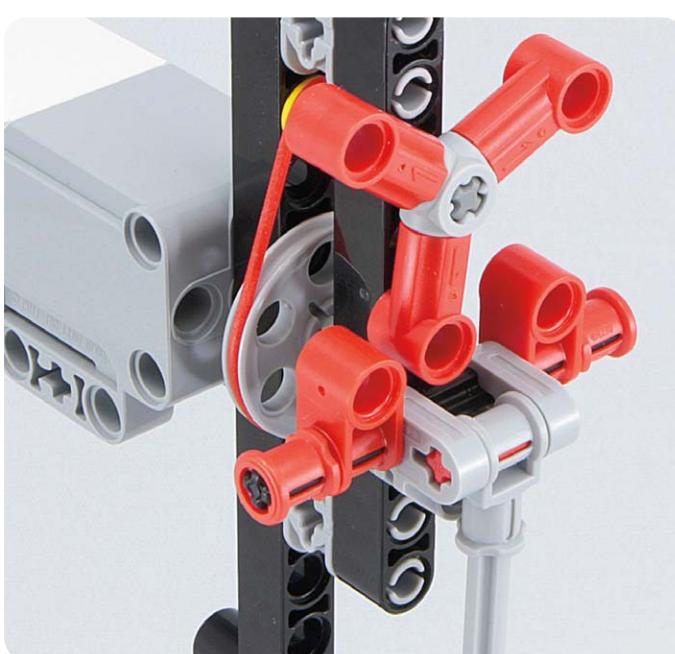
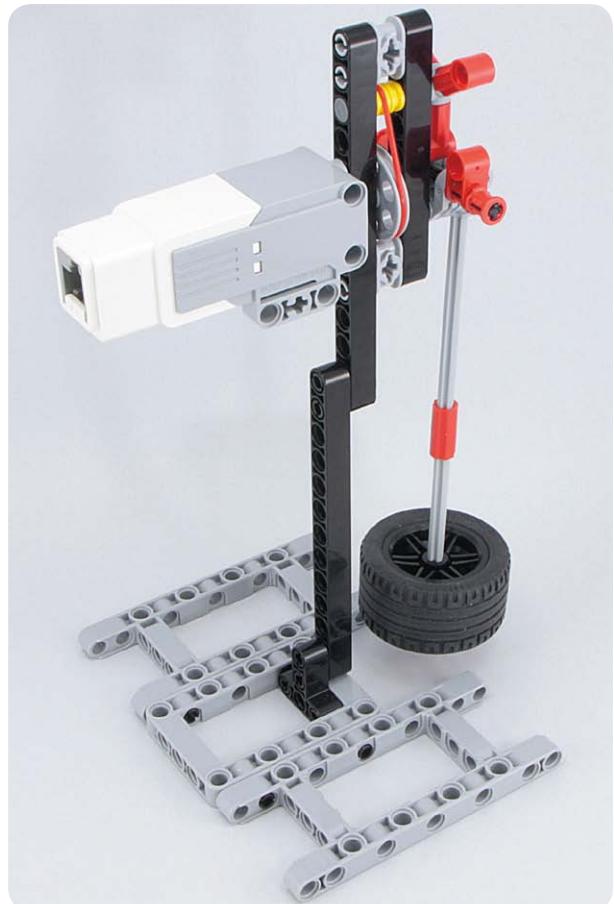
#155





#156

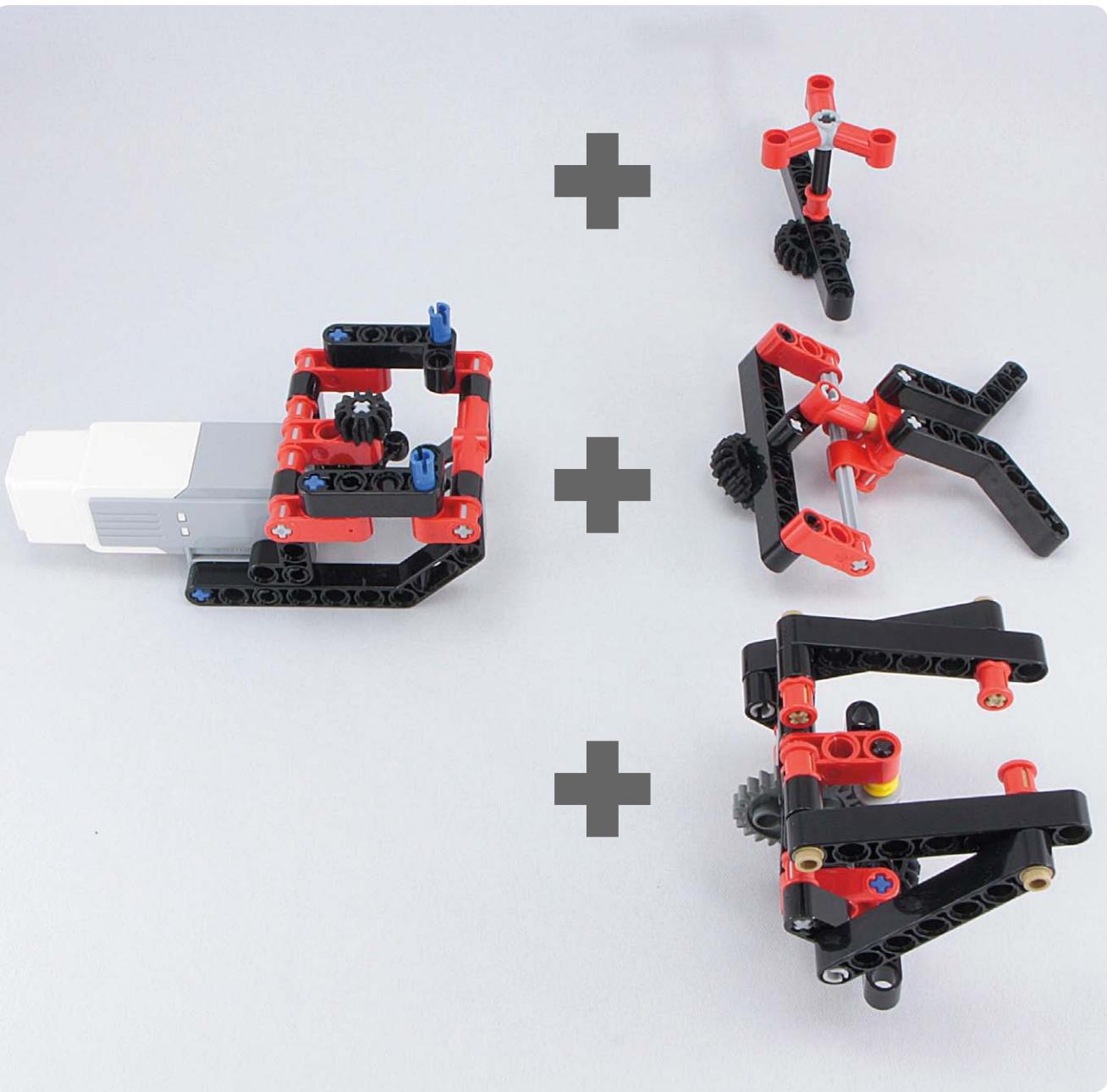


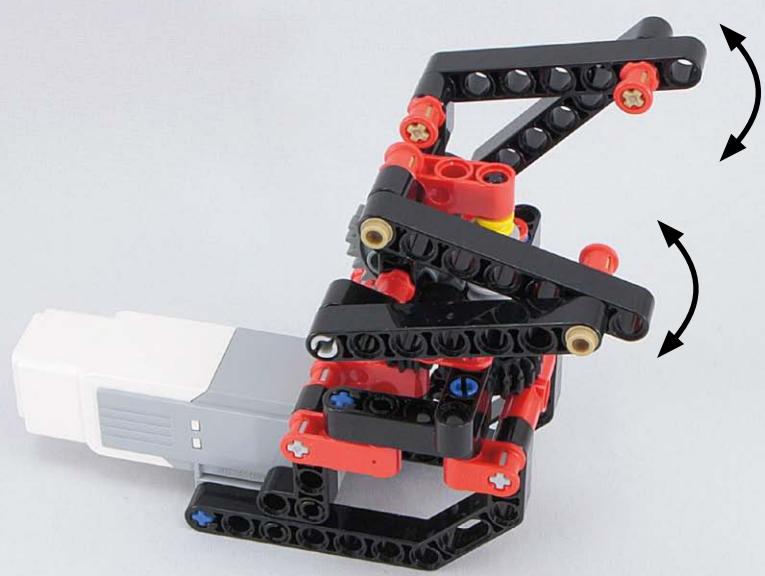
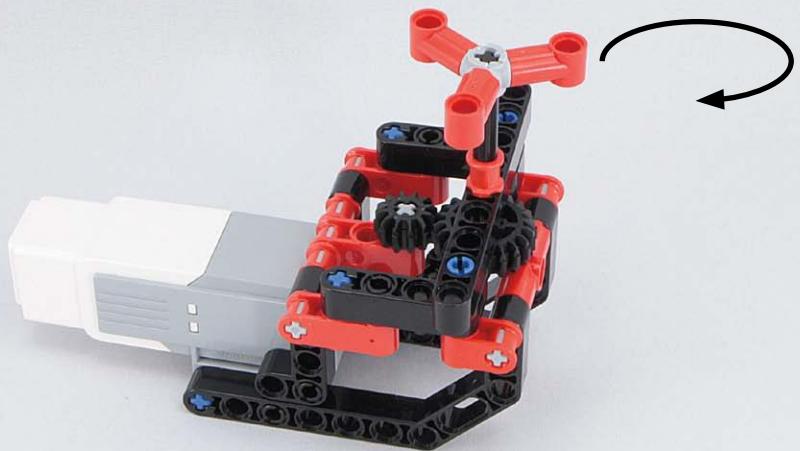


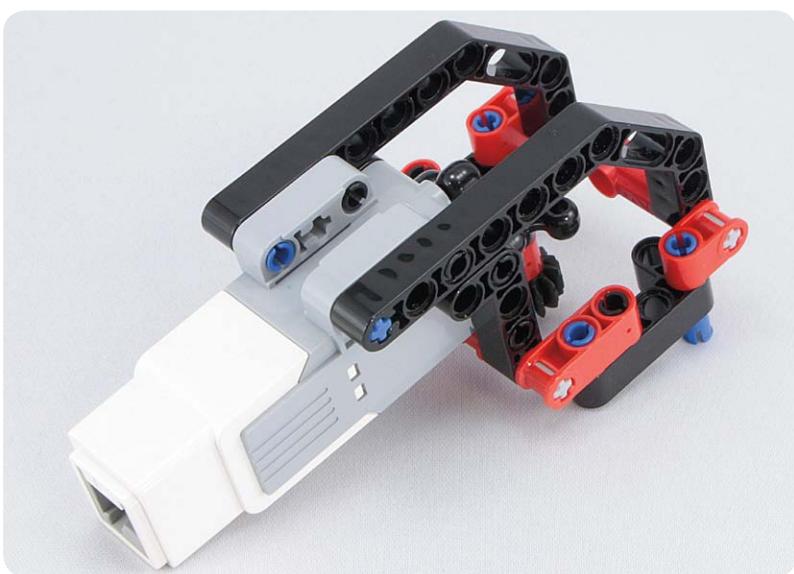
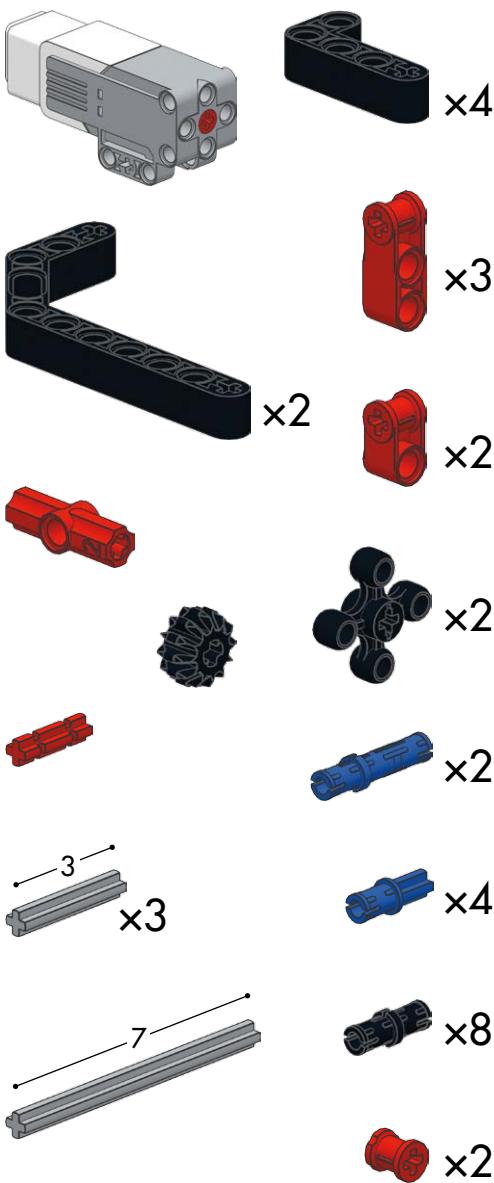
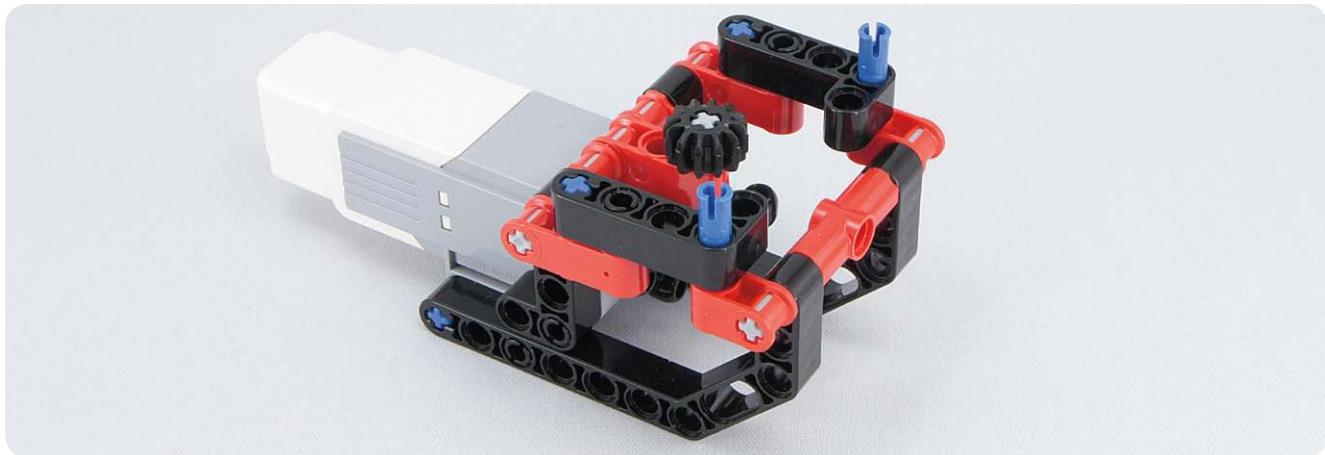


