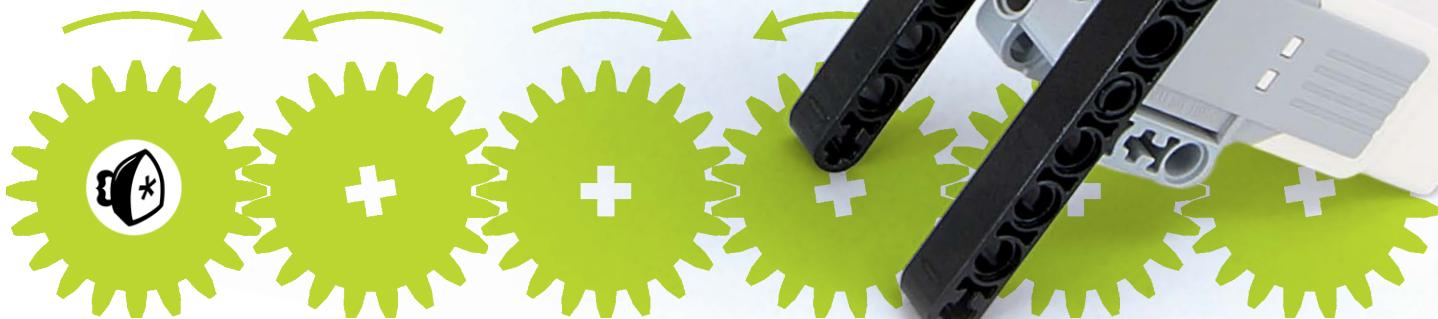


# THE LEGO® MINDSTORMS® EV3 IDEA BOOK



**YOSHIHITO ISOGAWA**



181 Simple Machines and Clever Contraptions

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**YOSHIHITO ISOGAWA**



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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?

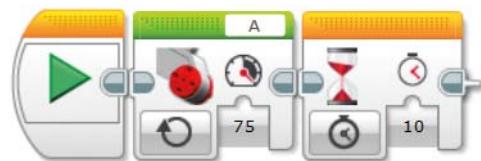
Other than this brief introduction and the table of contents, this book has almost no words. Instead, you'll find a series of photographs of increasingly complex models, each designed to demonstrate a mechanical principle or building technique.

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.

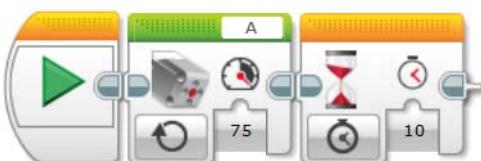
This is an idea book; it's about imagination. Rather than tell you what to see or think when you study the models, I encourage you to interpret them in your own way. Your interpretations will lead you to invent your very own models or use my mechanisms in entirely new ways!

## 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.

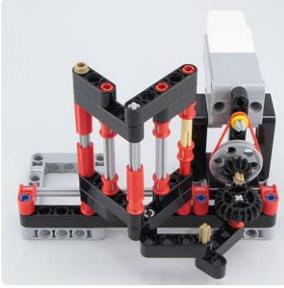


This program will rotate the Medium EV3 motor, then rest for a period.



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

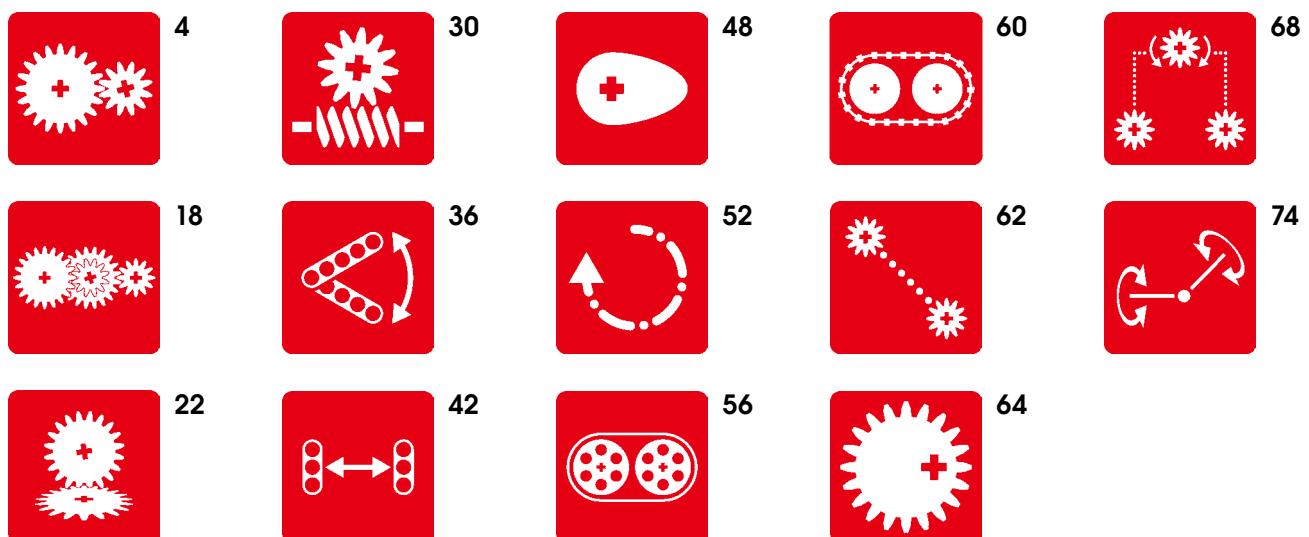
A few of the models in this book require special programs. Take note of these programs, as they are written to avoid damaging parts by overextending a mechanism's range of motion.



# PART 1



# Basic Mechanisms





# Gear ratios

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#1

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×2

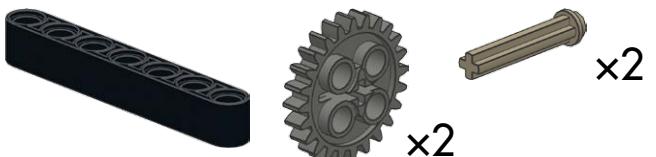
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#2

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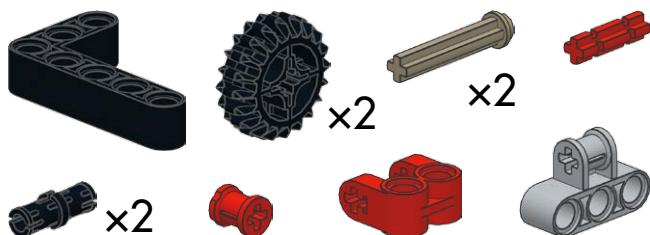


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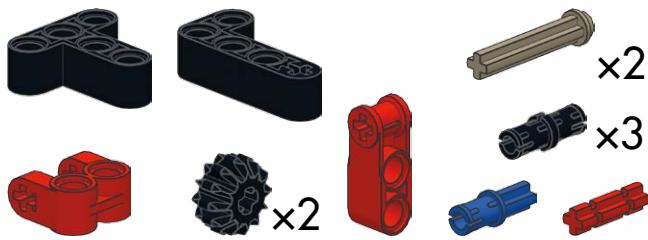
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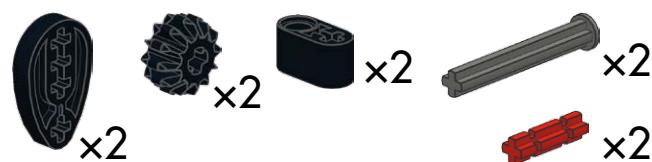


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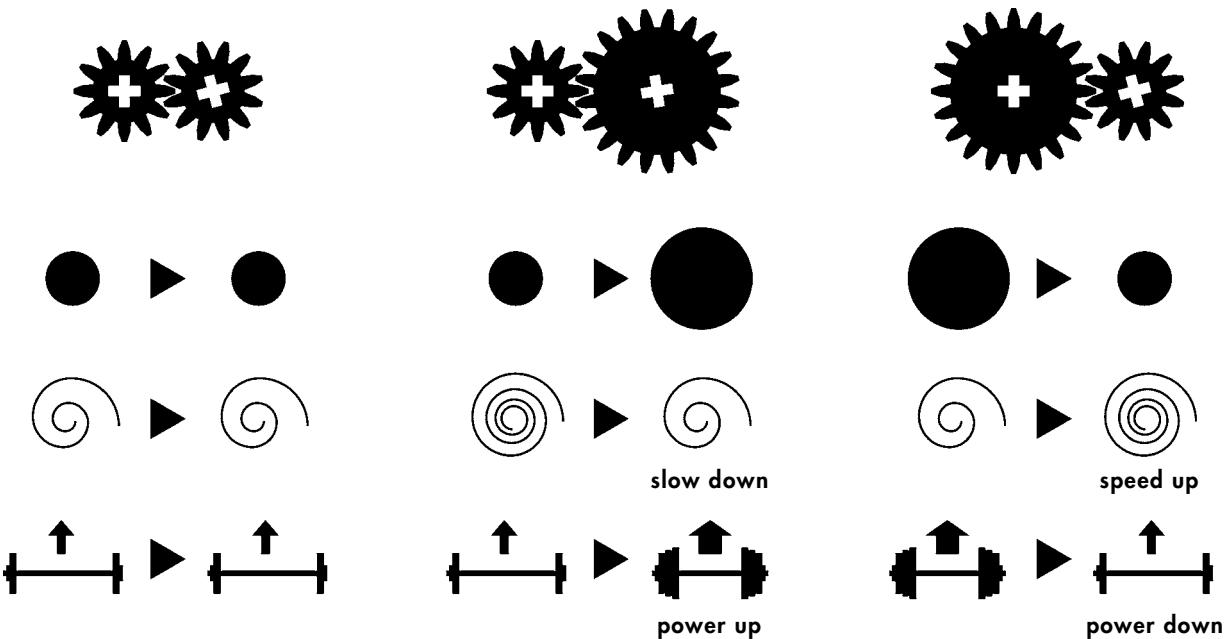


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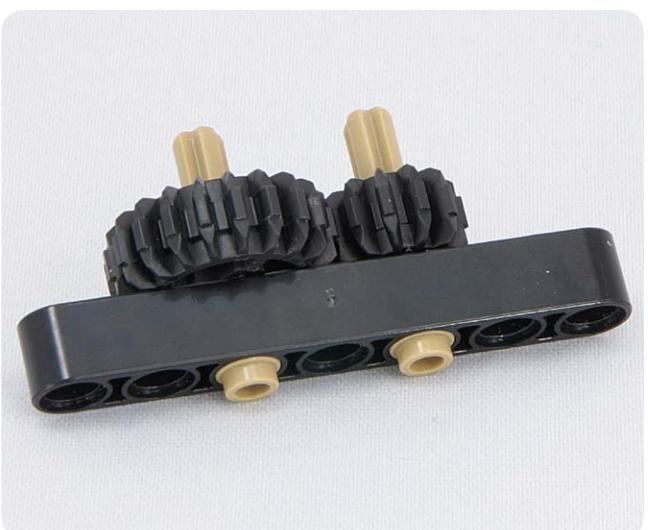


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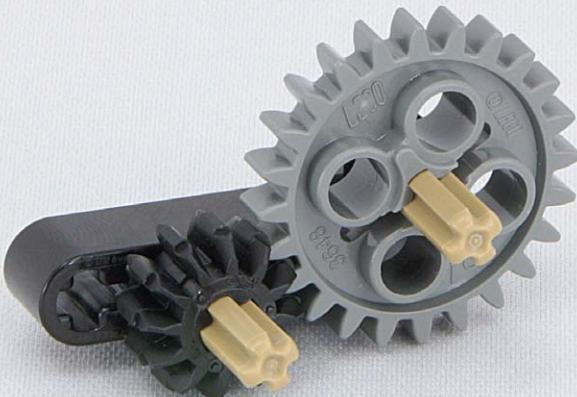
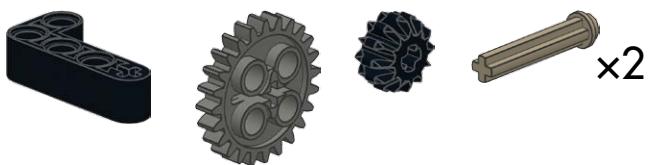
#7

$$12:20 = 3:5$$



#8

$12:24=1:2$



#9

$12:36=1:3$



## #10



$$20:36 = 5:9$$

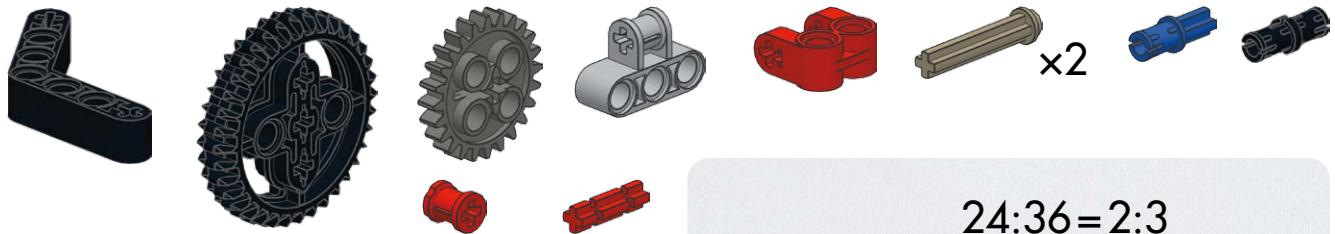


## #11

$$20:24 = 5:6$$



#12



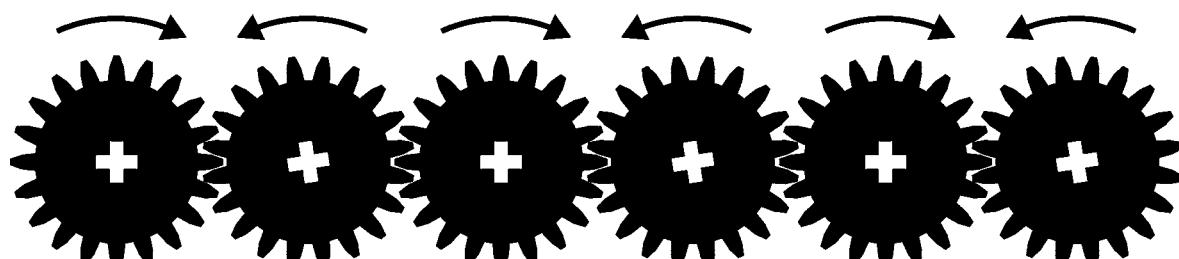
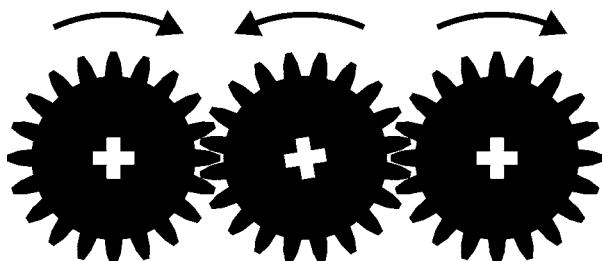
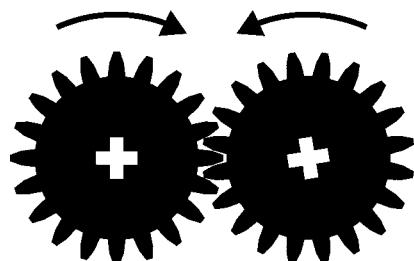
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$$12:20:12 = 3:5:3$$



## #14

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



#15



x2



x2



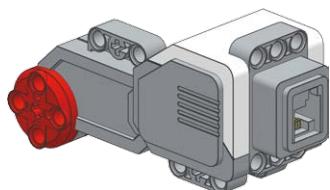
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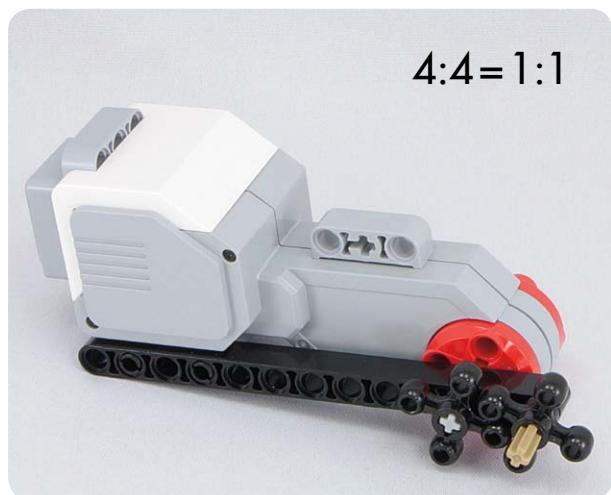
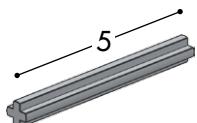
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x2



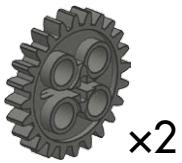
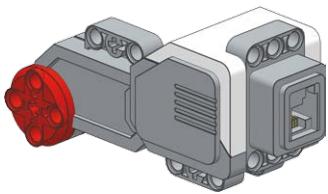
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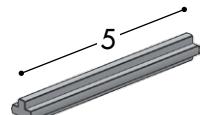
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x2



x2

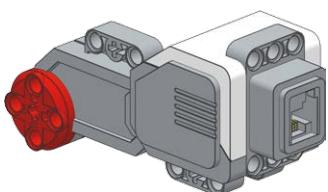


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#18



x2

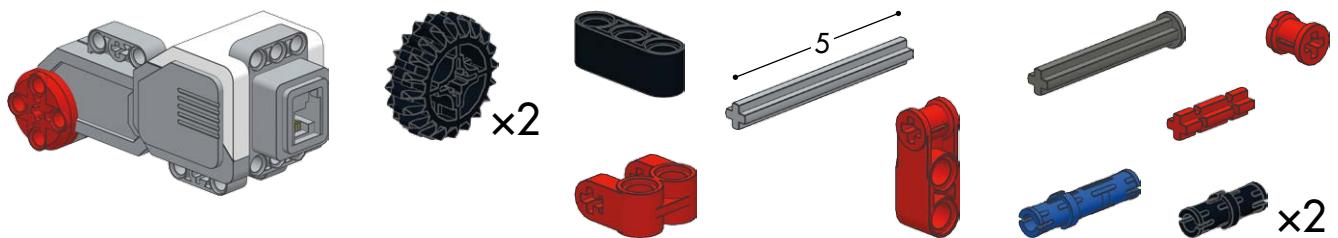


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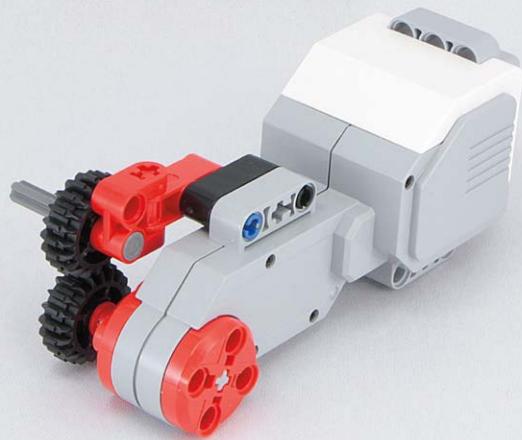


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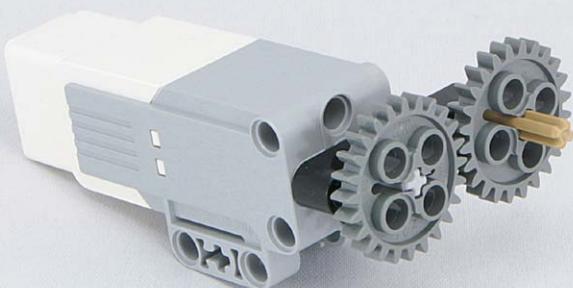
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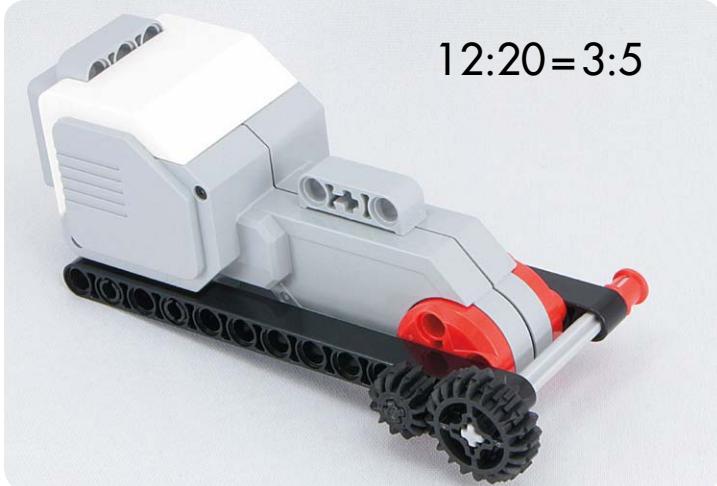
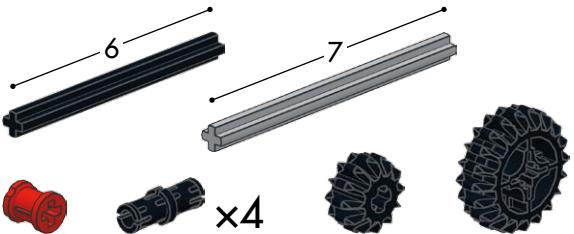
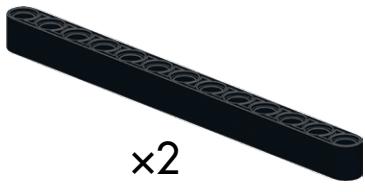
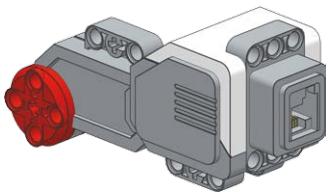
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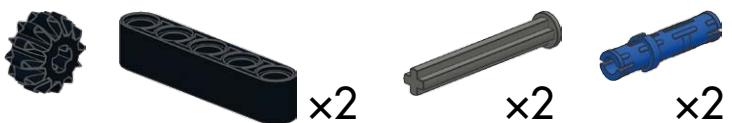
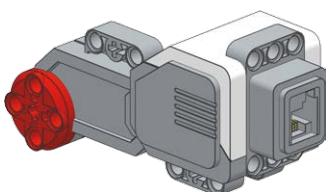
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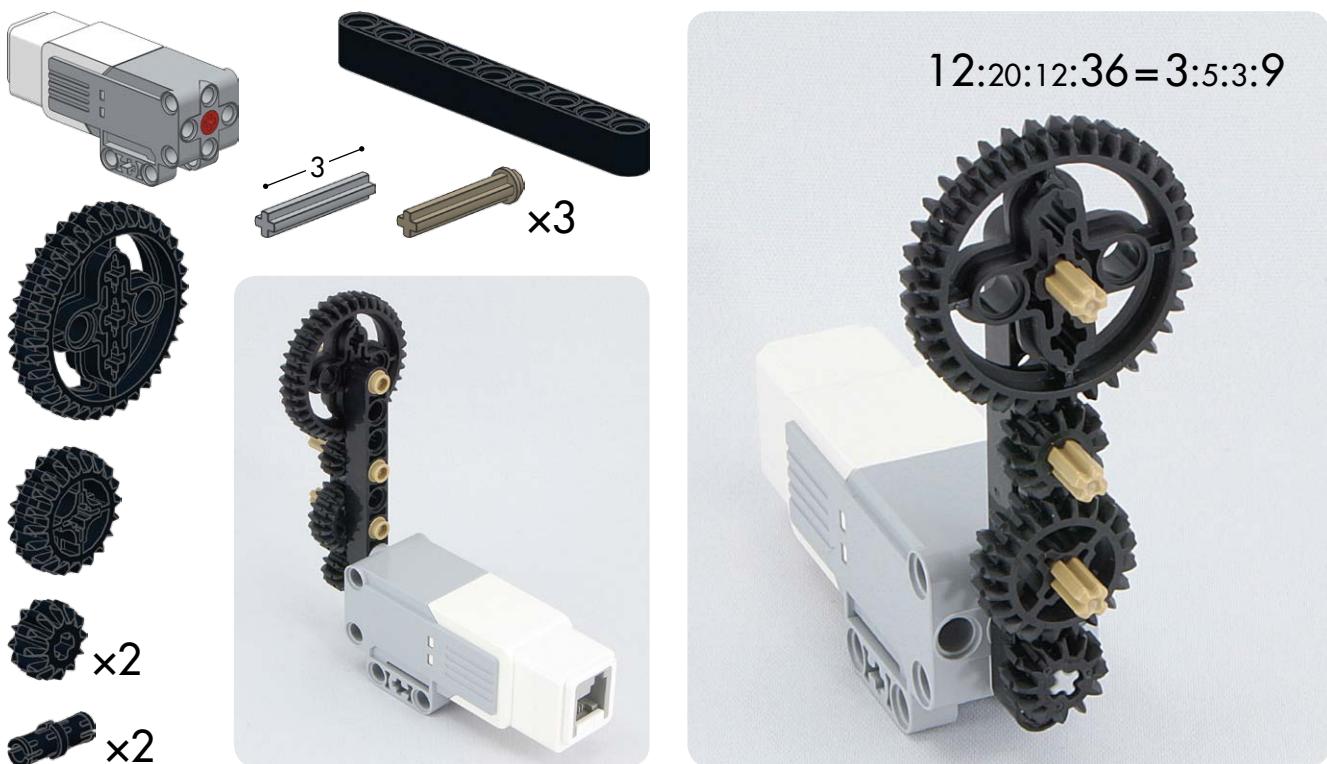
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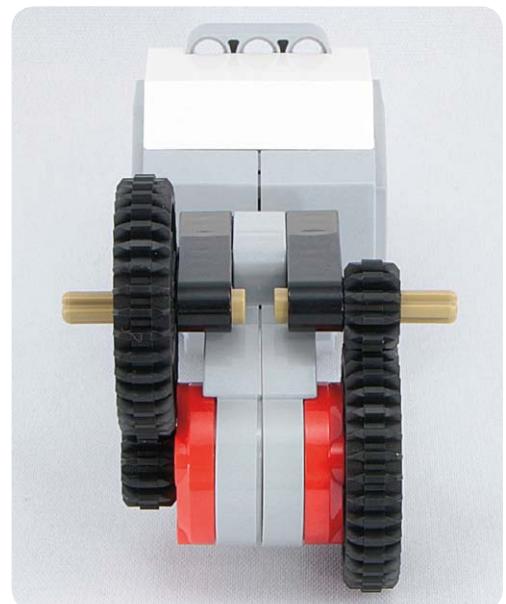
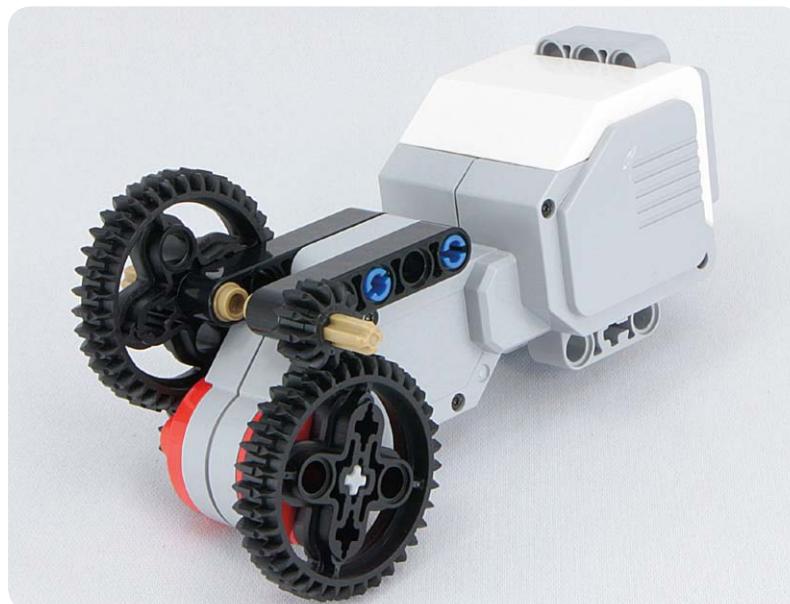
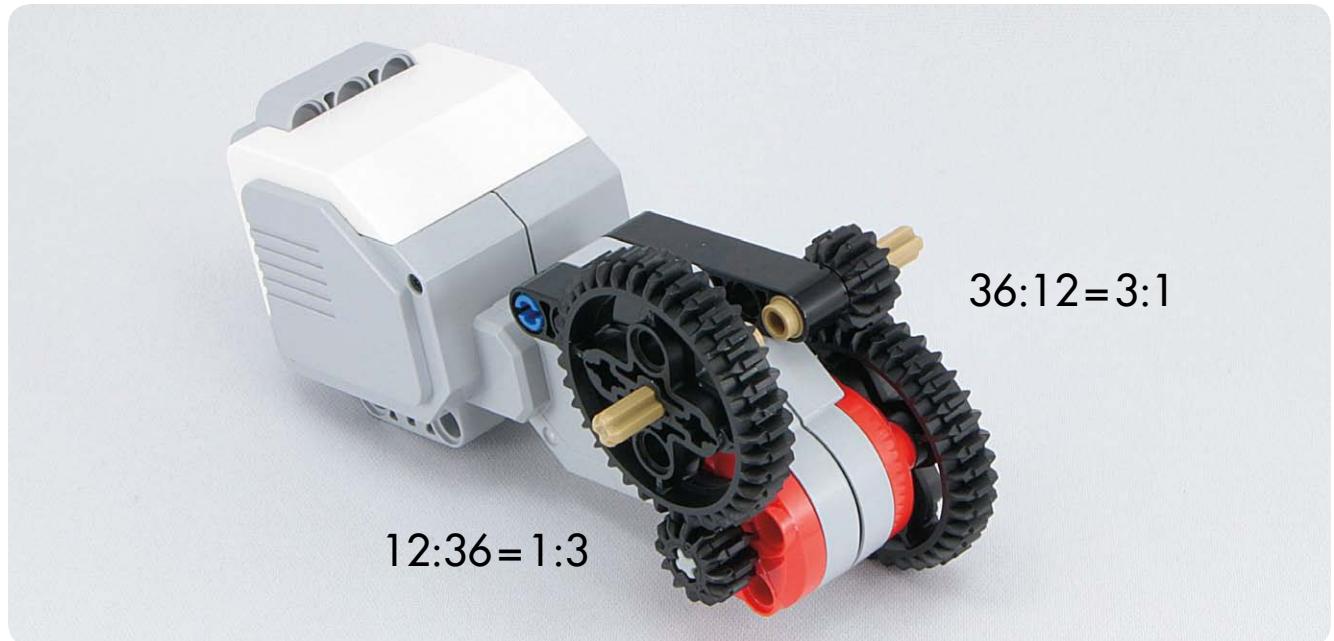
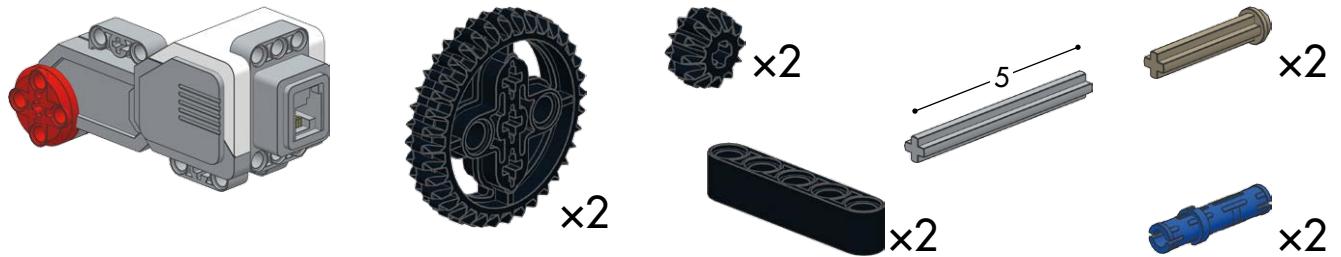
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## #24



#25



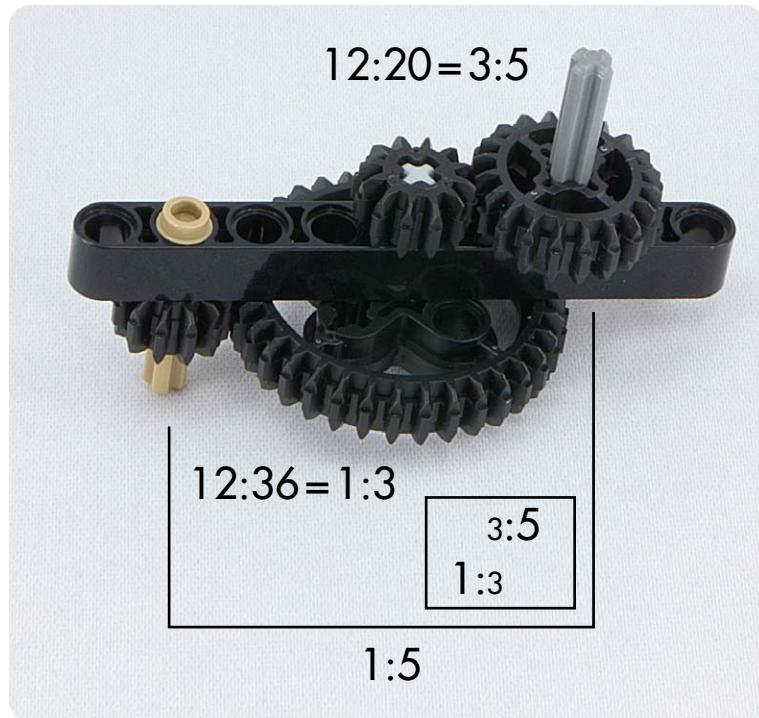


# Compound gear systems

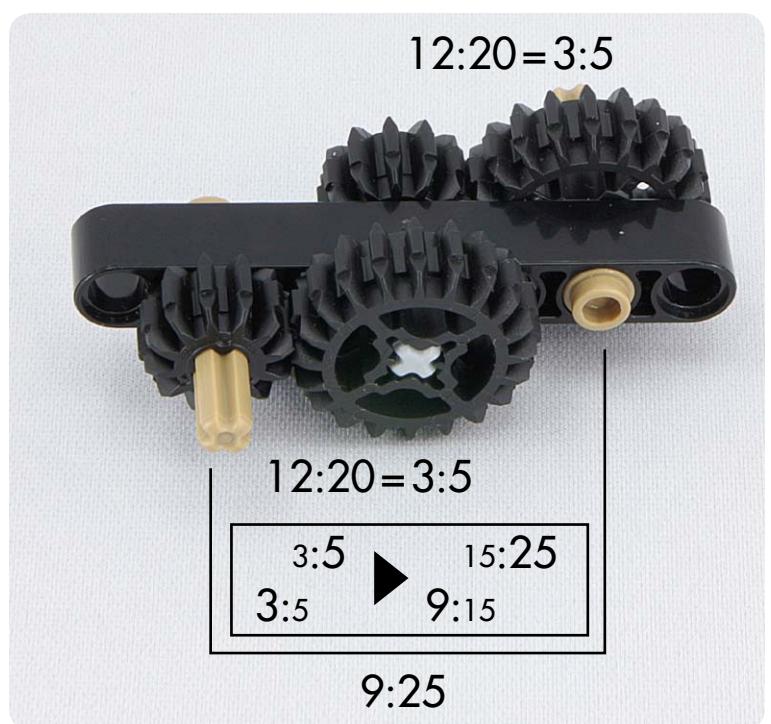
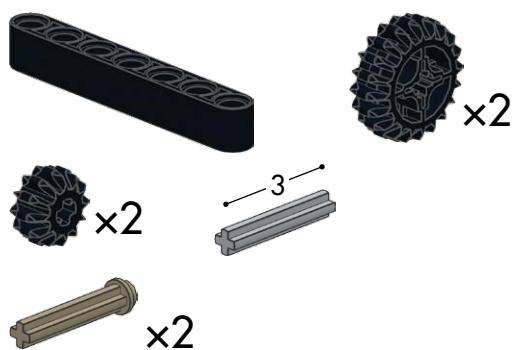
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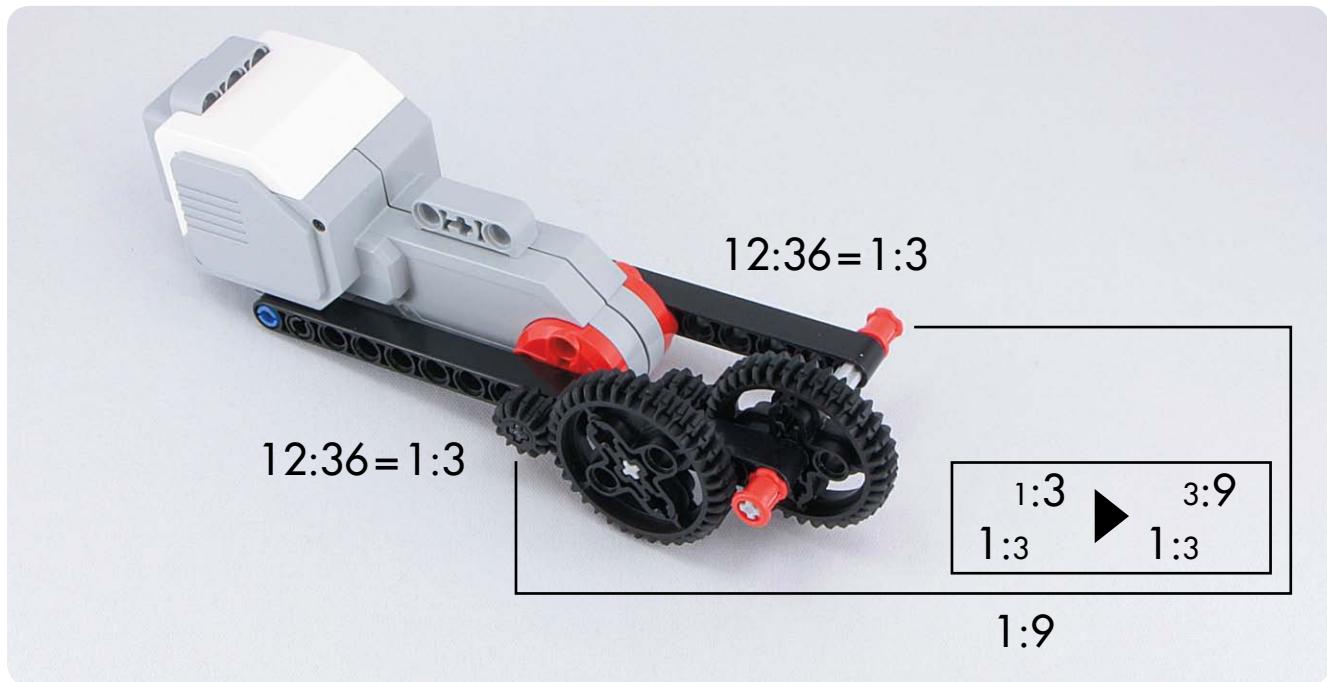
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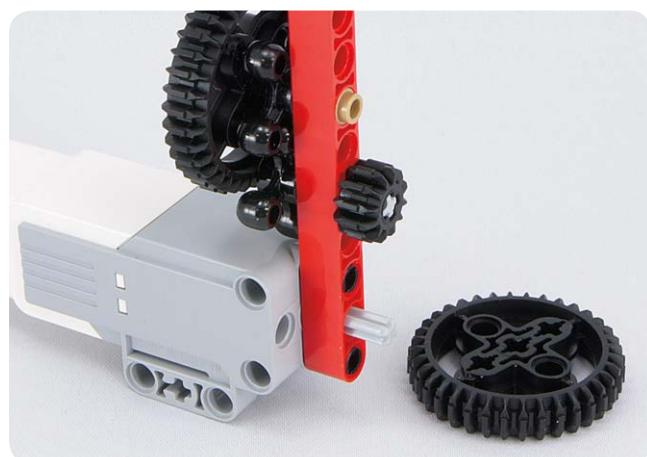
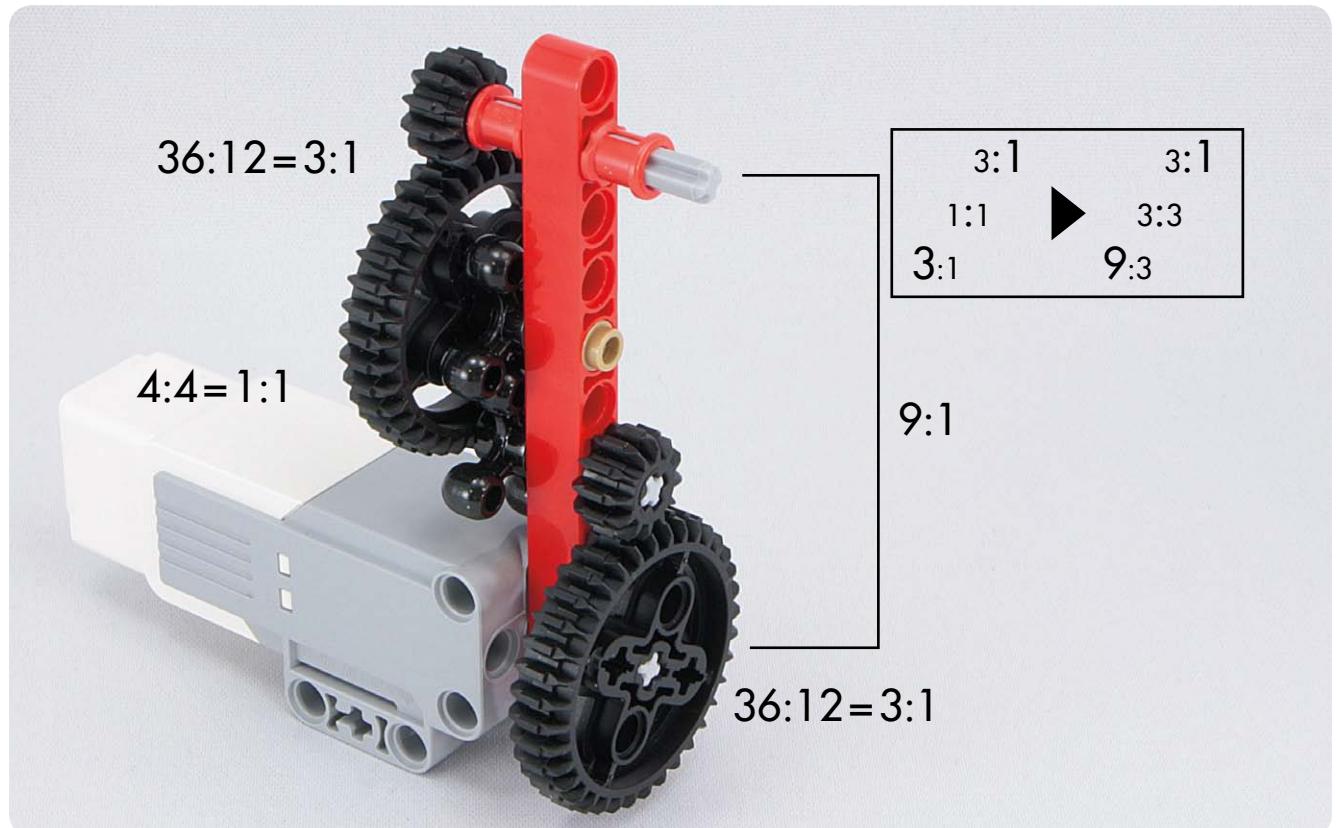
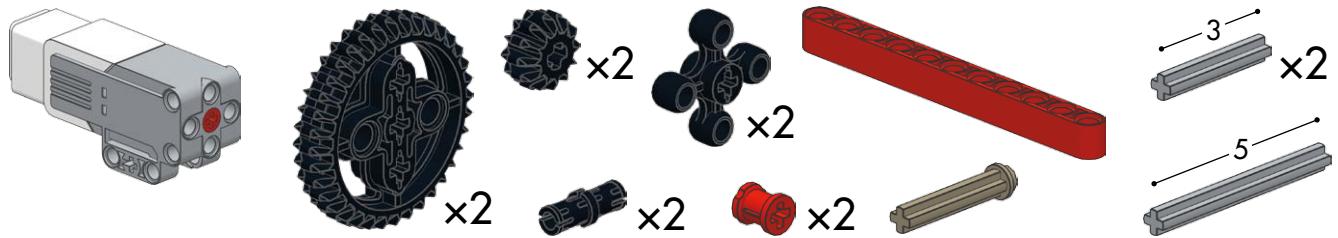
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## #29



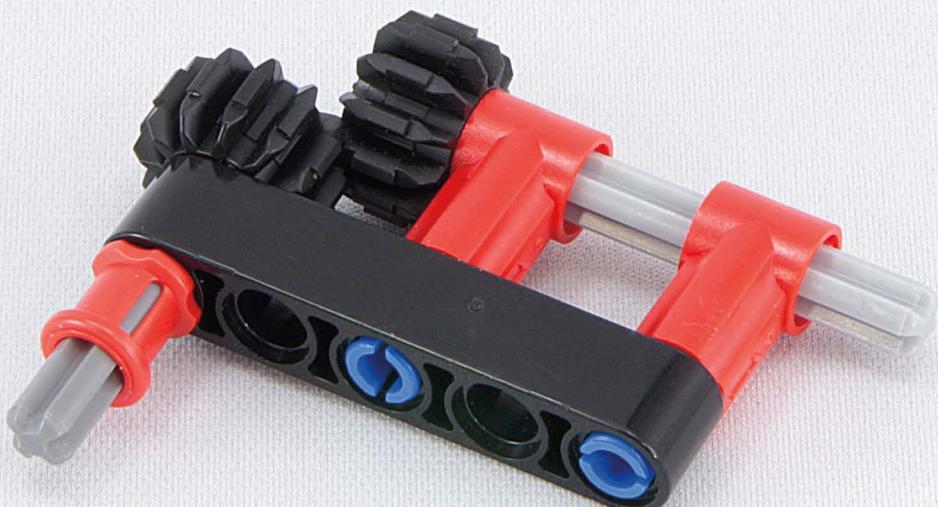
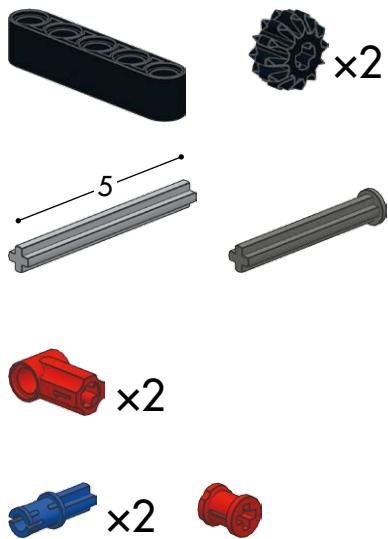
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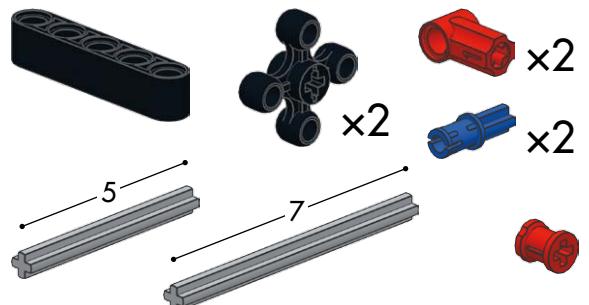


# Changing the angle of rotation

#31



## #32

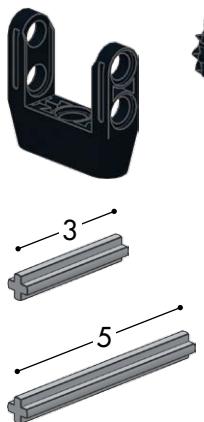


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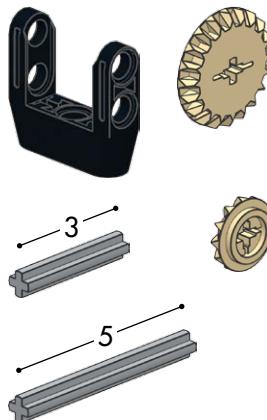


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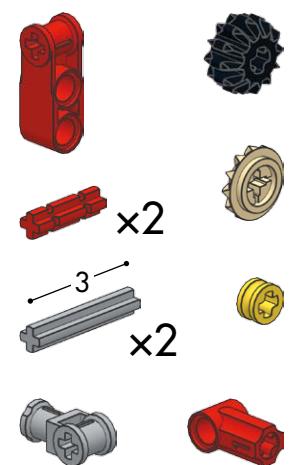
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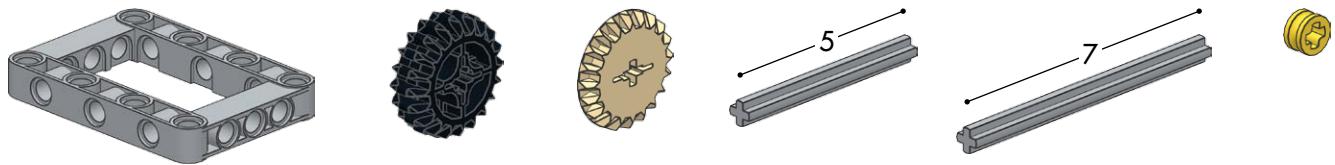
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#36



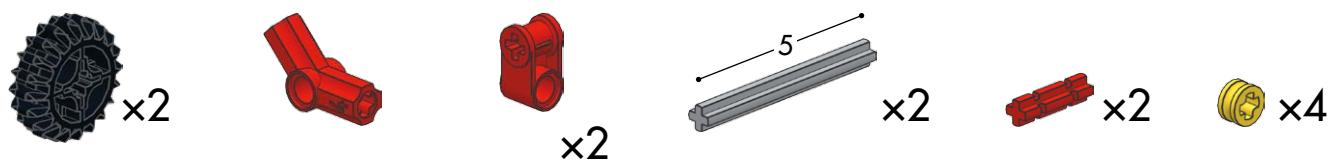
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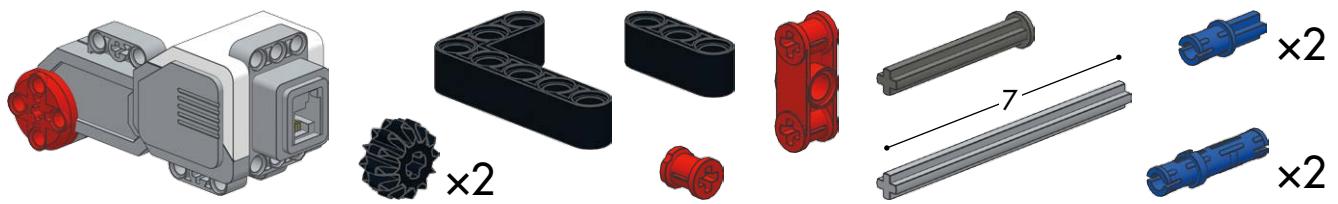
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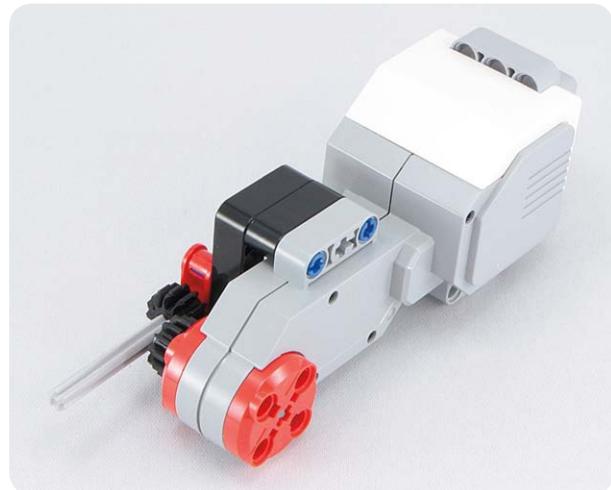
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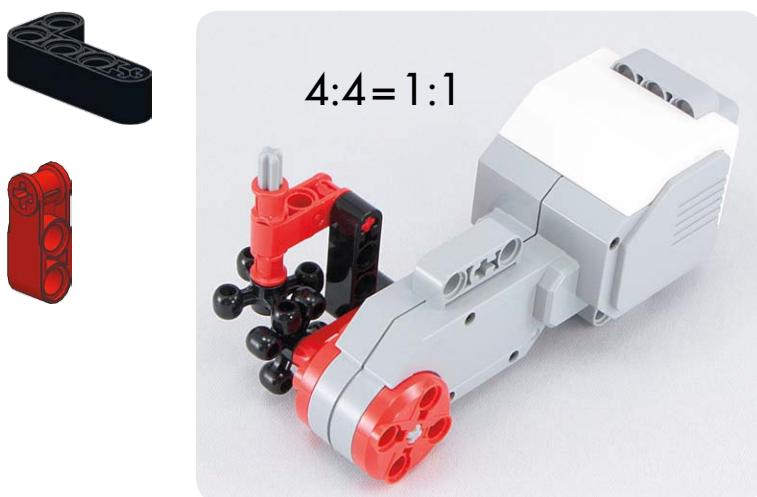
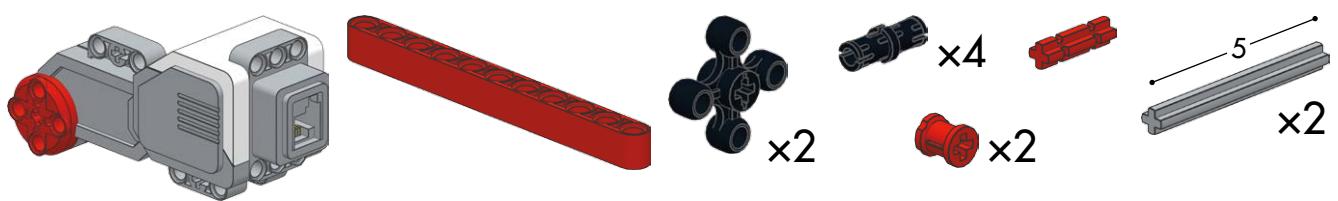
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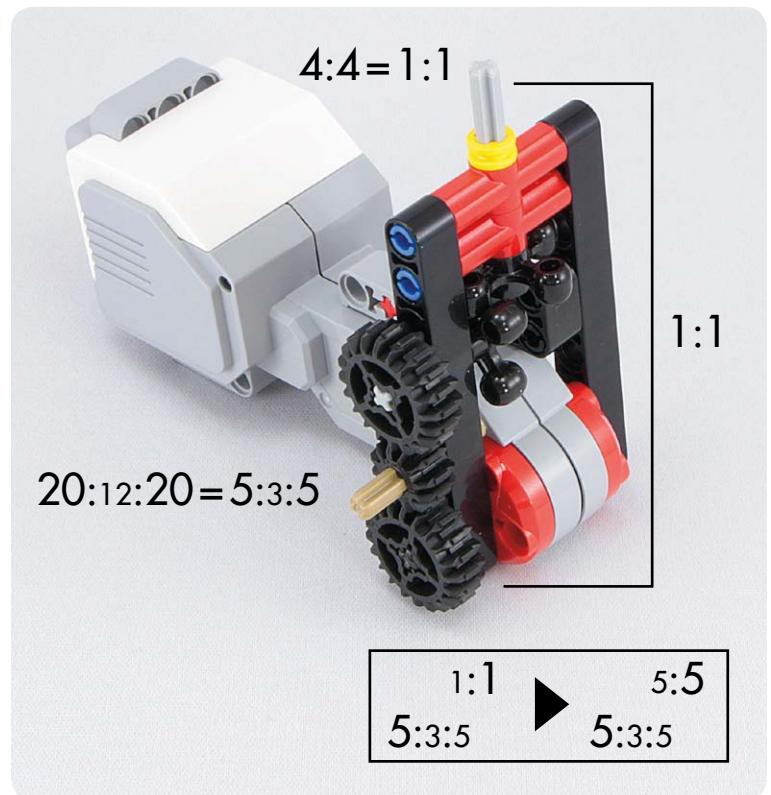
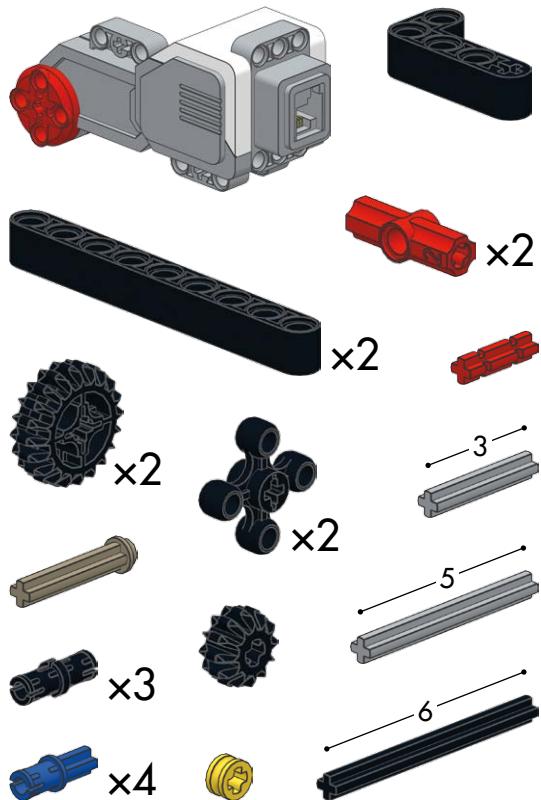
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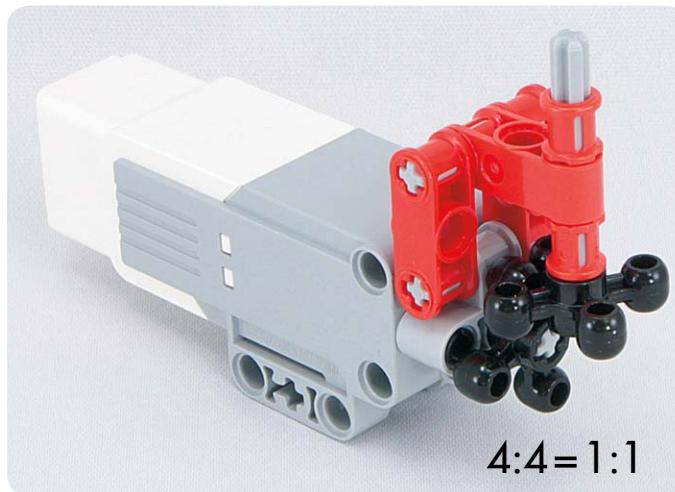
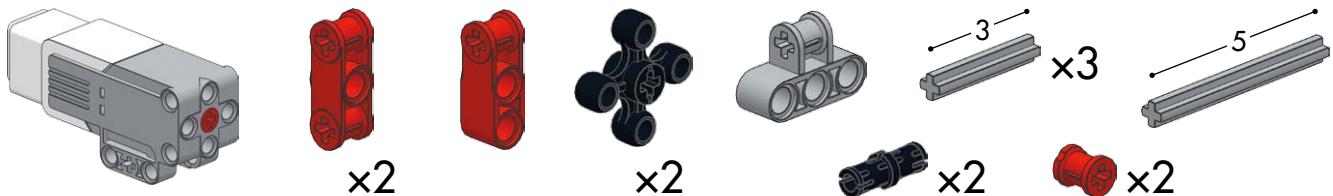
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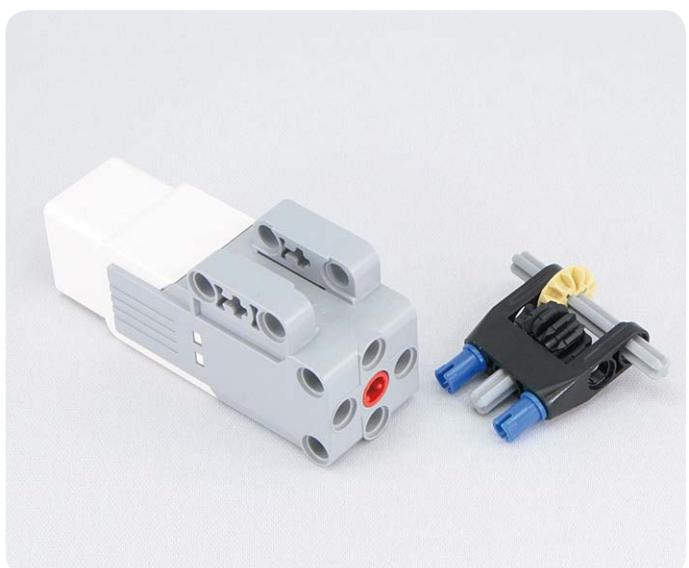
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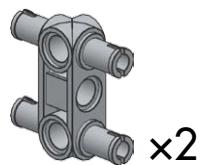
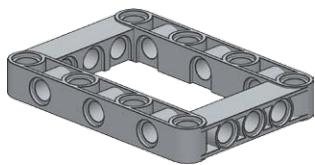
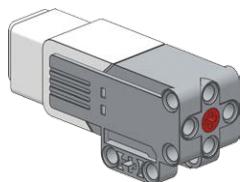
## #42



## #43



#44



x2



x2



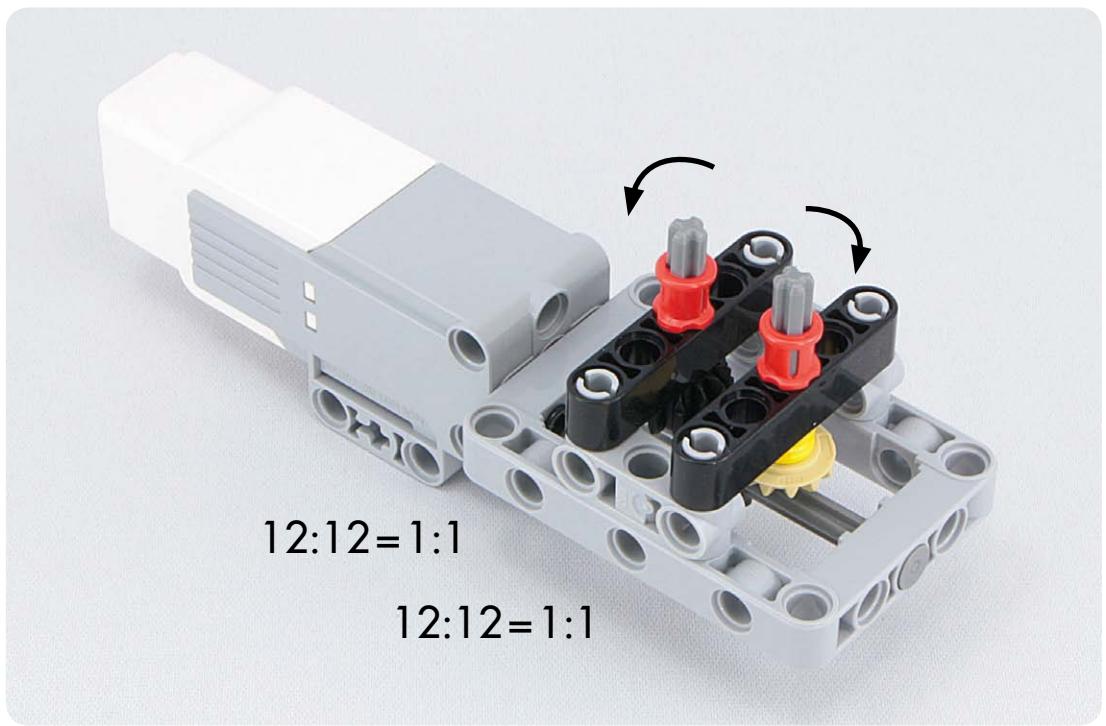
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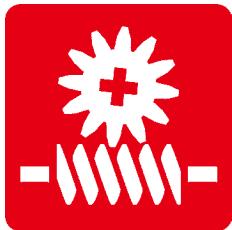


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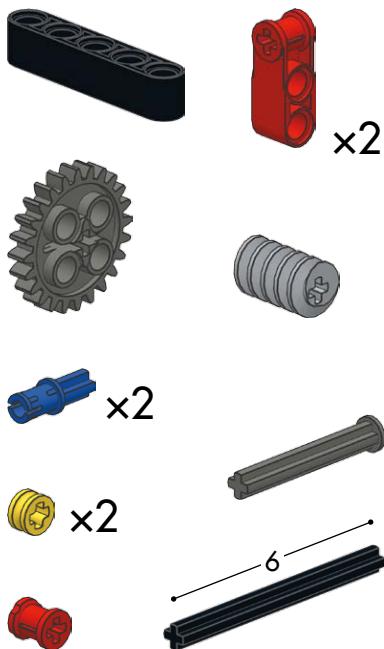
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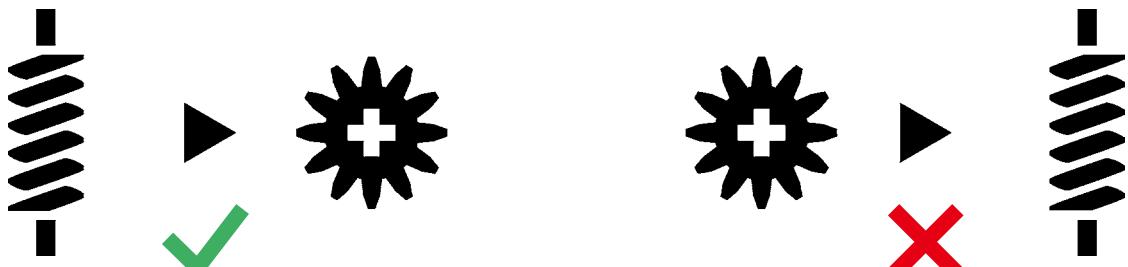




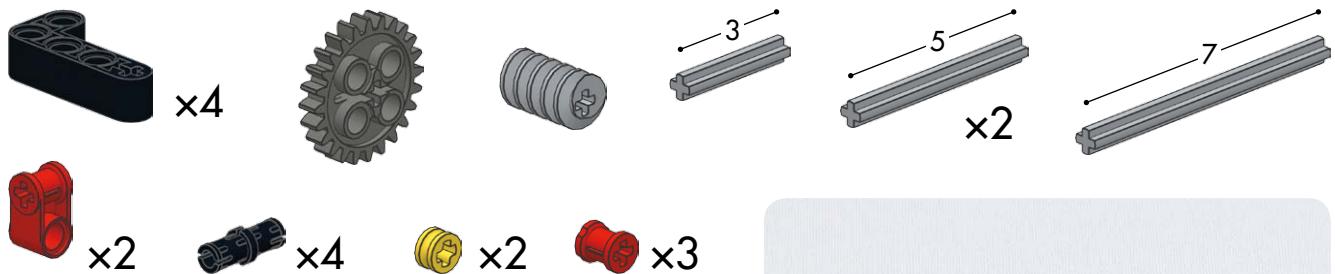
# Using worm drives

#45

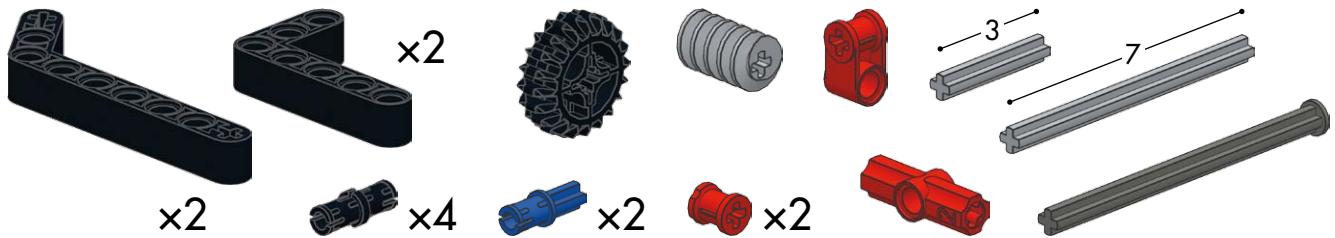




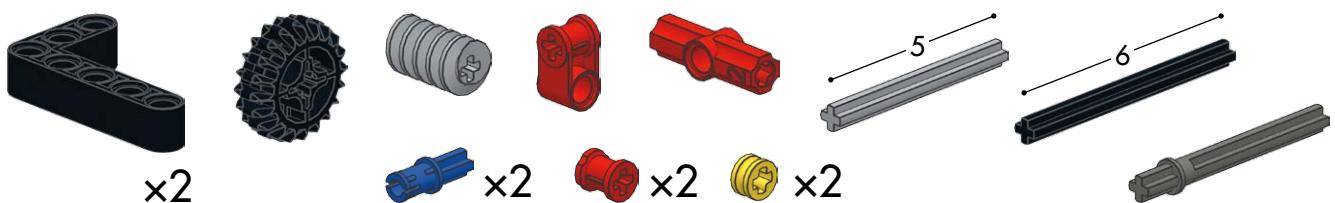
#46



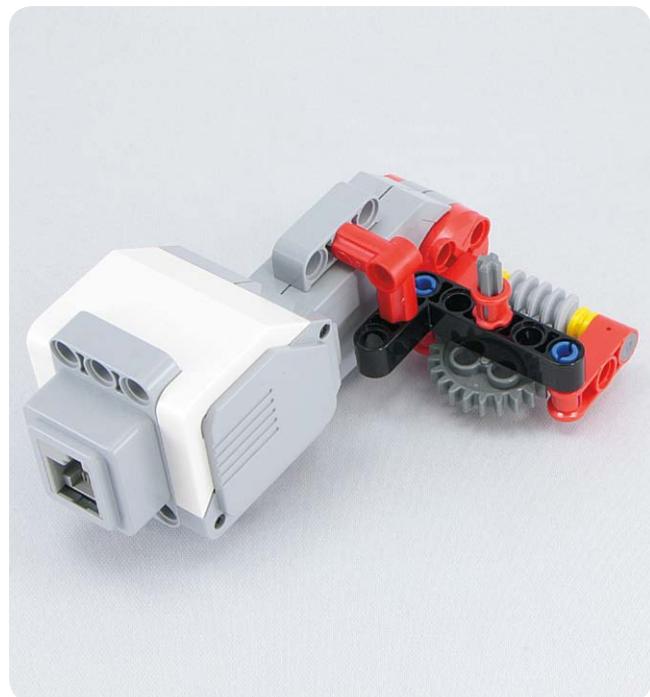
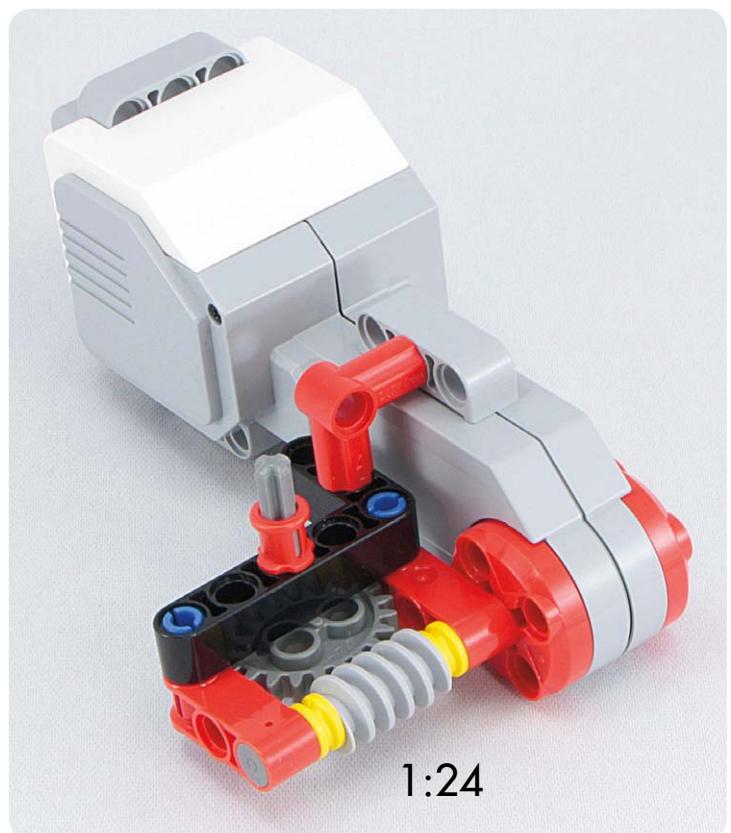
## #47



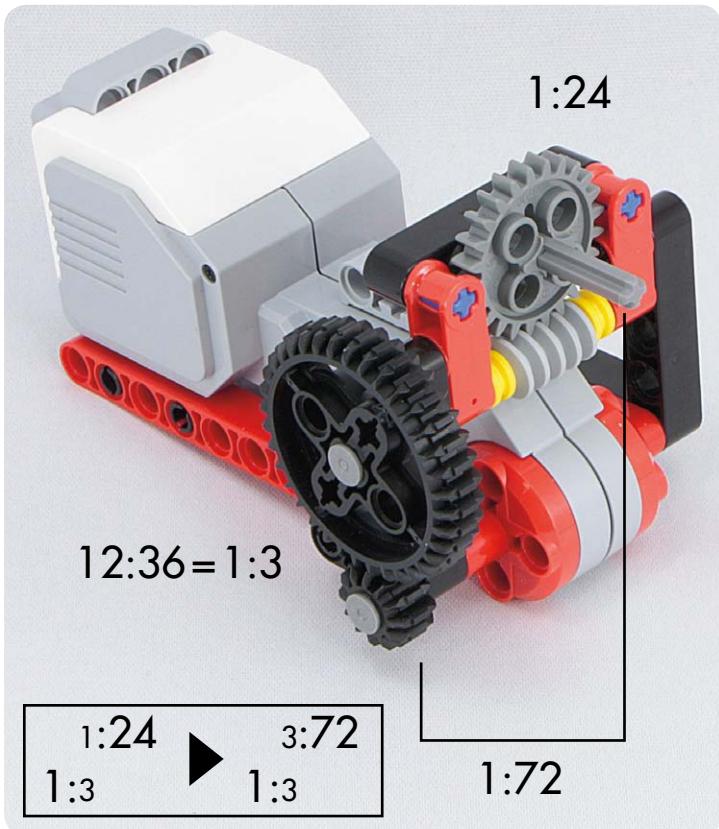
## #48



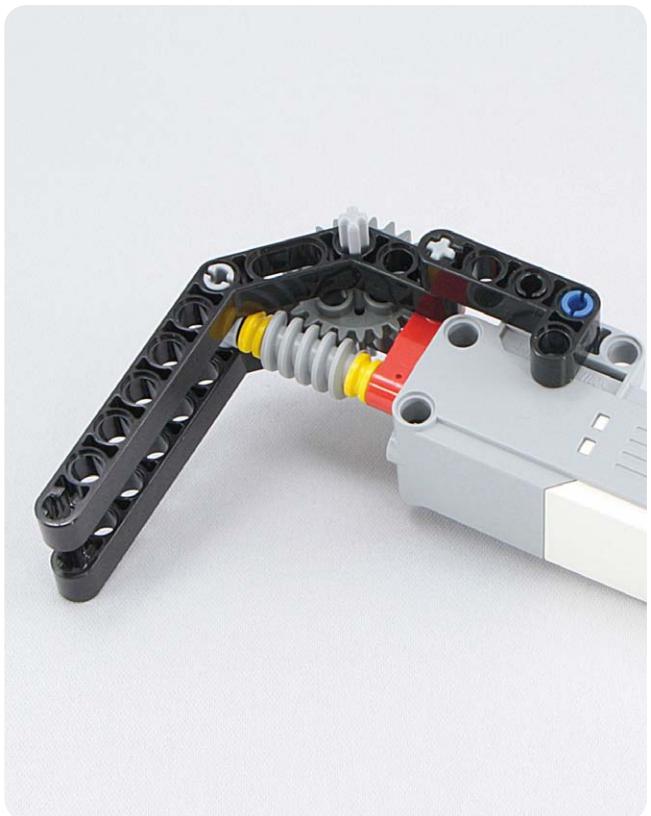
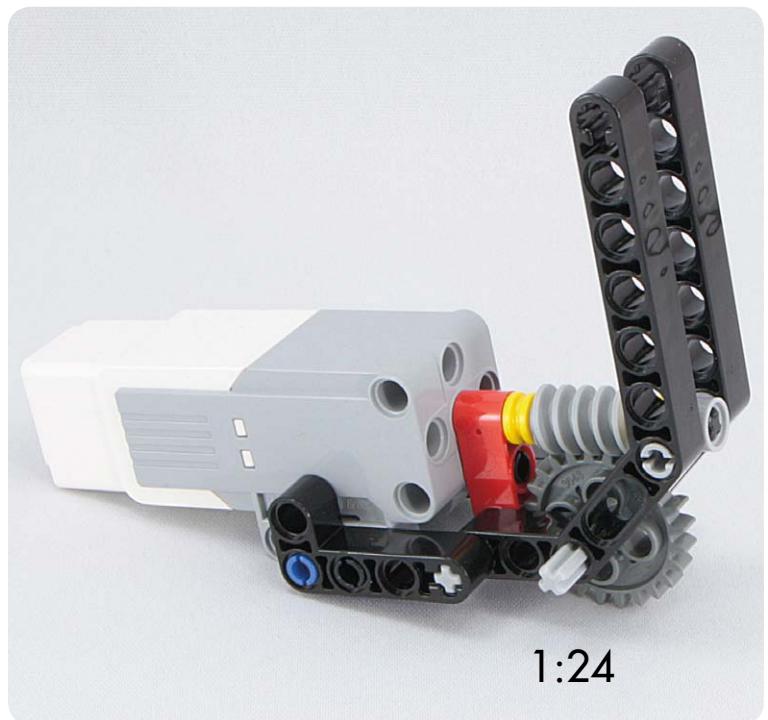
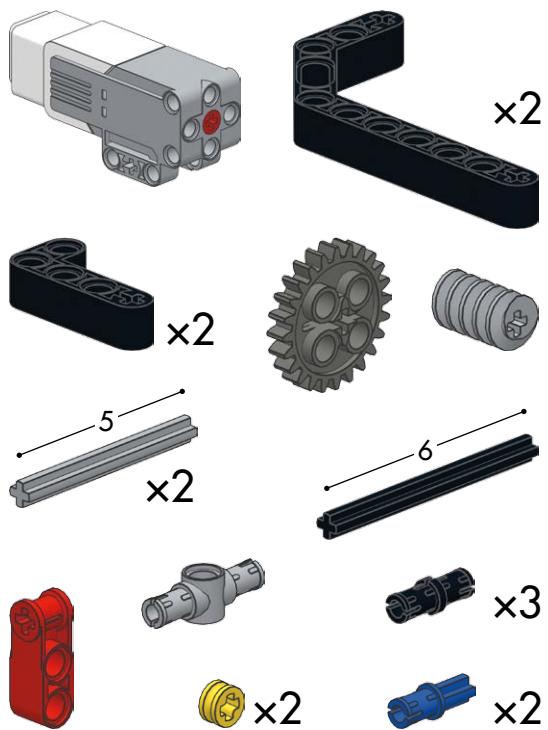
#49

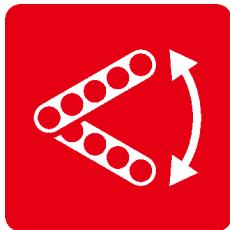


#50



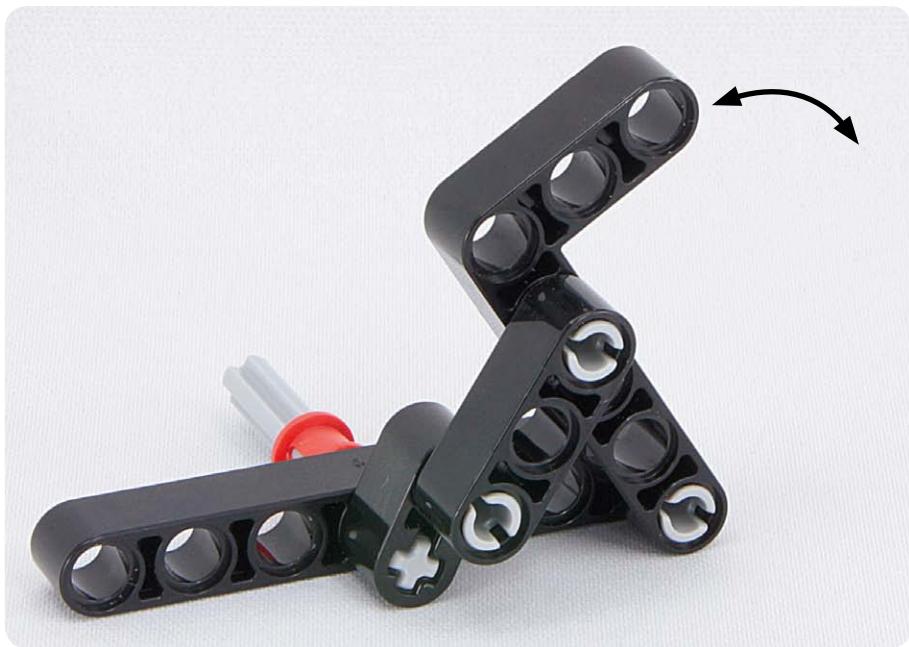
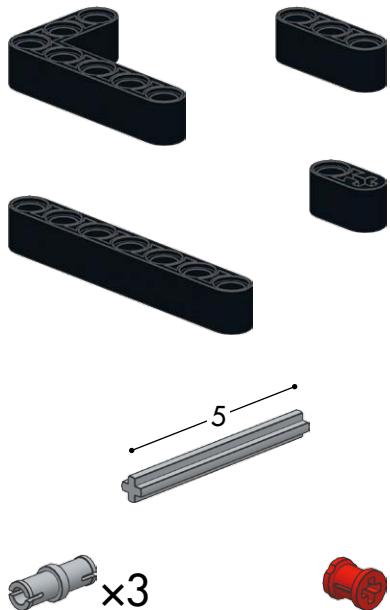
#51



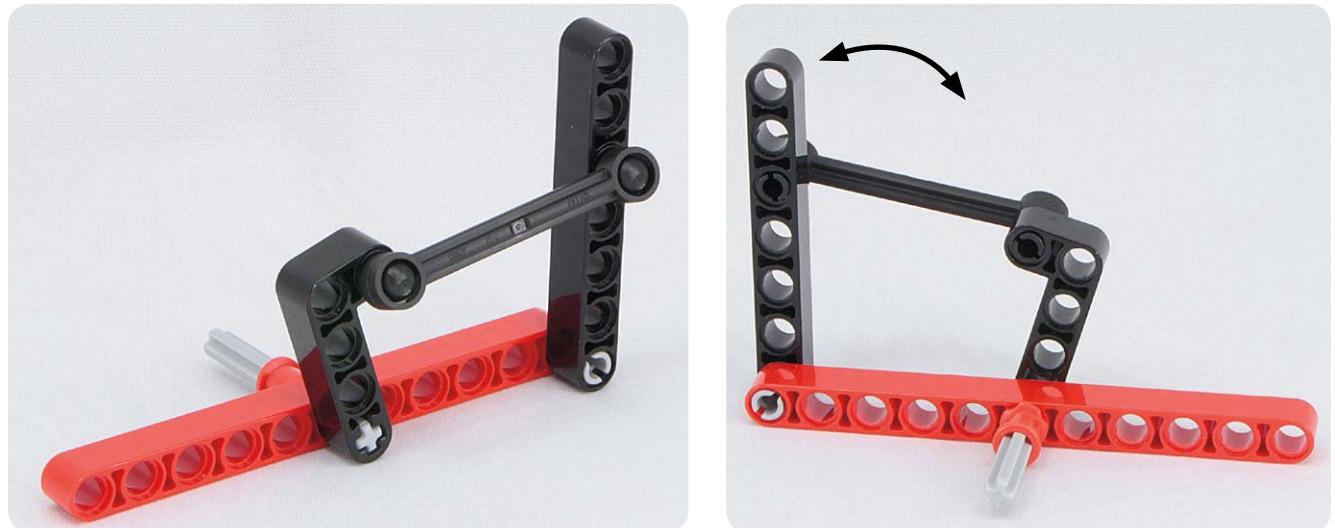


# Swinging mechanisms

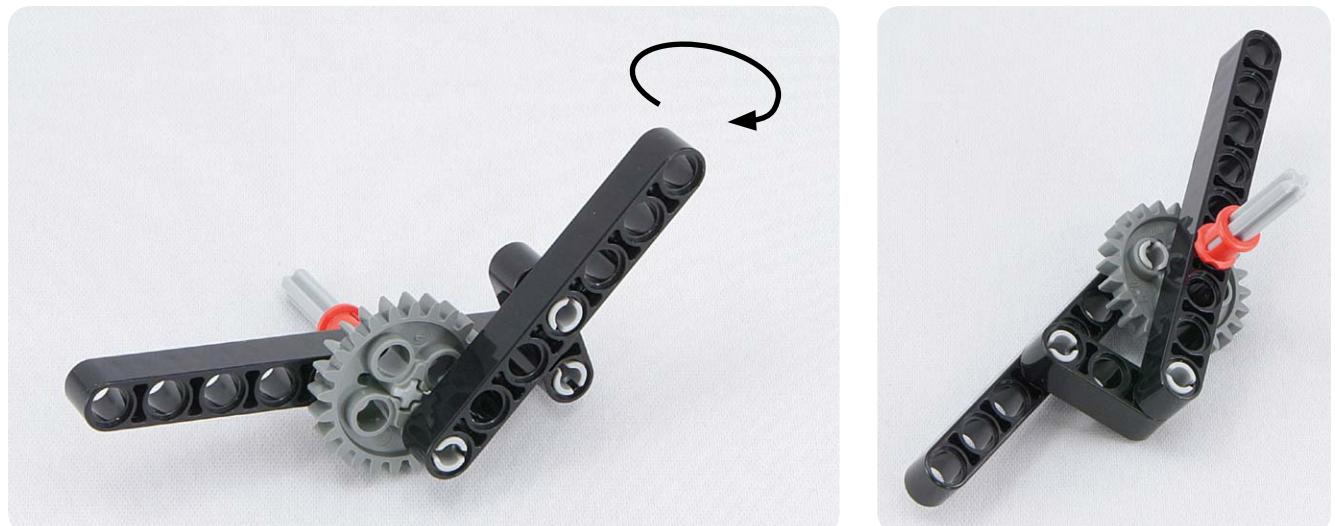
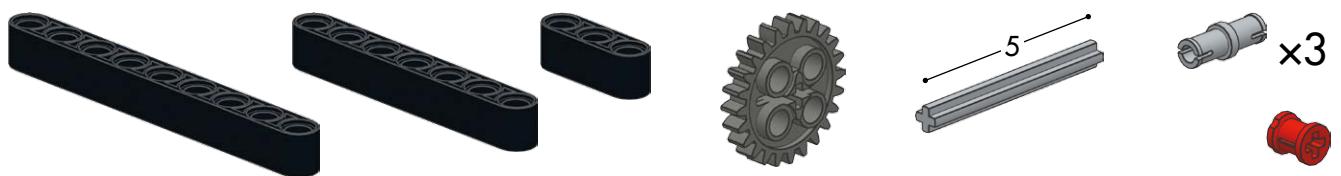
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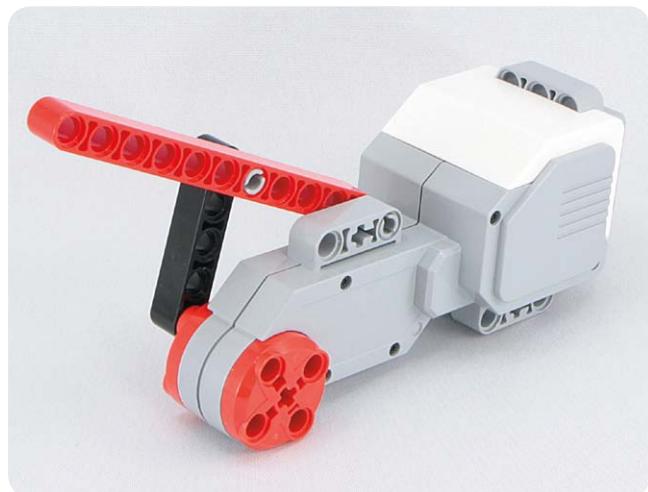
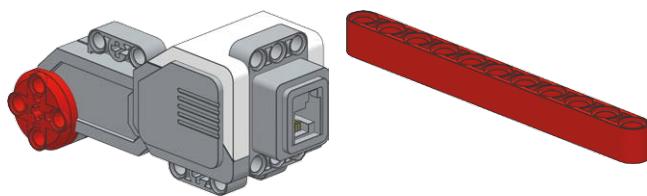
#53



