



# MINDSTORMS™

# ROBOTICS INVENTION

SYSTEM 1.5

CONSTRUCTION KIT

9747

## Introduction

The Constructopedia™ is a building guide for the Robotics Invention System™ 1.5. It offers suggestions, hints, and tips that help you get started with the Challenges in the software, as well as your own inventions.

To master a Challenge, follow these steps:

### 1. BUILD

Review the Design Brief on the CD-ROM and start building your robot. You can use the Constructopedia, or your imagination.



### 2. PROGRAM

You program your robot with RCX Code (included in the software). RCX Code determines how your robot reacts to its environment.



### 3. TEST

After downloading the program from your PC, your robot can move in and react to its environment. Now, let your creation loose and watch what happens.



With LEGO MINDSTORMS™, You Get **The Power of Robotics @ Your Command™!**

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## GETTING STARTED

The following steps will help you set up your Robotics Invention System™.


### Installing Batteries

For the RCX to work, 6 new AA/LR6 batteries are required. Alkaline are recommended. Rechargeable batteries can be used, but power may be reduced.



#### Instructions for use of battery box:

Never mix different types of batteries in one battery box. Always remove the batteries from the battery box for long-term storage or if they have reached the end of their life. Liquid leaking from dead batteries will damage the RCX. Rechargeable batteries should be recharged under adults supervision.

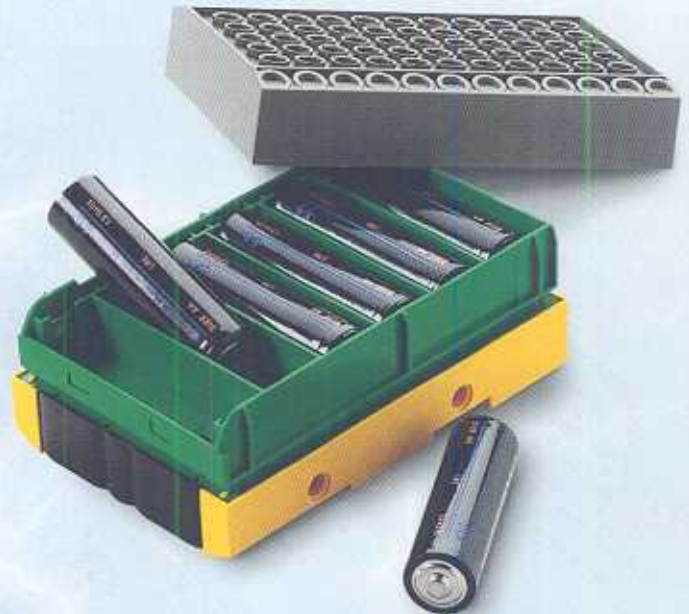
When the RCX's batteries are low, this icon  will appear in the RCX's display window.

### Connecting Motors

To connect a motor to the RCX, you need to use the black wires with connector plates.

Attach one end of the wire to the motor and the other end to a black output port.

The side you attach the wire to can affect the direction of the motor. When building models in this book it is important to attach the wires as shown.



Install batteries as shown.





*Motor turns  
one direction.*



*Motor turns  
other direction.*

### Connecting Sensors

To connect the Touch Sensor to the RCX, you need to attach one end of the wire to the sensor and the other to a gray sensor port.



The Light Sensor already has a wire connected to it. Attach its plate to a gray sensor port.



When building the models in this book, it is important to connect the sensors to the ports shown in the building instructions.

### Building the Pathfinder

The Pathfinder is a robot that you will use in the Training Mission section of the CD-ROM. It is an introduction to building robots.

The next pages show you how to build it.



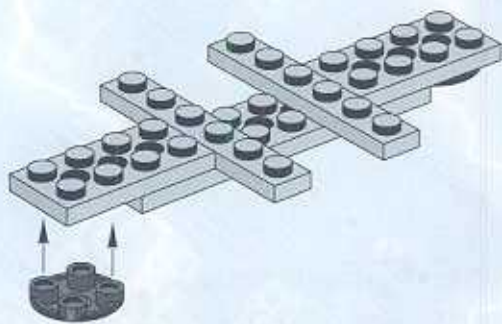
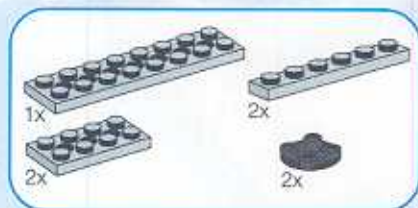