Using attachments to change motion

#157



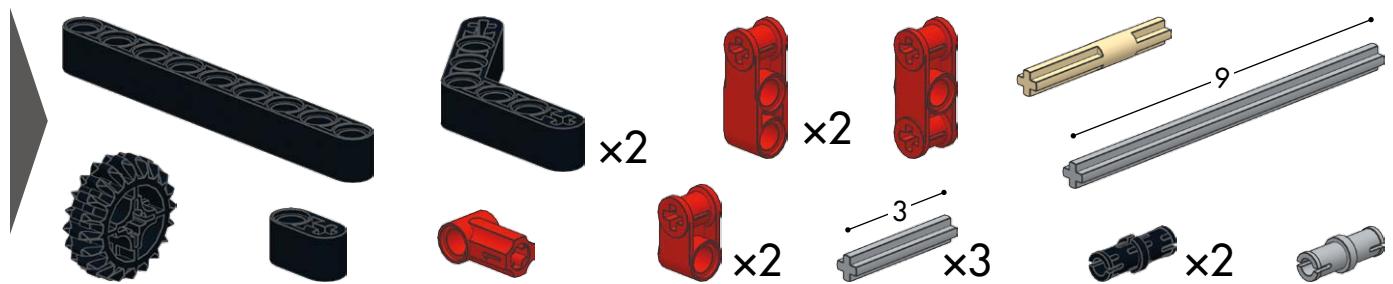


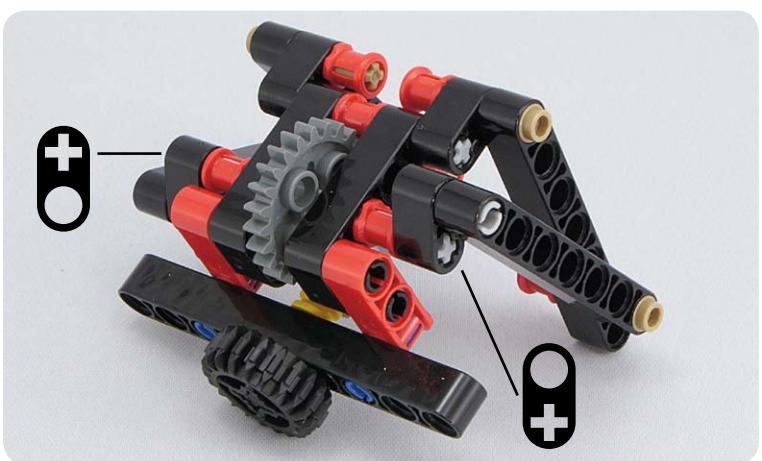


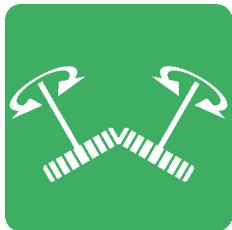


3
x3



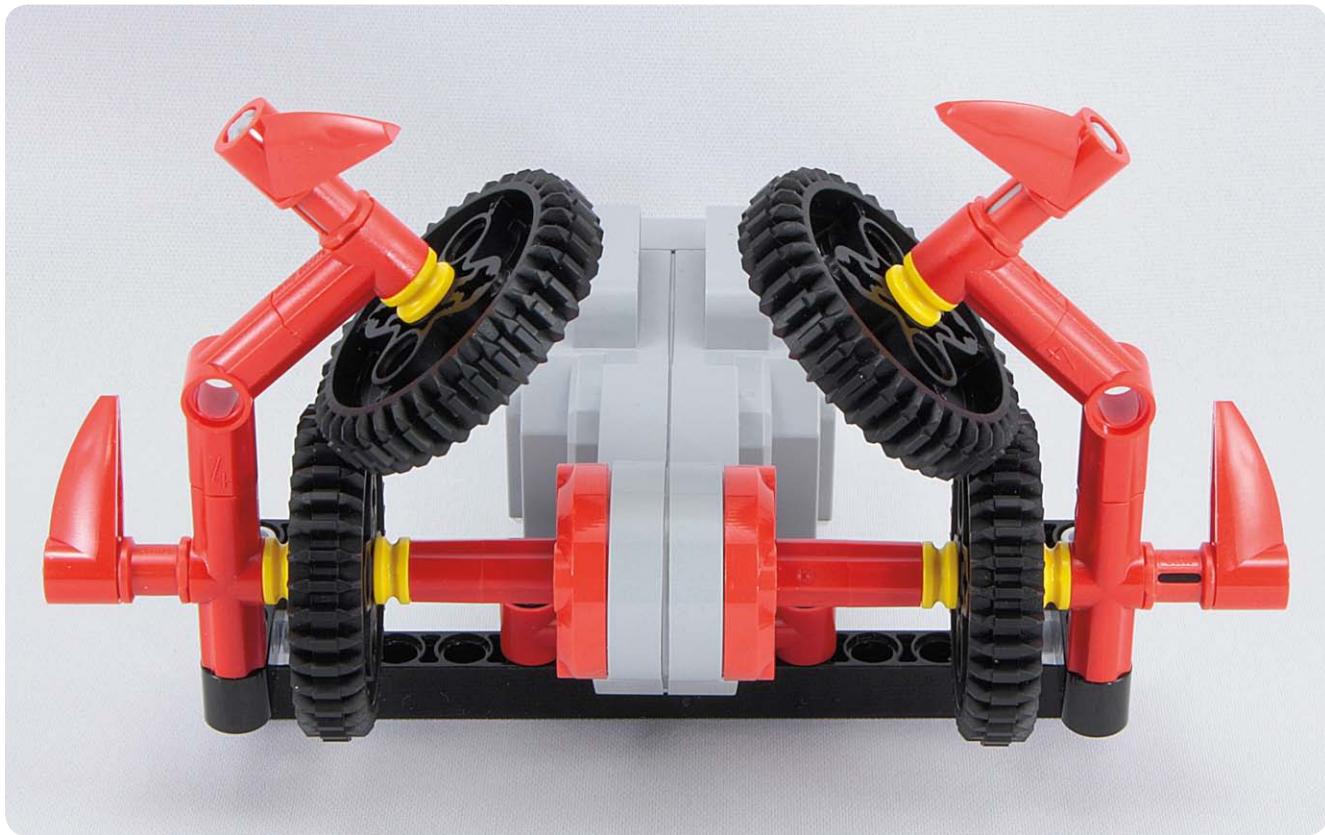
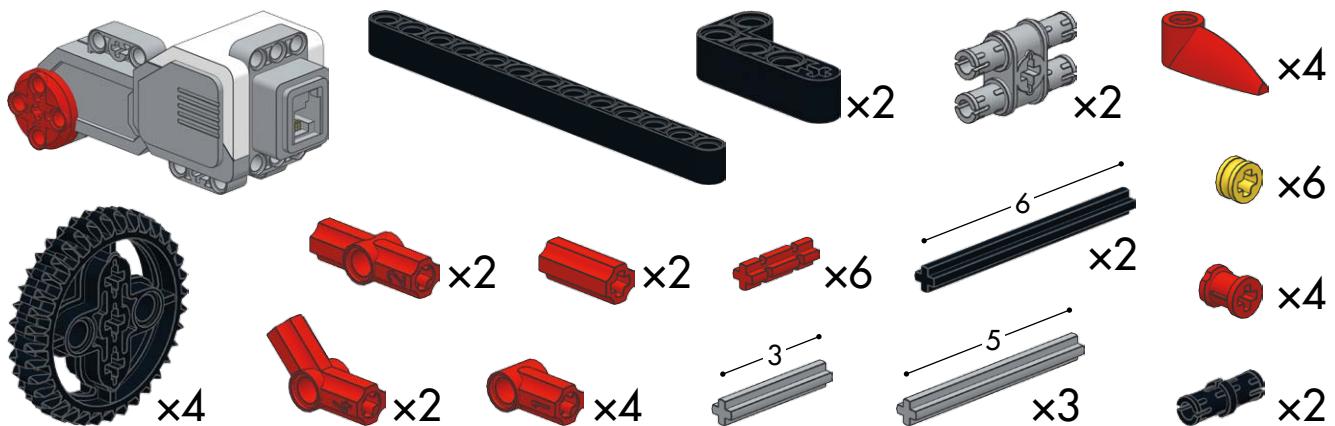






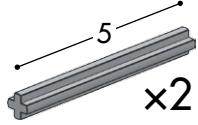
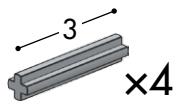
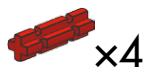
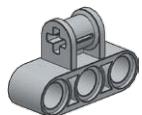
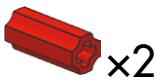
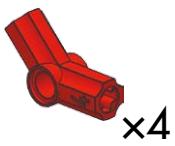
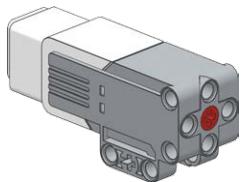
Mesing gears diagonally

#158

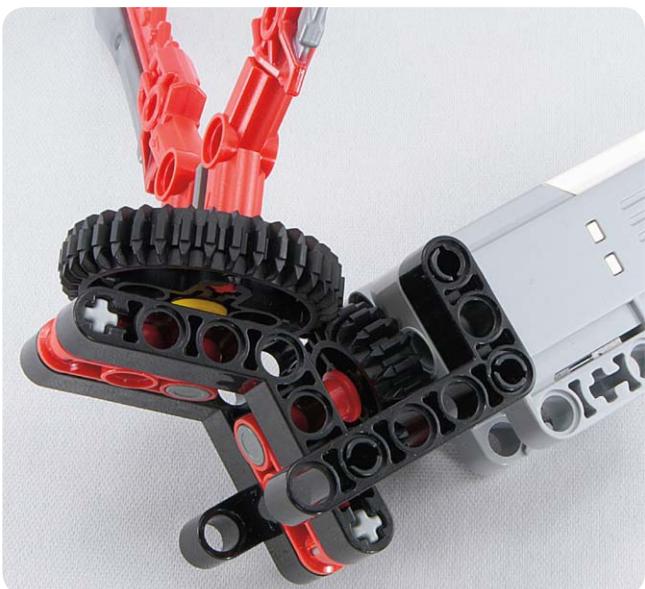
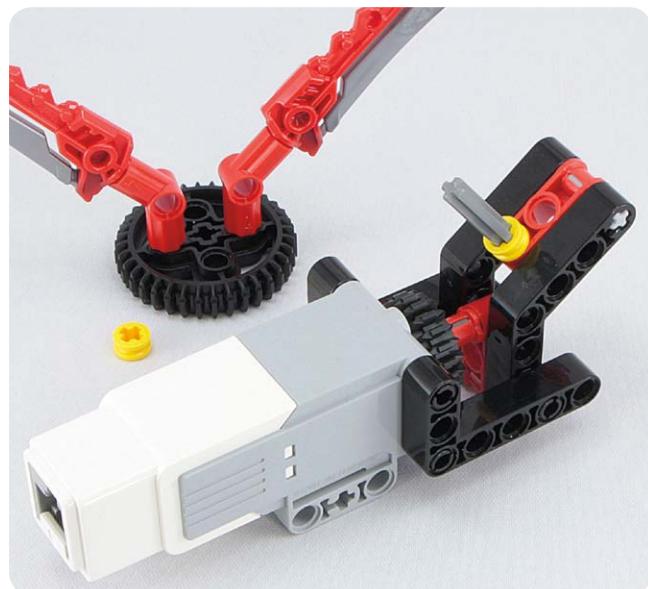


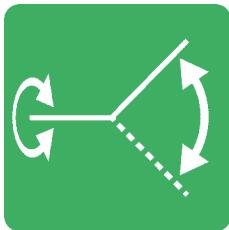


#159



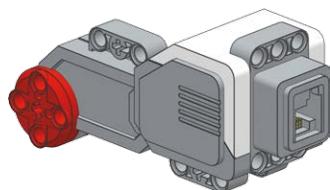
#160



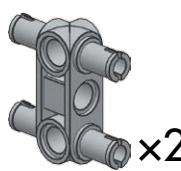
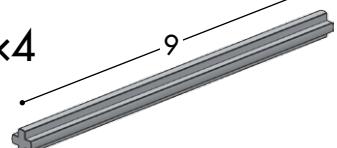