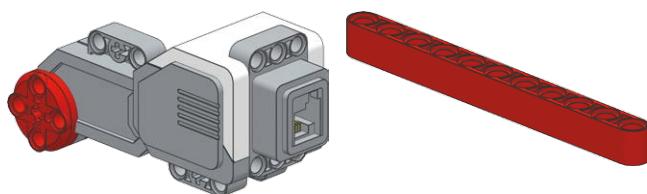
#54



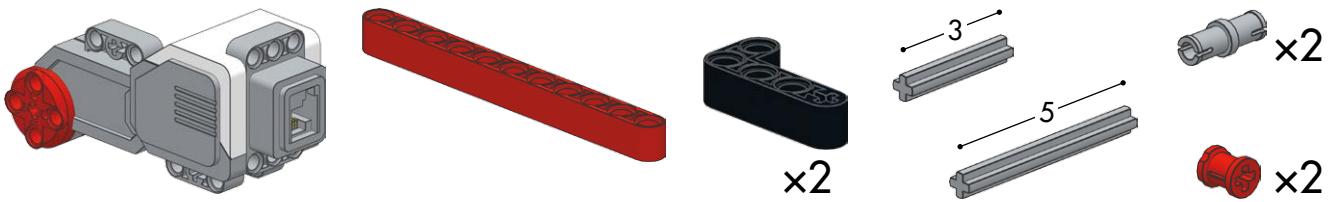
#55



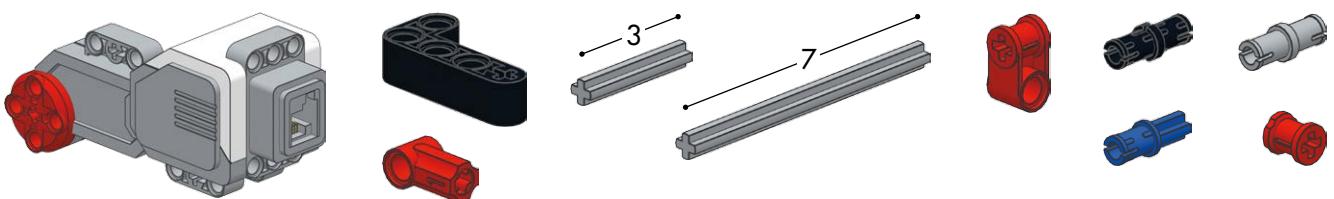
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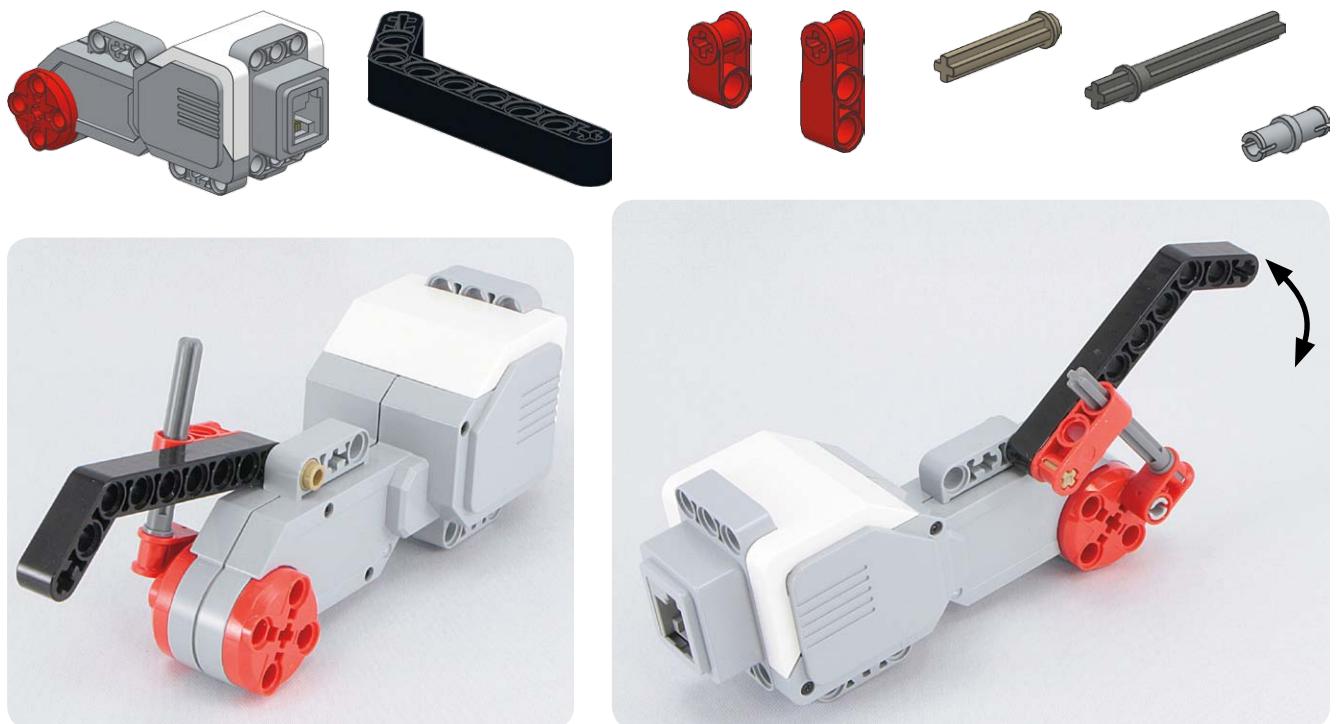
## #57



## #58



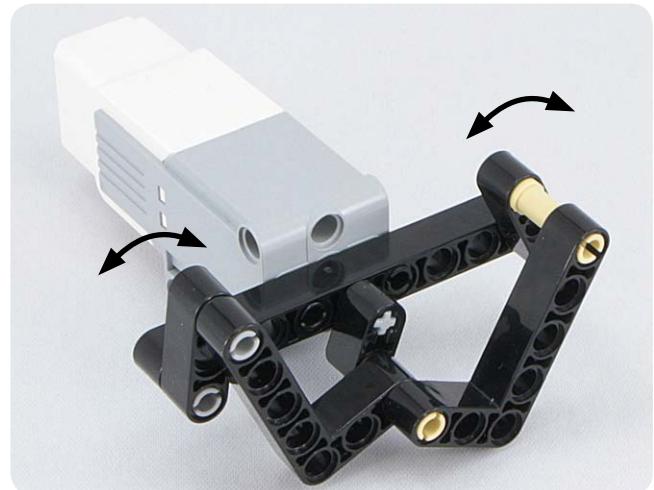
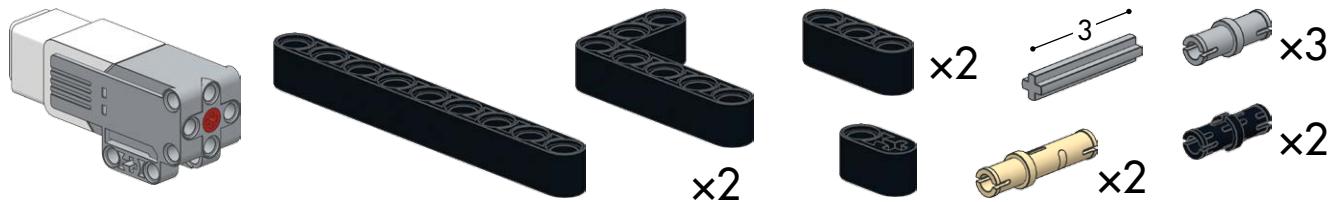
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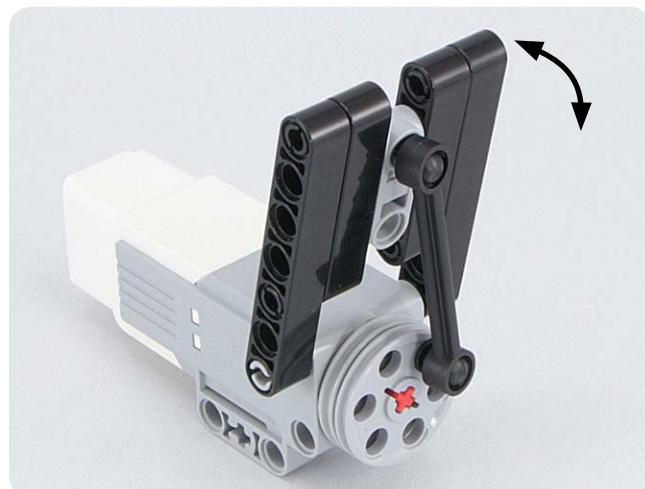
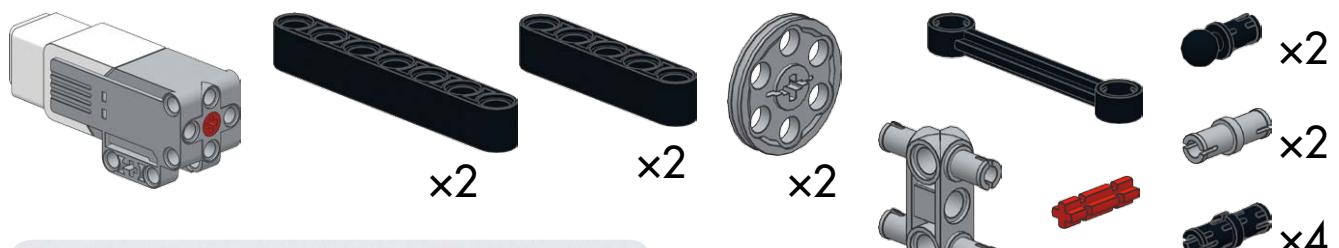
#60



#61



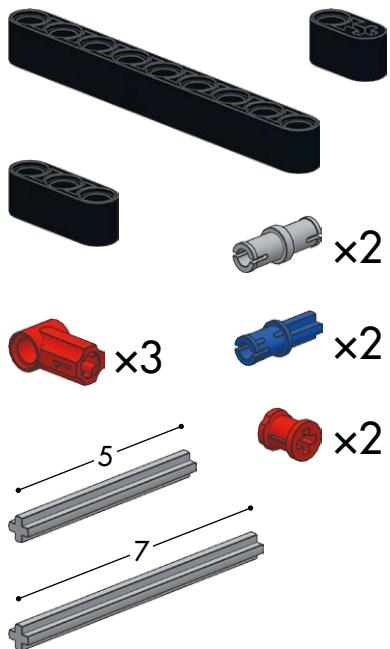
#62



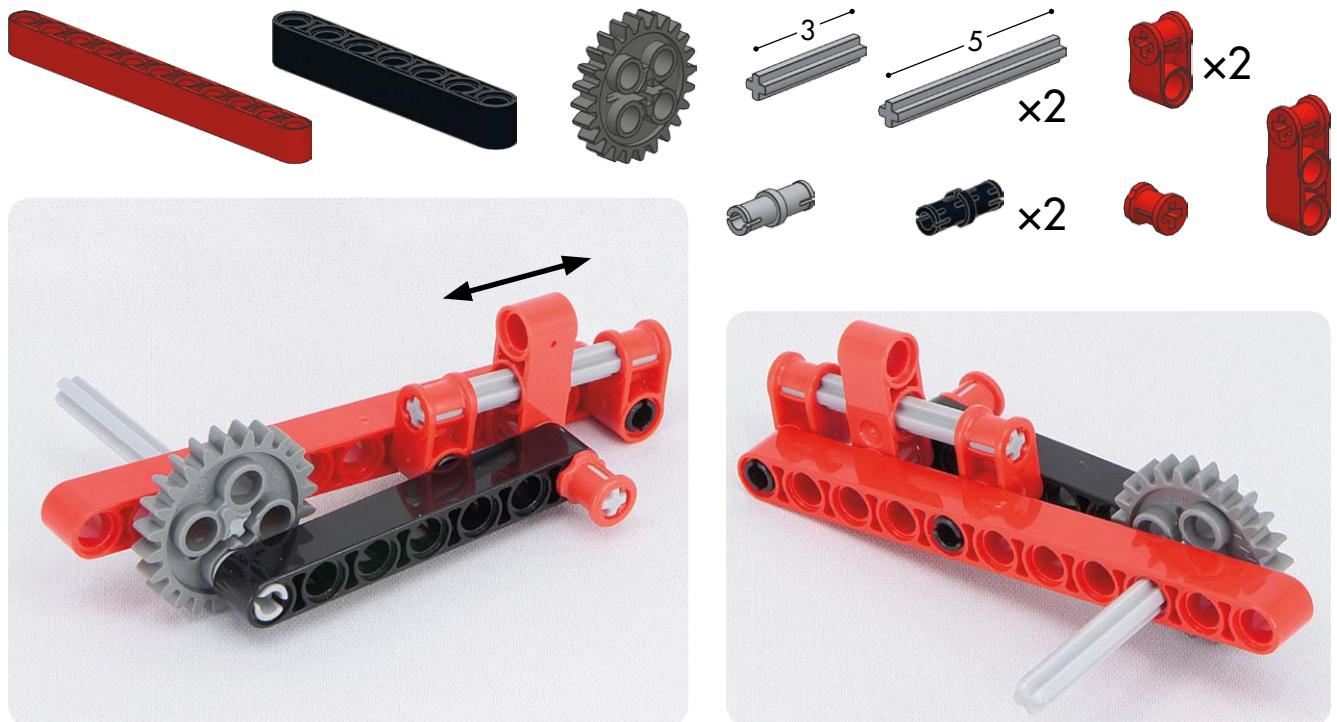


# Reciprocating mechanisms

#63



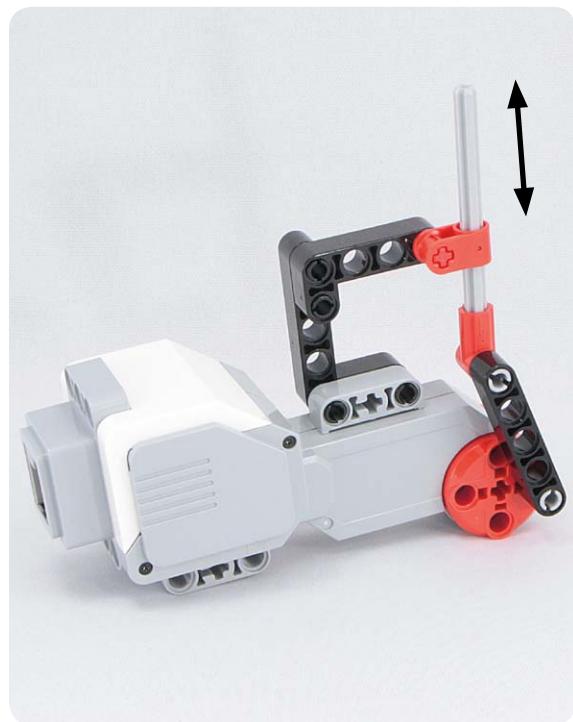
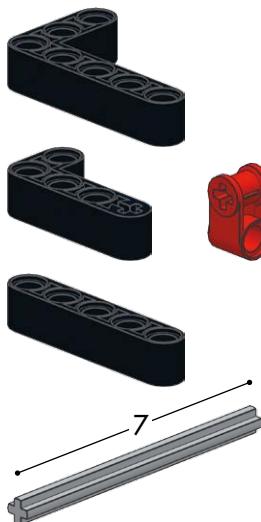
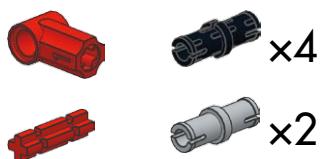
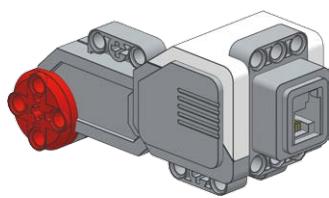
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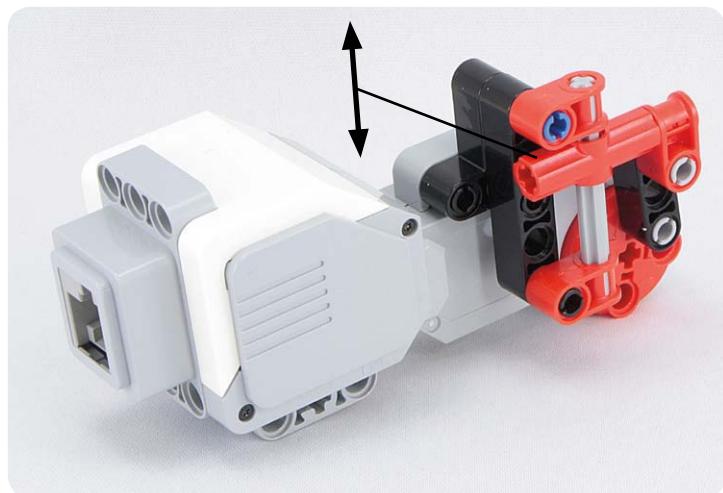
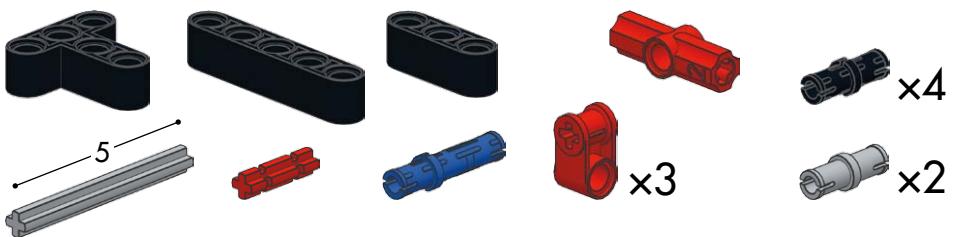
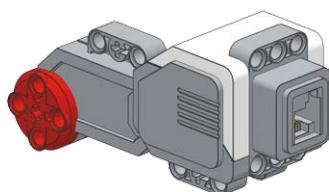
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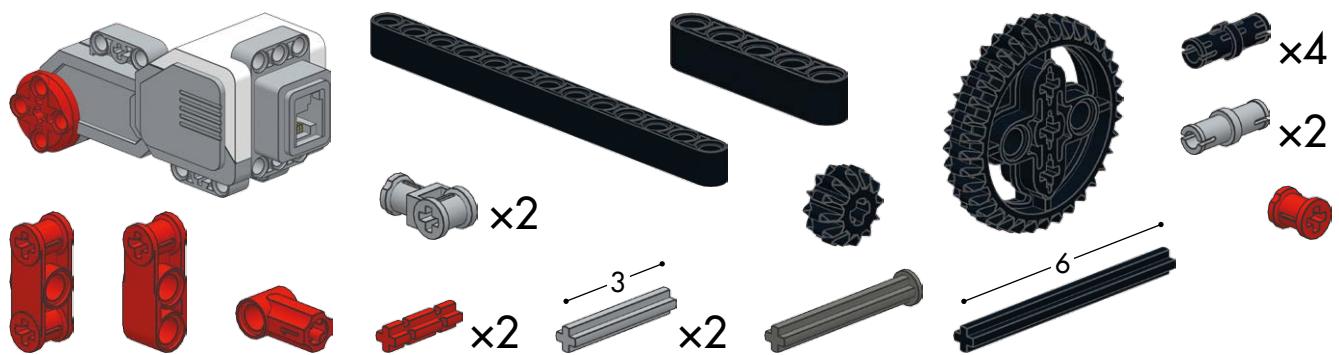
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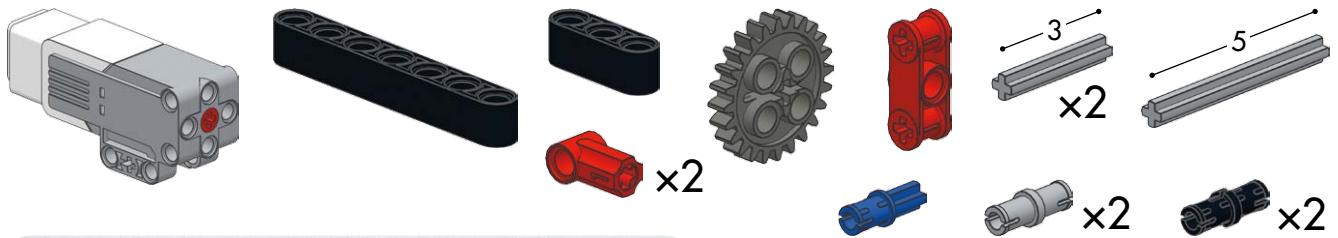
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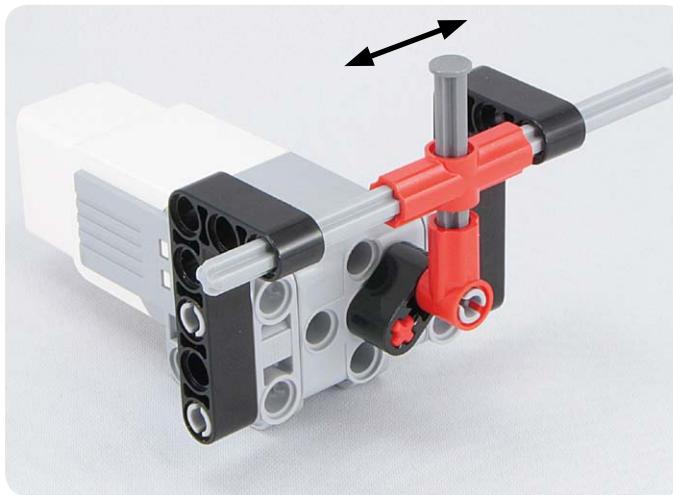
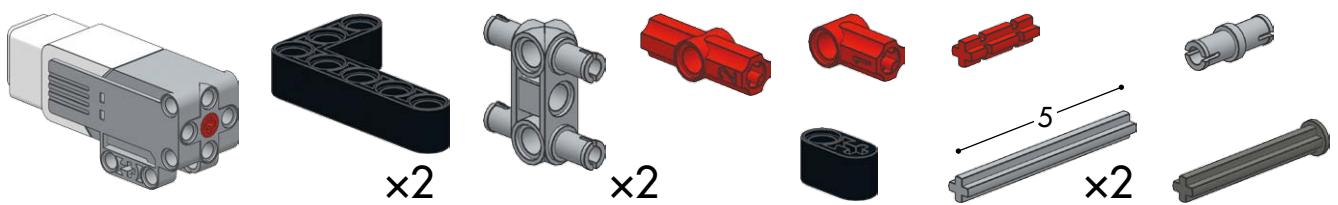
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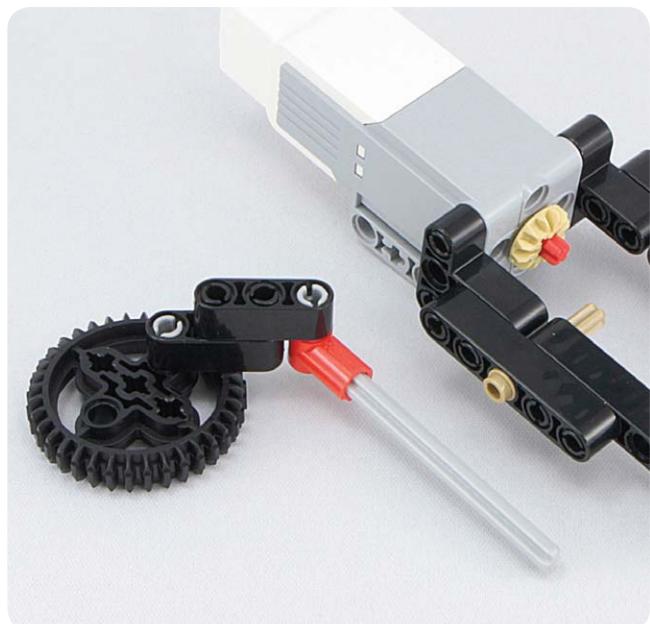
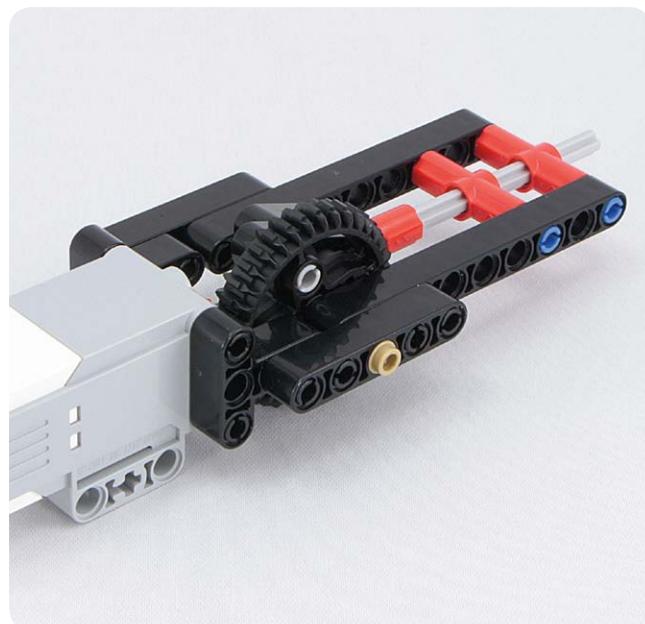
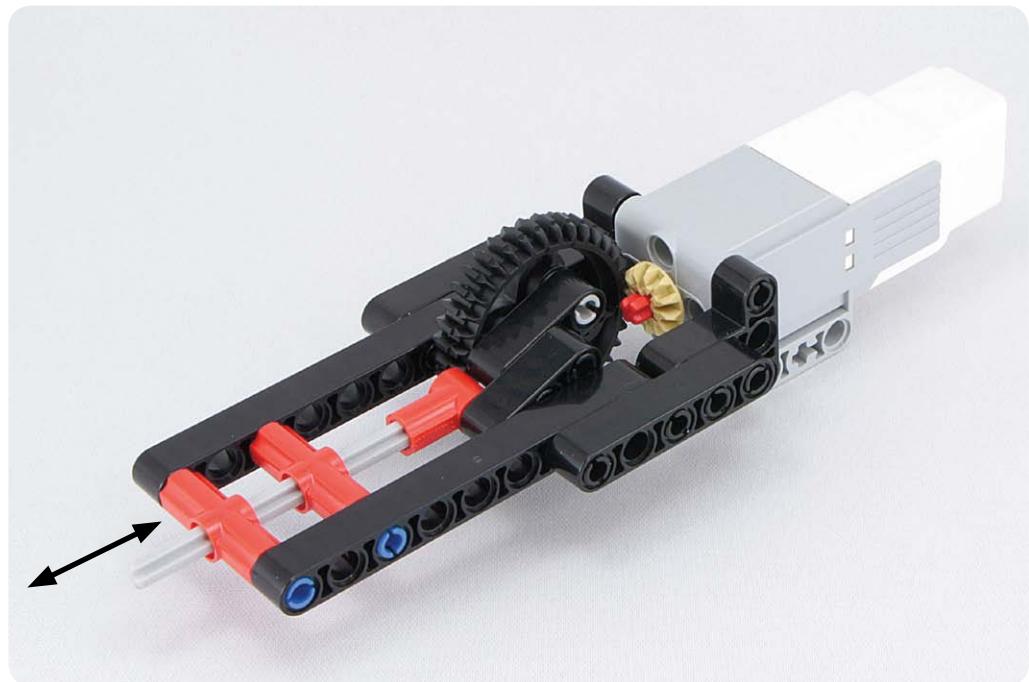
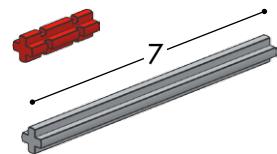
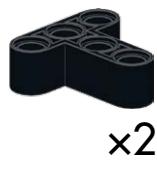
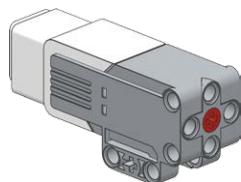
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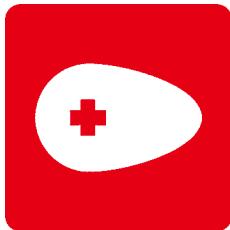


## #70



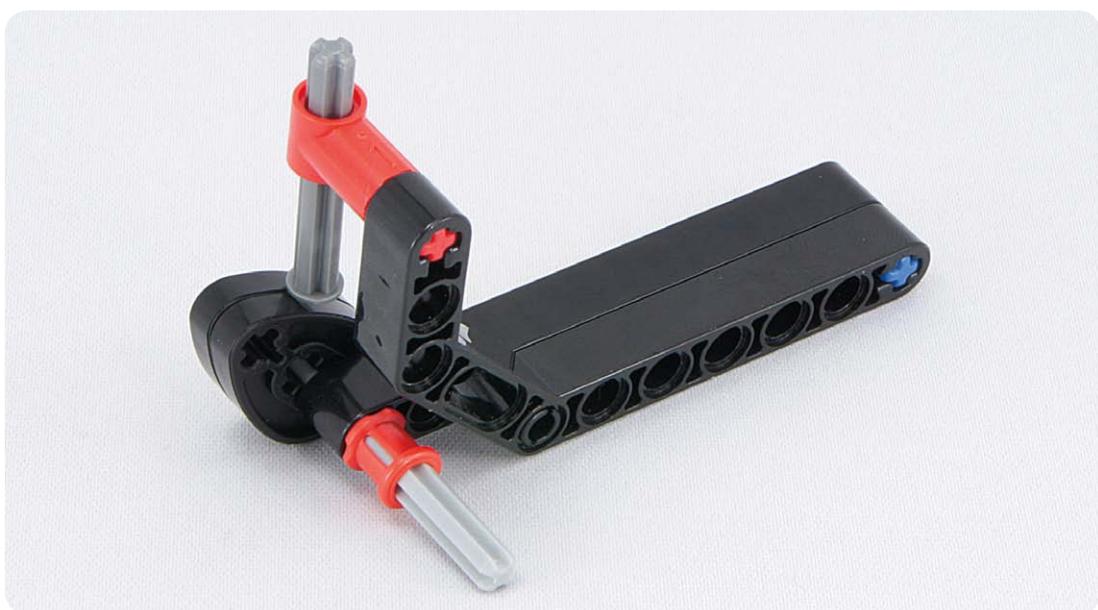
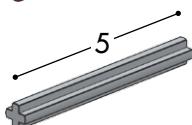
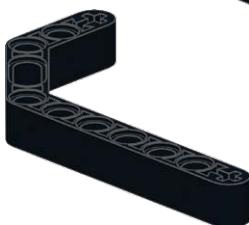
## #71





# Cam mechanisms

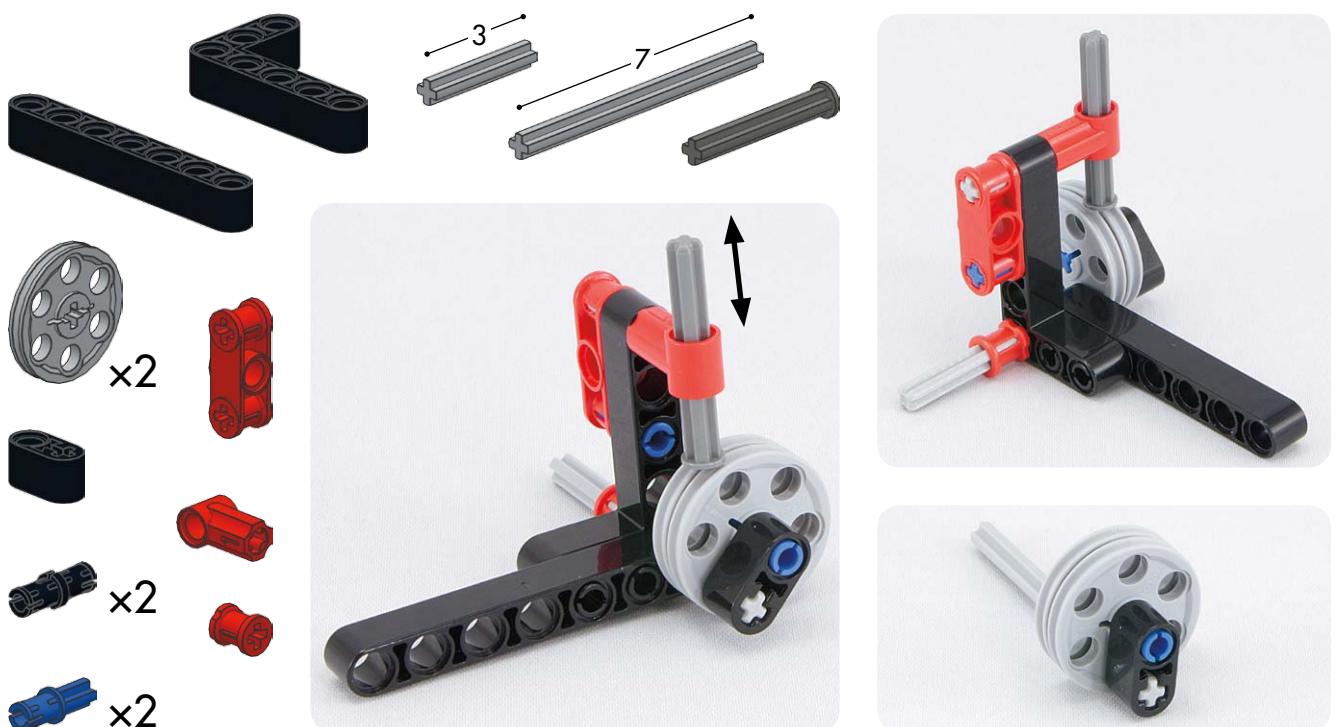
#72



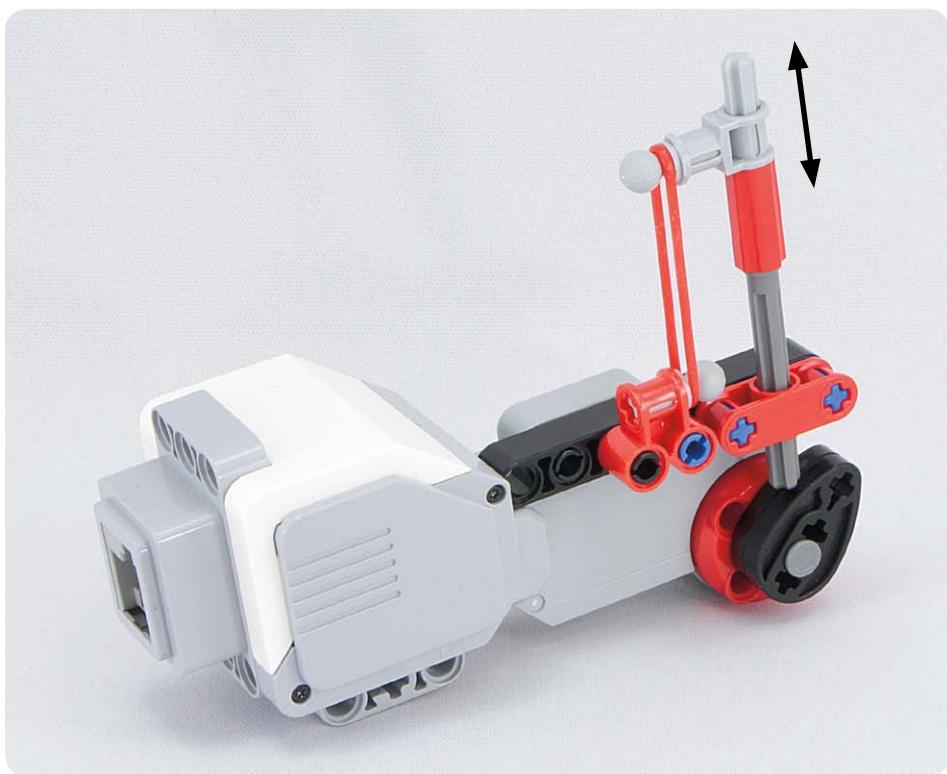
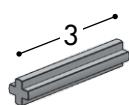
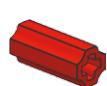
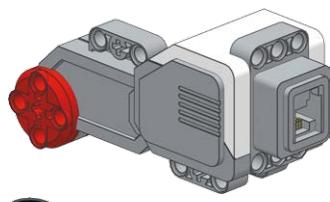
## #73



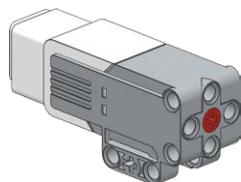
## #74



#75



## #76



x2



x2

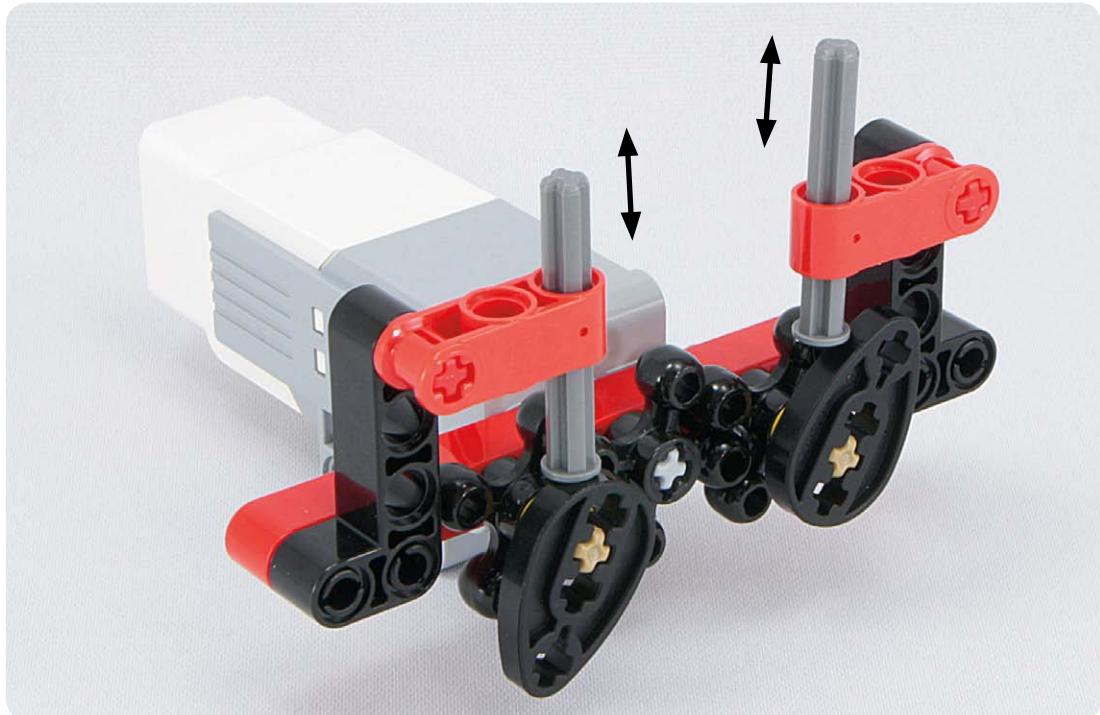
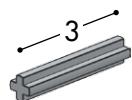


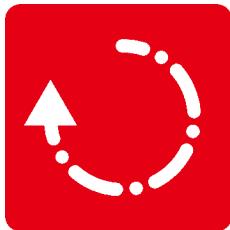
x3



x2

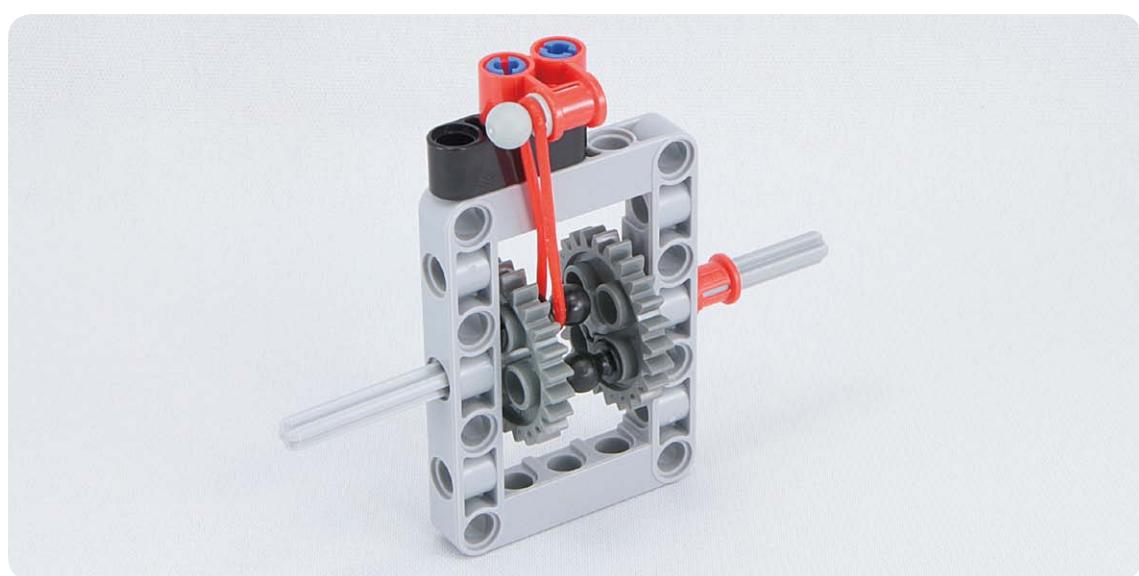
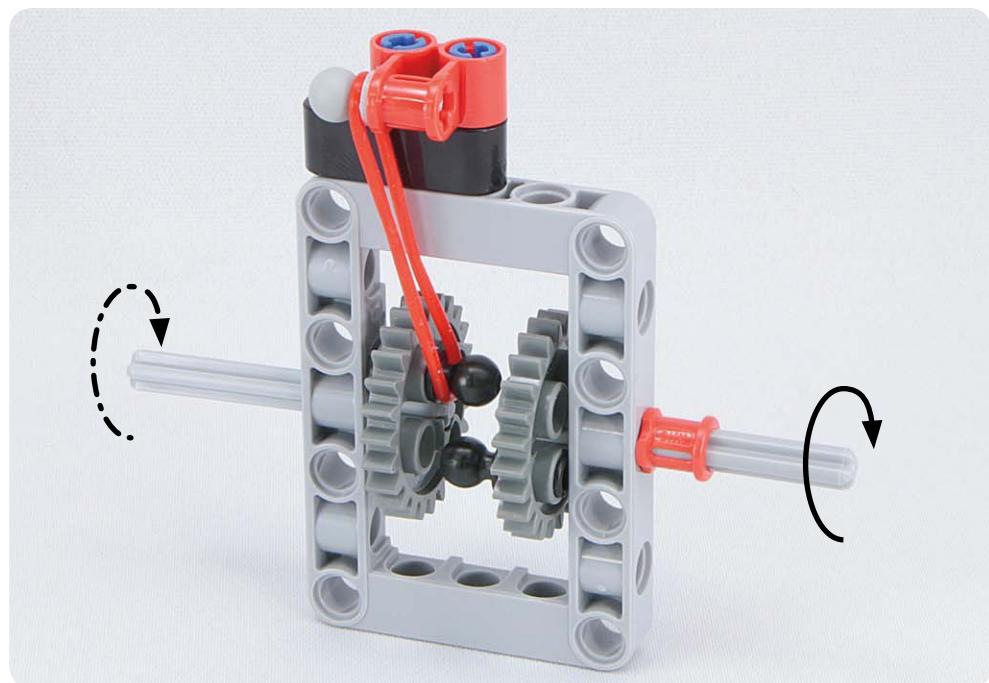
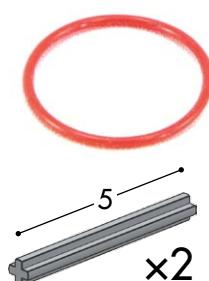
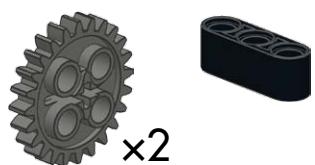
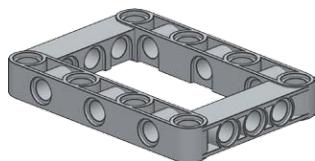
red Technic beam x2



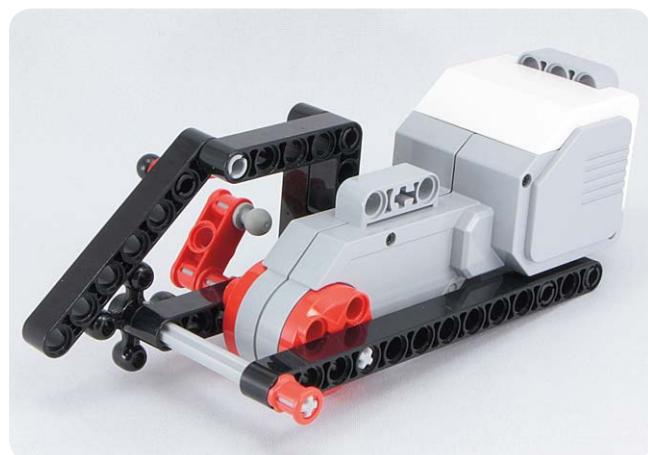
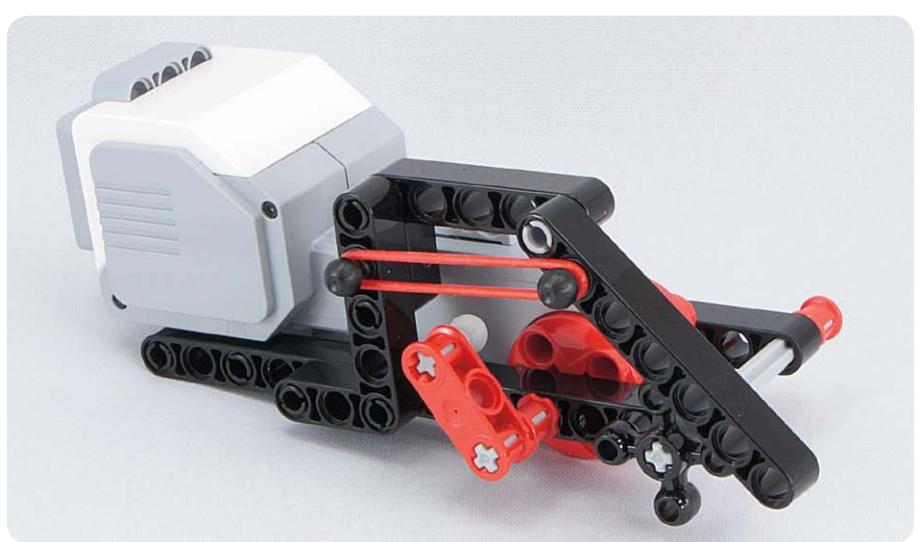
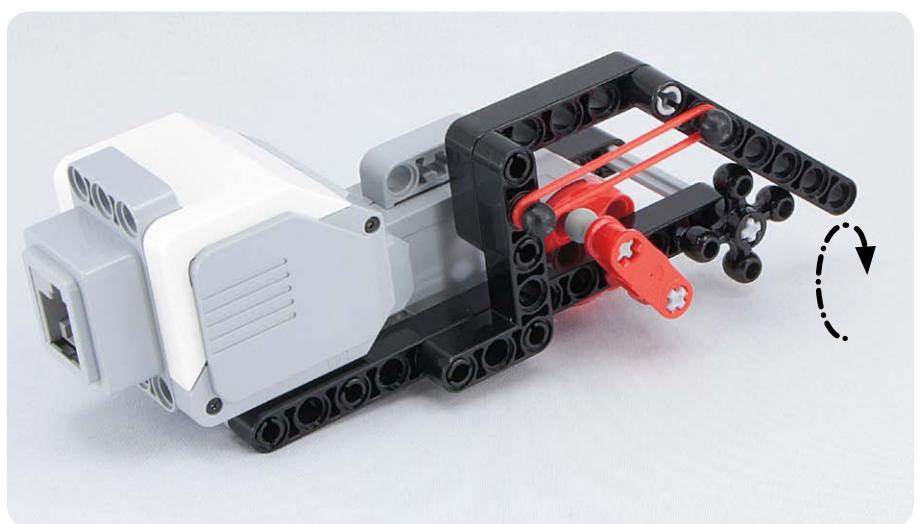
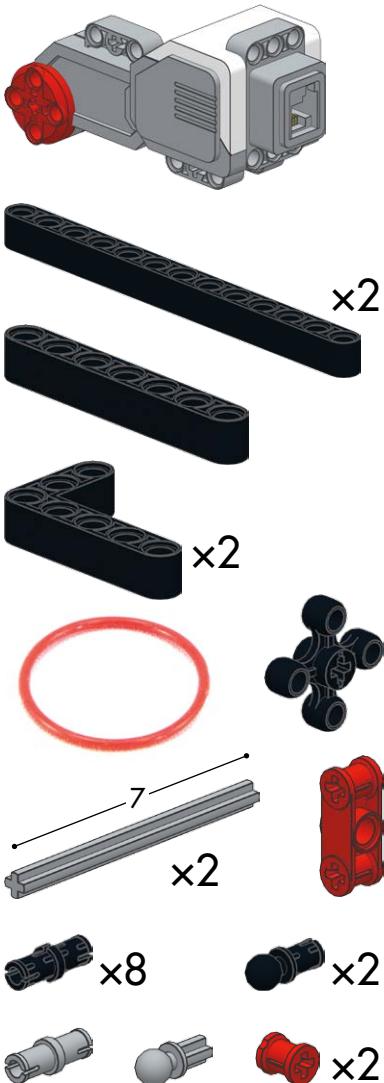


# Intermittent motion

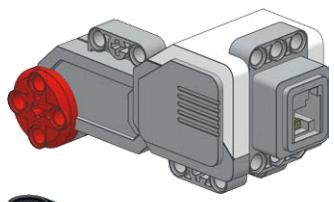
#77



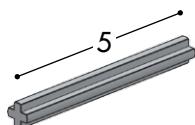
## #78



## #79



x2



x2



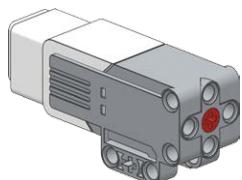
x2



x2



## #80



x2

x2

x2



x3



x2



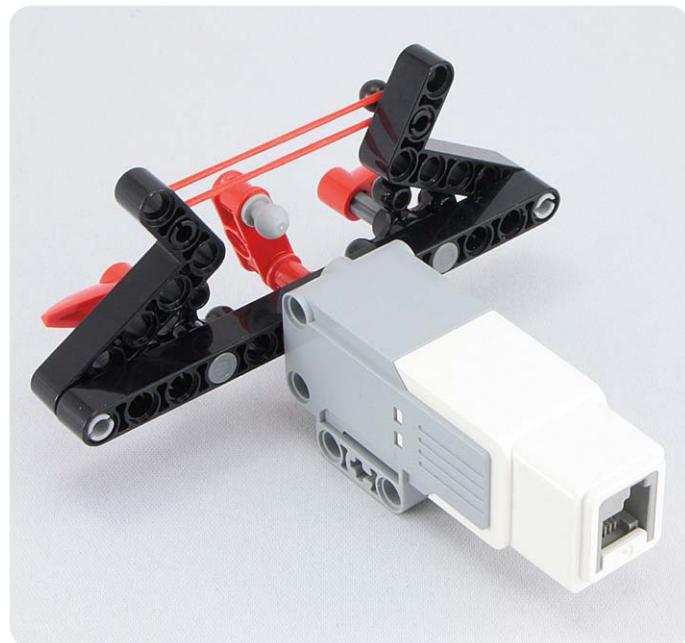
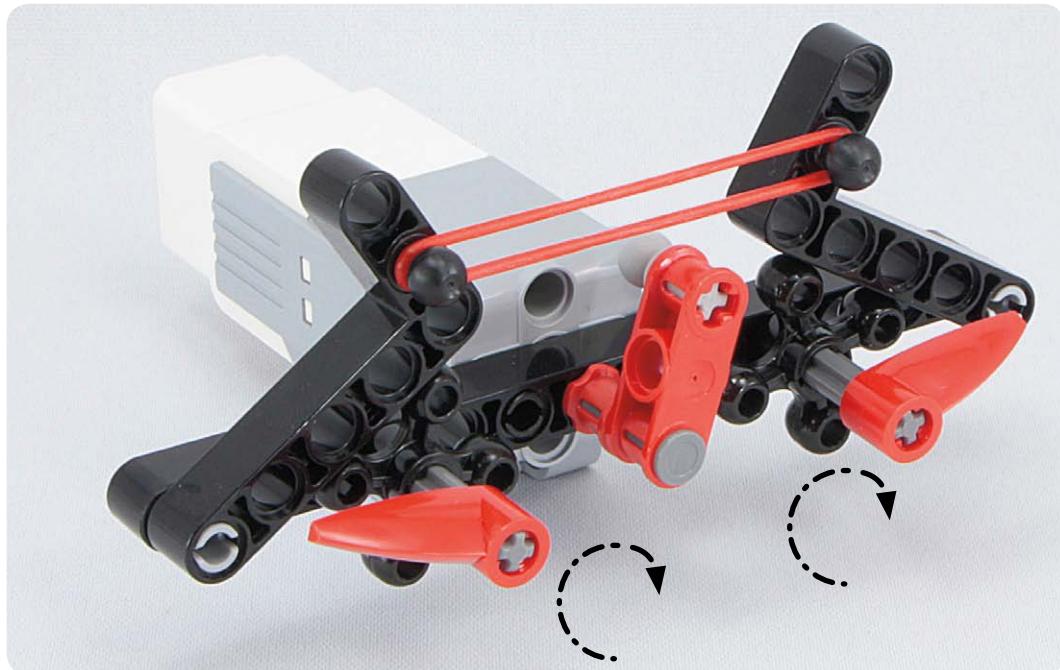
x2



x2



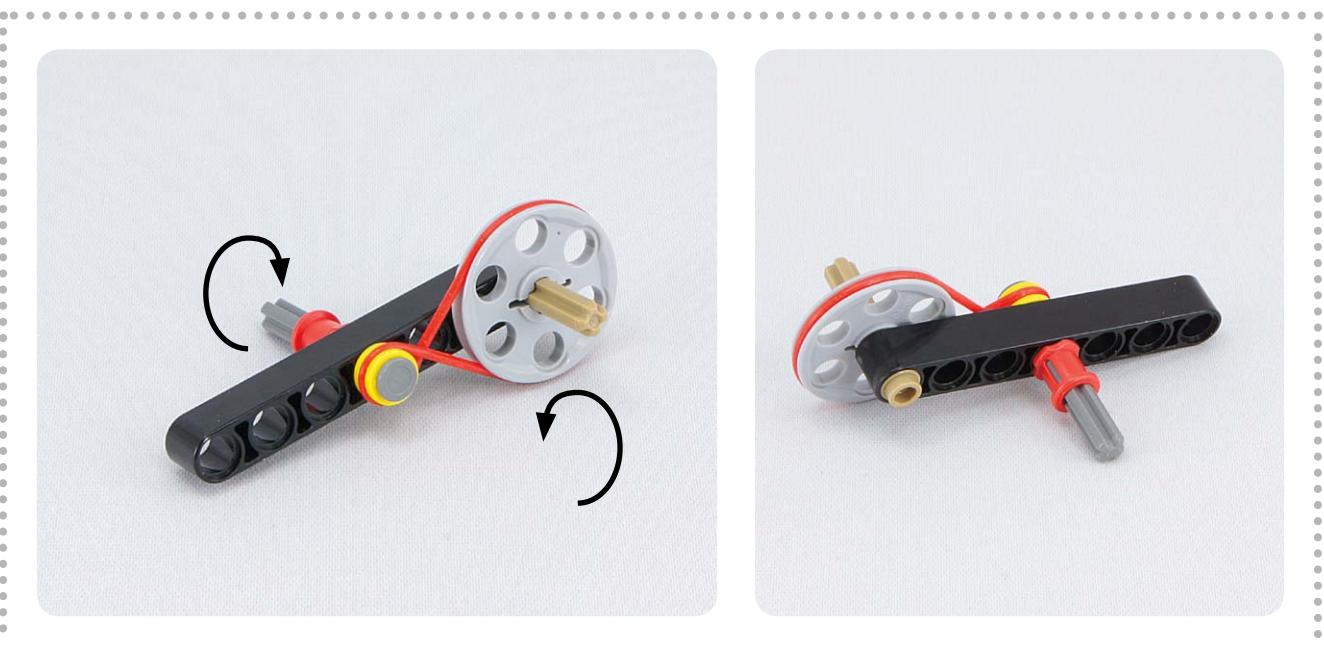
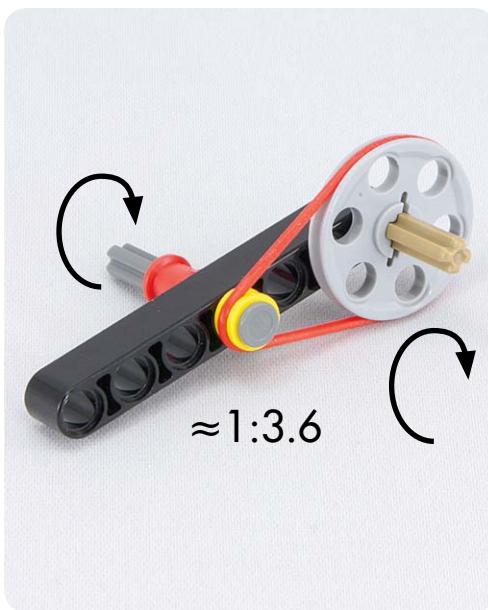
x2





# Transmitting rotation with rubber bands

#81



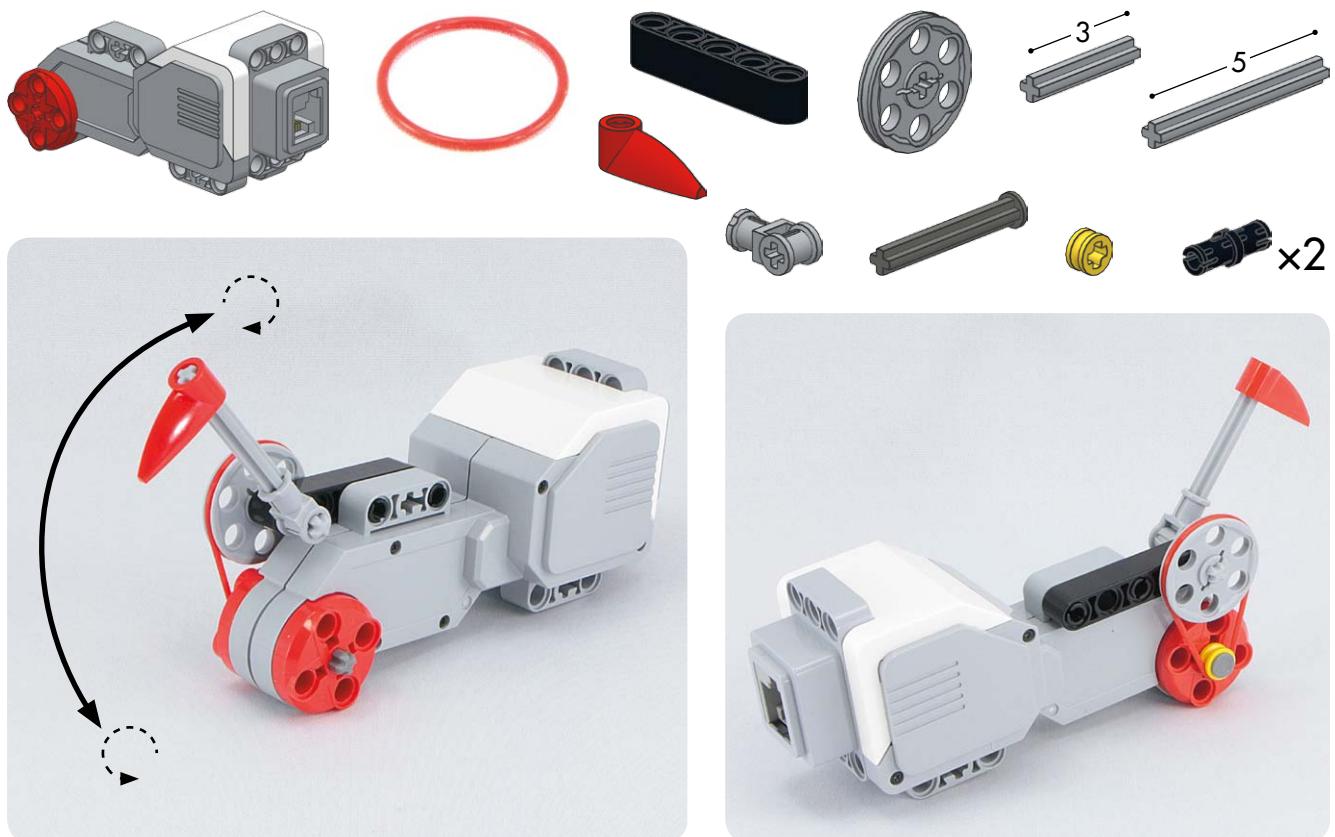
## #82



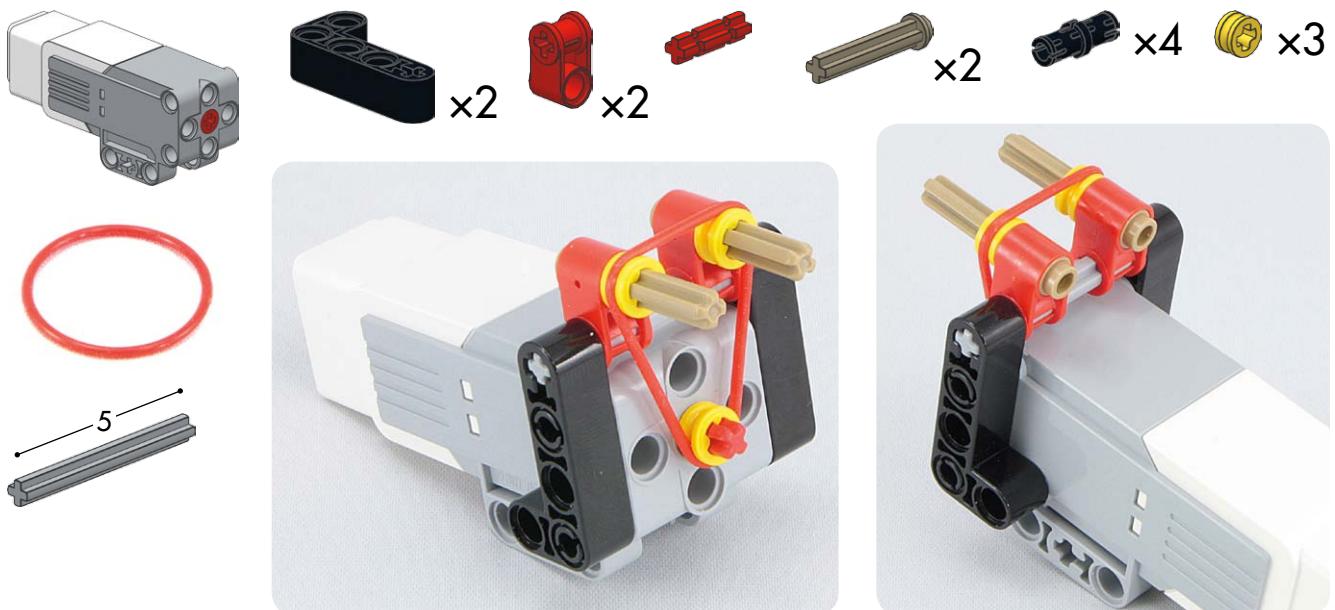
## #83



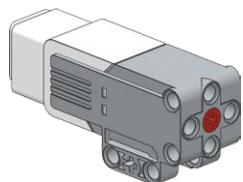
## #84



## #85



## #86



x2



x2



x2



x2



x6

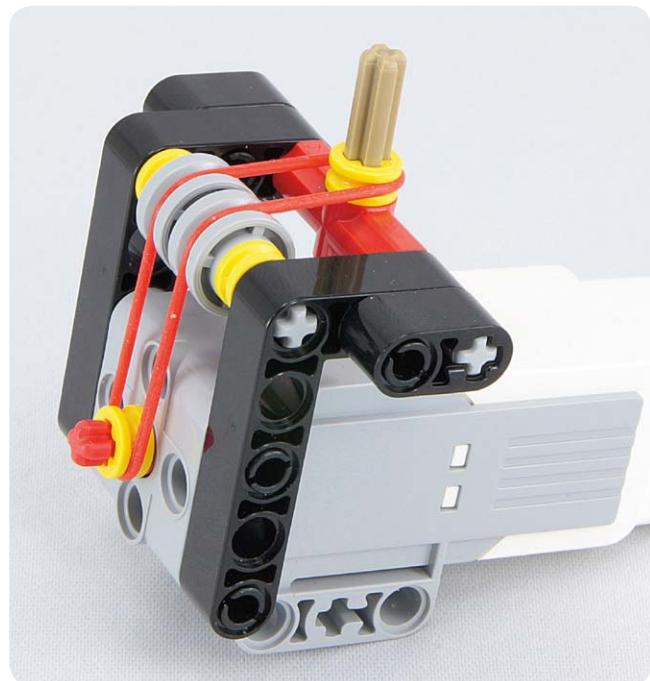


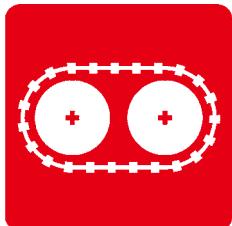
x4



— 3 —  
x2

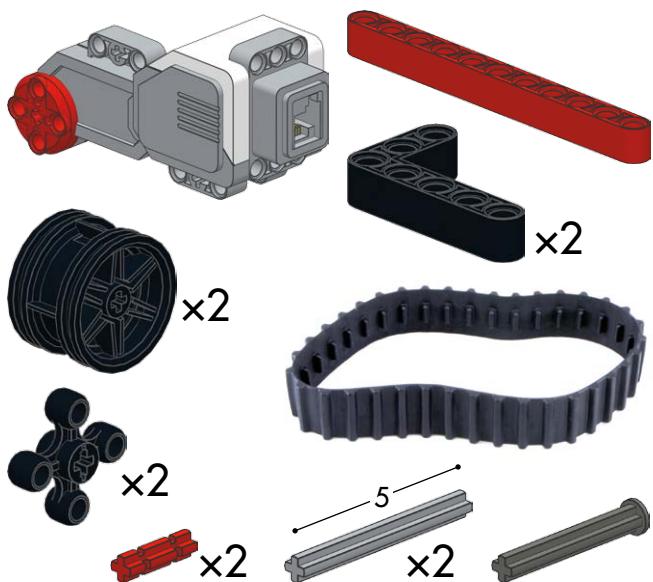
— 5 —  
x2



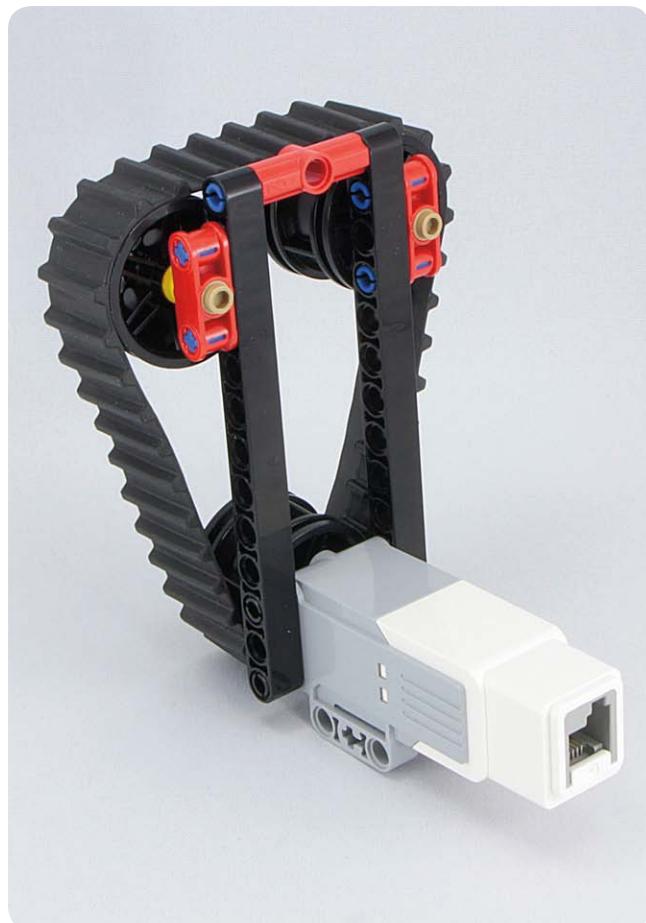
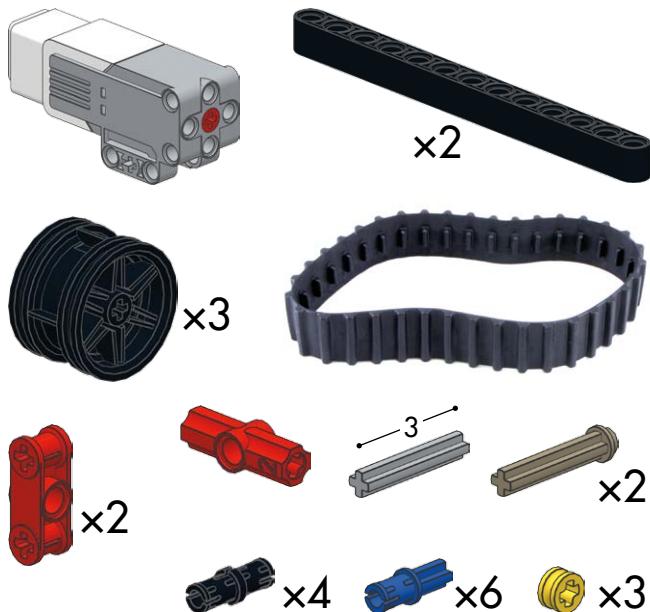


# Transmitting rotation with caterpillar treads

#87



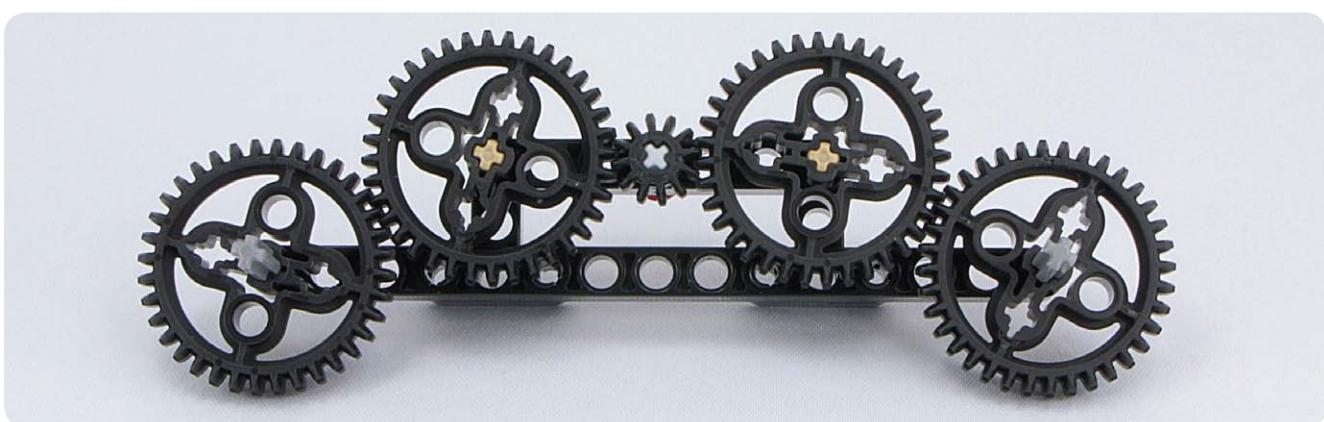
## #88



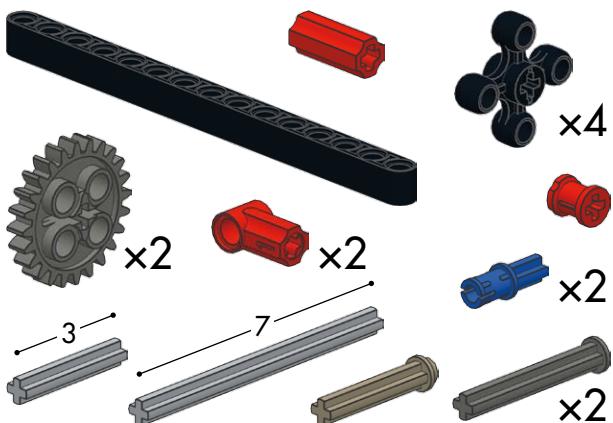


# Transmitting rotation over a long distance

#89

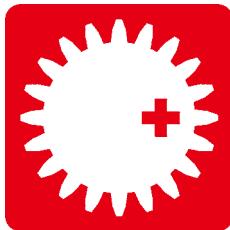


## #90



## #91



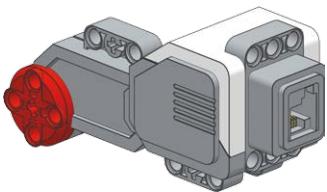


# Off-center axes of rotation

#92

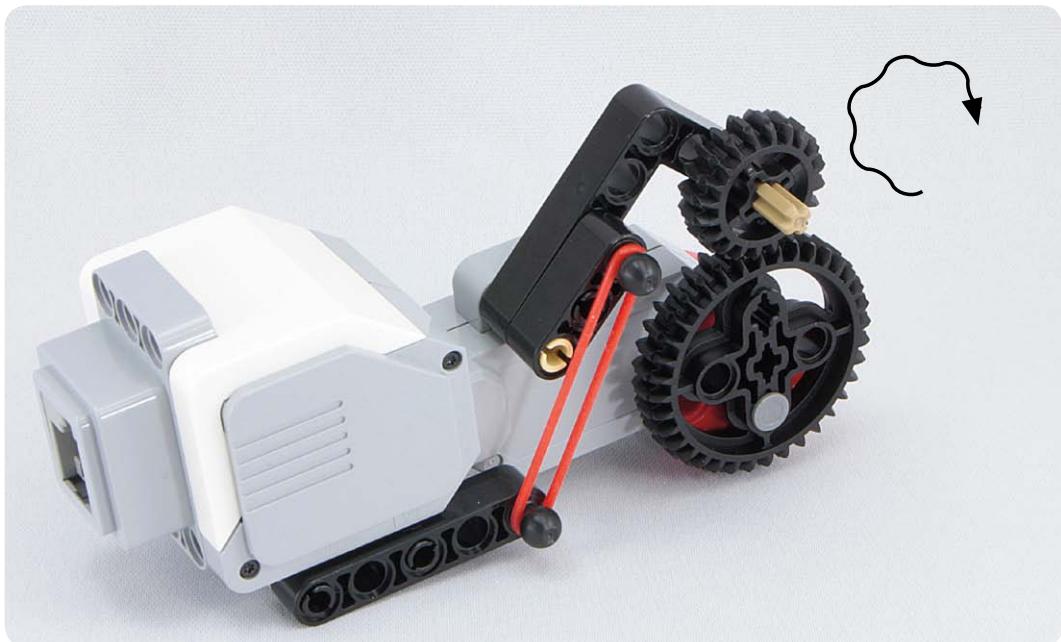


#93



x2

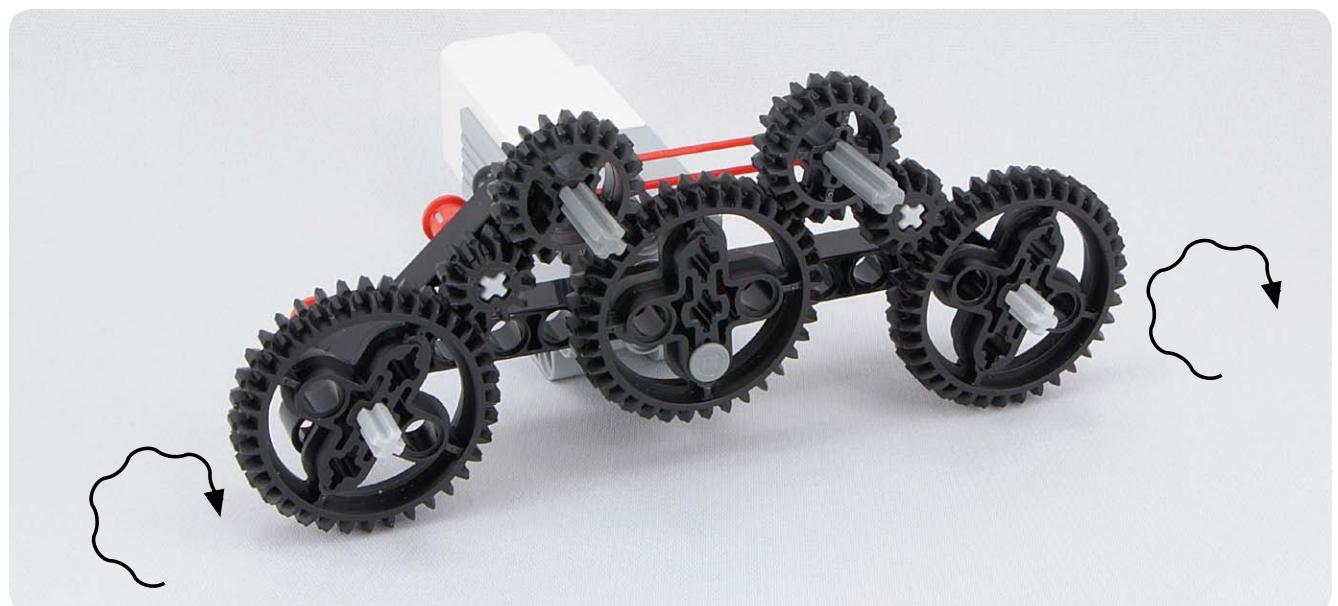
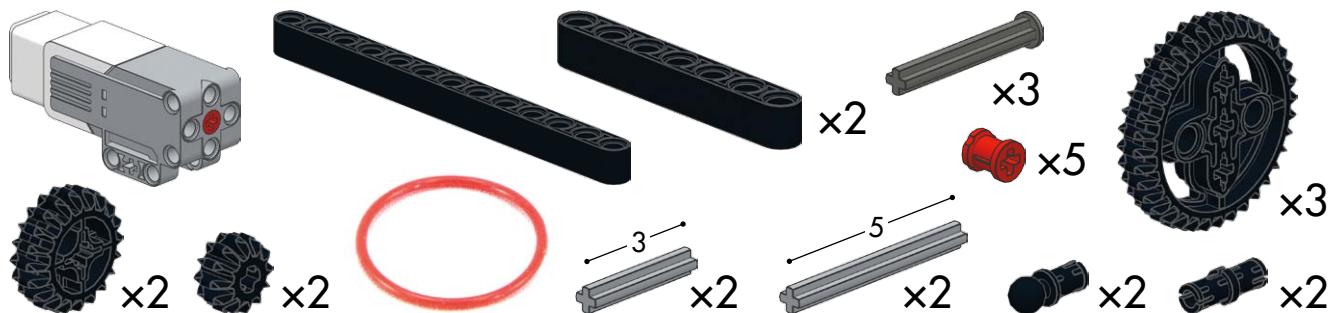
x3

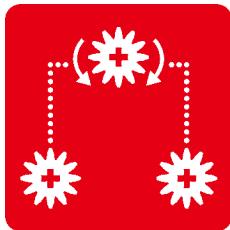


#94



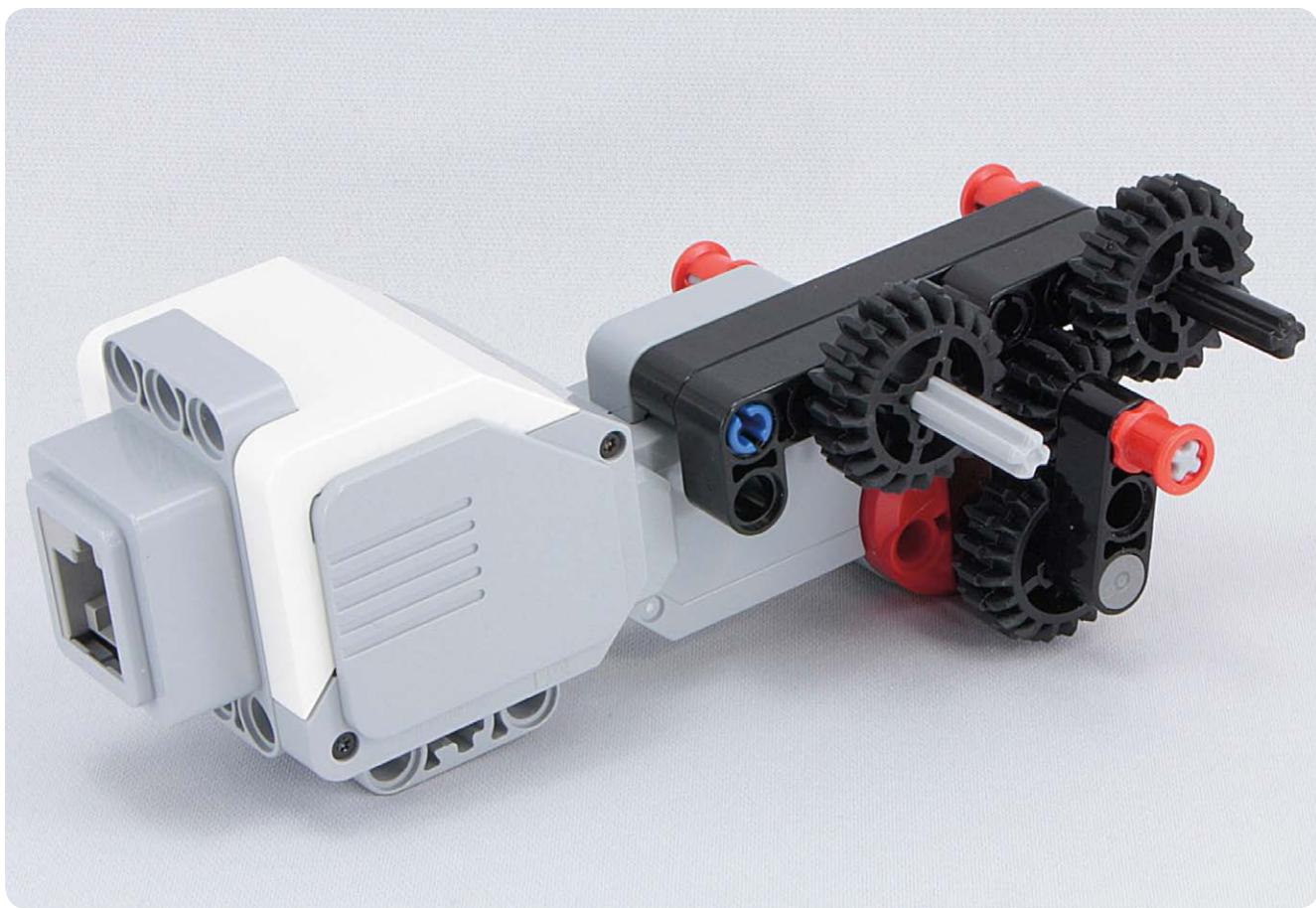
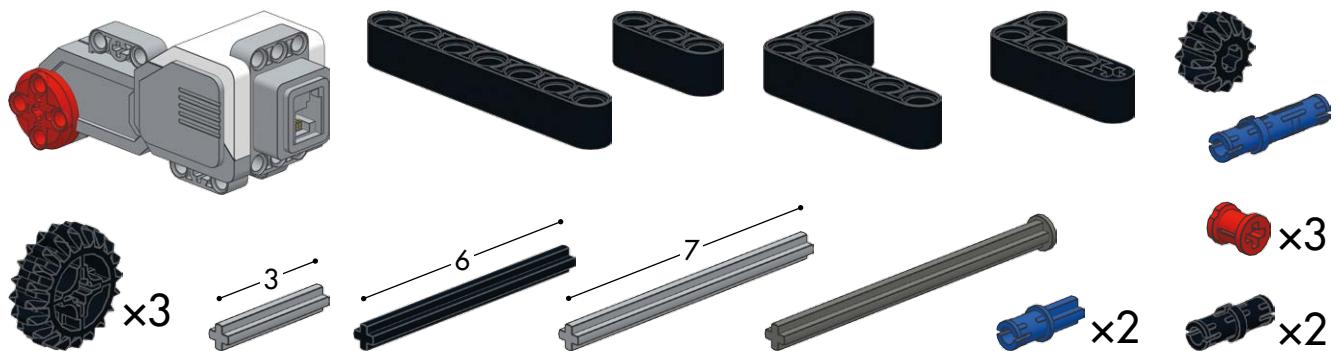
#95