## PATHFINDER

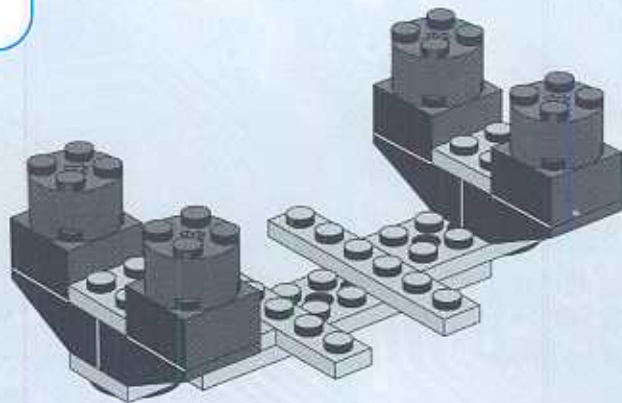
The Pathfinder is a robot you build for the software's Training Missions.

To build the robot, follow these four steps (check that the batteries are installed before starting).

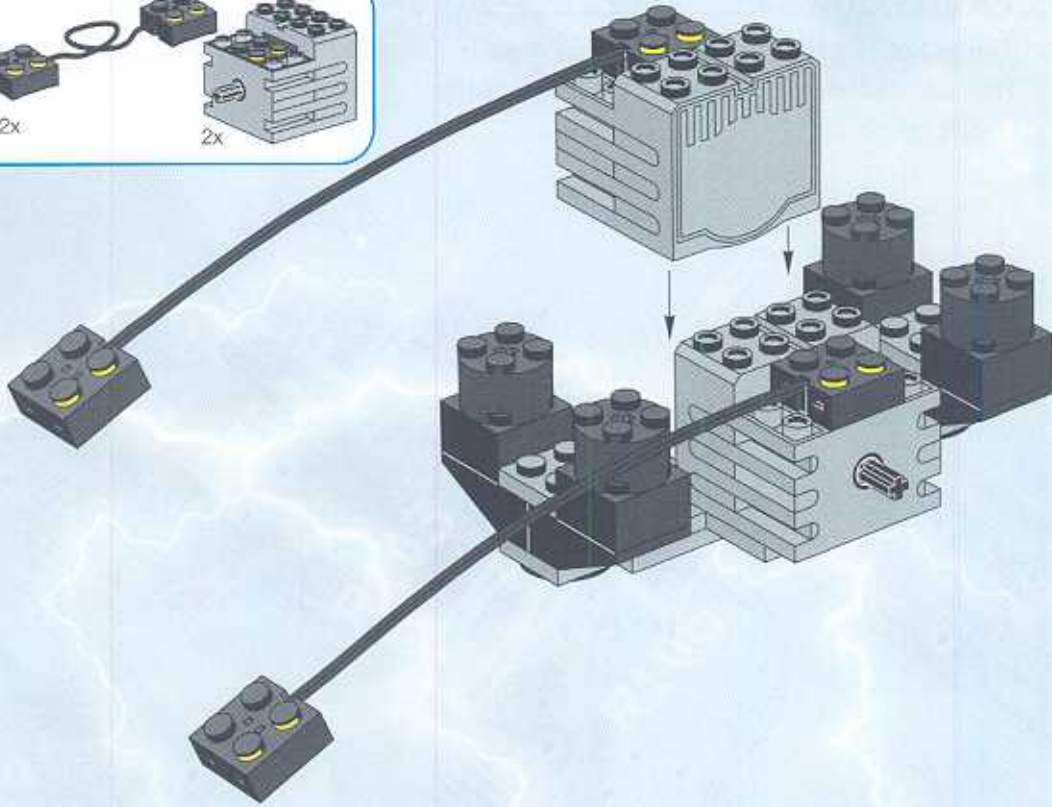
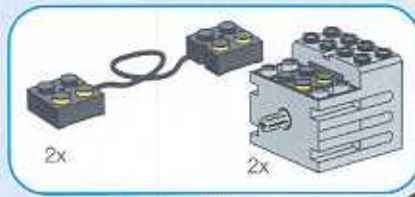
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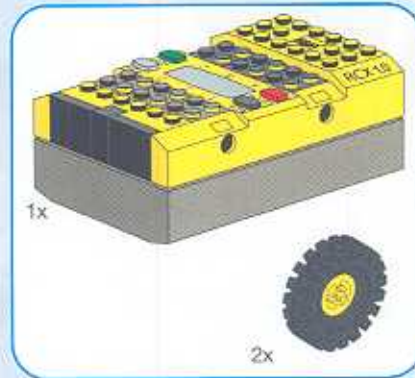