Changing the angle of rotation freely

#161



x4



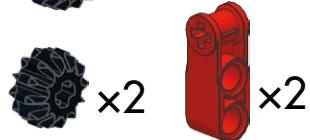
x2



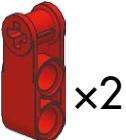
x2



x2



x2

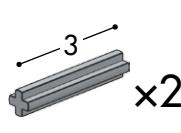


x4

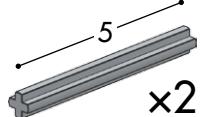


x2

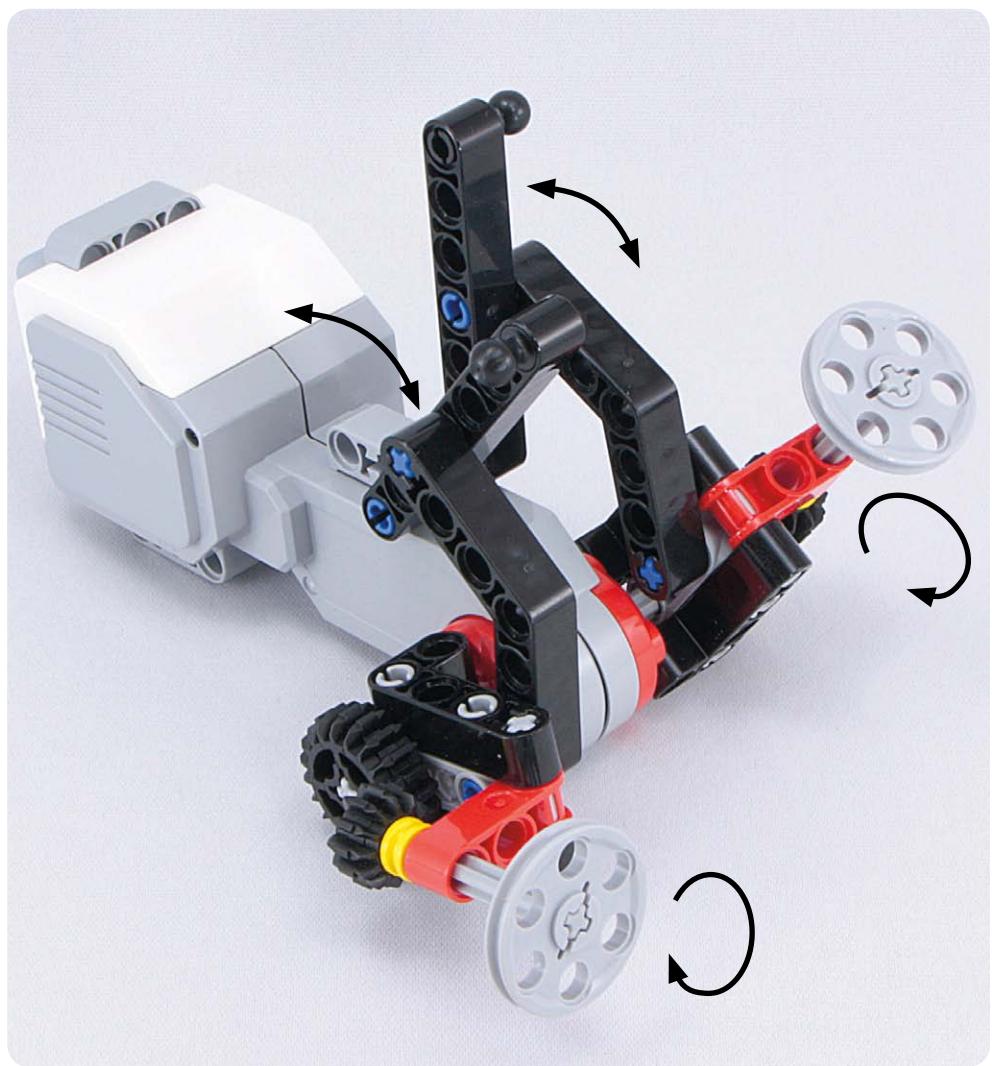
x2

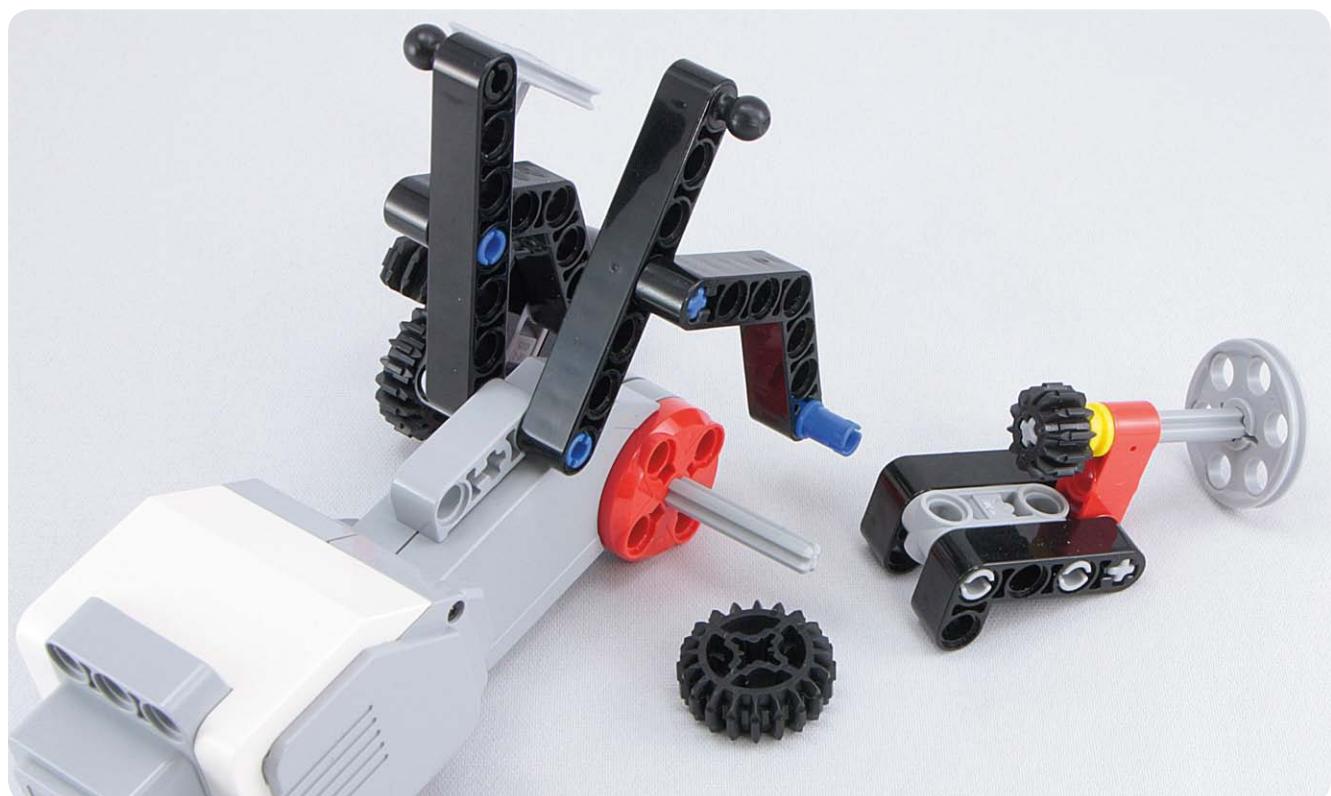


x2

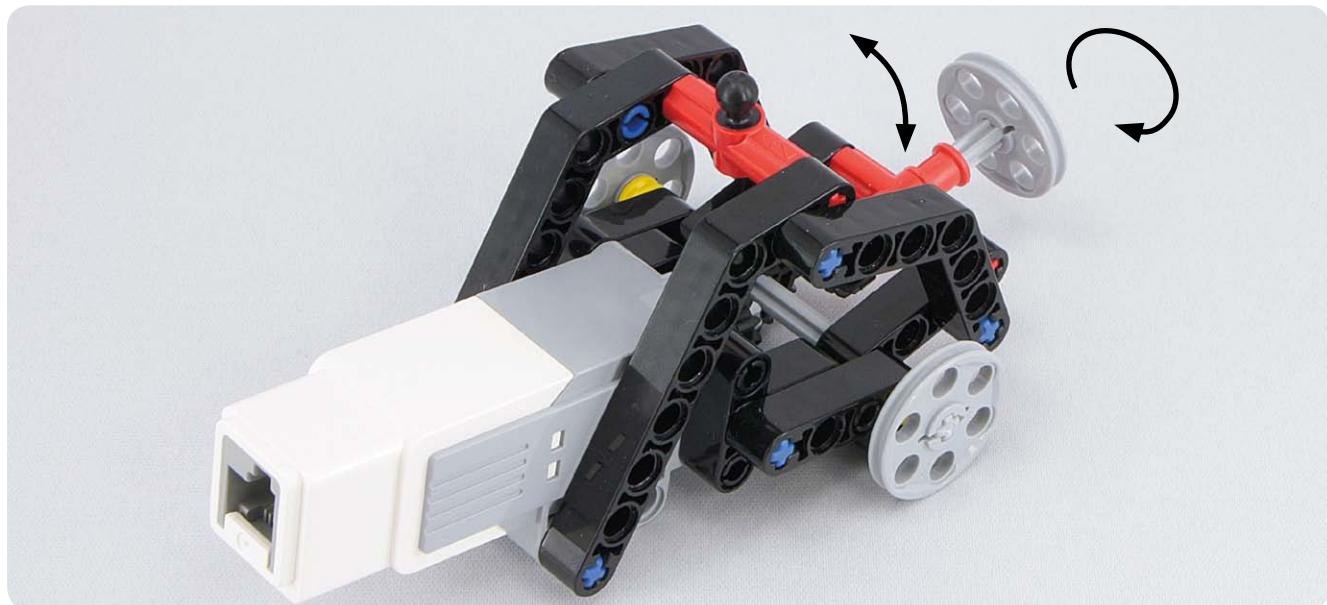
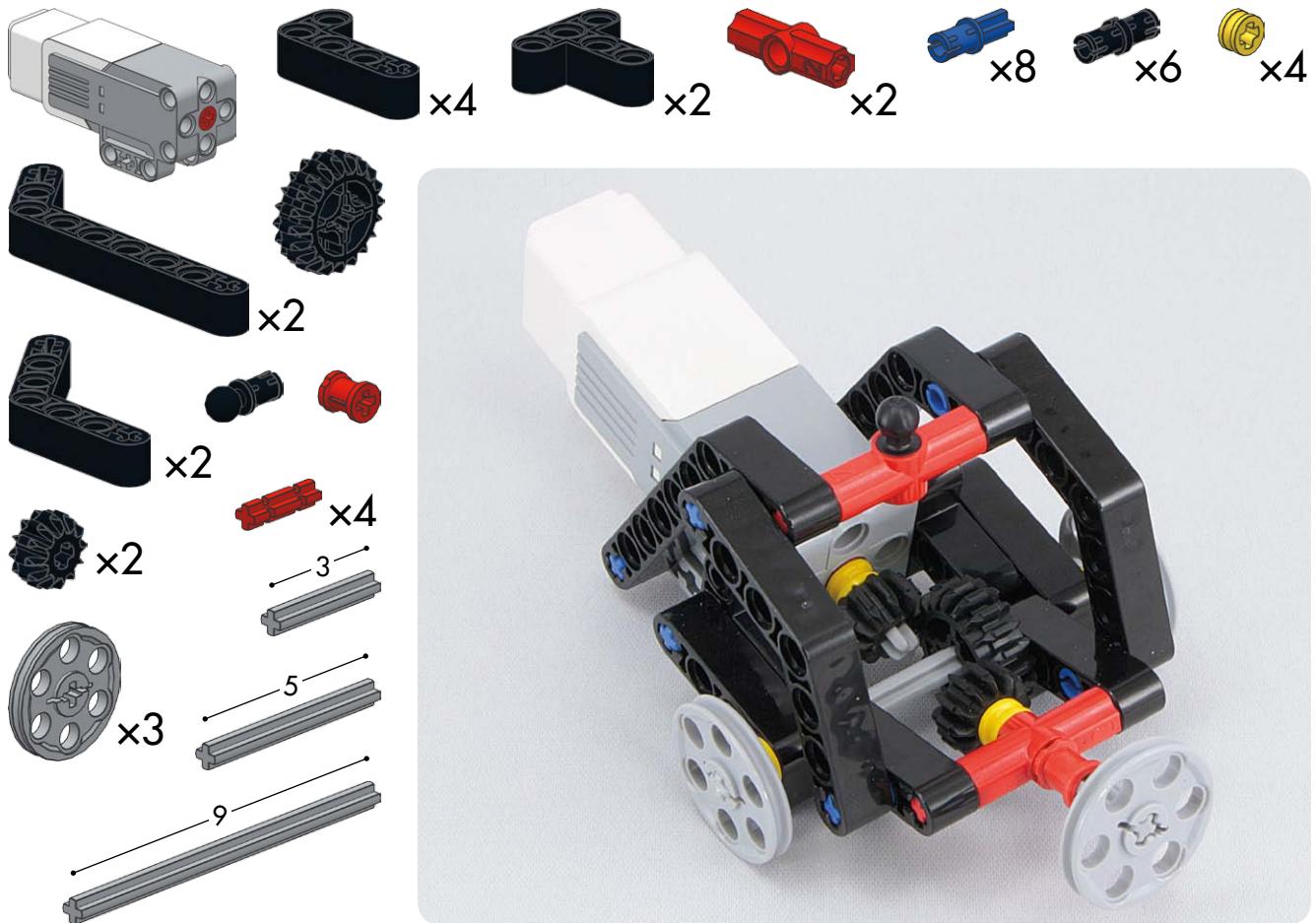