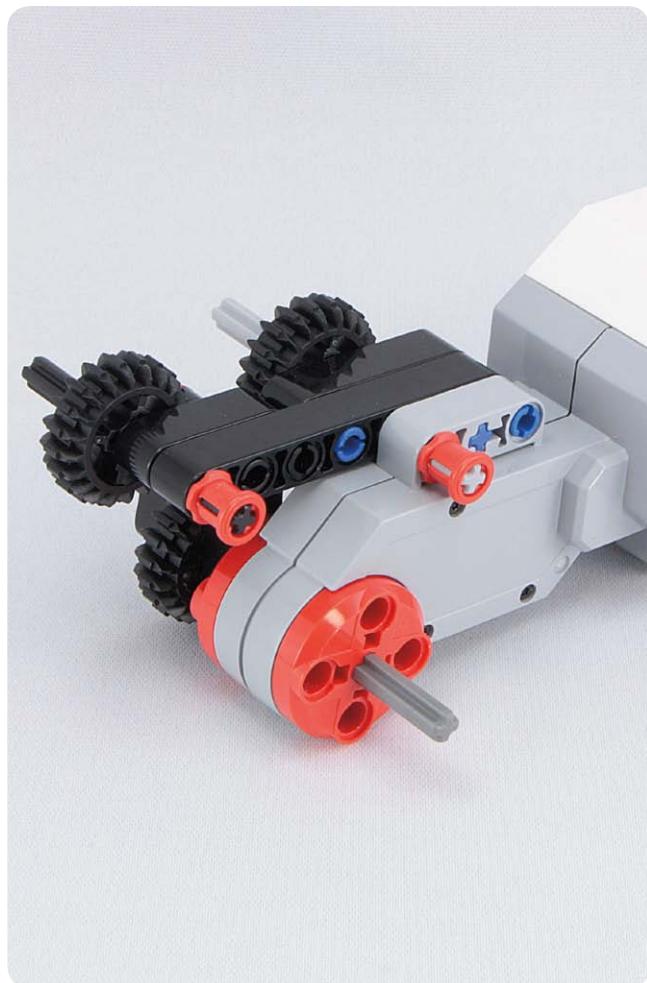




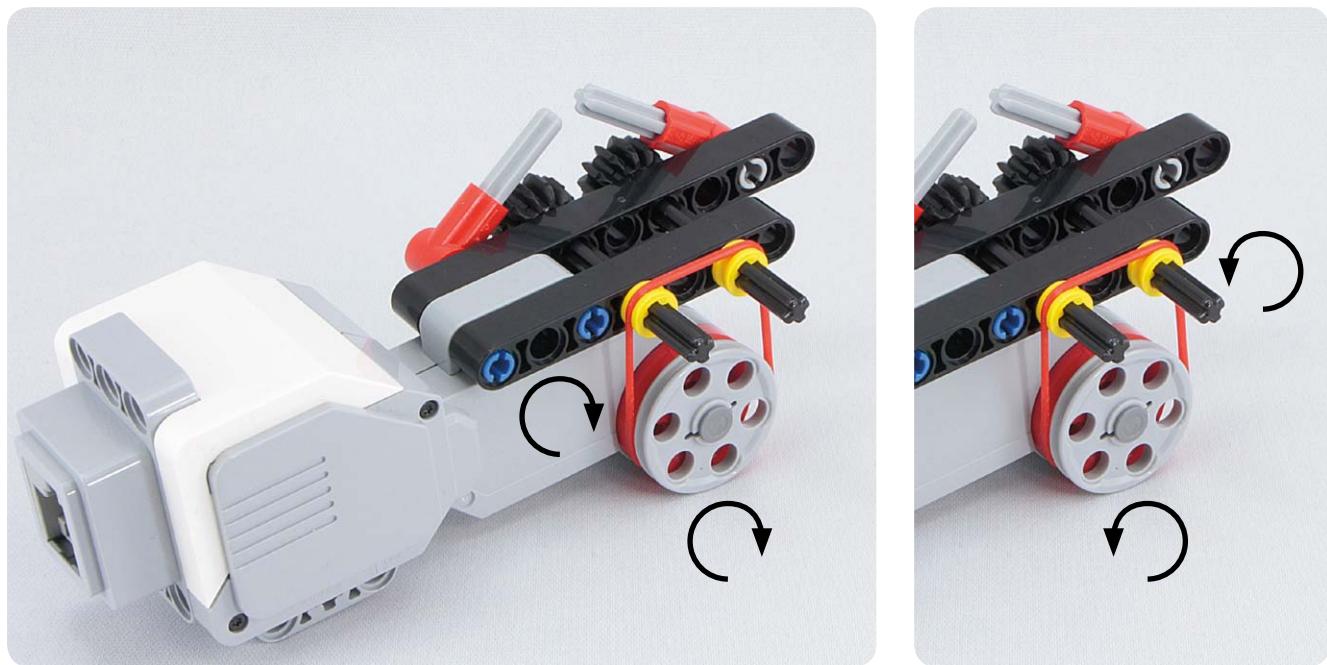
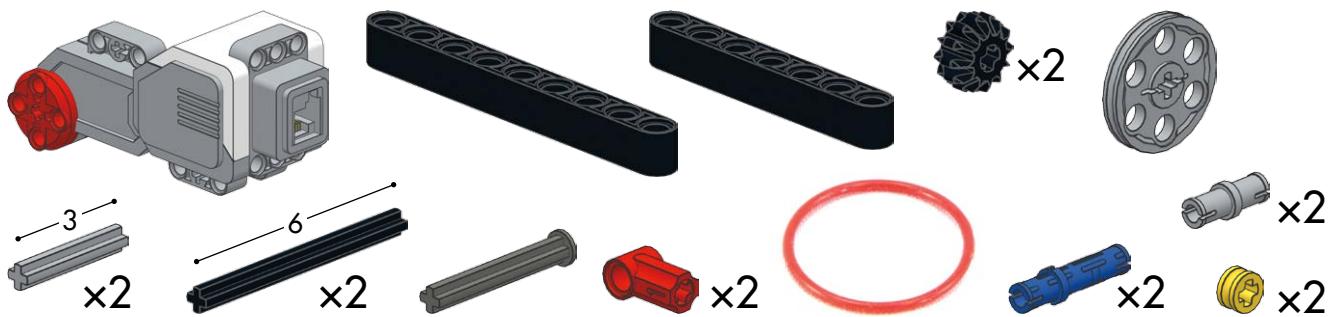
# Changeover mechanisms using rotational direction

#96

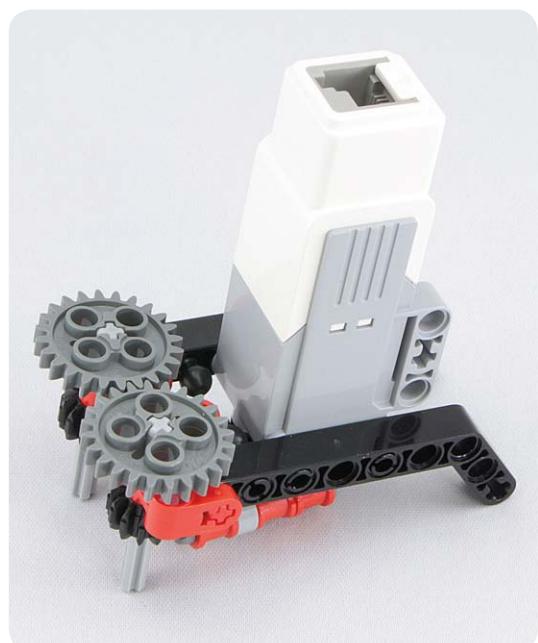
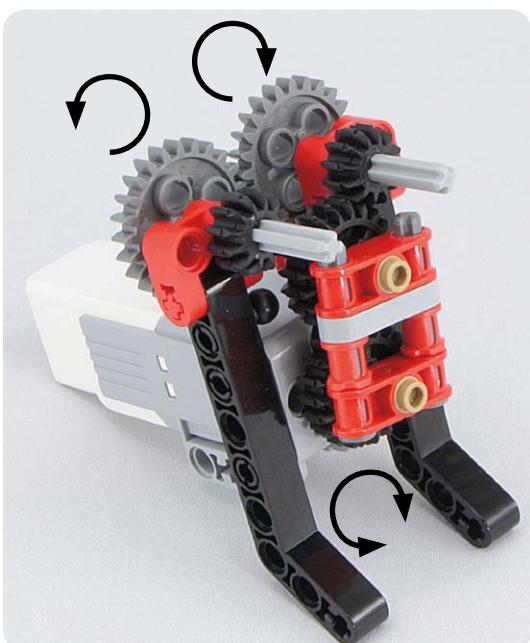
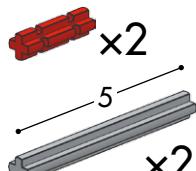
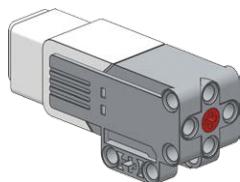




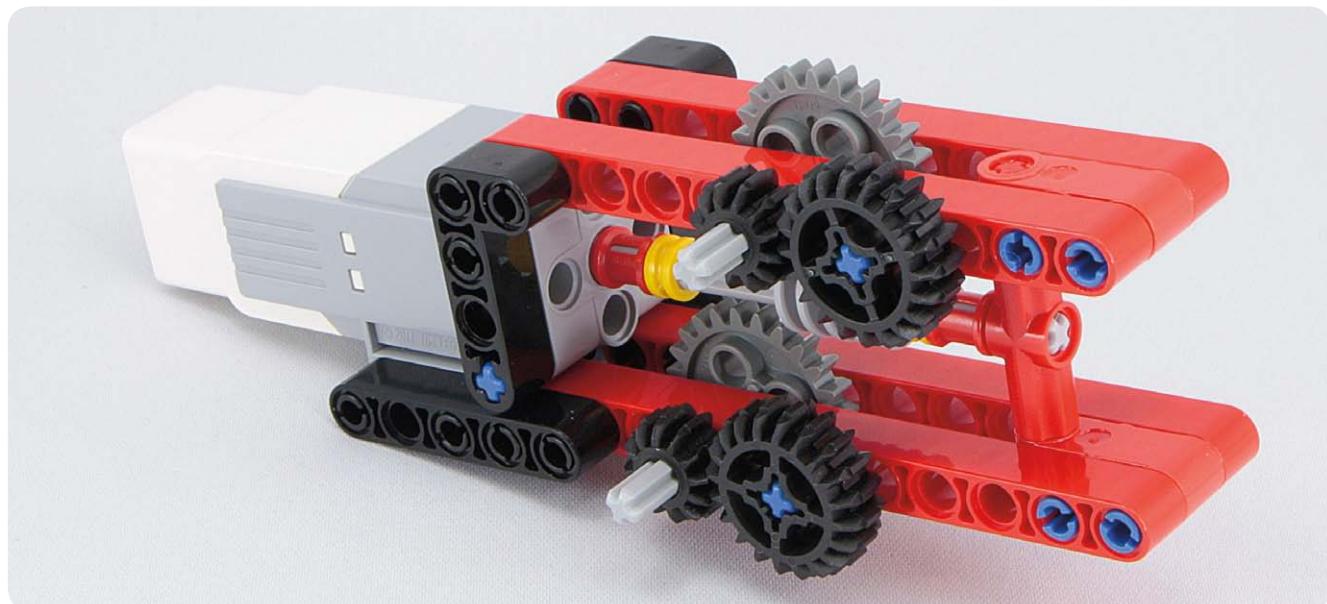
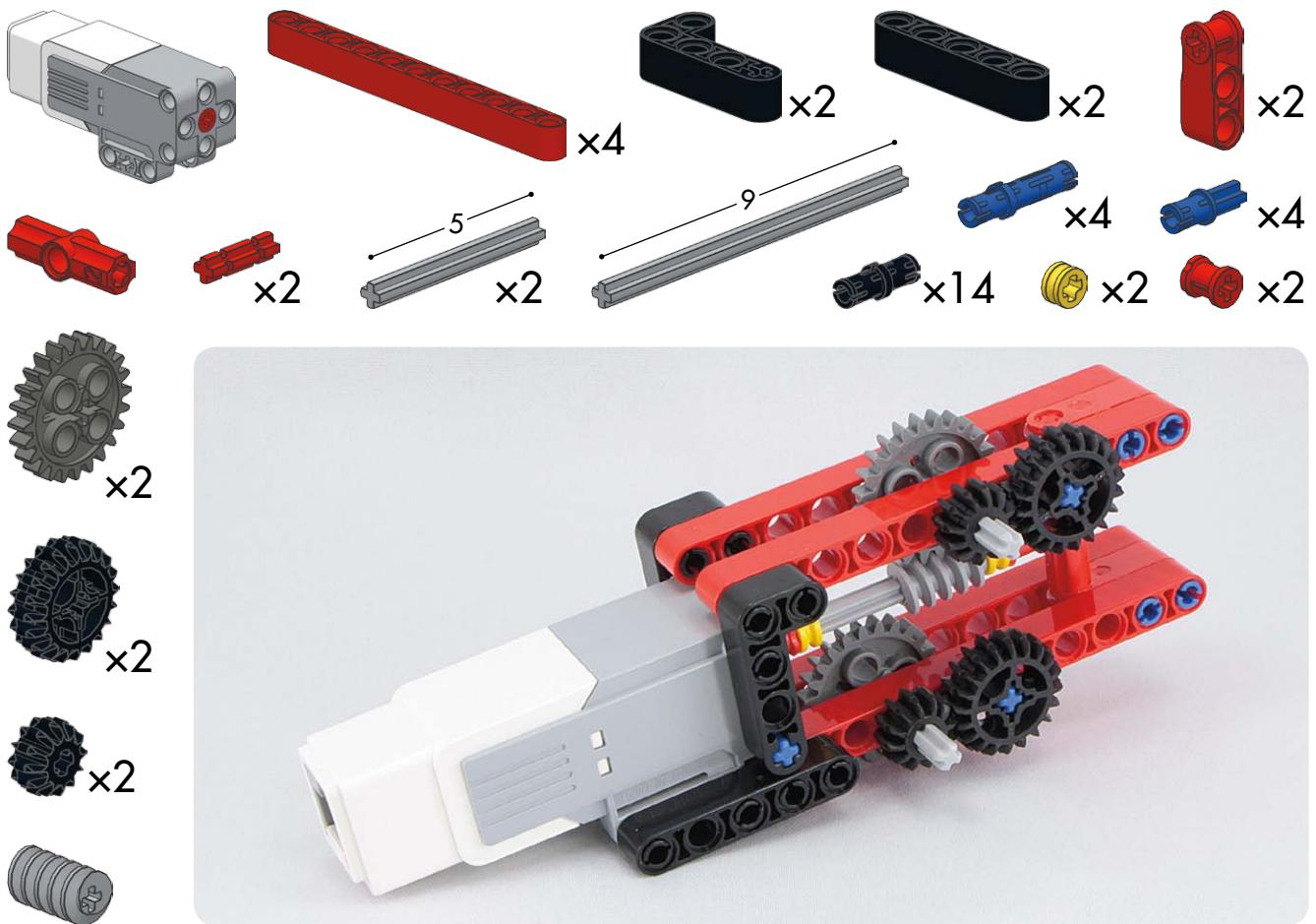
## #97

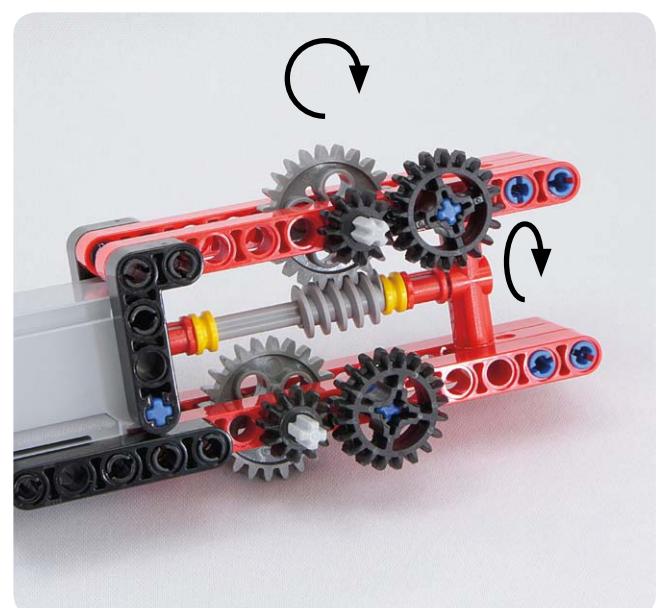
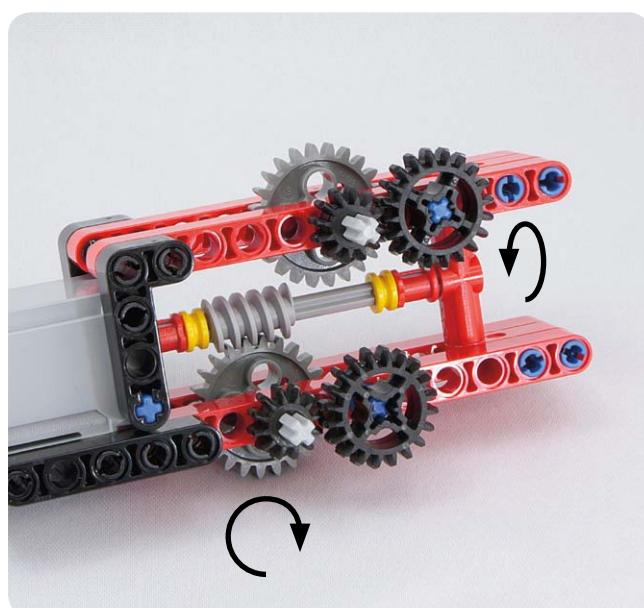
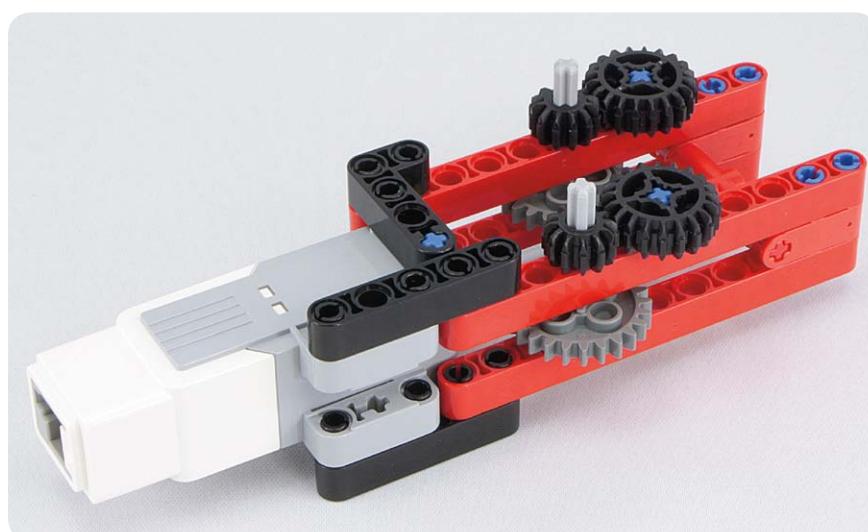
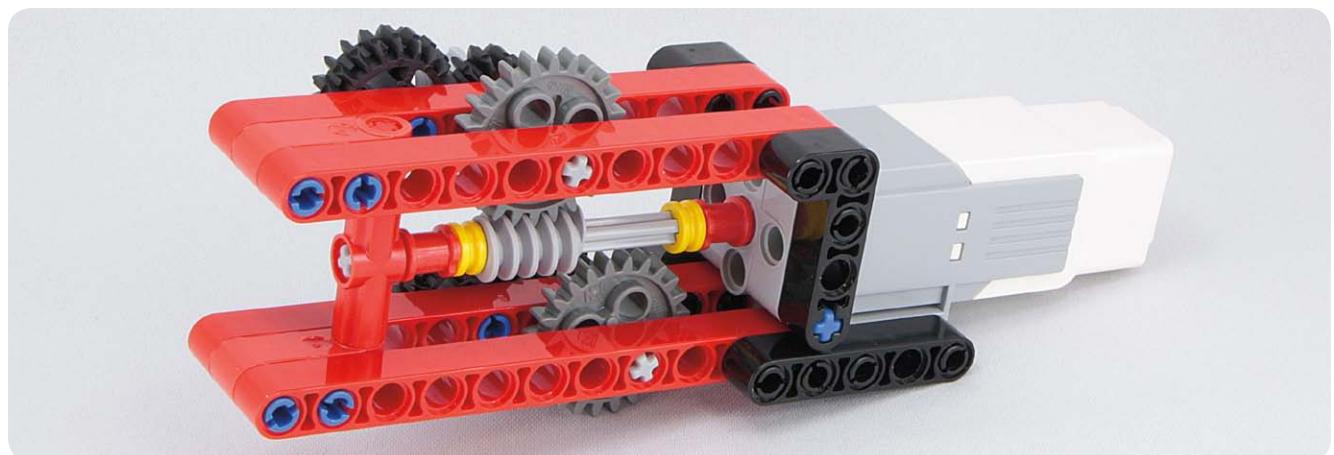


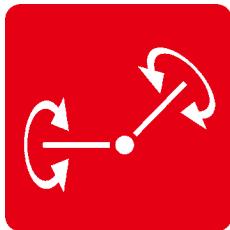
## #98



## #99

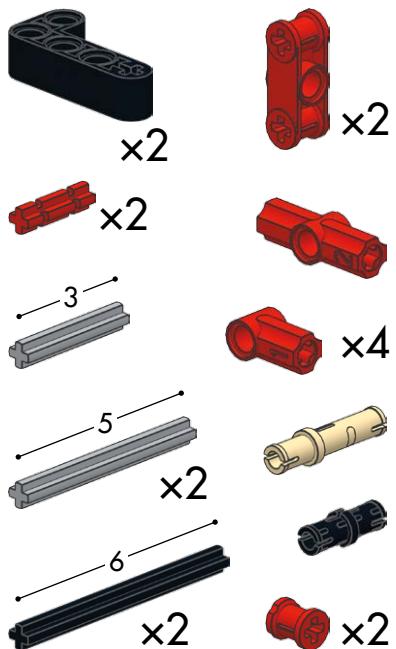




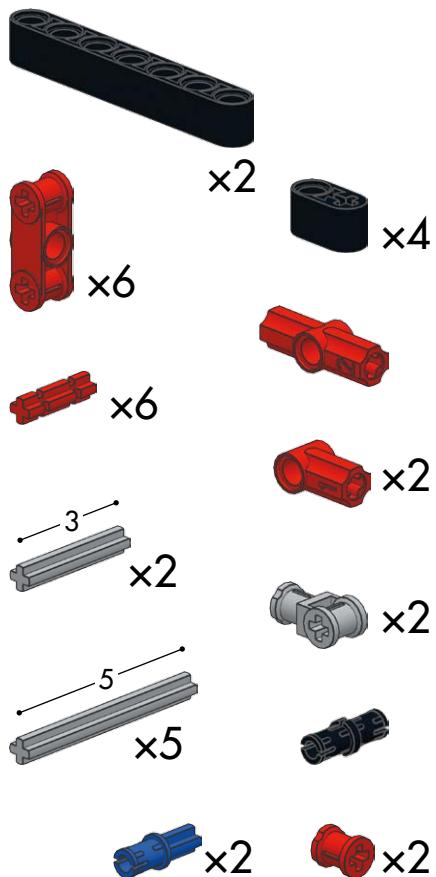


# Universal joints

#100



# #101





# PART 2



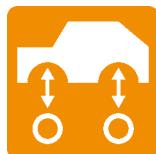
# Vehicles



78



90



100



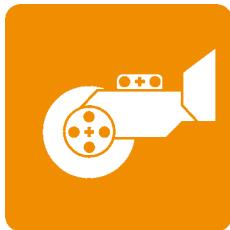
82



94

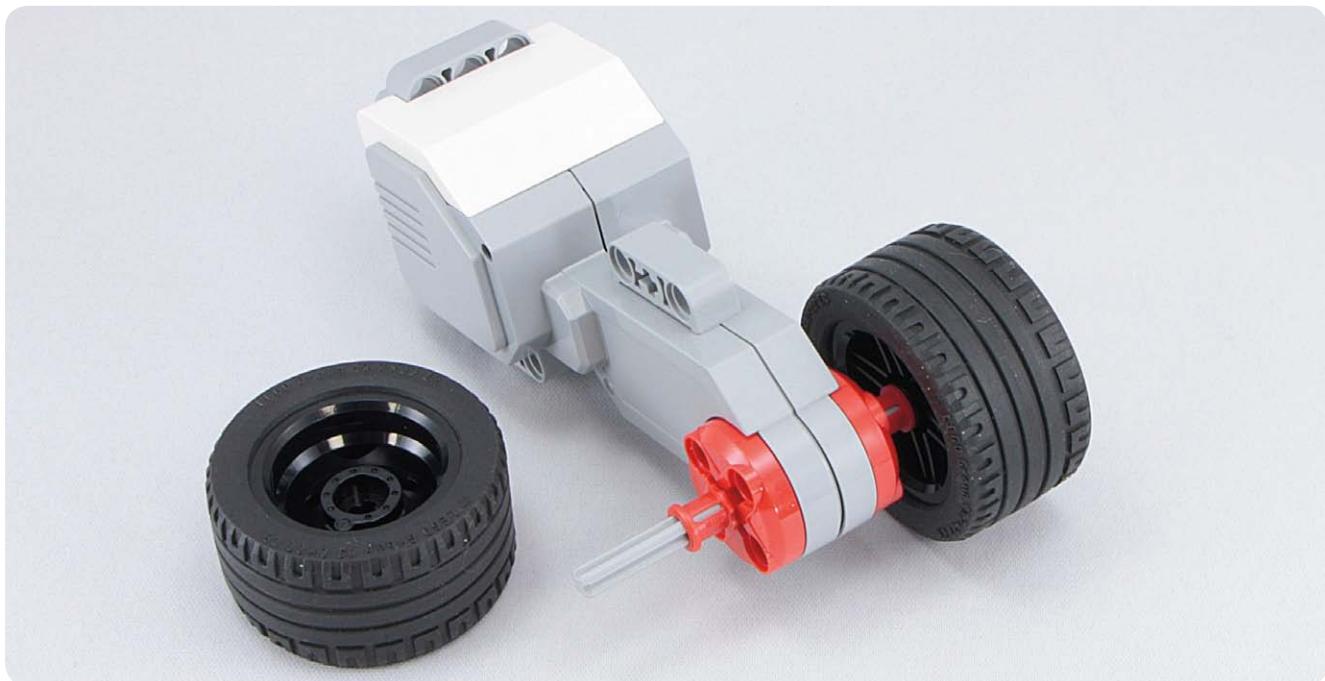
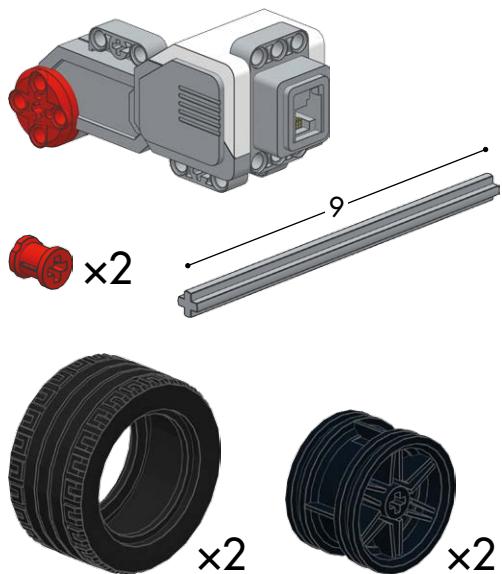


104

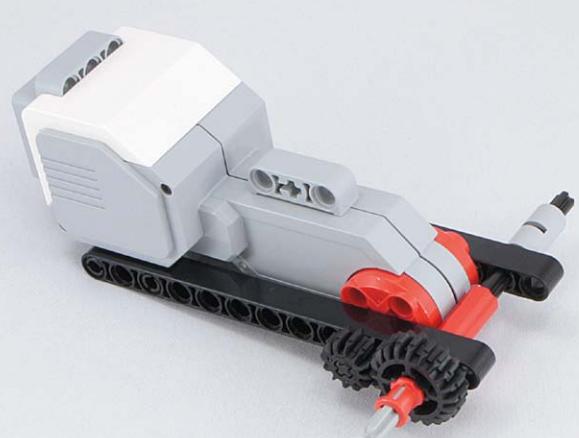
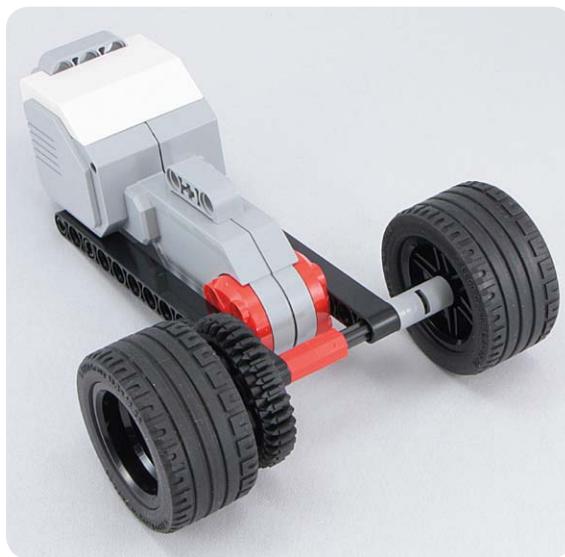


# Driving wheels with a motor

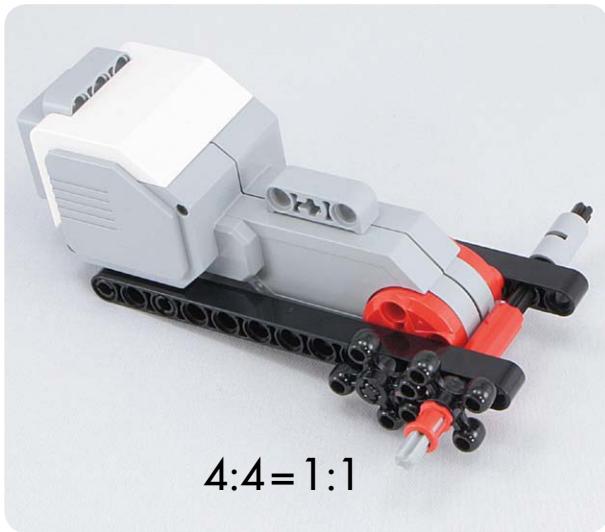
#102



## #103

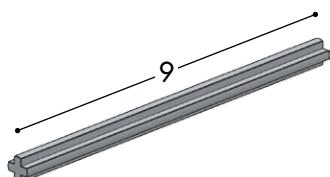
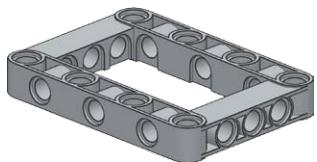
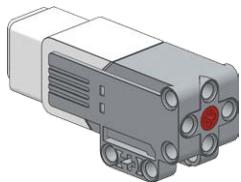


12:20 = 3:5



4:4 = 1:1

# #104



x2



x2



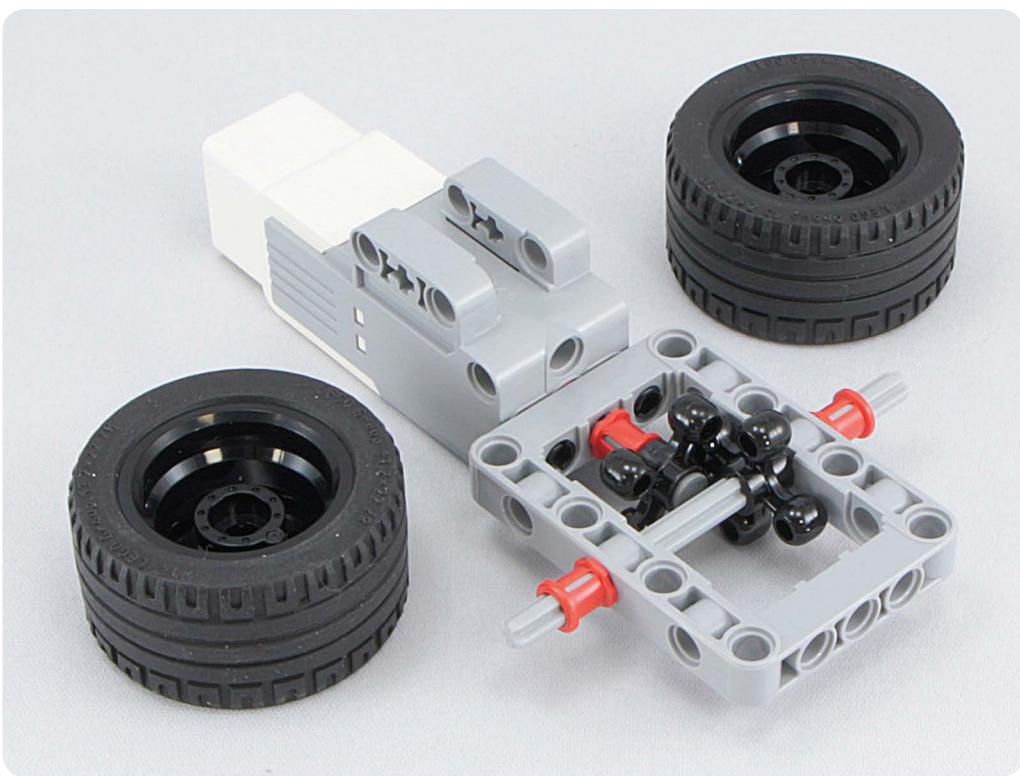
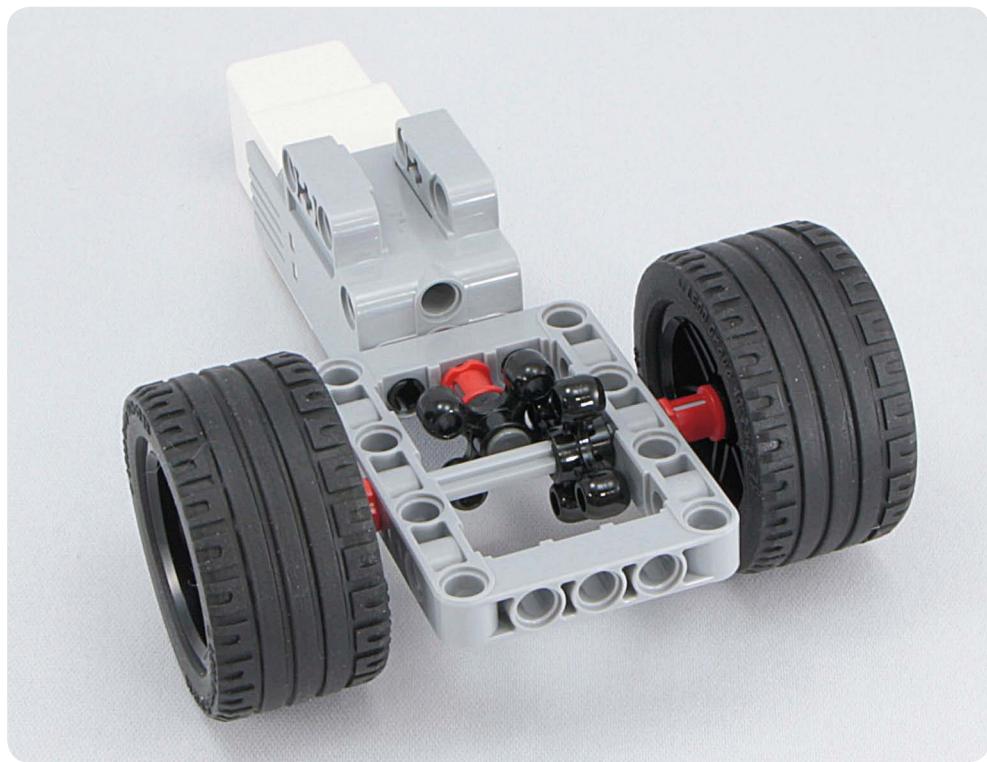
x2



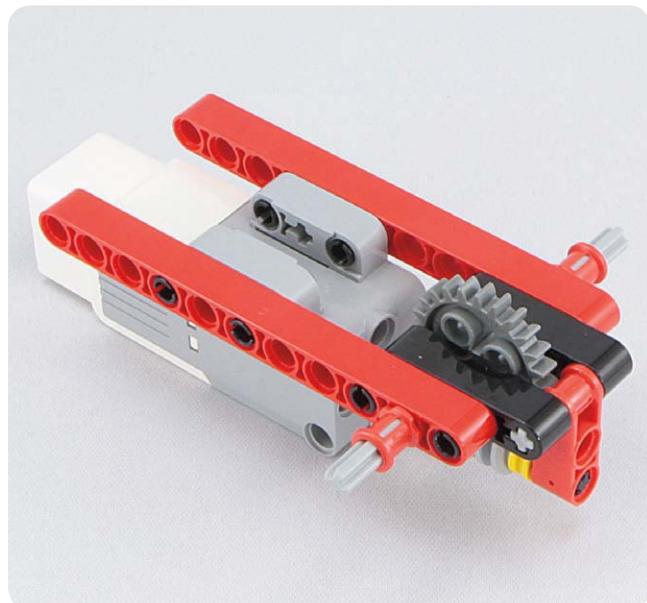
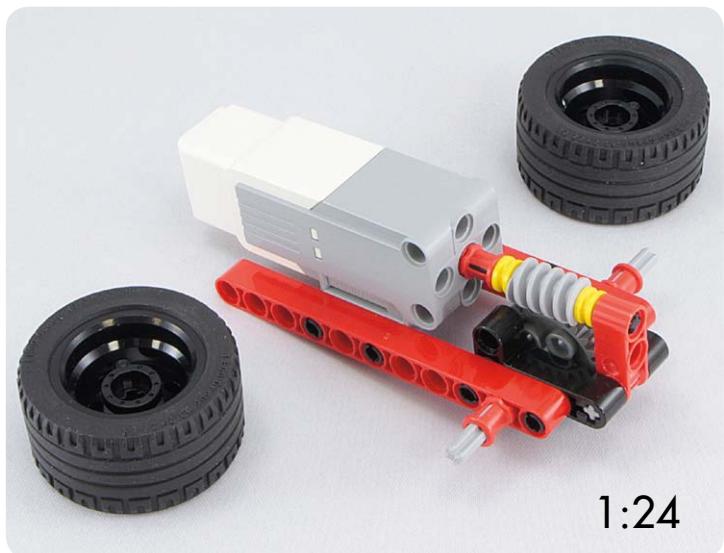
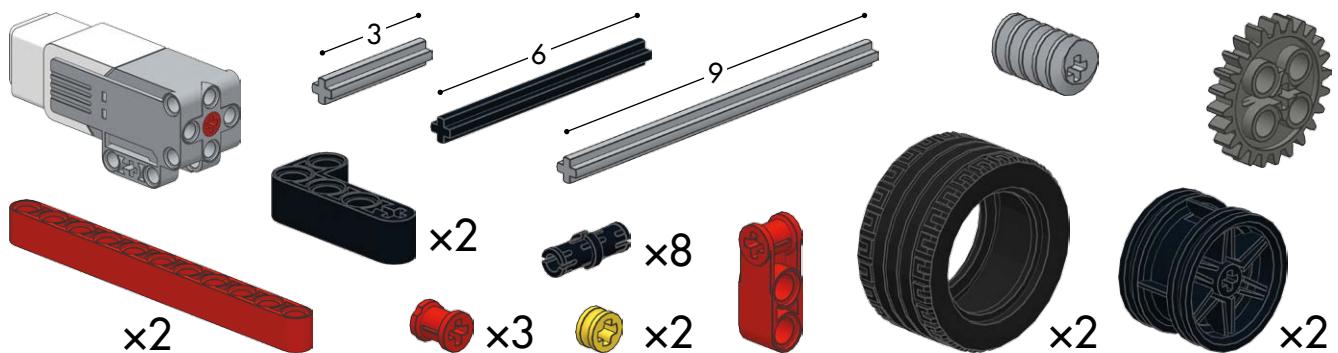
x2

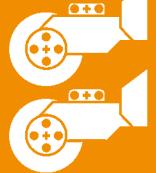


x3



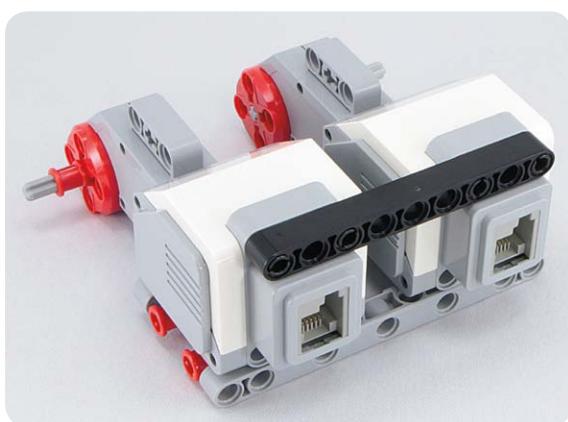
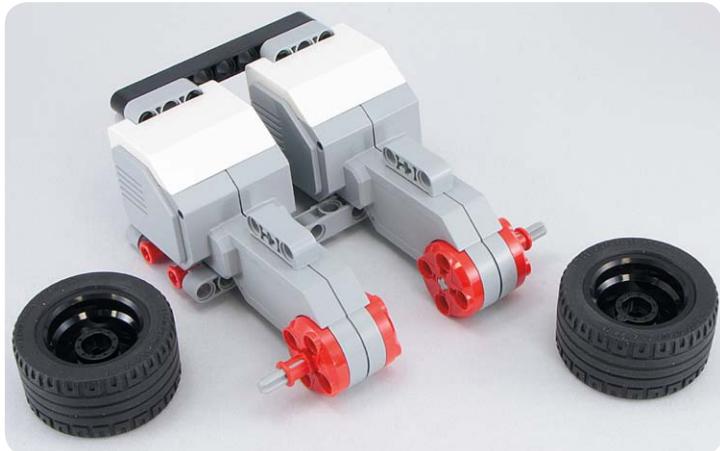
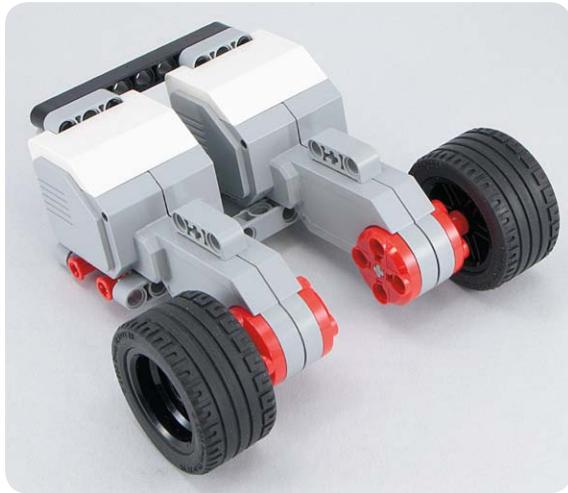
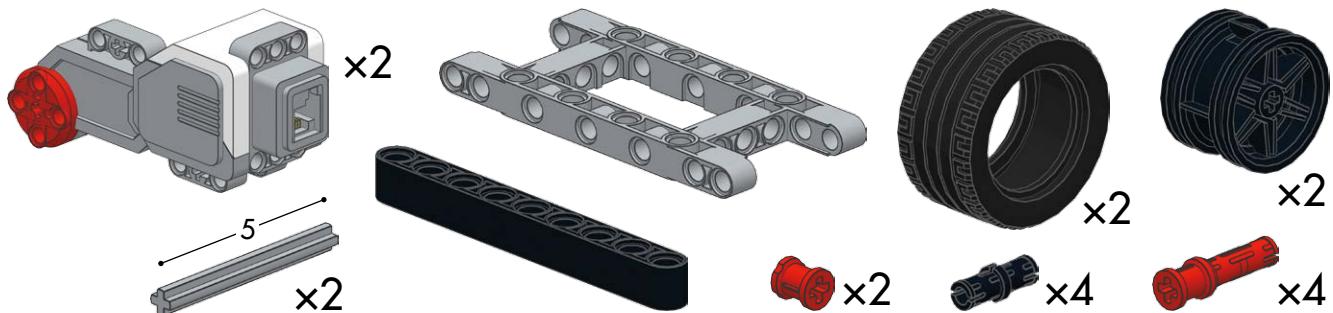
# #105



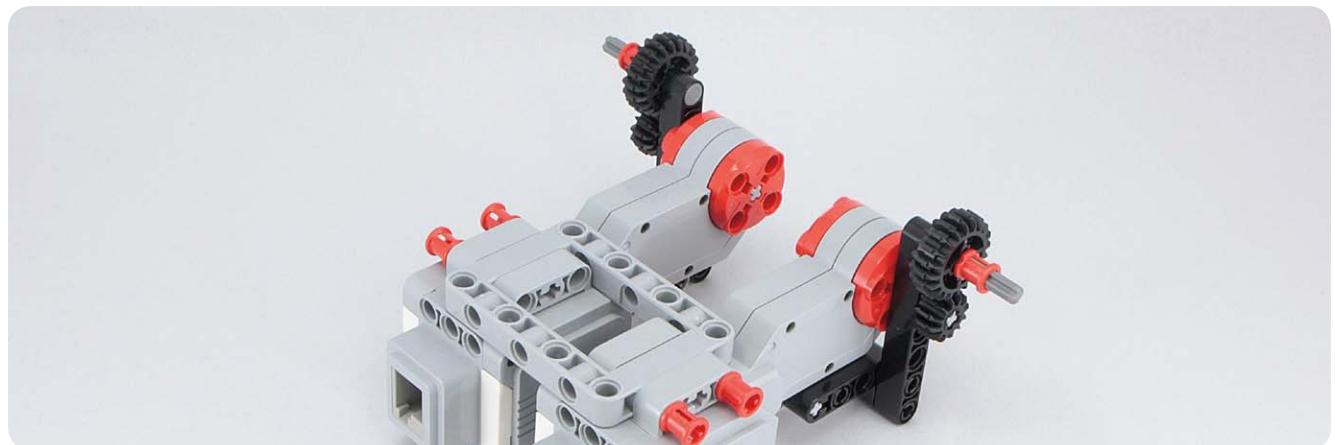
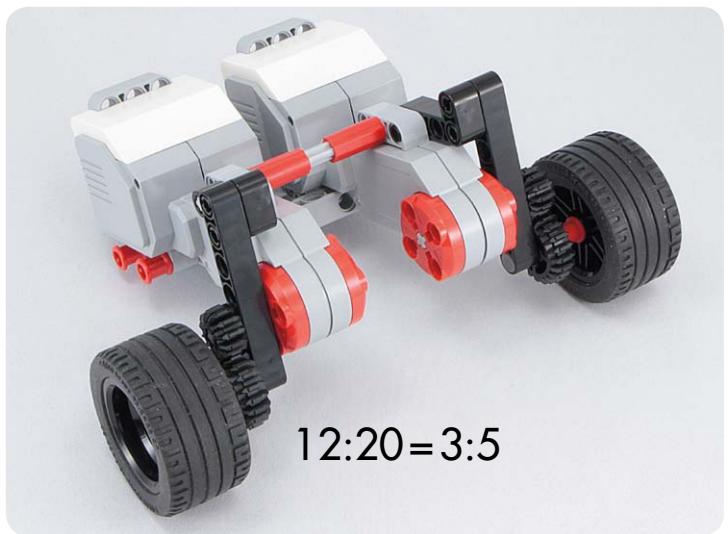


# Driving wheels with two motors

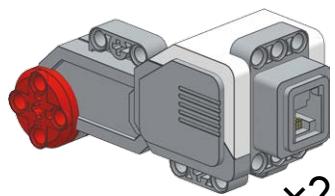
#106



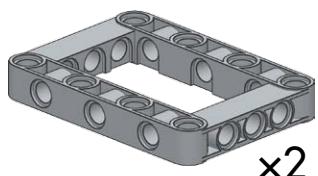
## #107



## #108



4x



10x

4x

2x

2x



4x

2x



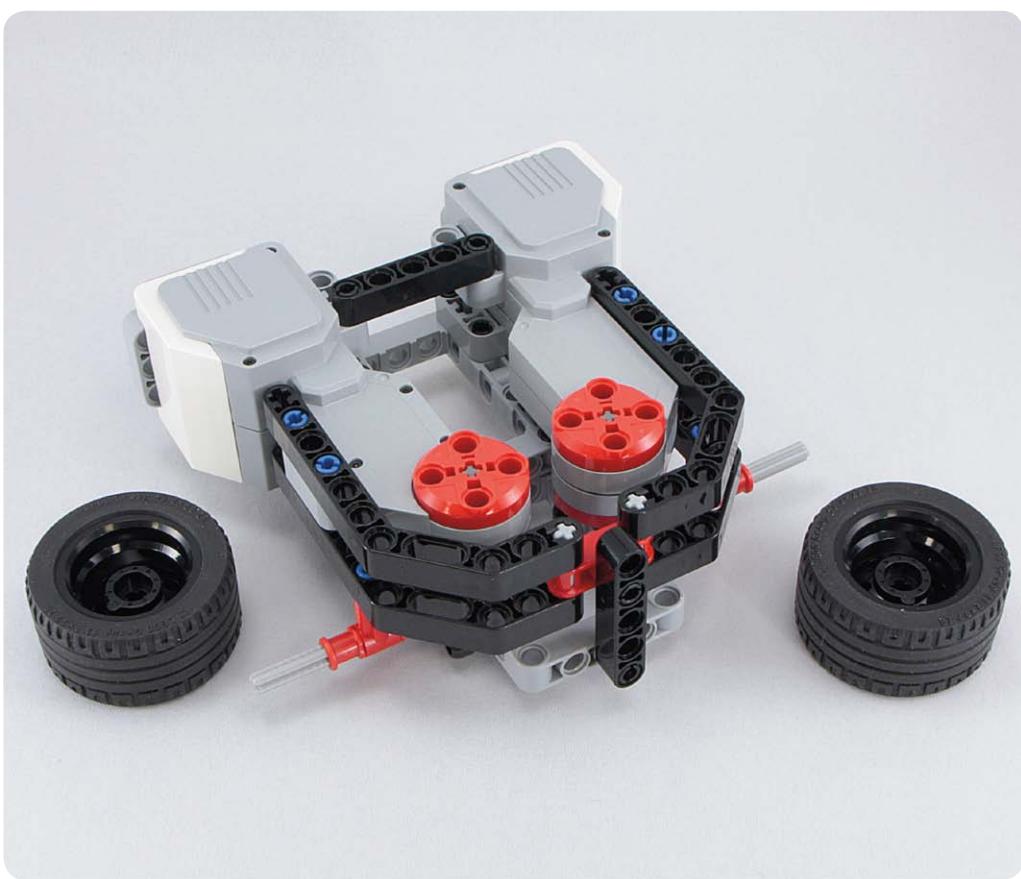
4x

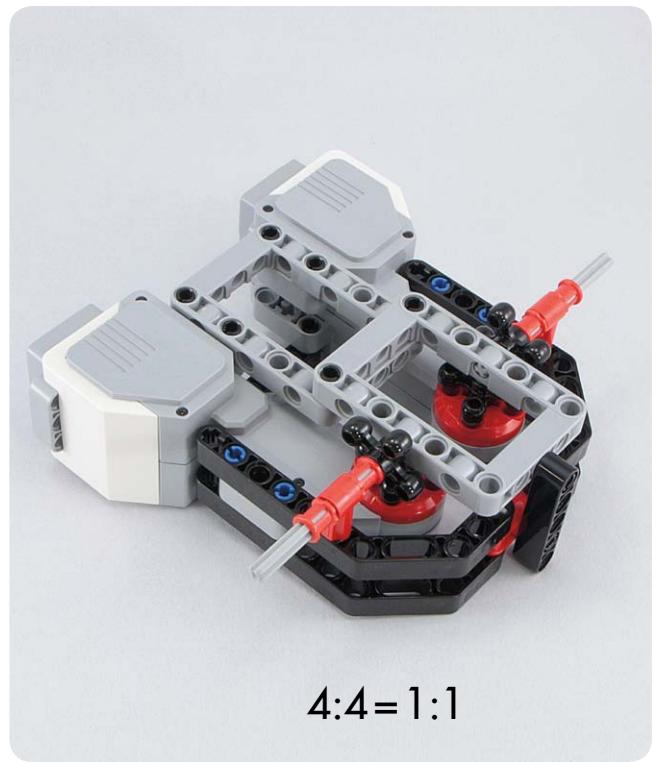
2x

2x

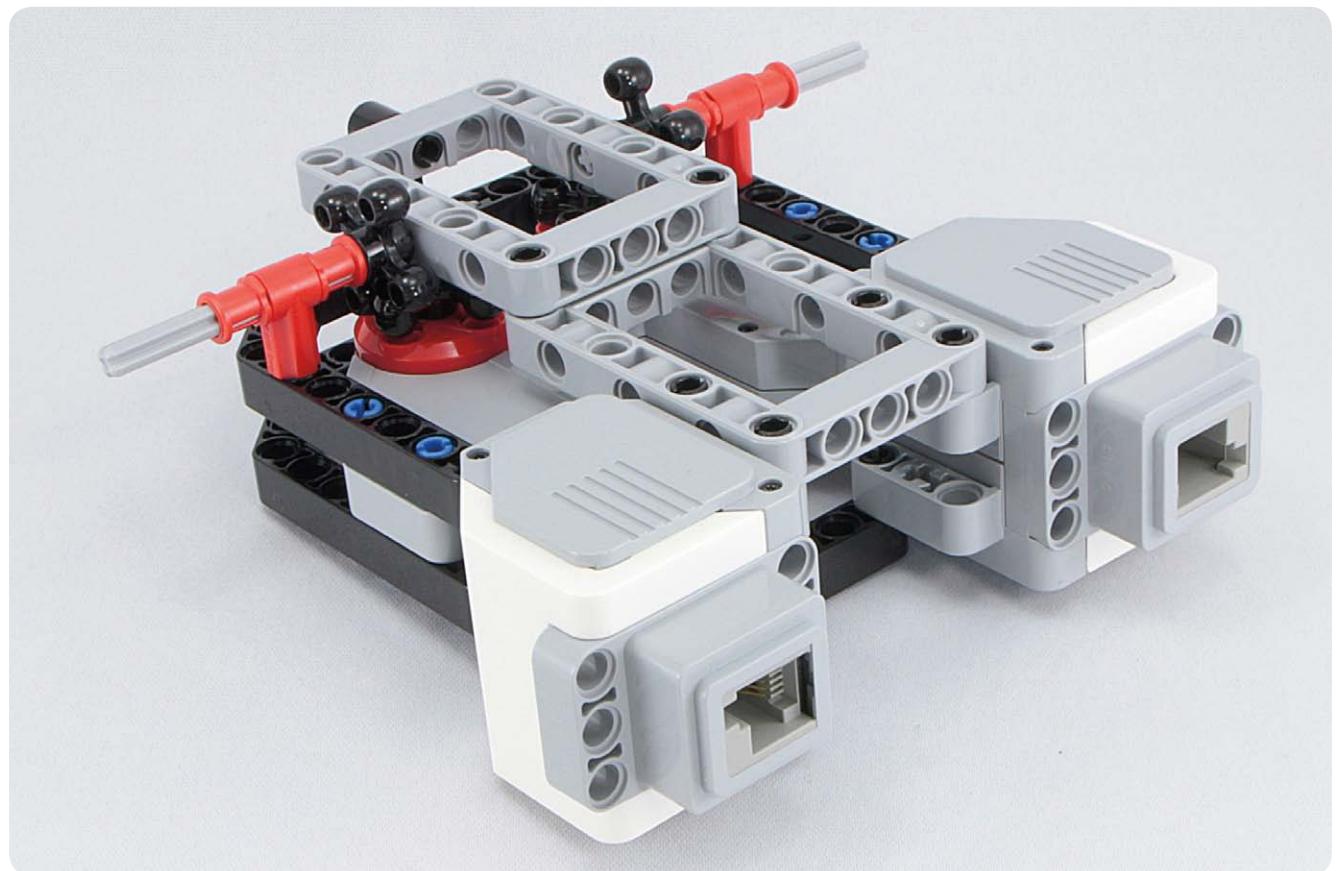
2x

2x

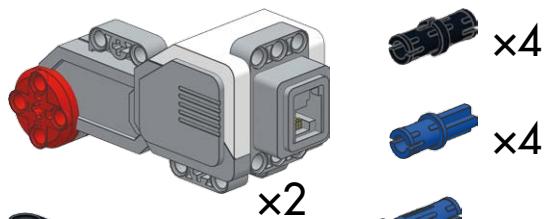




$4:4 = 1:1$



## #109



x4

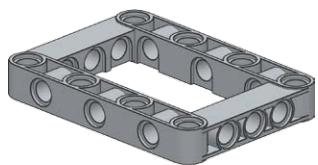
x4

x10



x4

x2



x4



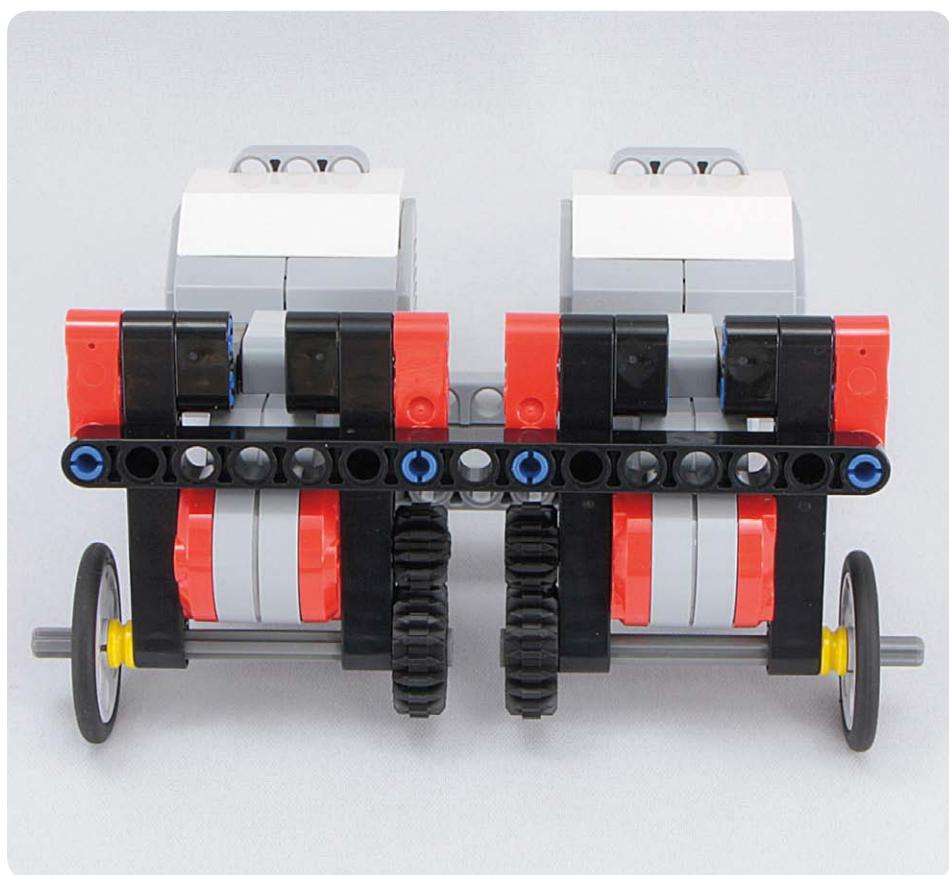
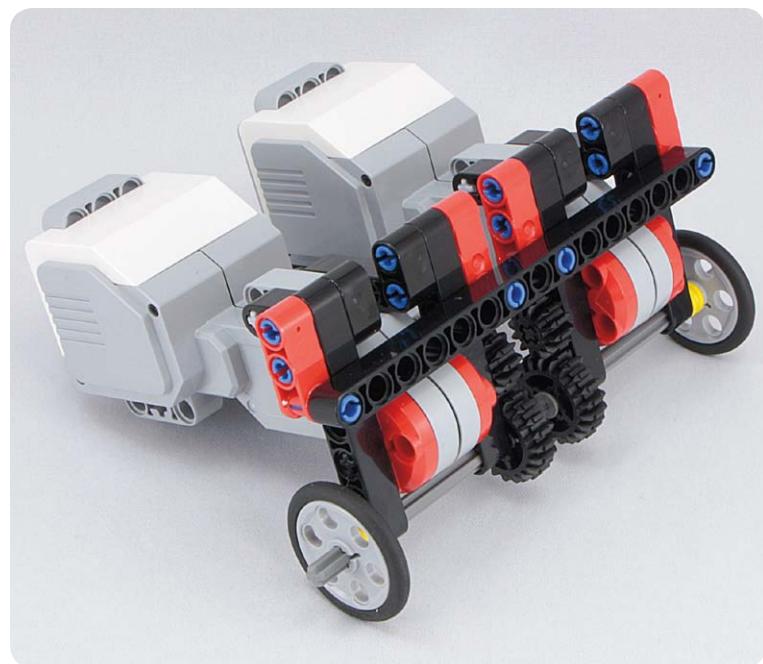
x2      x2

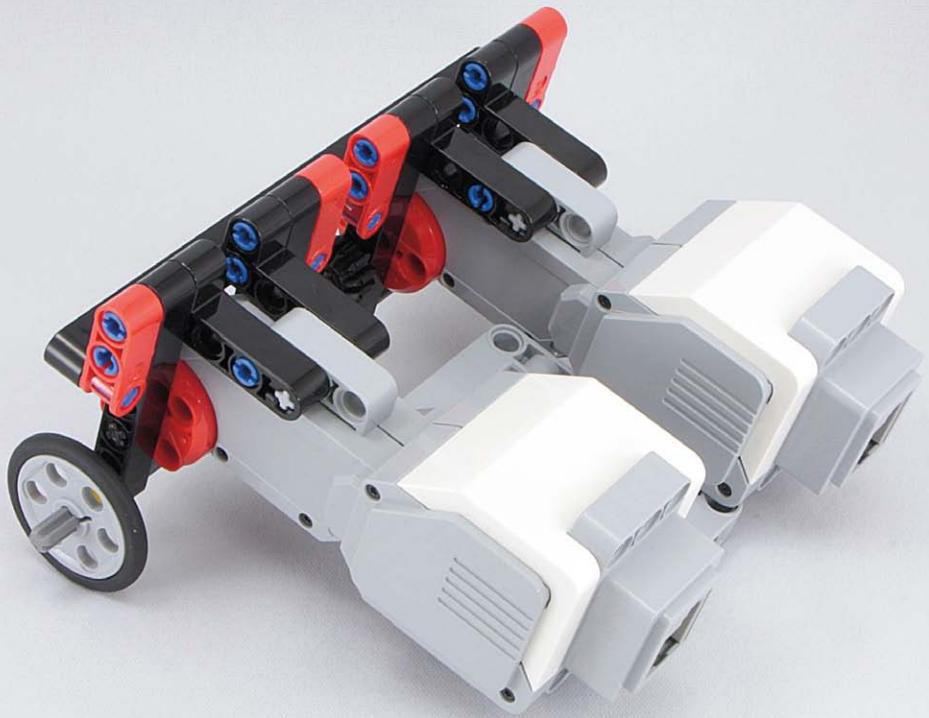
x4

x2

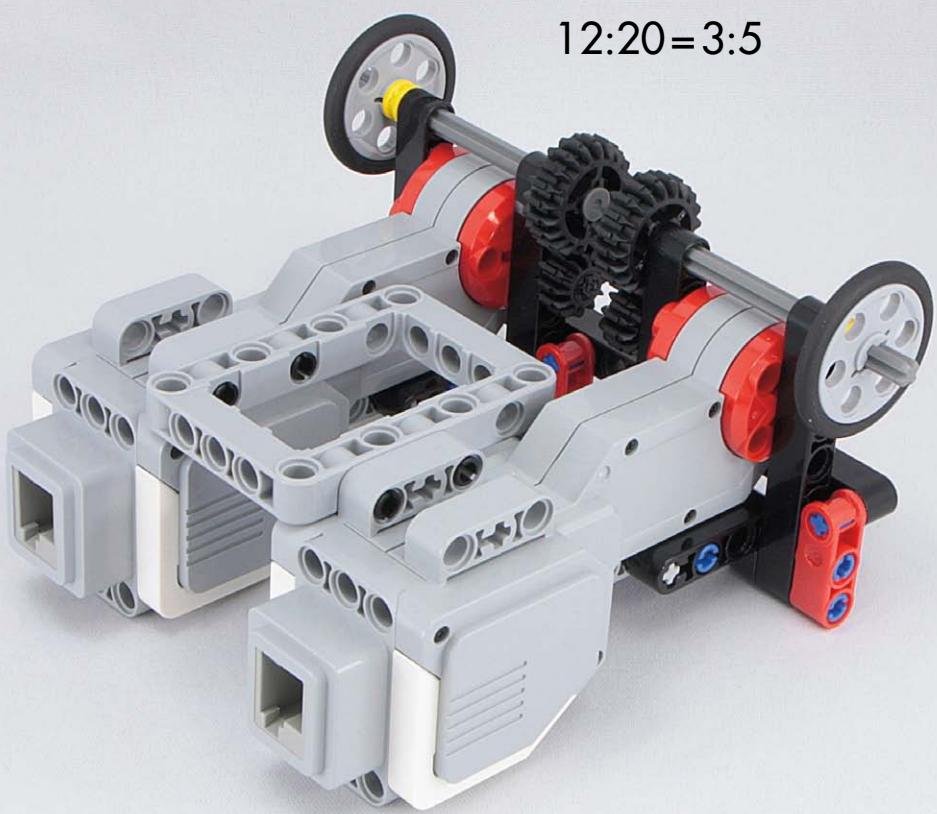
6 →  
x2

3 →  
x2

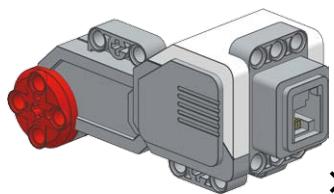




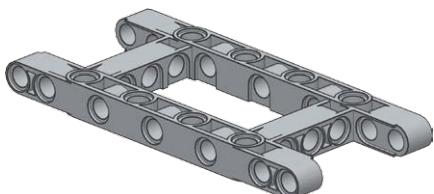
12:20=3:5



# #110



x2



x4



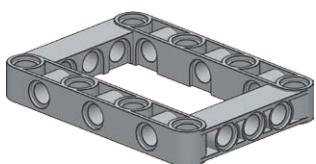
x2



x2



x2



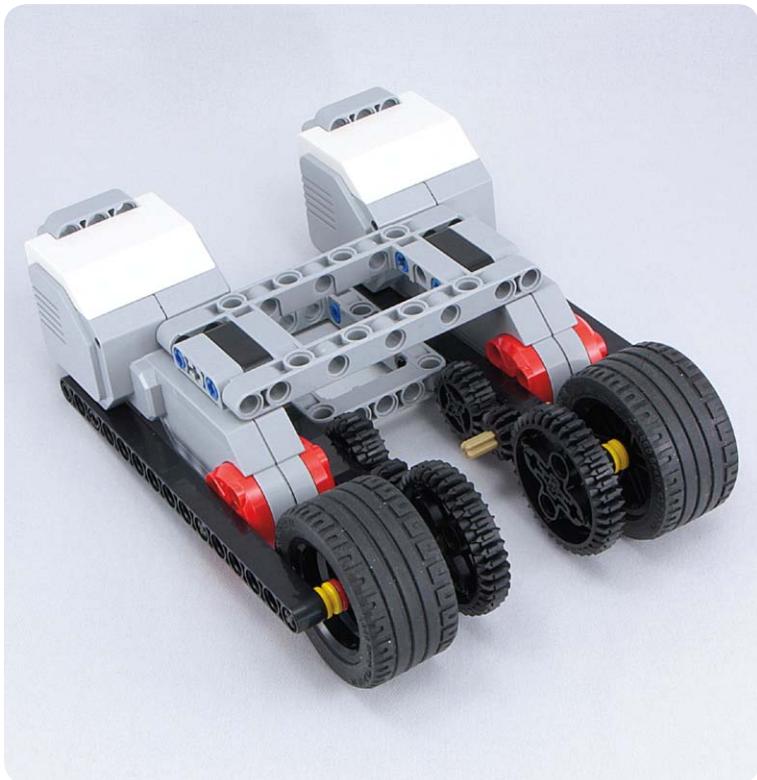
x2



x2



x4



x2



x8



x6

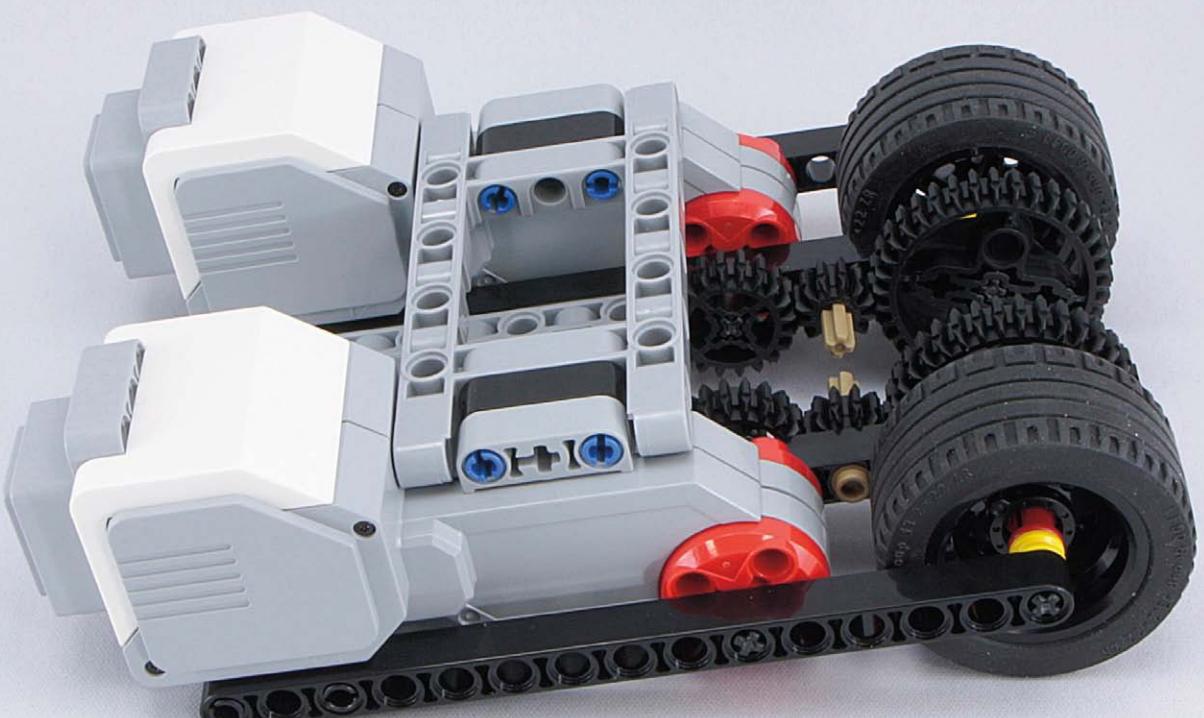


x2

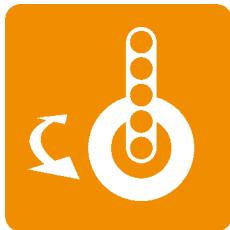


x4





20:36=5:9



# Caster wheels

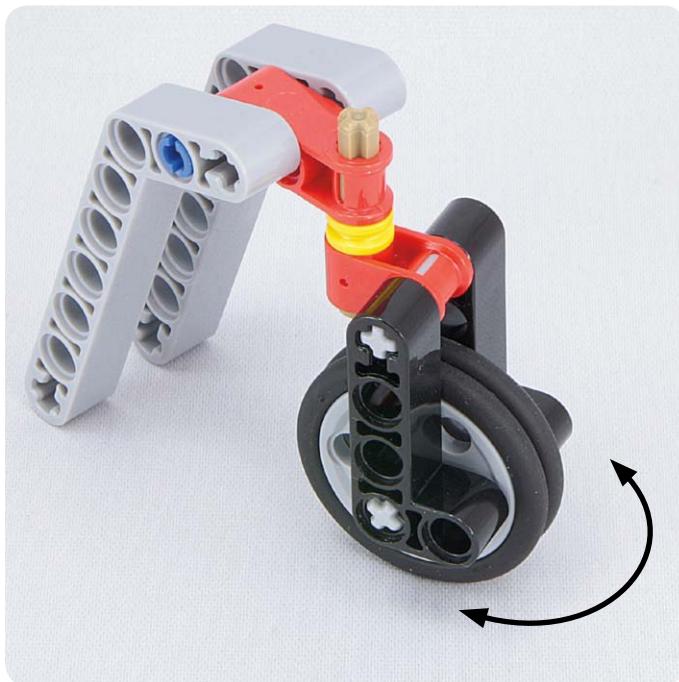
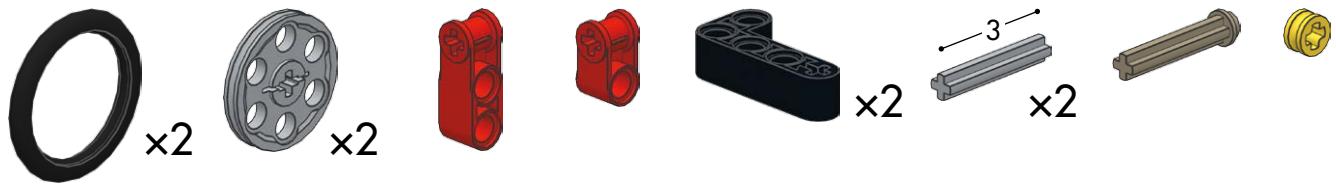
#111



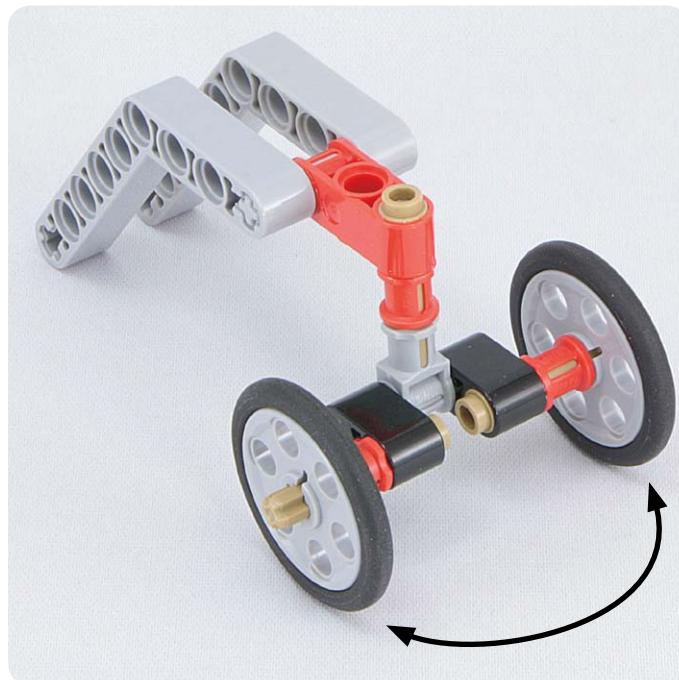
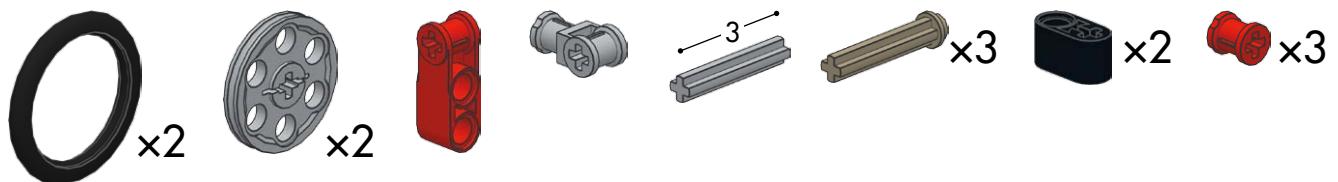
## #112

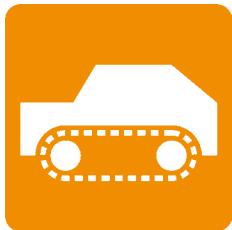


# #113



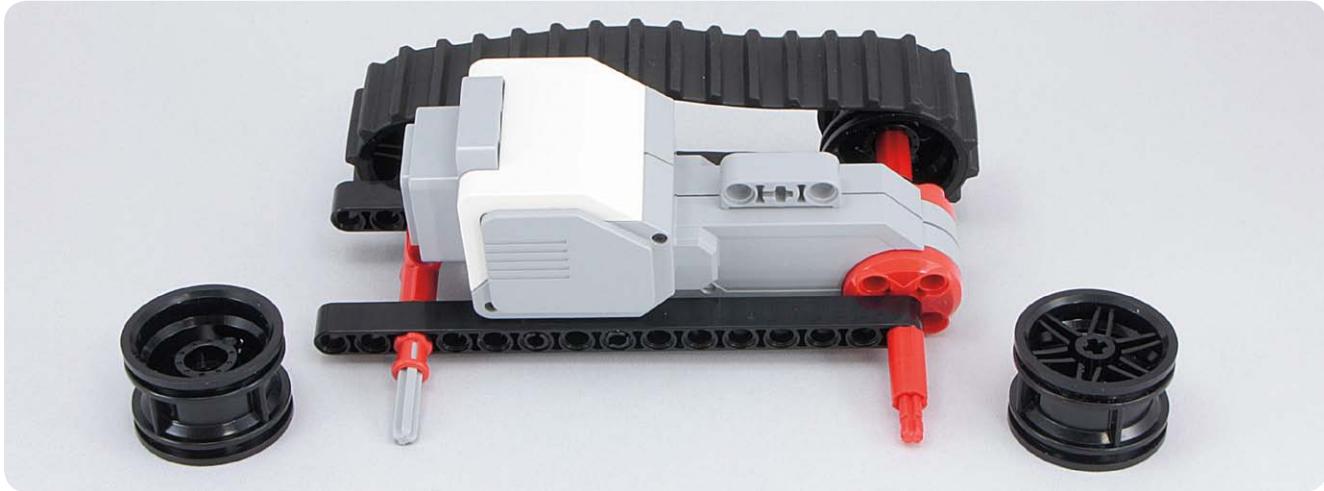
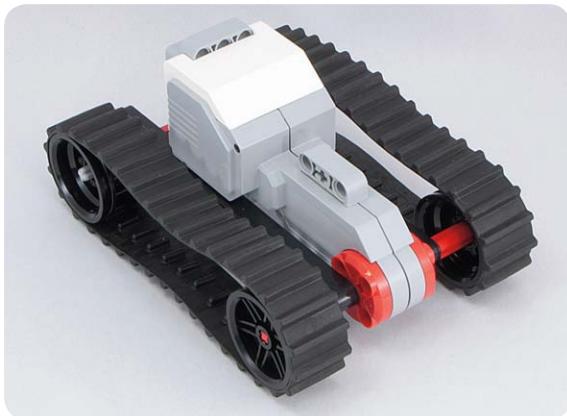
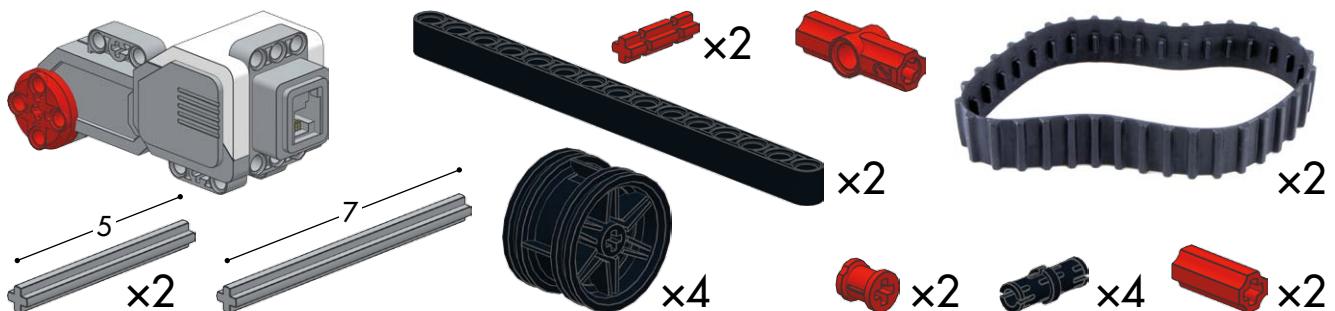
# #114



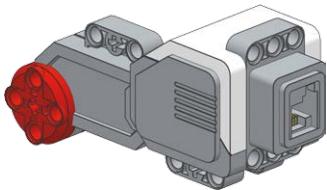


# Crawlers

#115



#116



x2



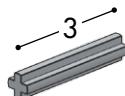
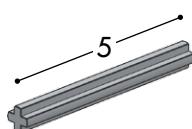
x2



x2



x2



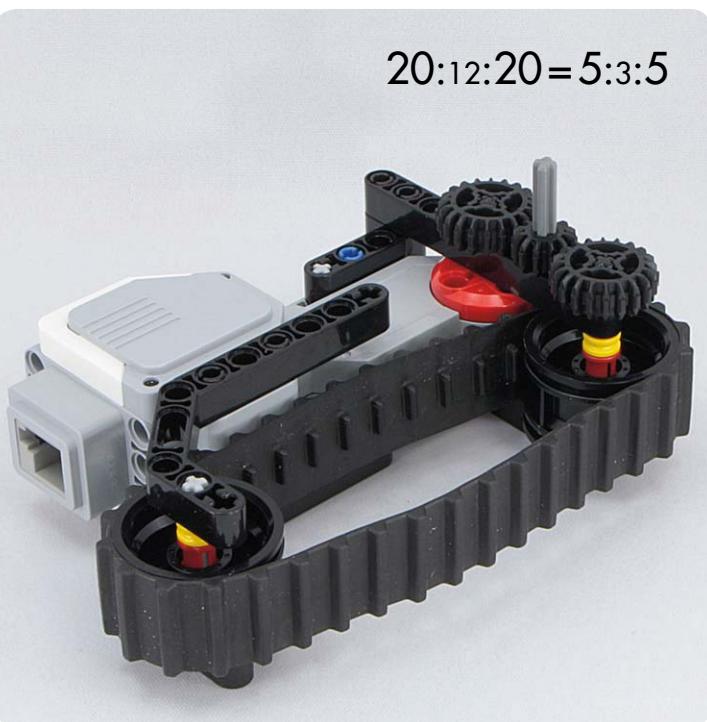
x2



x2



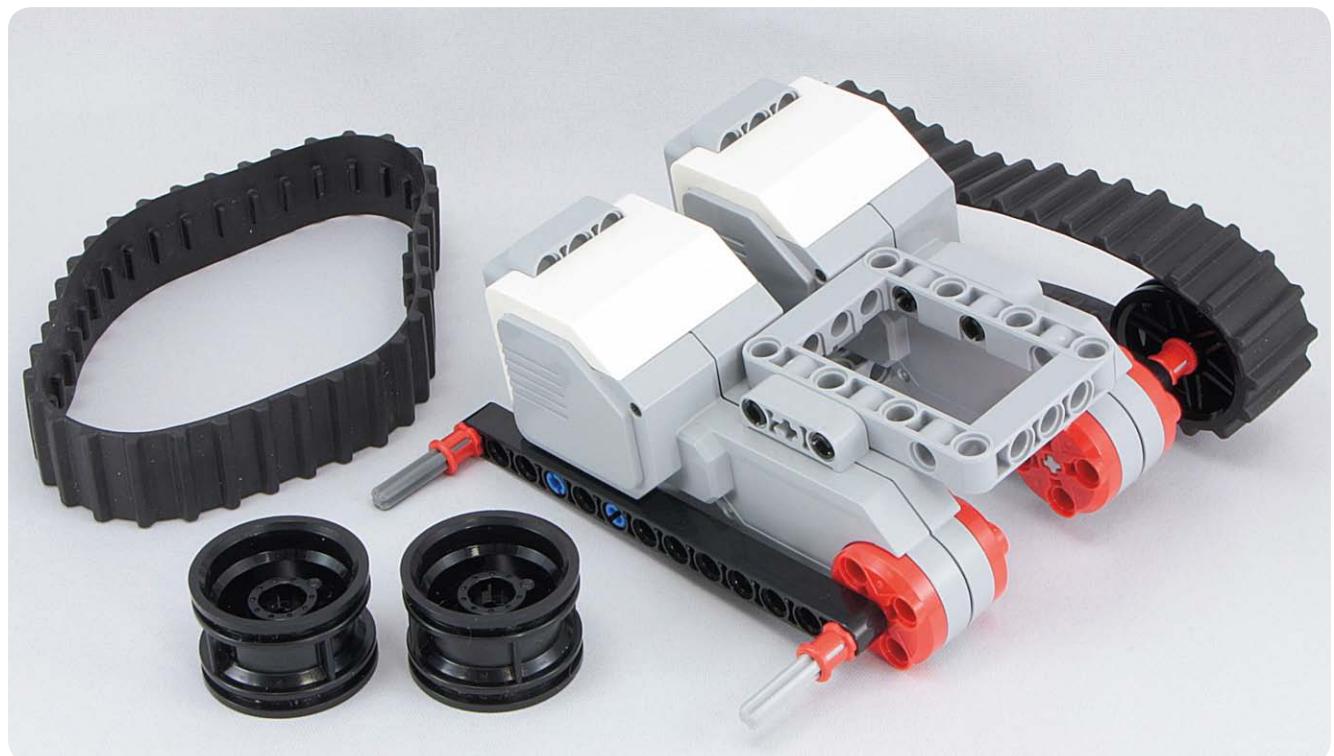
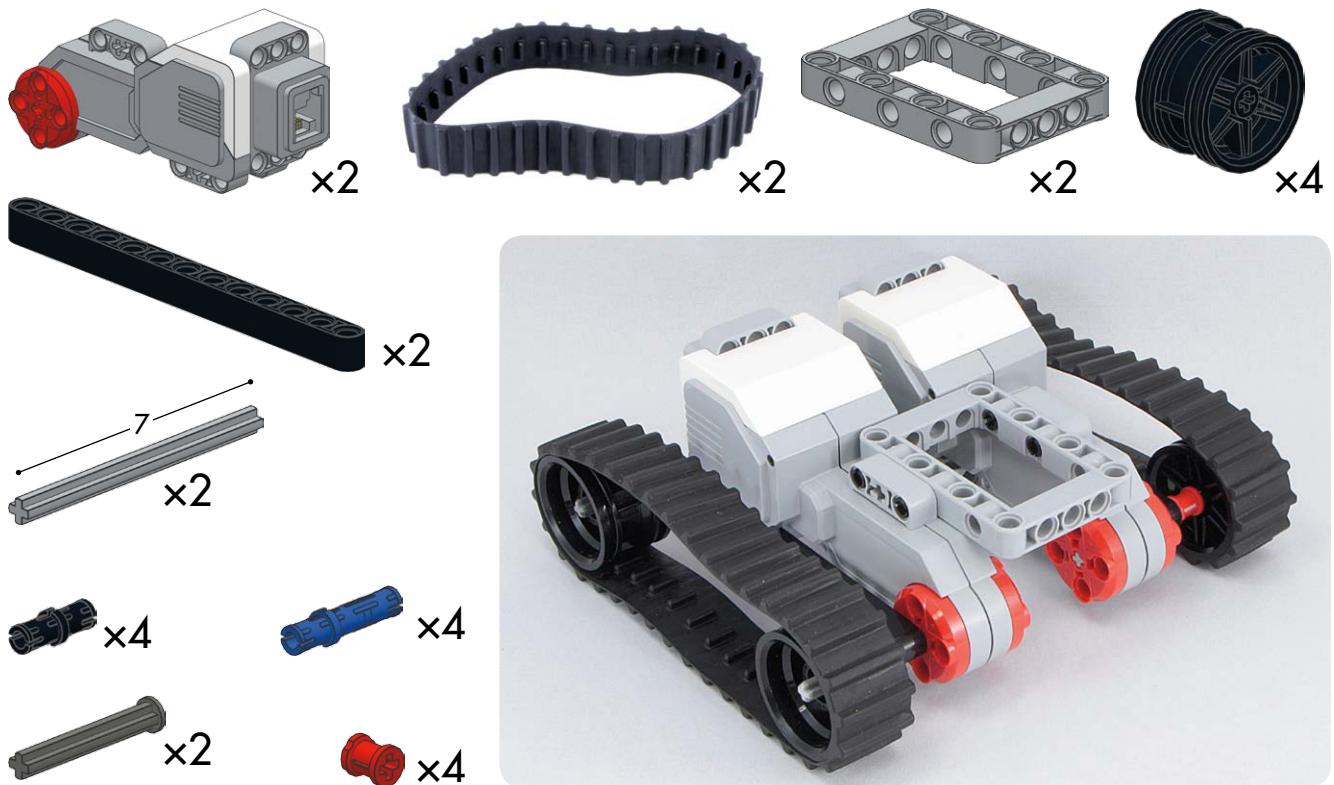
x4