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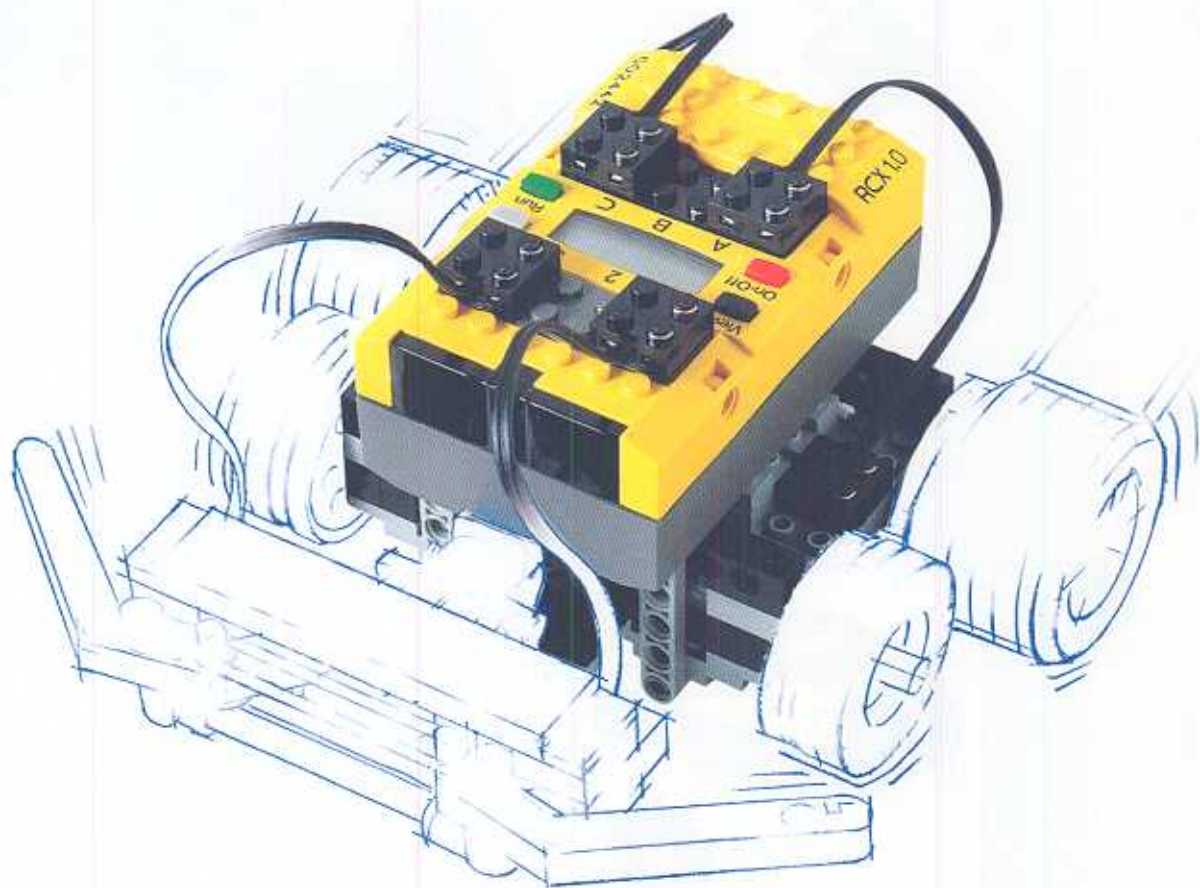


Now you can use the Pathfinder for the Training Missions.



## PROJECT IDEAS

Below are the three robots used in the Challenges. You can also design your own robots for the Challenges.



### The Roverbot

is a sturdy and steady-going little robot that explores your house. It is able to move around obstacles, as well as follow a bright light and a black line.