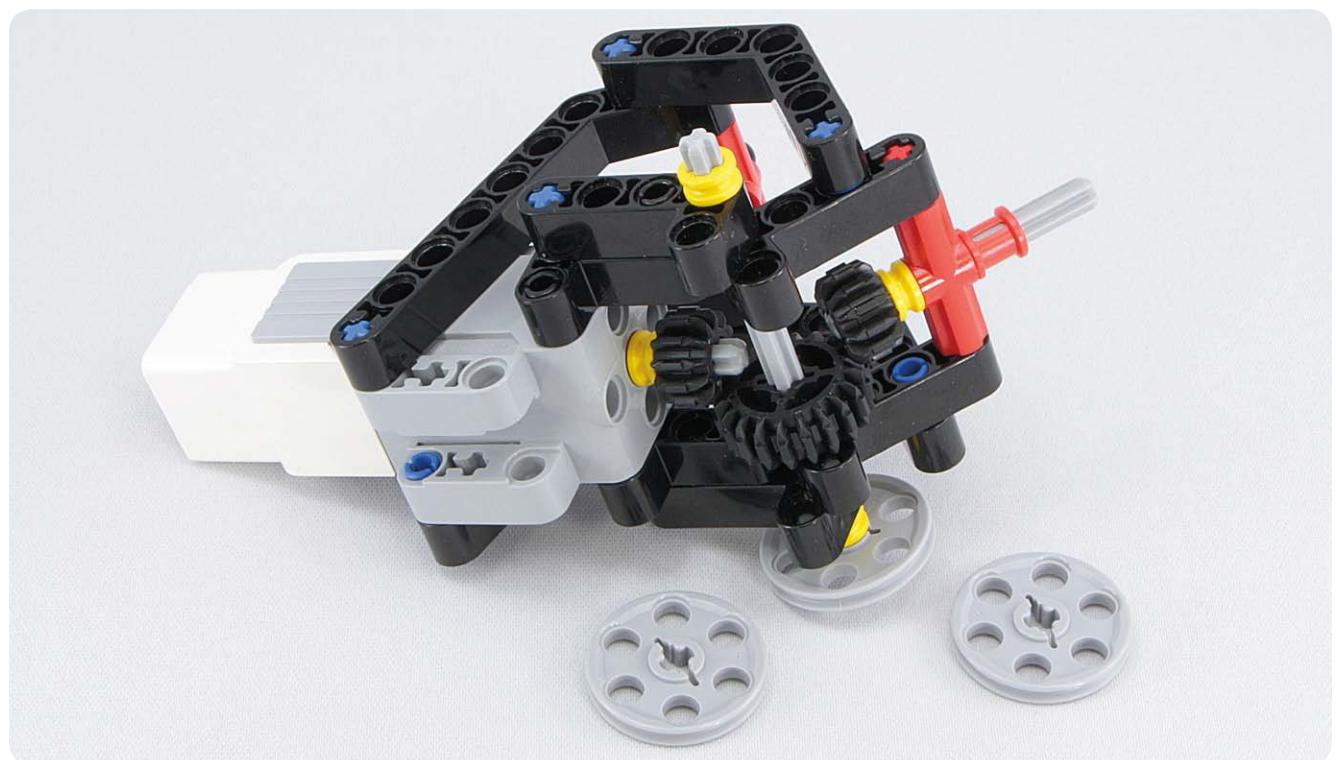
x2



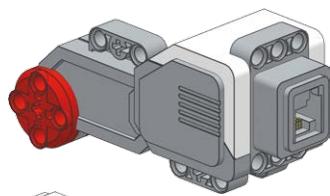


#162





#163



x2



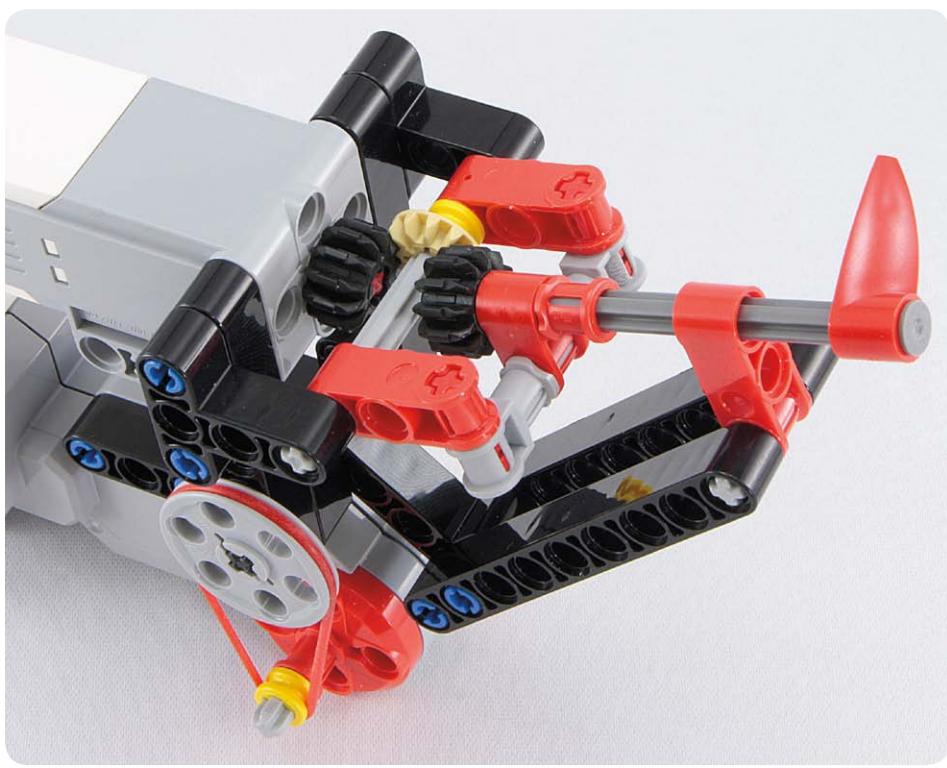
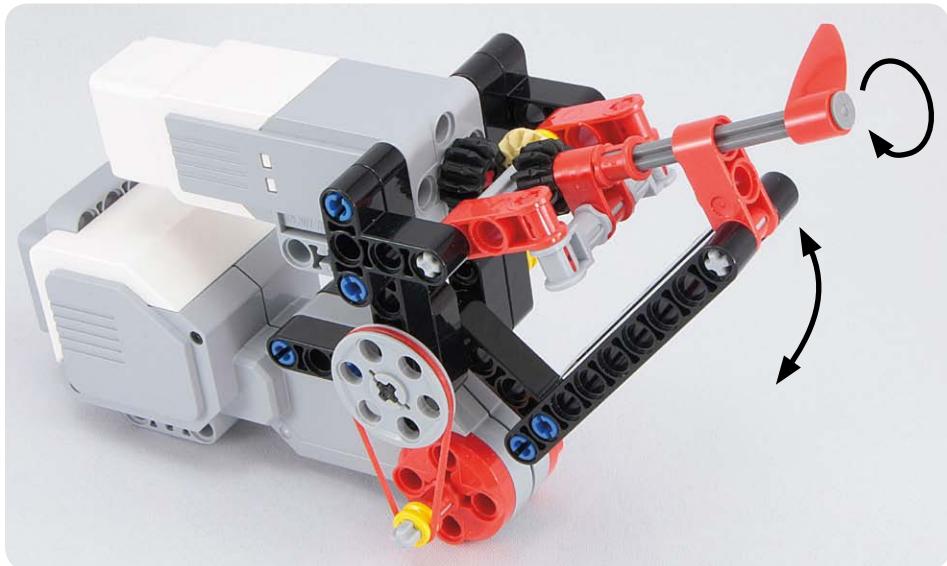
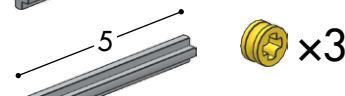
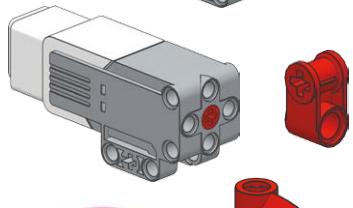
x2

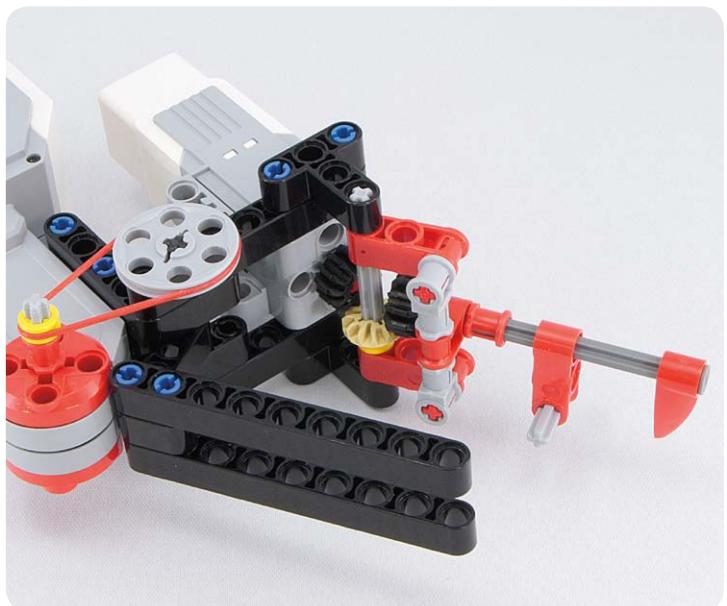
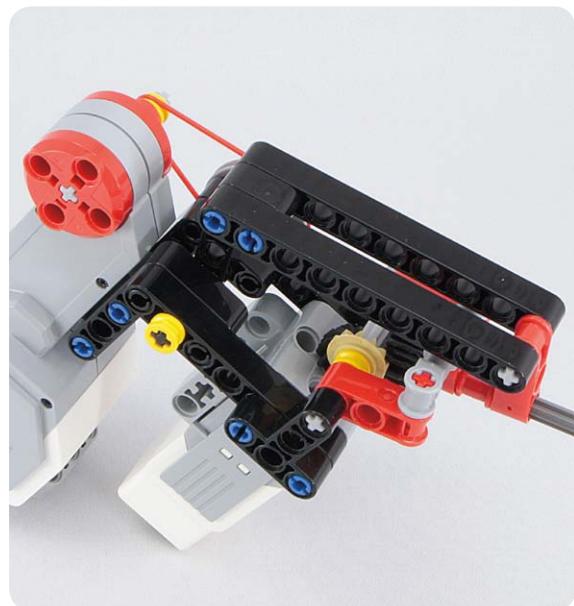
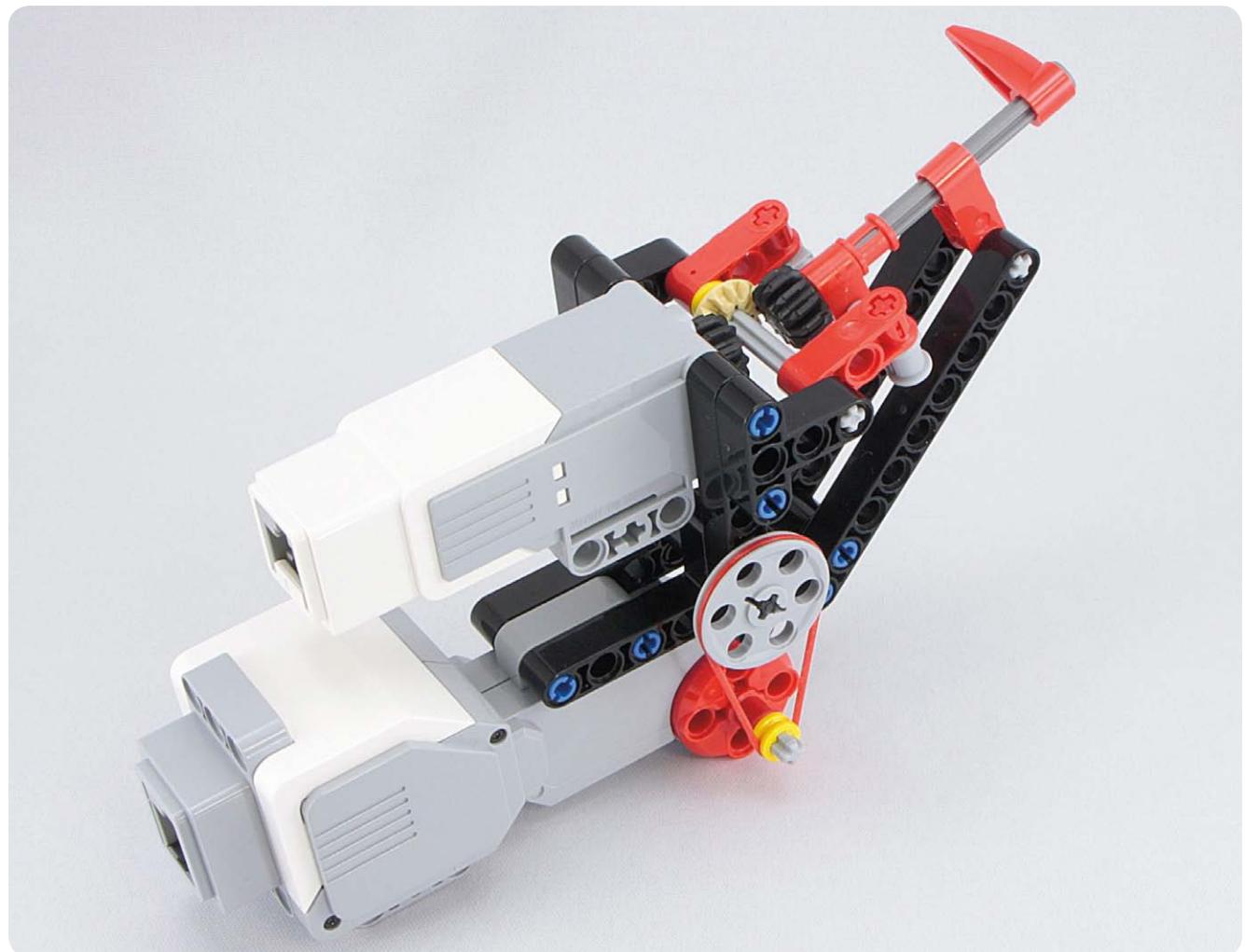