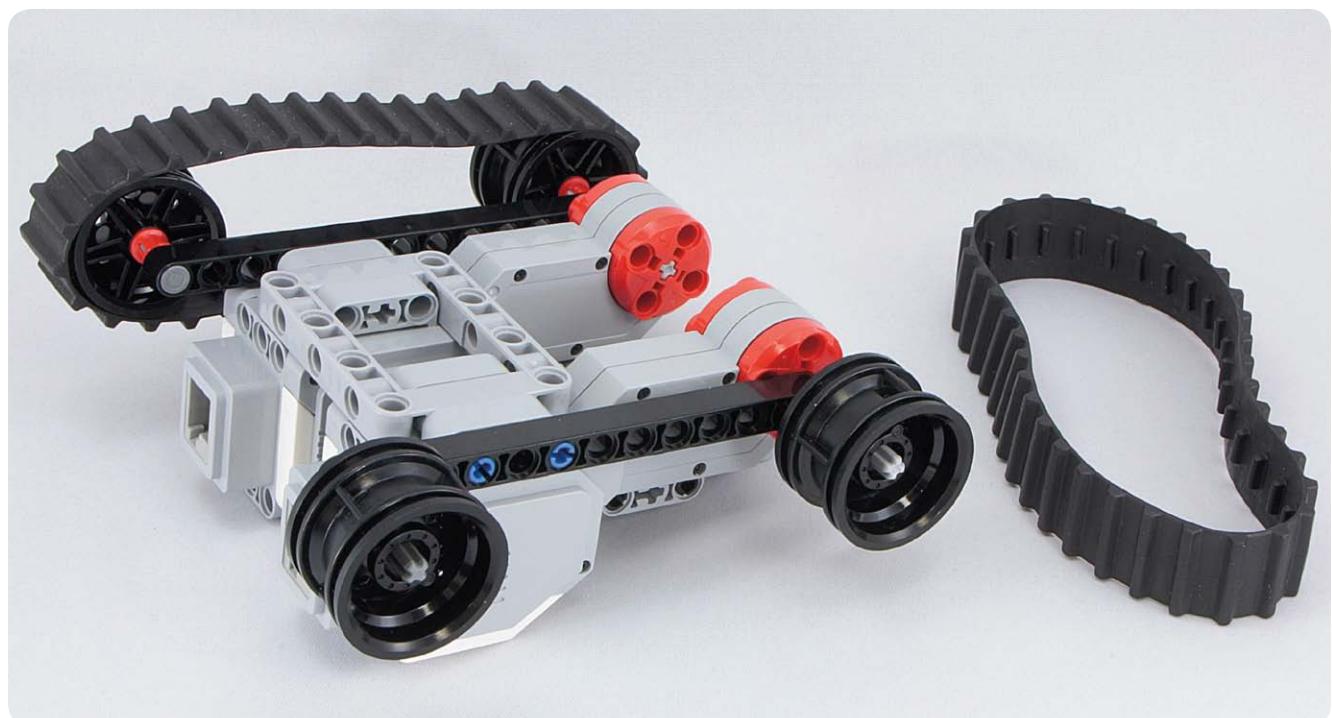
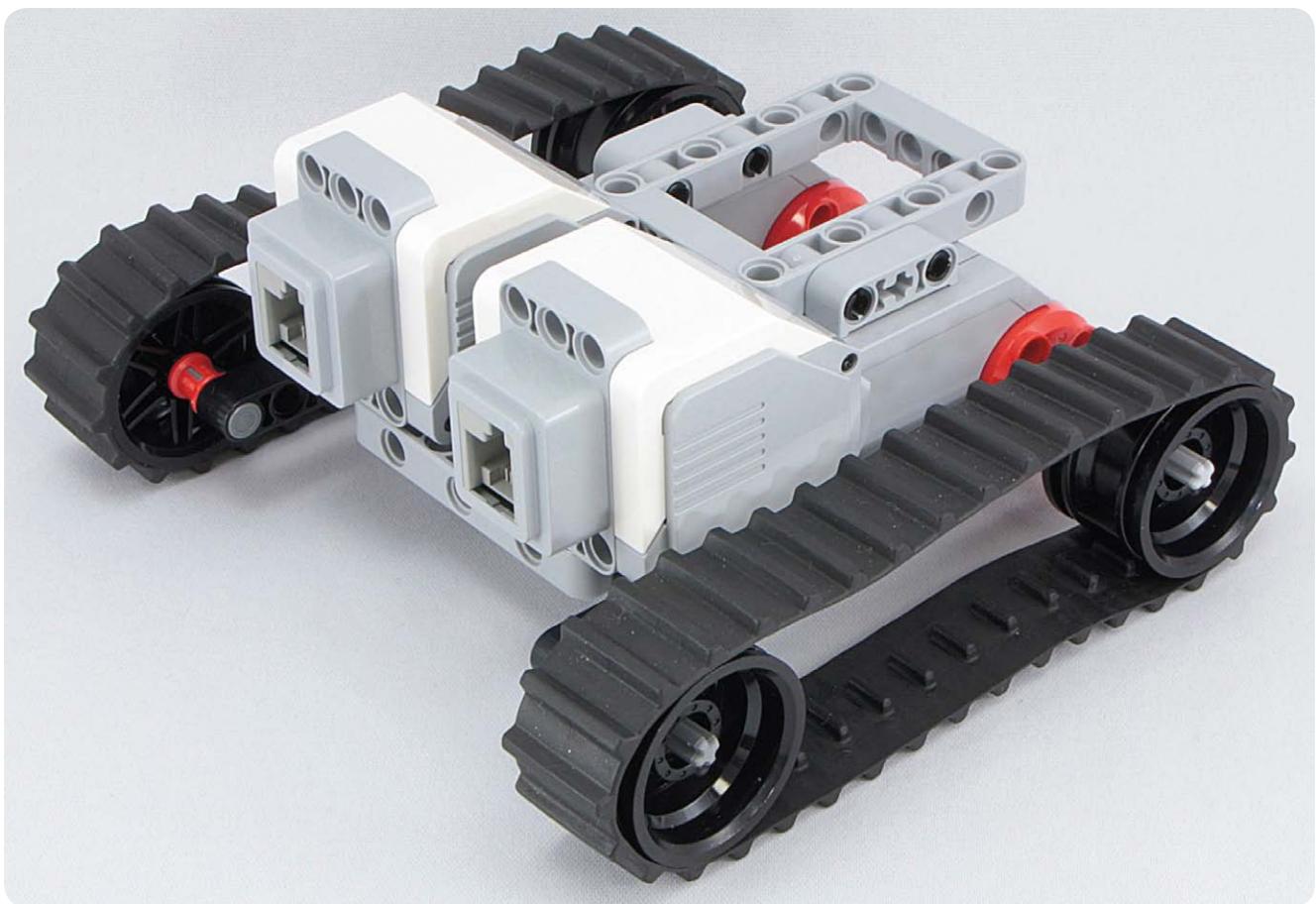


$$20:12:20 = 5:3:5$$

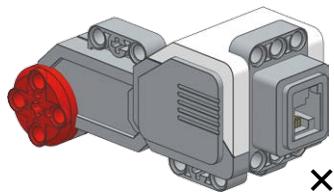


#117





# #118



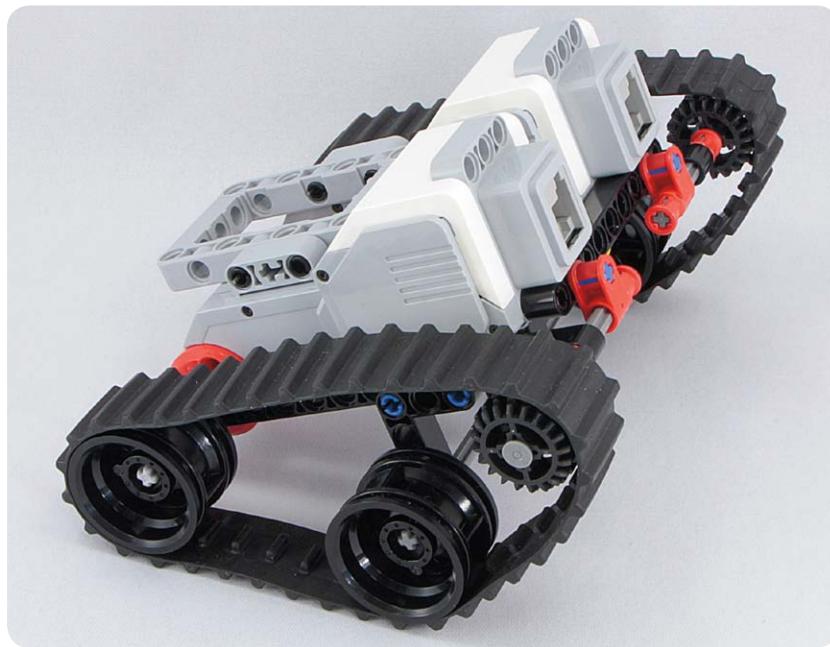
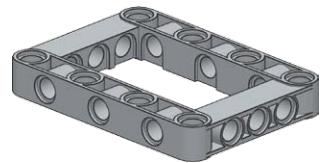
x2



x2



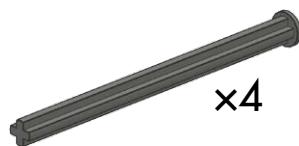
x4



x2



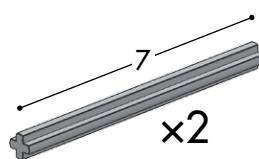
x4



x4



x2



x2



x4



x12



x2



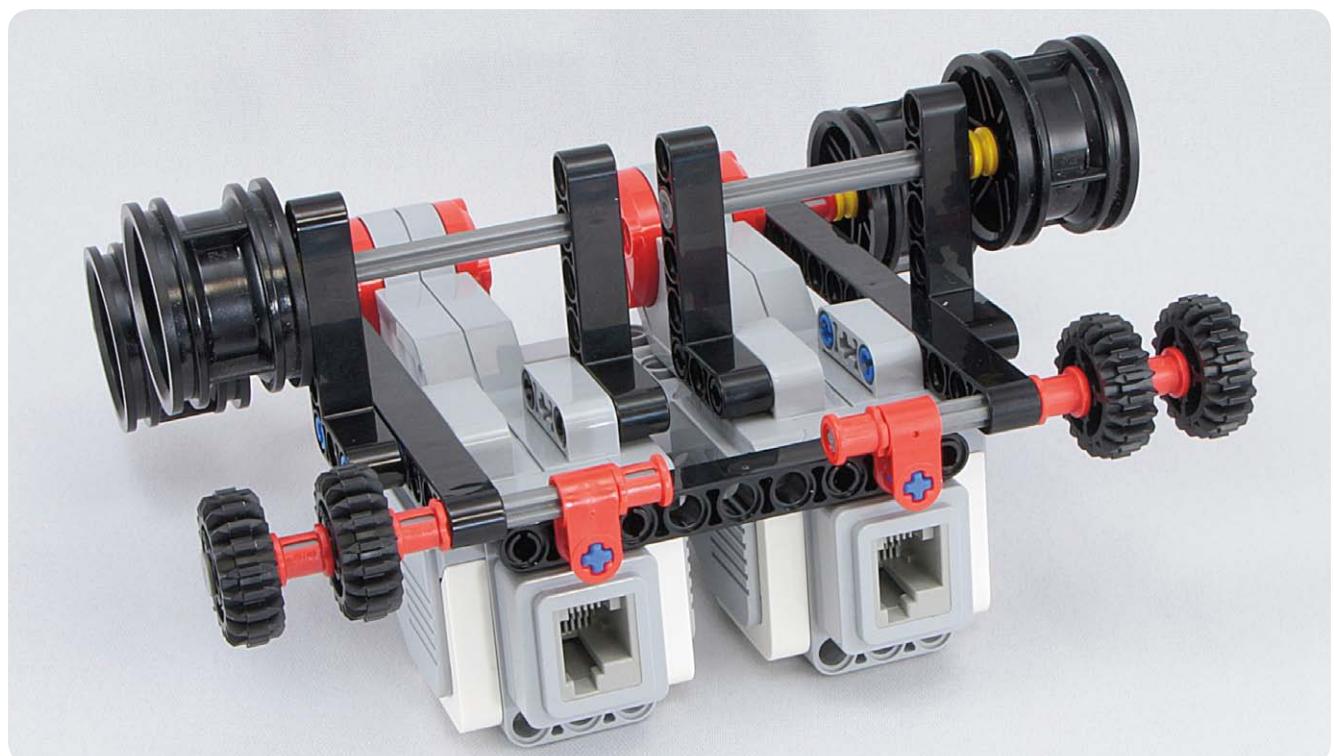
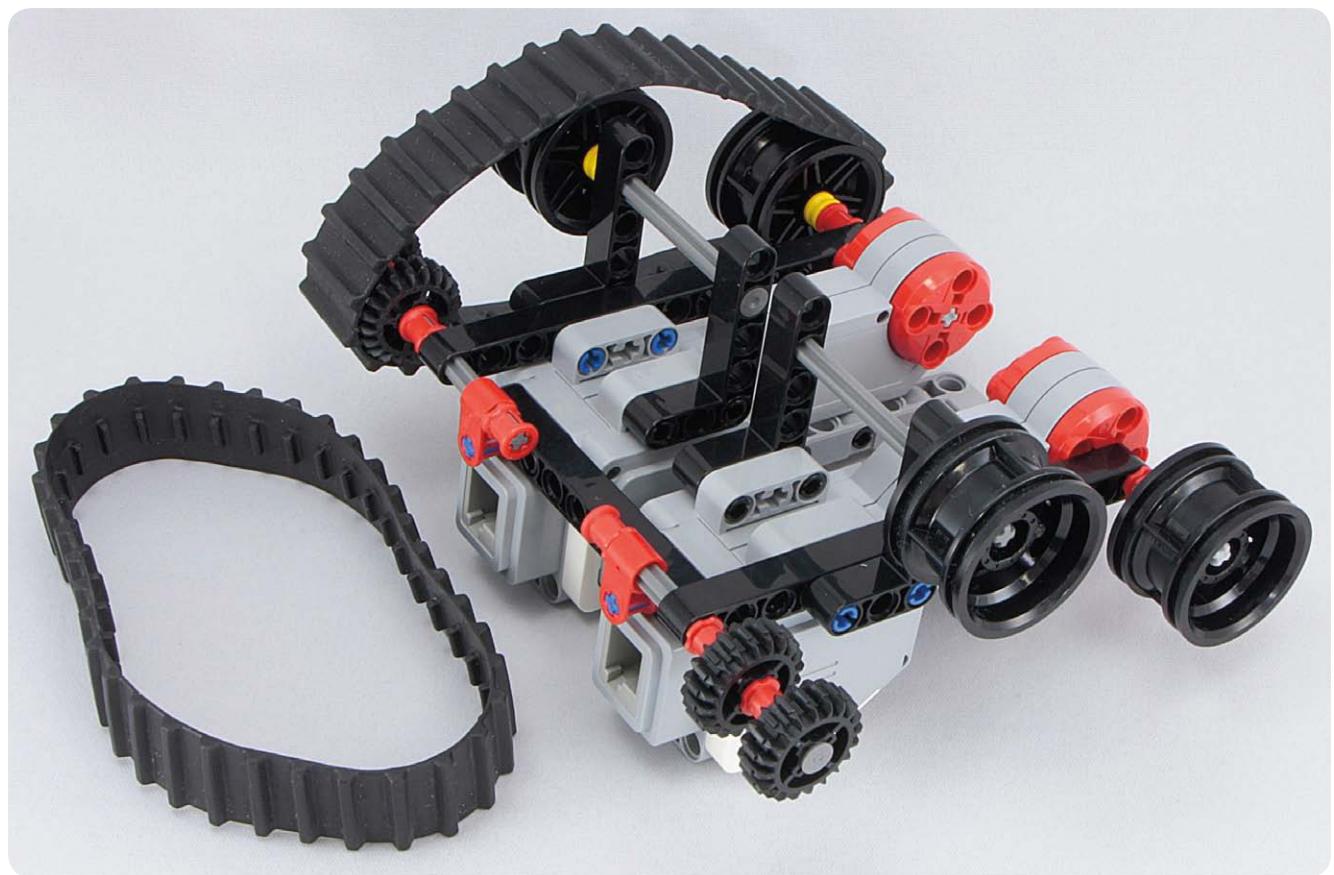
x4

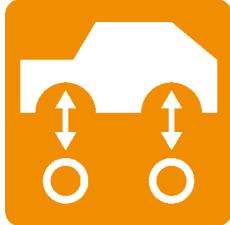


x8



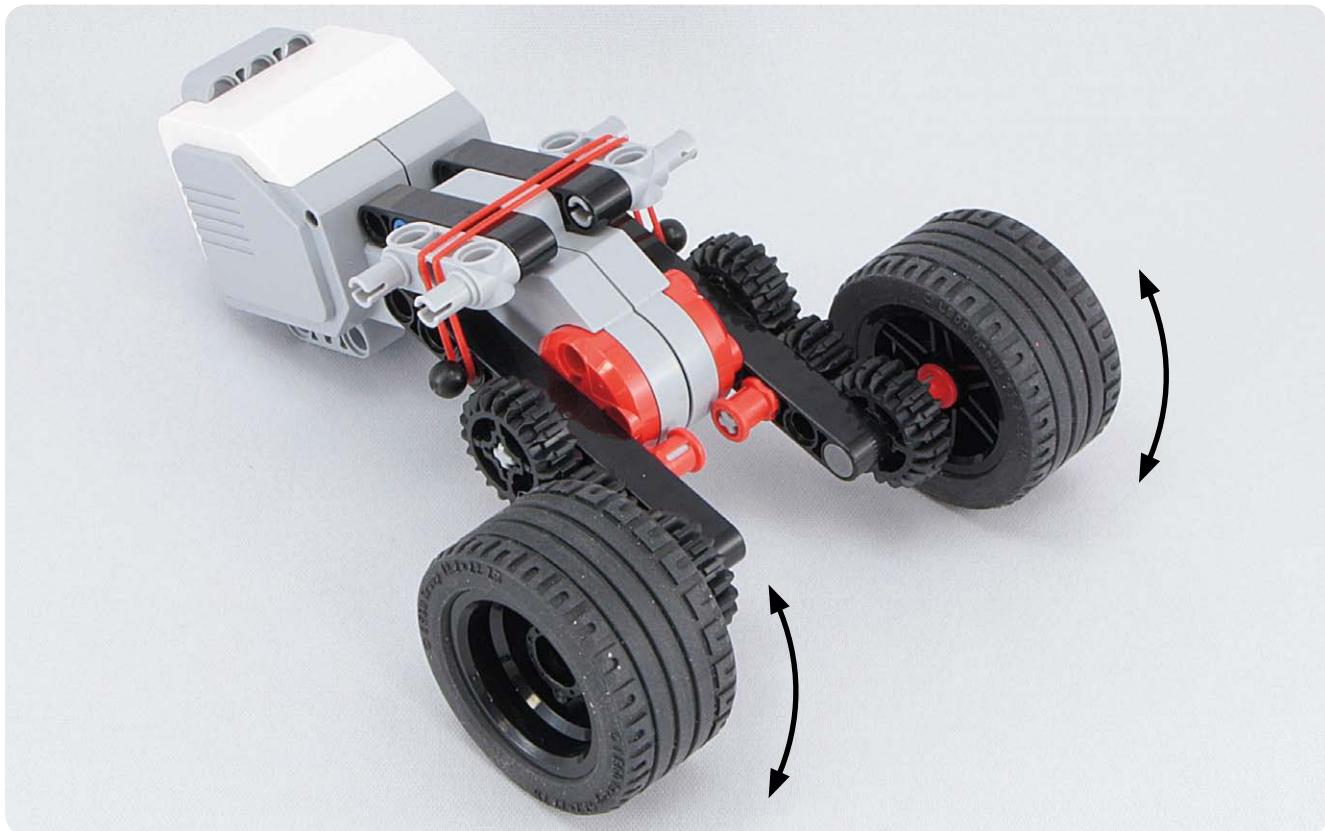
x4

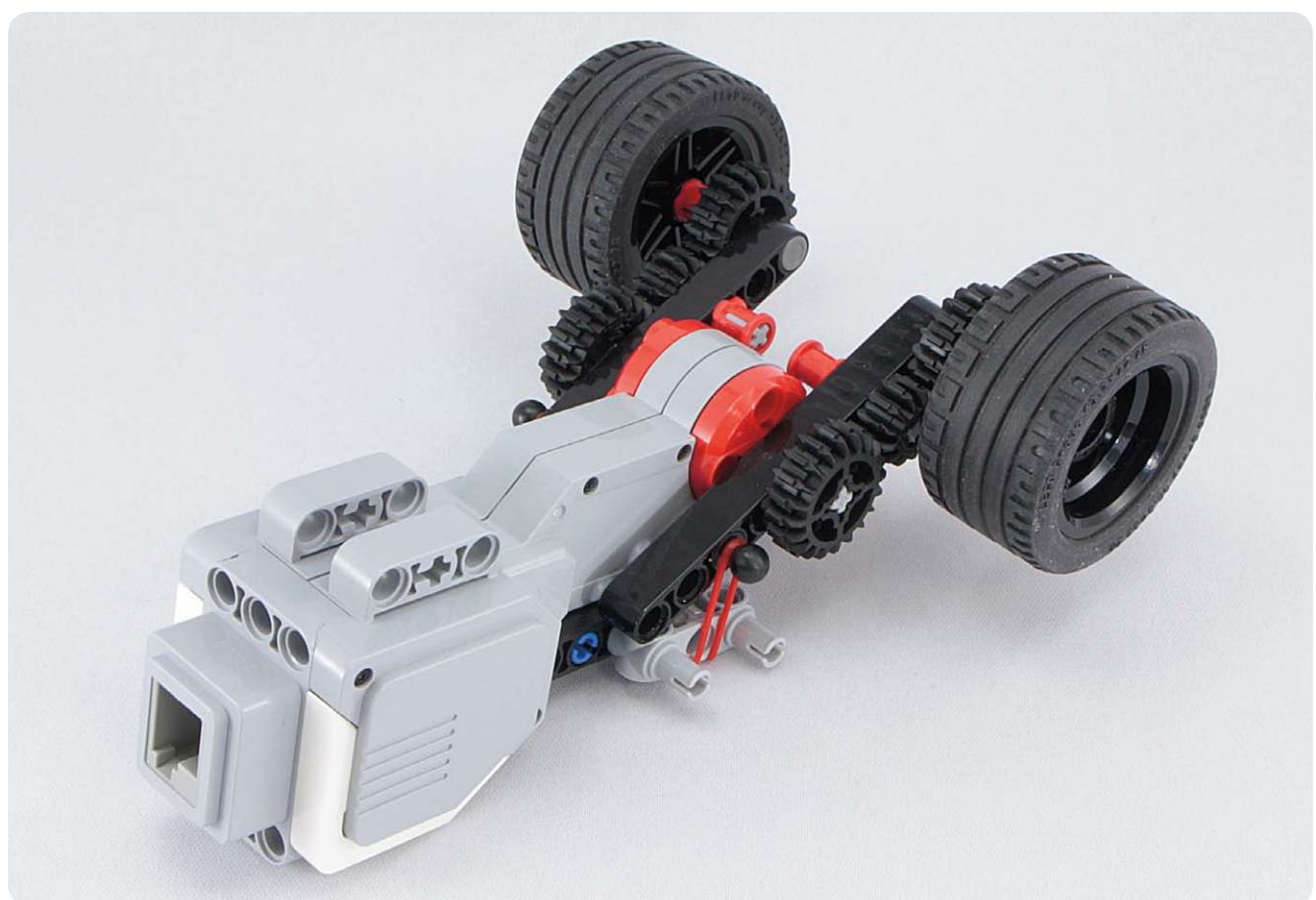
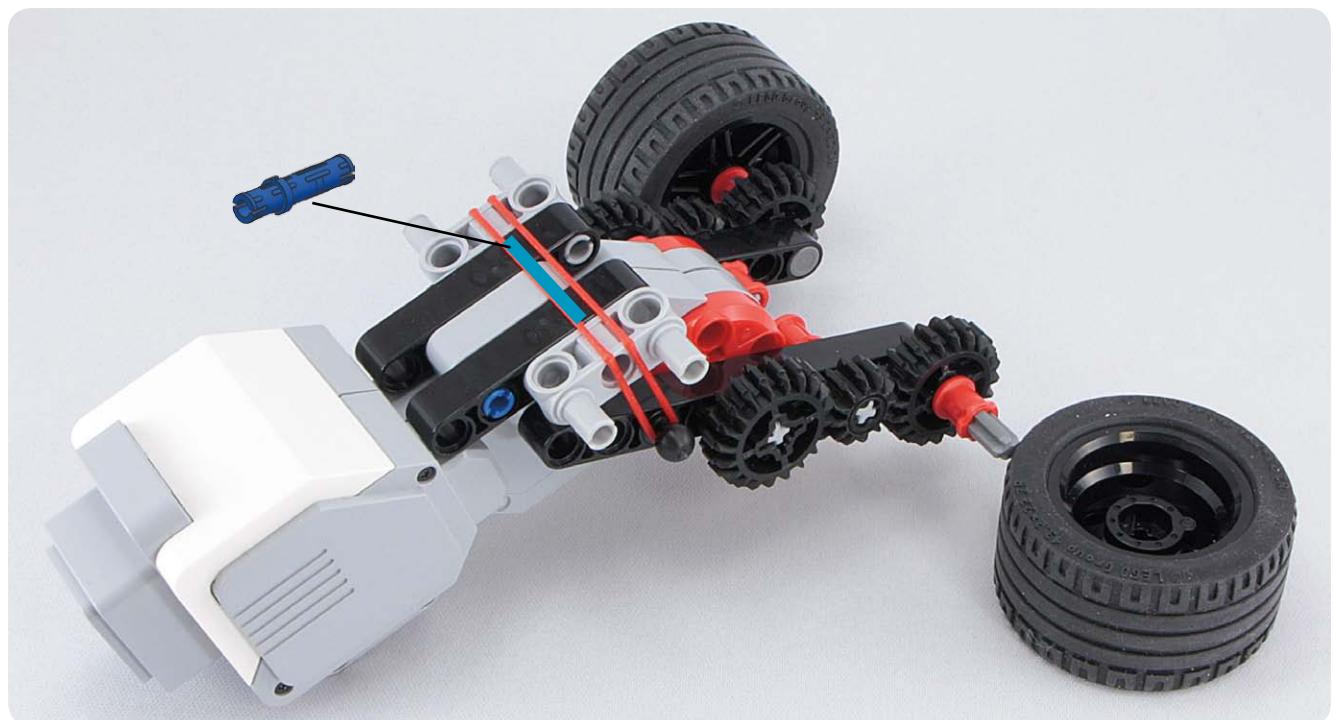




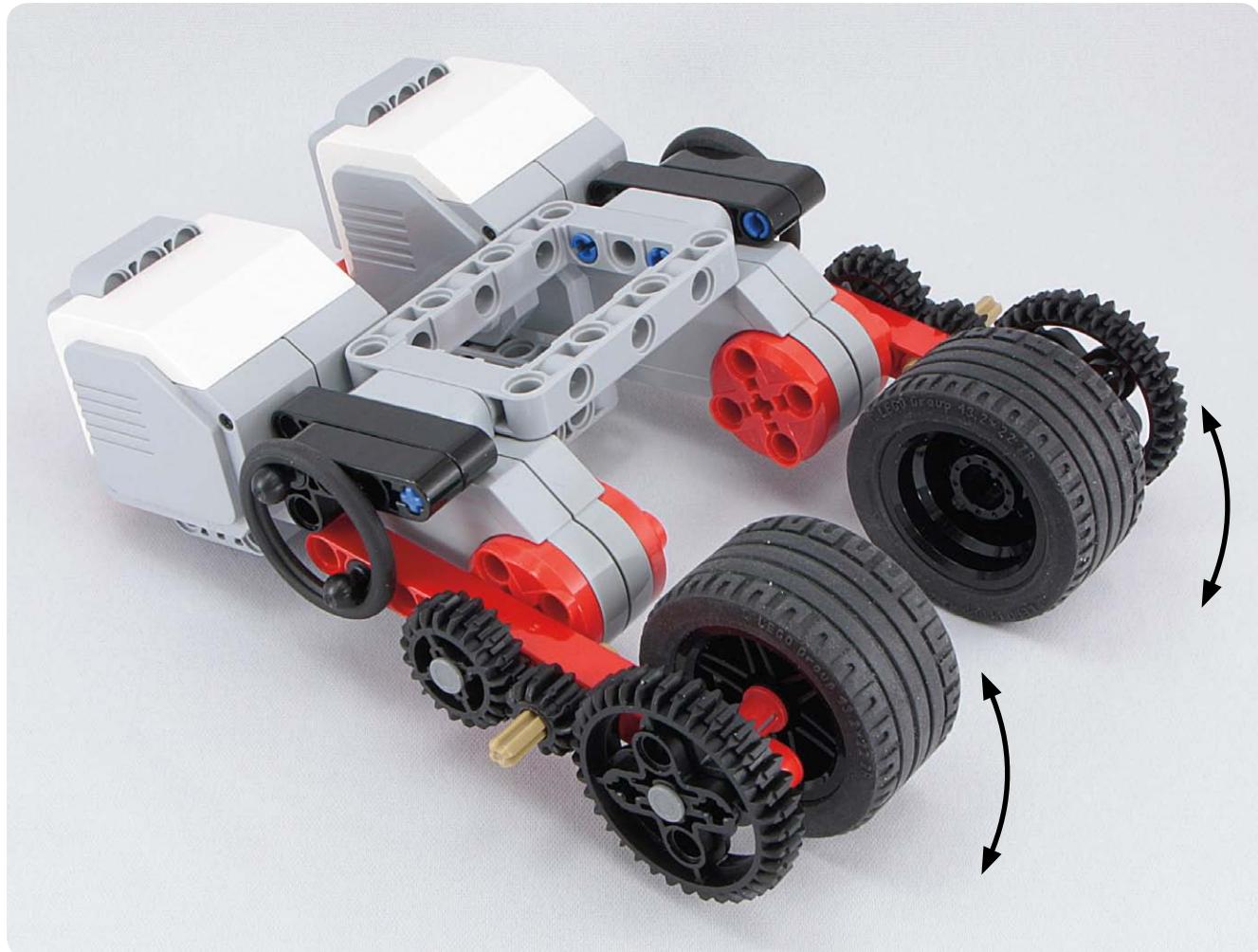
# Suspended wheels

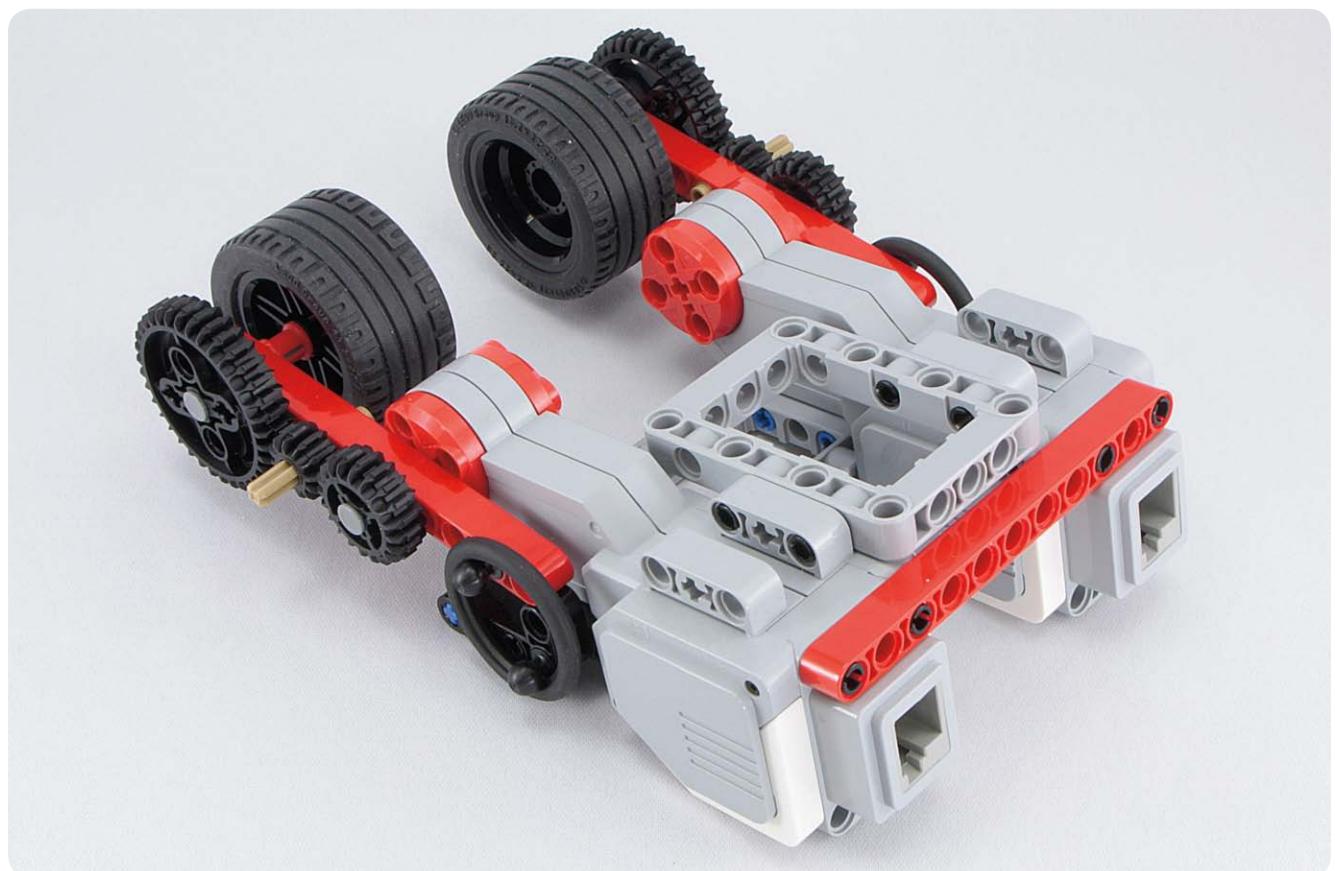
#119

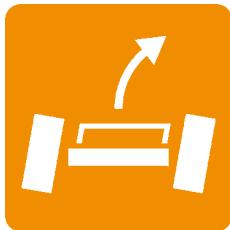




## #120

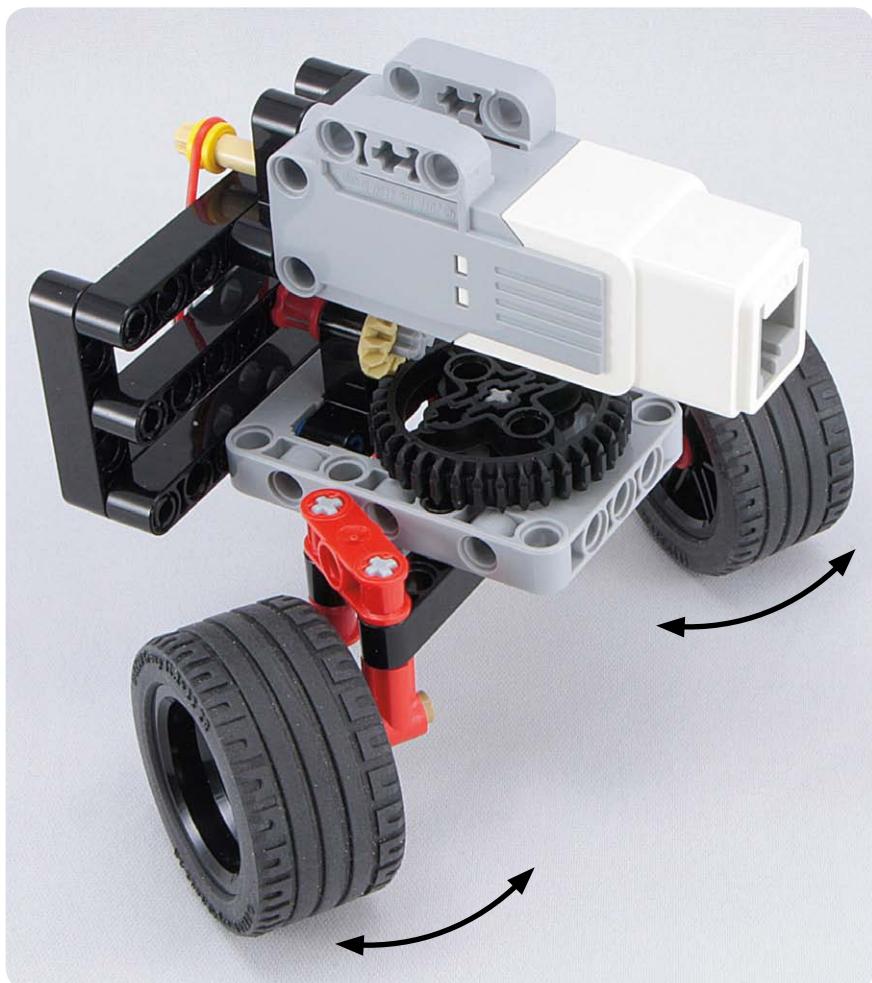
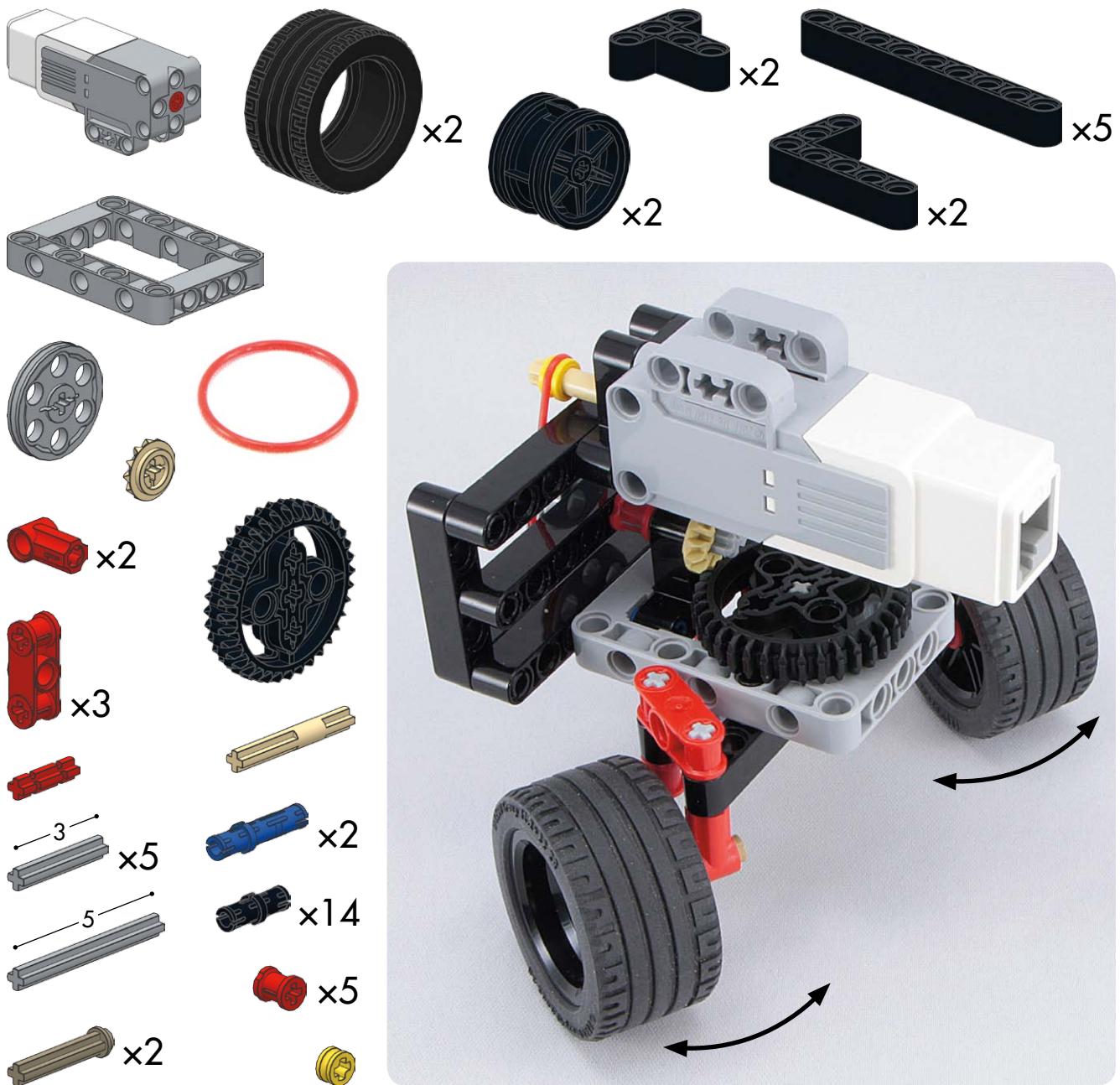


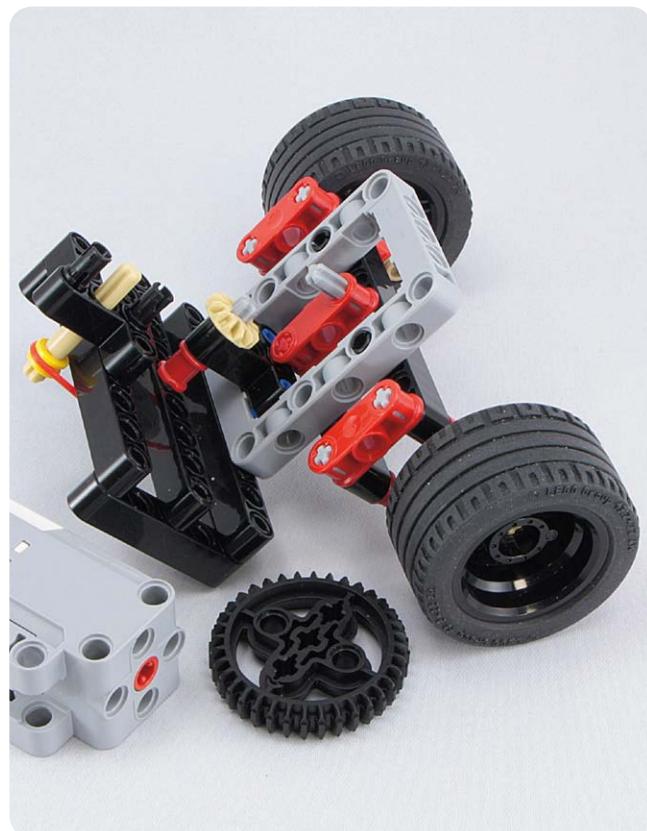
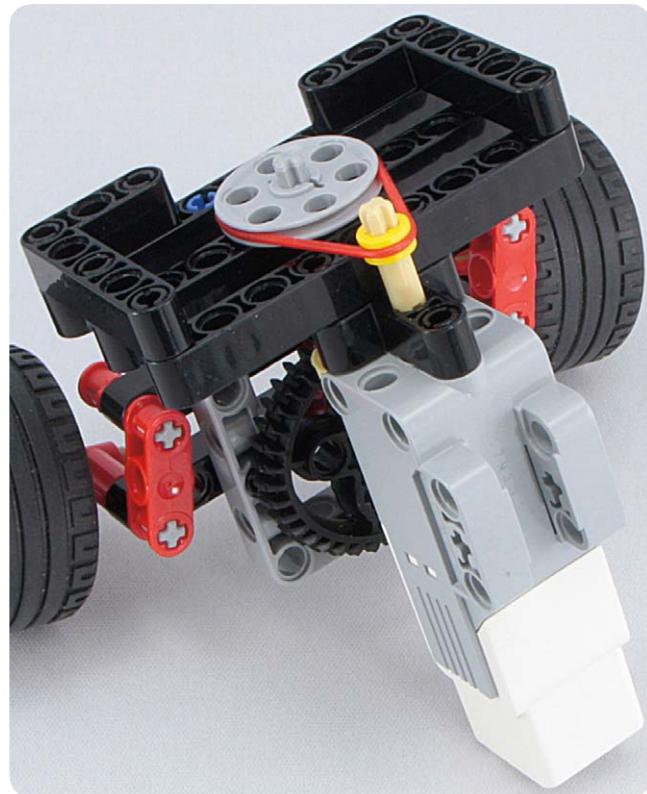




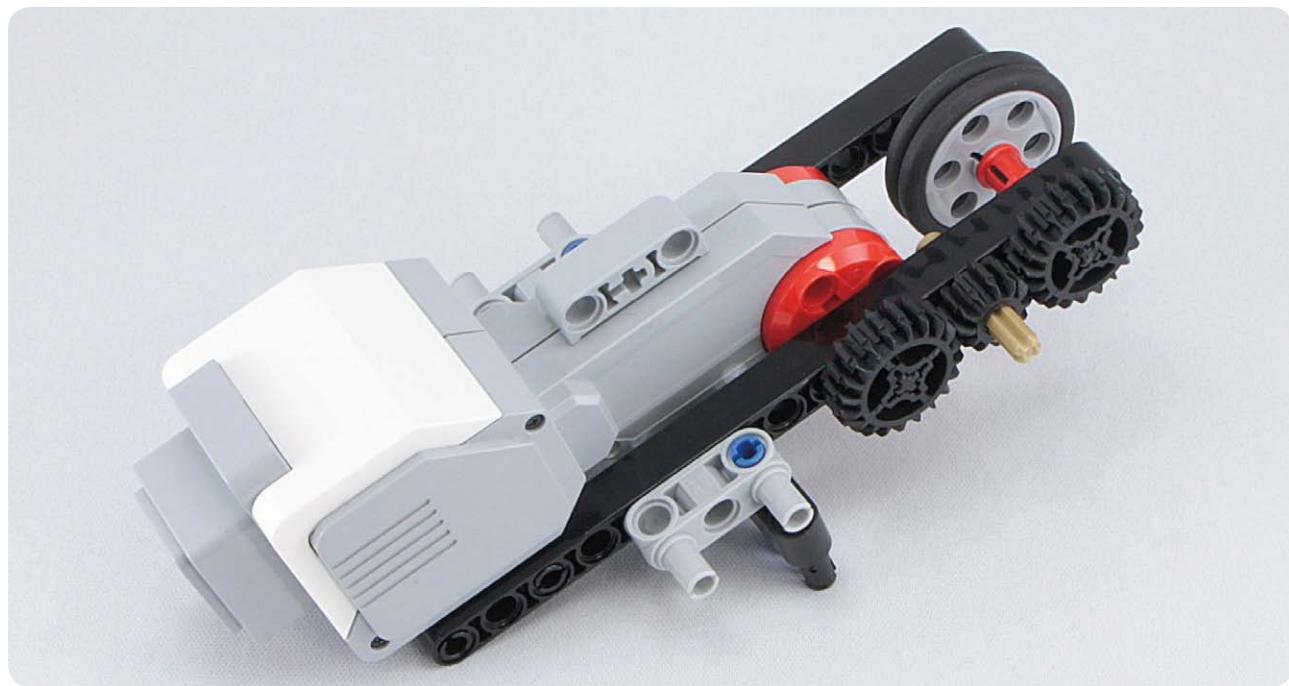
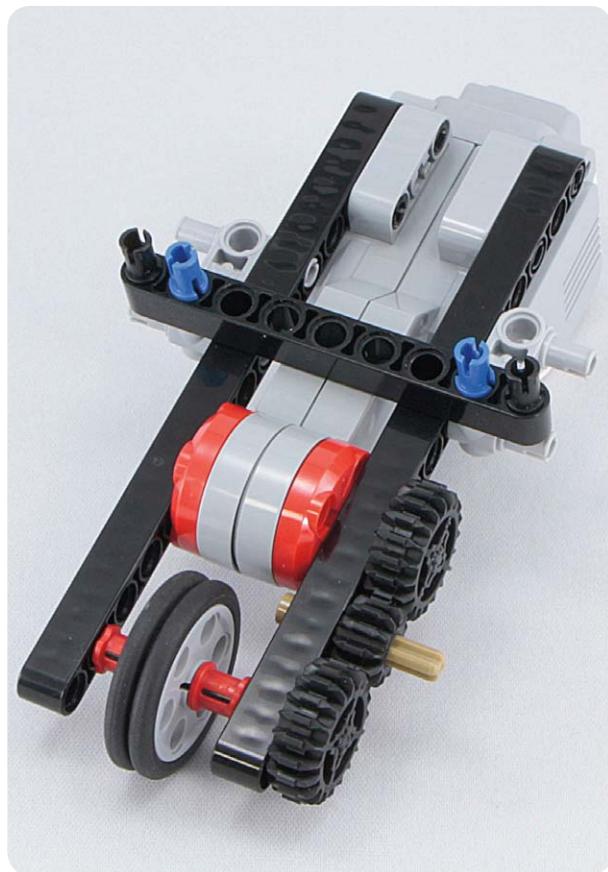
# Steering

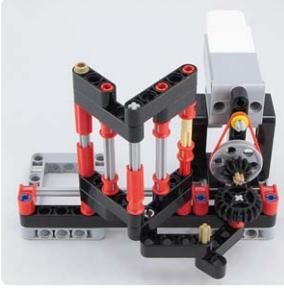
#121











# PART 3



# Moving Without Tires



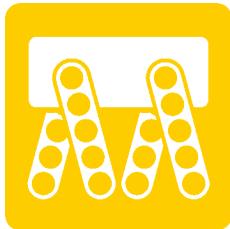
110



122

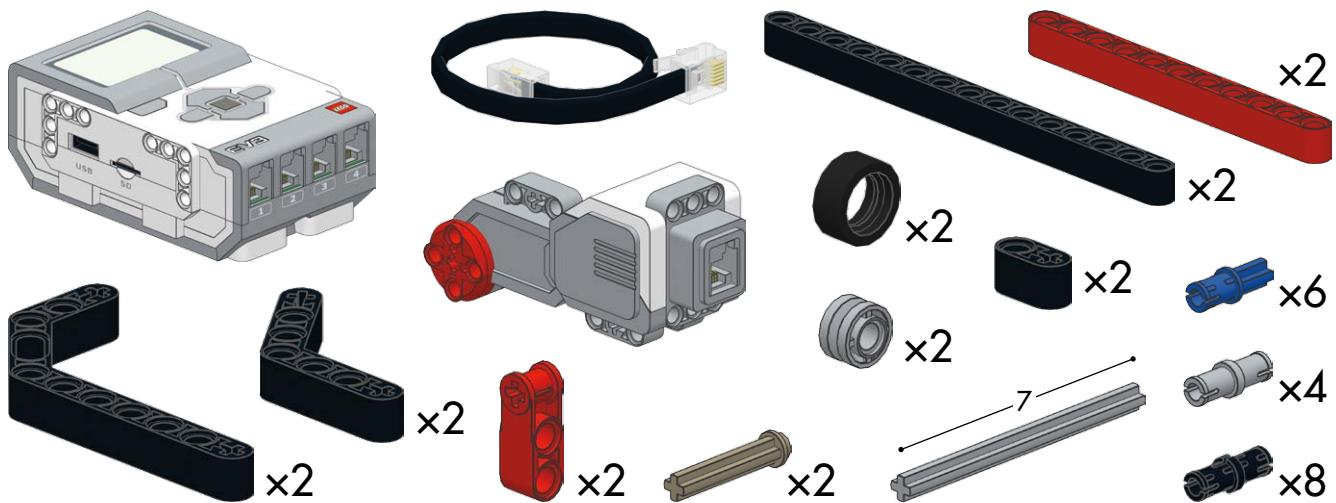


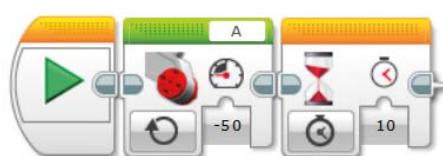
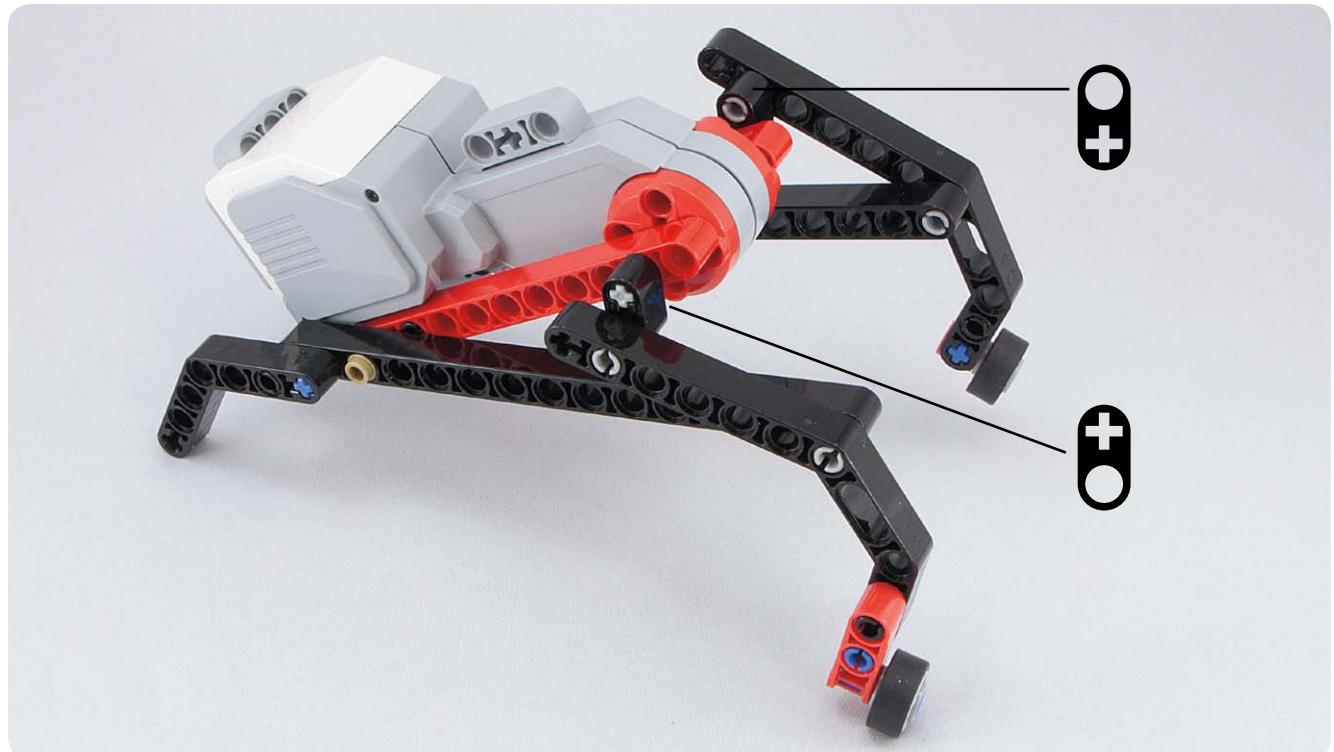
126



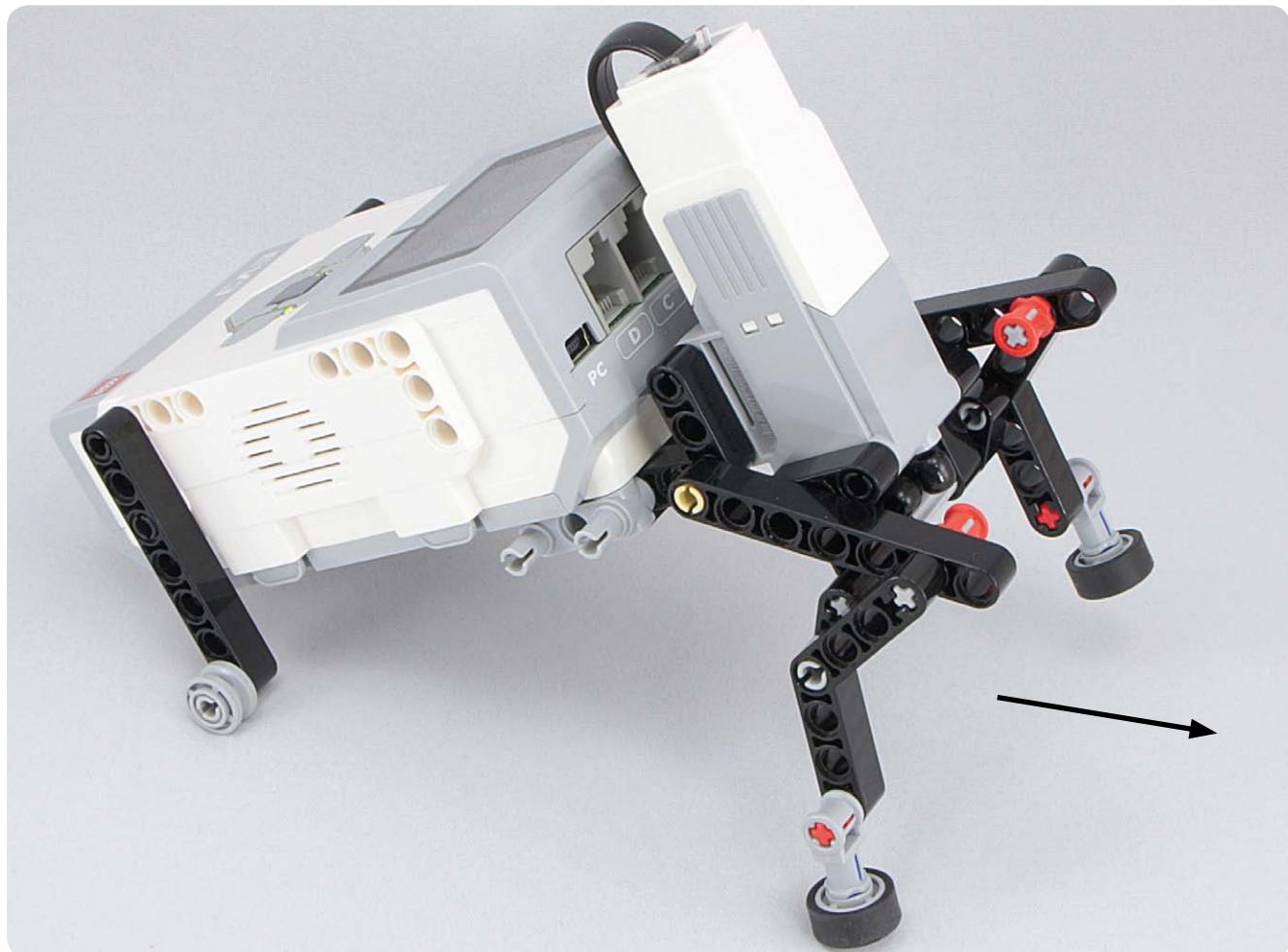
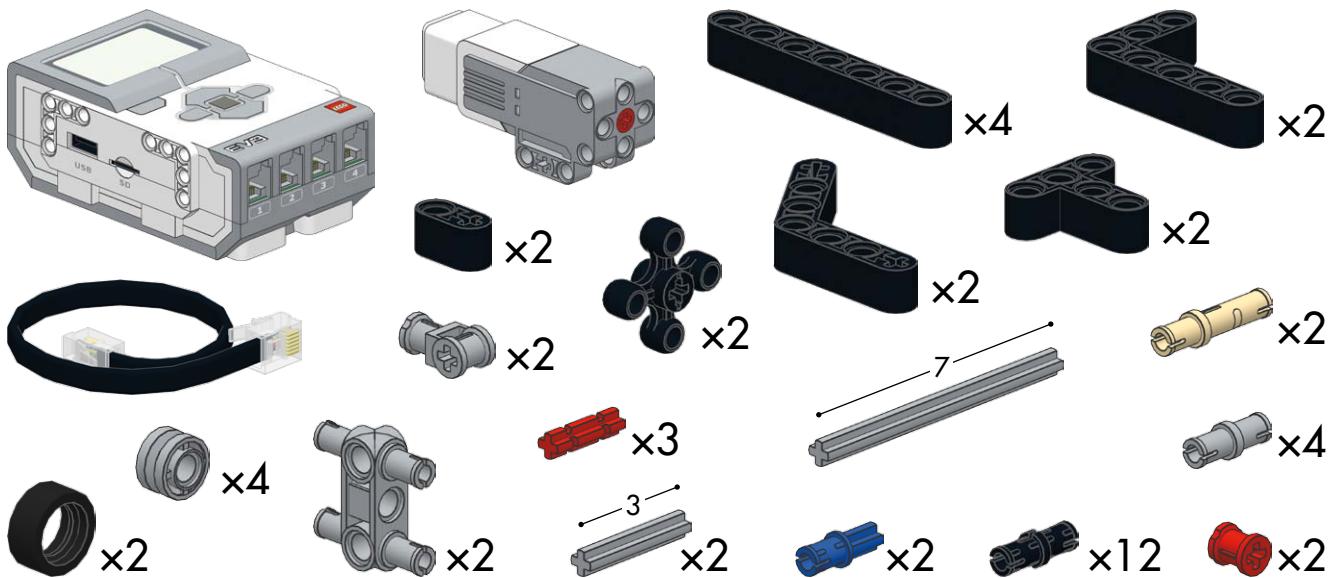
# Walking machines

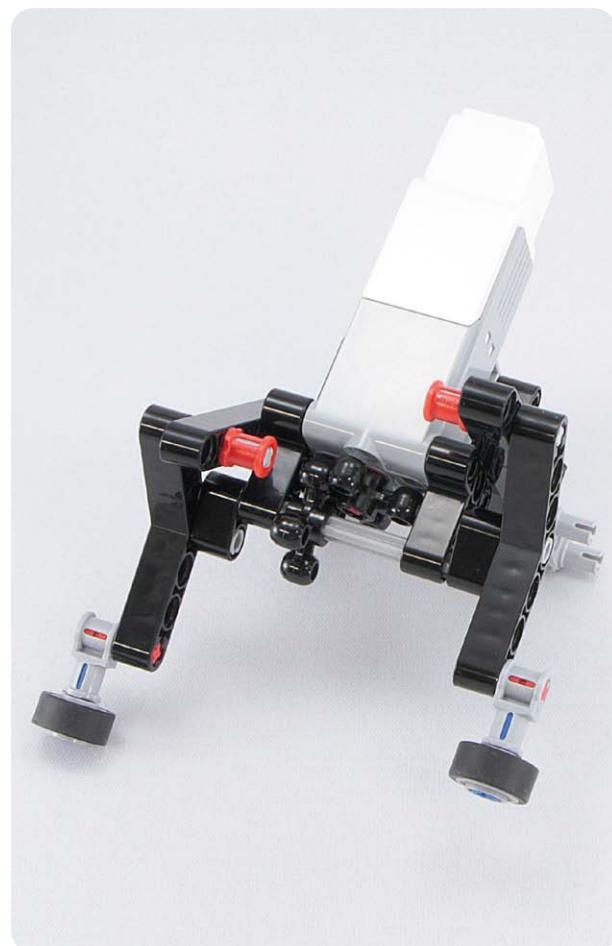
#122



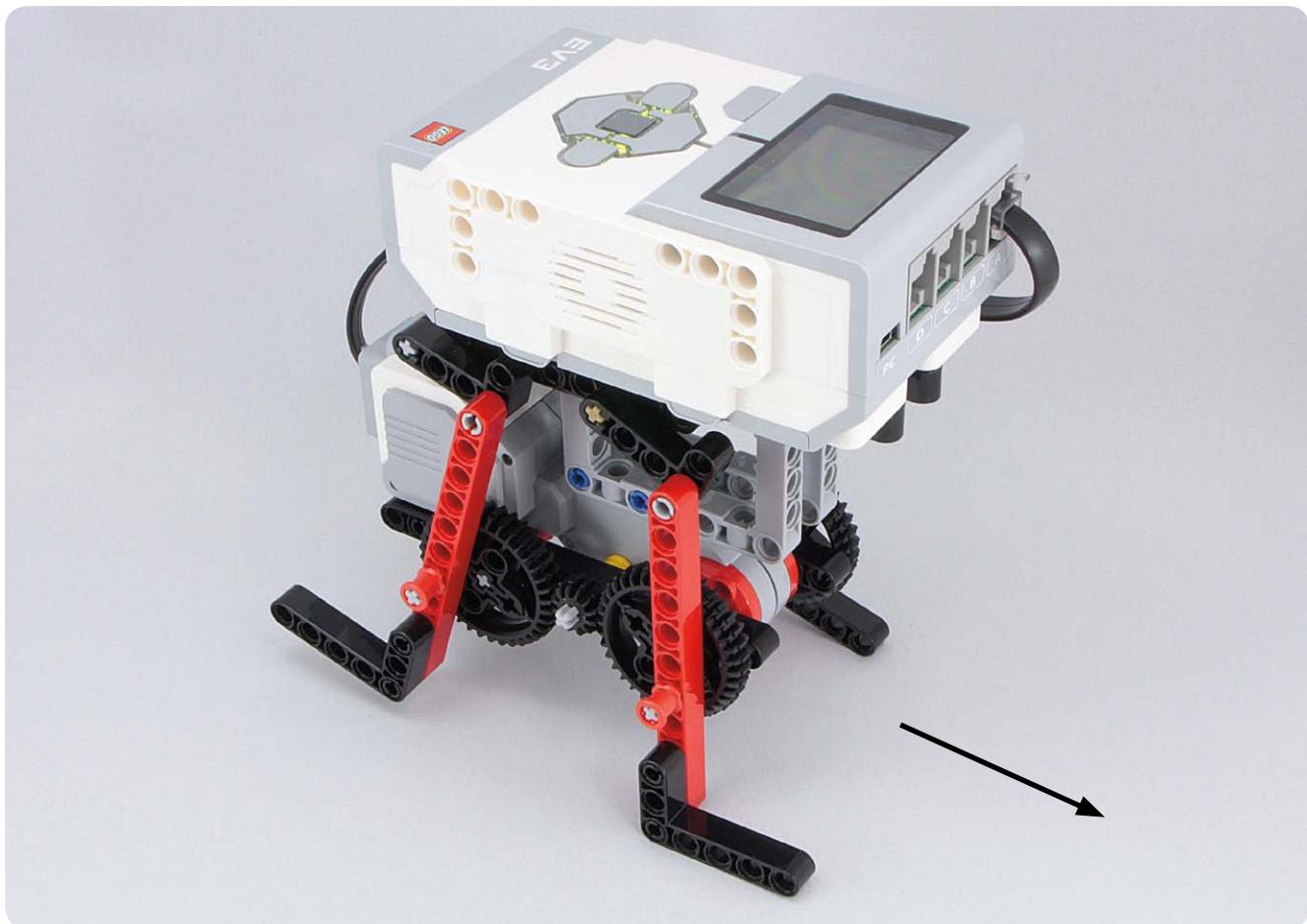
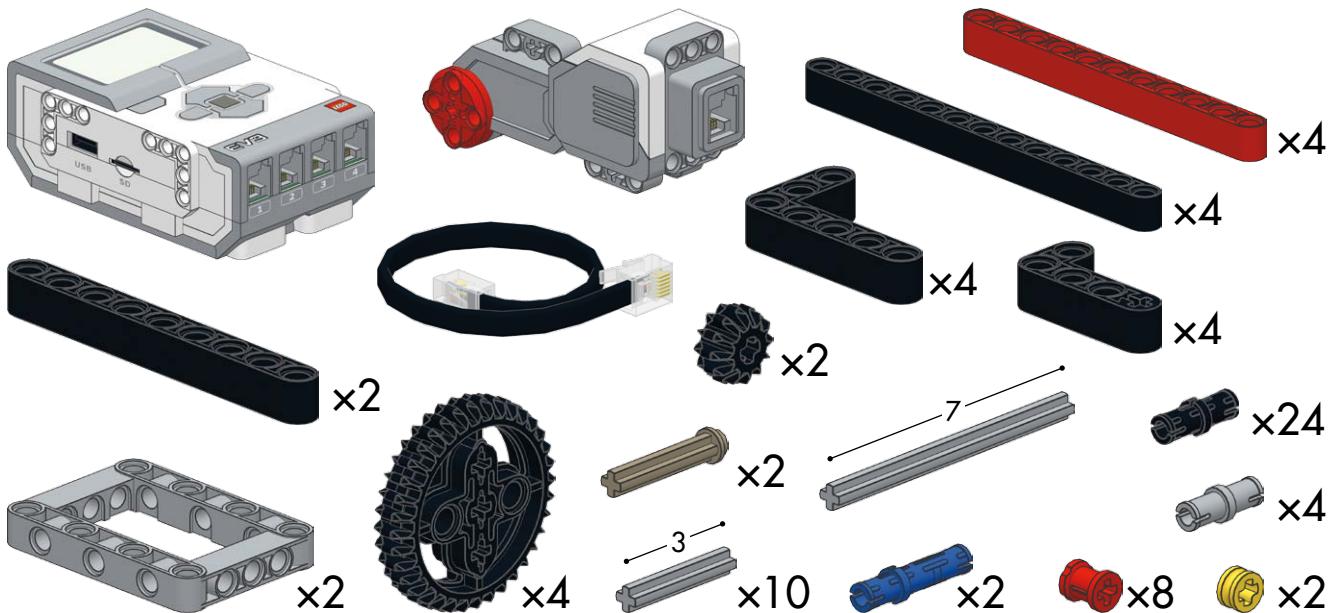


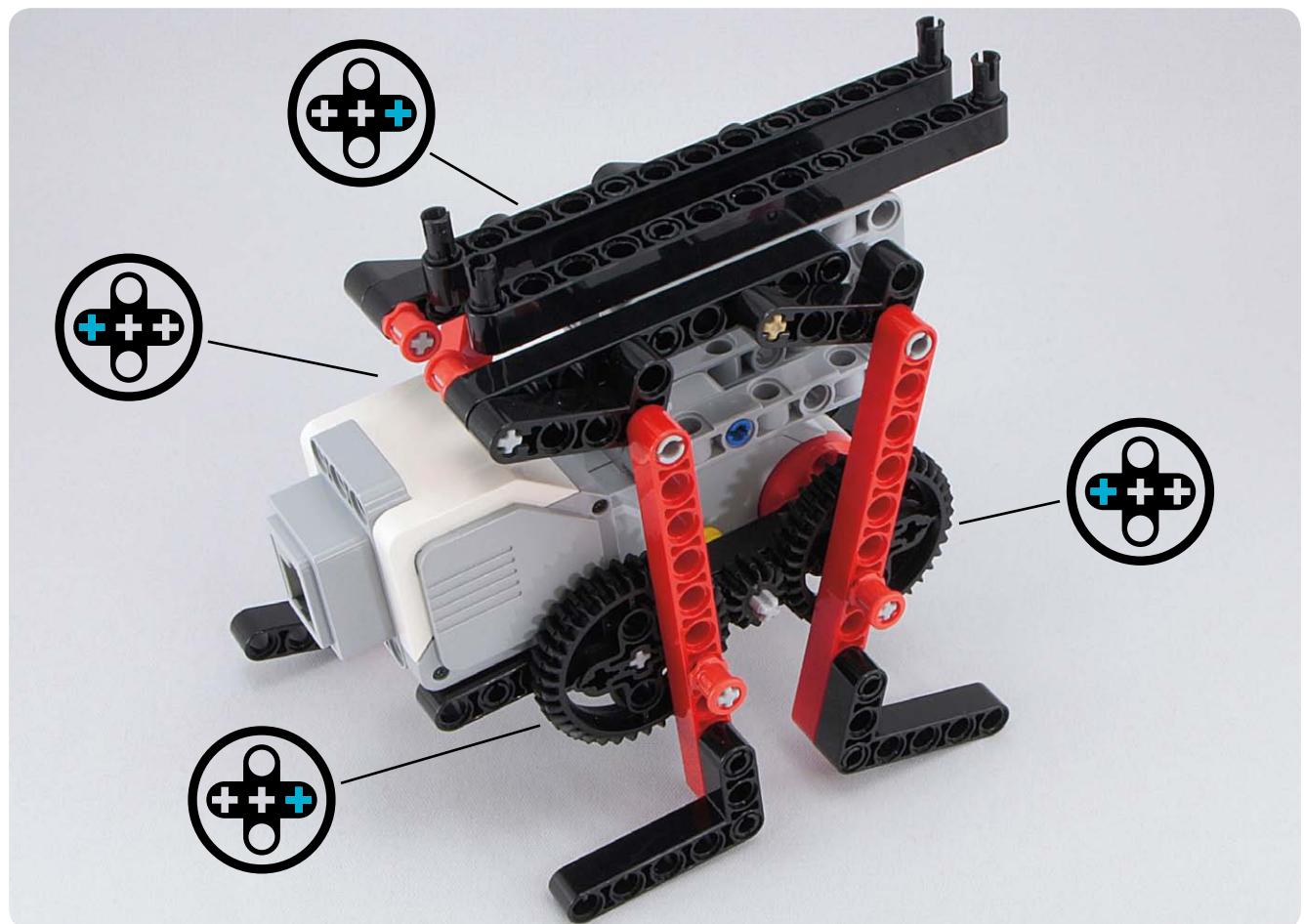
## #123

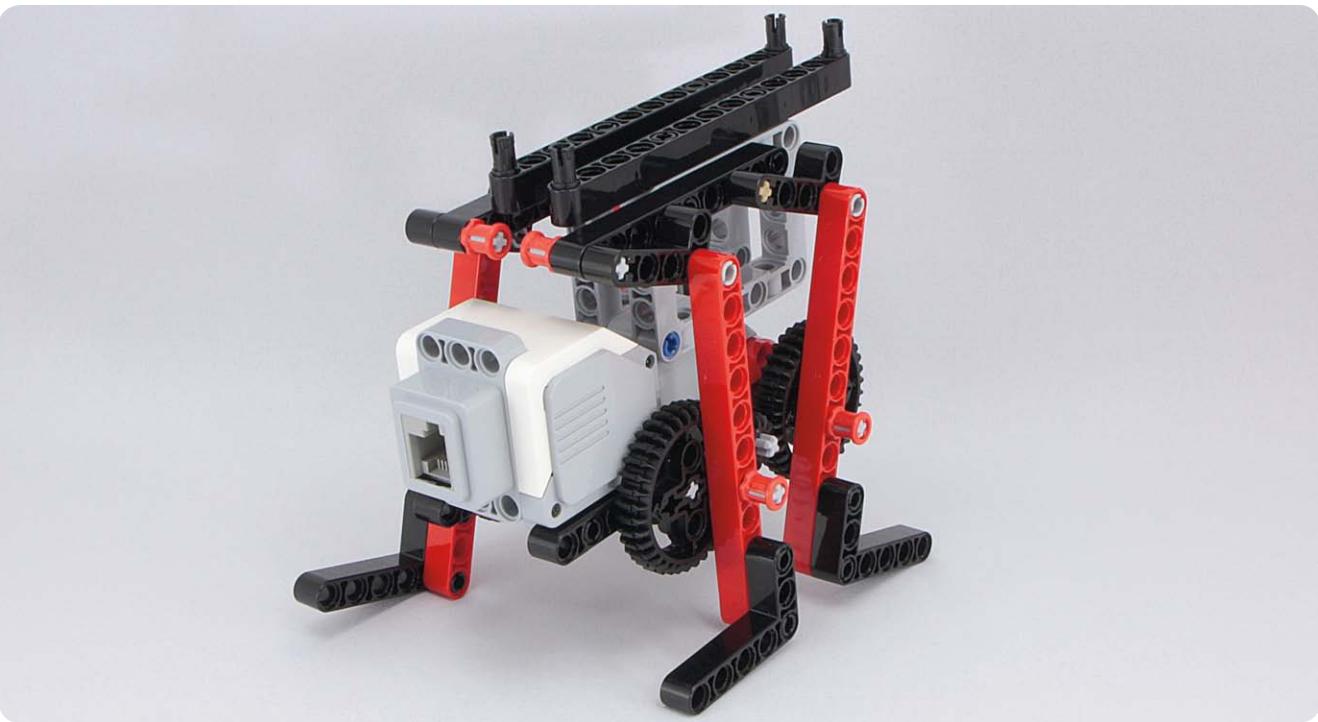
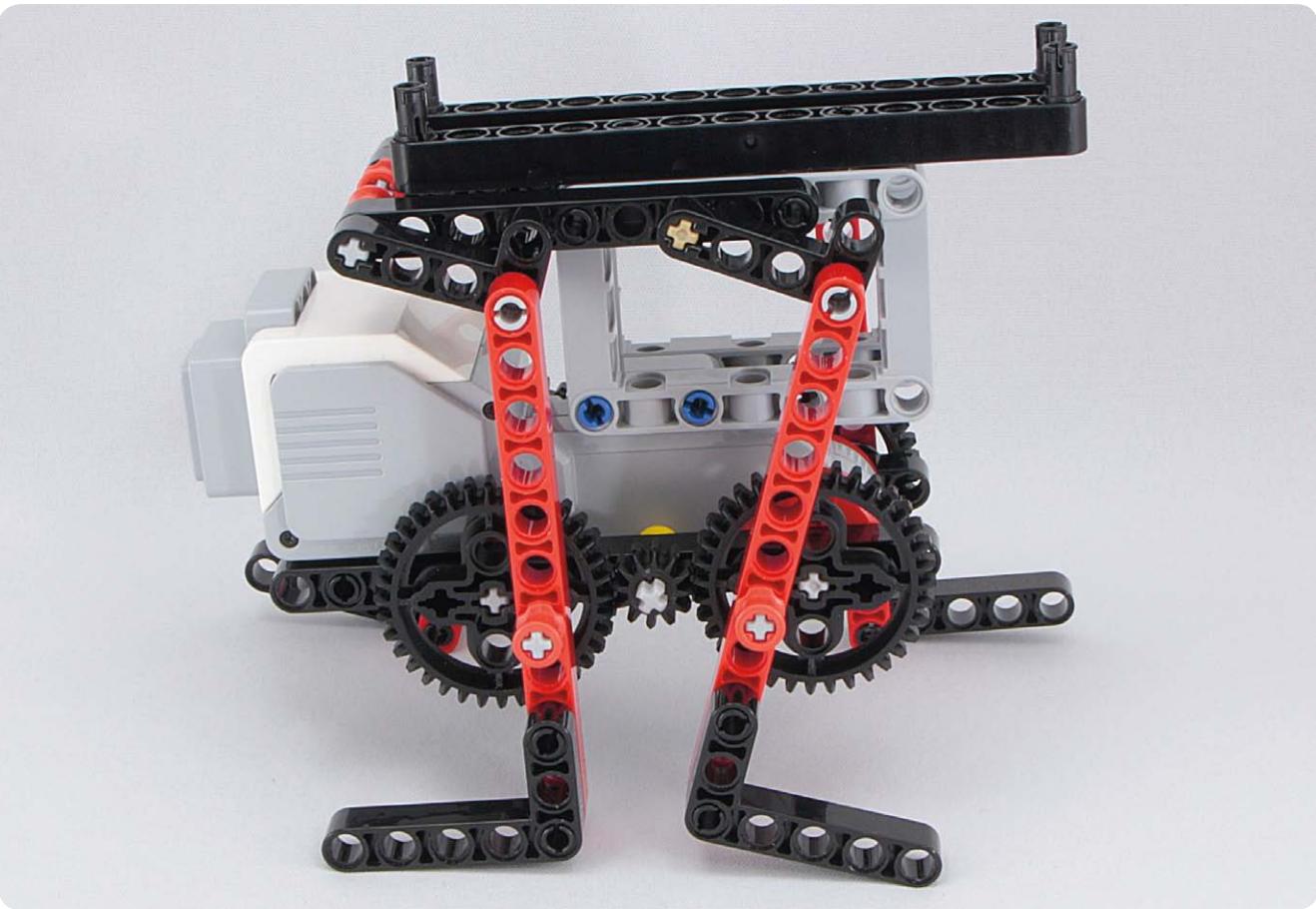


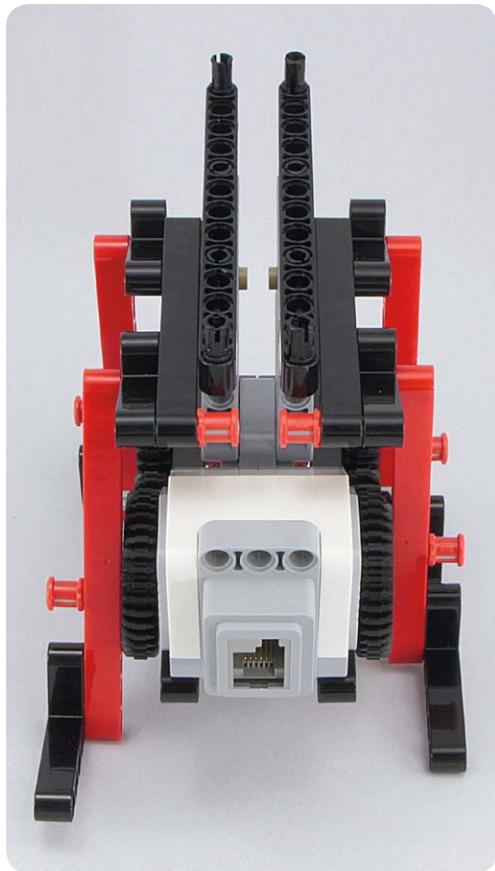


#124

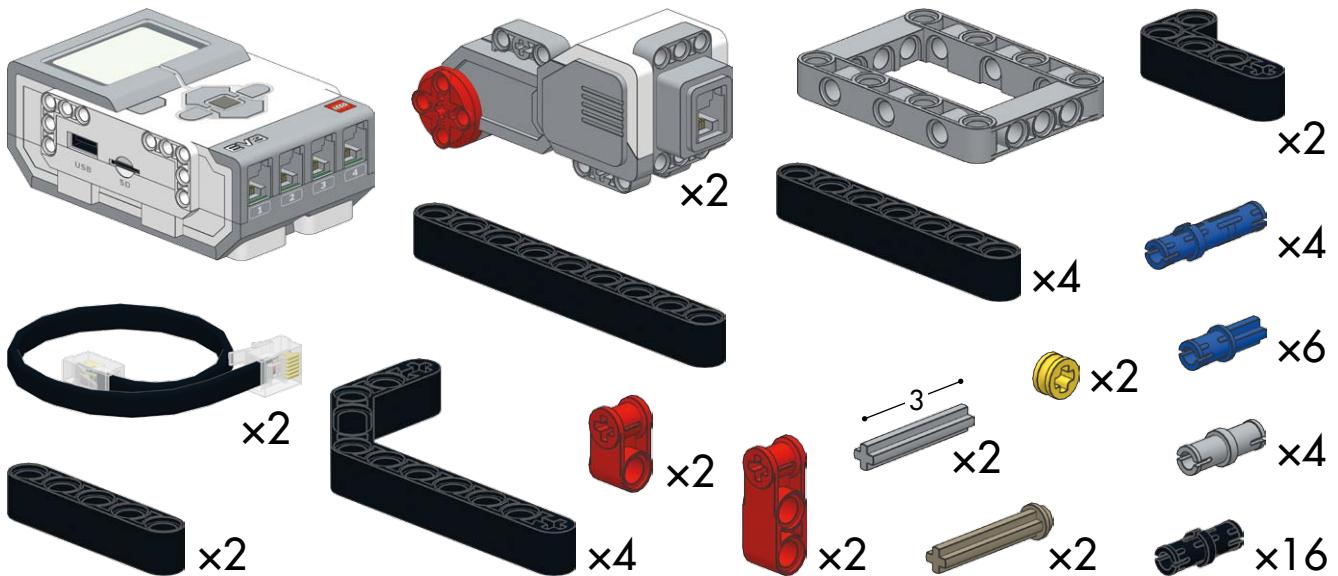


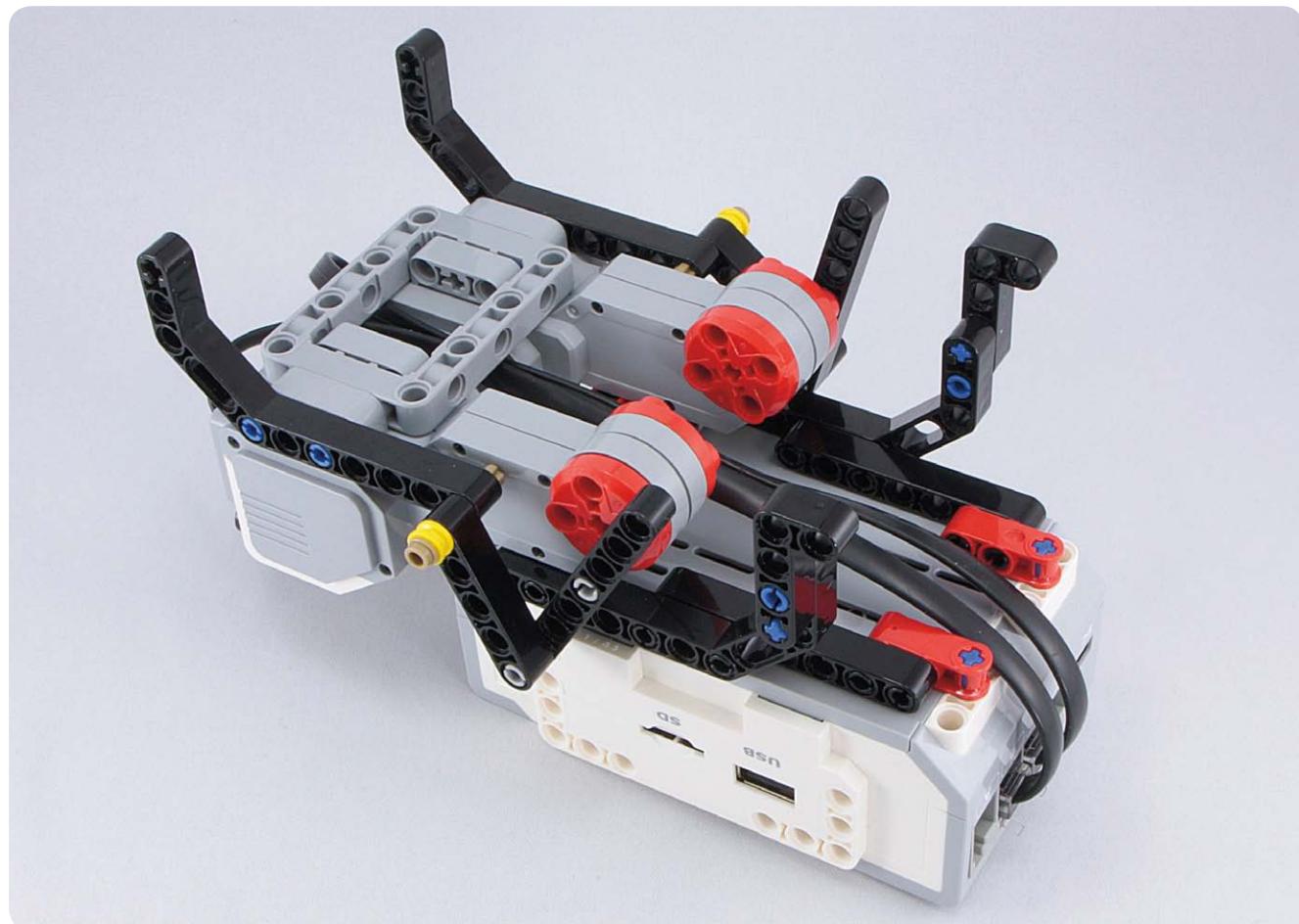




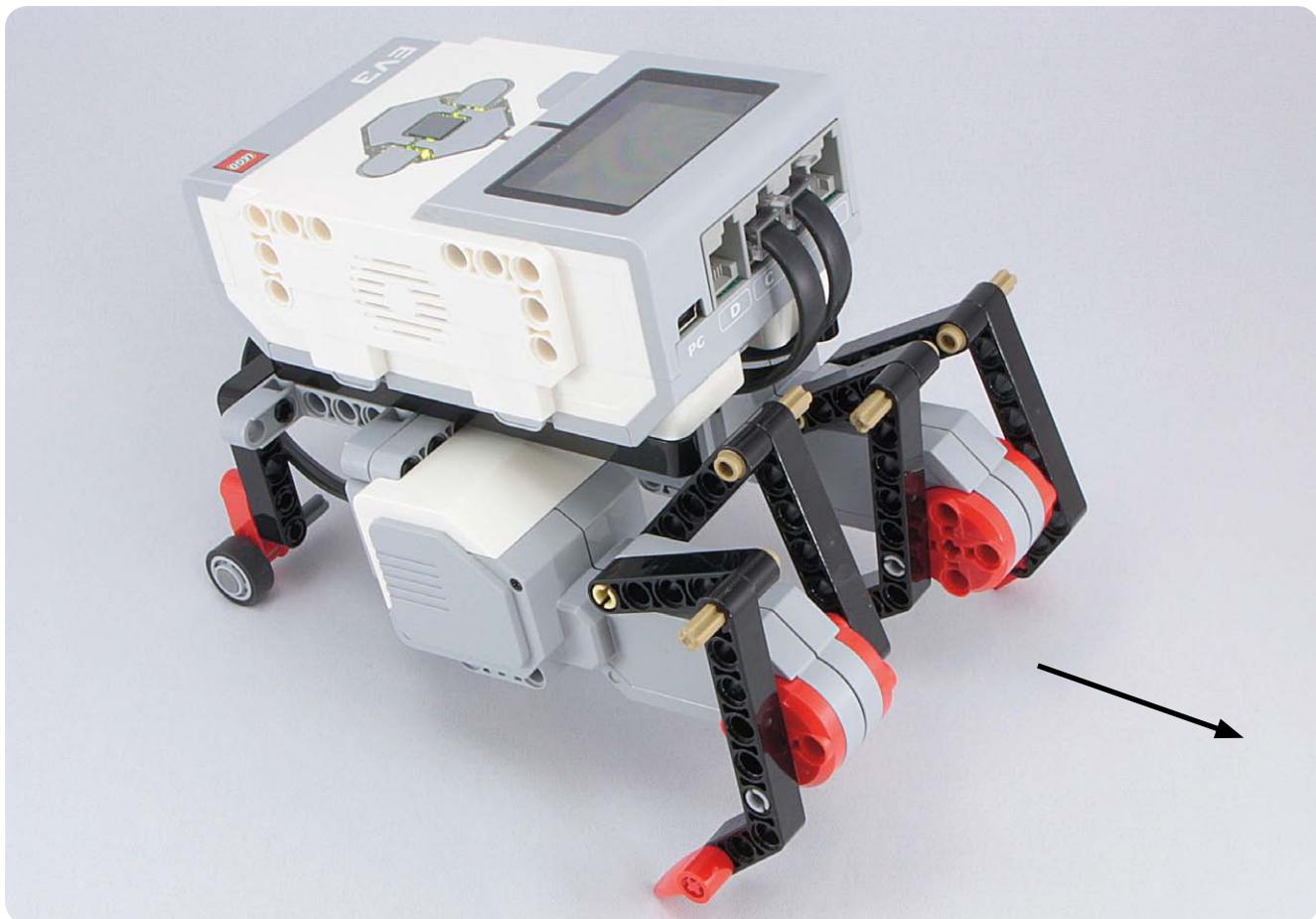
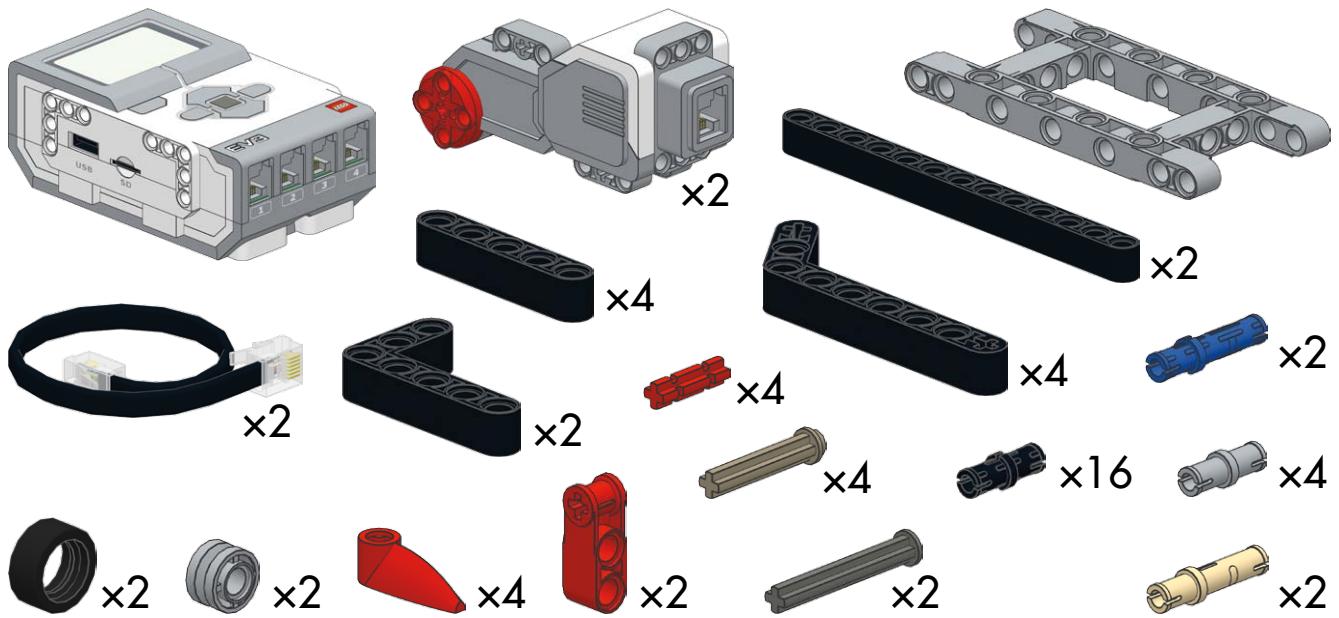