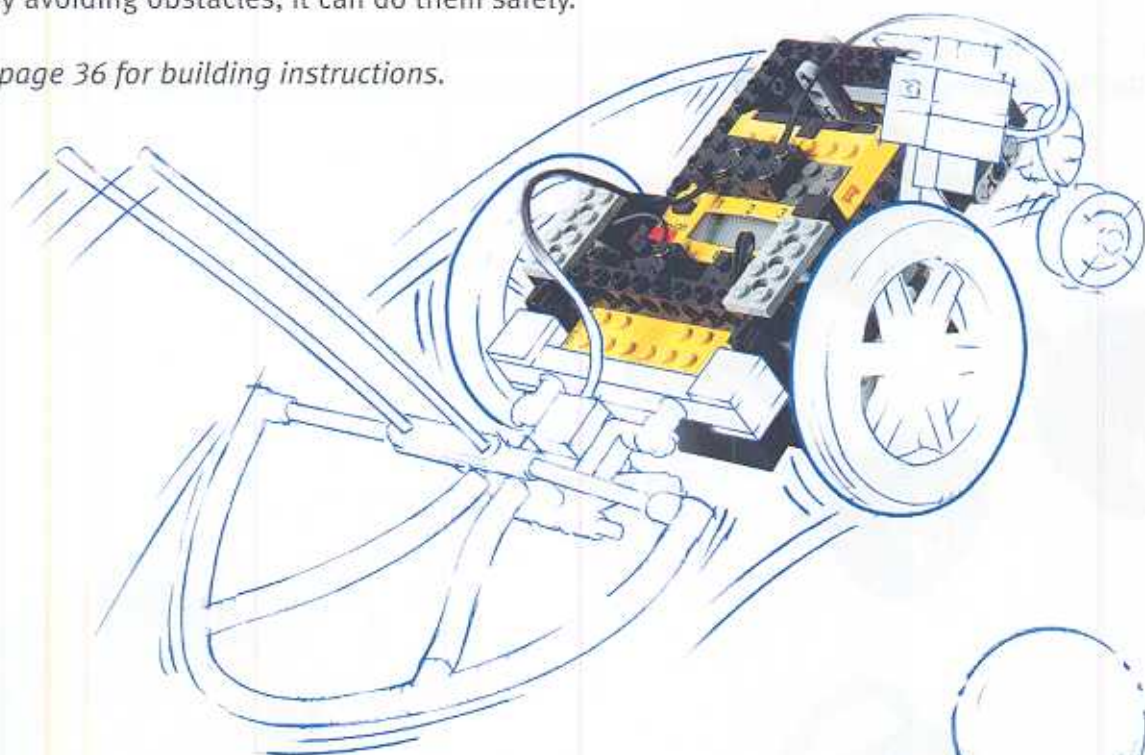
*Go to page 10 for building instructions.*



## The Acrobat

is a fast, wild robot that darts all over the place. It is a little clown that can do acrobatic stunts, and, by avoiding obstacles, it can do them safely.

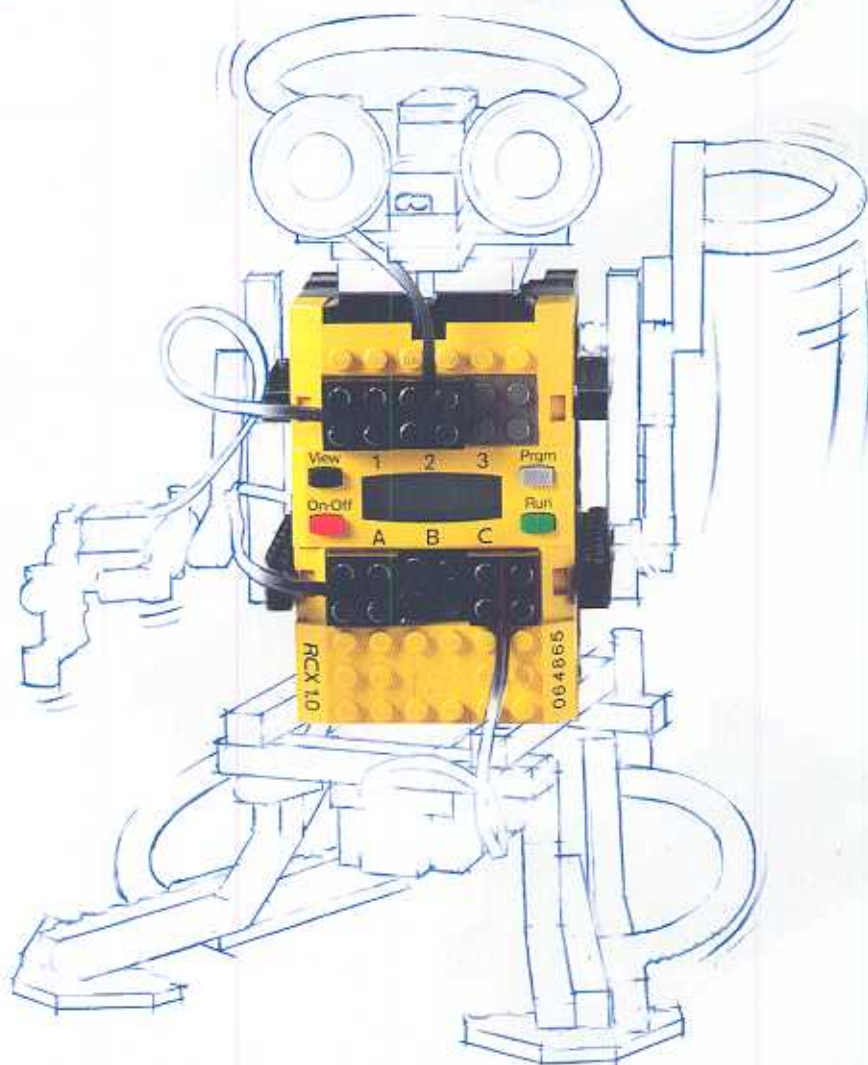
*Go to page 36 for building instructions.*