x2



x2







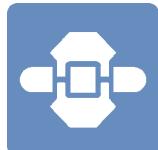
PART 5



Sensors



206



214

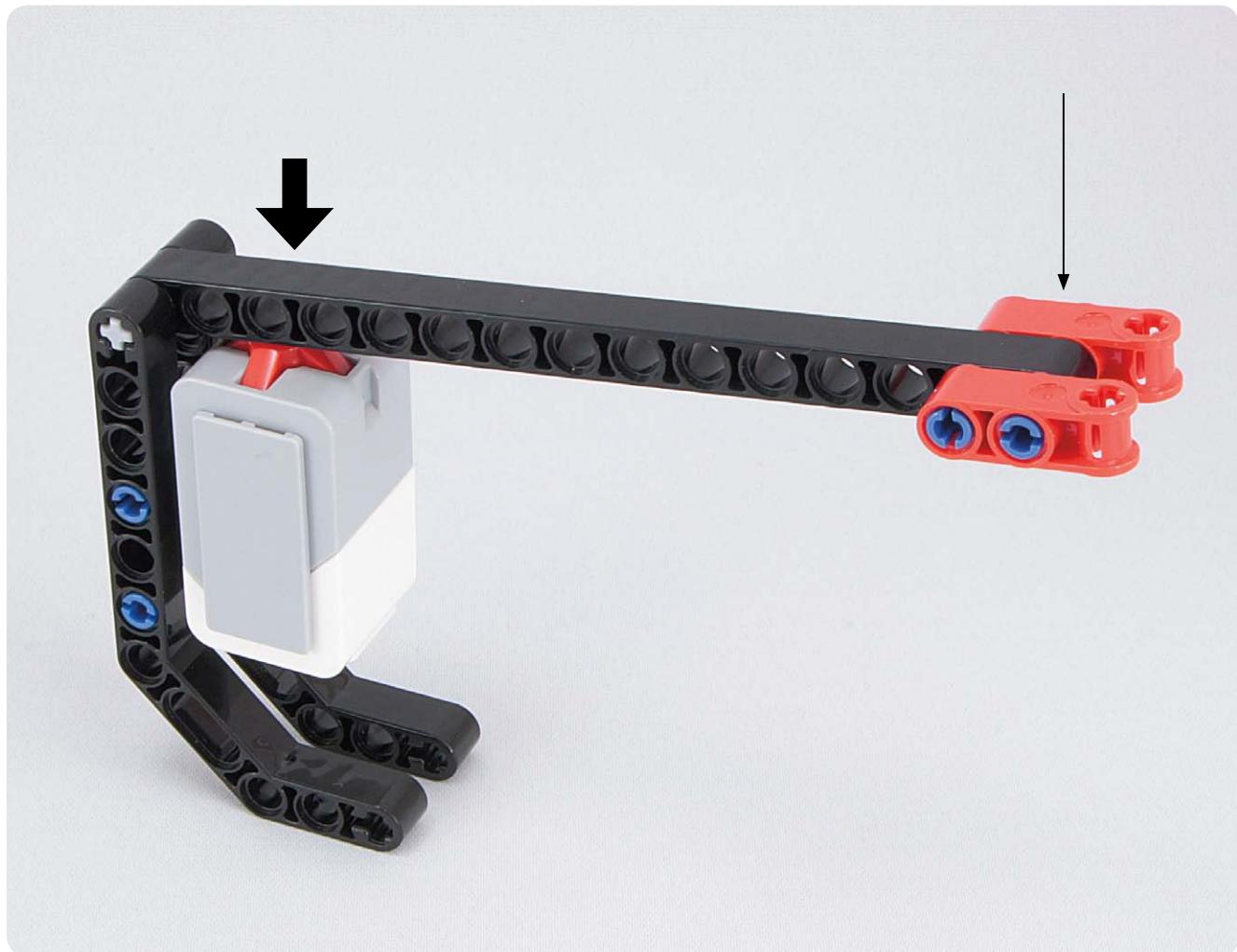
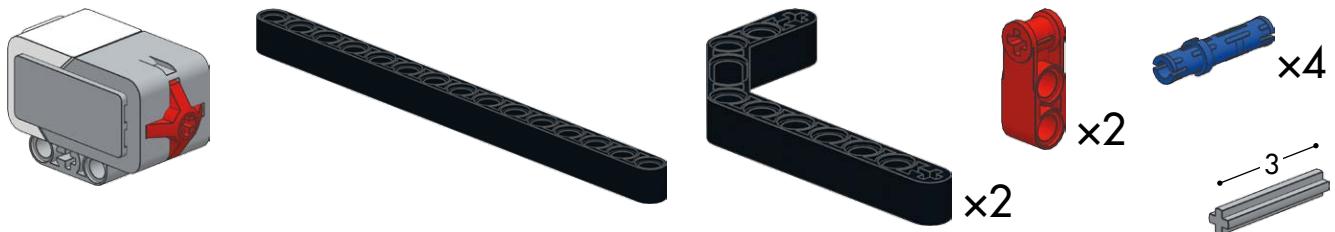


216

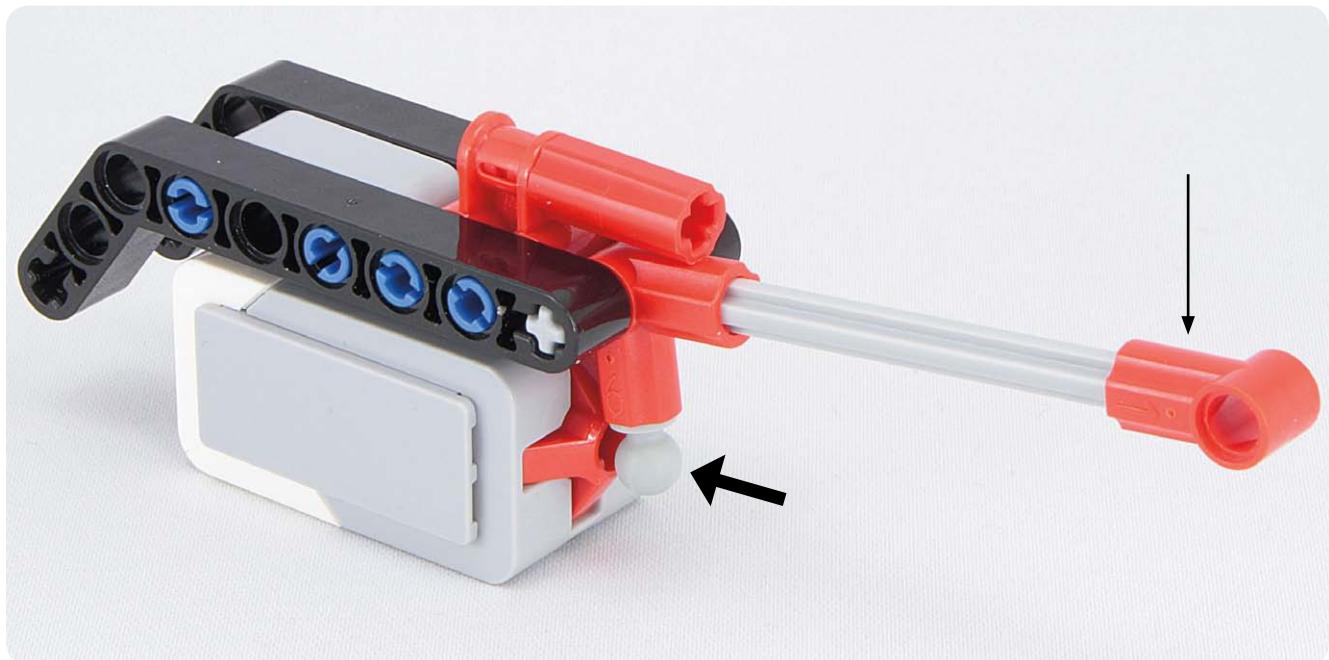
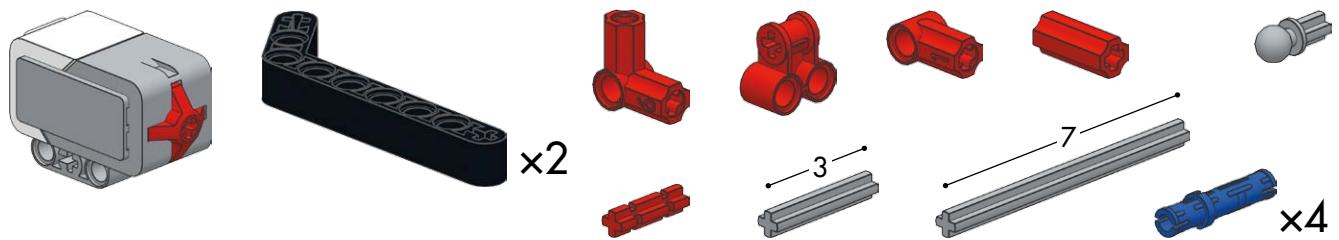