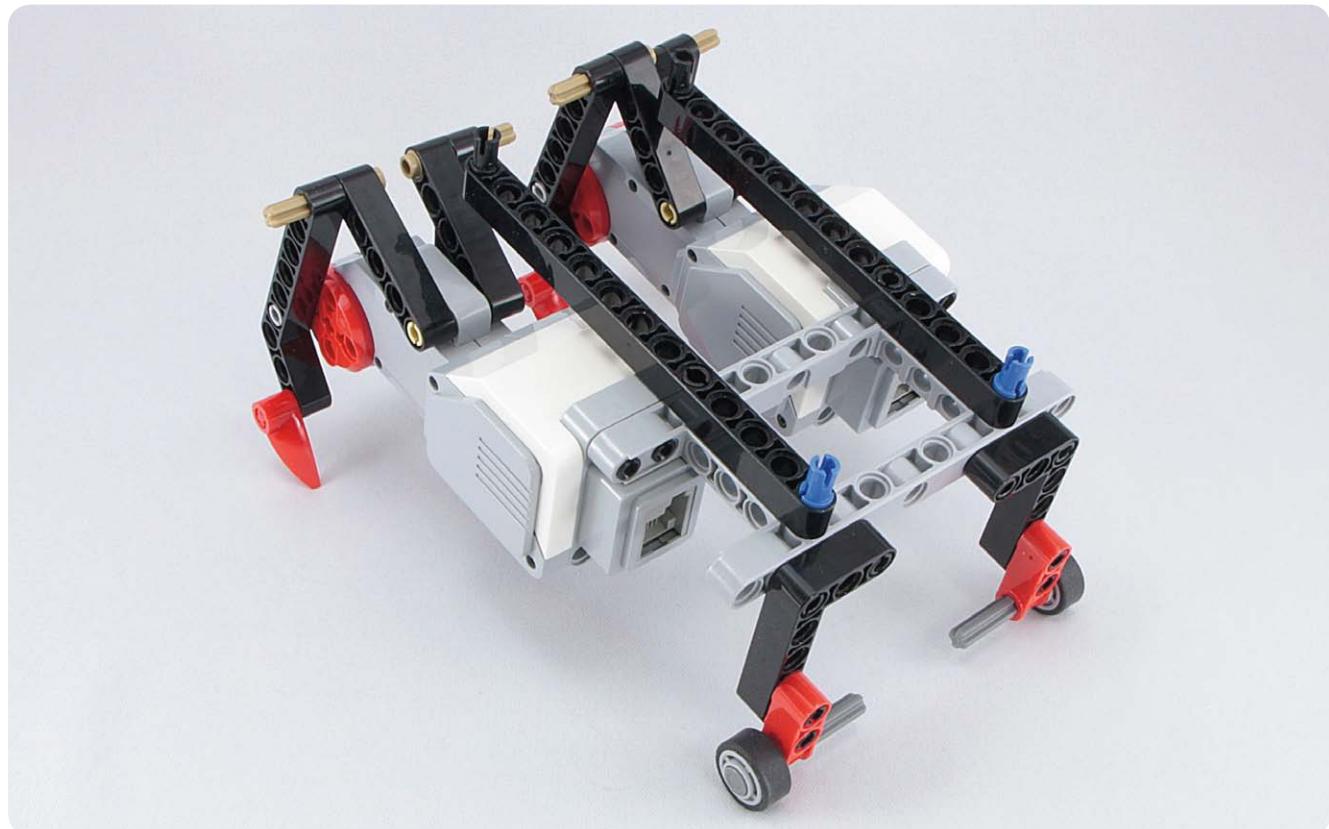
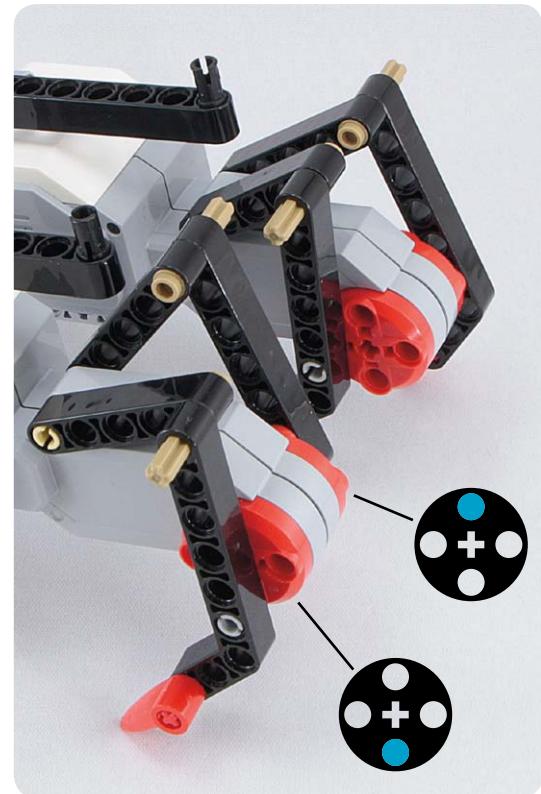
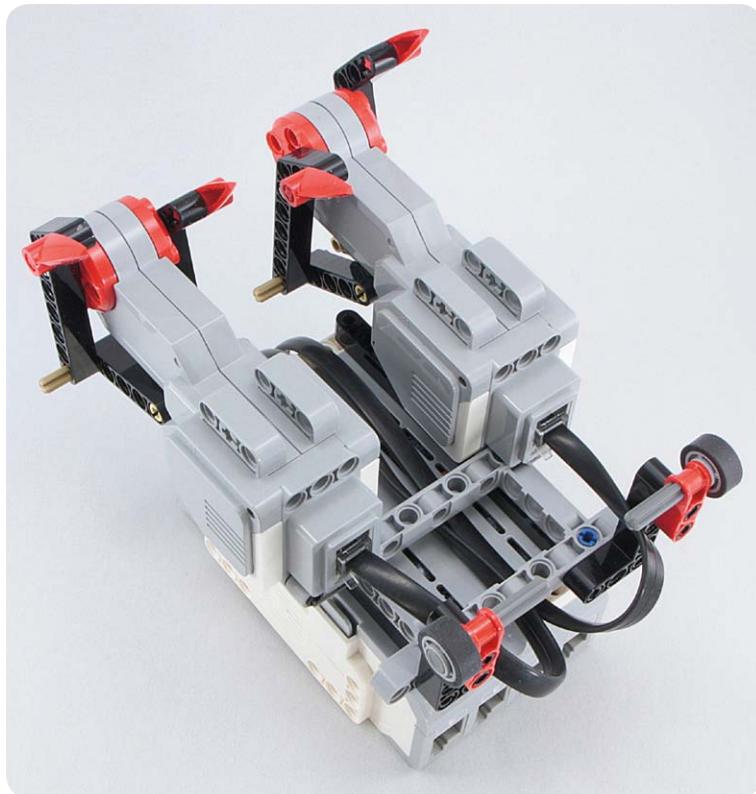
#125

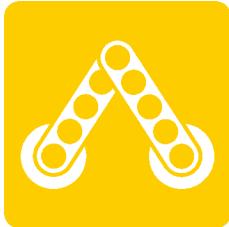




#126

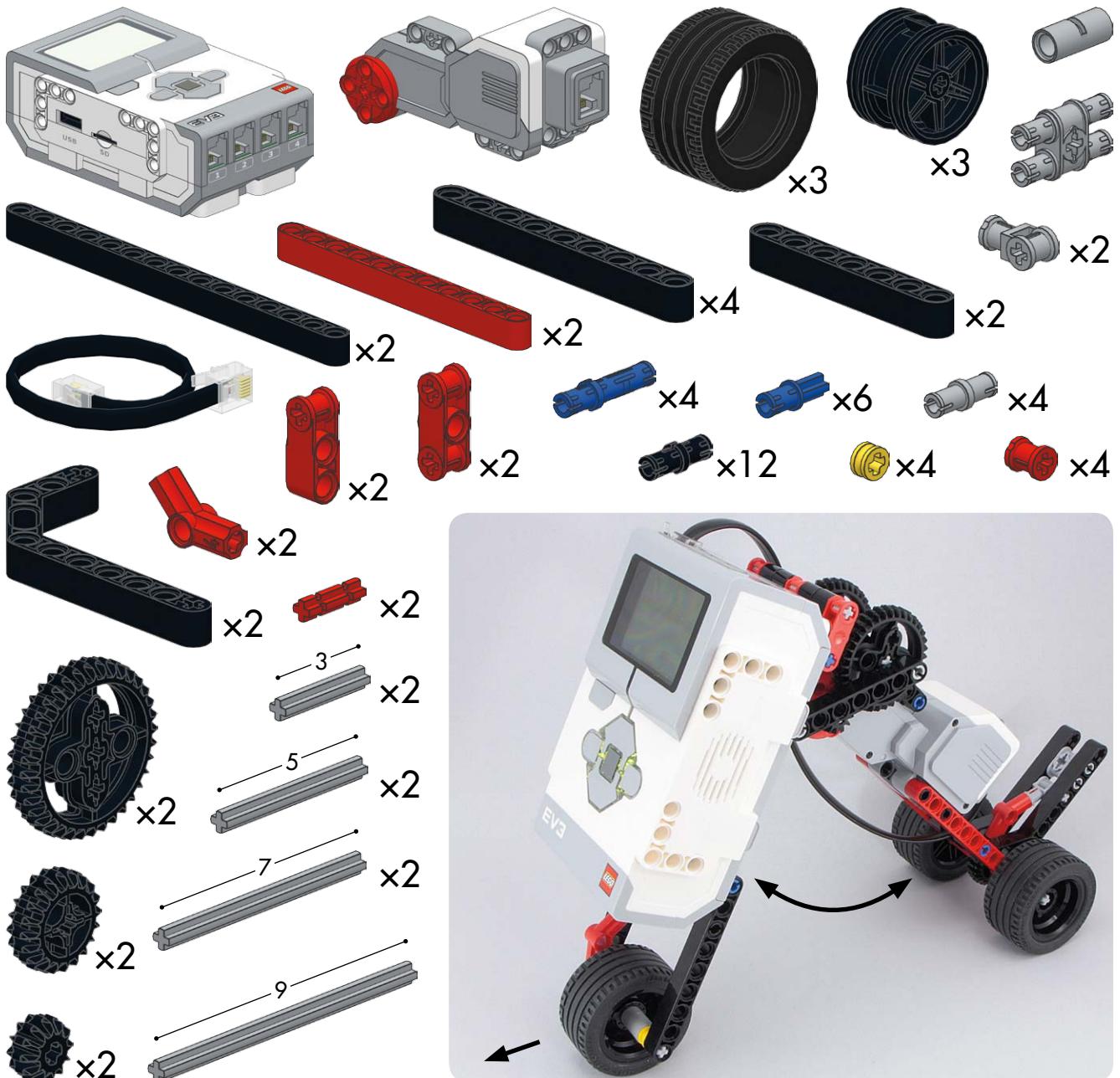


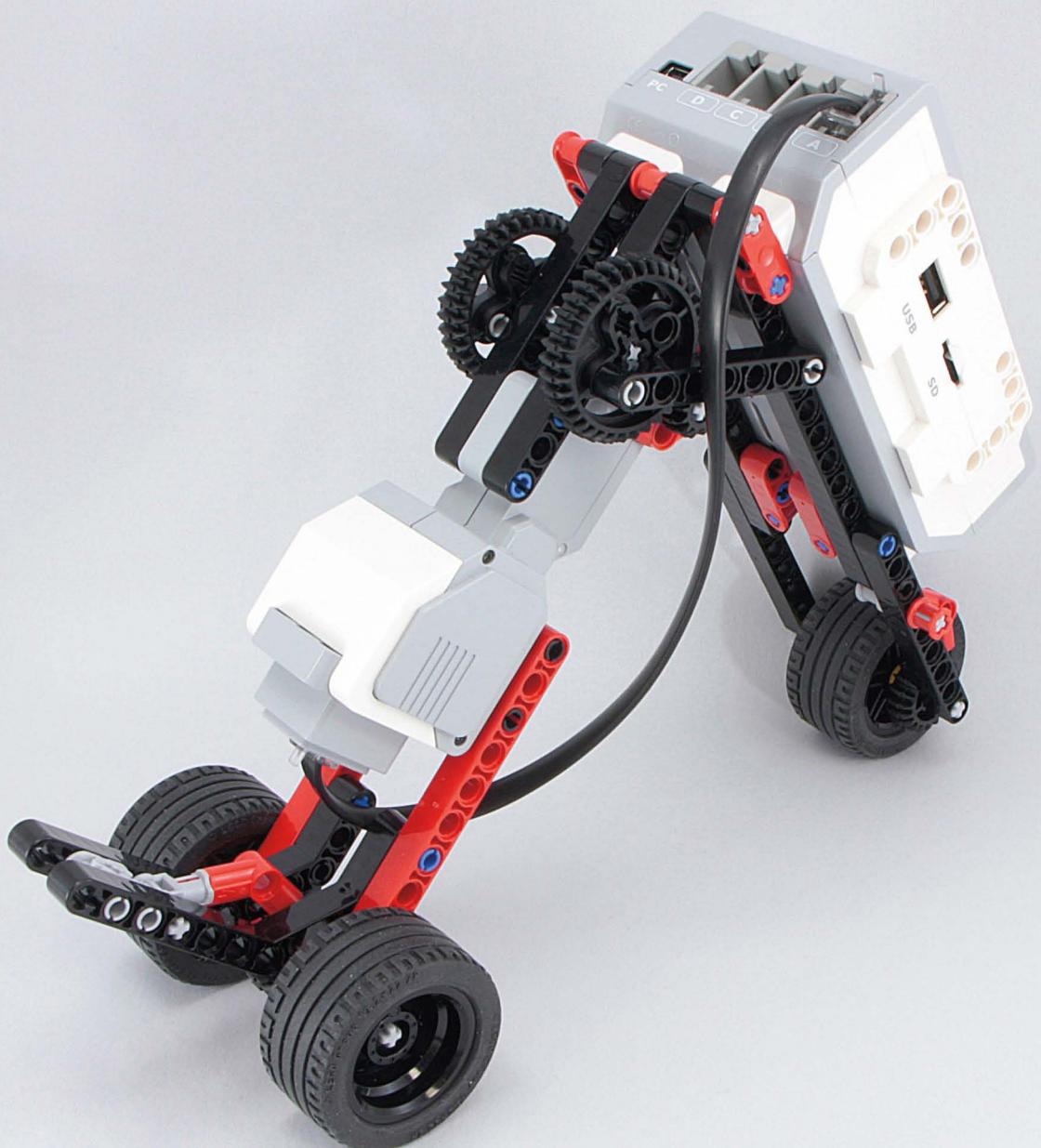


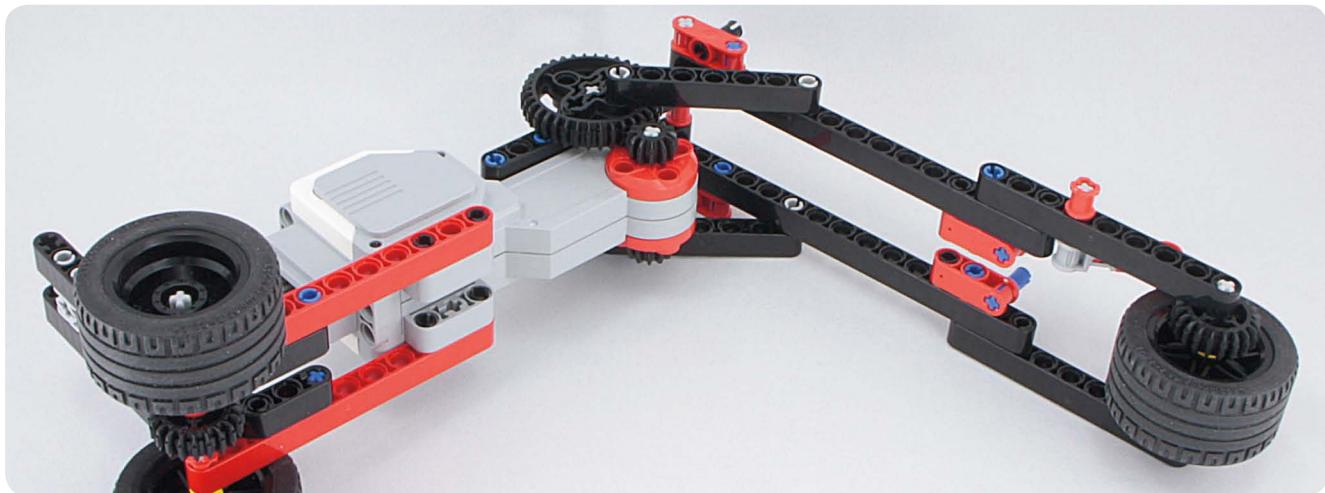
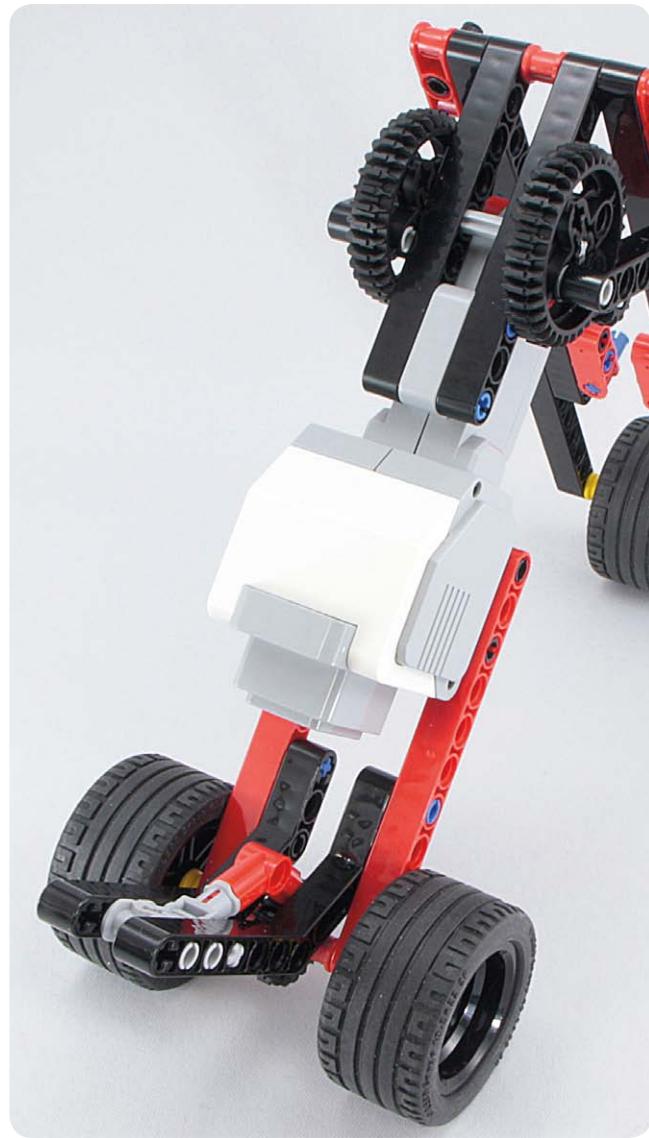
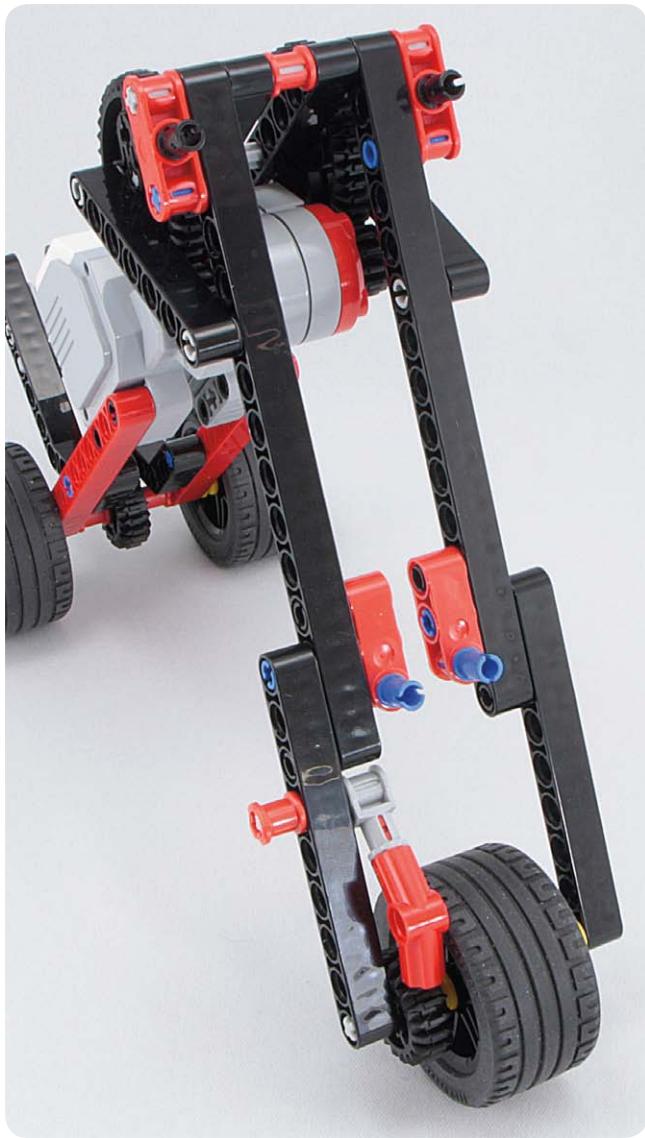


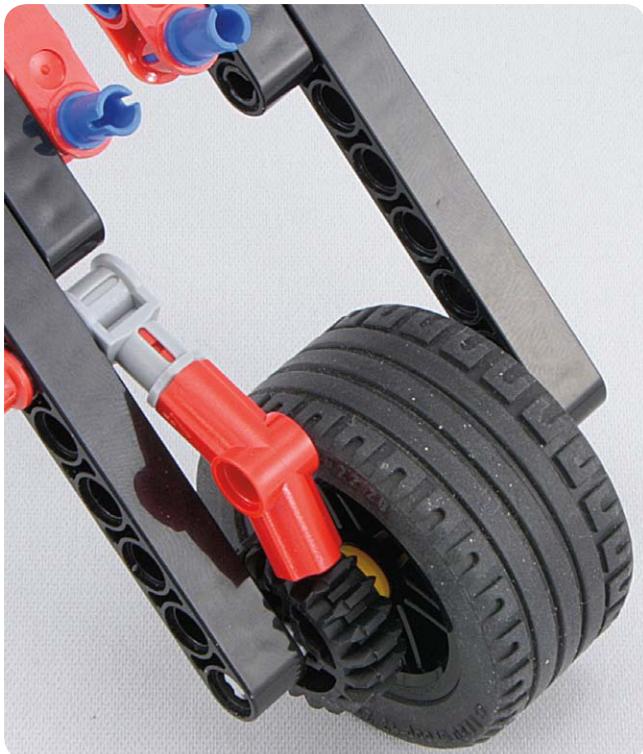
# Moving like an inchworm

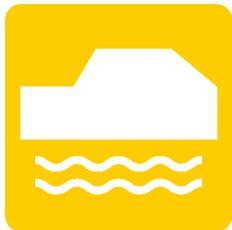
#127







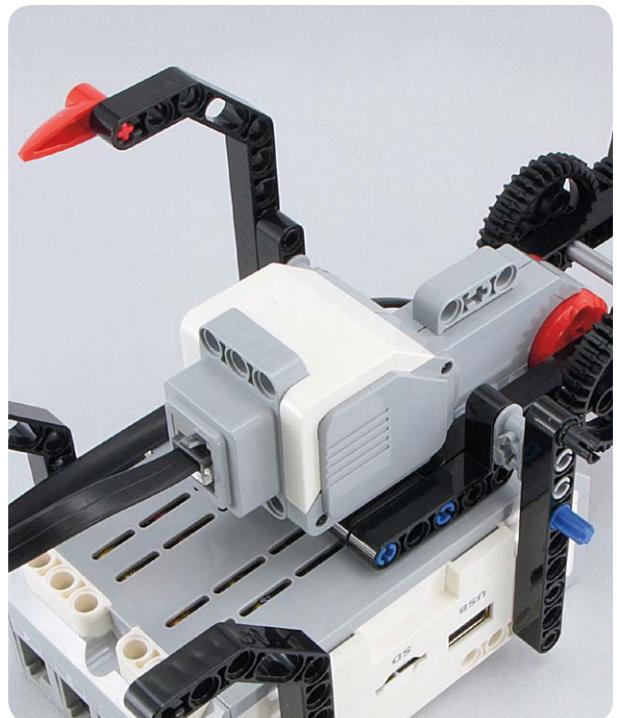
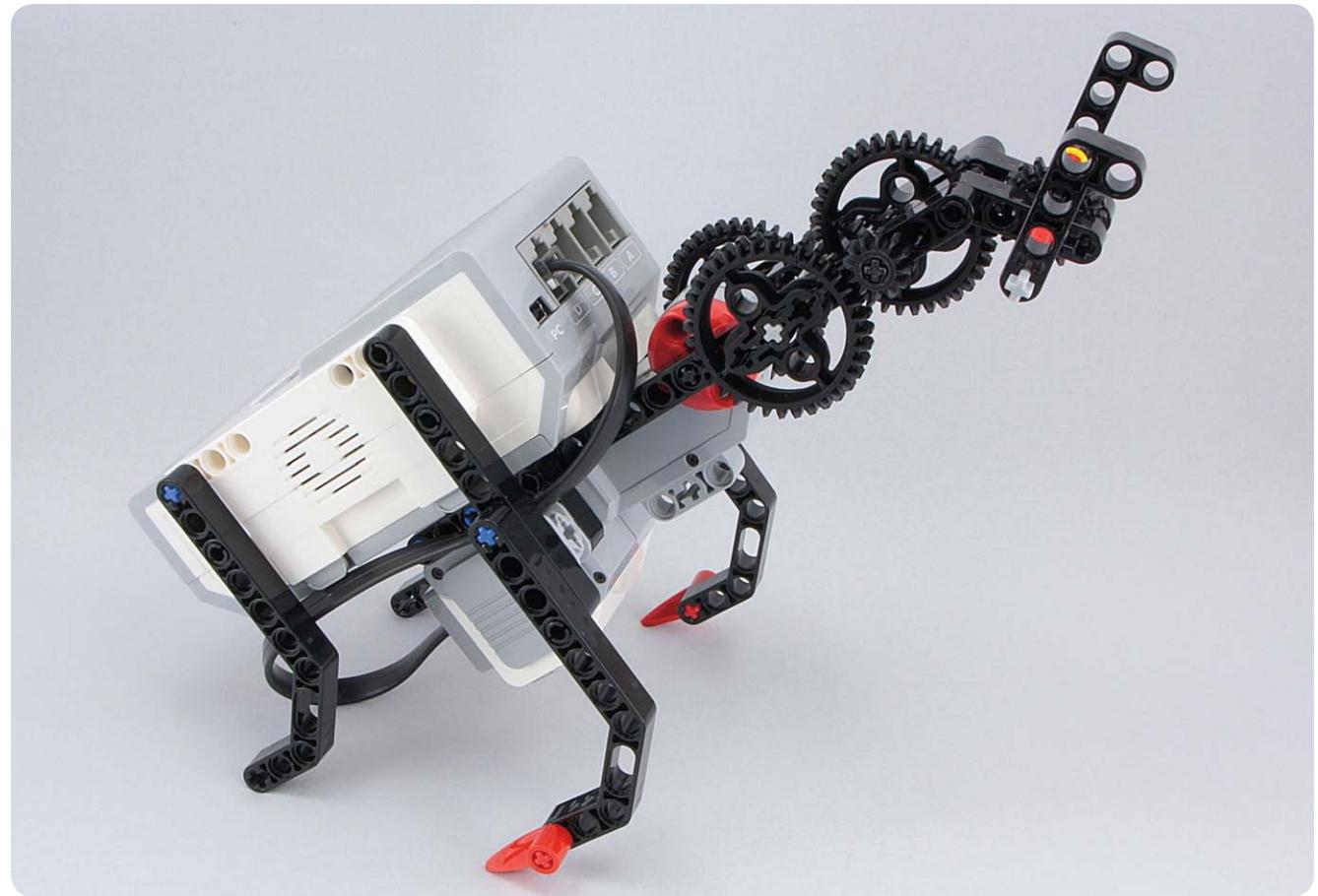


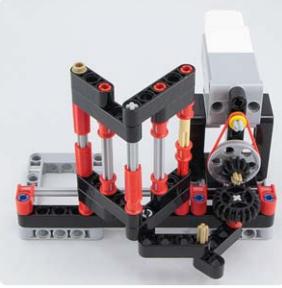


# Moving through vibration

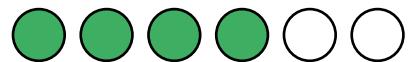
#128







# PART 4



# Arms, Wings, and Other Movements



130



158



180



194



140



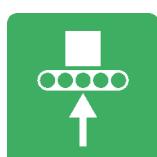
168



184



198



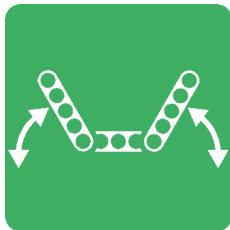
152



176

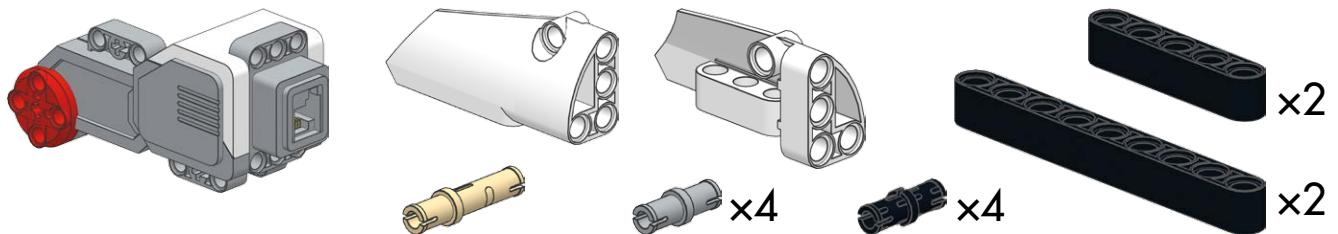


188

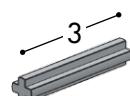
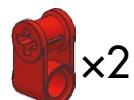
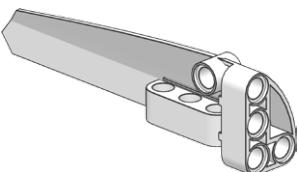
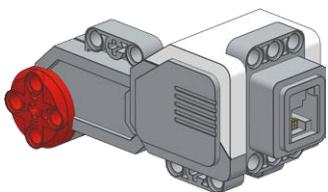


# Flapping wings

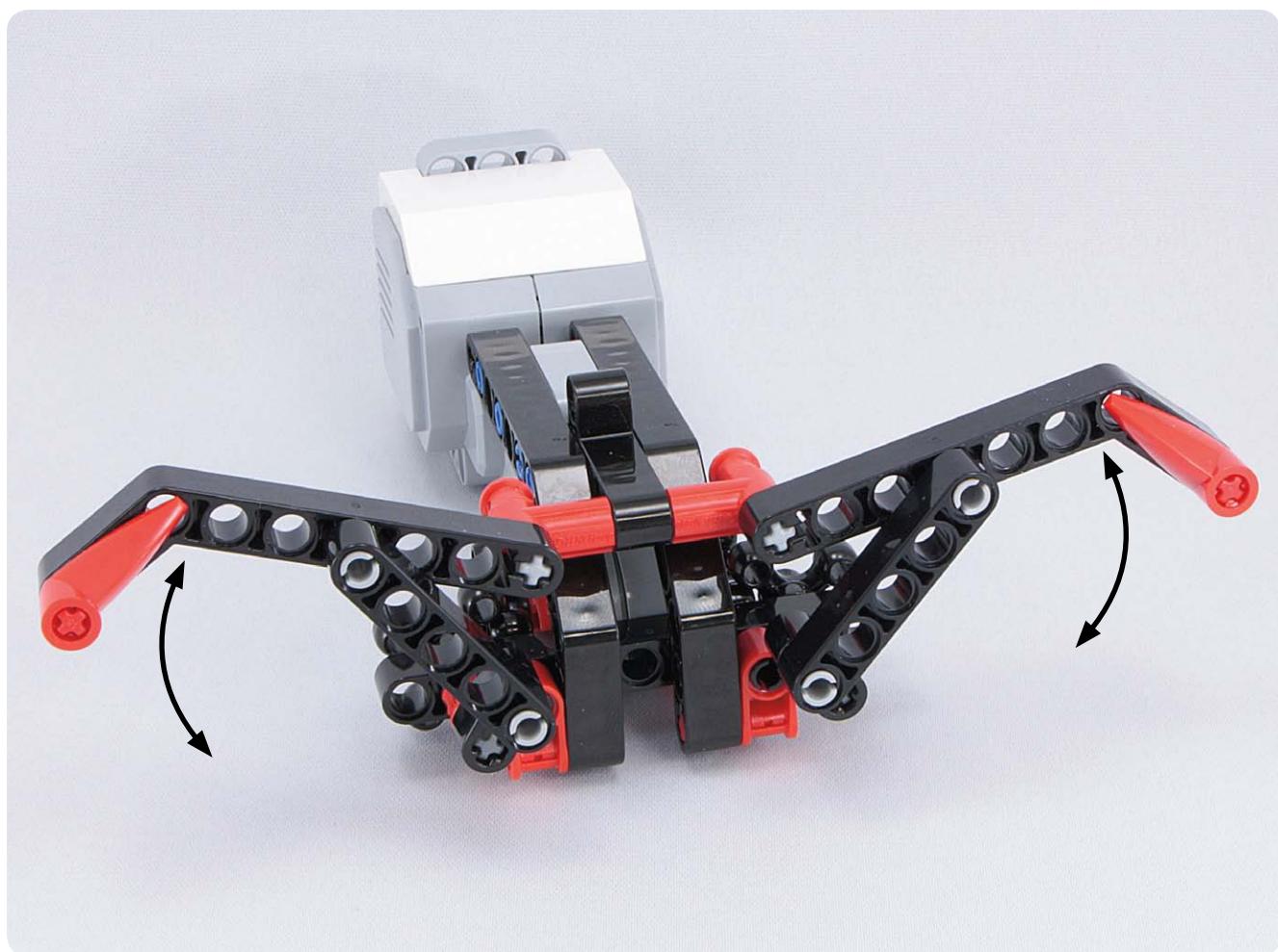
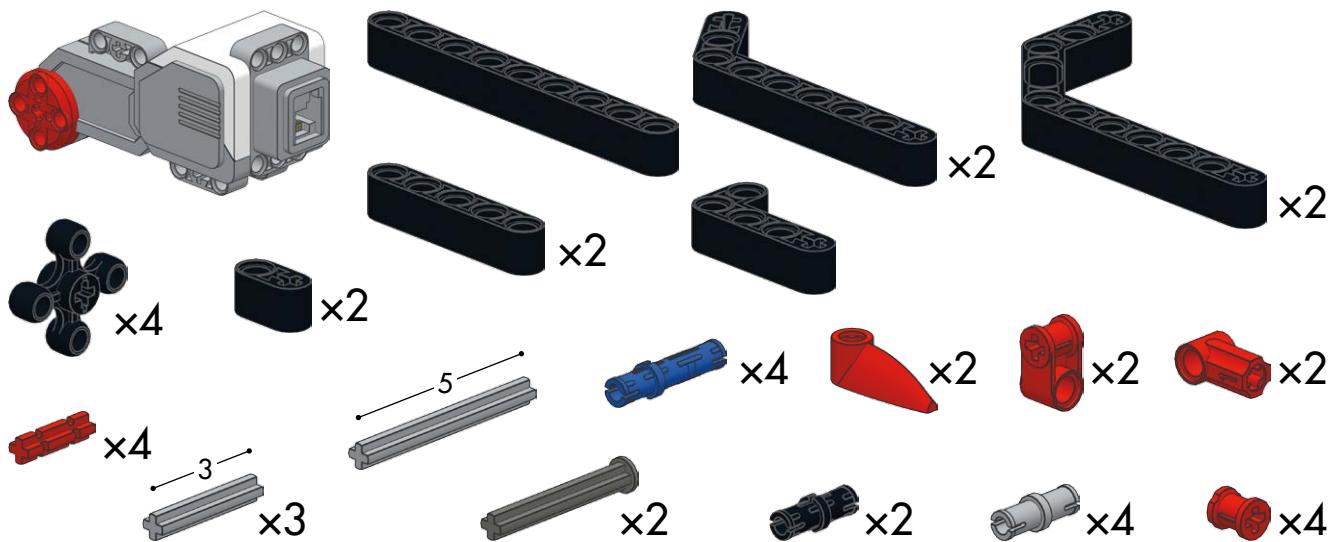
#129



# #130

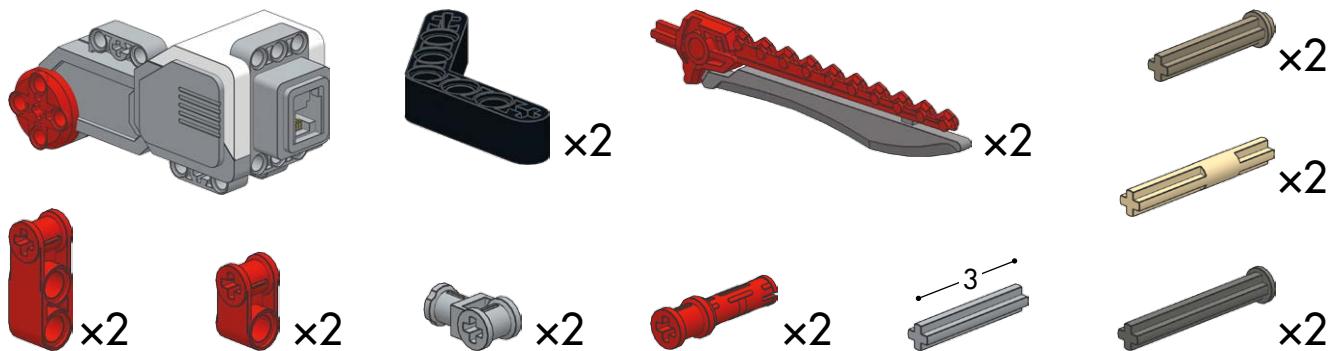


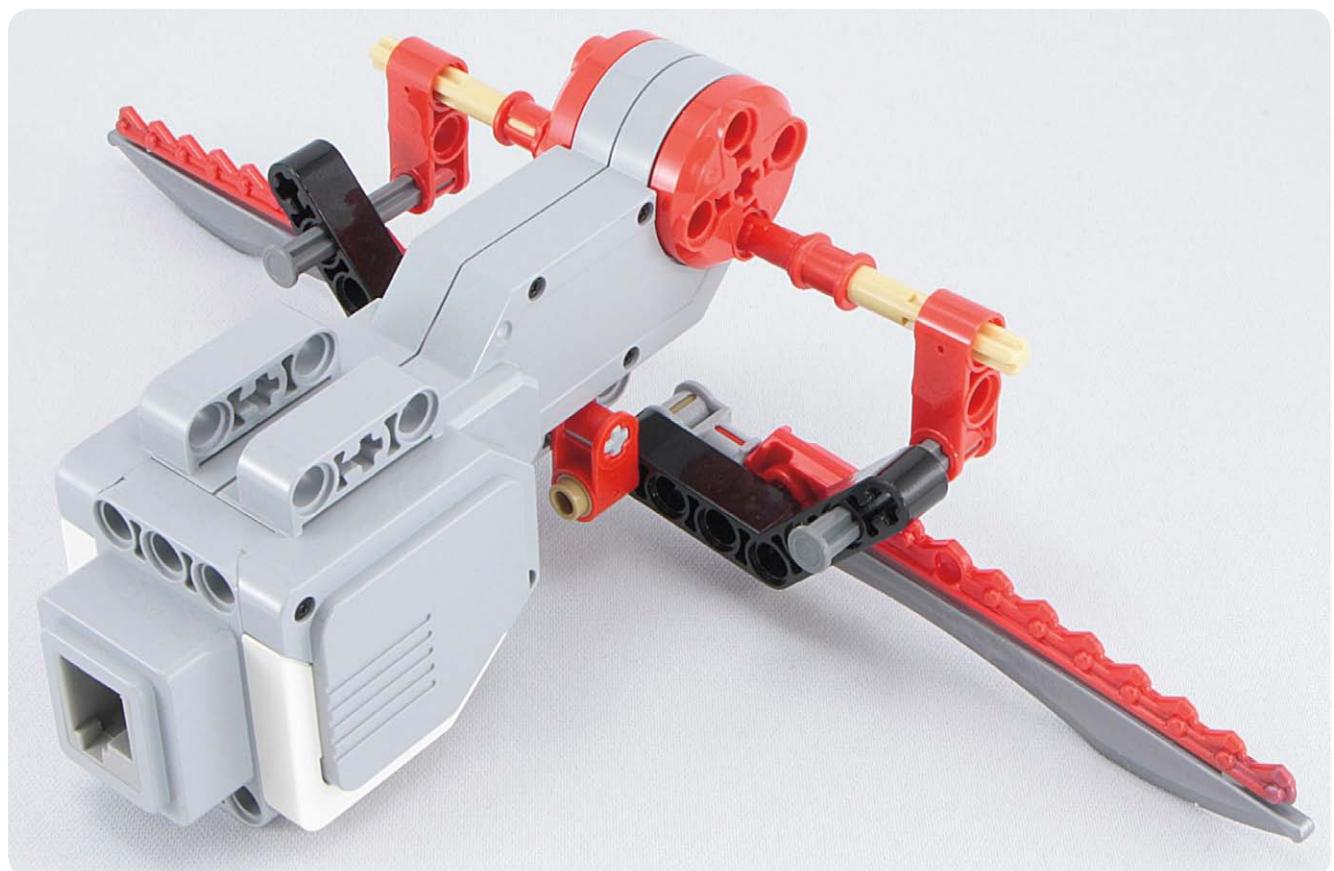
## #131



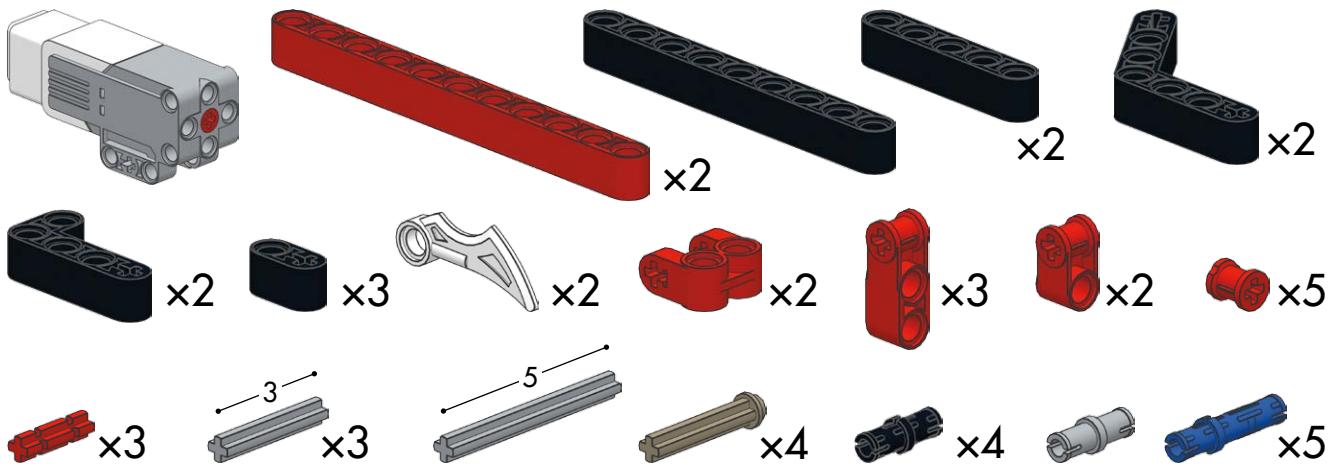


## #132



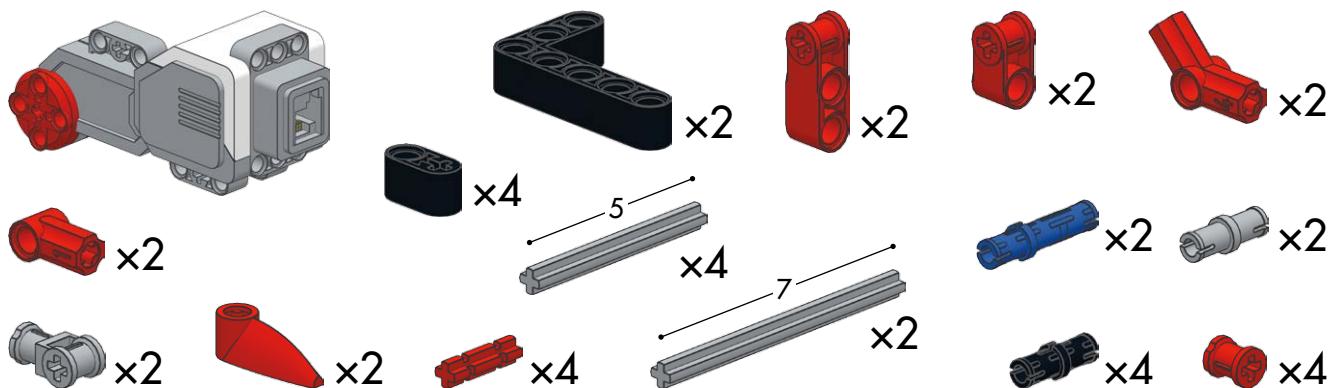


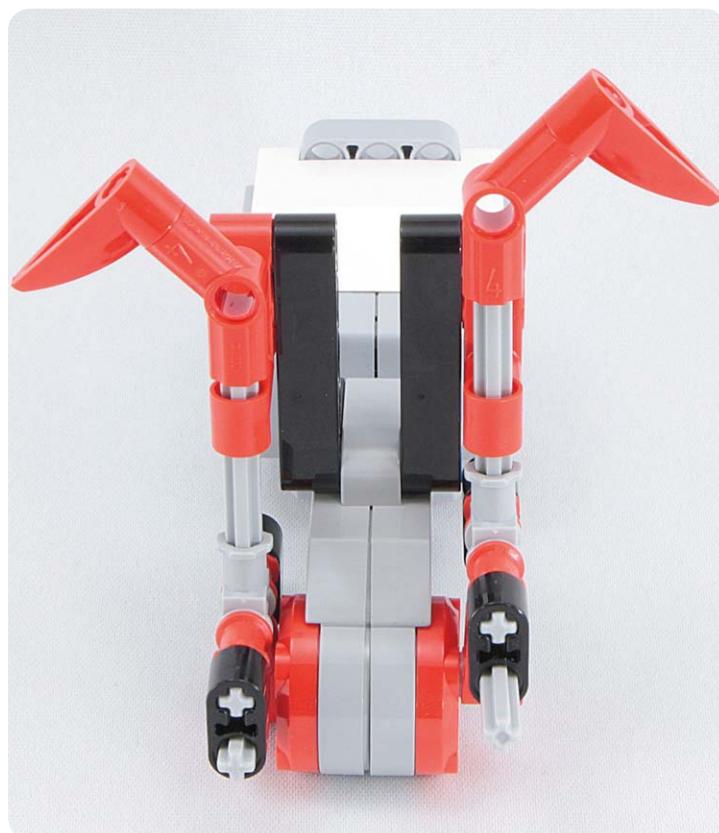
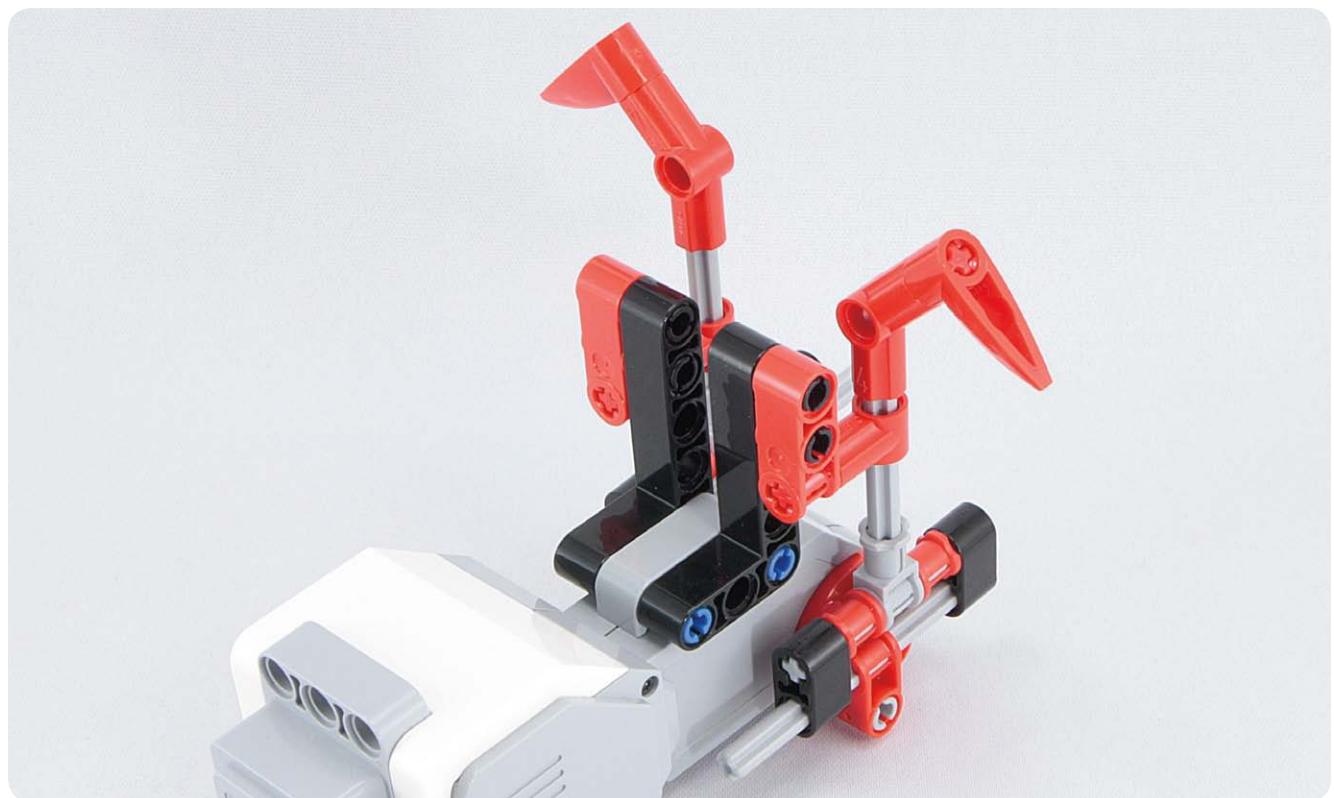
## #133

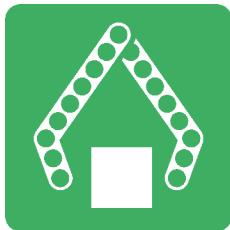




#134

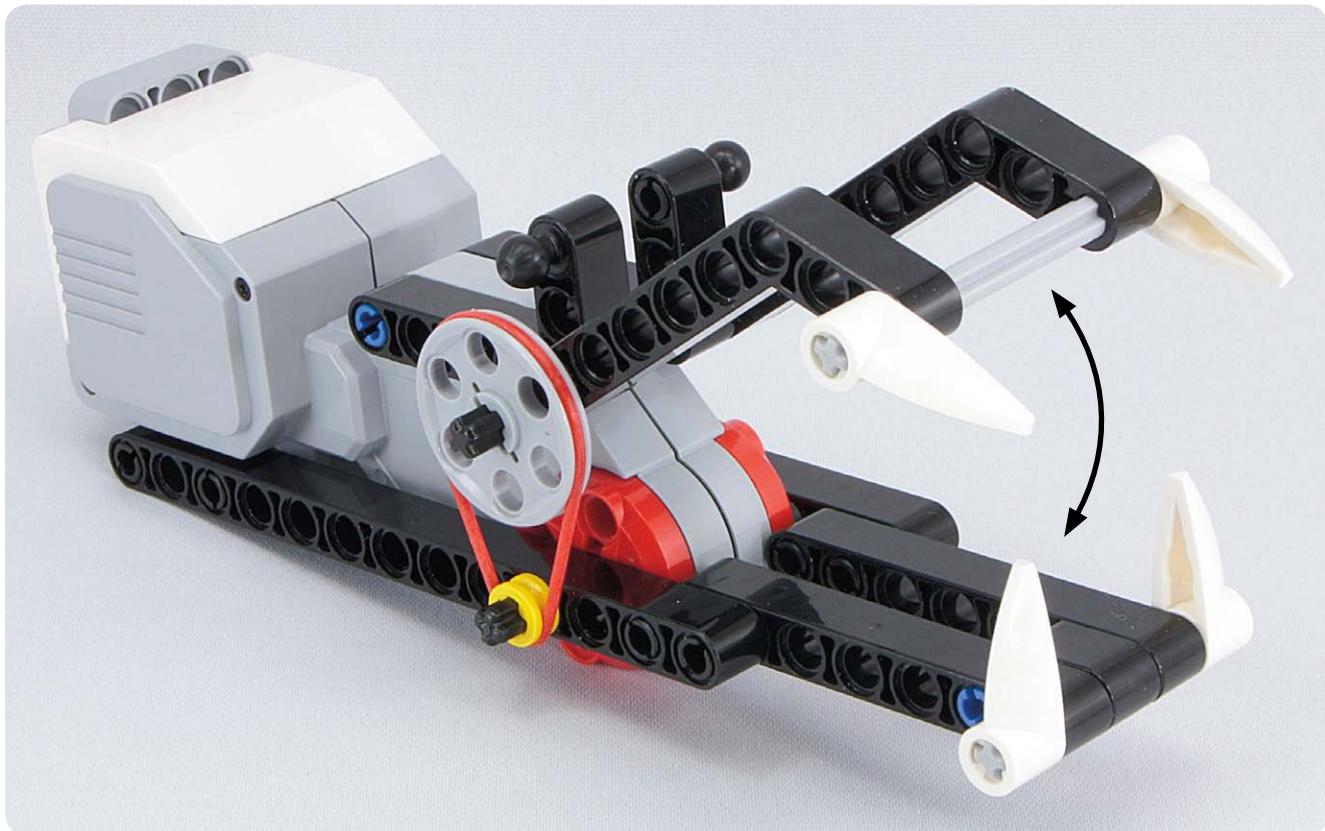
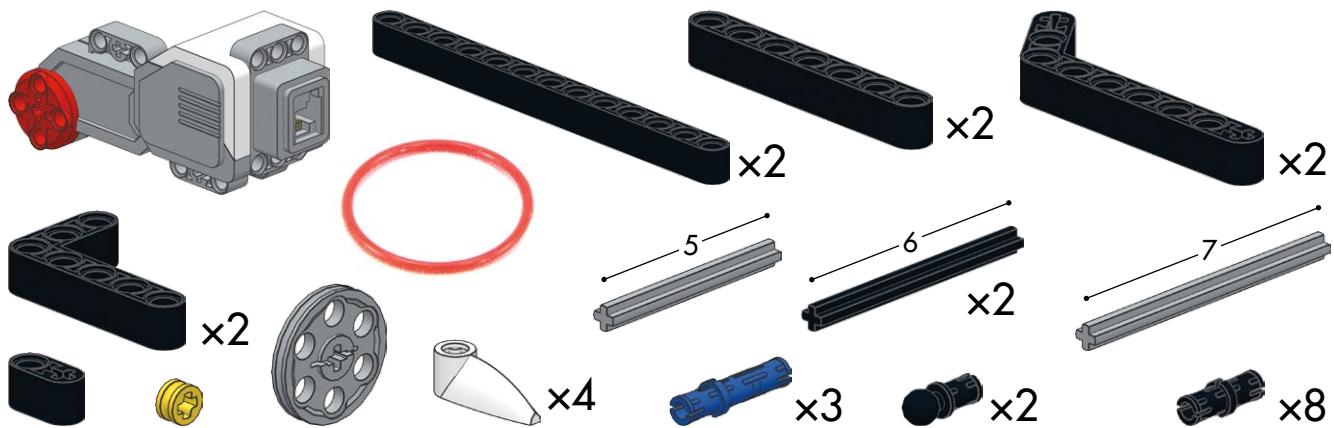


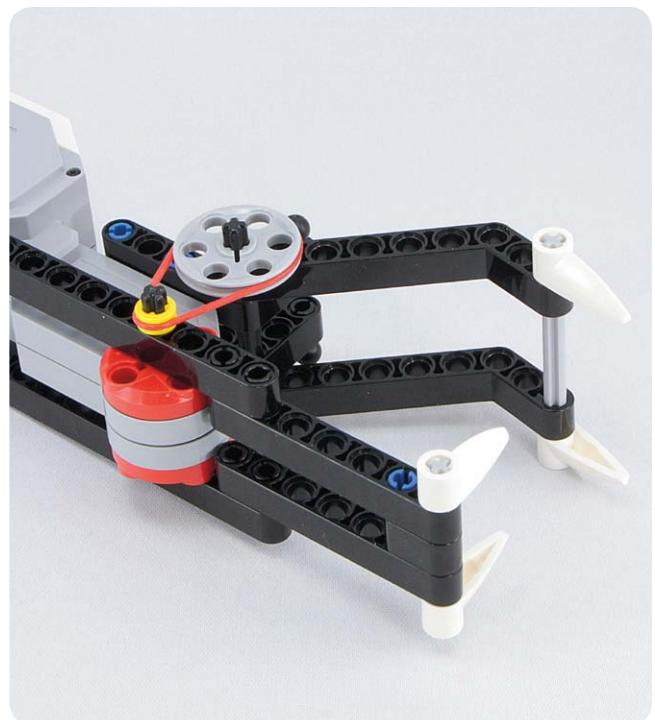
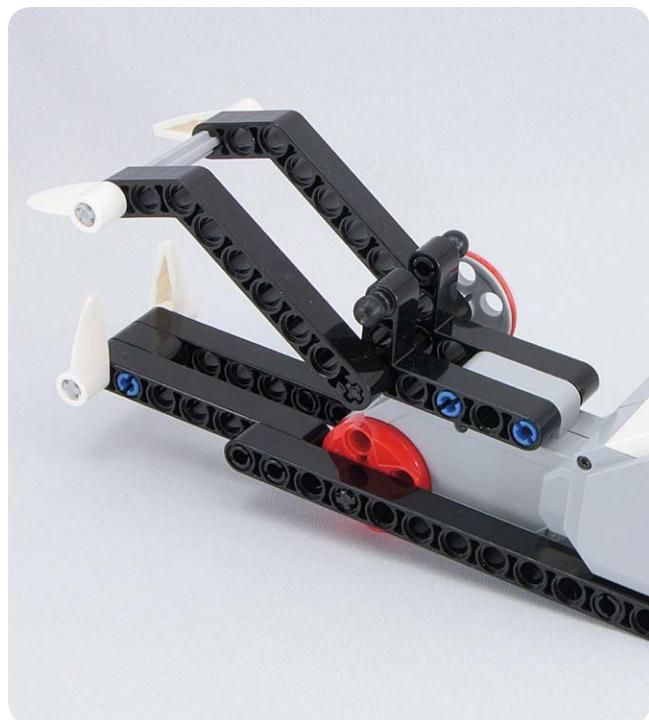
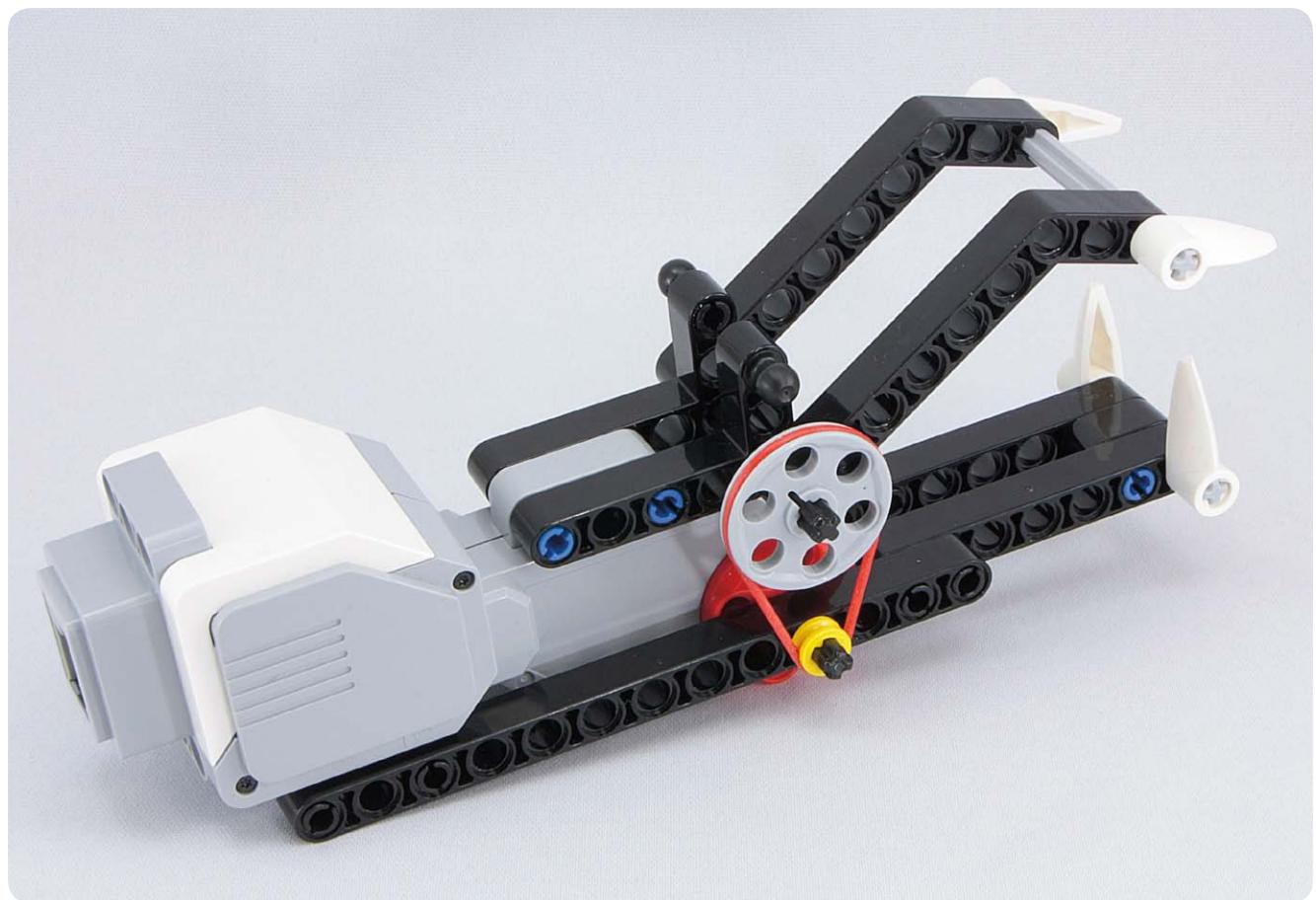




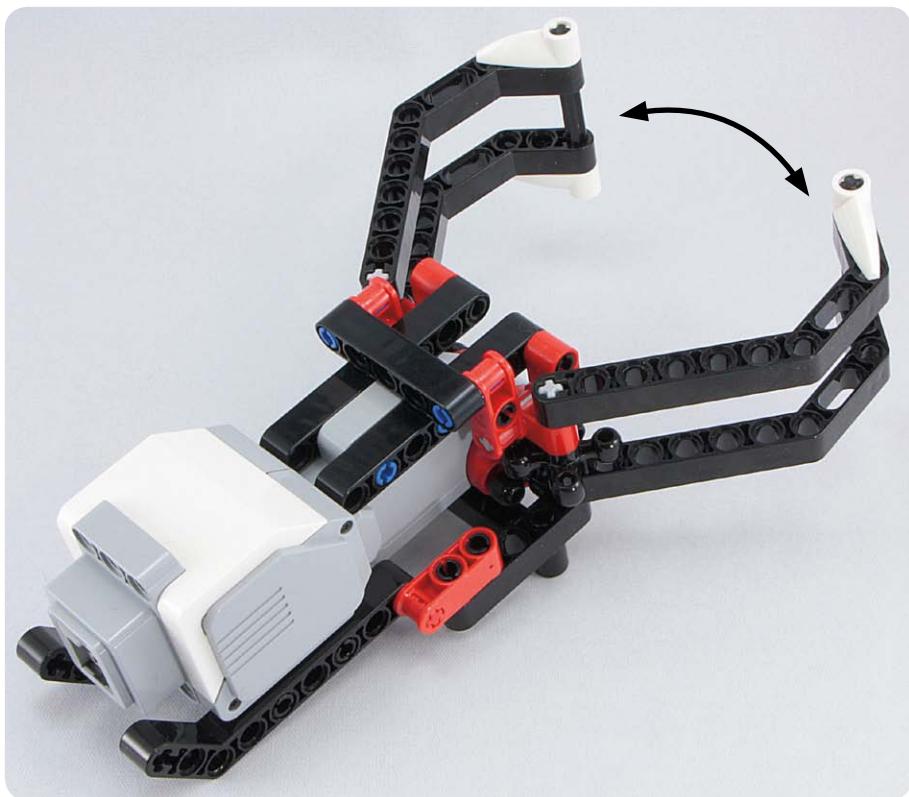
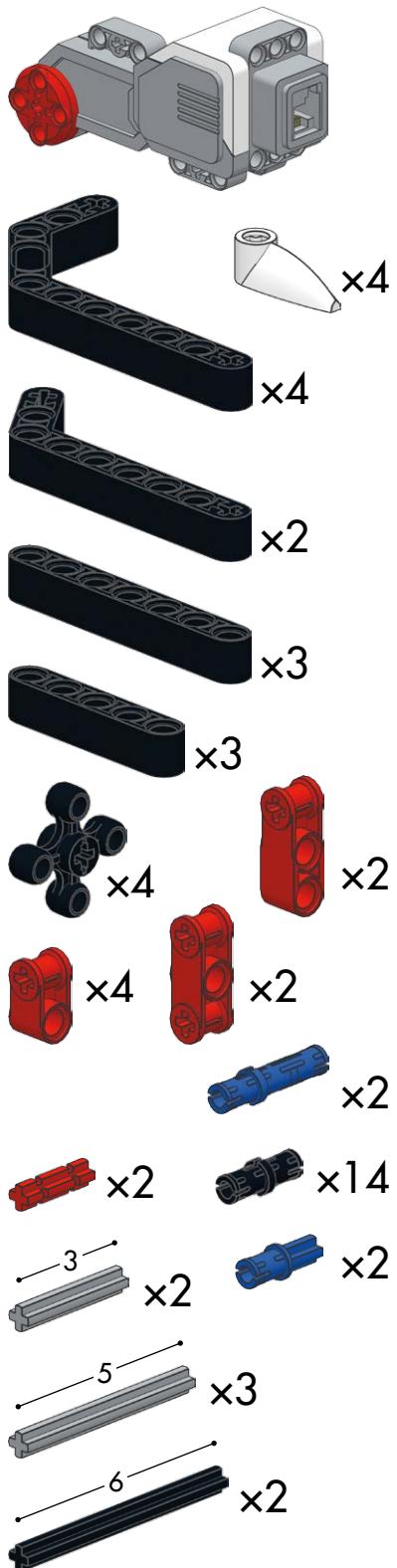
# Gripping fingers

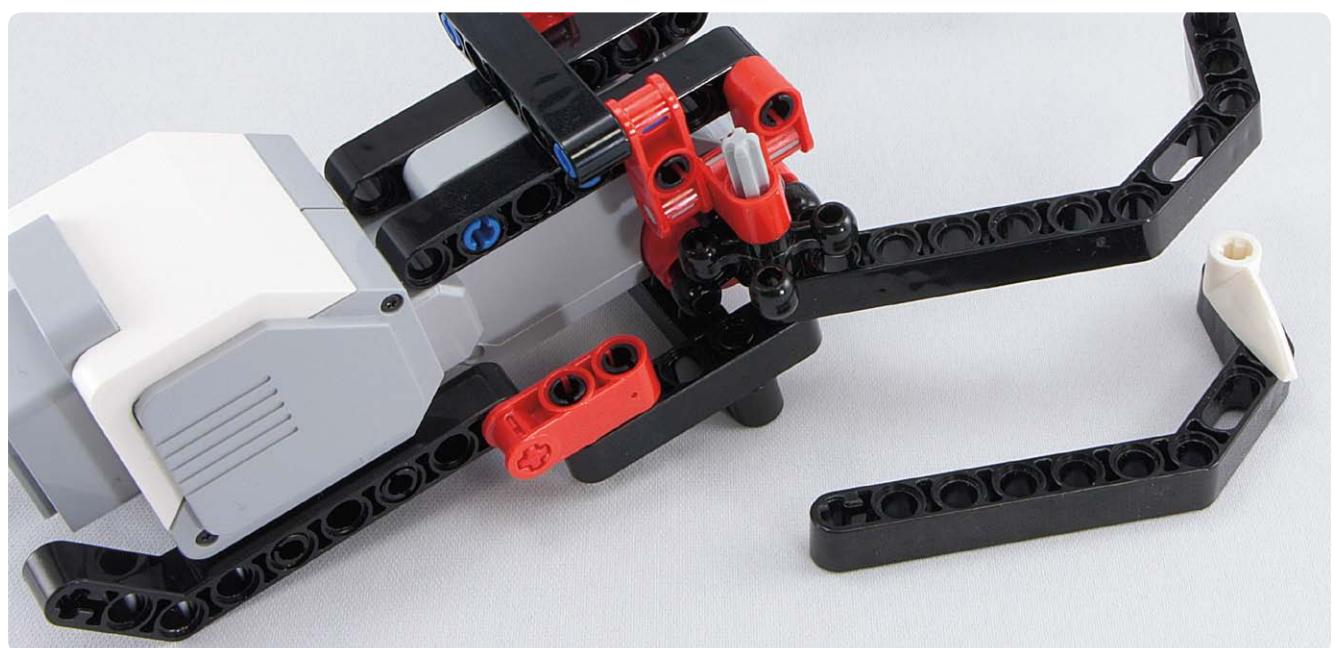
#135



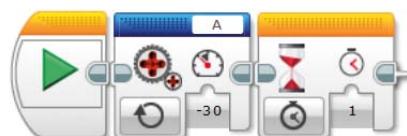


## #136

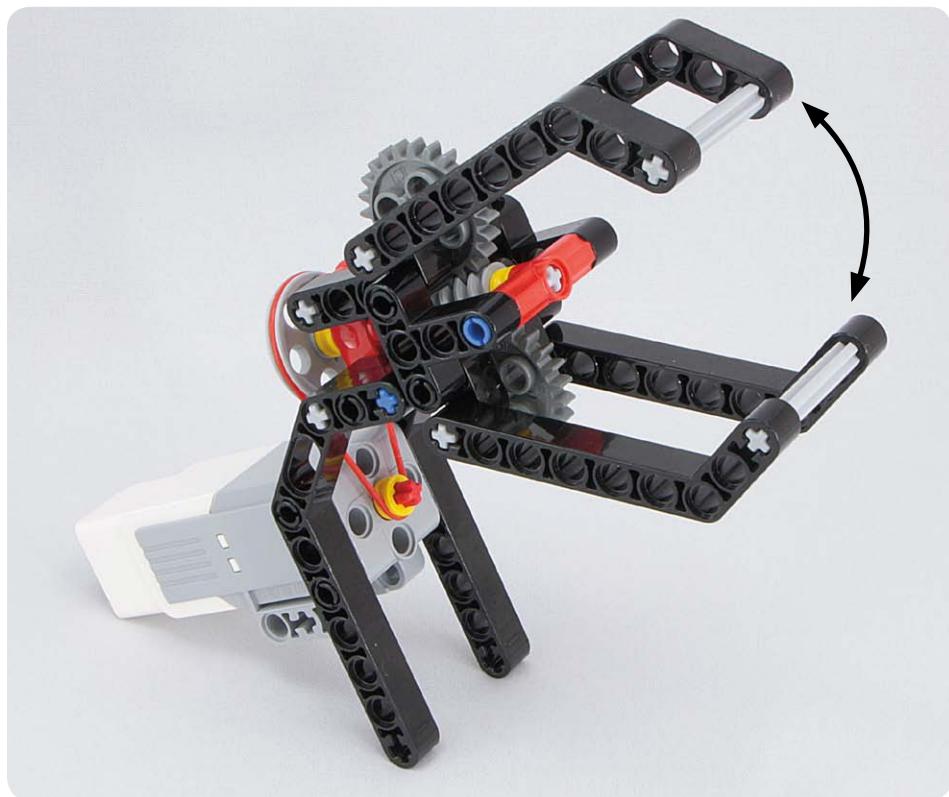
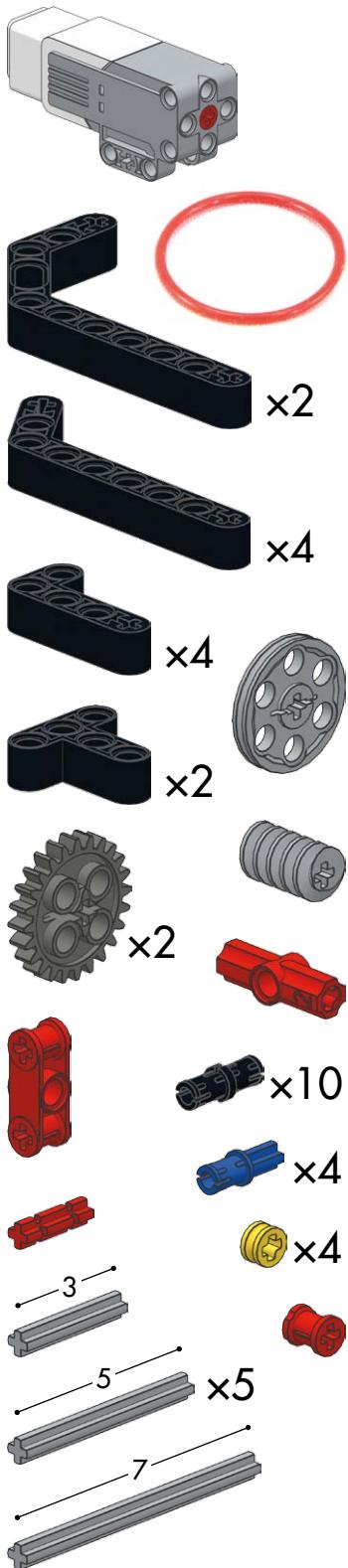




To avoid overextending the mechanism,  
use this program instead of the standard one.