## The Inventorbot

is a smart and attentive standing robot. It can greet you, throw an object, and act as an intruder alarm. It will do your bidding, after you program it to.

*Go to page 56 for building instructions.*





## ROVERBOT SECTION

Here is an overview of the Roverbot.

The following pages show building instructions for each part.

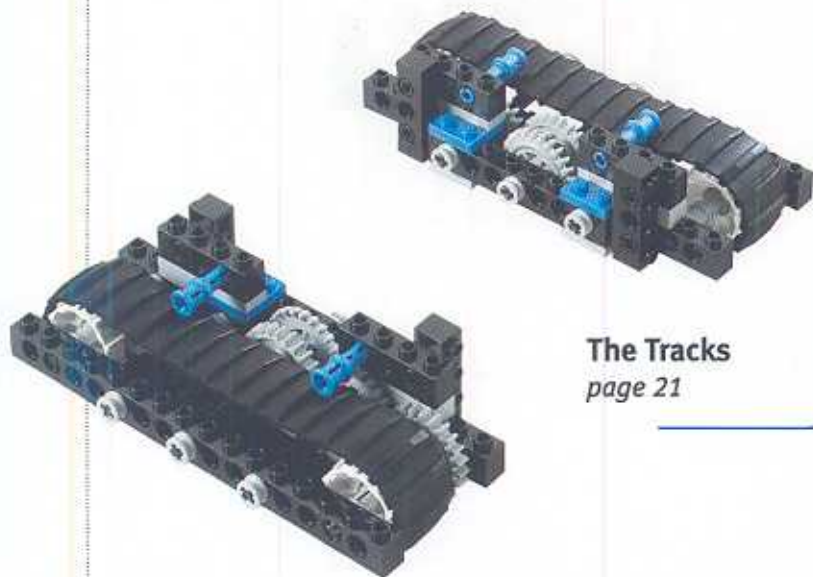
Start by building the Driving Base, then choose which attachments you want to add.



**The Wheel Sets**  
*page 17*



**The Legs**  
*page 18*



**The Tracks**  
*page 21*



**The Driving Base**  
*page 12*

The Driving Base, together with the RCX forms the Roverbot.

Note: For additional attachments, as well as design suggestions, go to **Special Features** on *page 88*.

Examples of a Roverbot.