Ideas for using the touch sensor

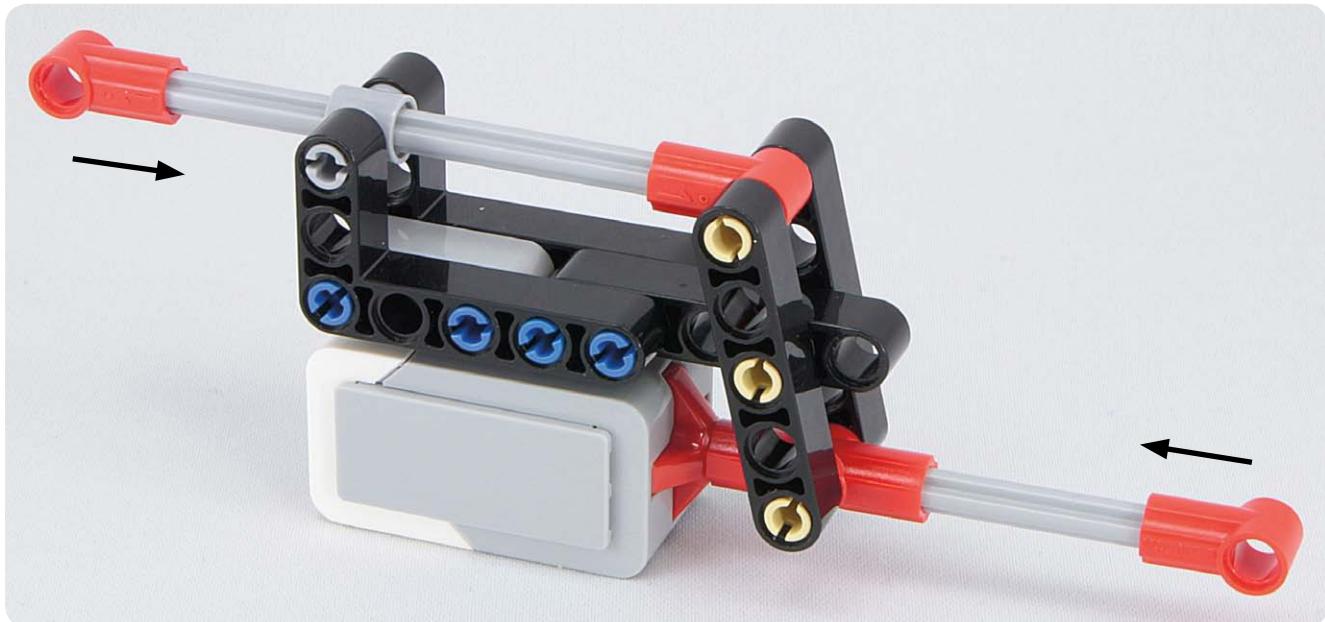
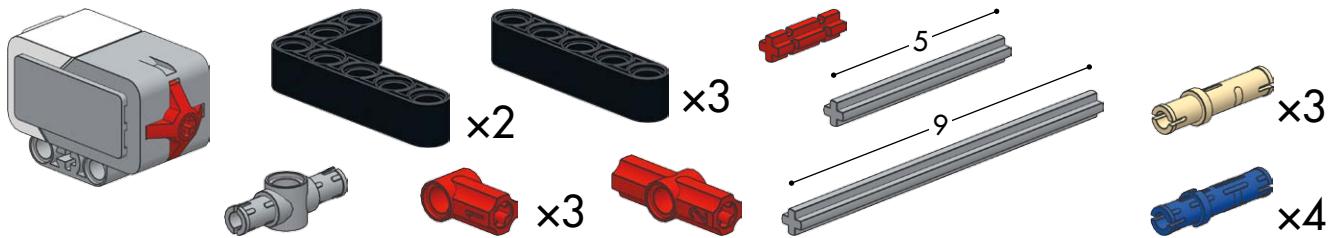
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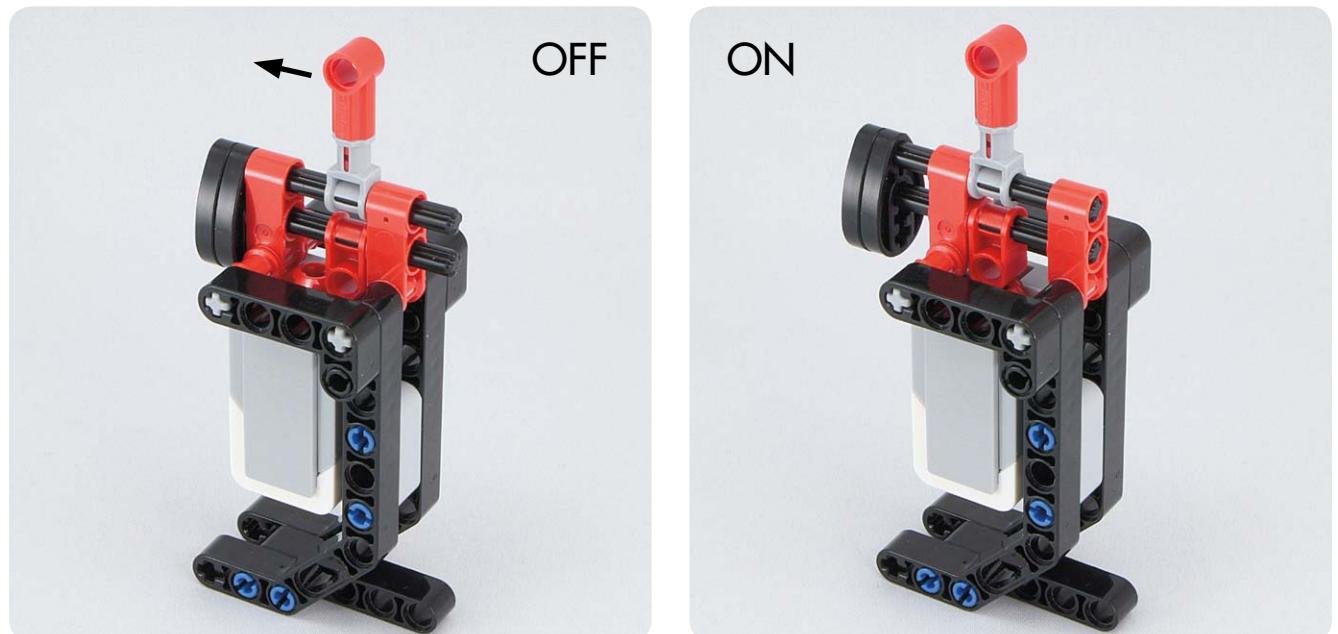
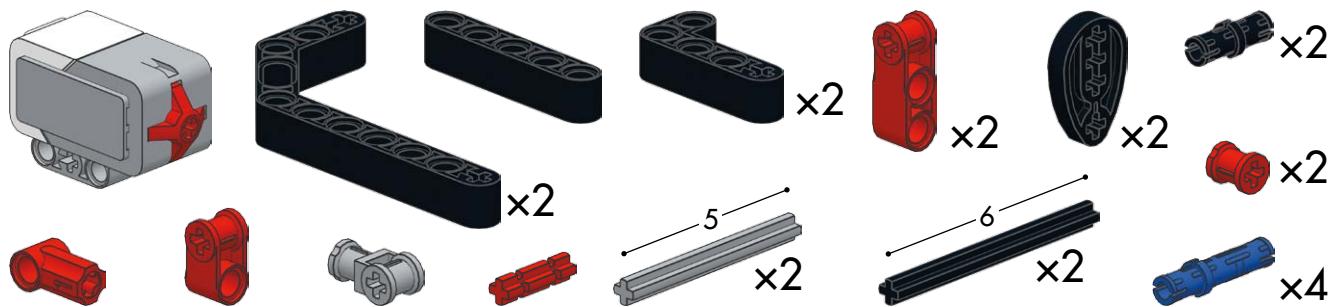
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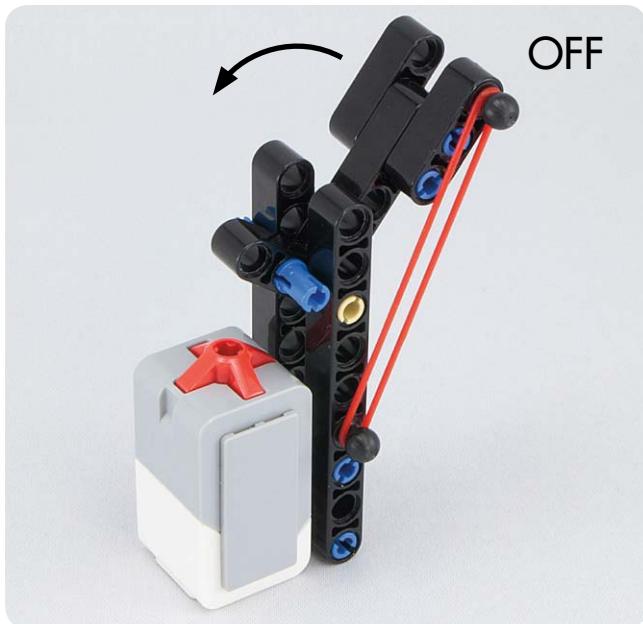
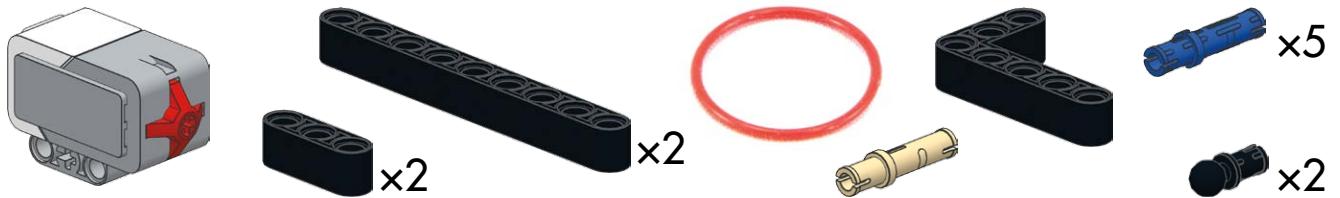
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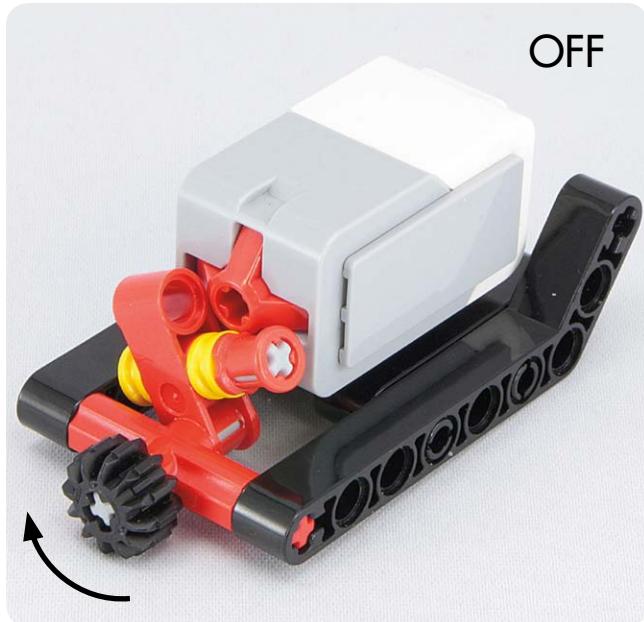
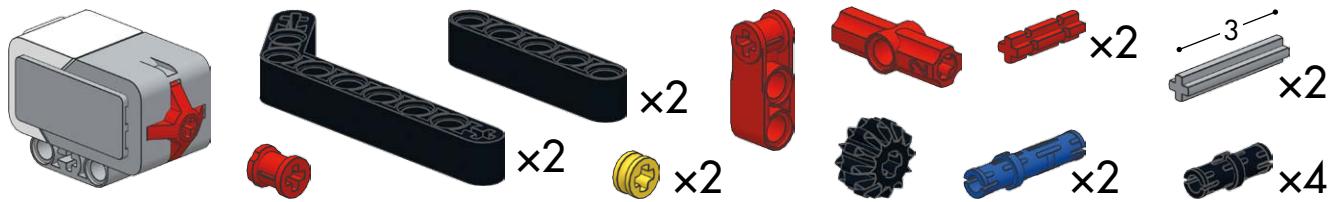
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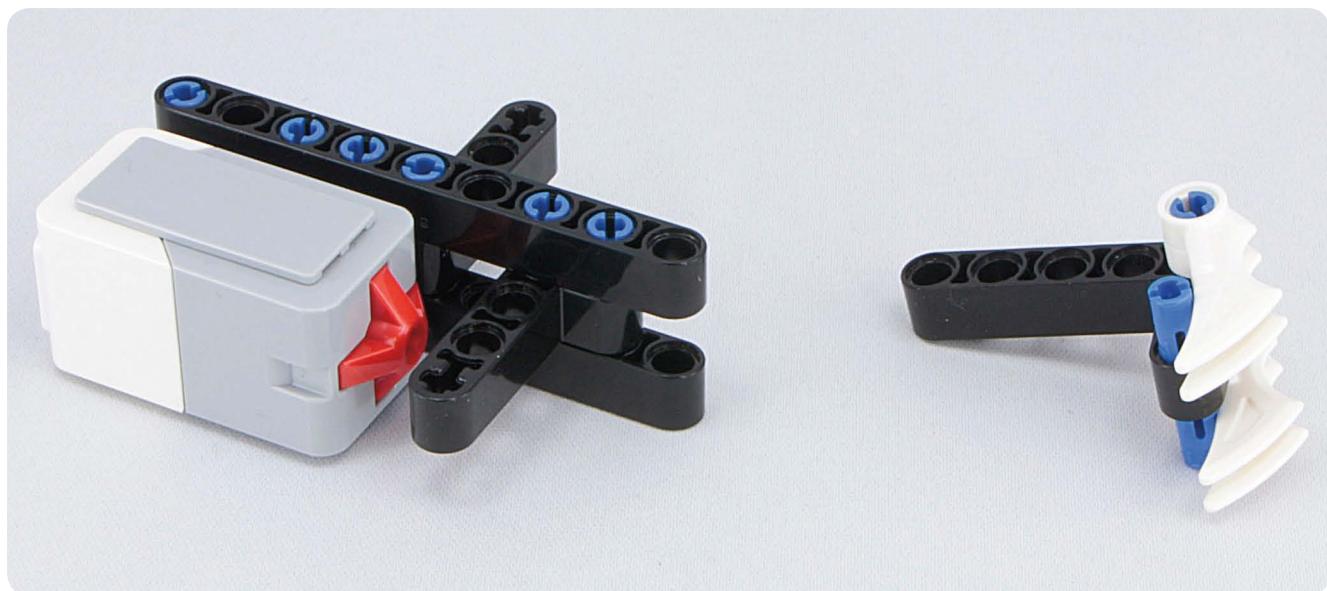
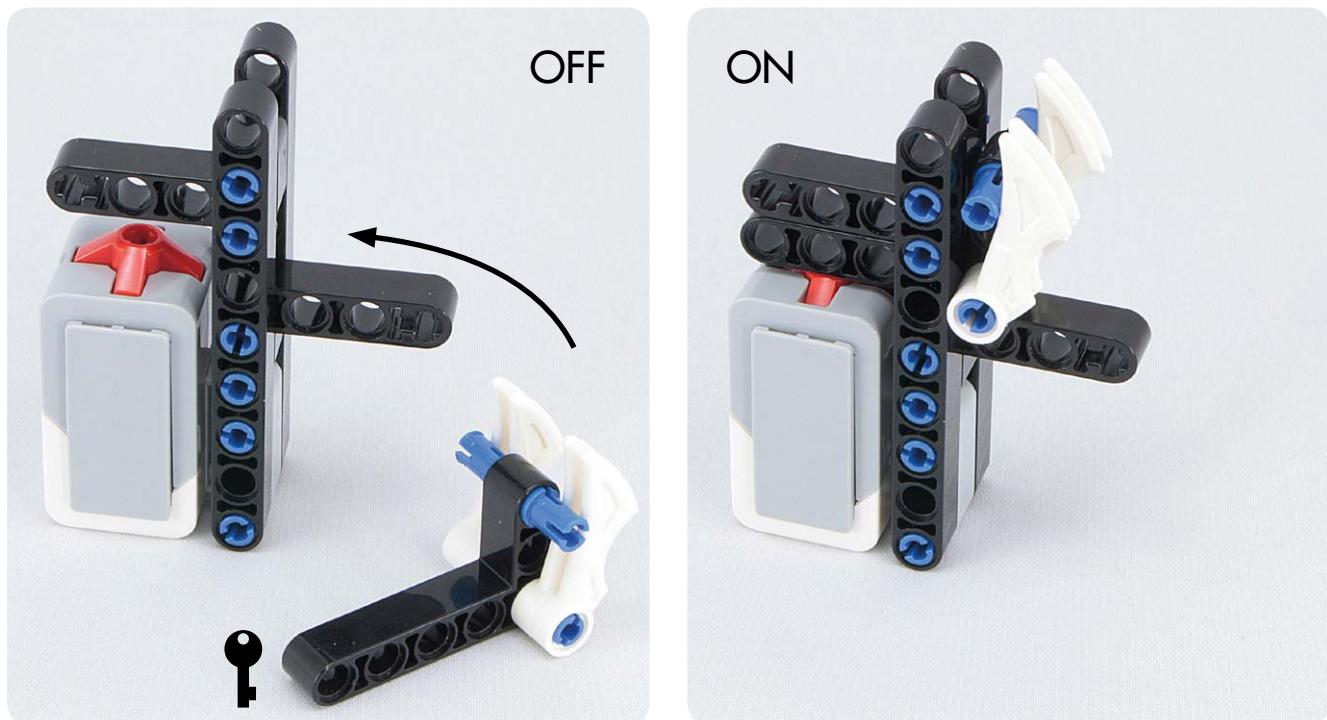
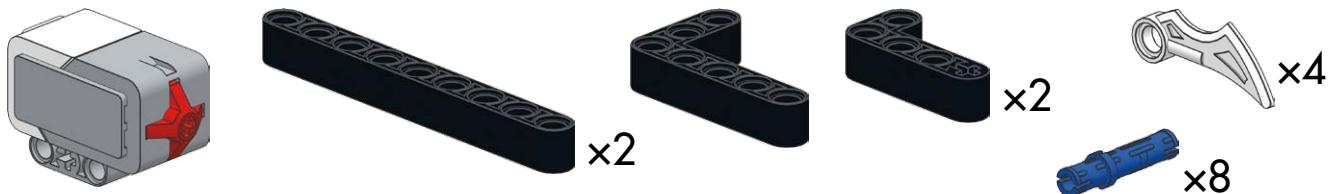
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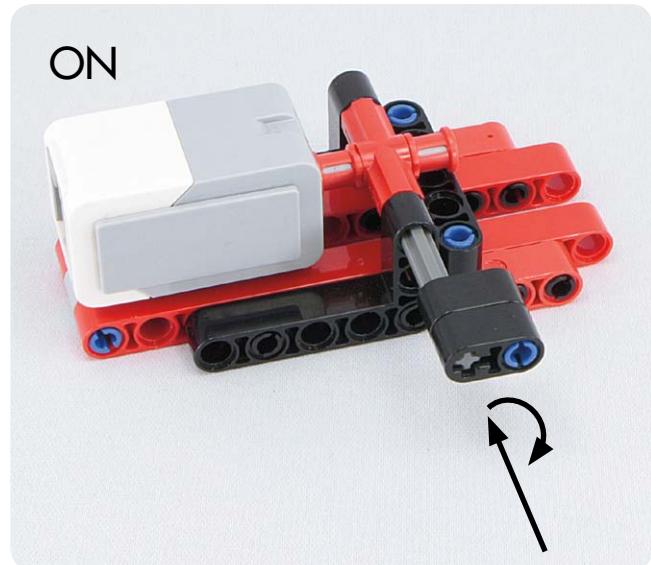
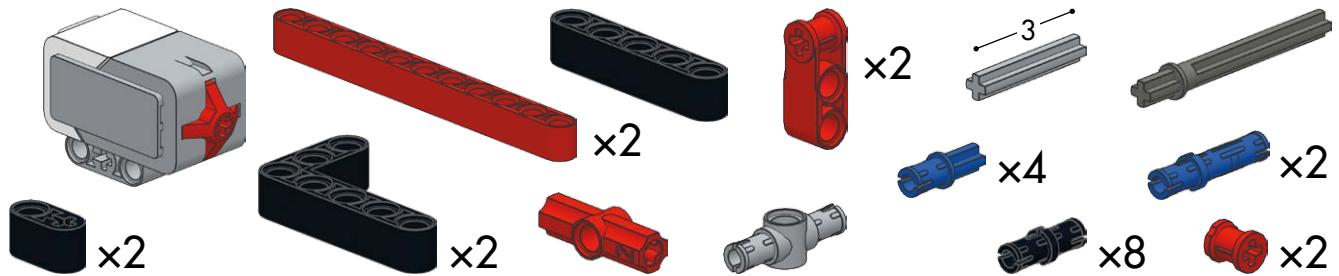
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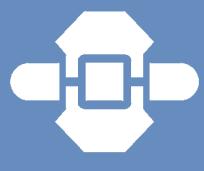