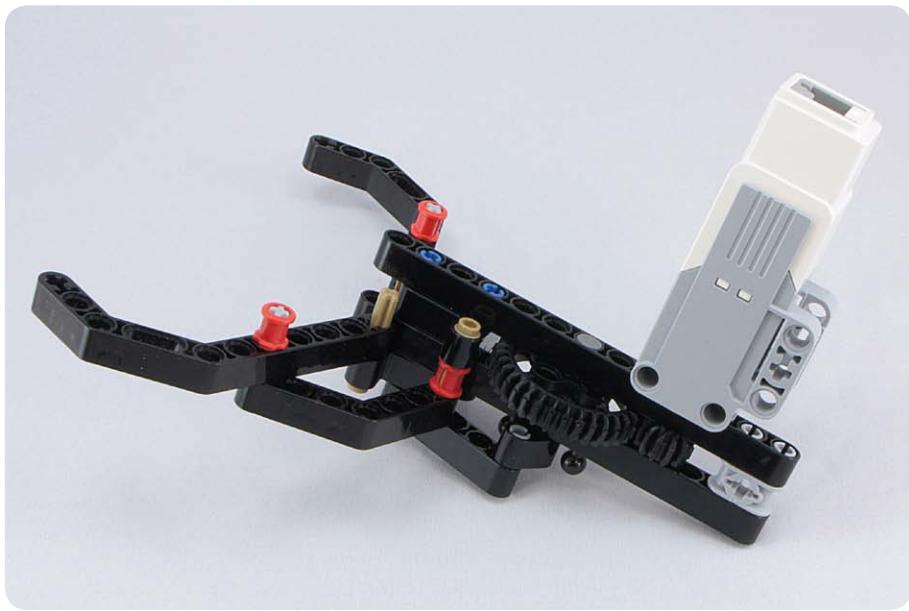
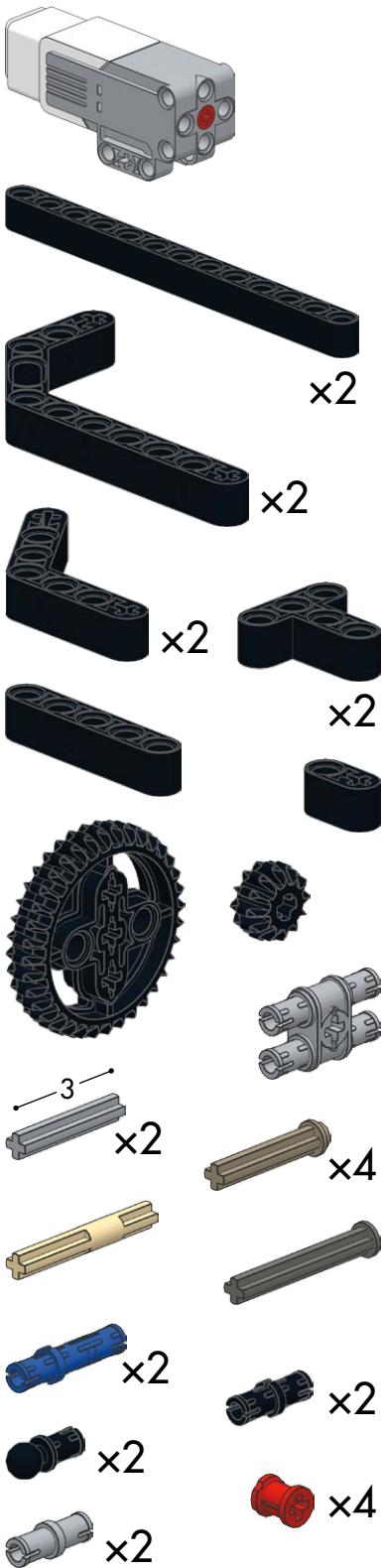


## #137



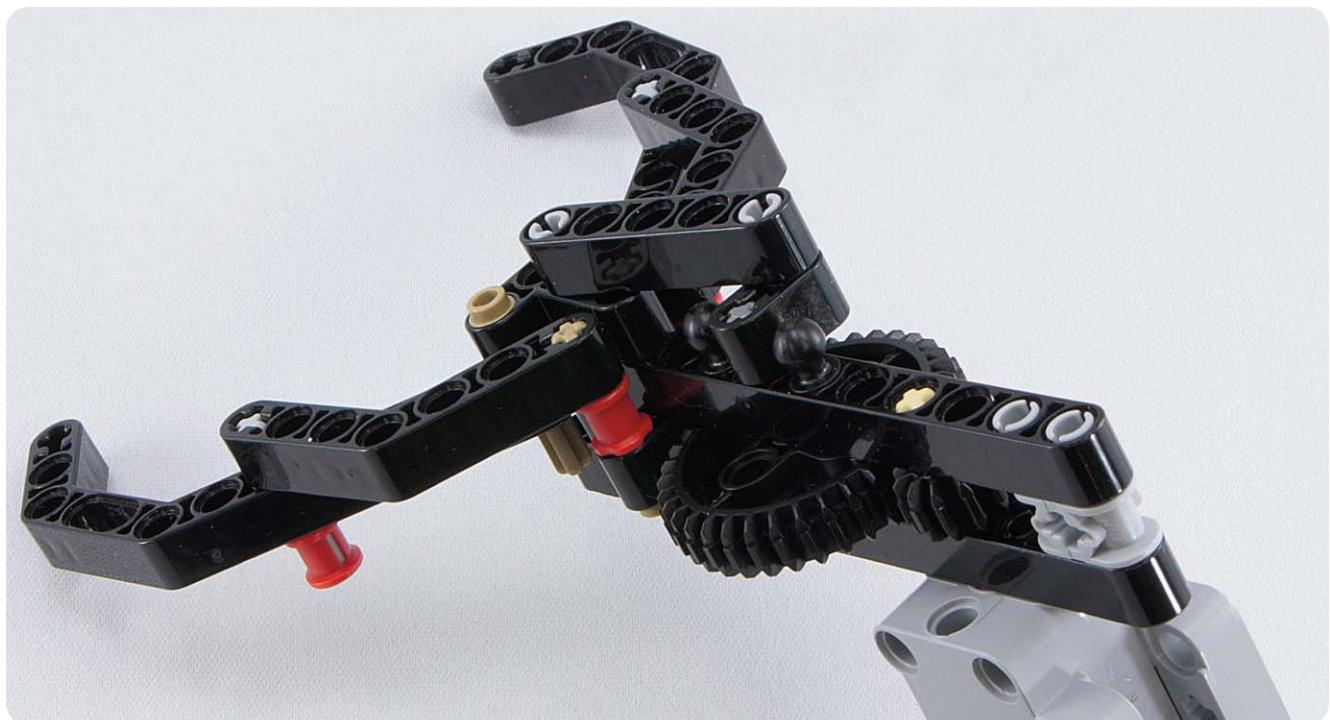
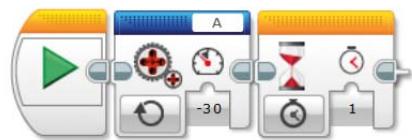


#138

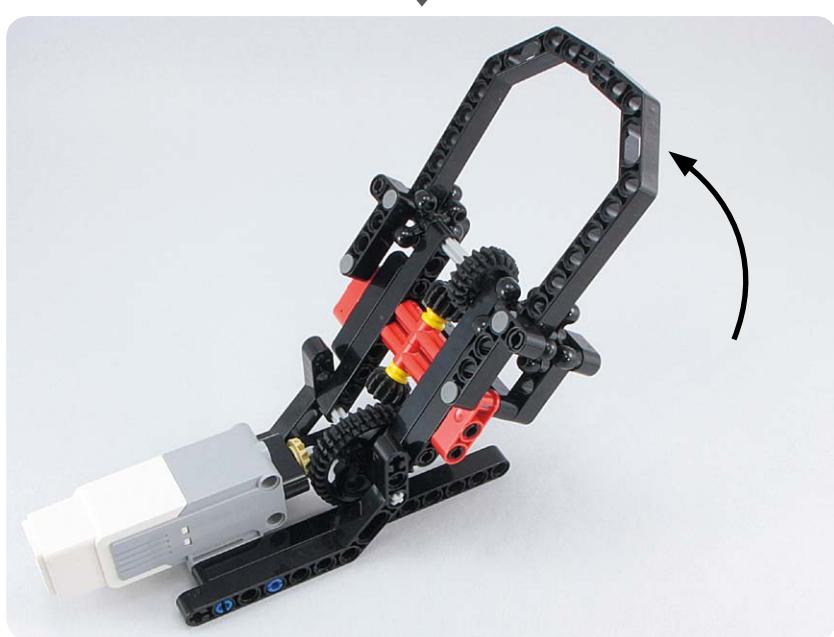
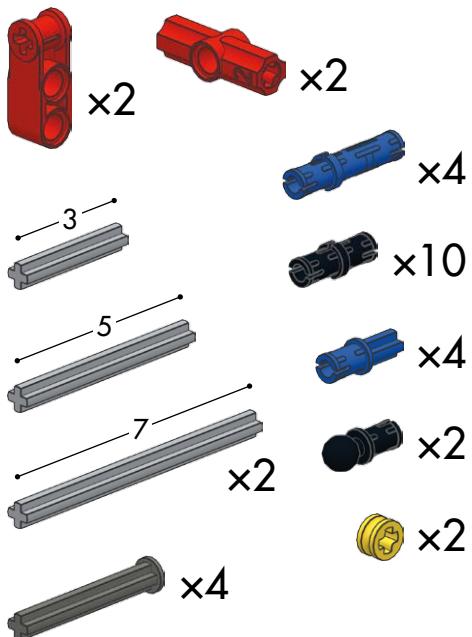
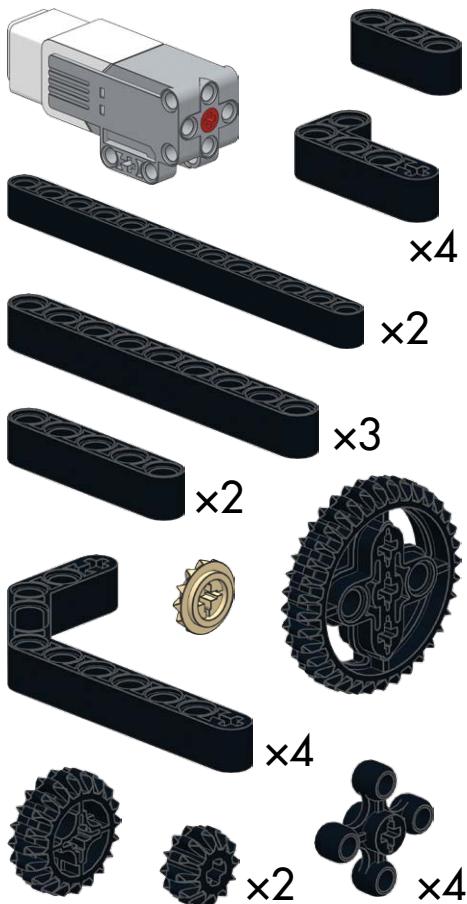


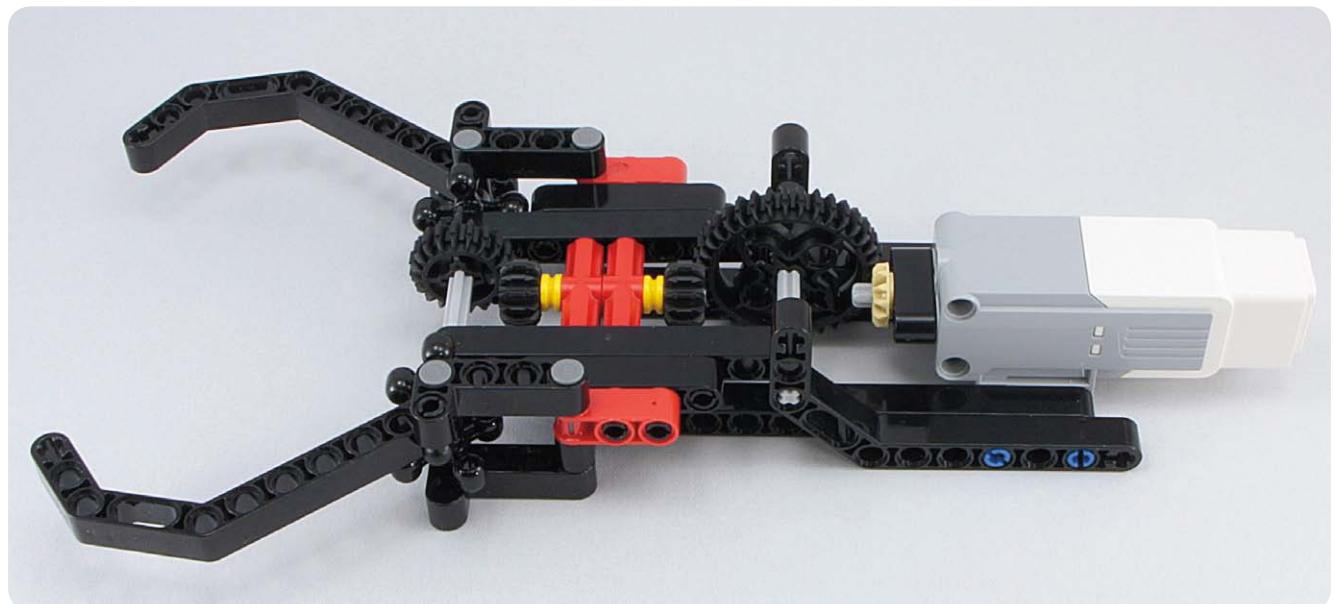
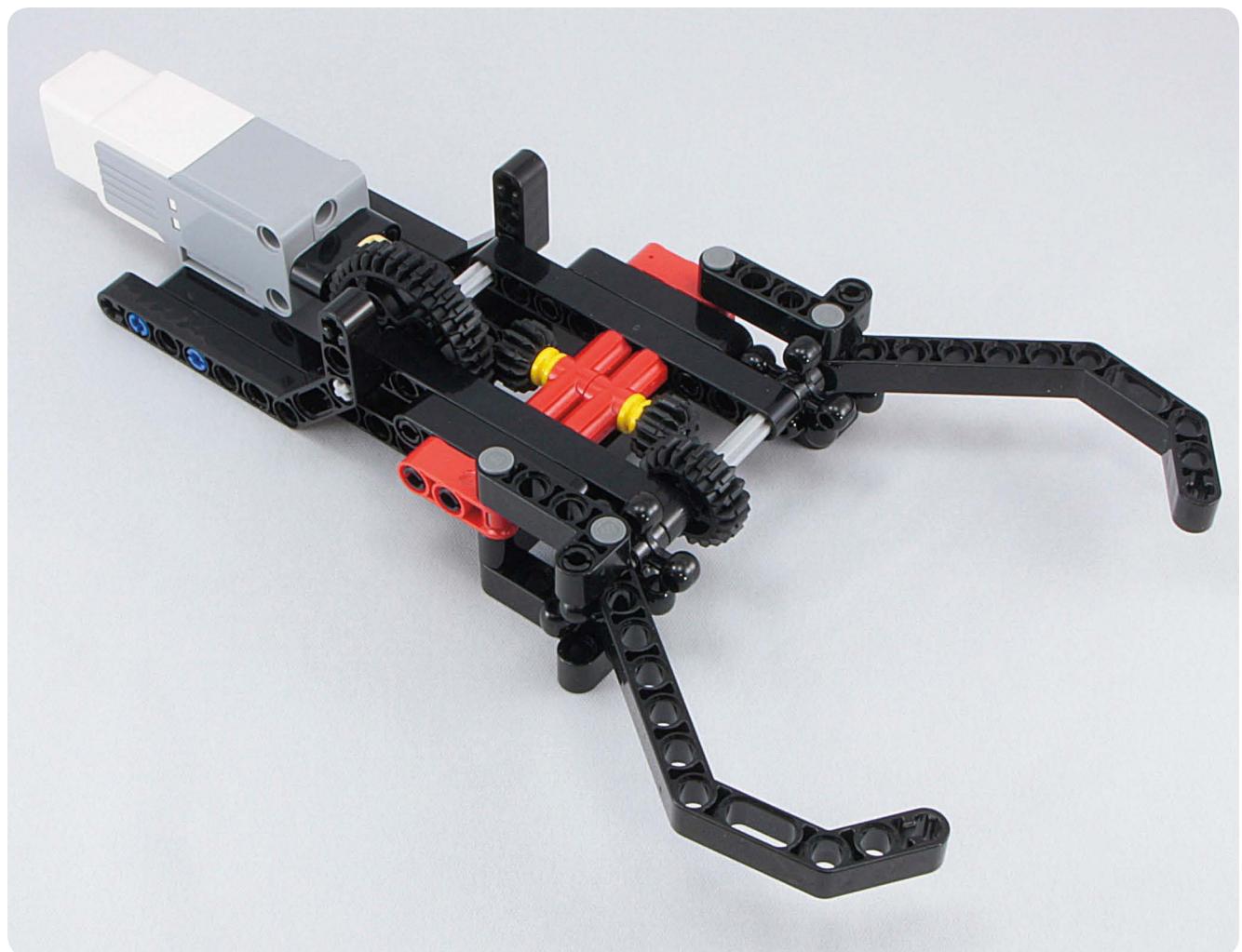


To avoid overextending the mechanism, use this program instead of the standard one.

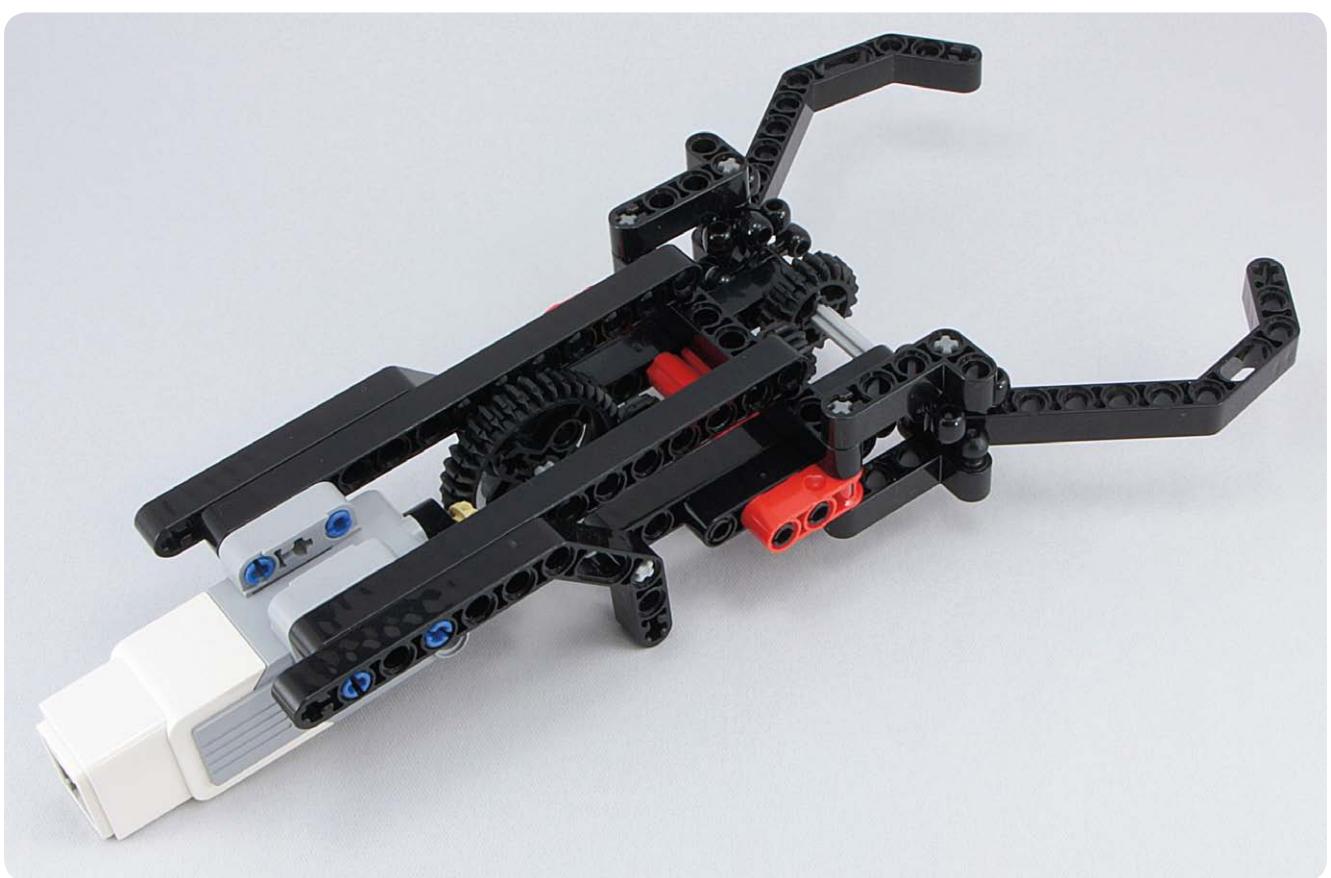
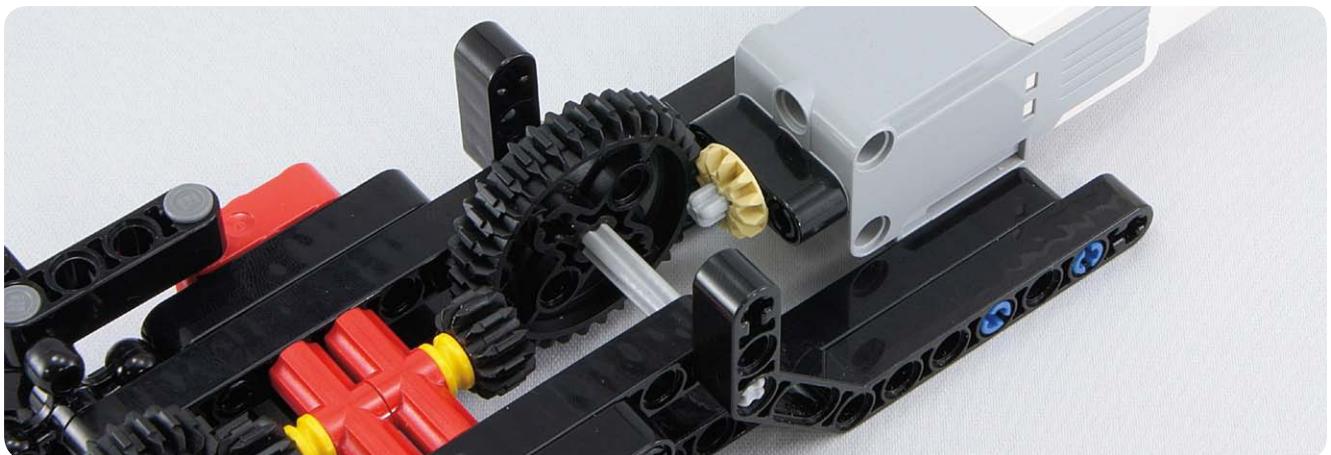


# #139

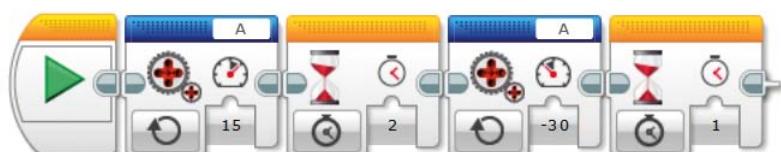


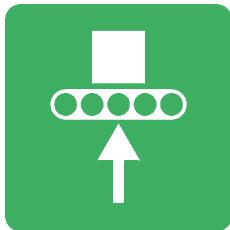






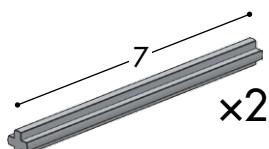
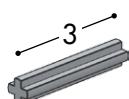
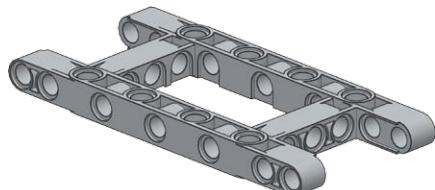
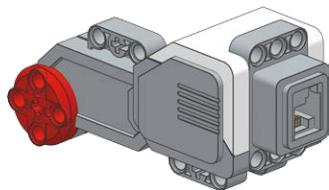
Here's a program  
for this arm.

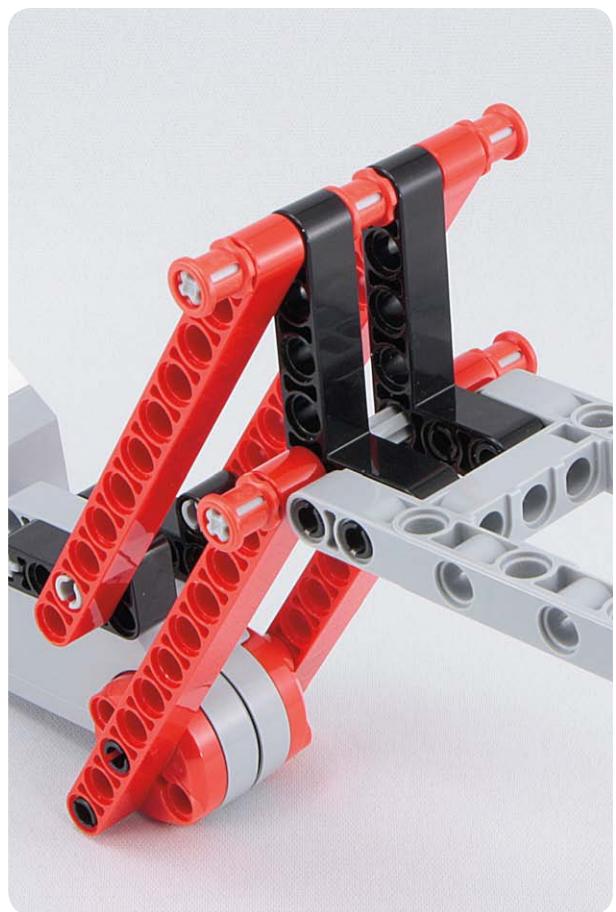
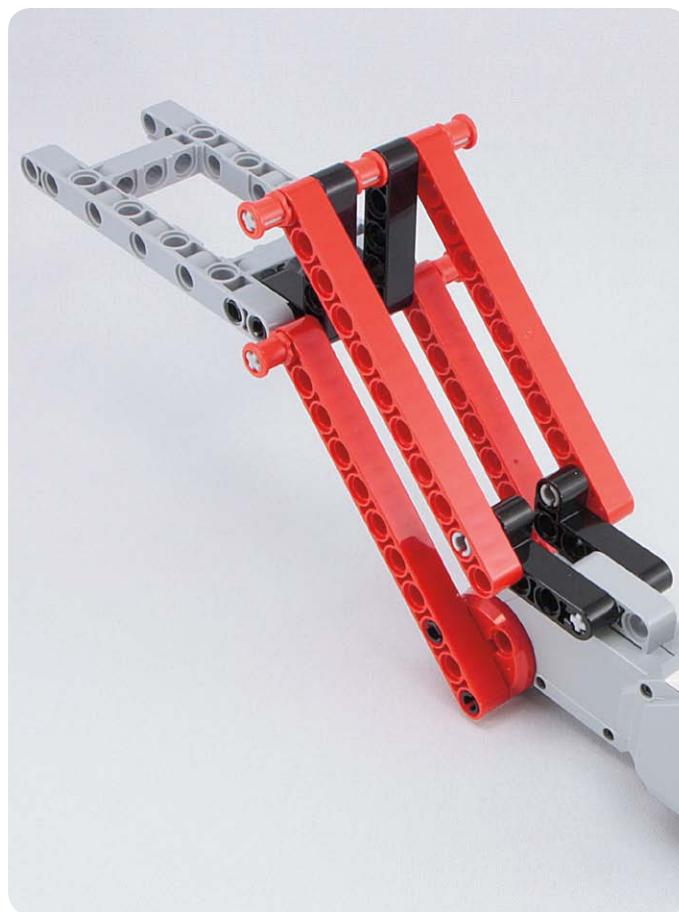
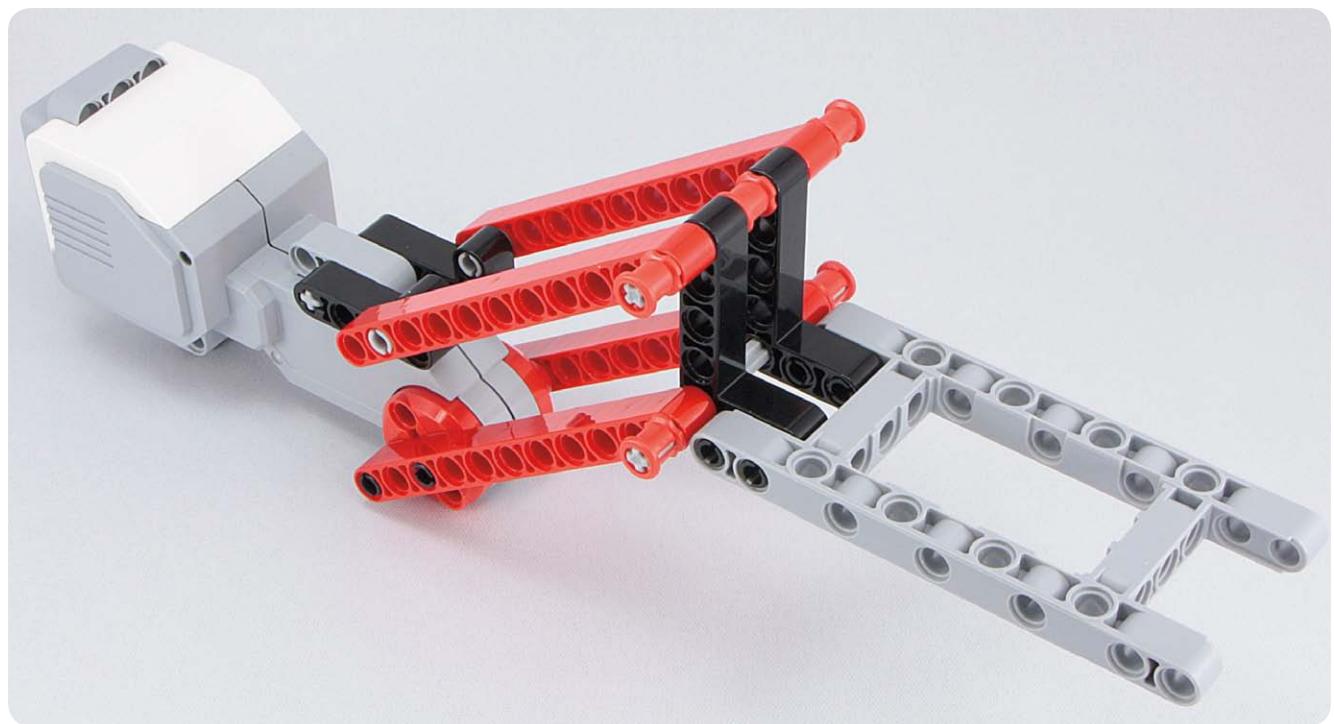




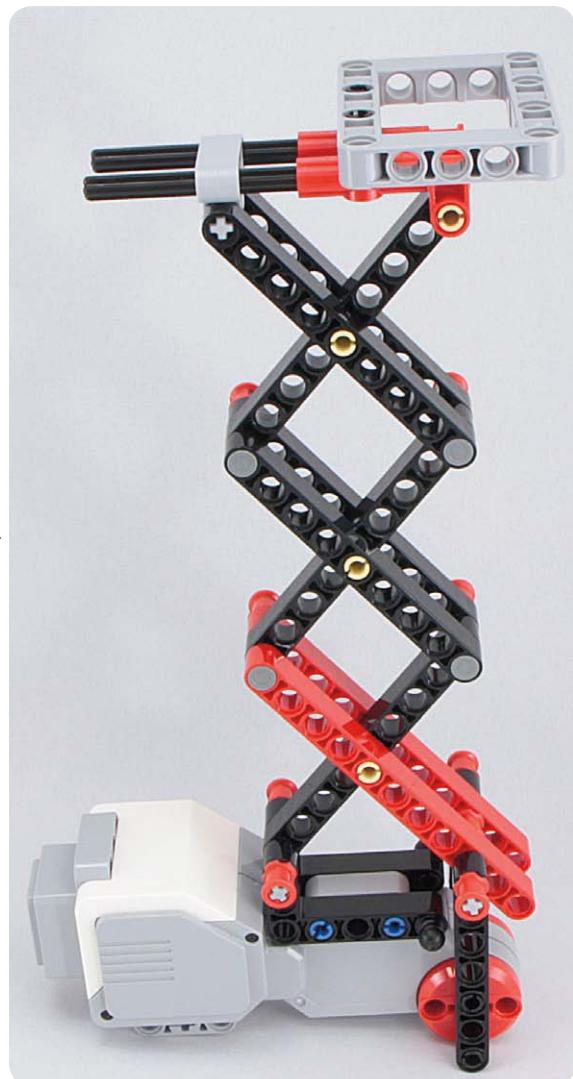
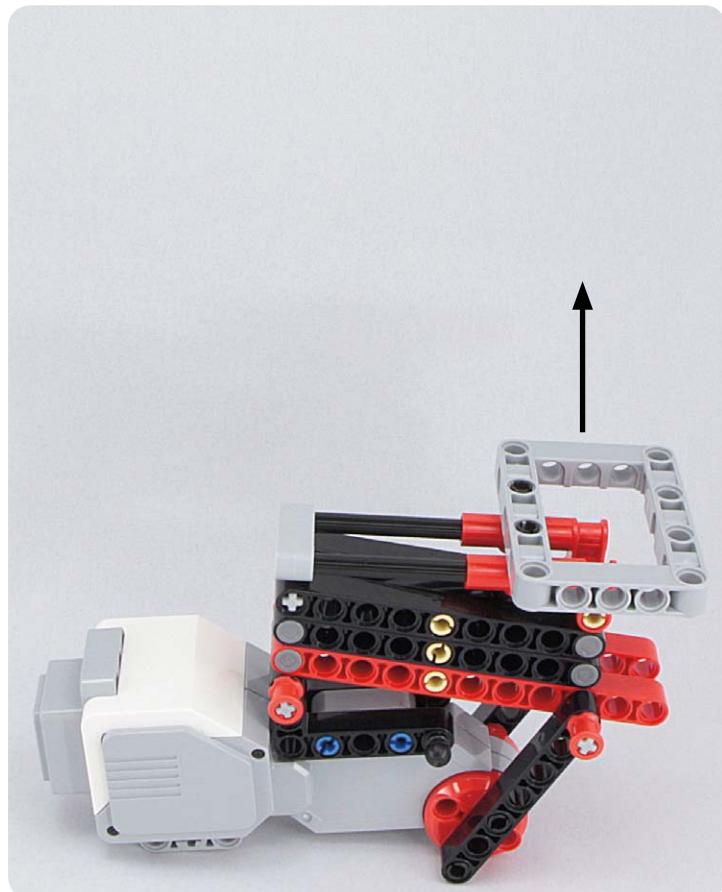
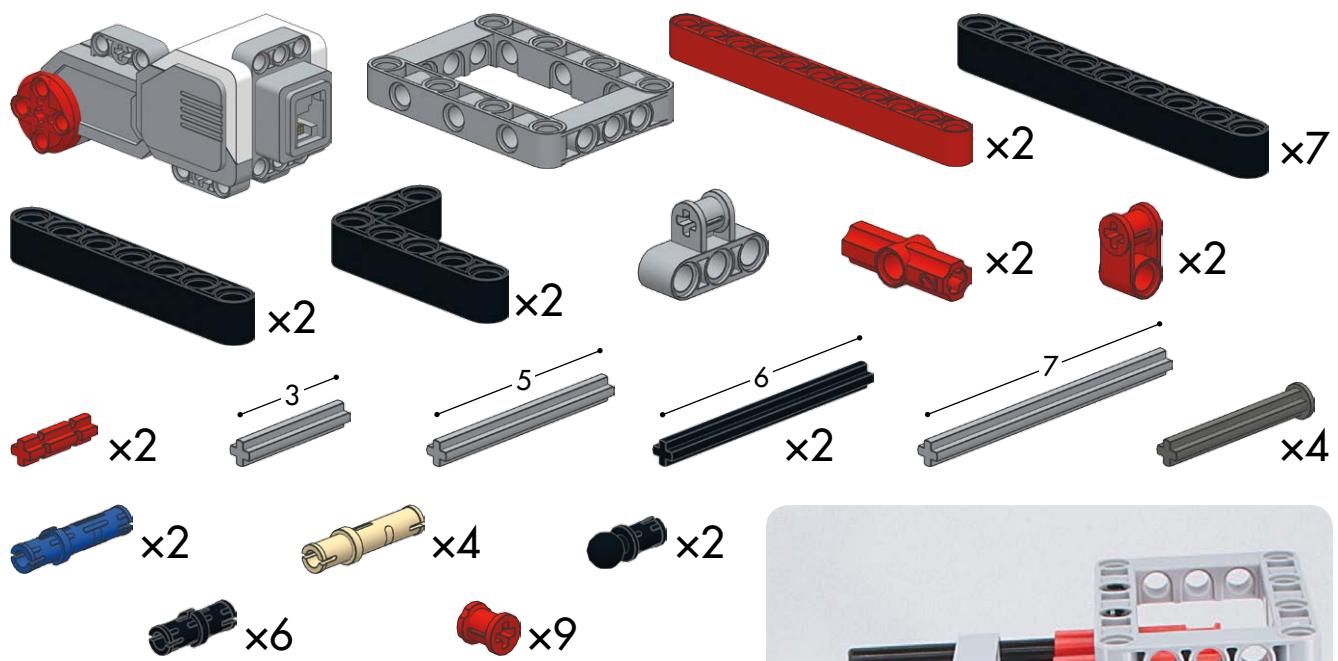
# Lifting things

#140



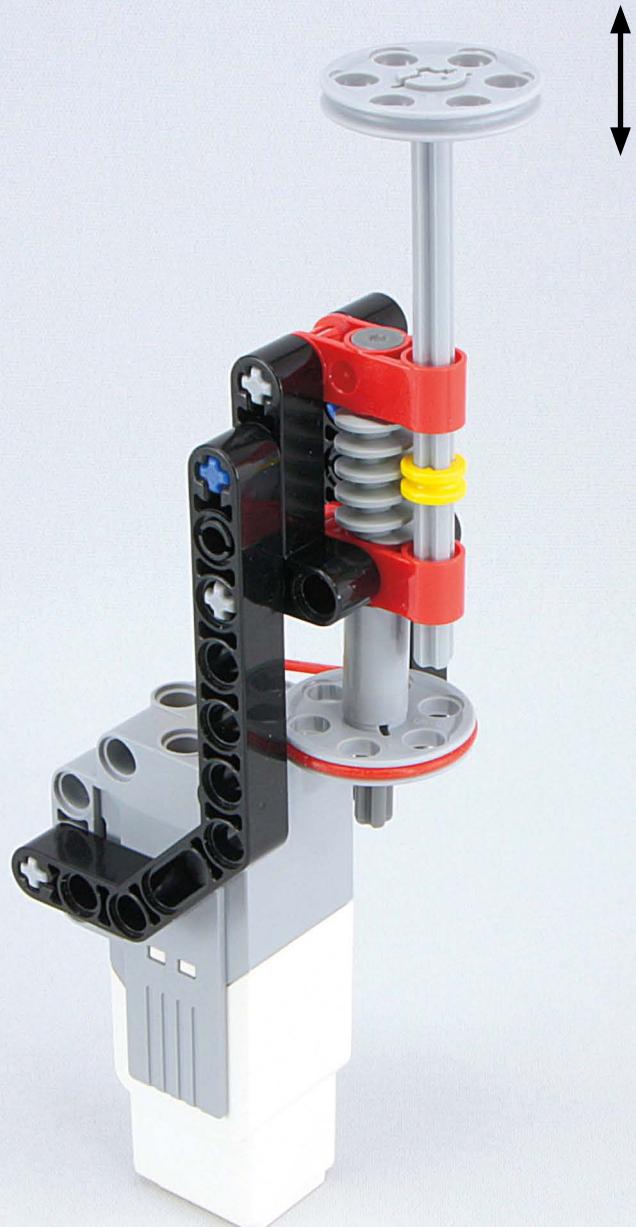


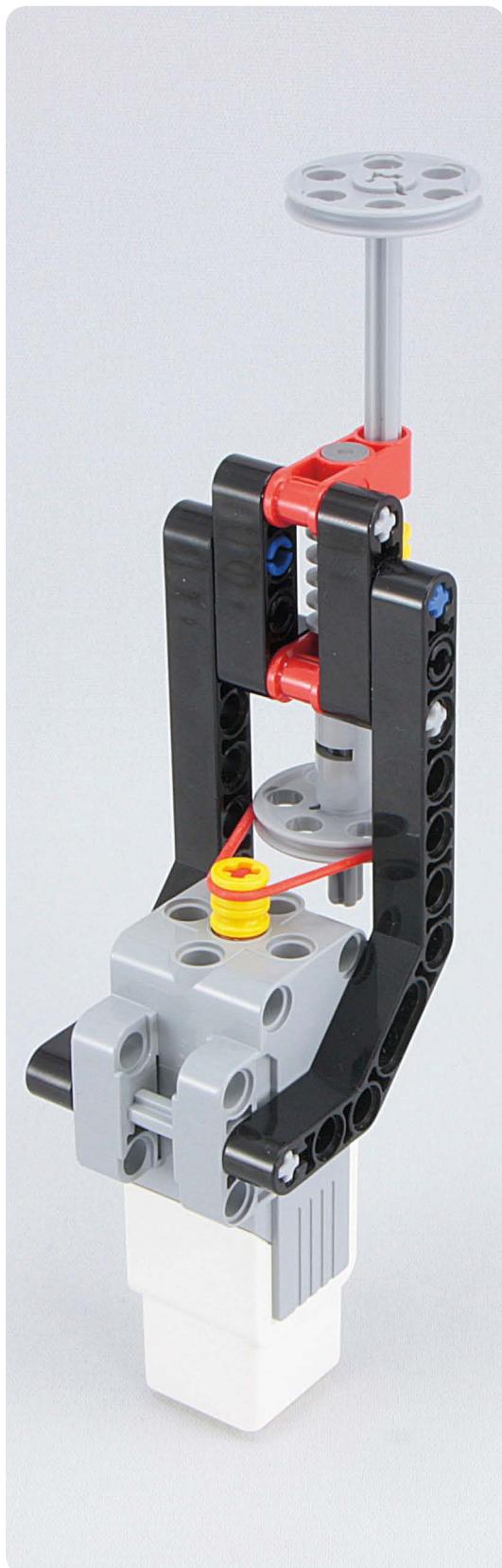
#141

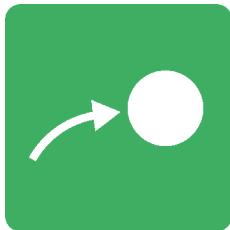




#142

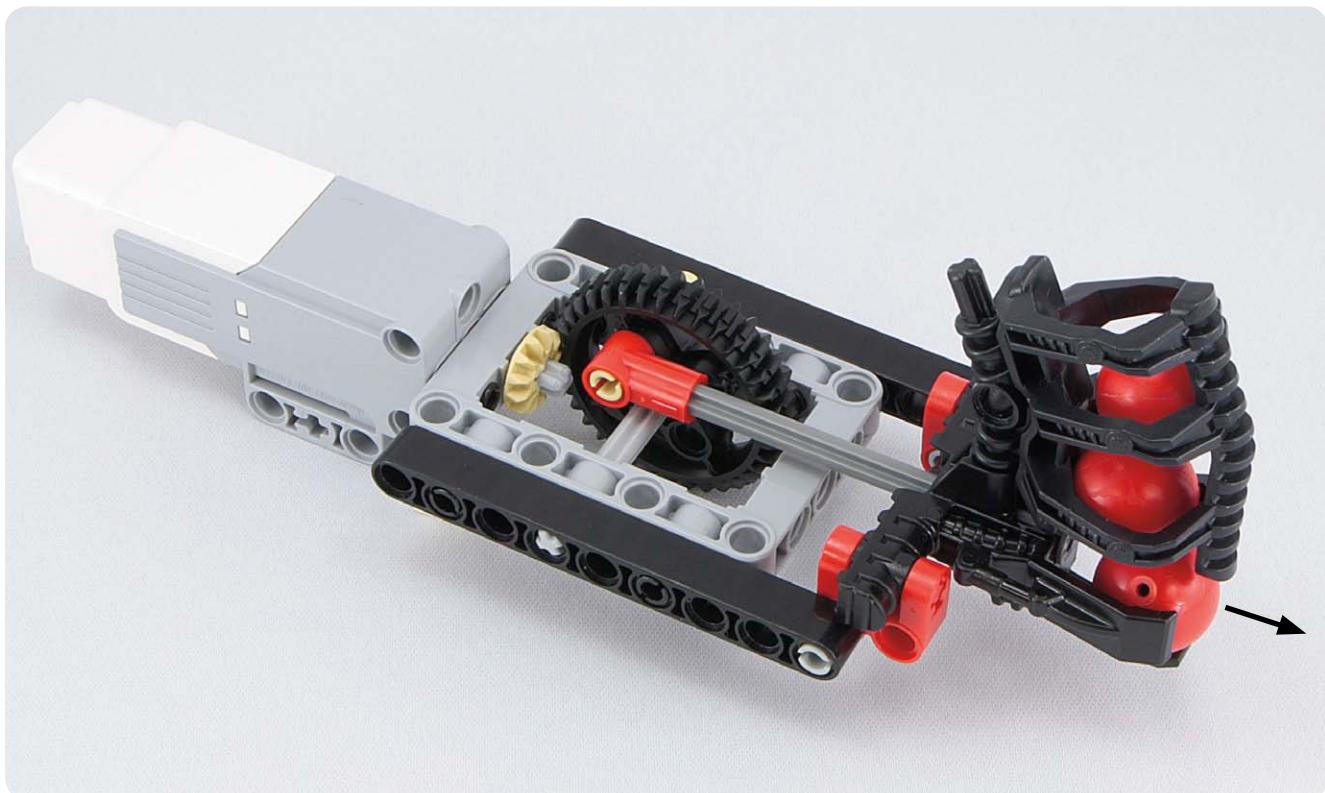
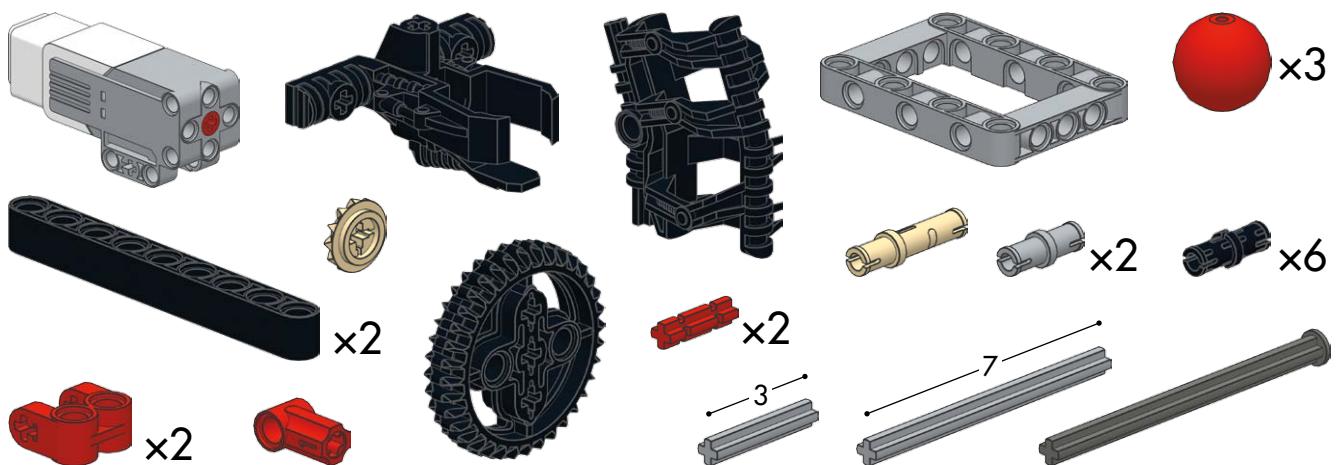


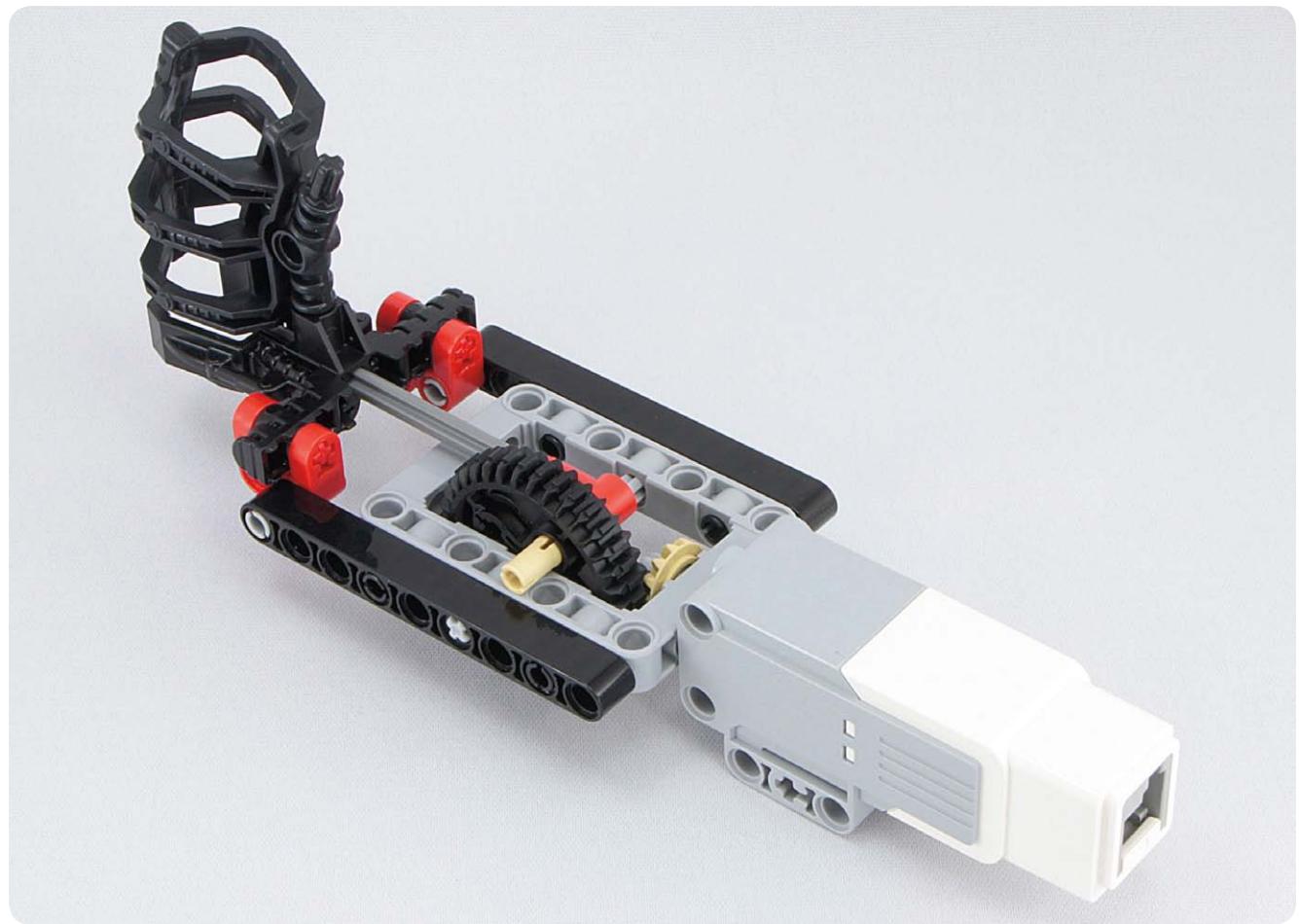




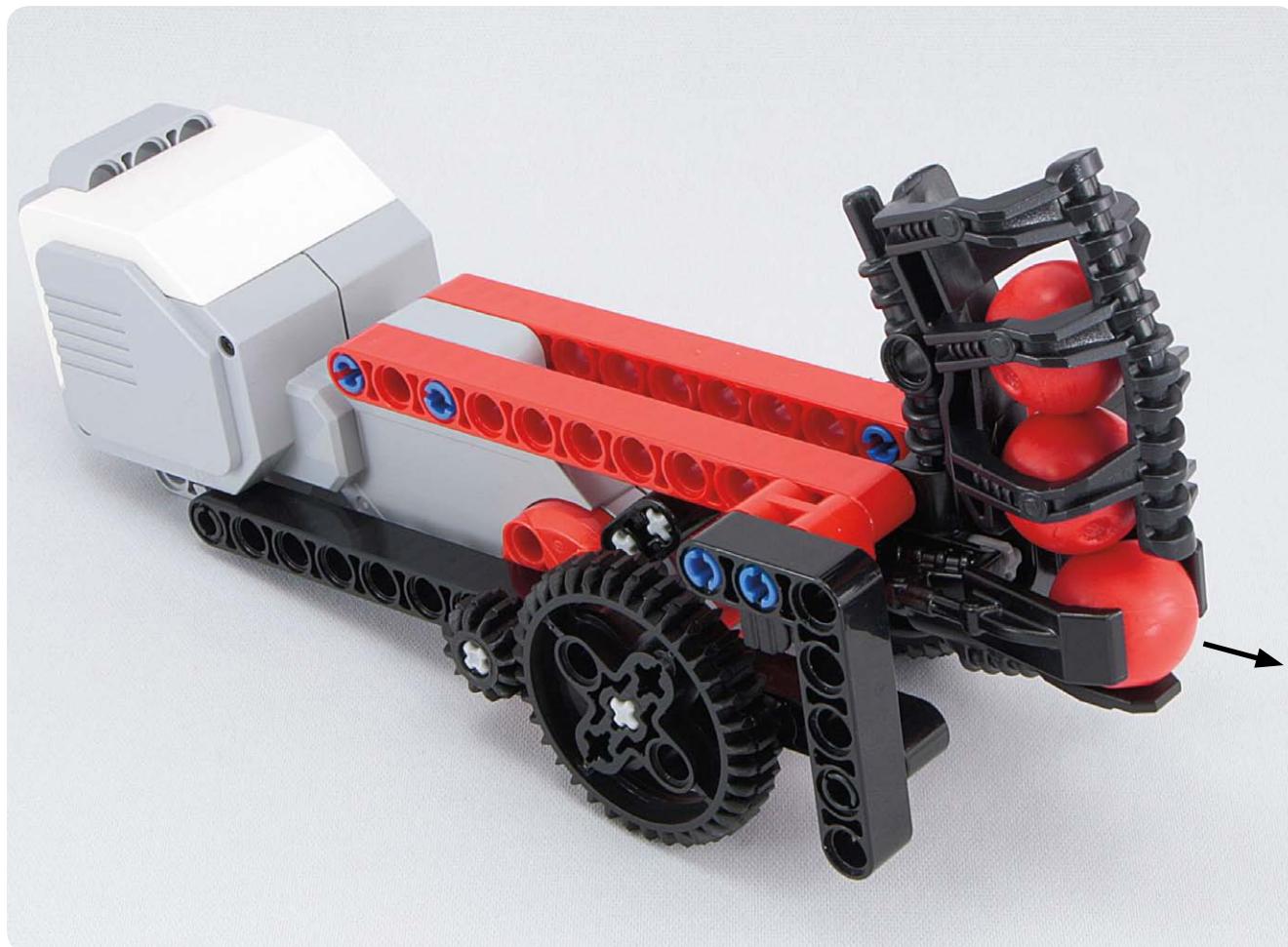
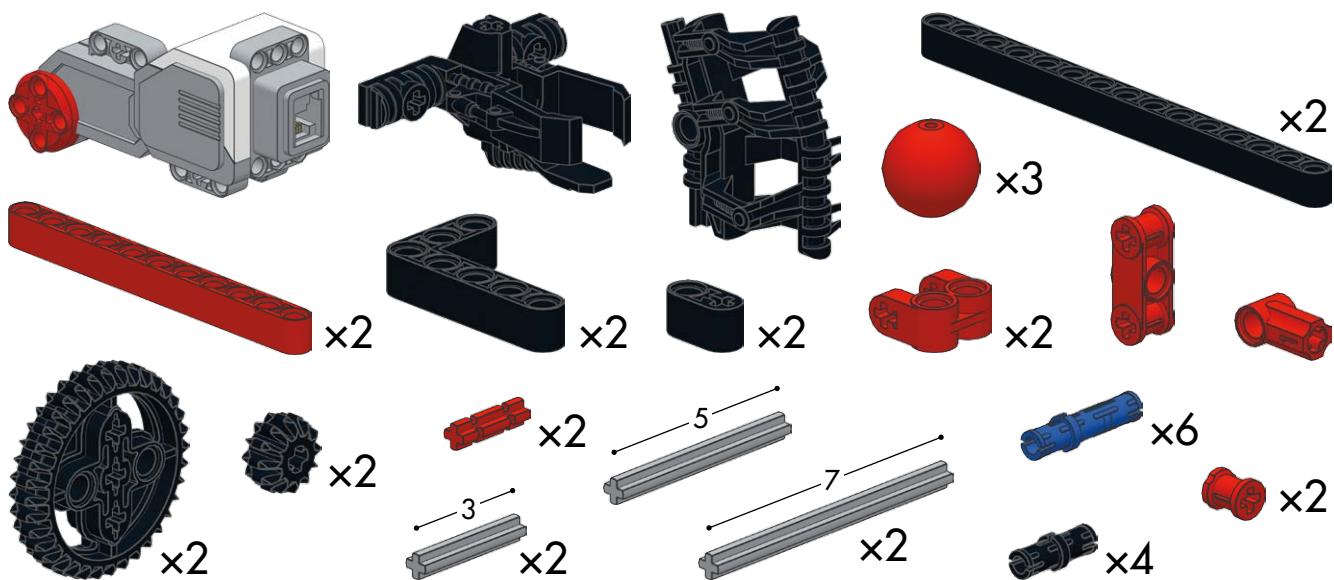
# Shooting things

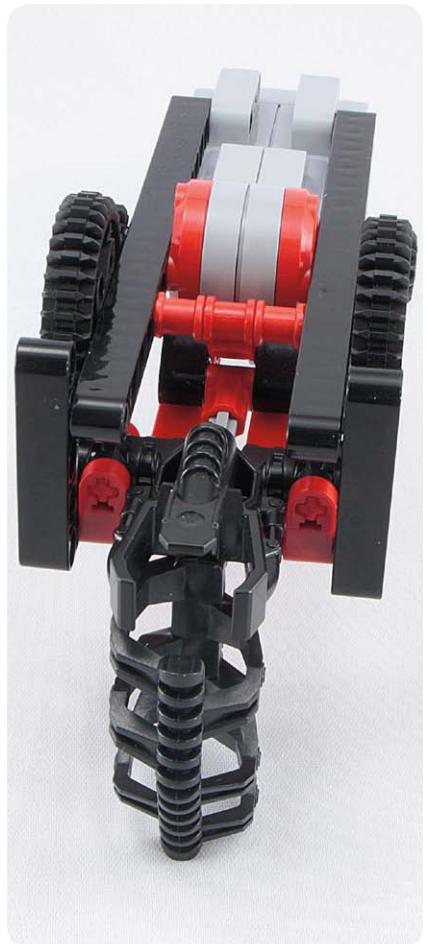
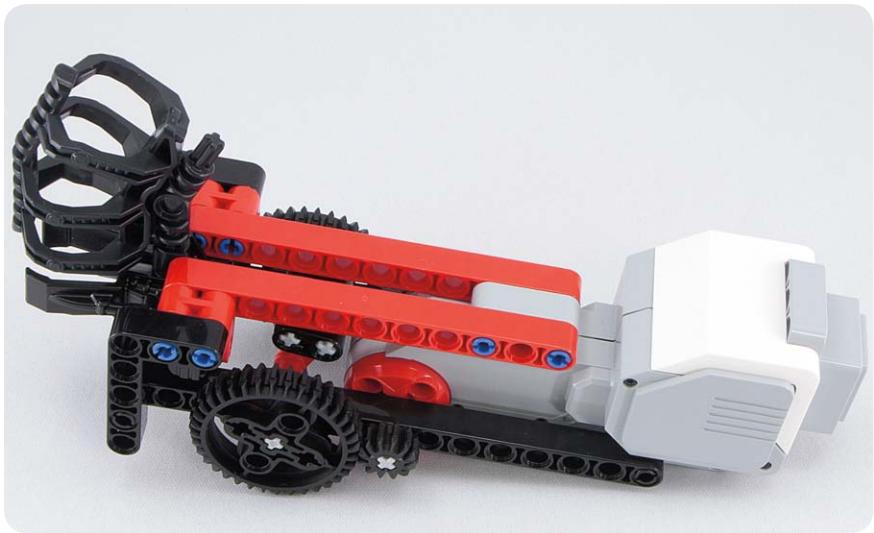
#143



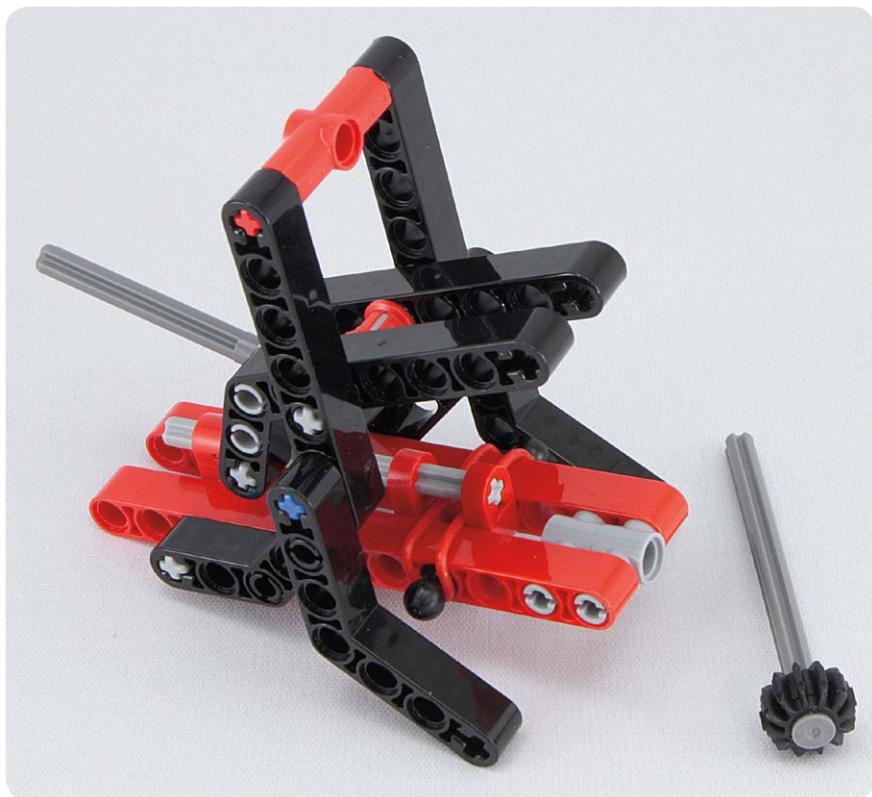
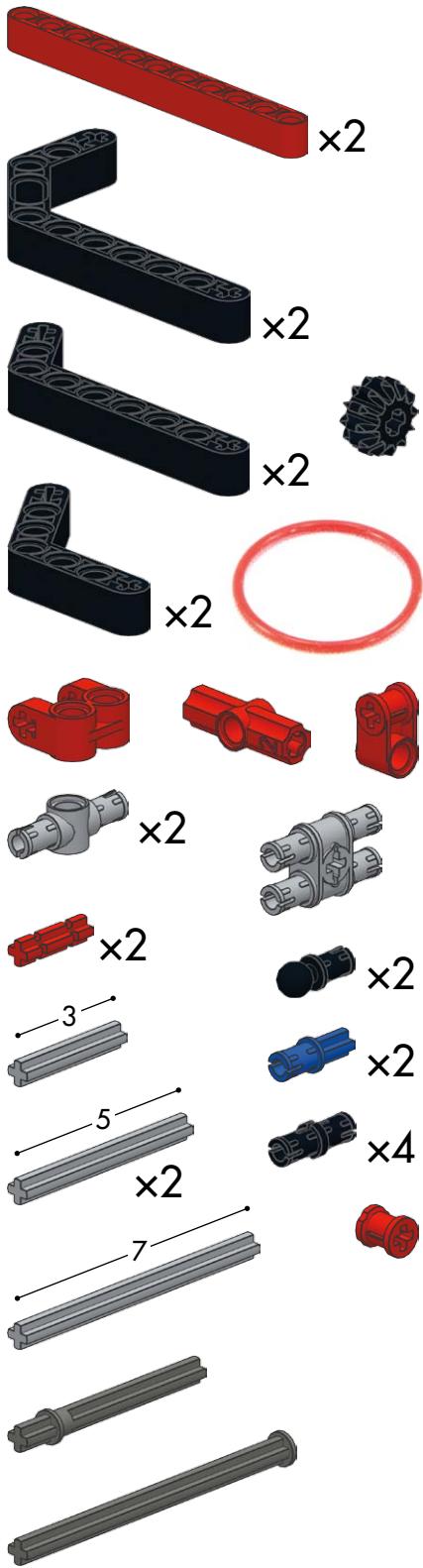


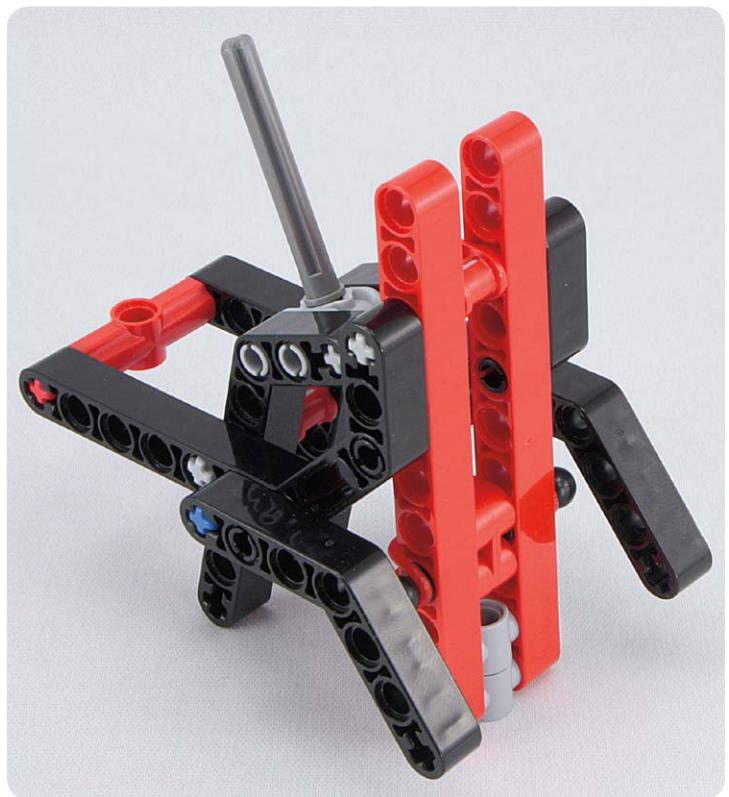
#144





#145



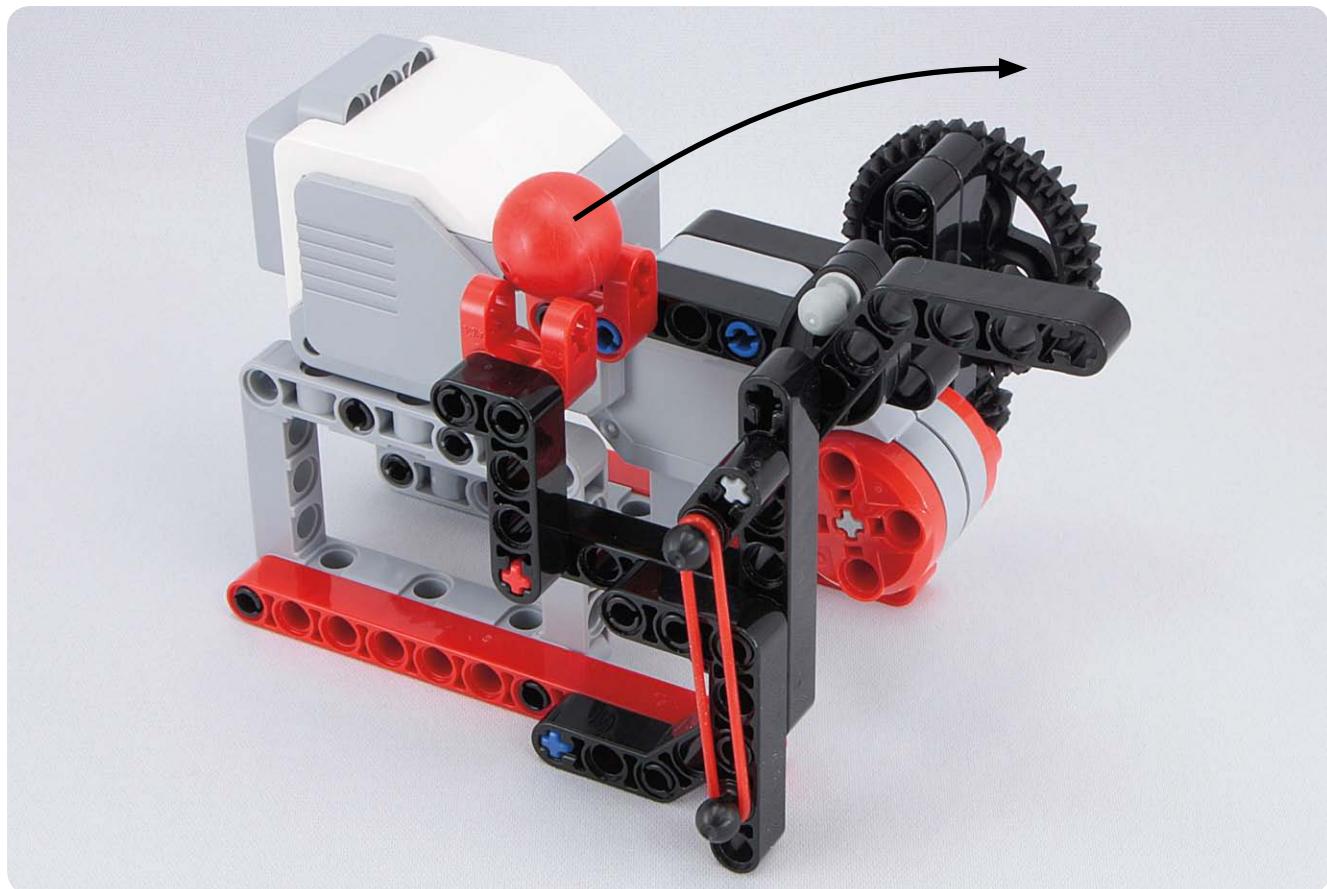
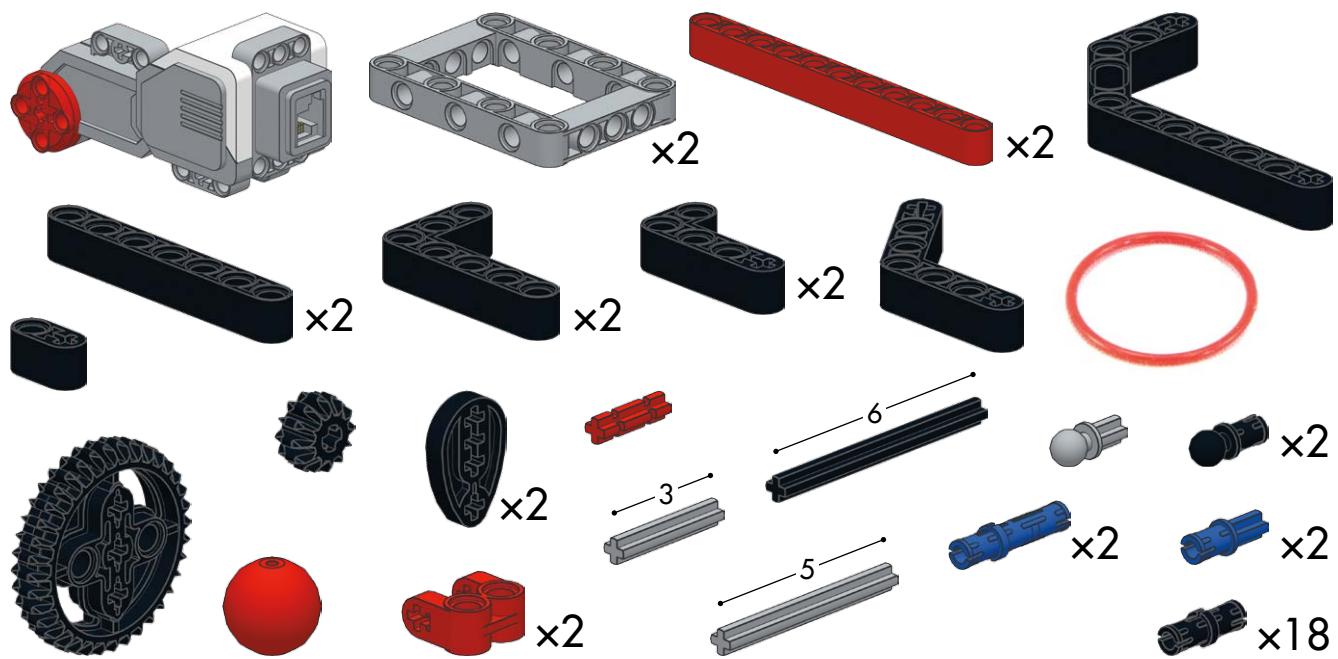


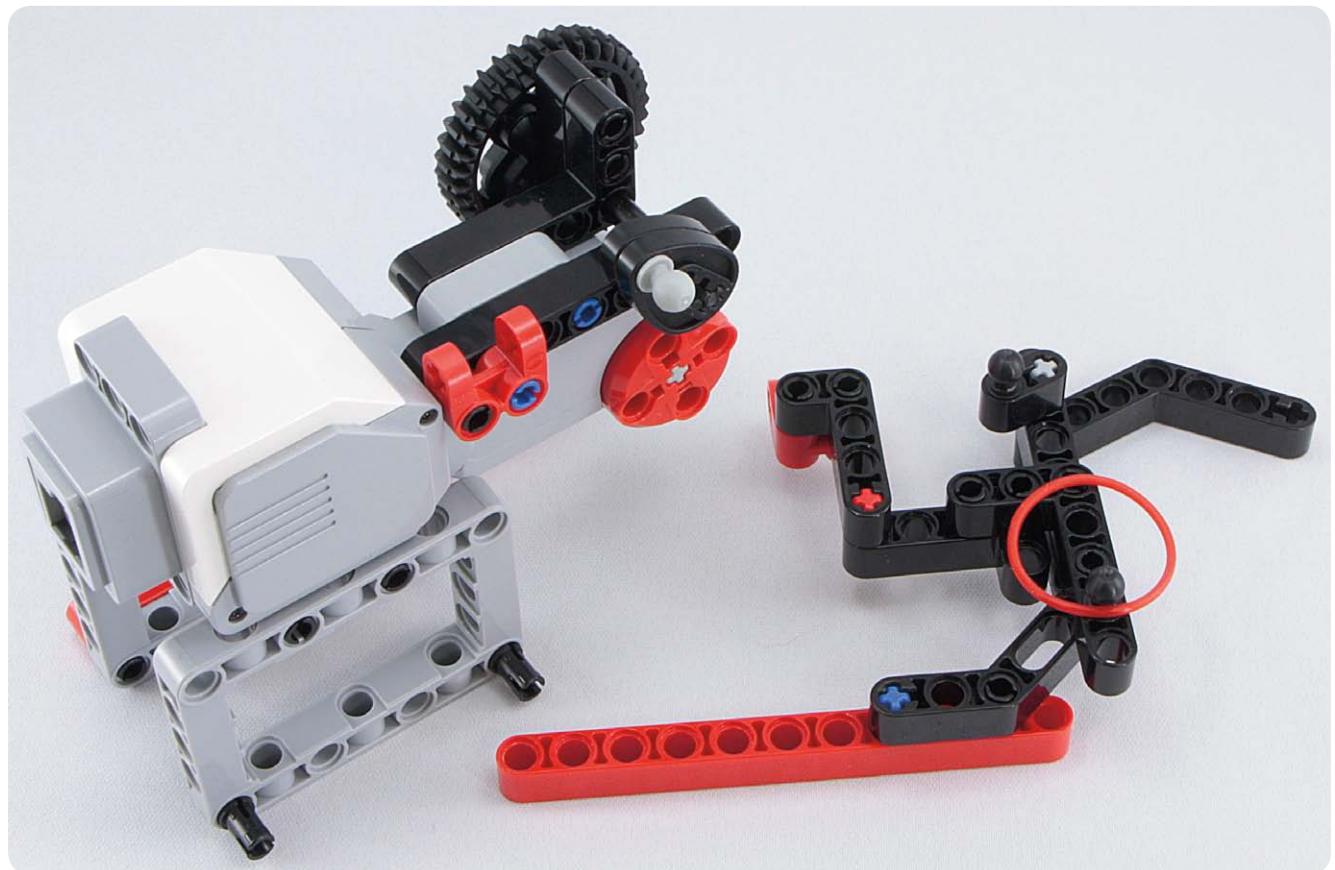
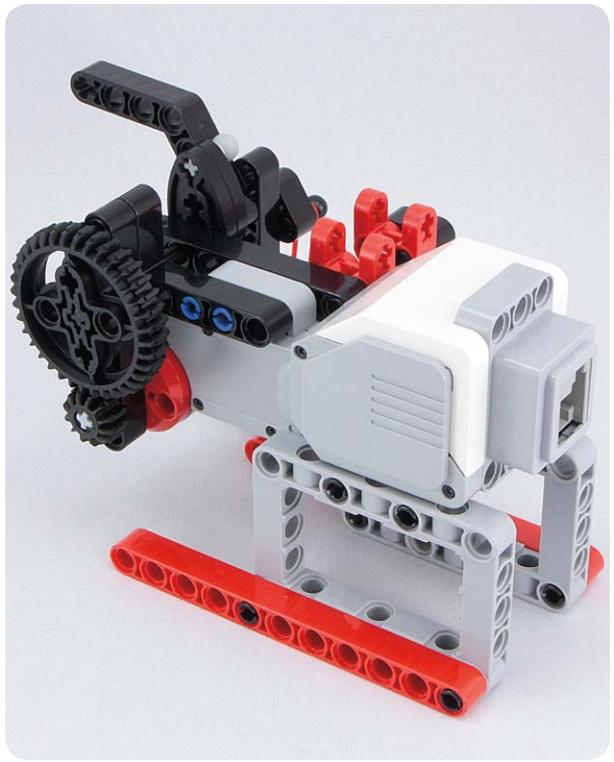
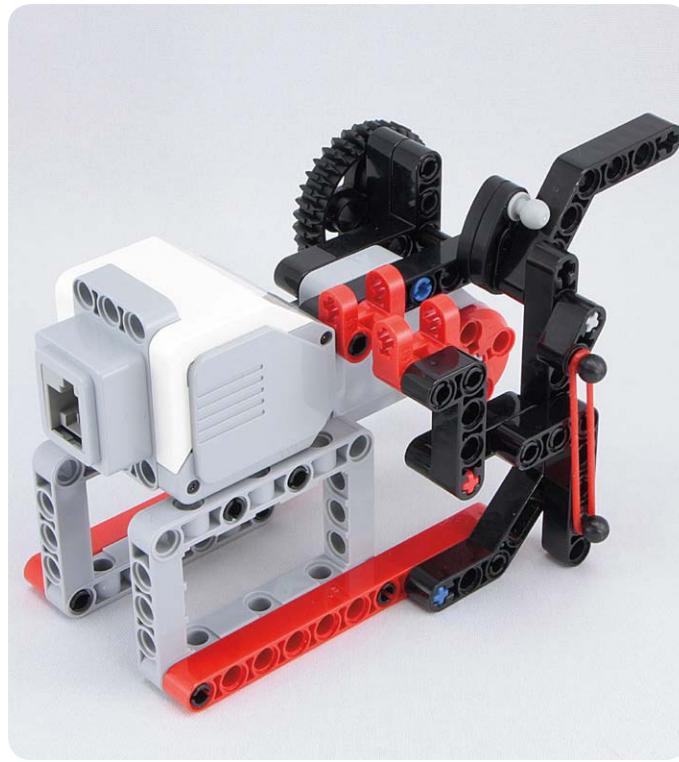
## #146

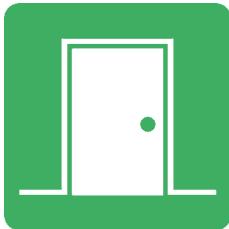




# #147

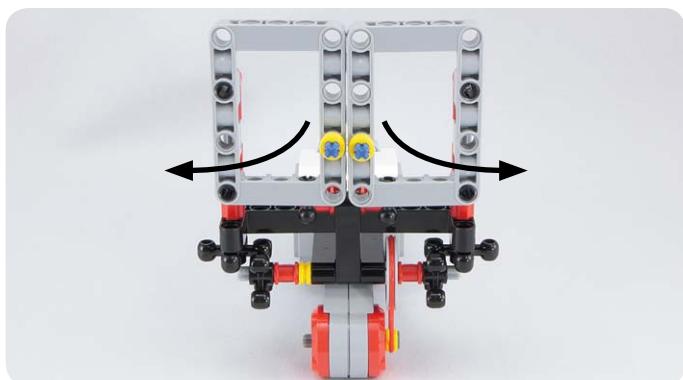
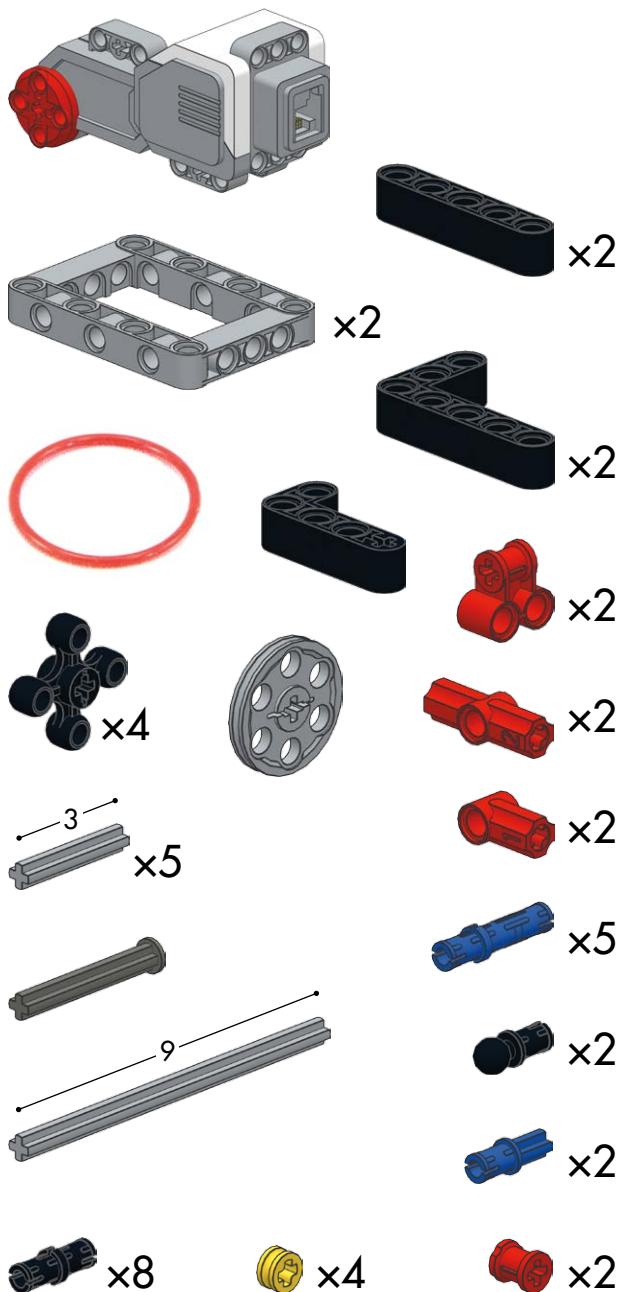


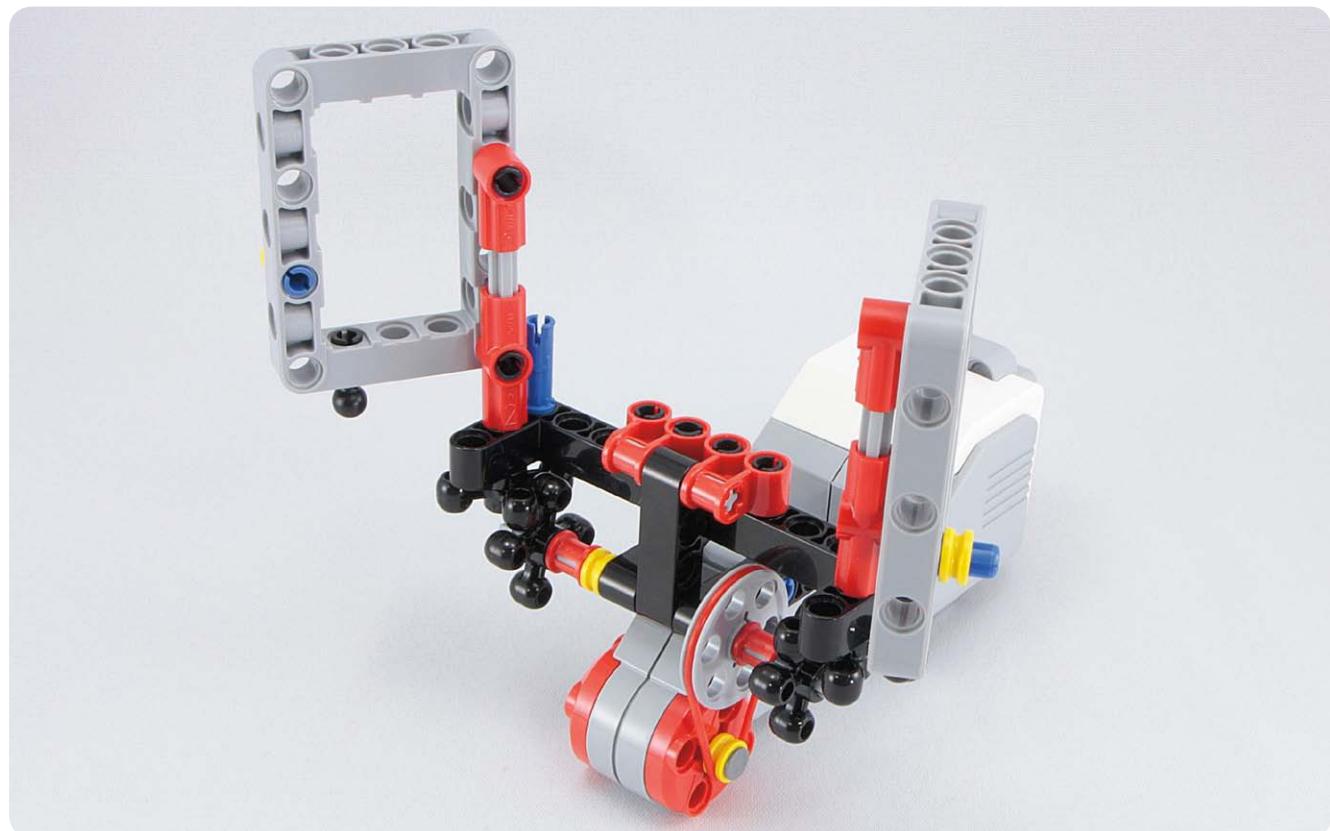
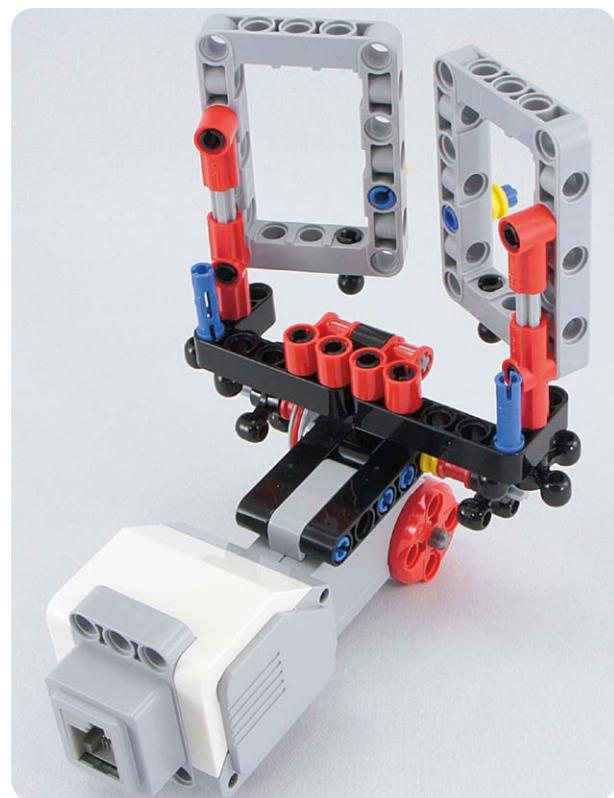
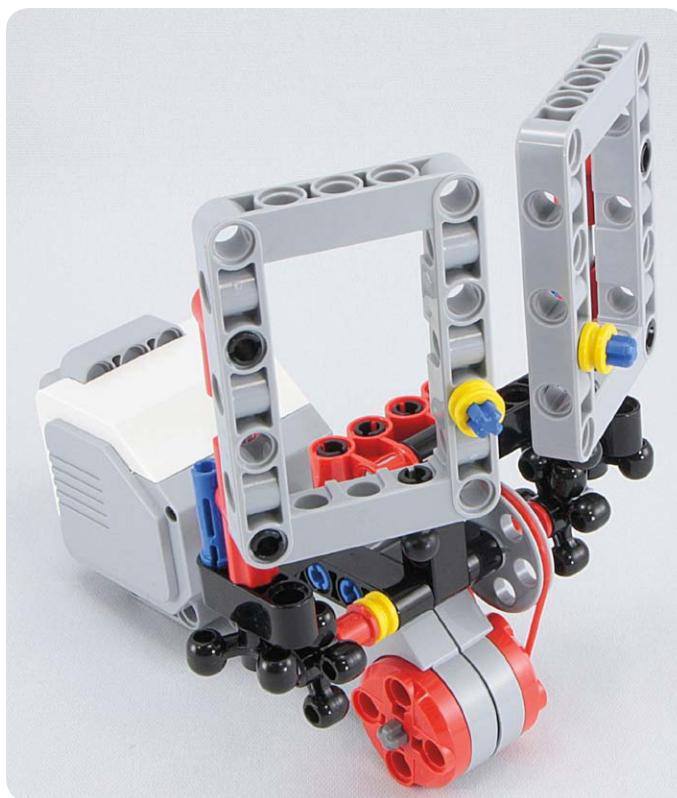




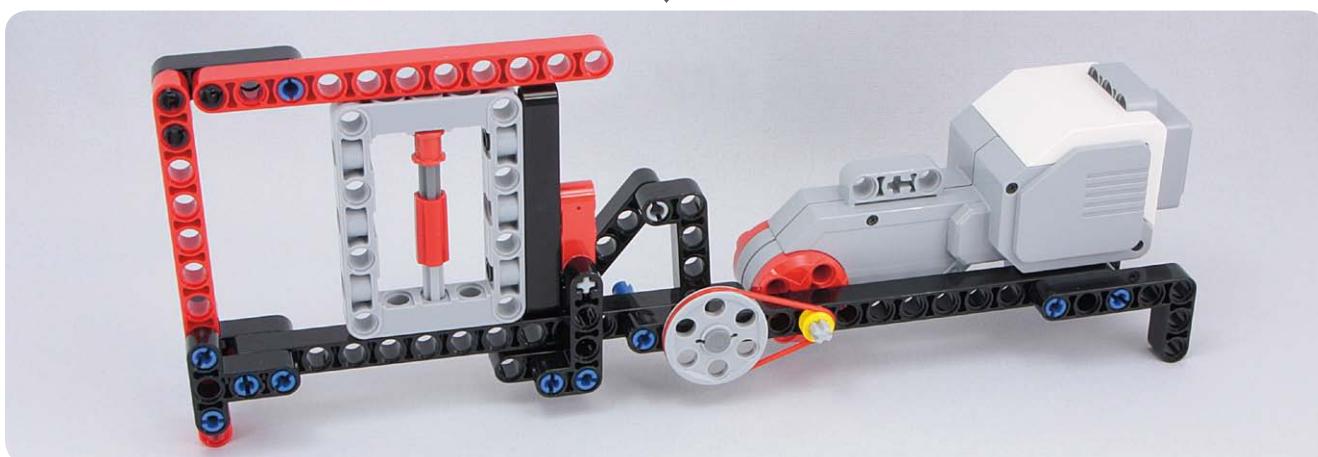
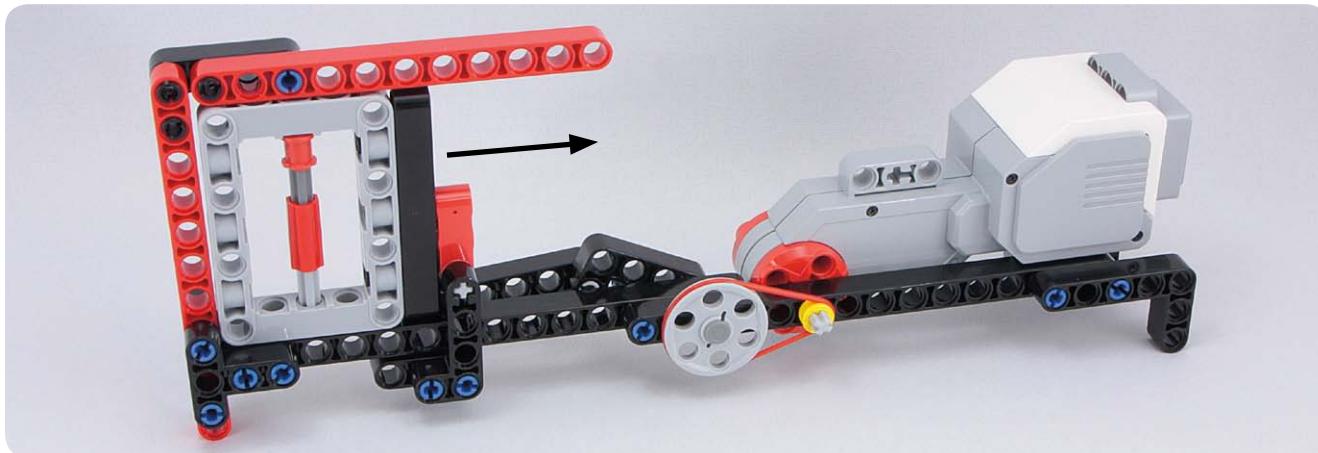
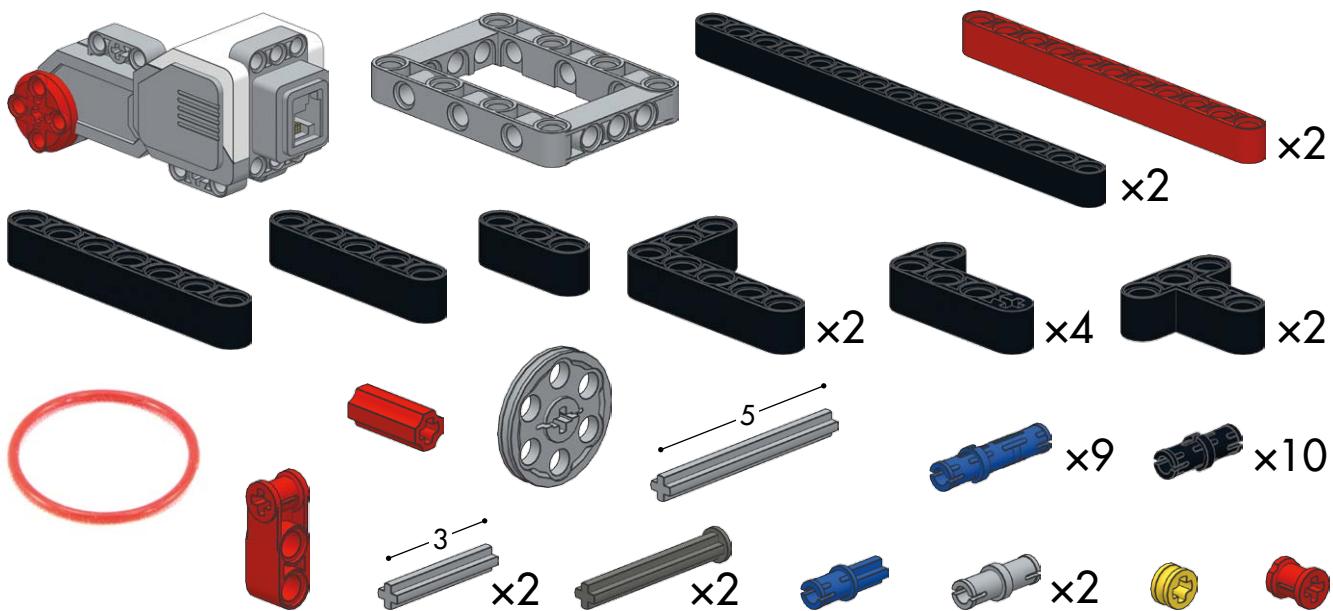
# Automatic doors