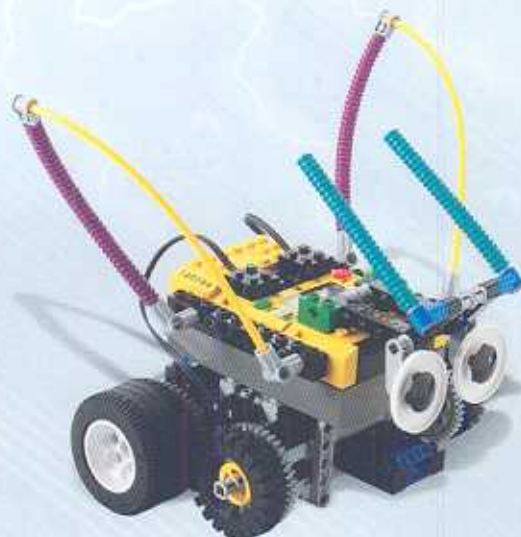
**The Single Bumper**  
page 26



**The Double Bumper**  
page 30



**The Light Sensor**  
page 34

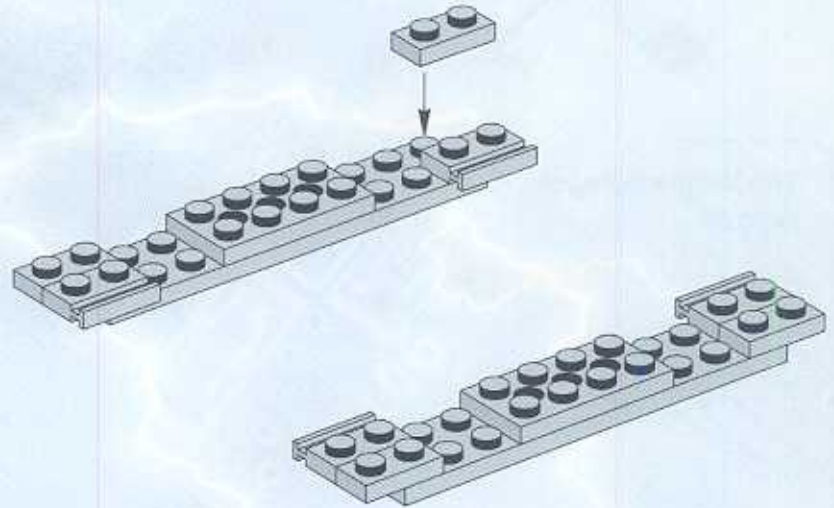
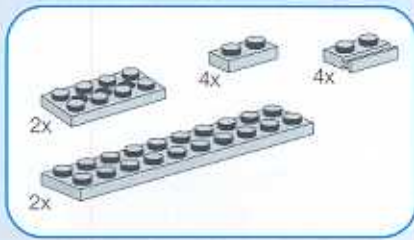




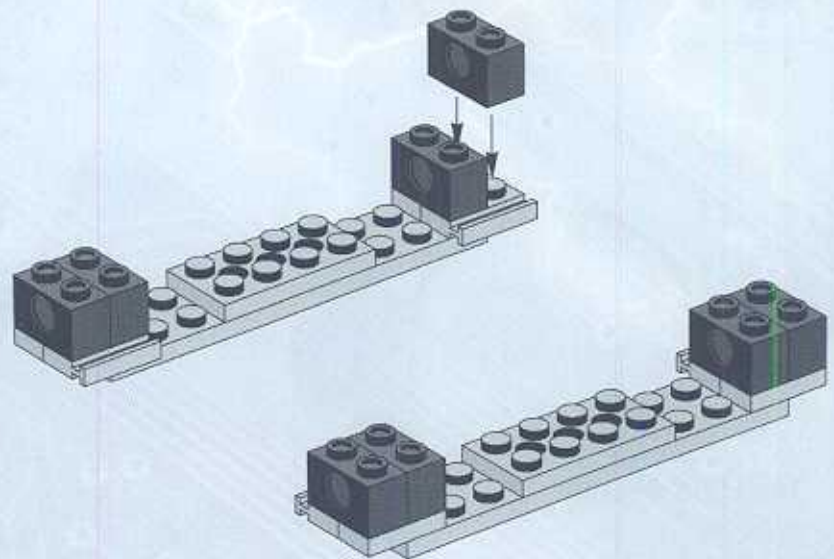
## Driving Base

Check that your RCX has working batteries before starting.