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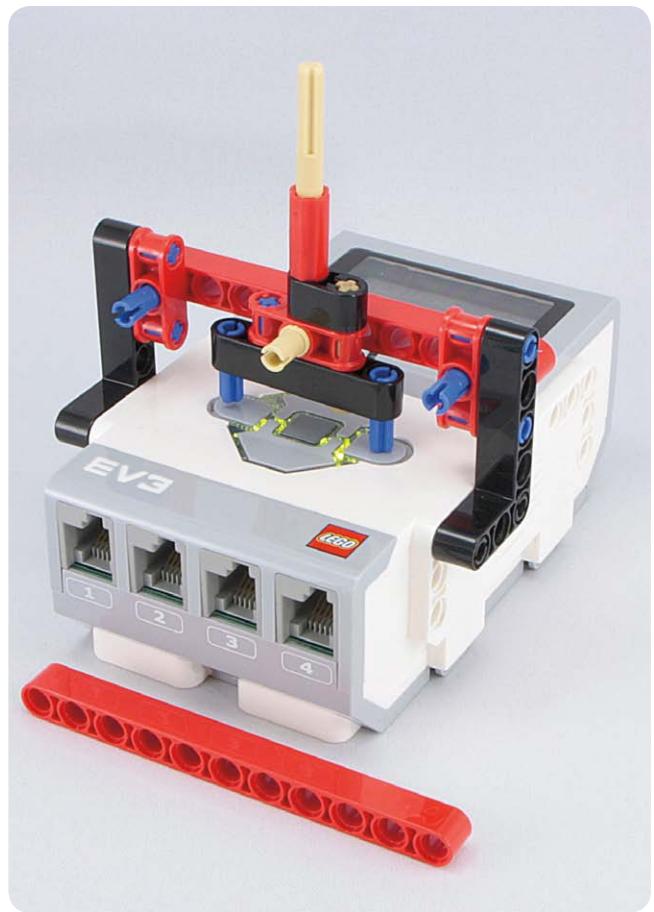
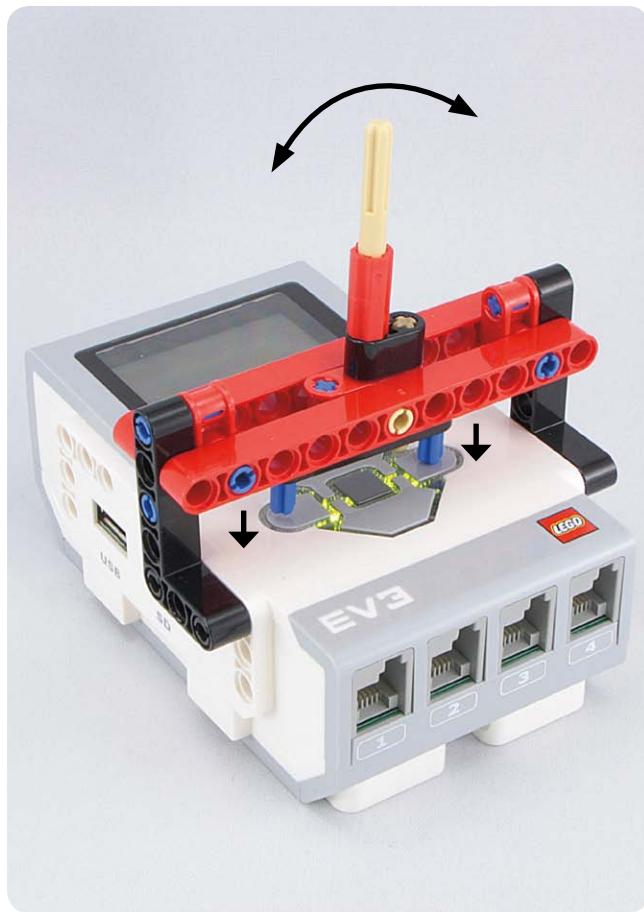
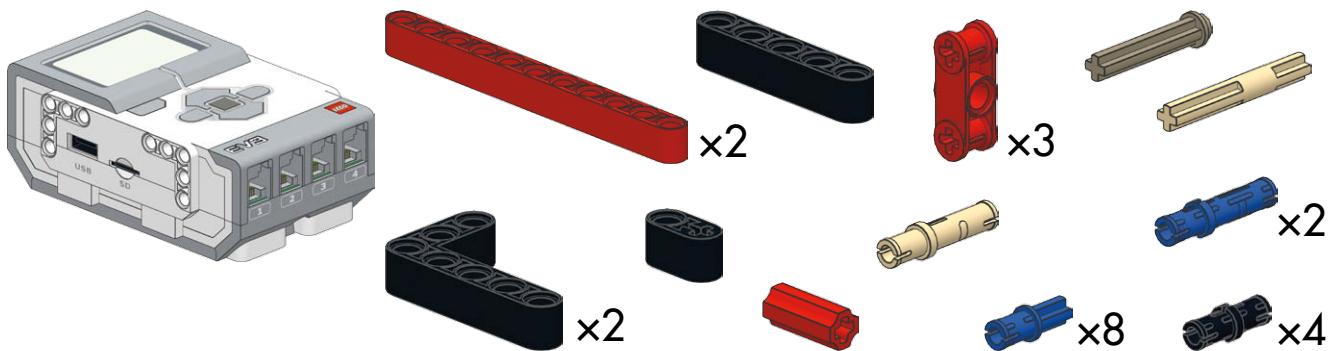
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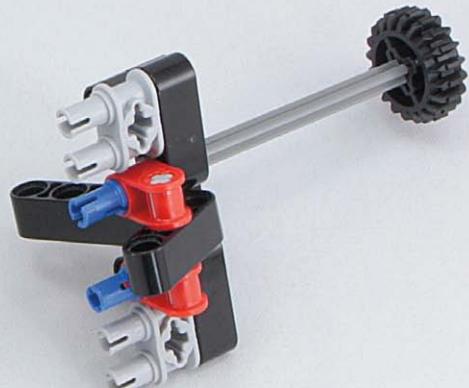
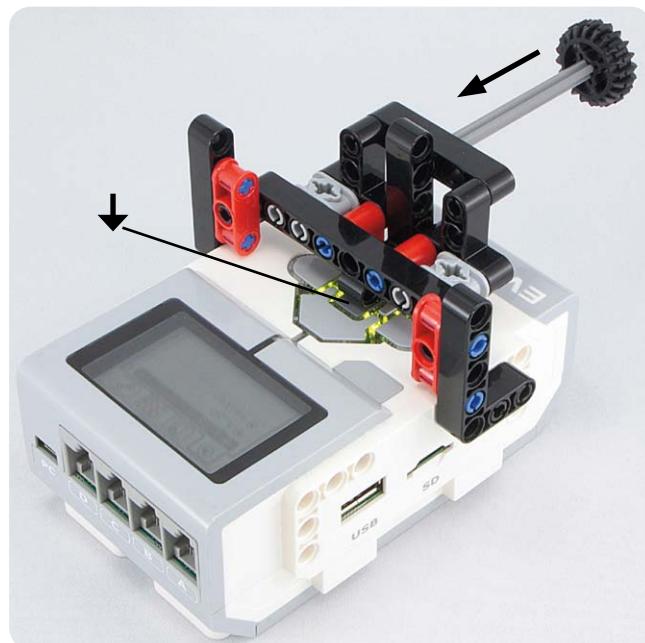
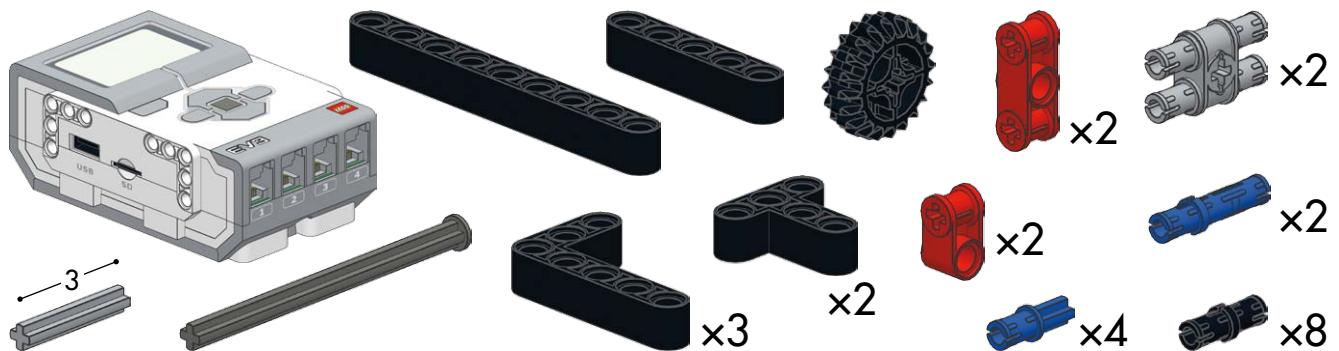