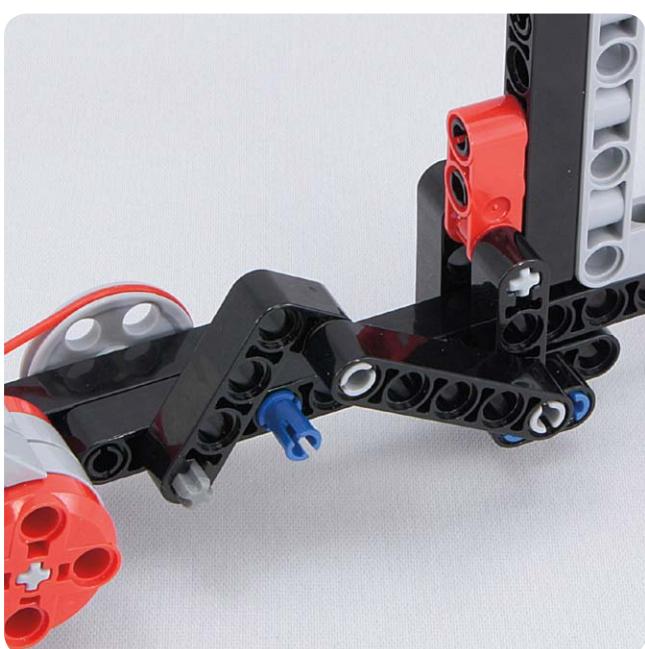
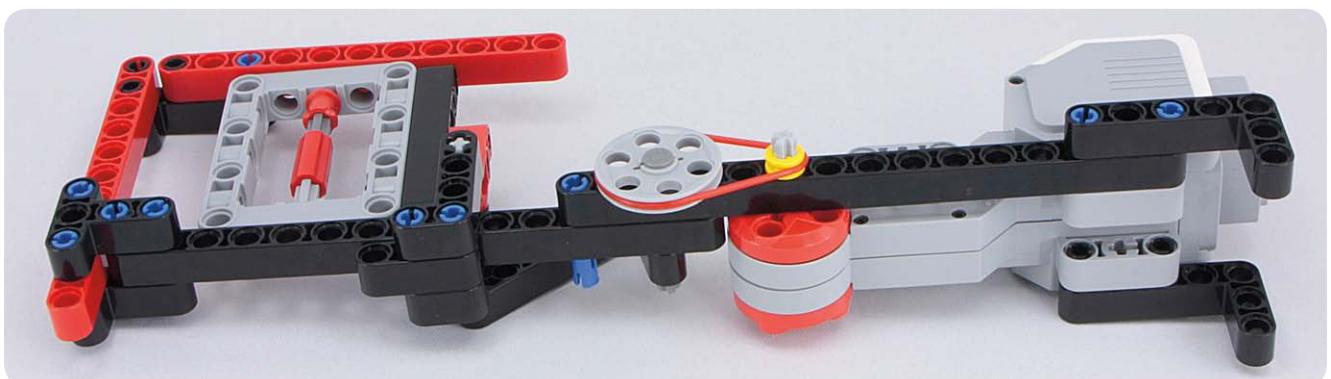
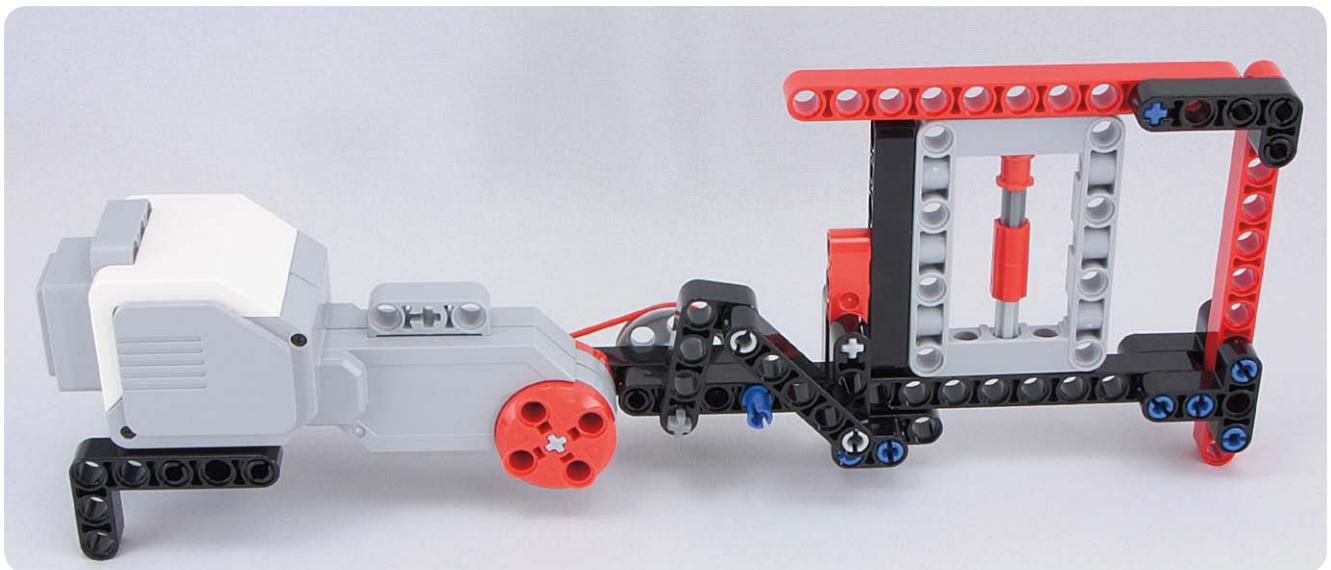
#148



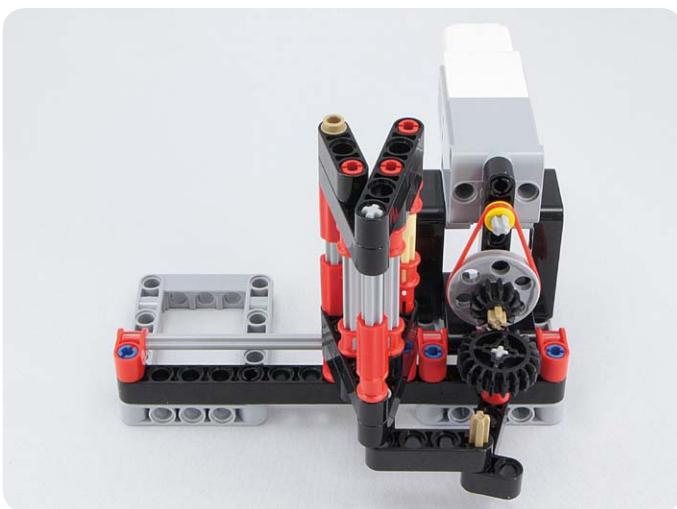
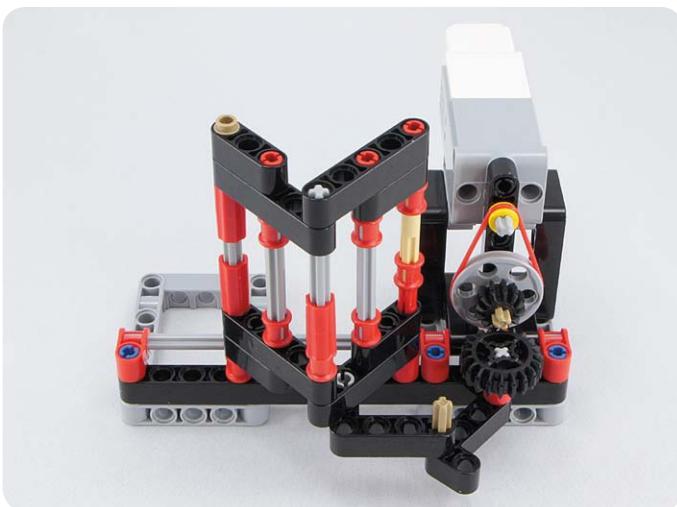
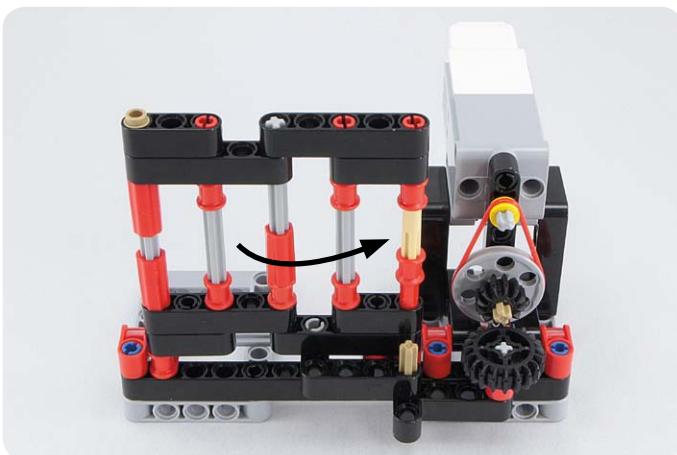


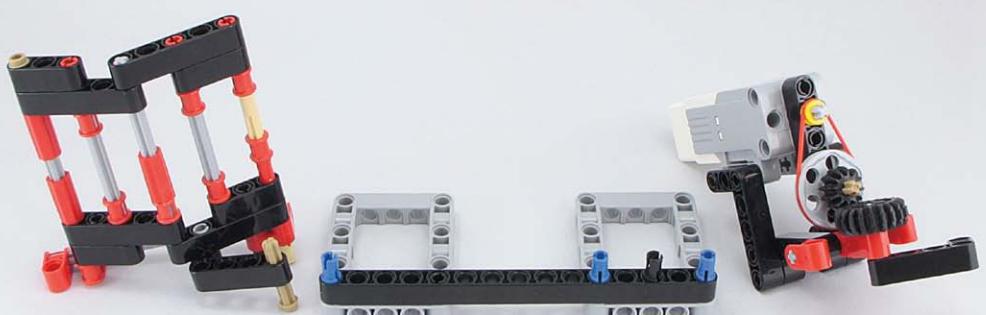
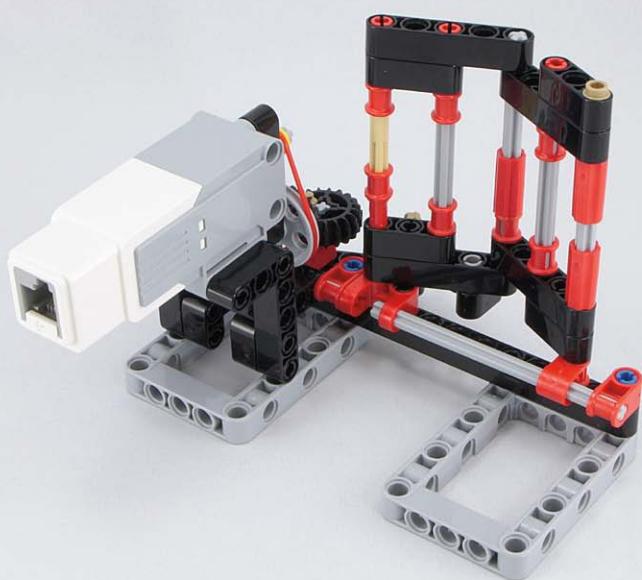
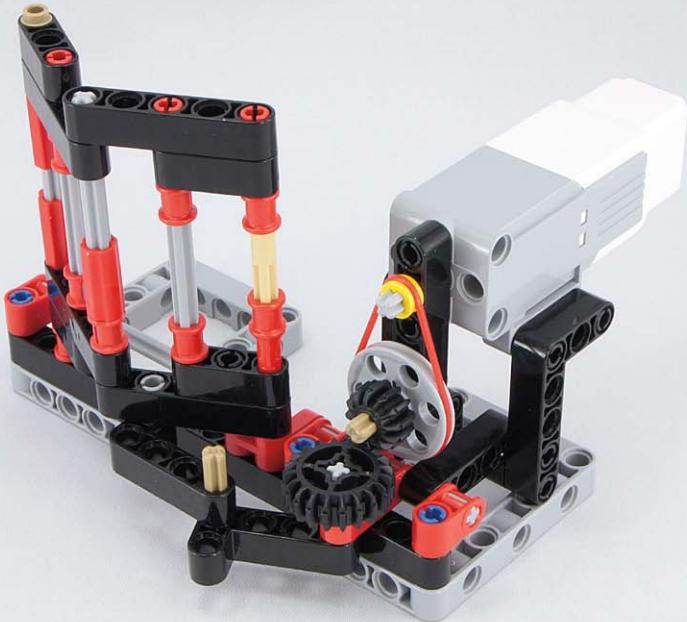
#149

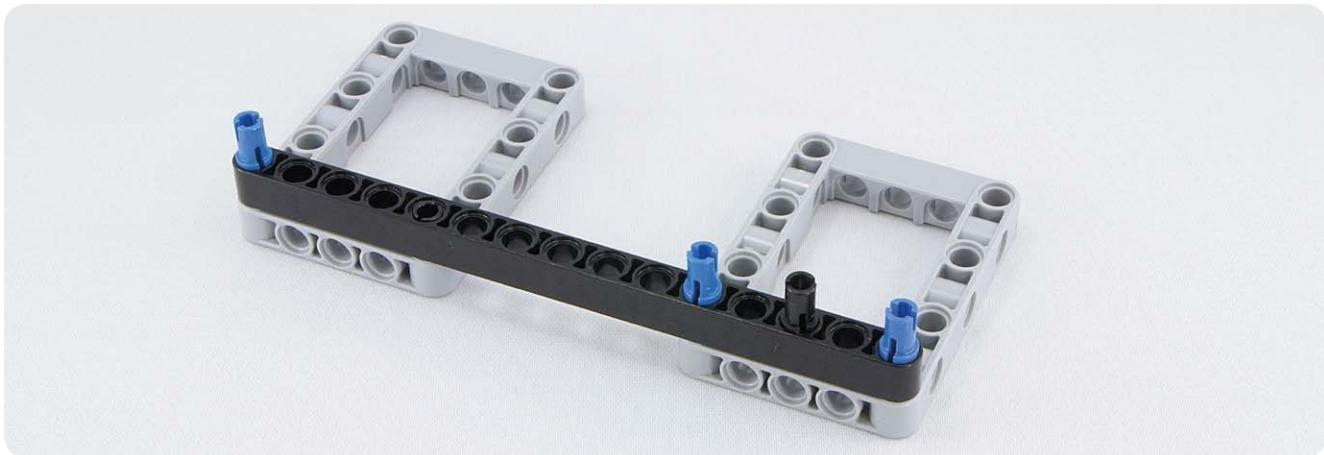


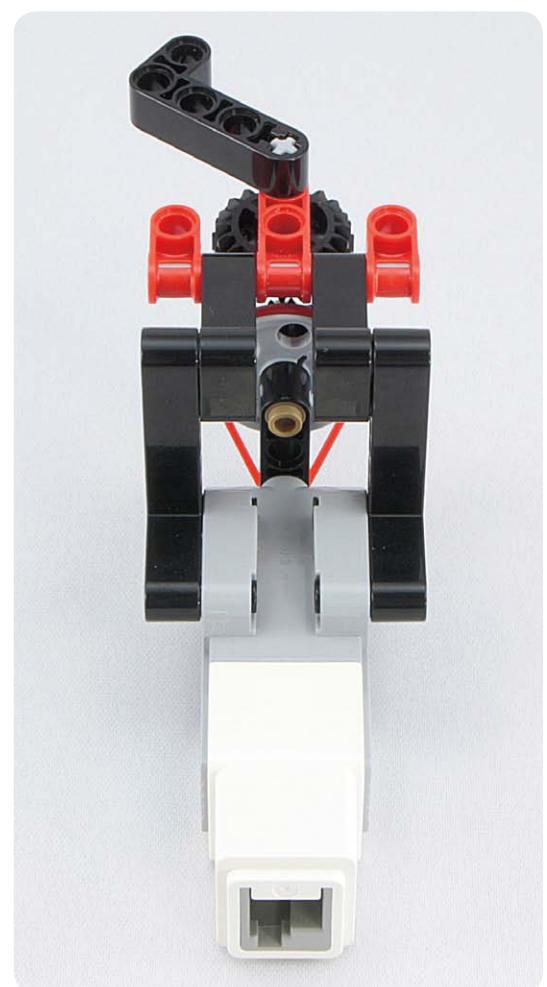
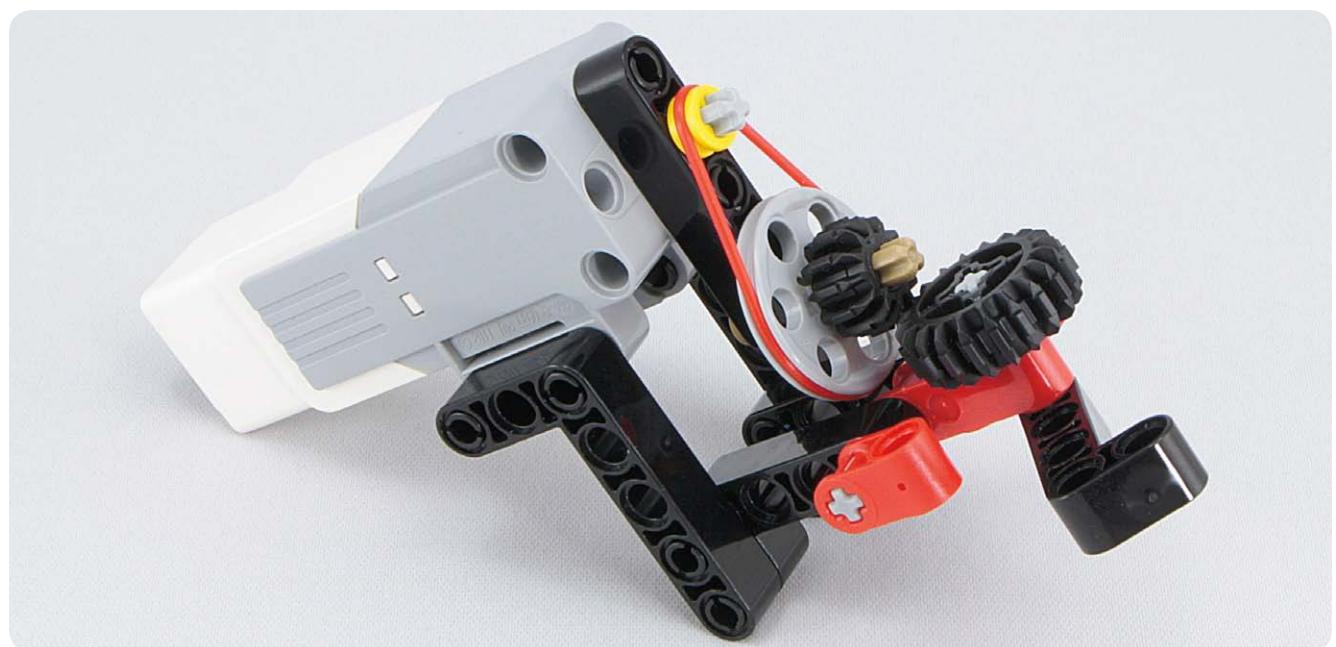


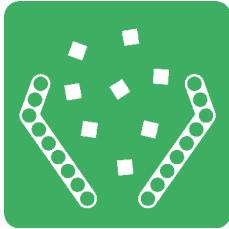
#150





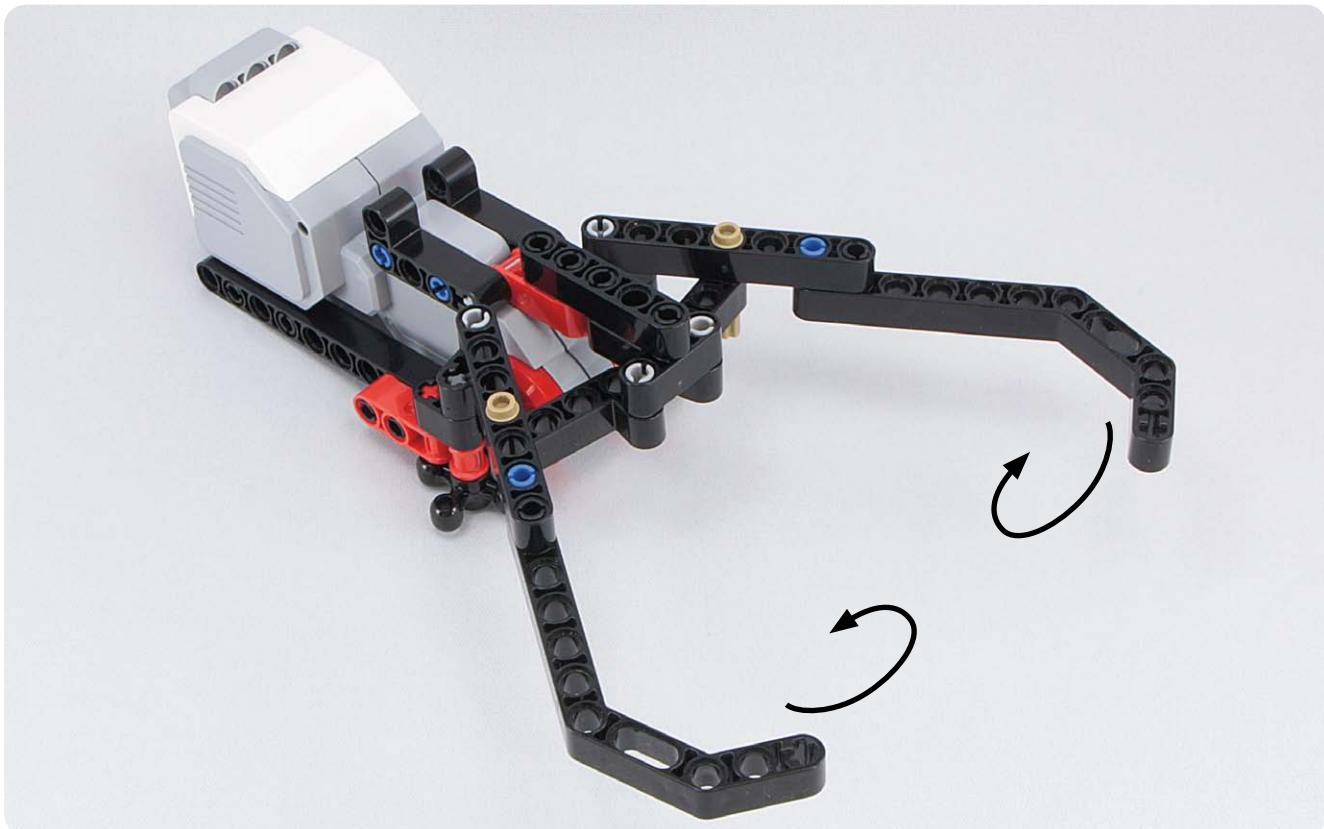
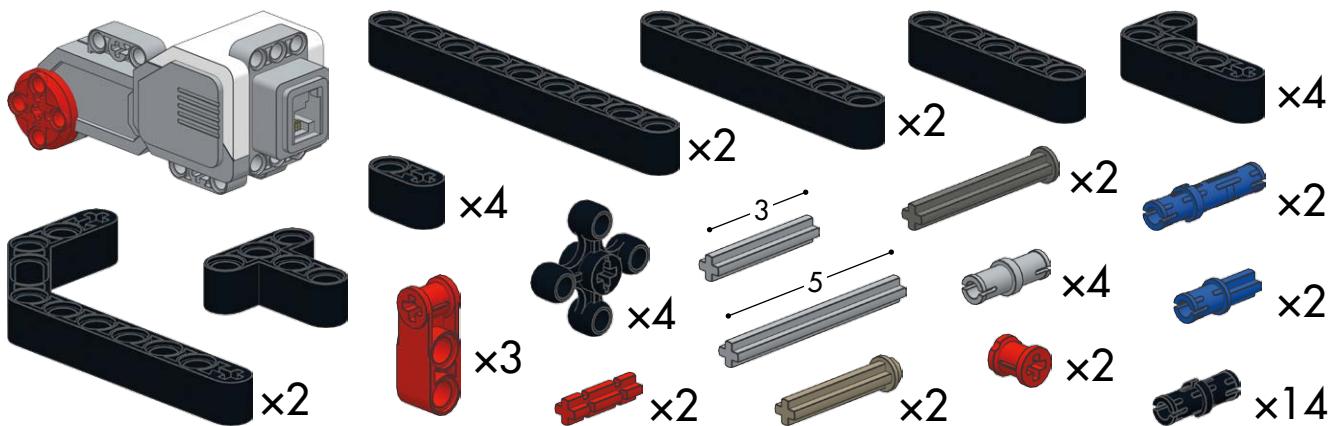


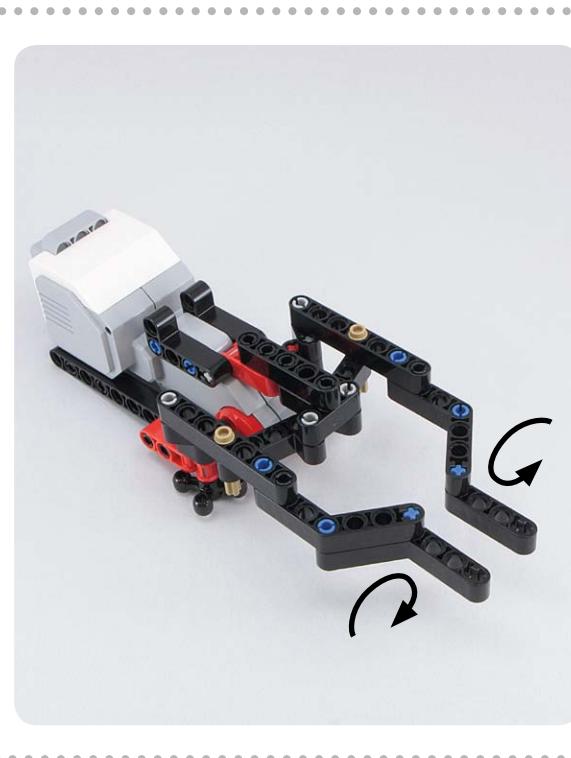
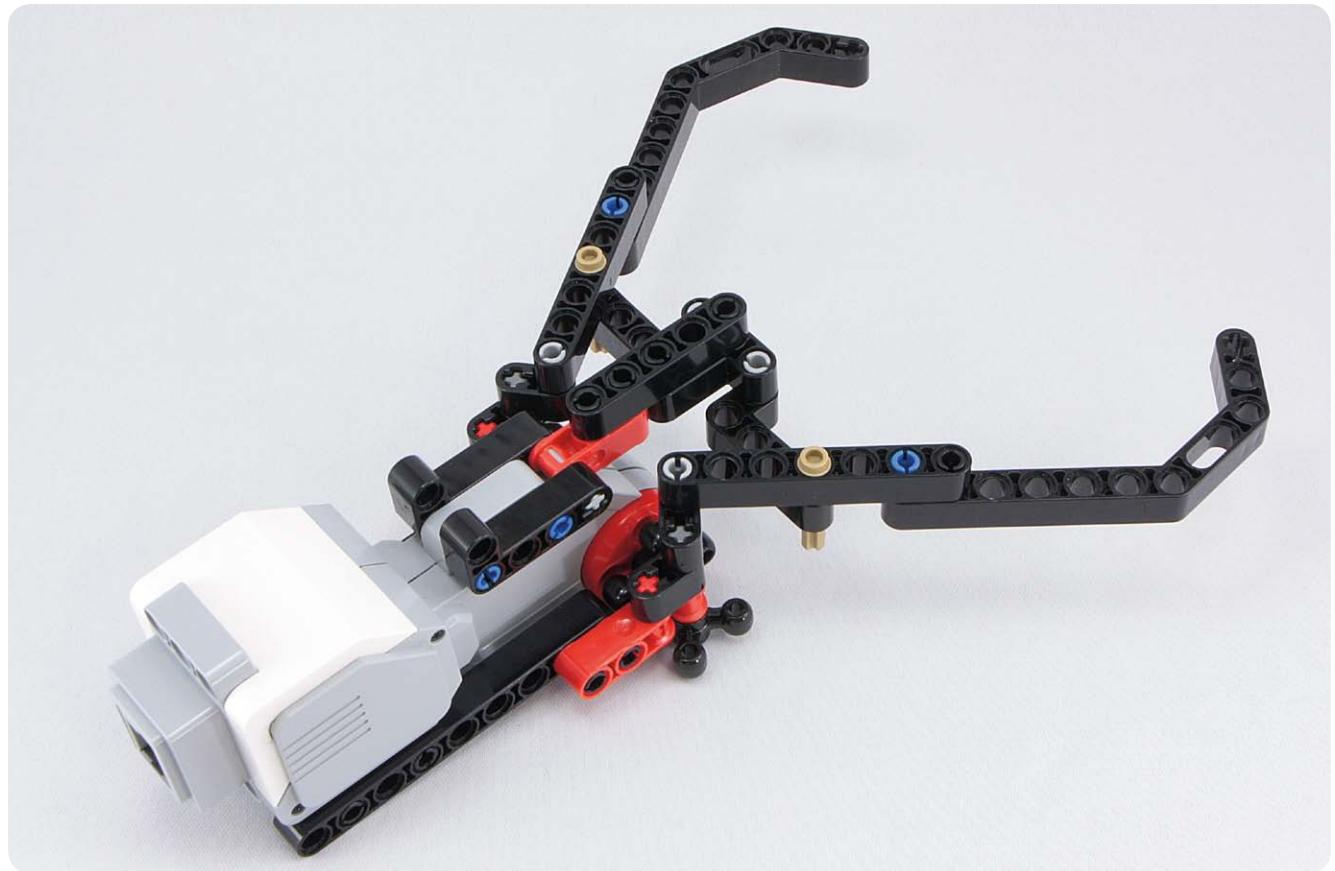




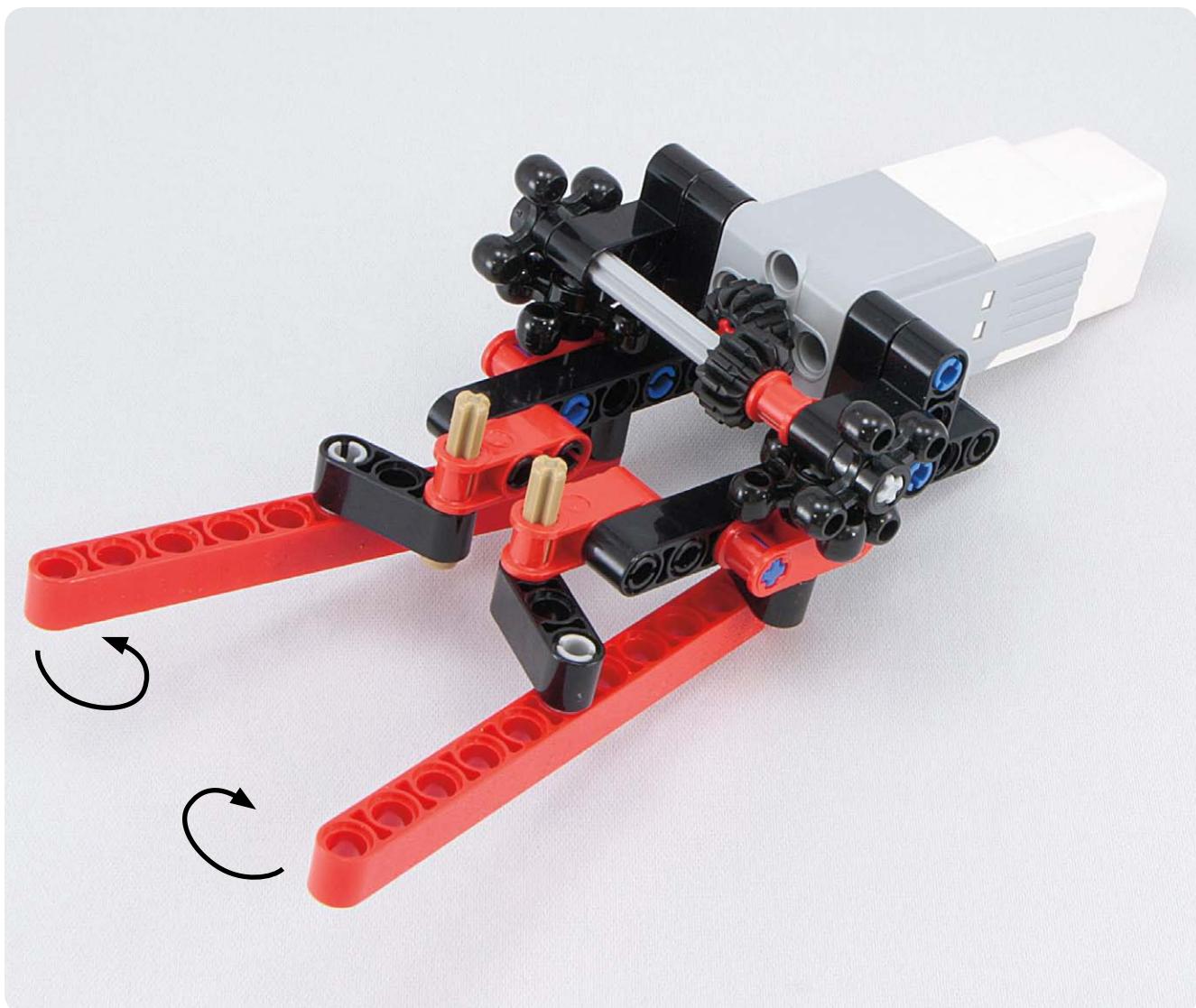
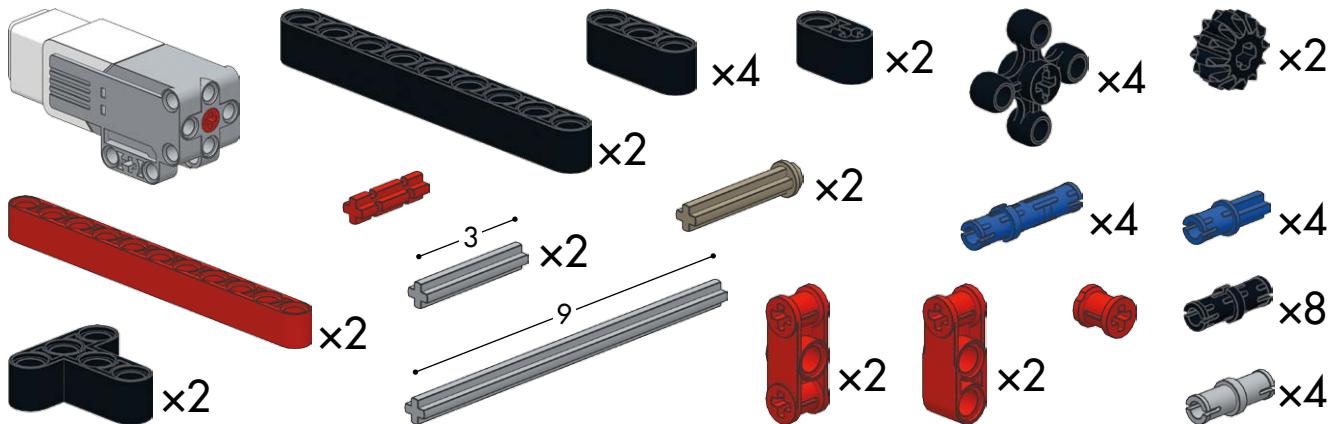
# Raking up or out

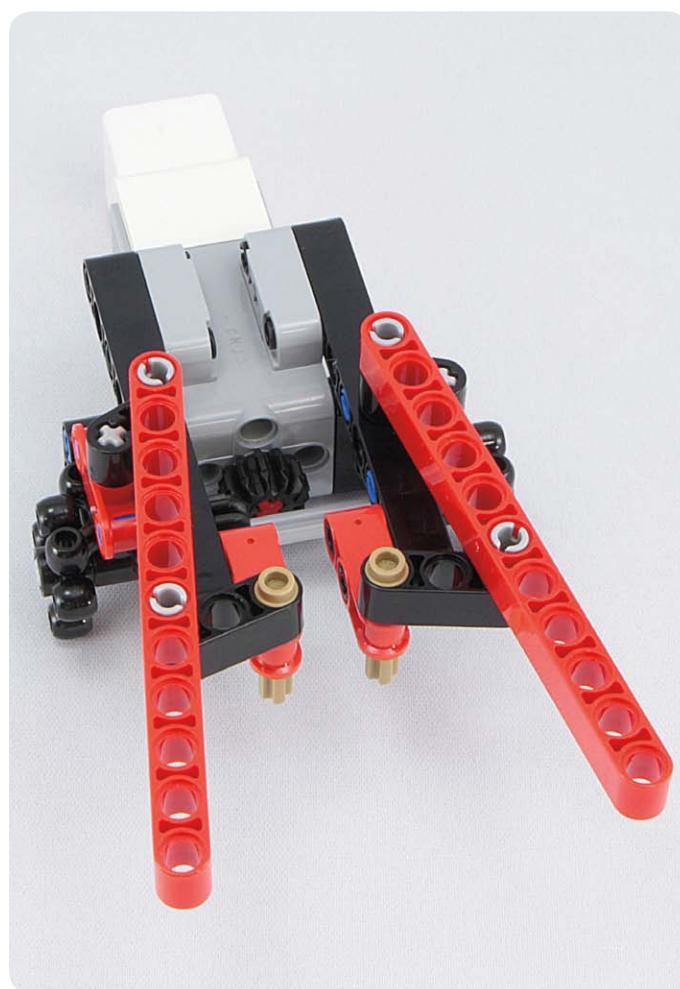
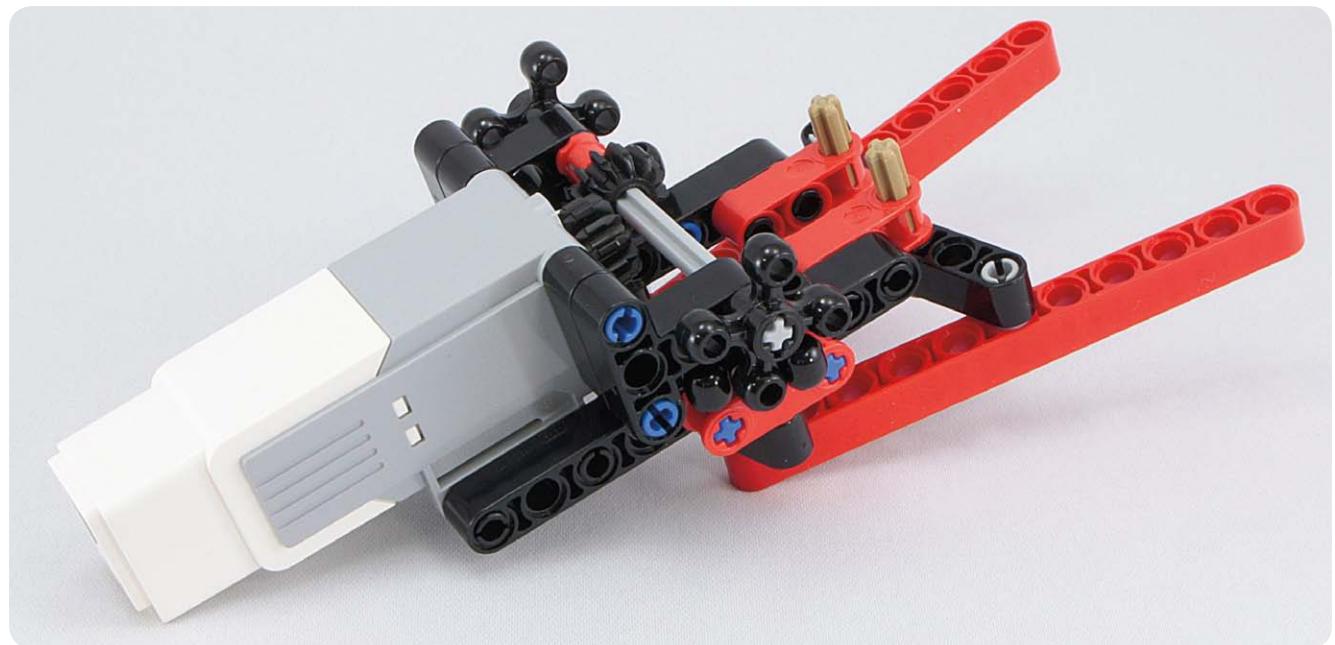
#151





#152

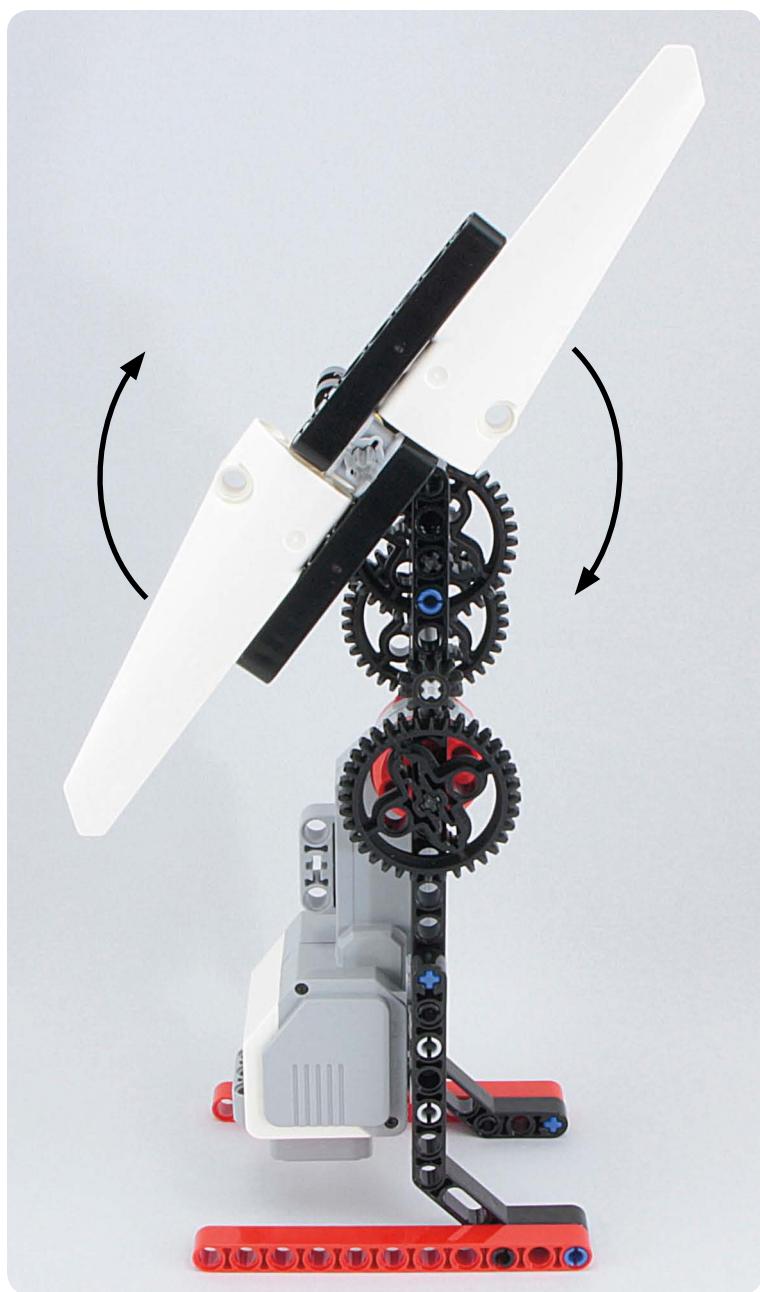


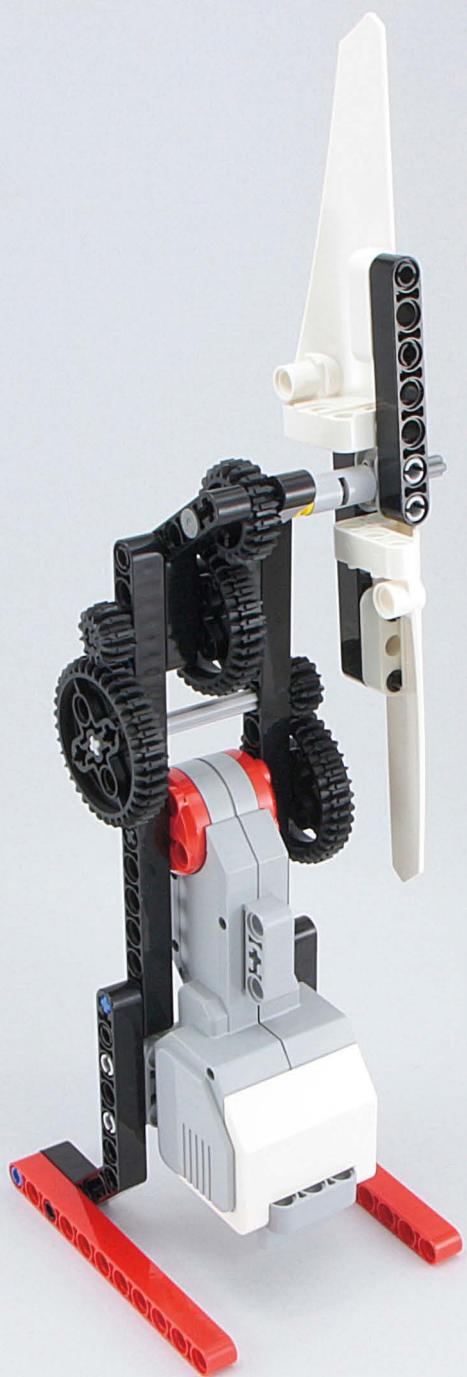
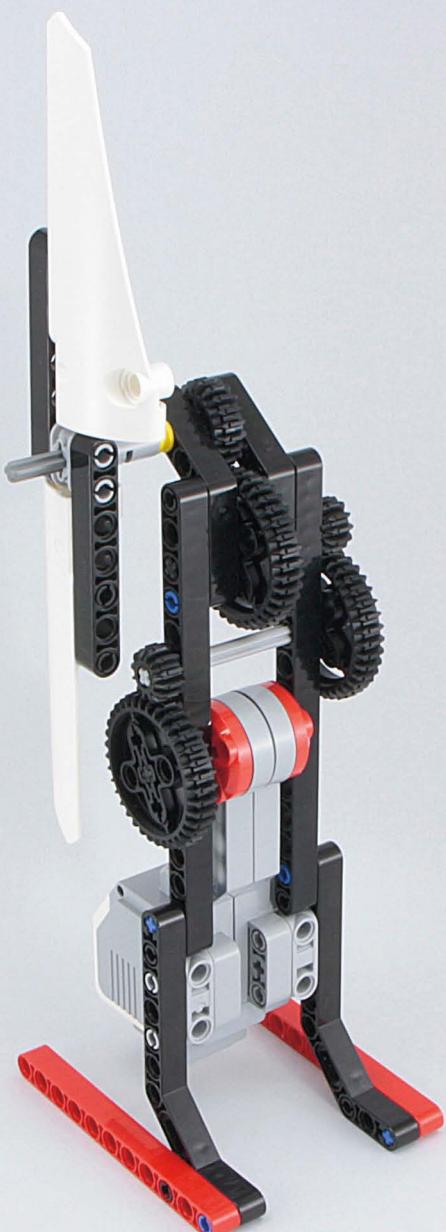




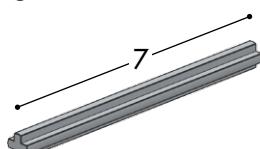
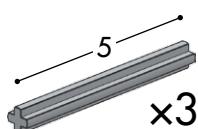
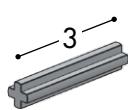
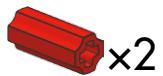
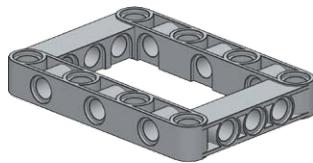
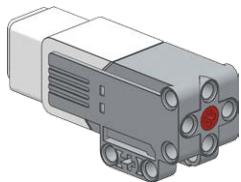
# Creating wind

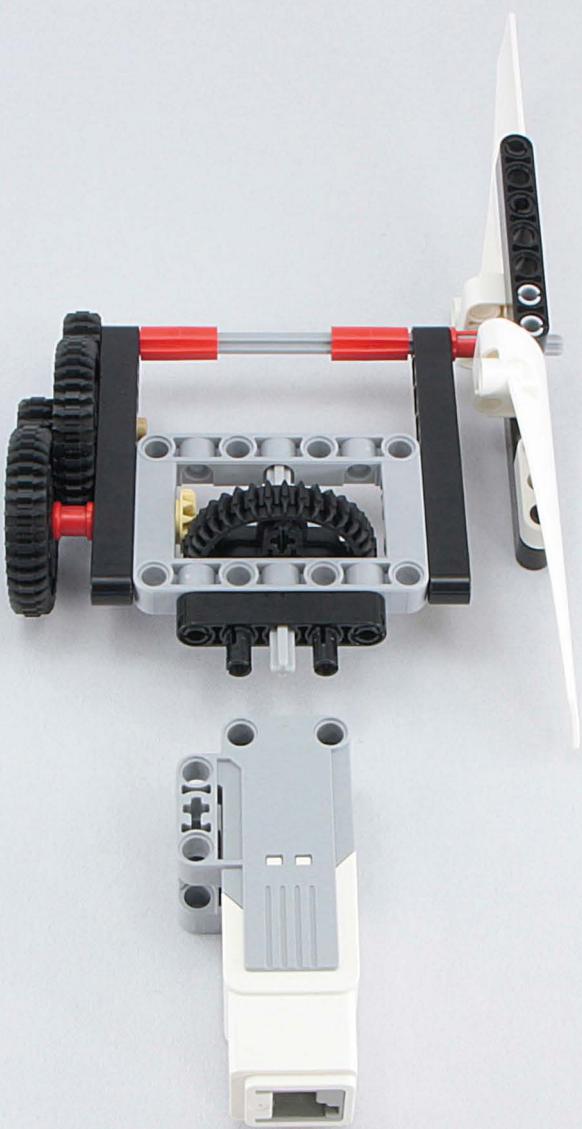
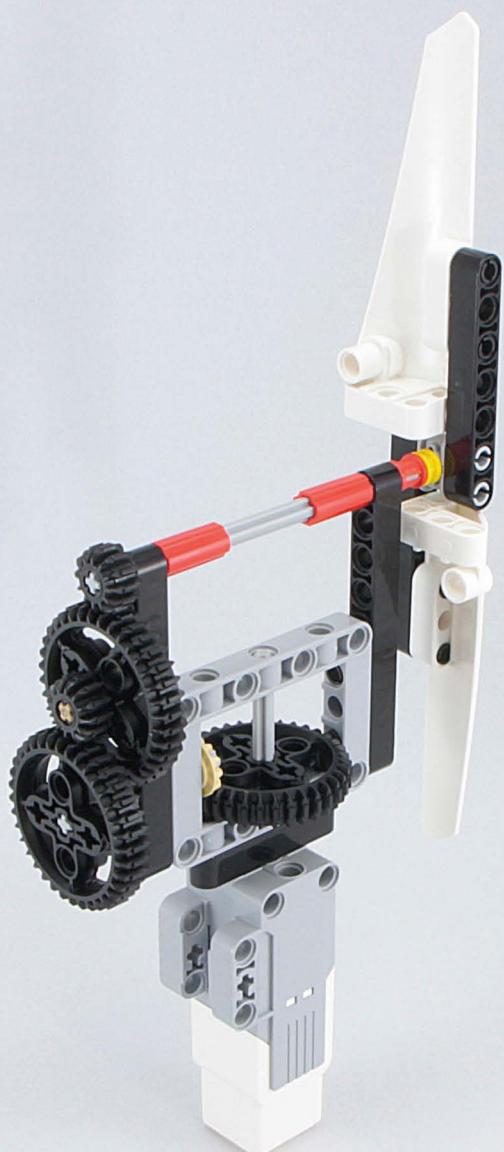
#153

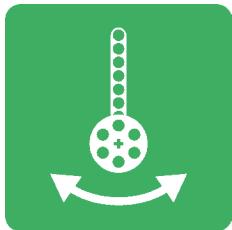




# #154

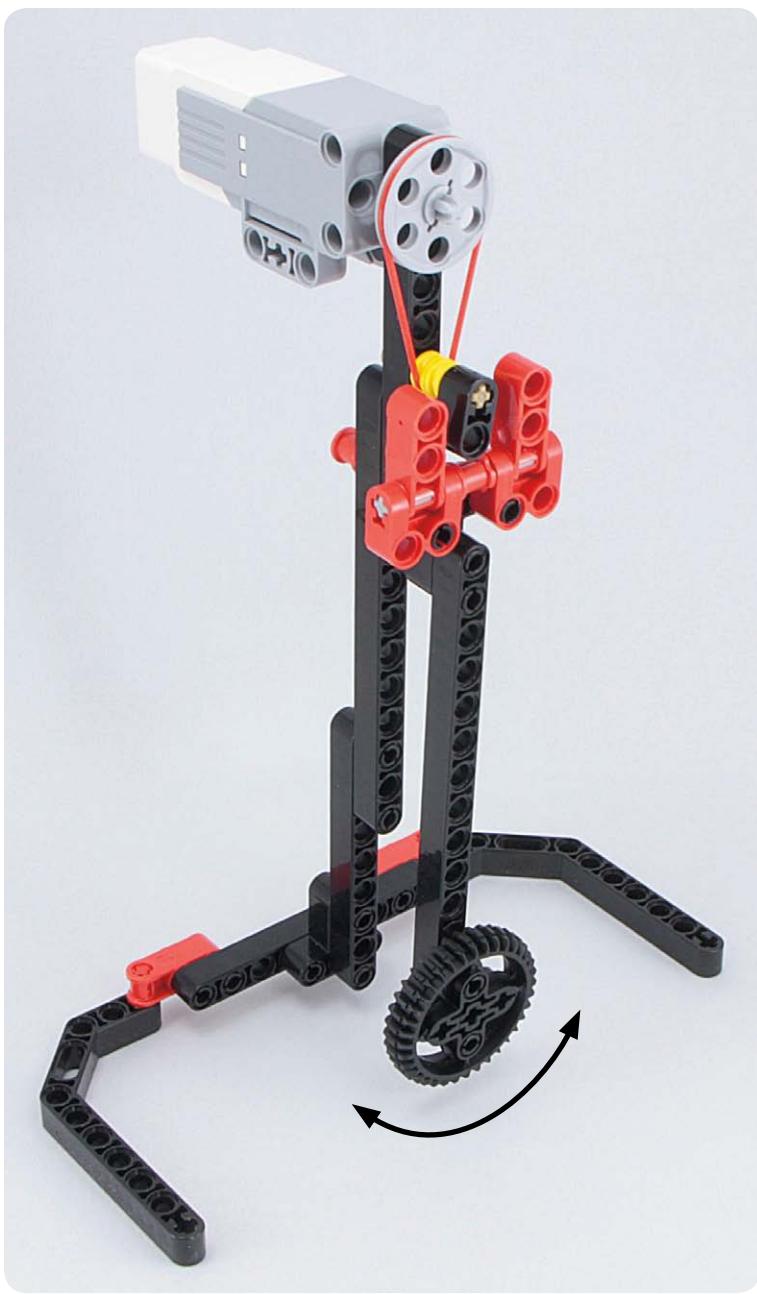
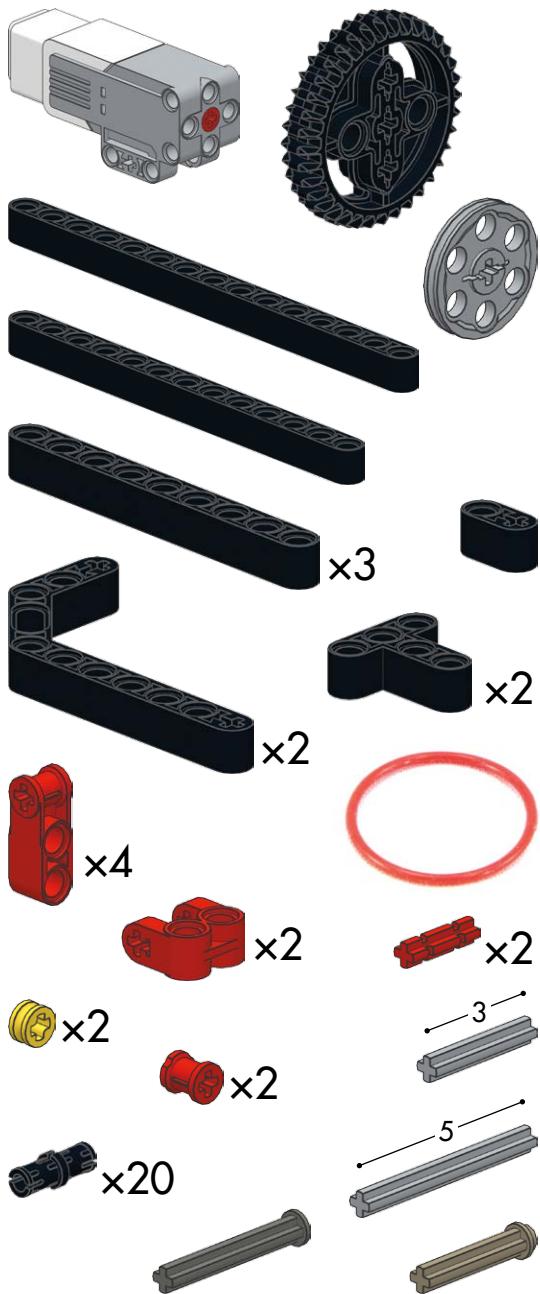


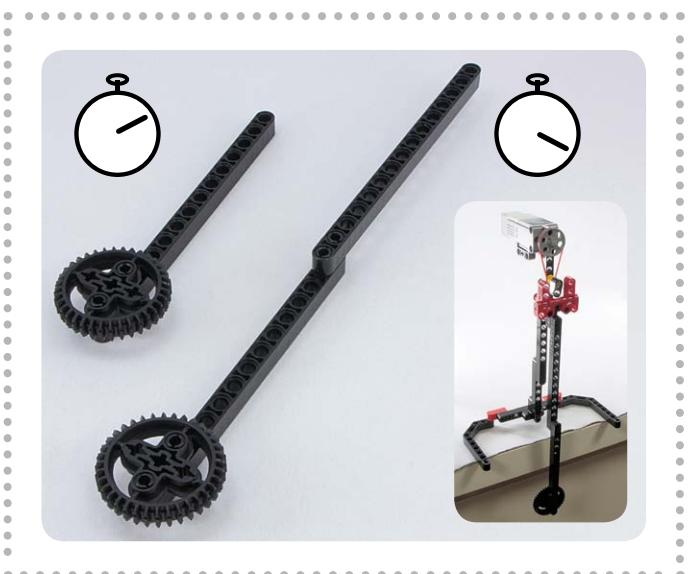
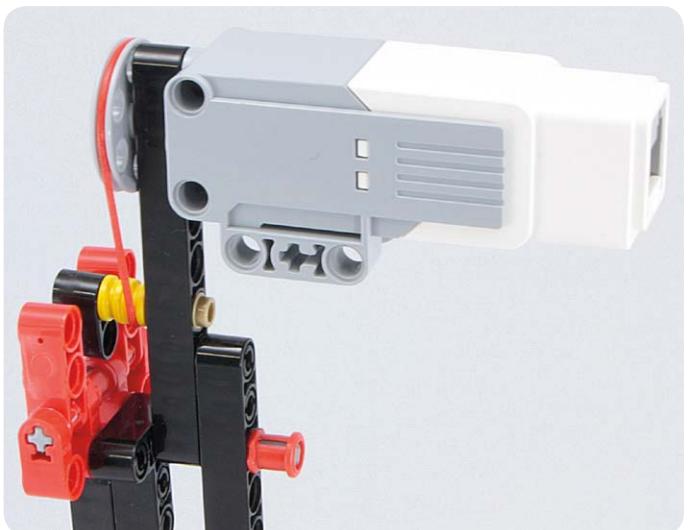




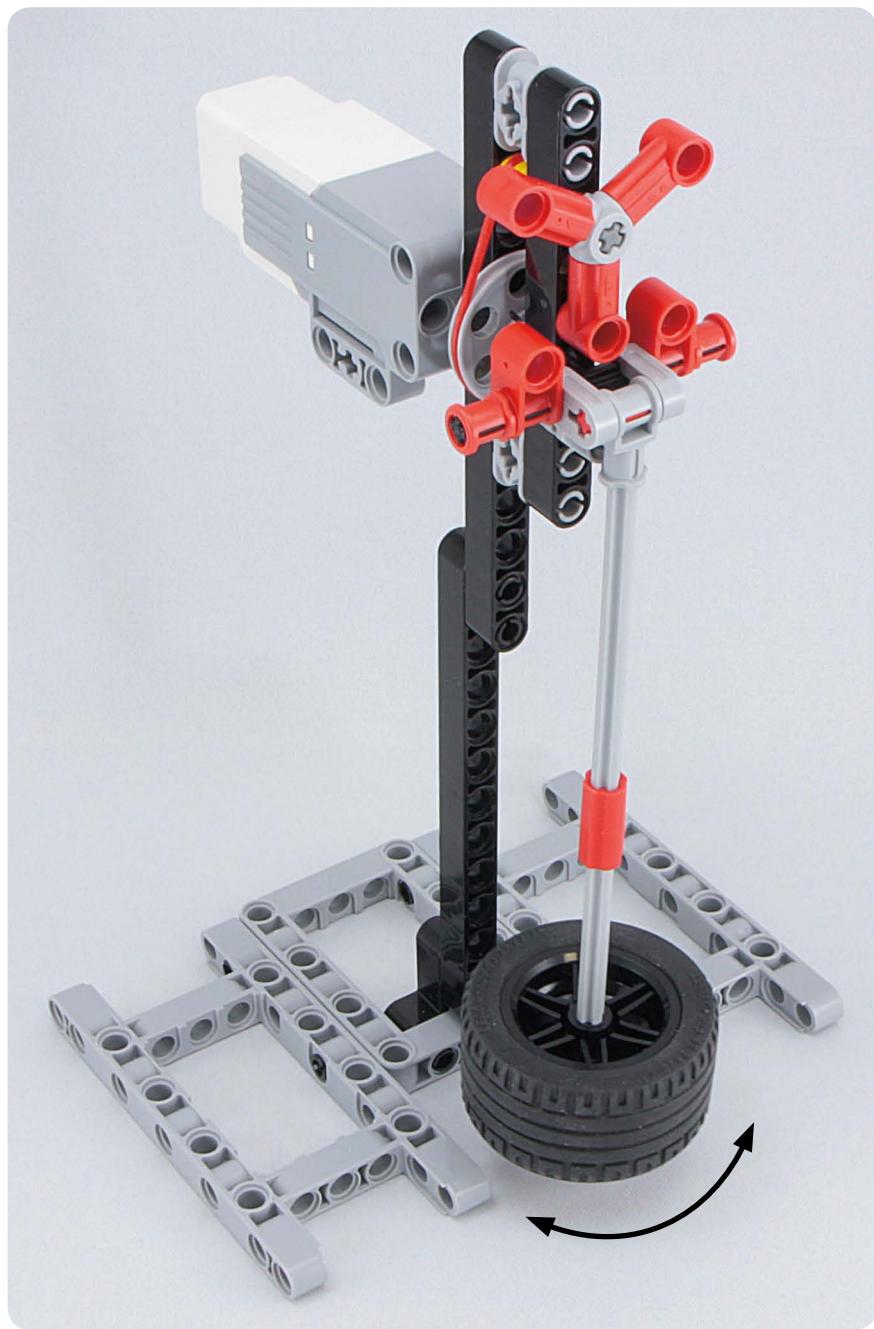
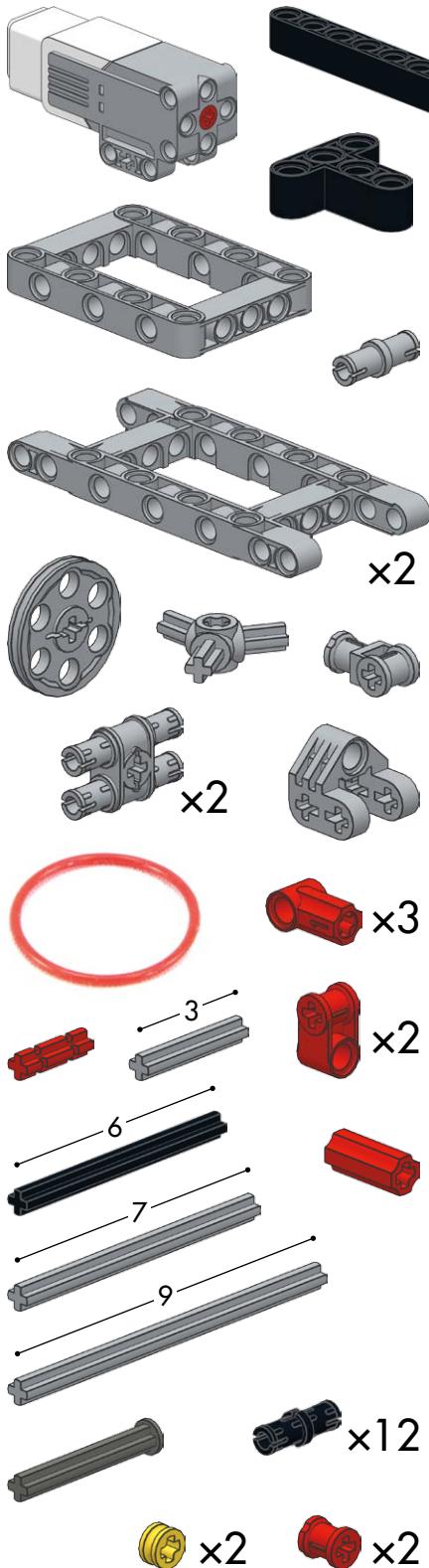
# Swinging a pendulum

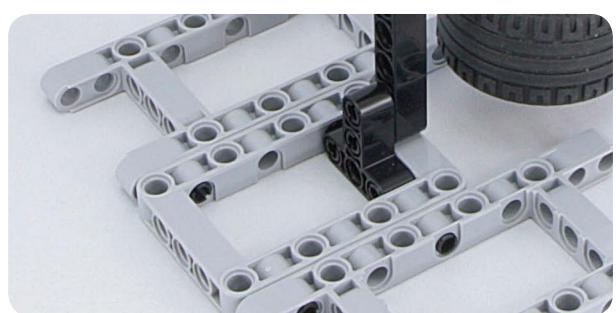
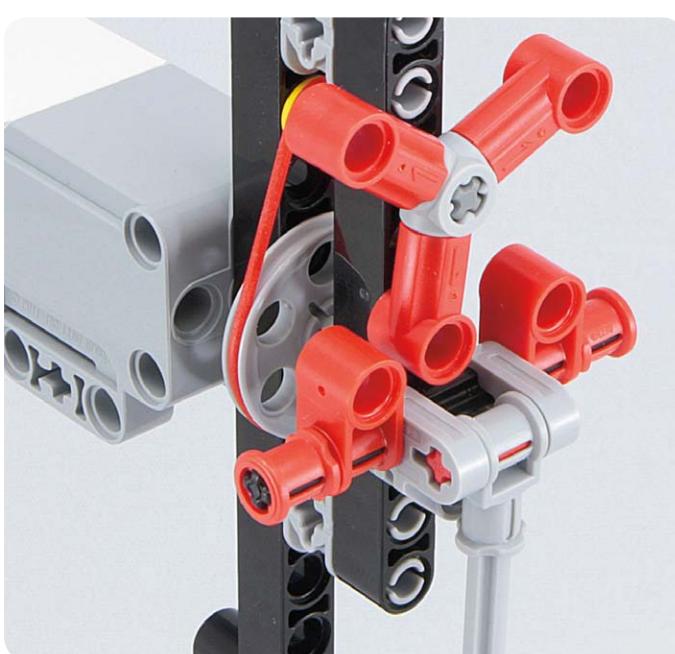
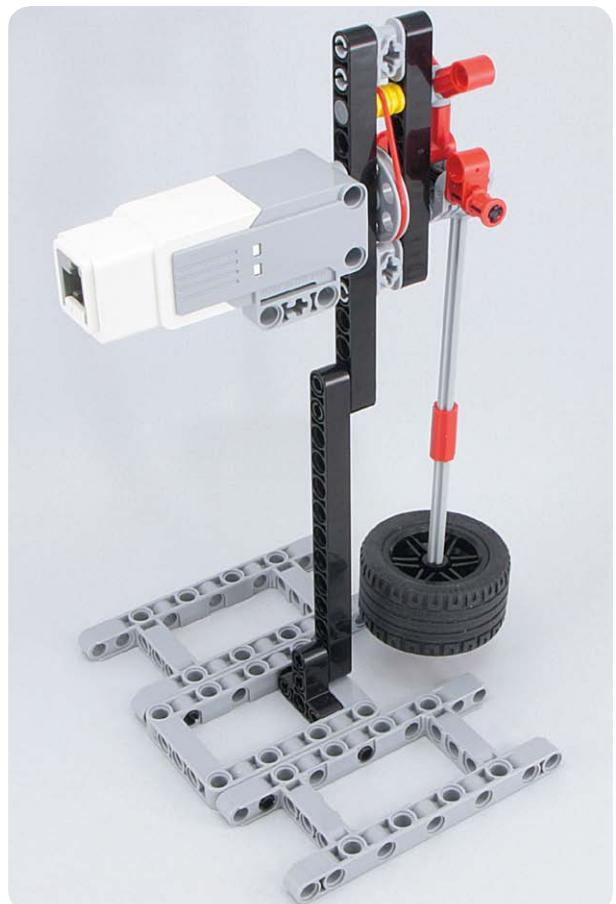
#155





#156

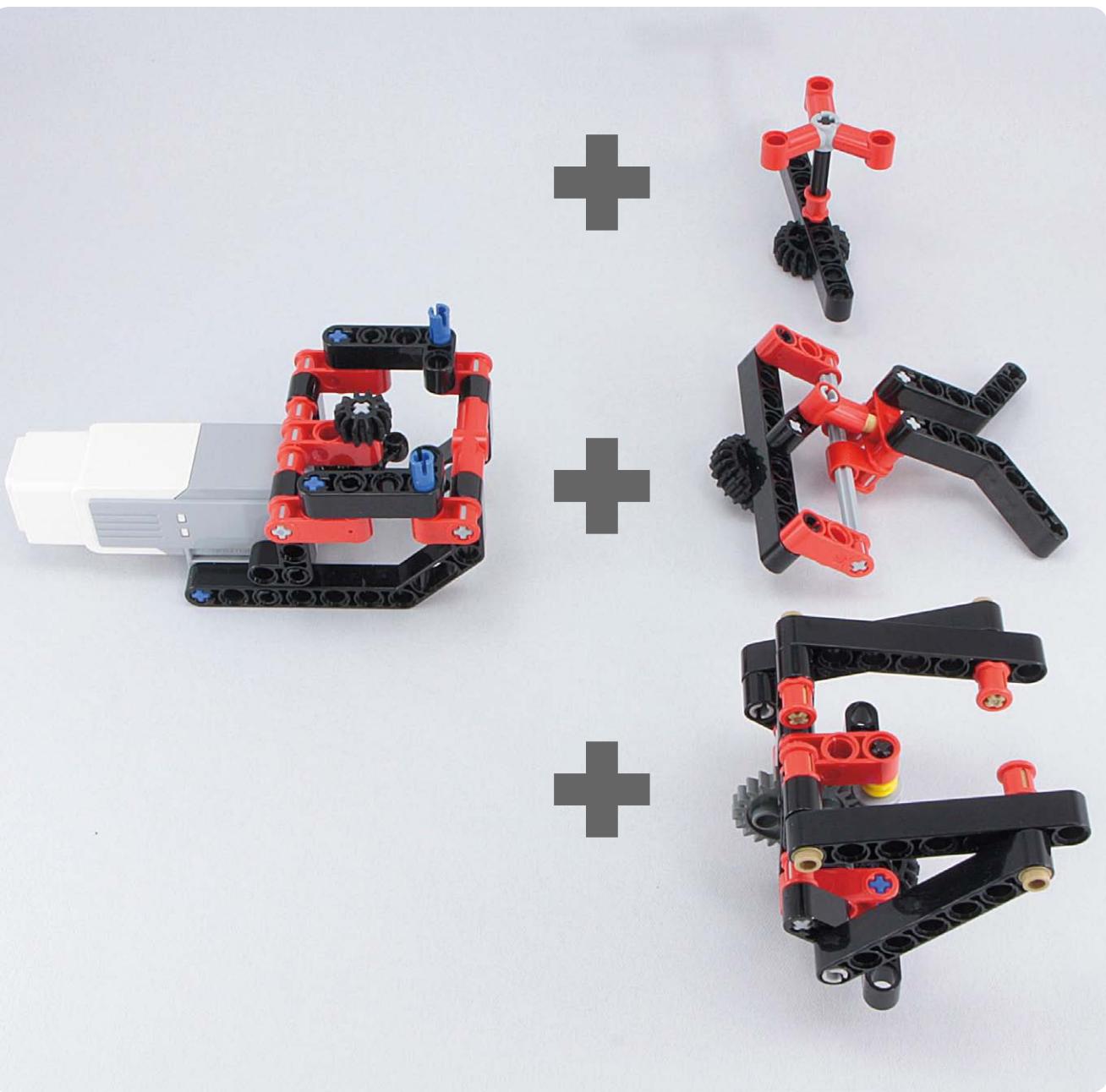


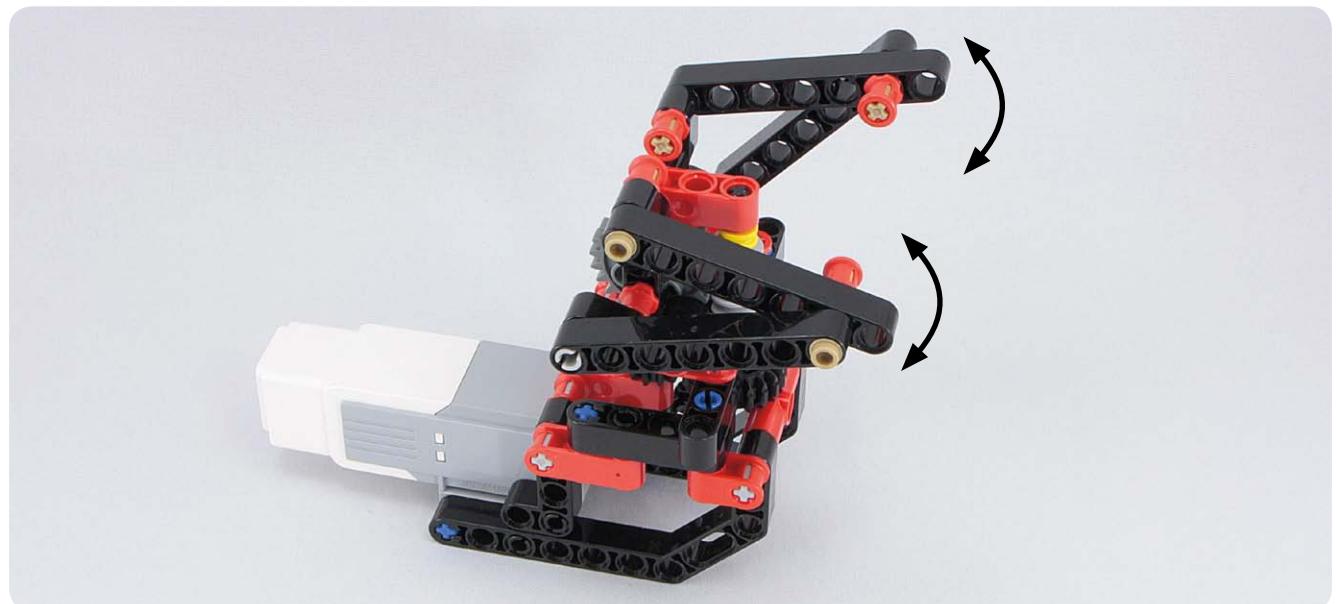
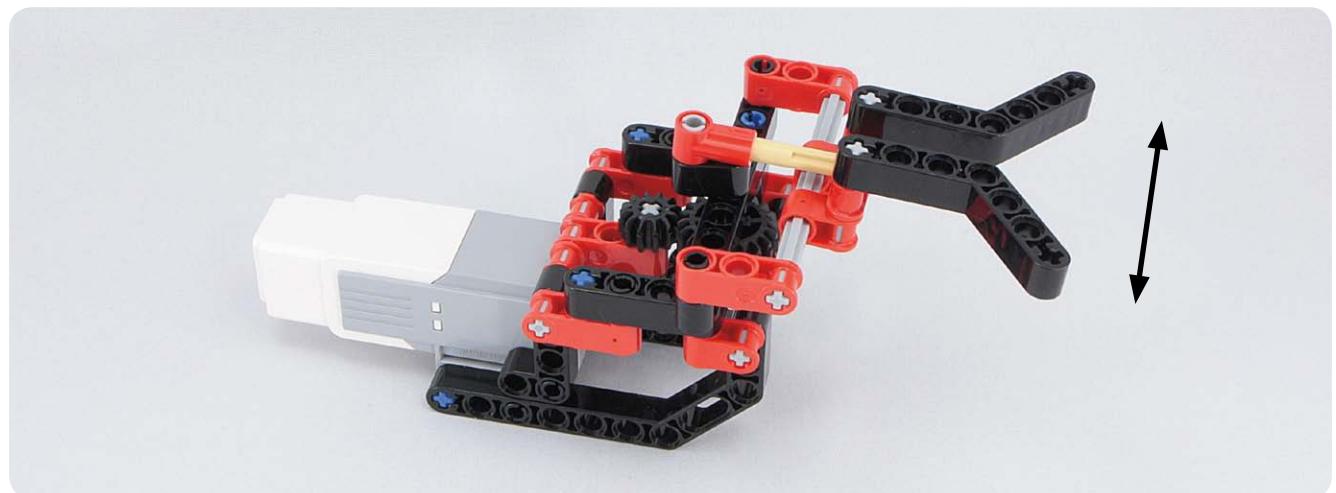
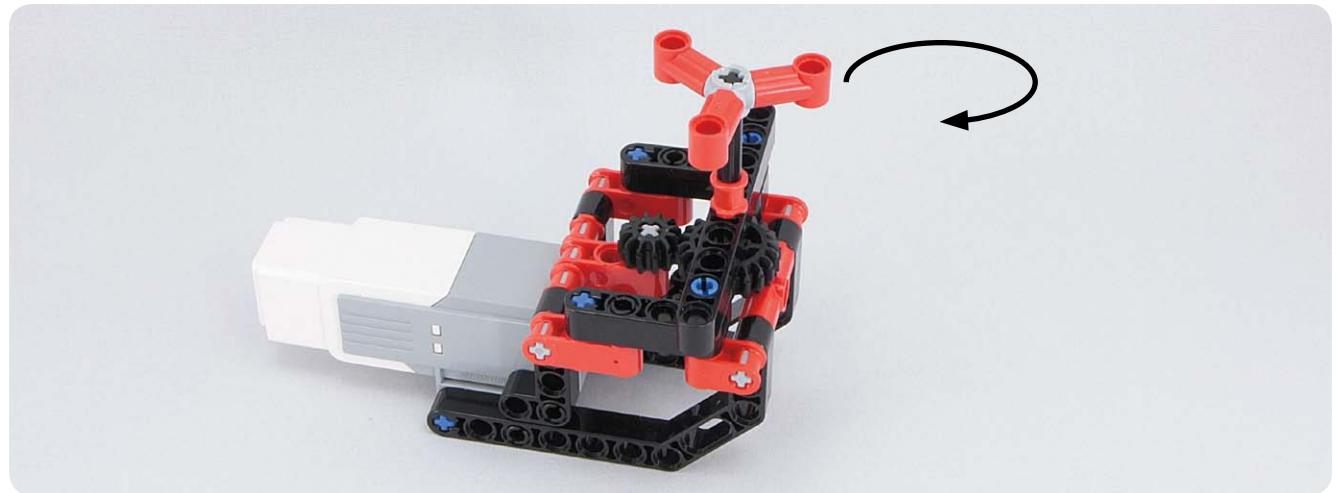


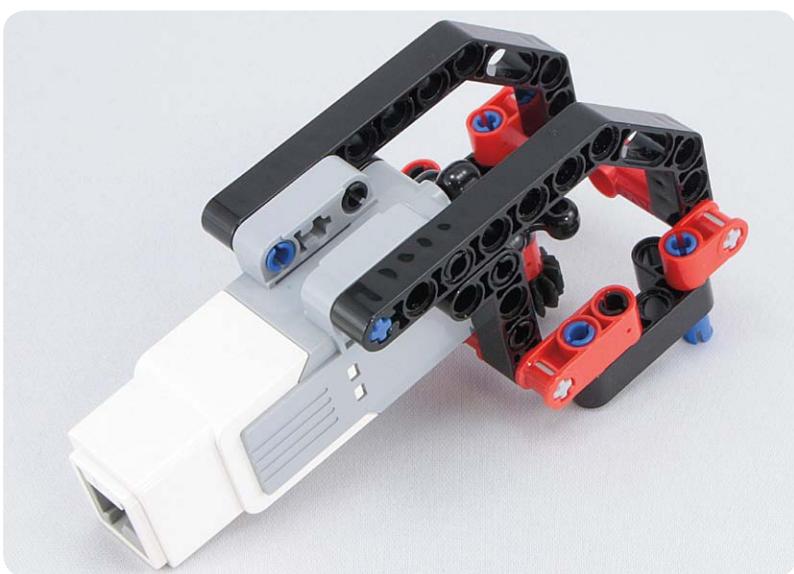
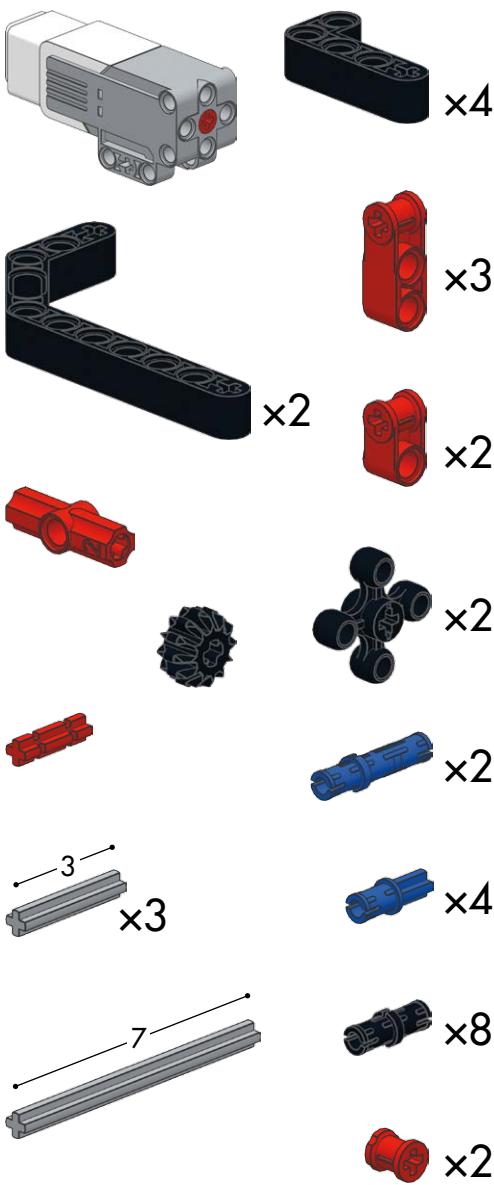
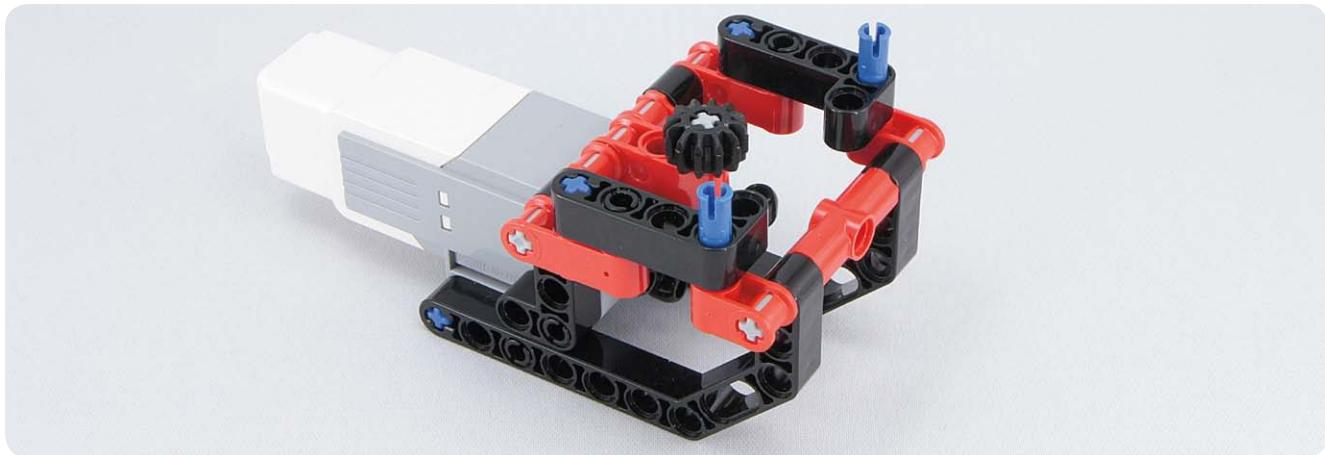