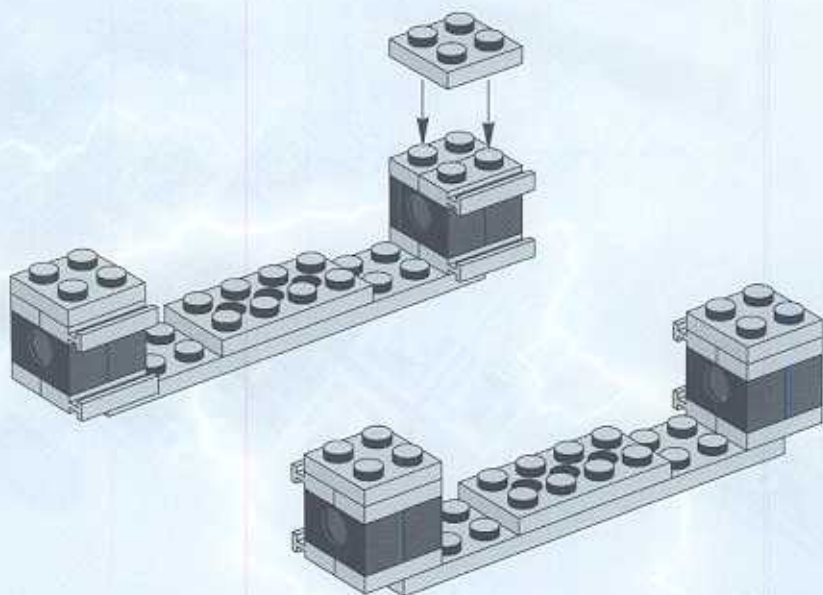
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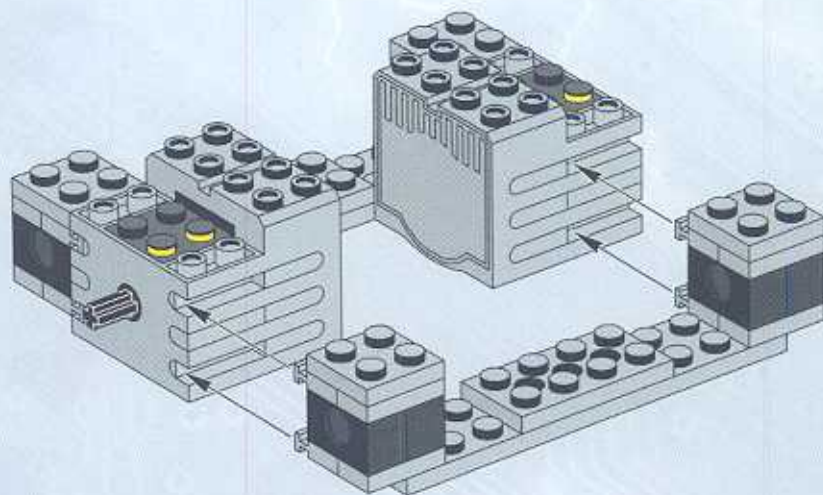
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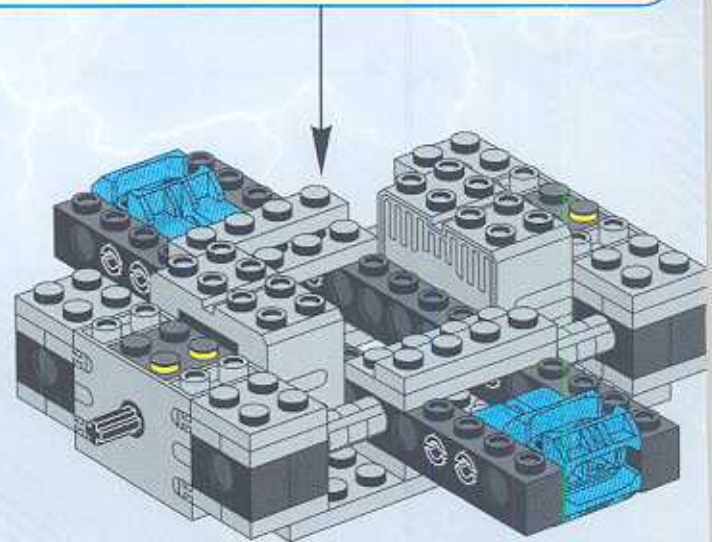
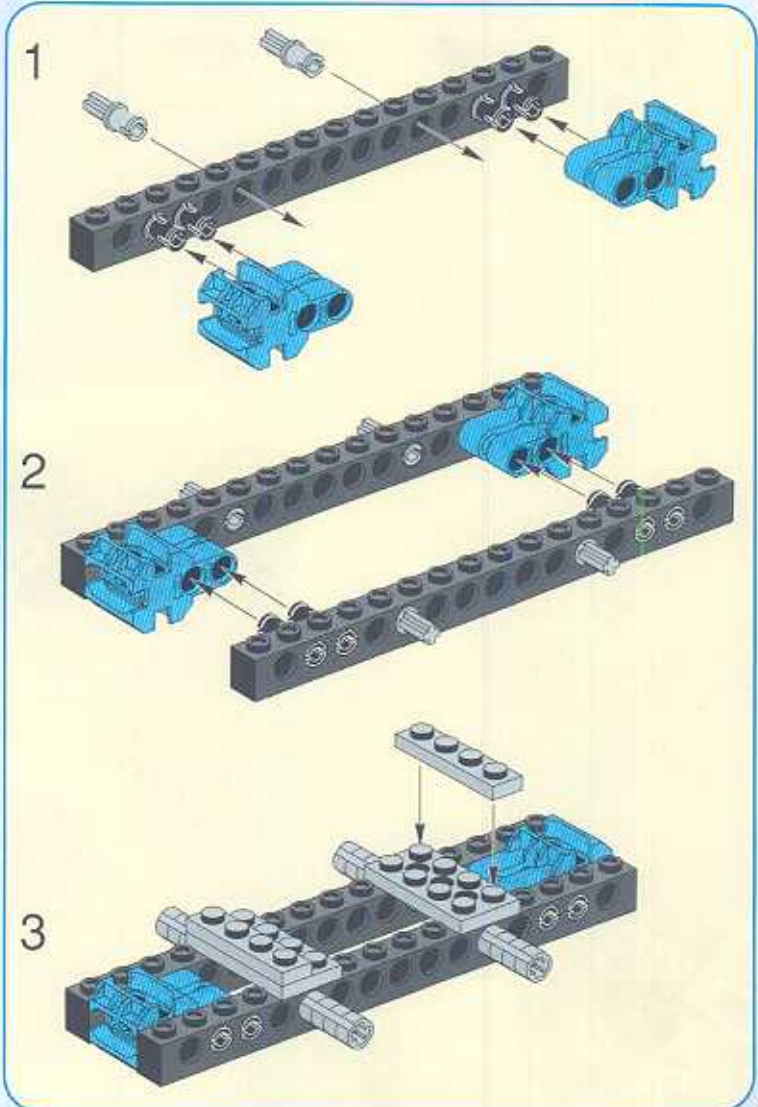
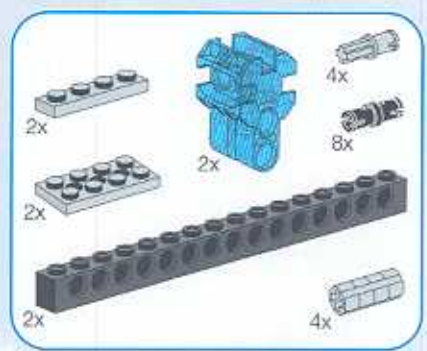