Ideas for using the buttons of the Intelligent EV3 Brick

#172



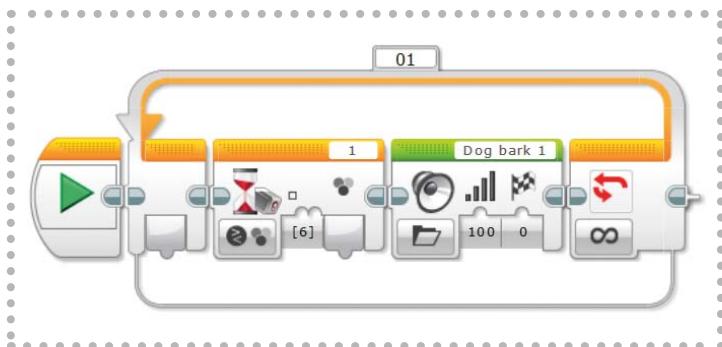
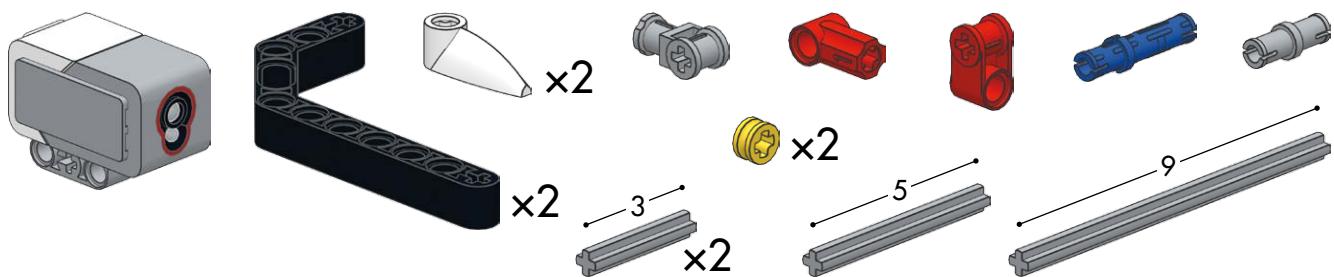
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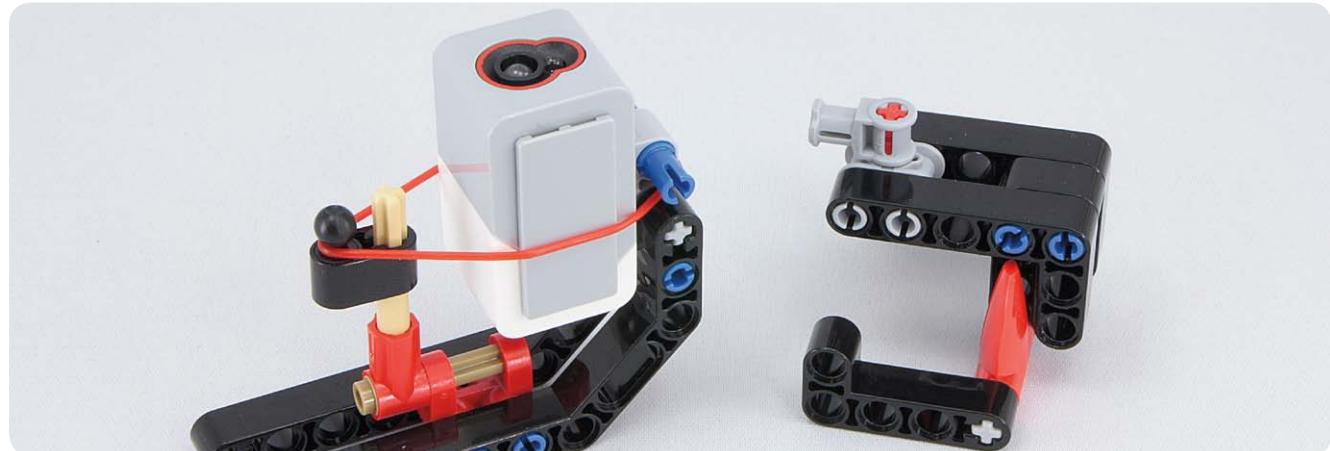
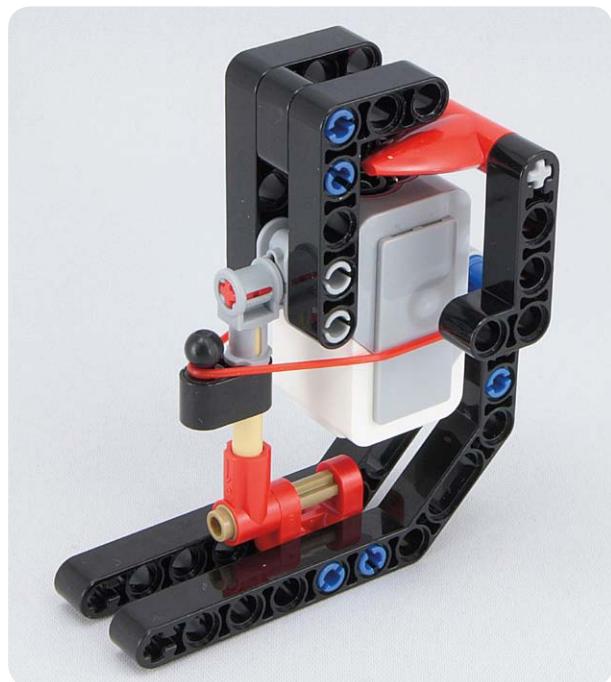
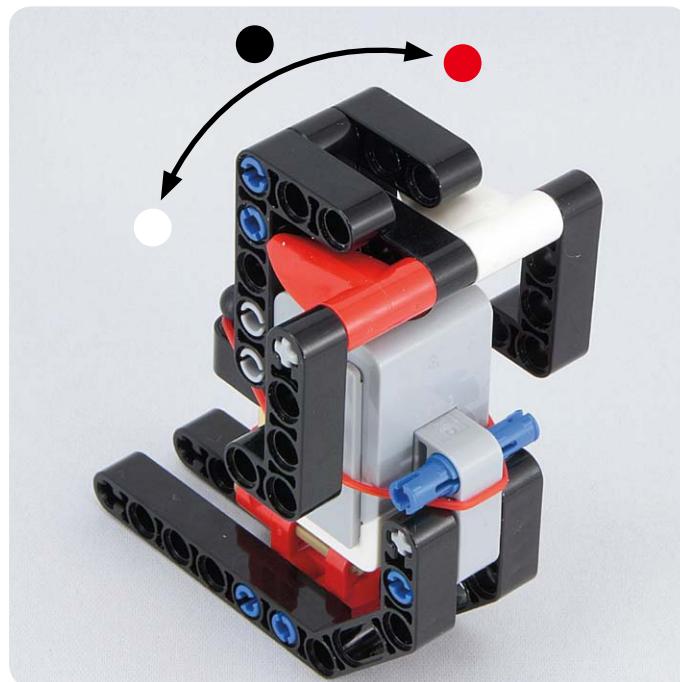
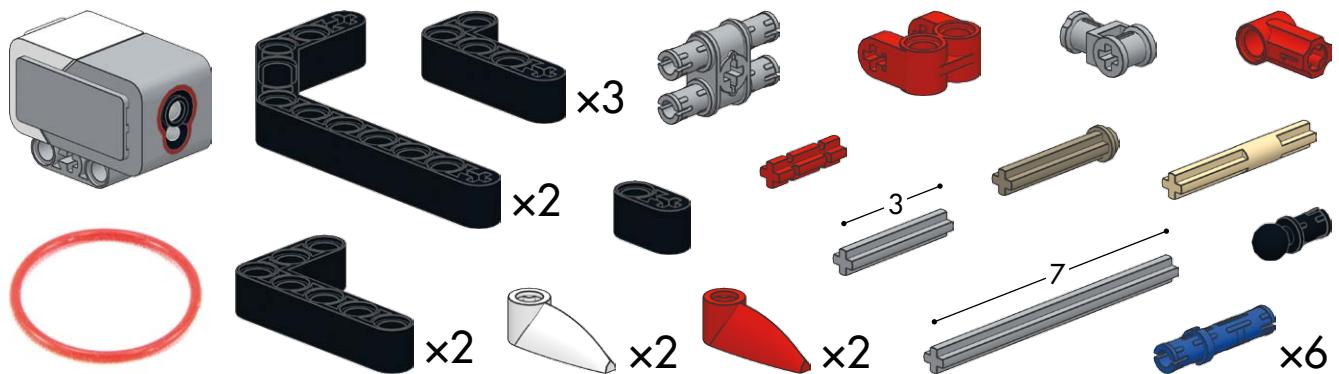


Ideas for using the color sensor

#174



#175





PART 6



Something Extra

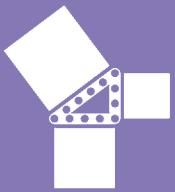


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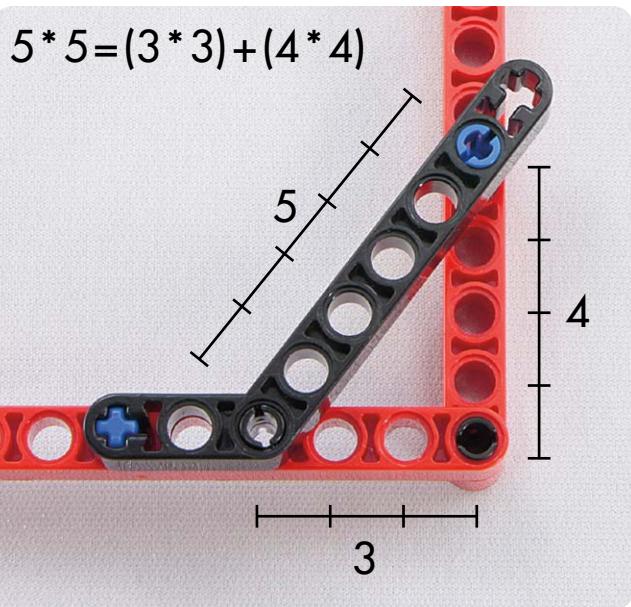
222

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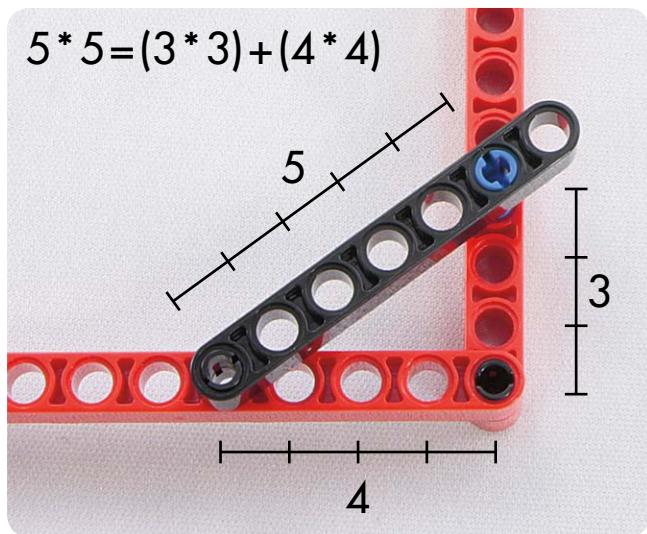


Using the Pythagorean theorem

#176

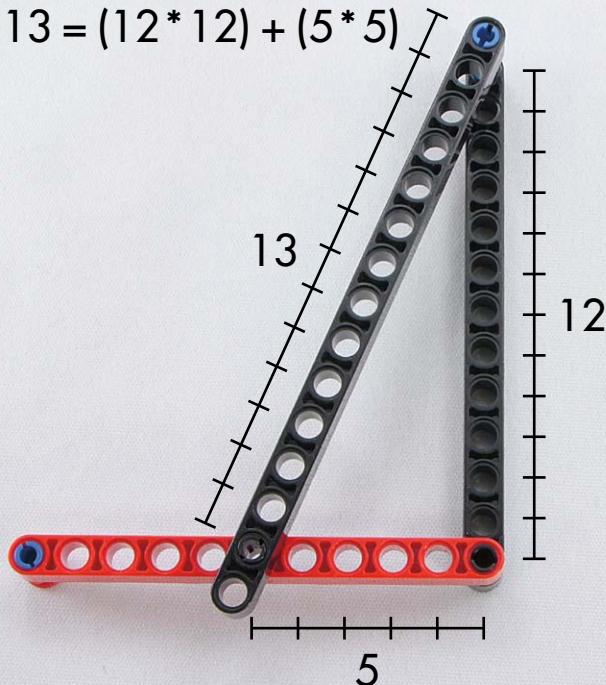


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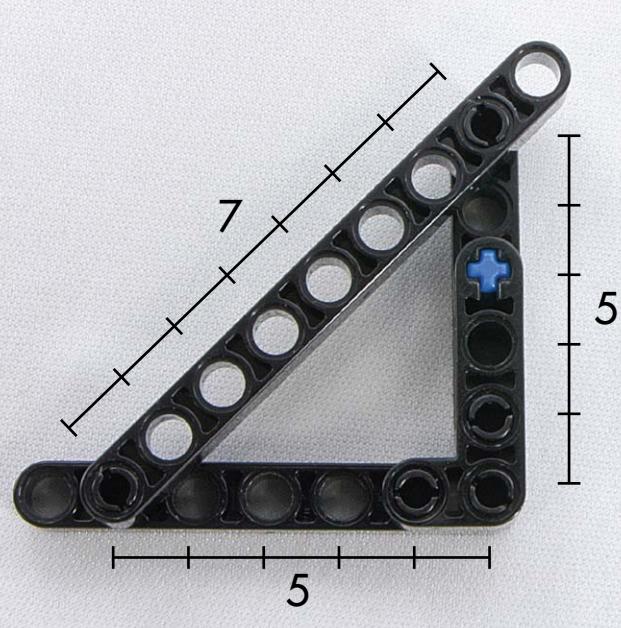
#178

$$13 \cdot 13 = (12 \cdot 12) + (5 \cdot 5)$$



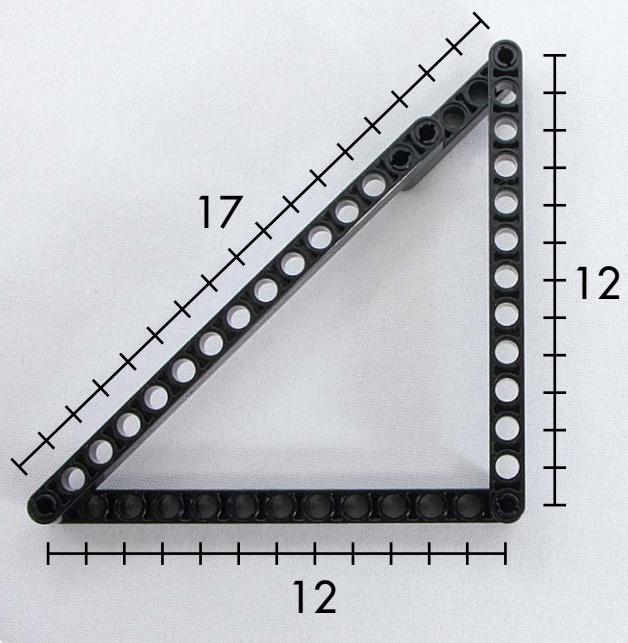
#179

$$7 \cdot 7 \approx (5 \cdot 5) + (5 \cdot 5)$$



#180

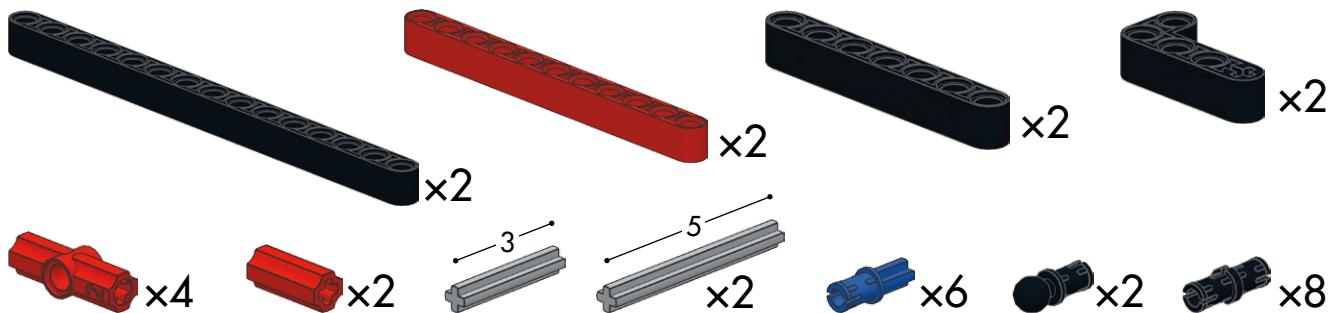
$$17 \cdot 17 \approx (12 \cdot 12) + (12 \cdot 12)$$





Try building something handy!

#181





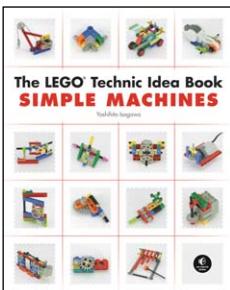
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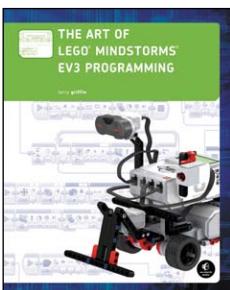
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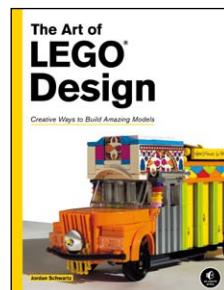
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Yoshihito Isogawa is a LEGO luminary with 46 years of building experience. He is the author of the *LEGO Technic Idea Book* series (No Starch Press) as well as many Japanese-language LEGO books.



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