# Using attachments to change motion

#157

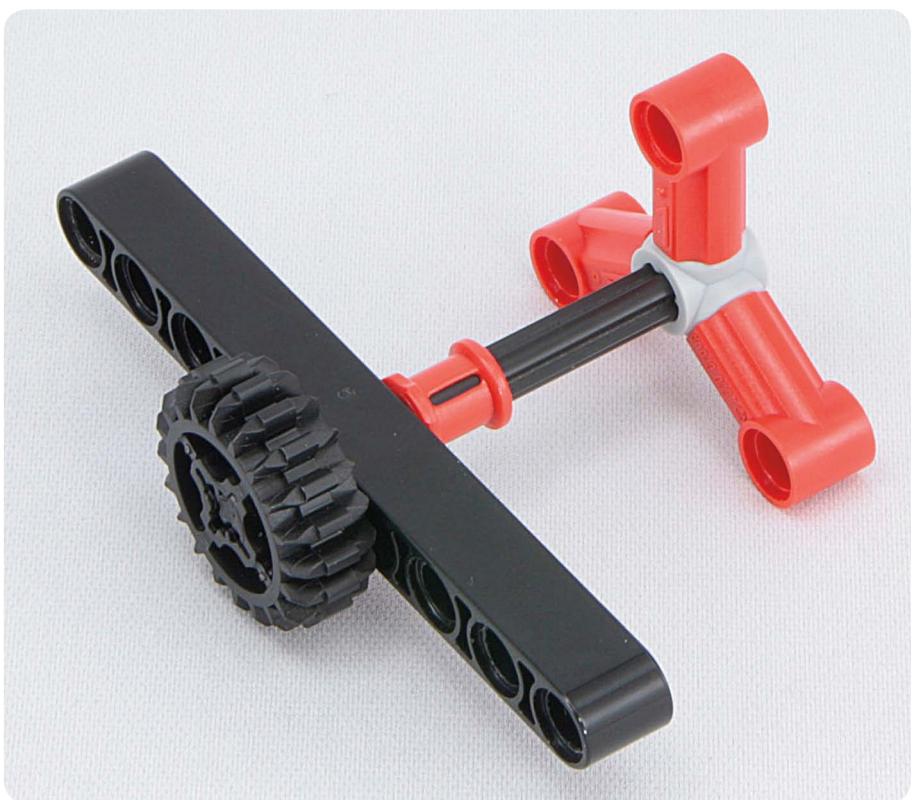


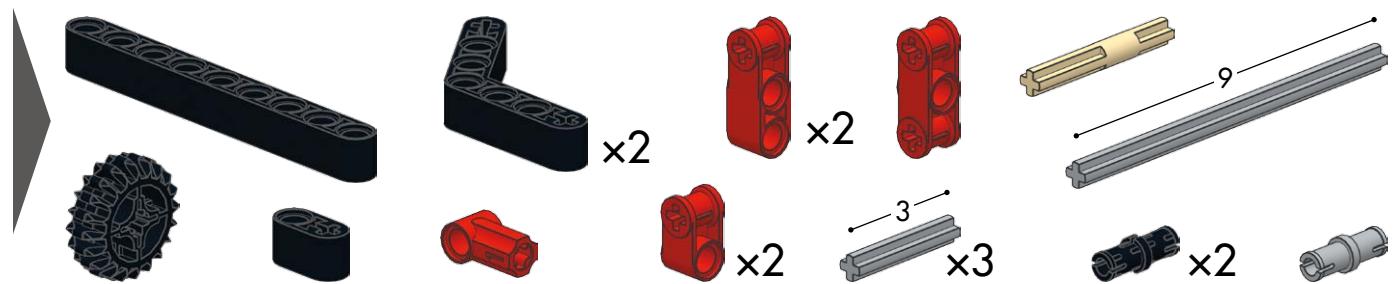


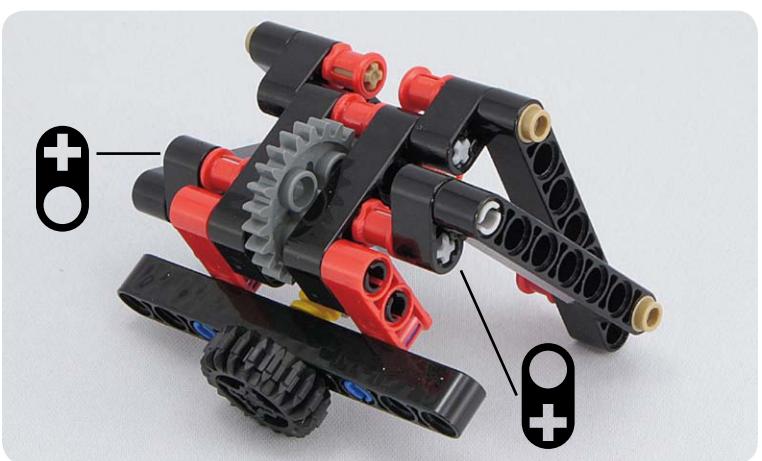


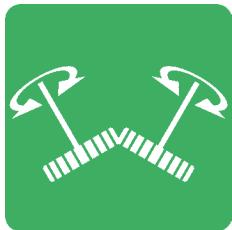


x3



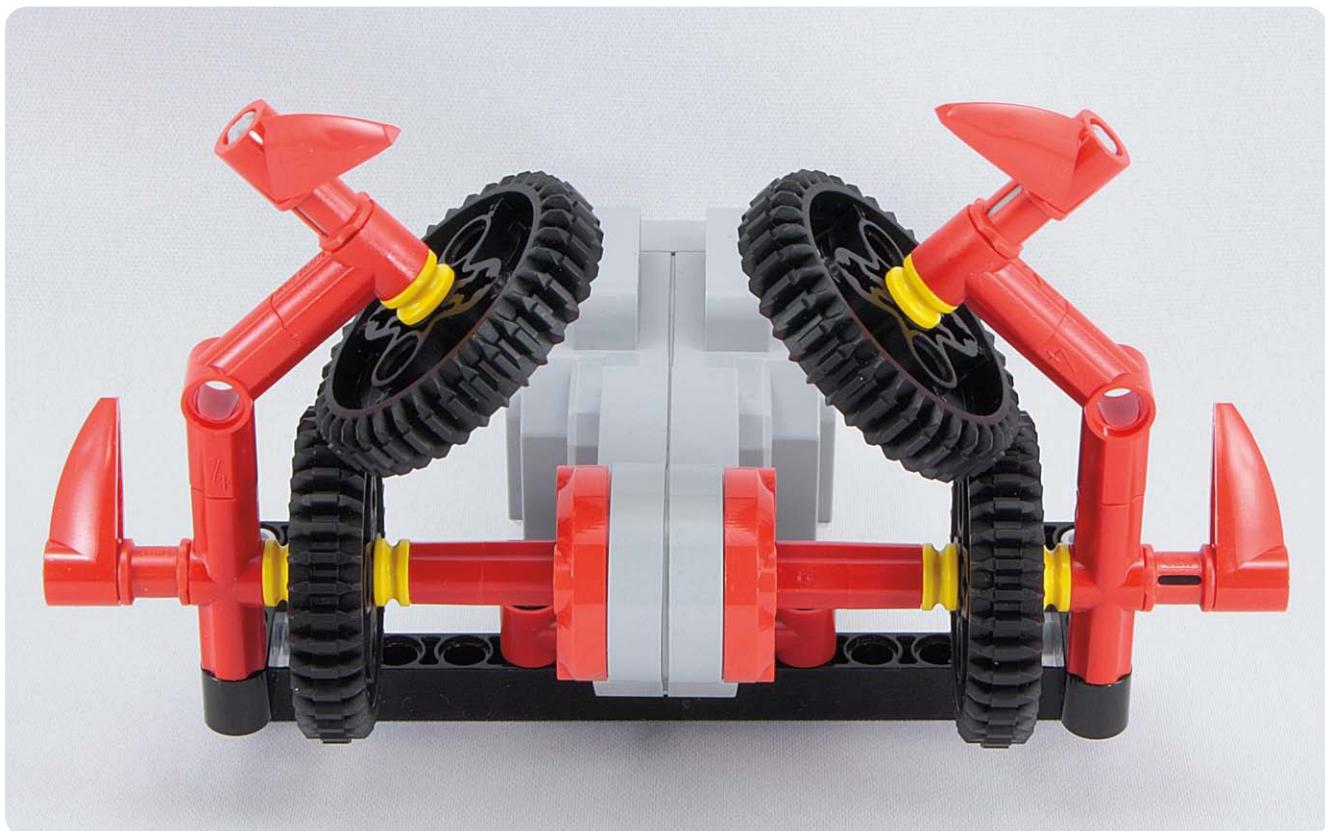
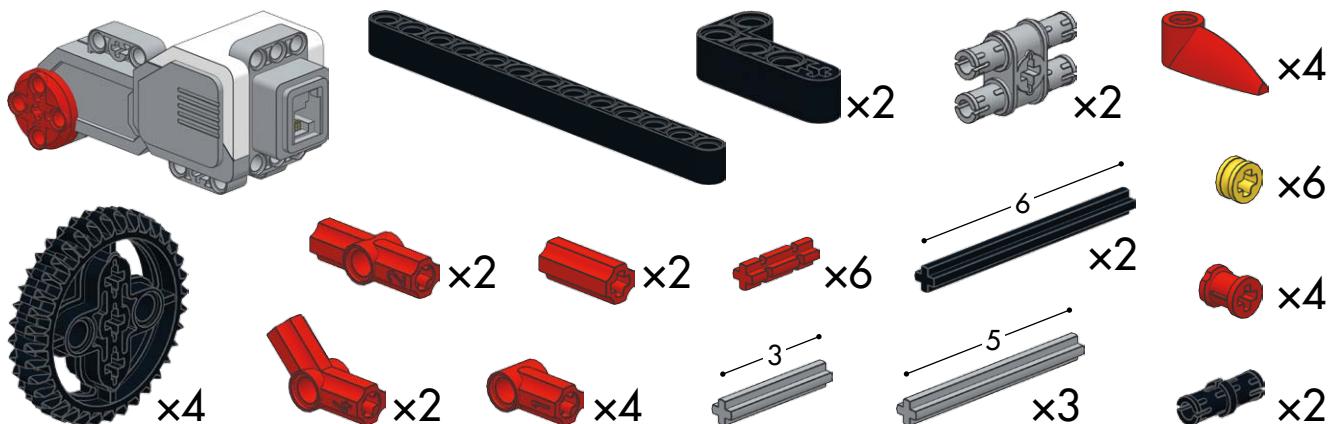






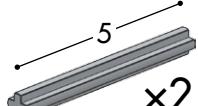
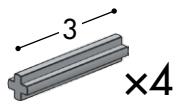
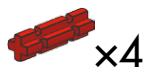
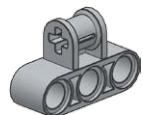
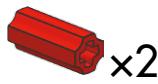
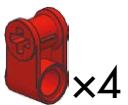
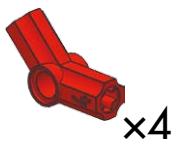
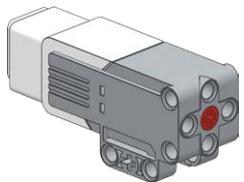
# Mesing gears diagonally

#158

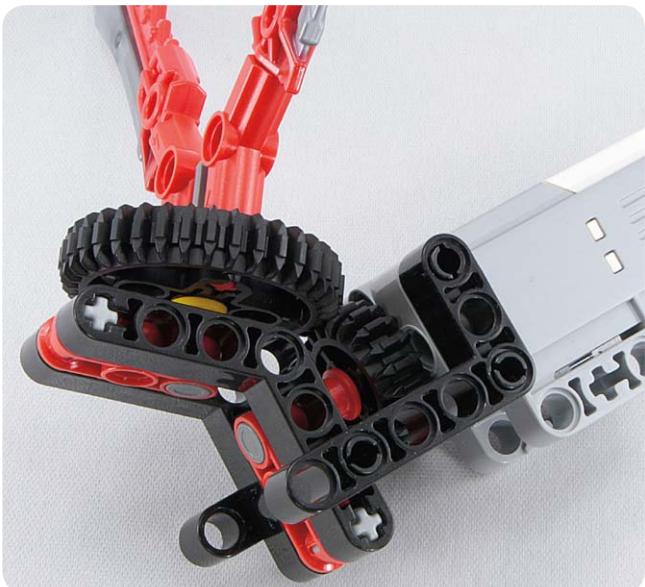
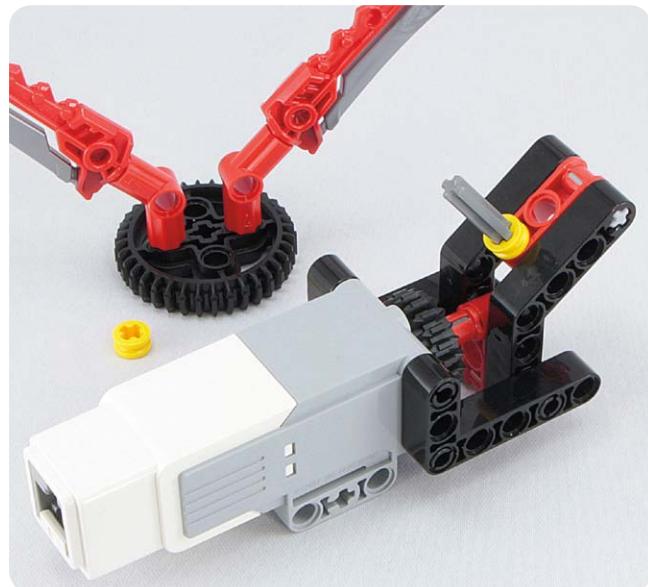


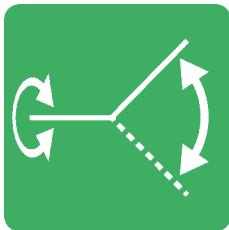


## #159



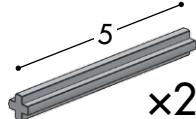
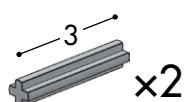
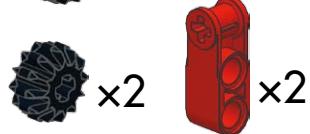
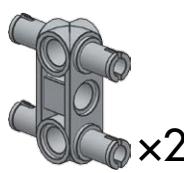
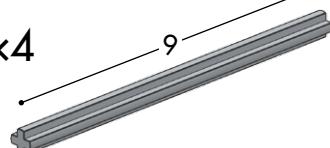
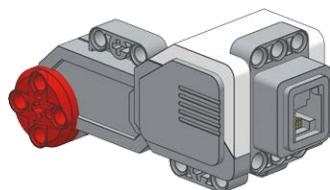
## #160





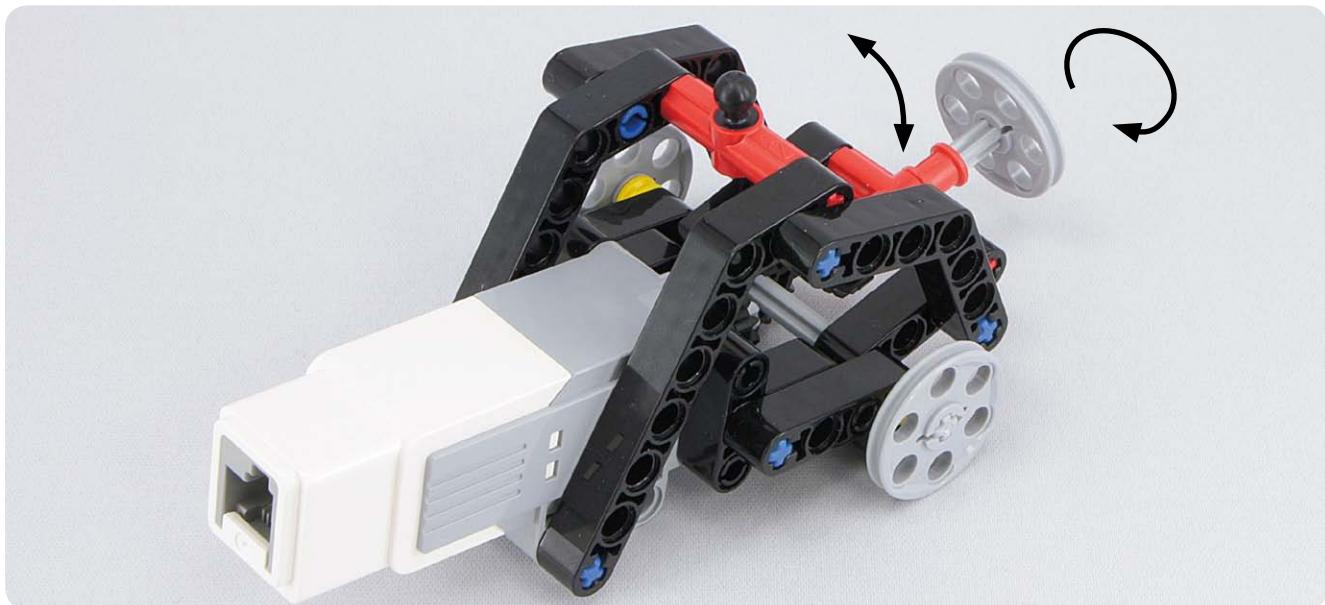
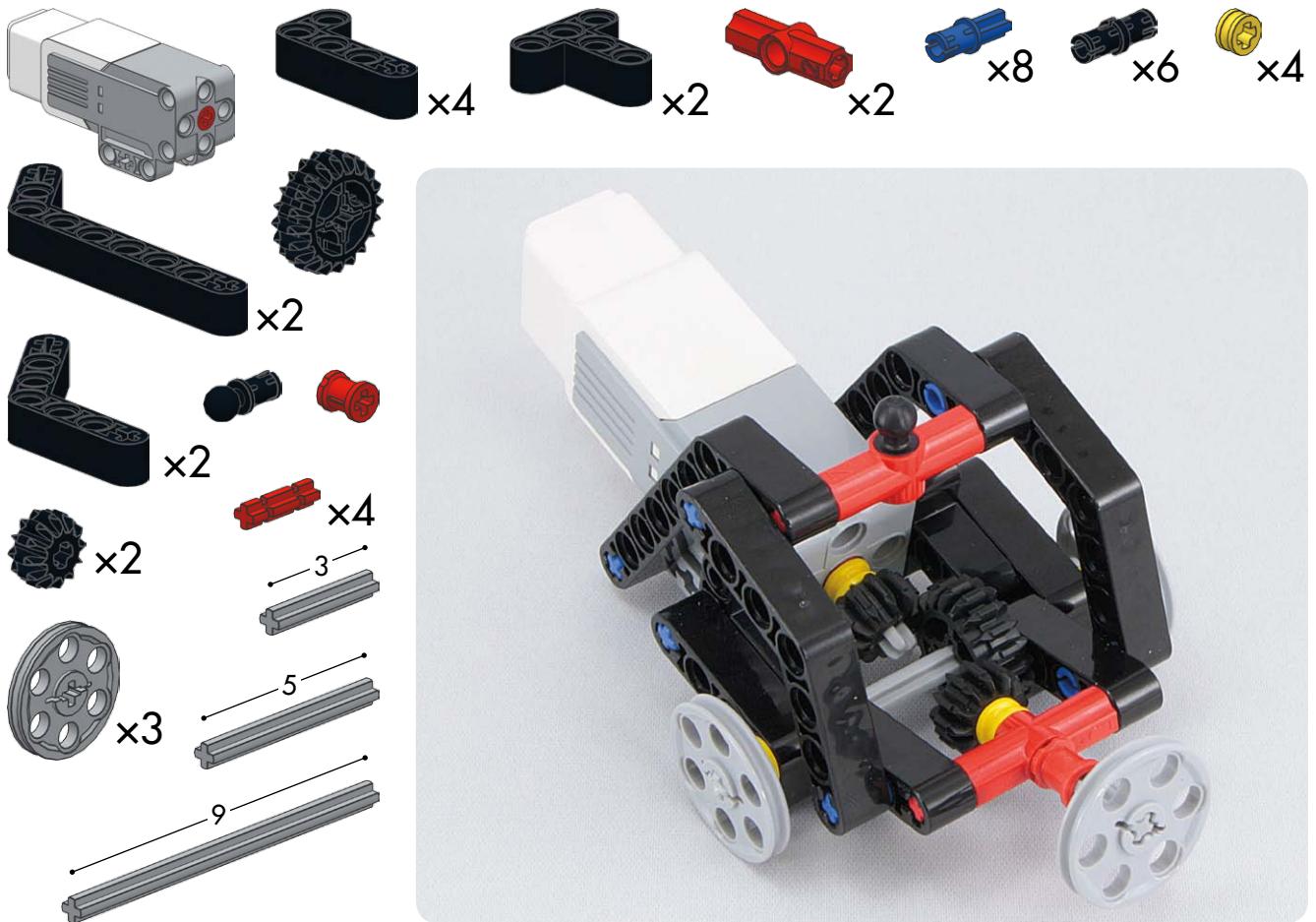
# Changing the angle of rotation freely

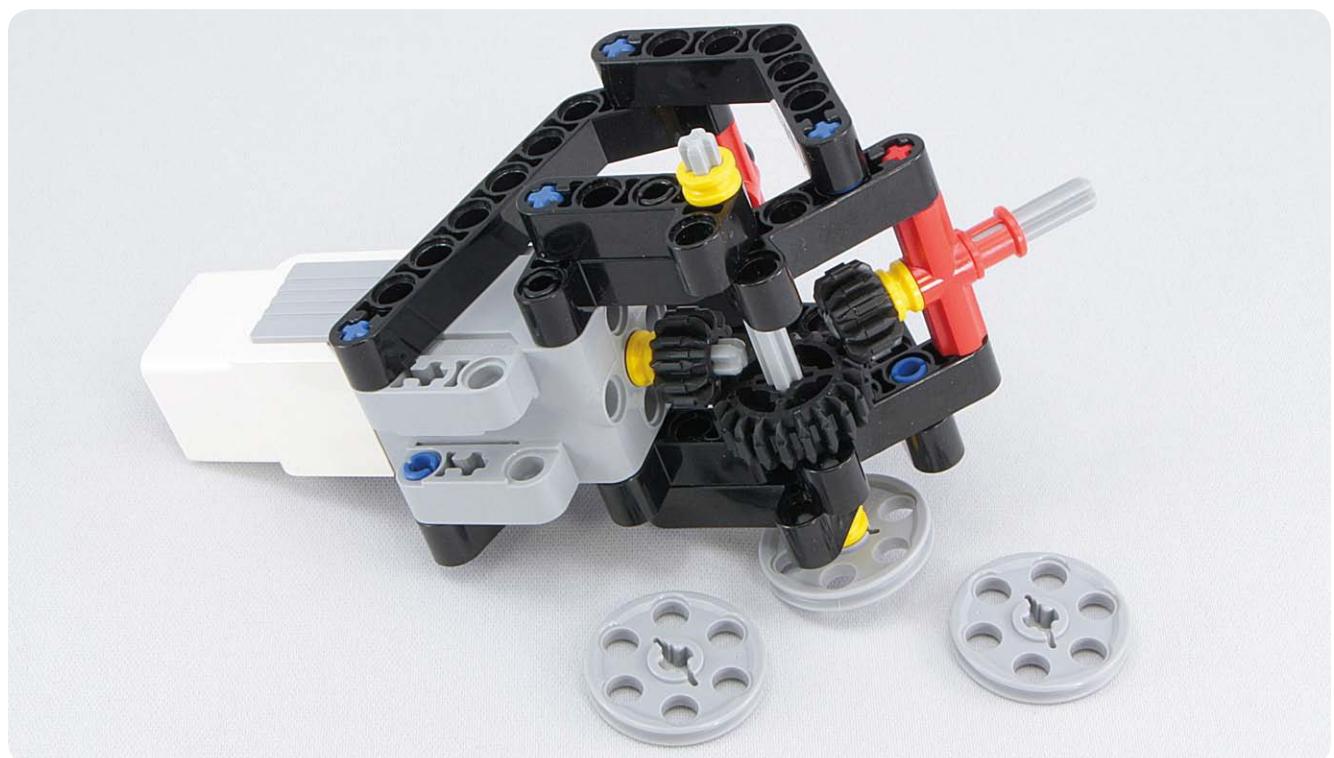
#161



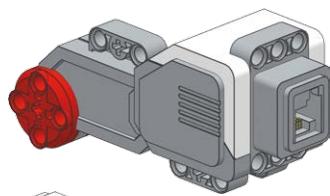


#162





# #163



x2



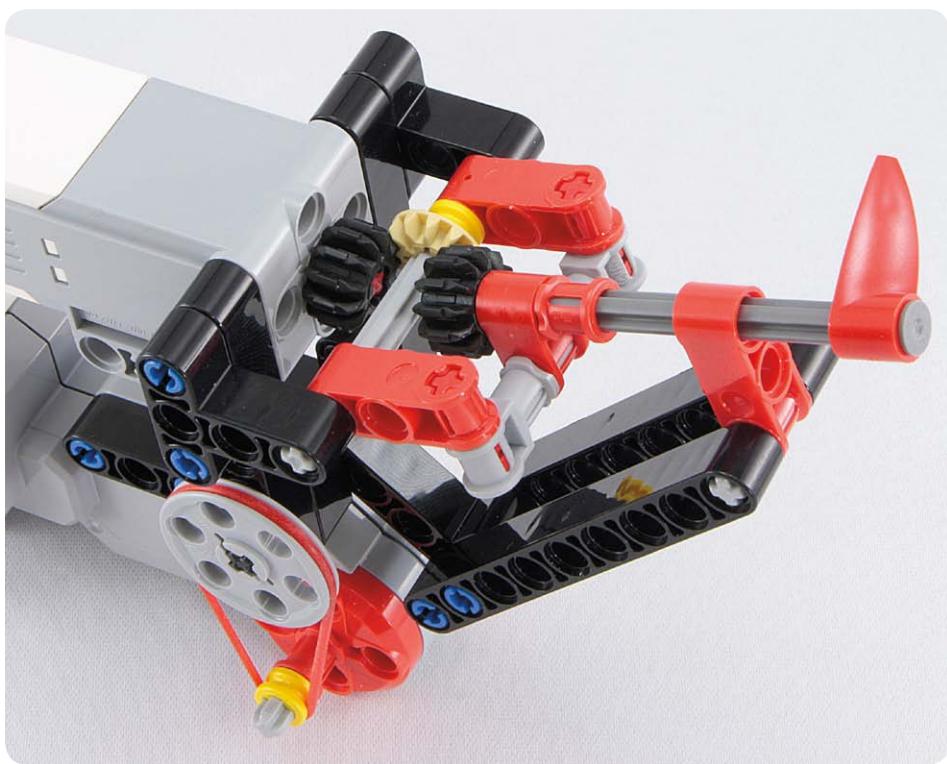
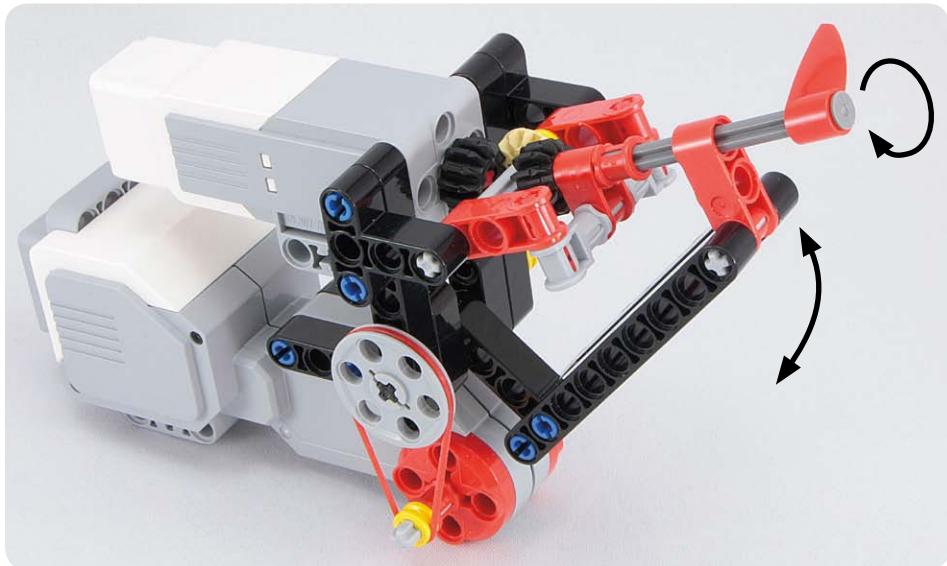
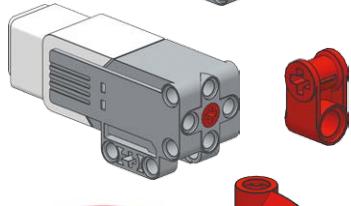
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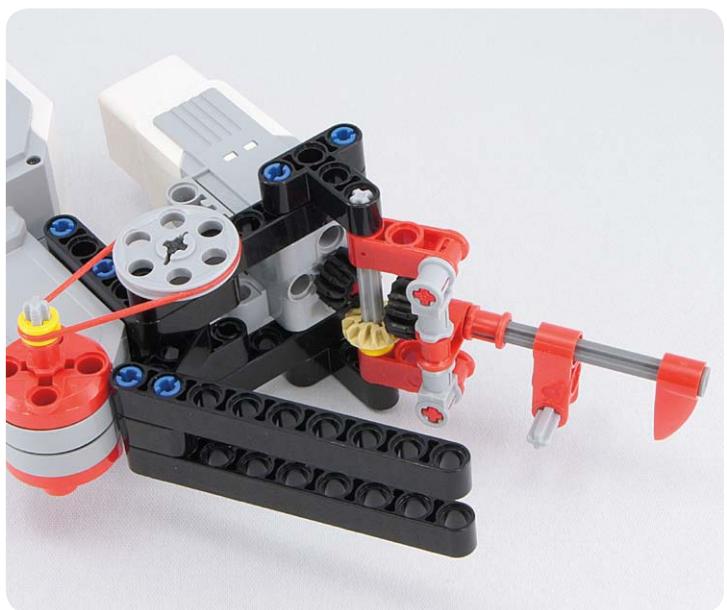
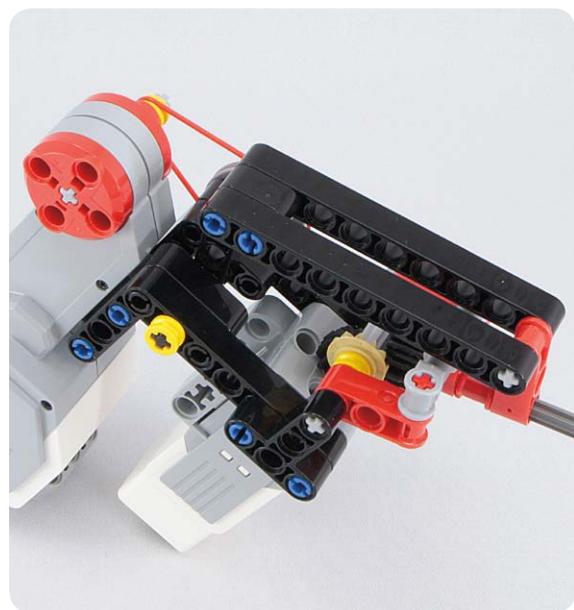
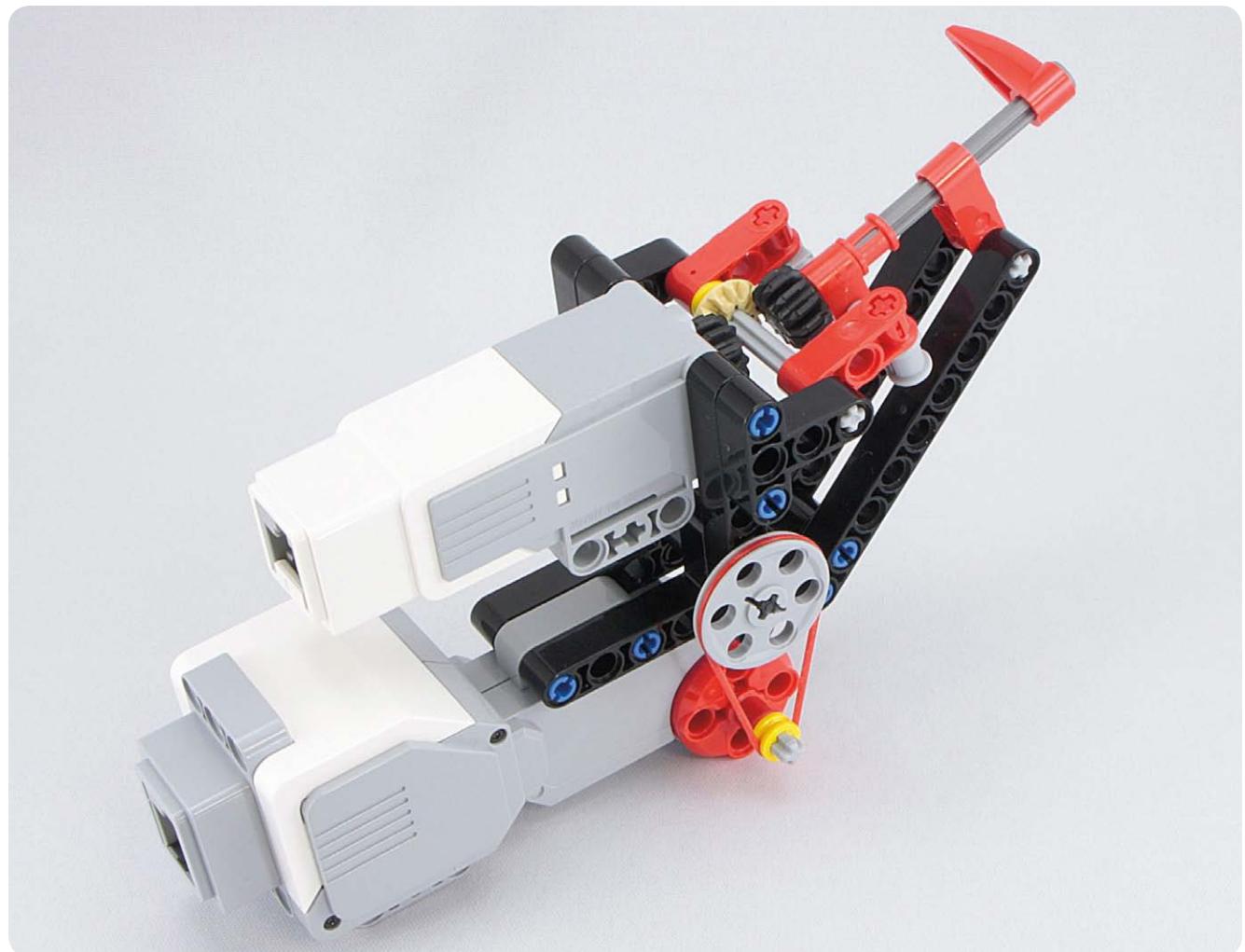


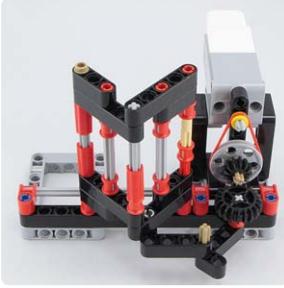
x2



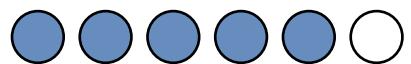
x2







# PART 5



# Sensors



206



214

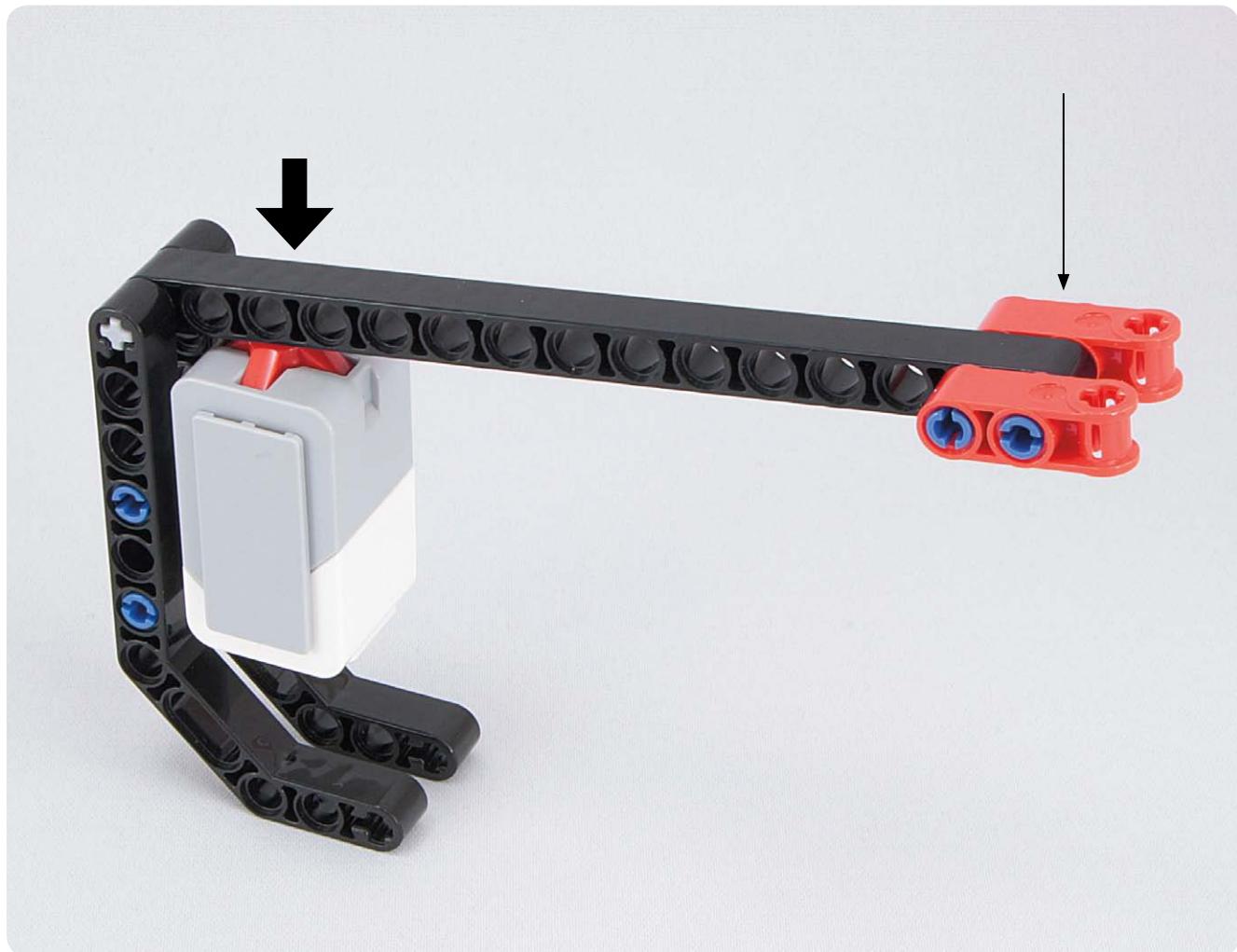
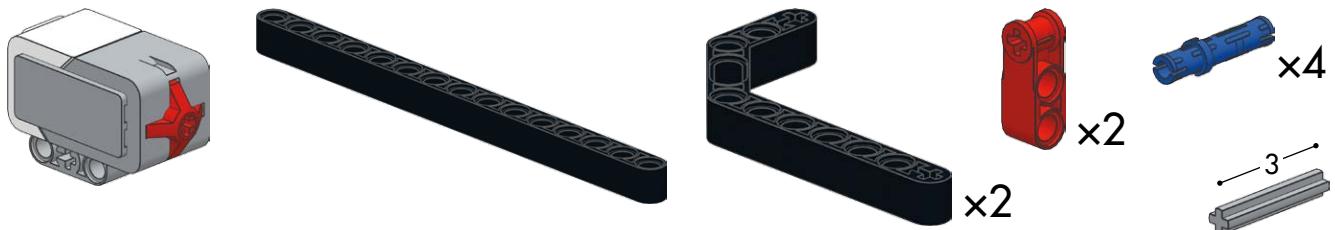


216

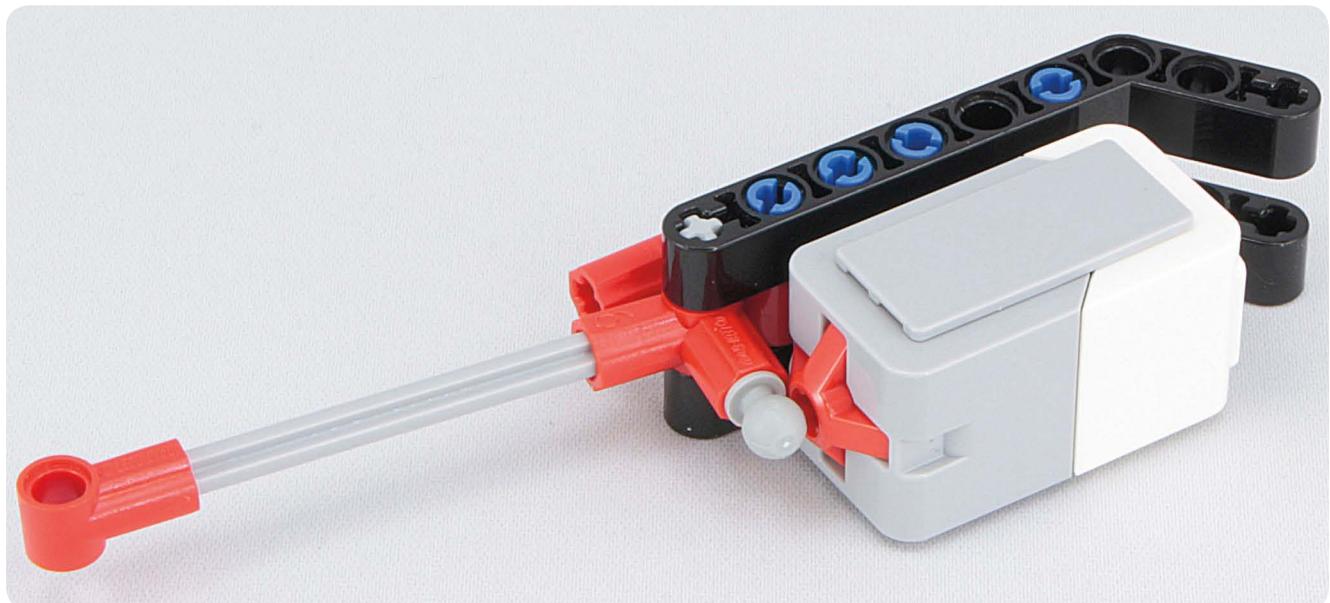
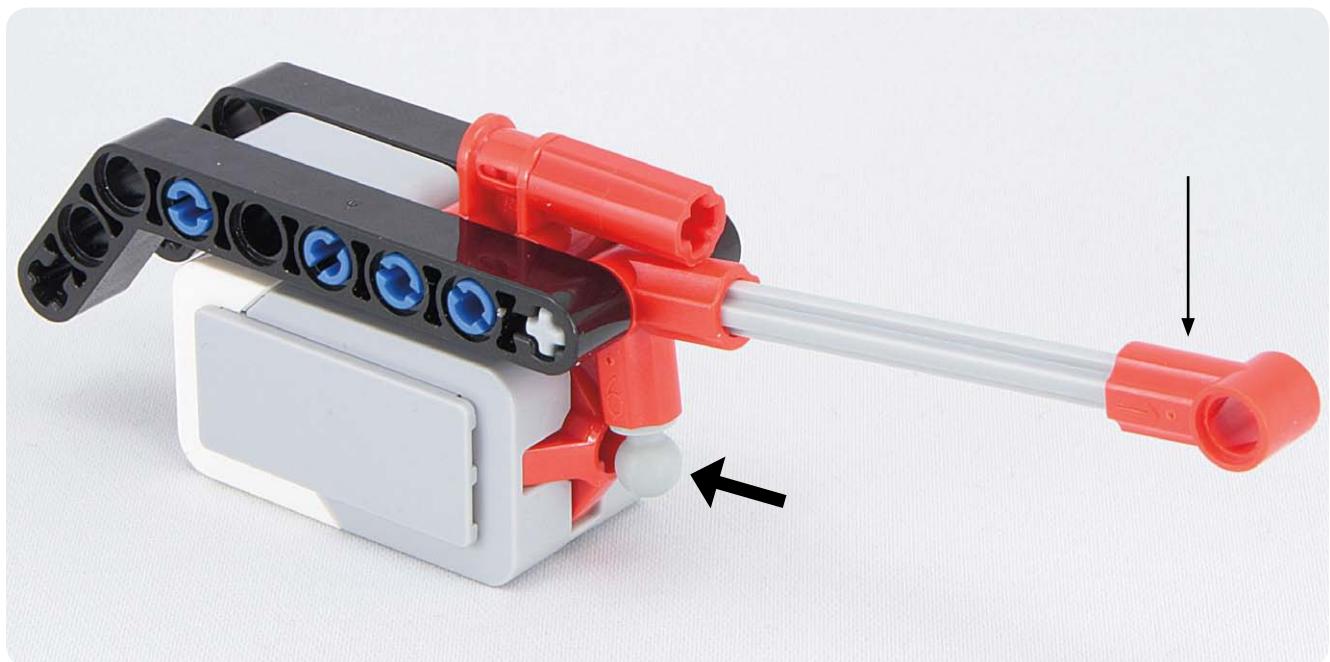
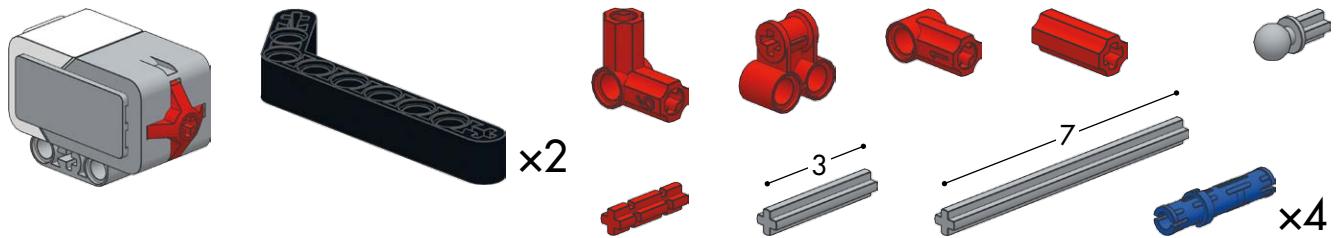


# Ideas for using the touch sensor

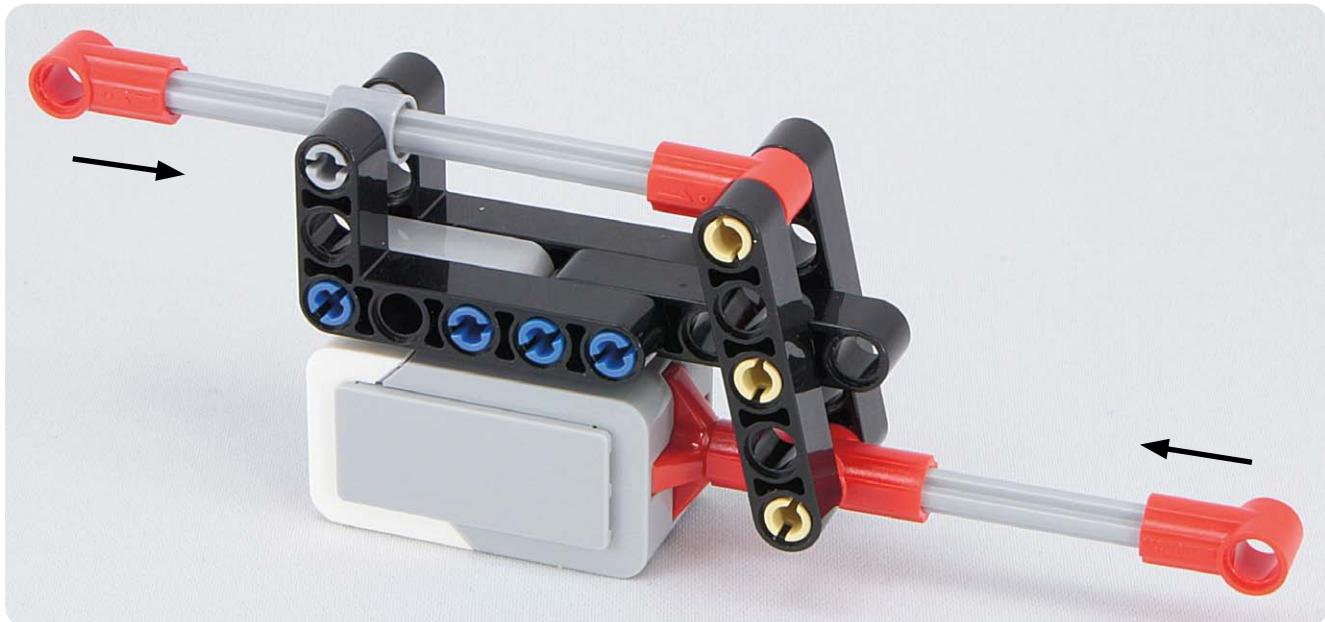
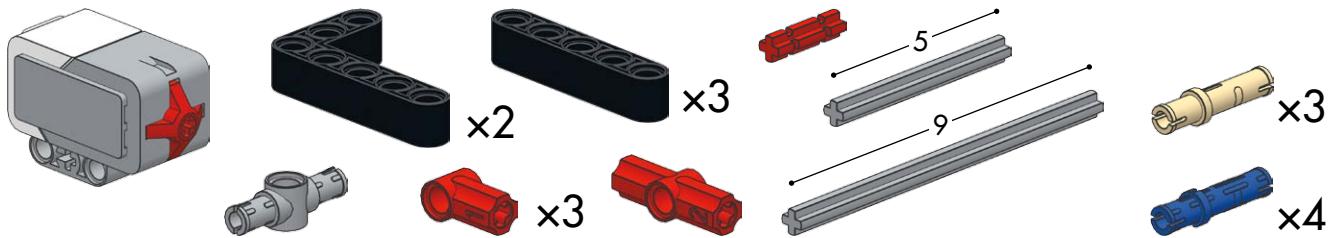
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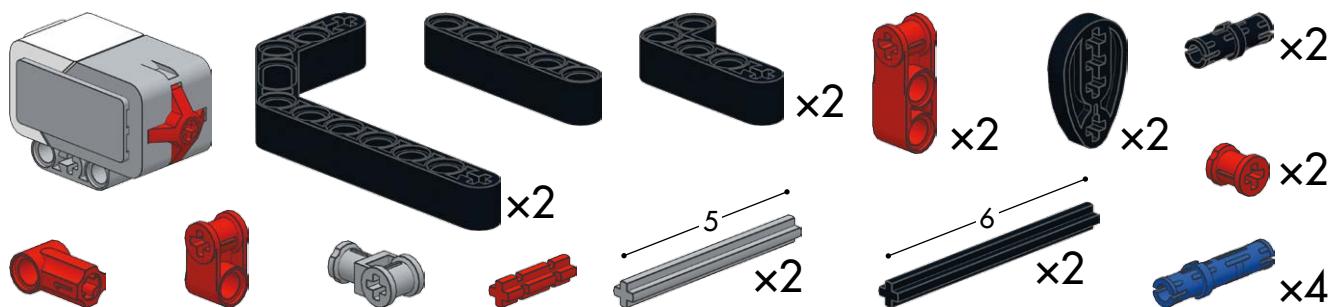
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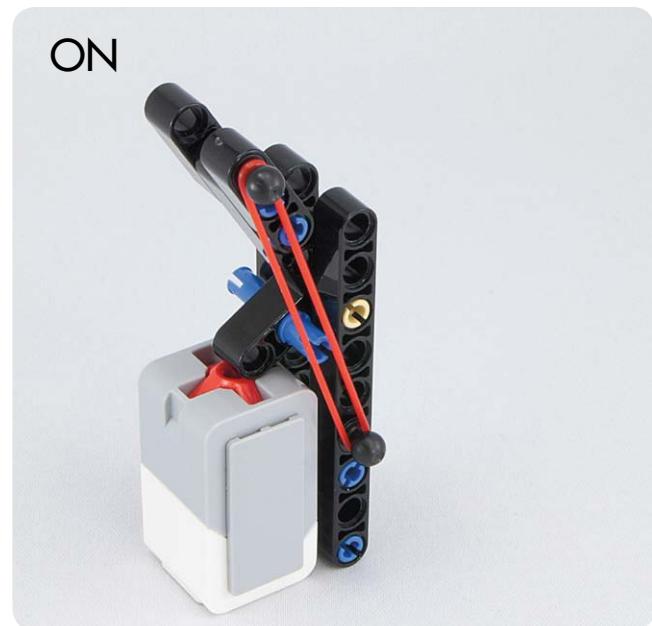
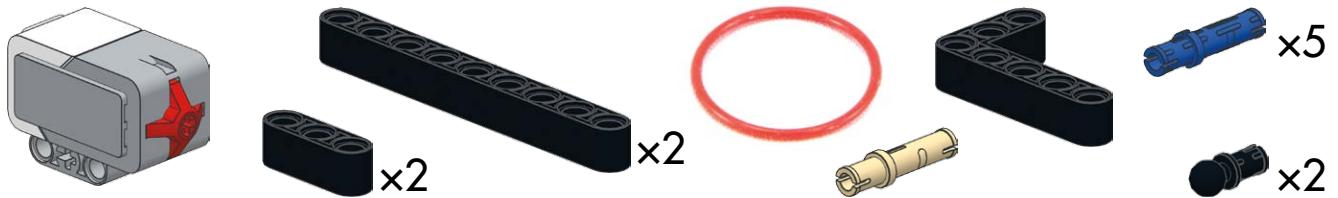
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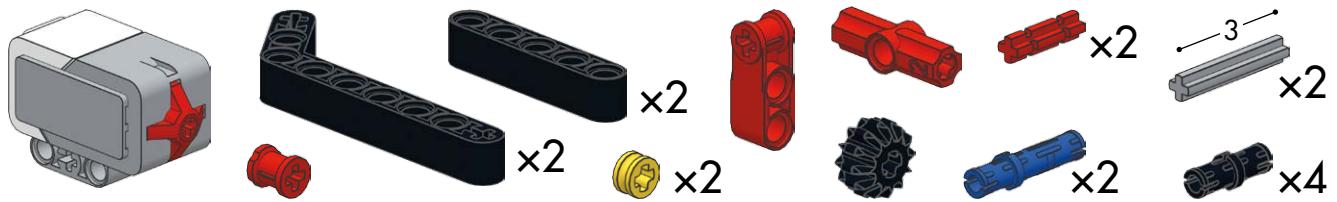
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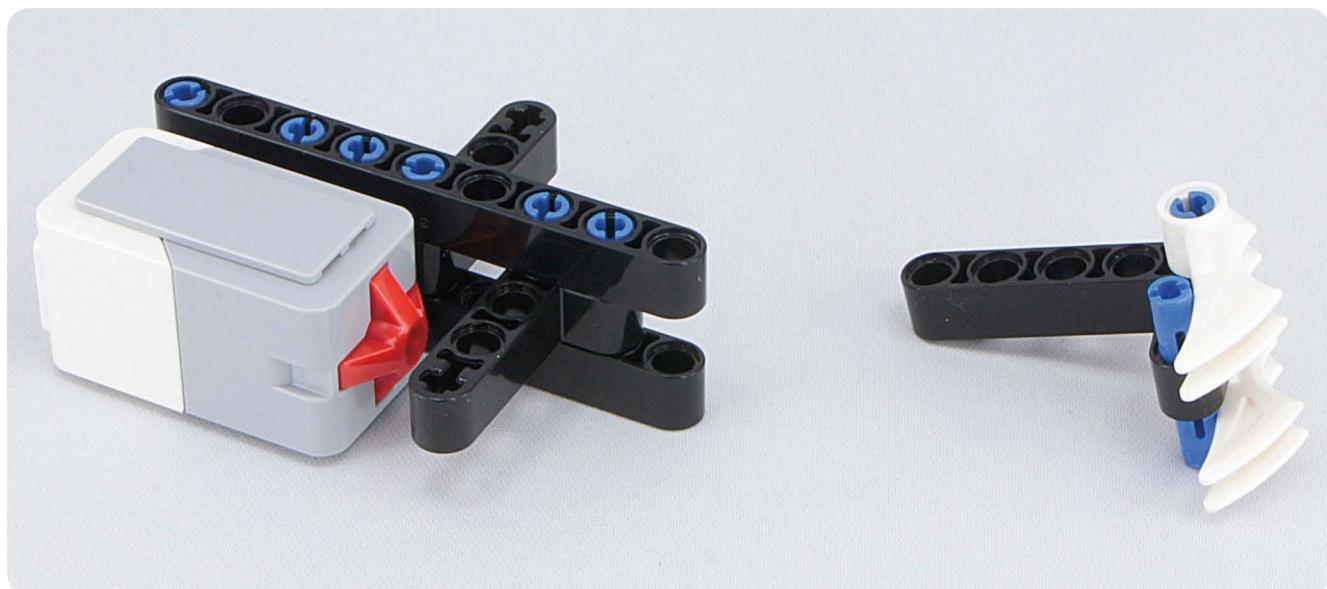
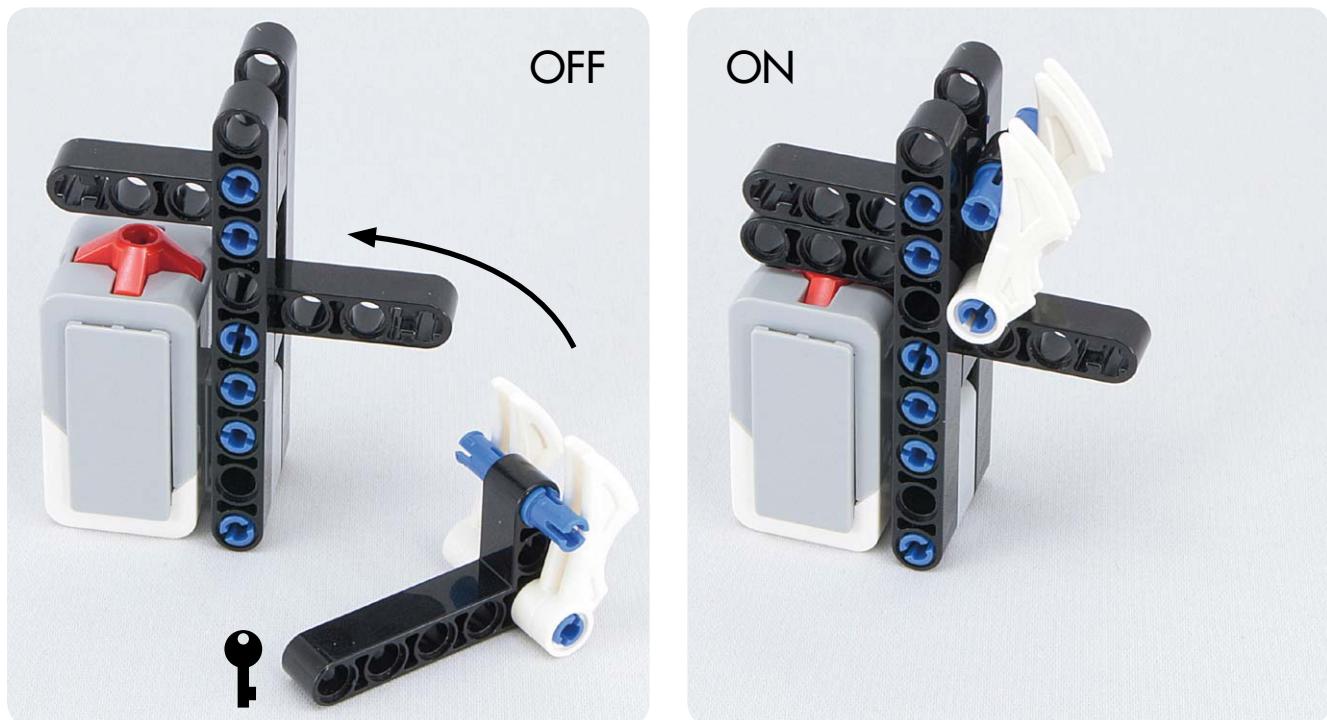
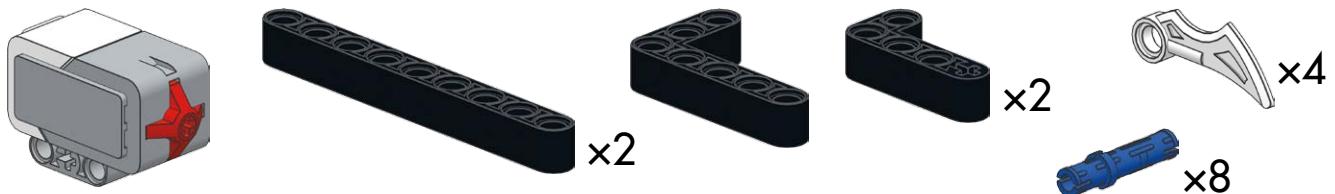
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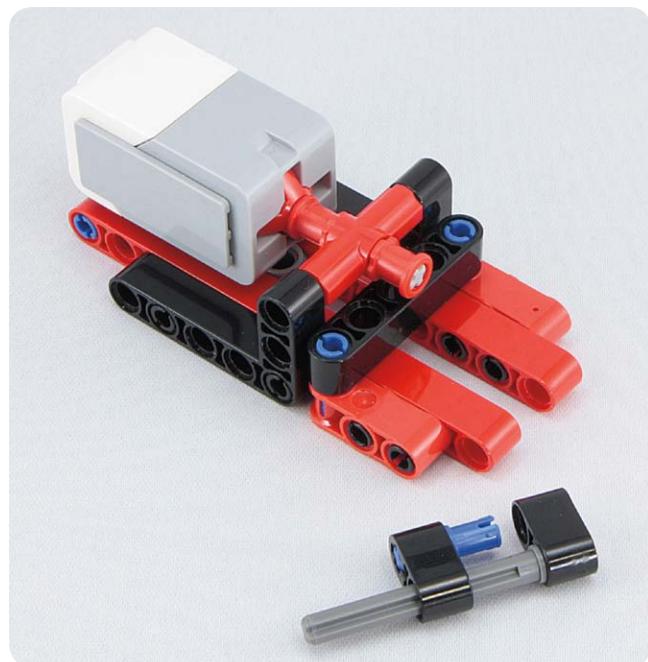
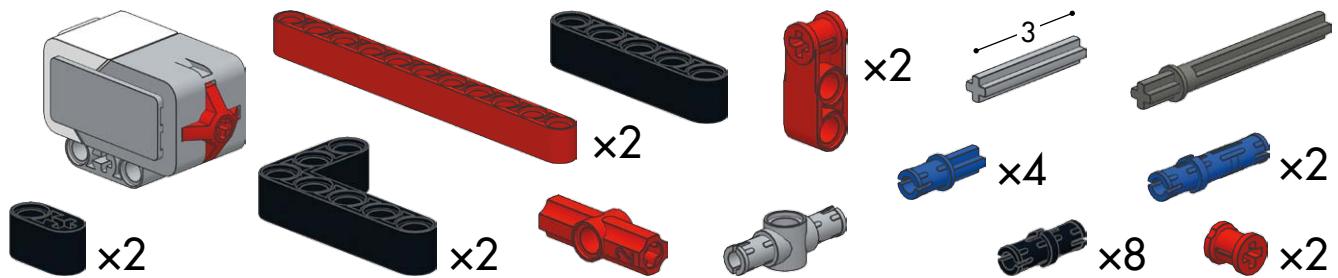
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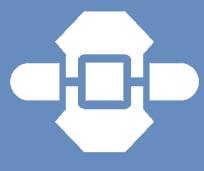


#170



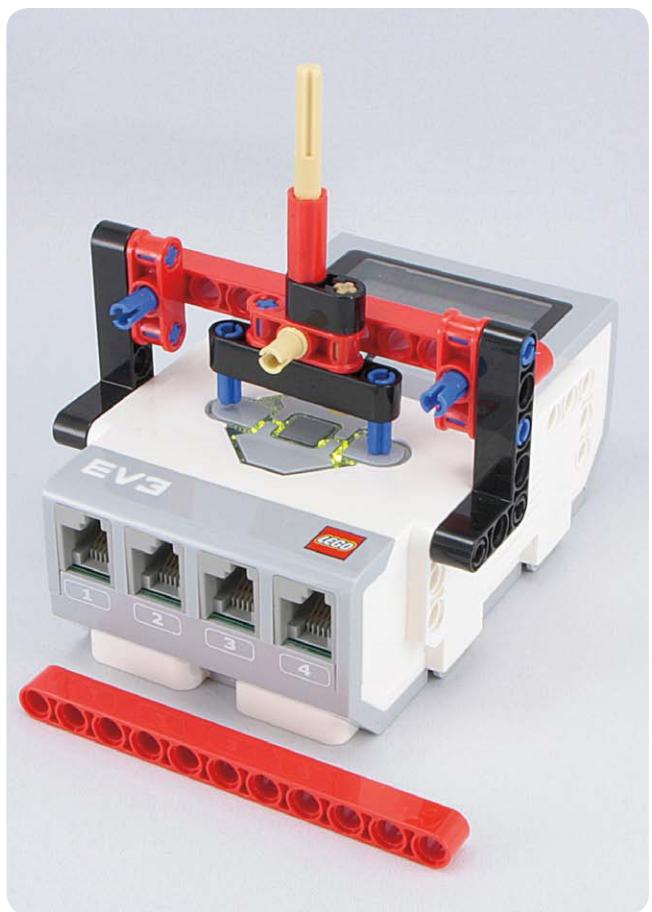
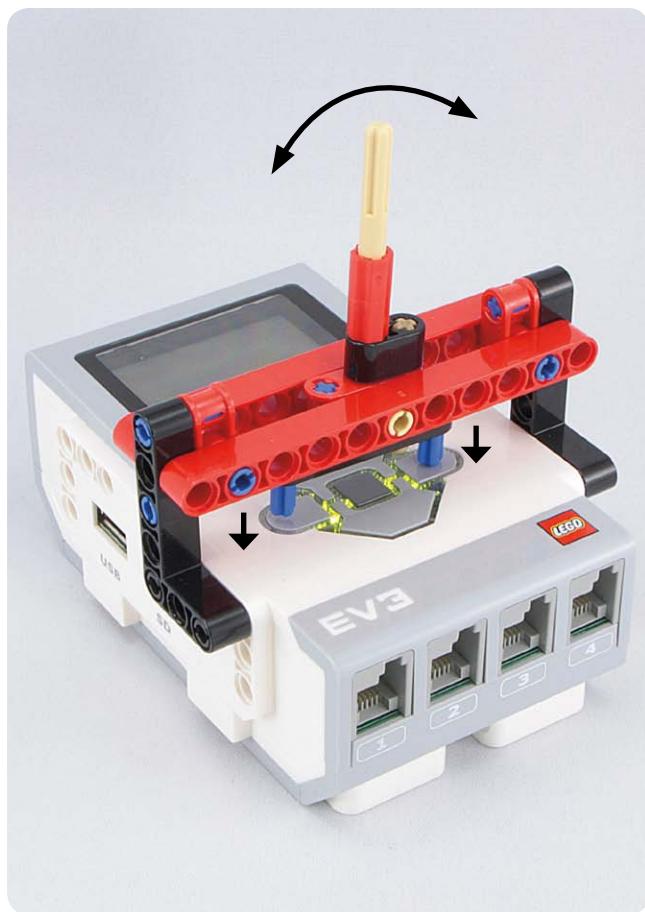
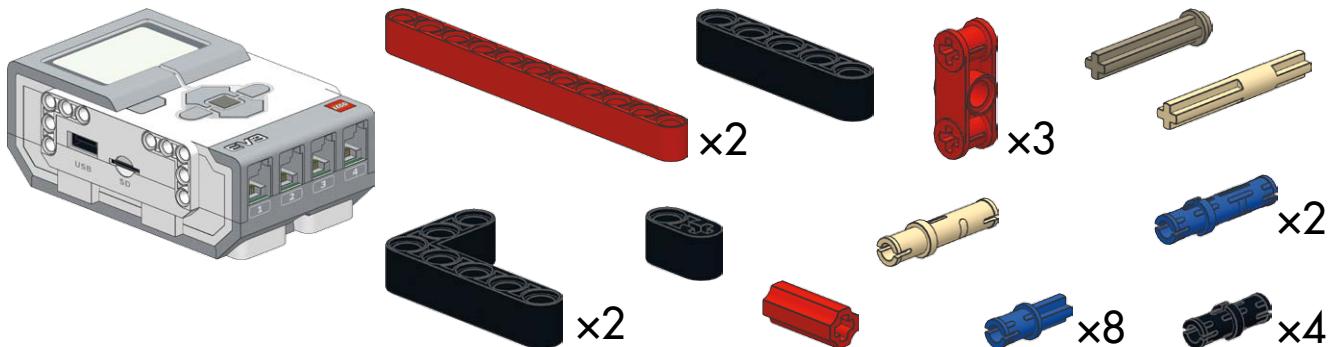
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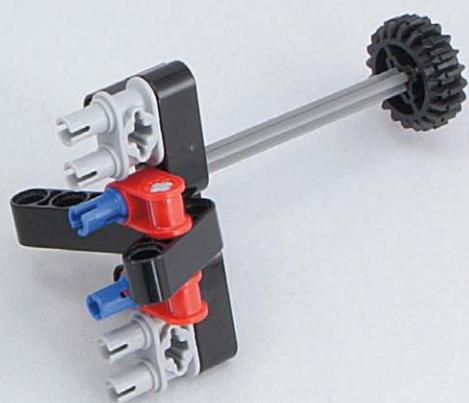
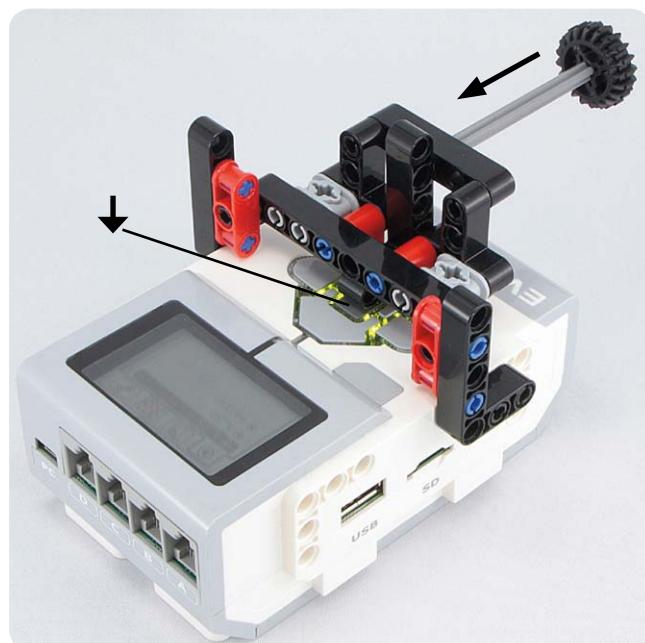
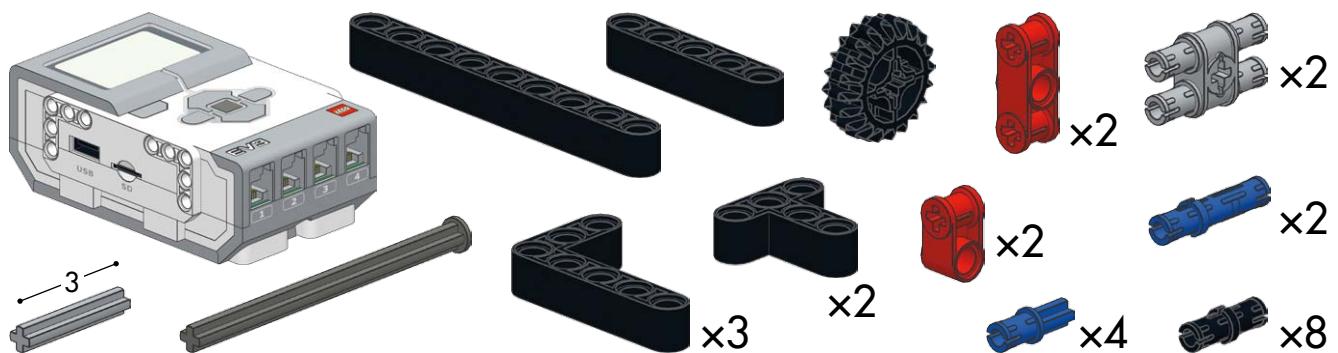


# Ideas for using the buttons of the Intelligent EV3 Brick

#172



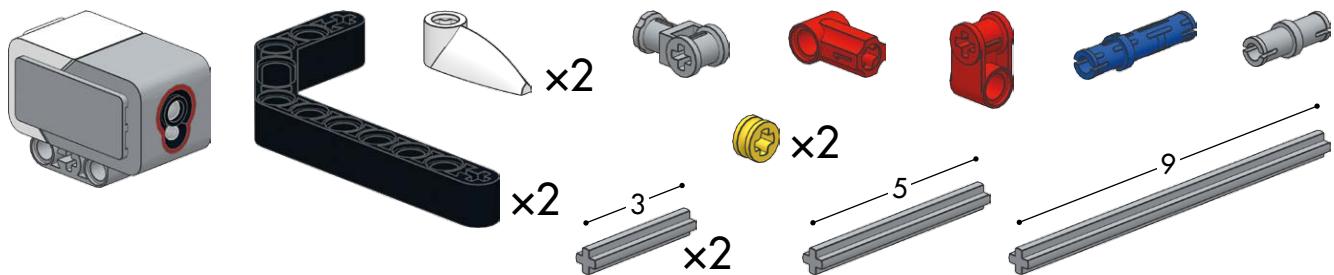
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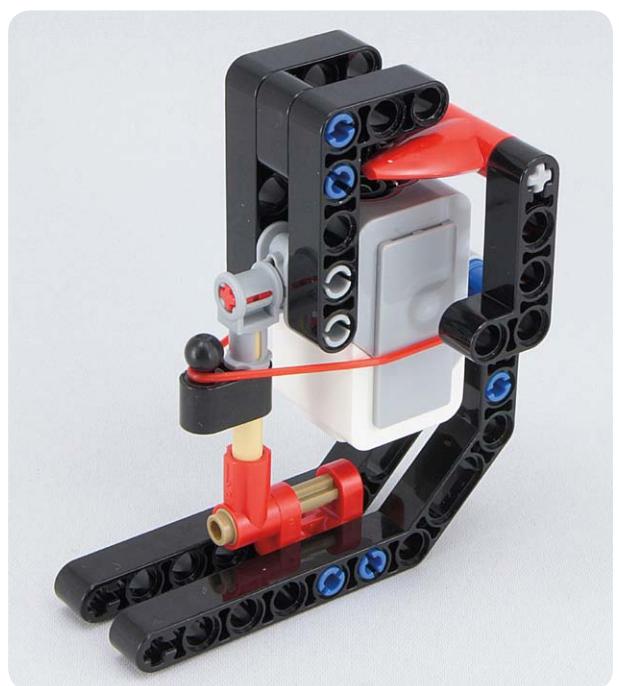
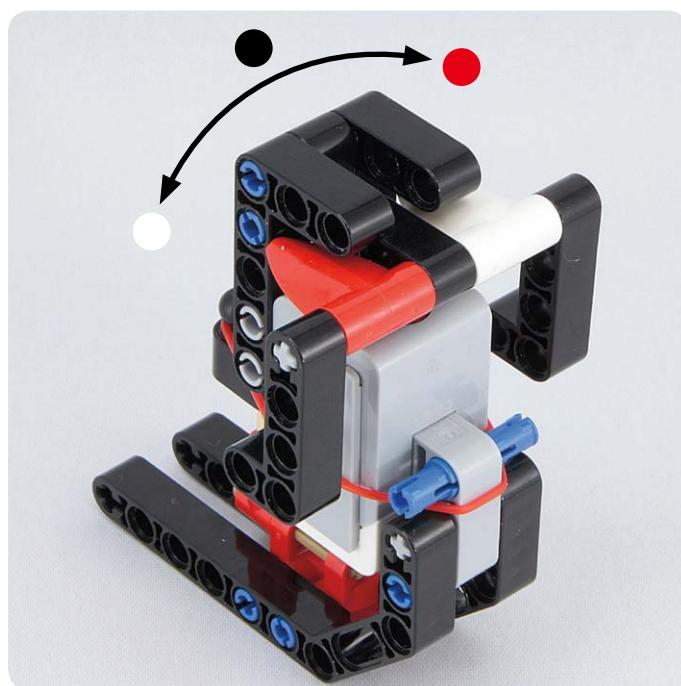
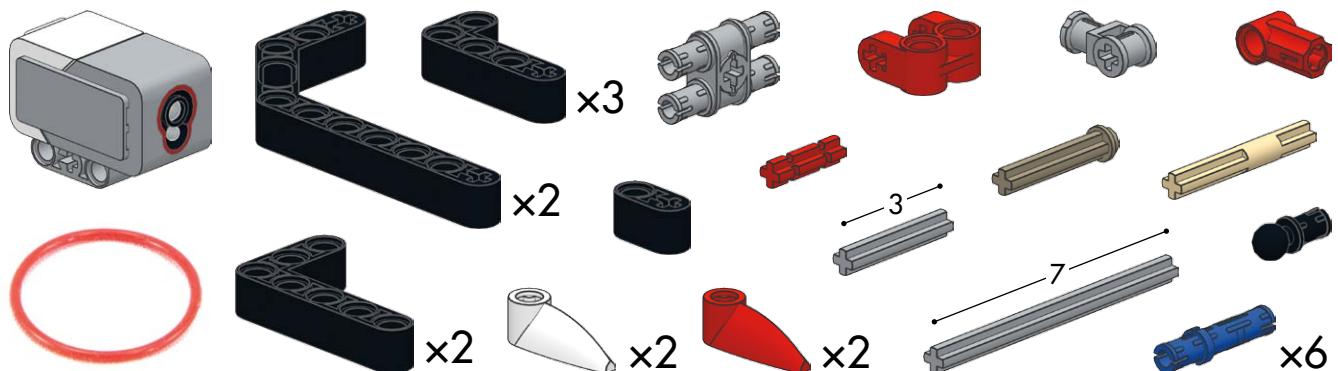


# Ideas for using the color sensor

#174

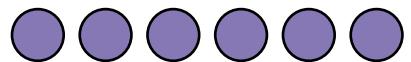


#175





# PART 6



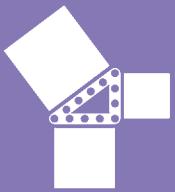
# Something Extra



220



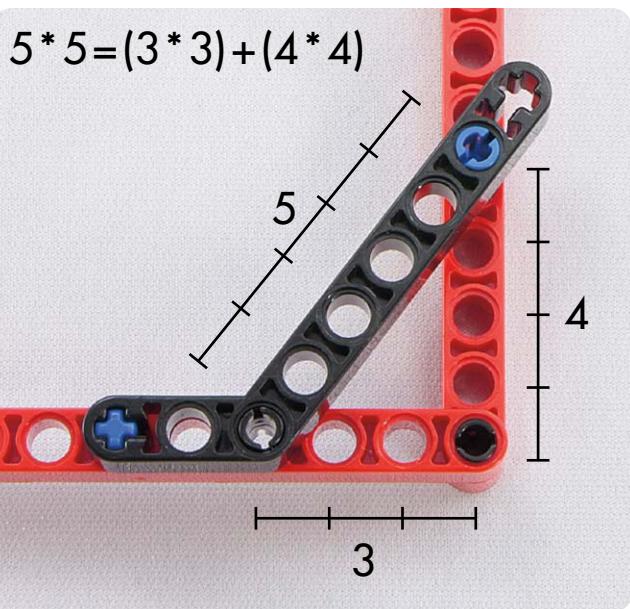
222



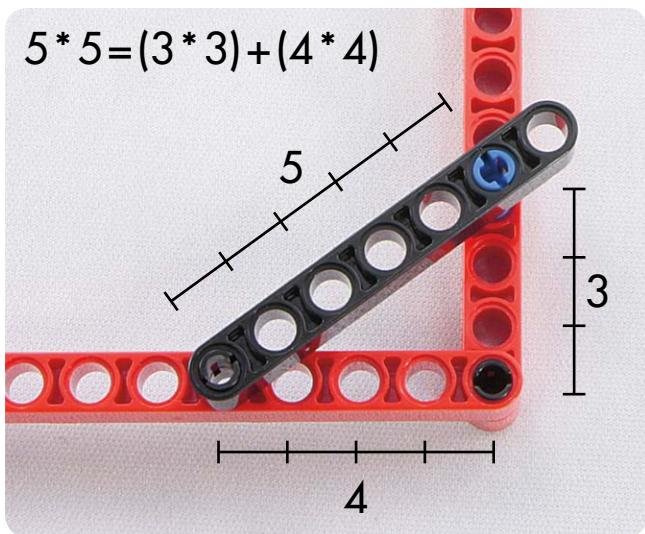
# Using the Pythagorean theorem

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#176

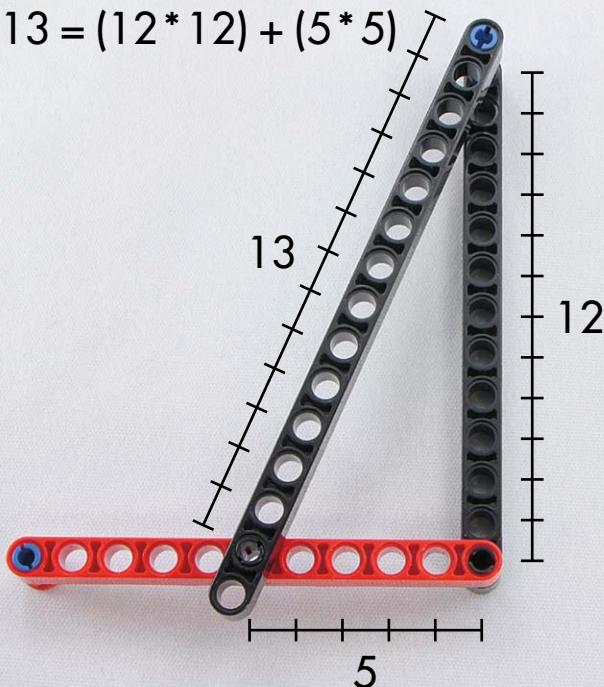


#177



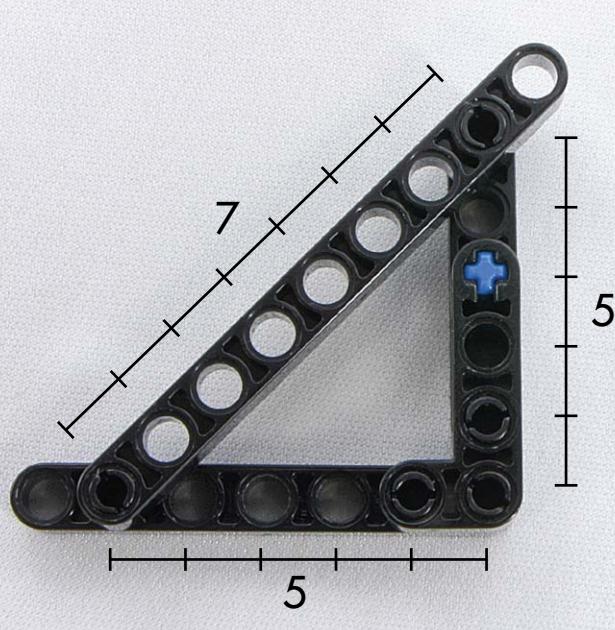
#178

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



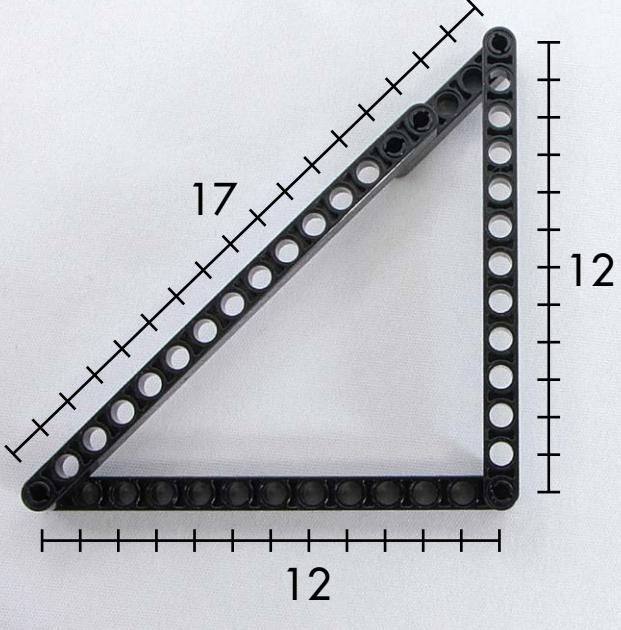
#179

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



#180

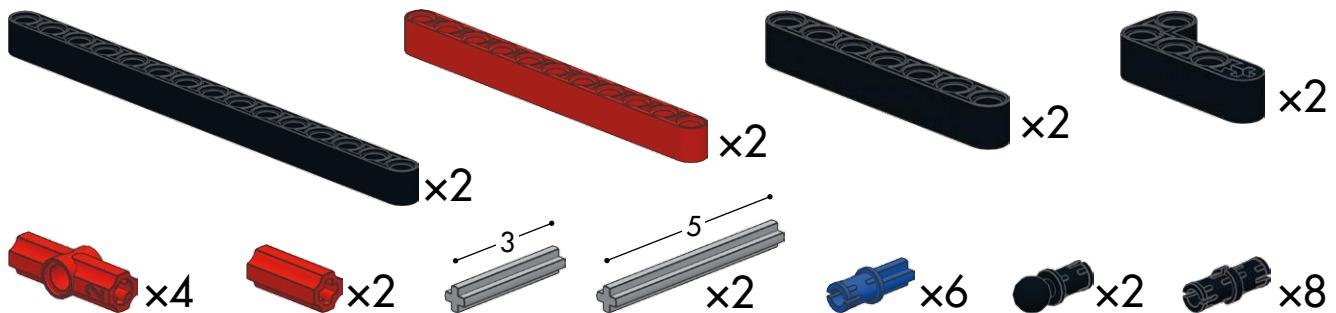
$$17 \cdot 17 \approx (12 \cdot 12) + (12 \cdot 12)$$





# Try building something handy!

#181





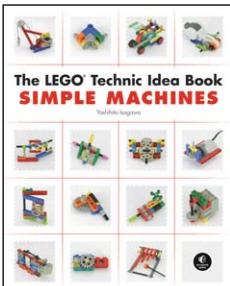
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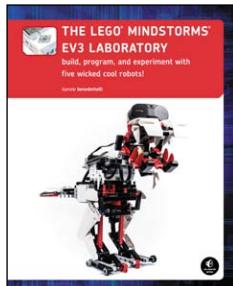
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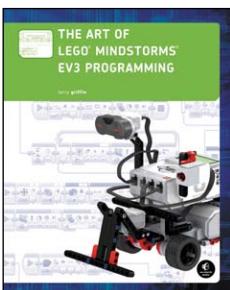
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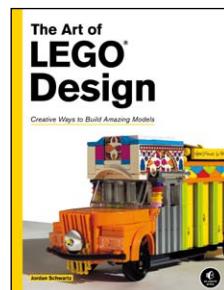
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### ABOUT THE AUTHOR

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



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