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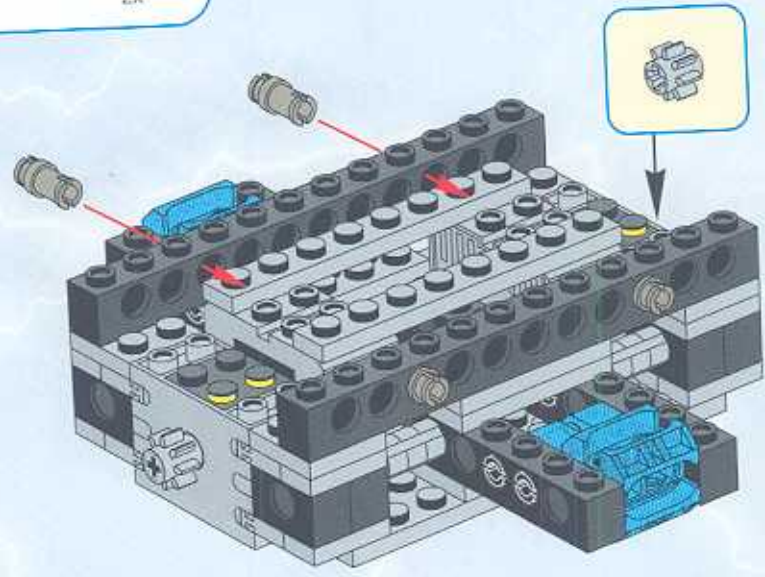
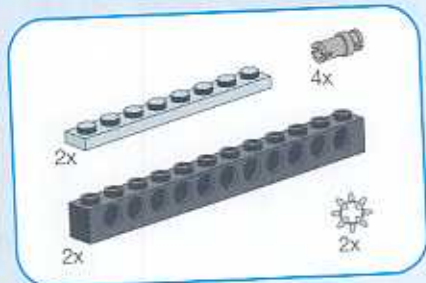


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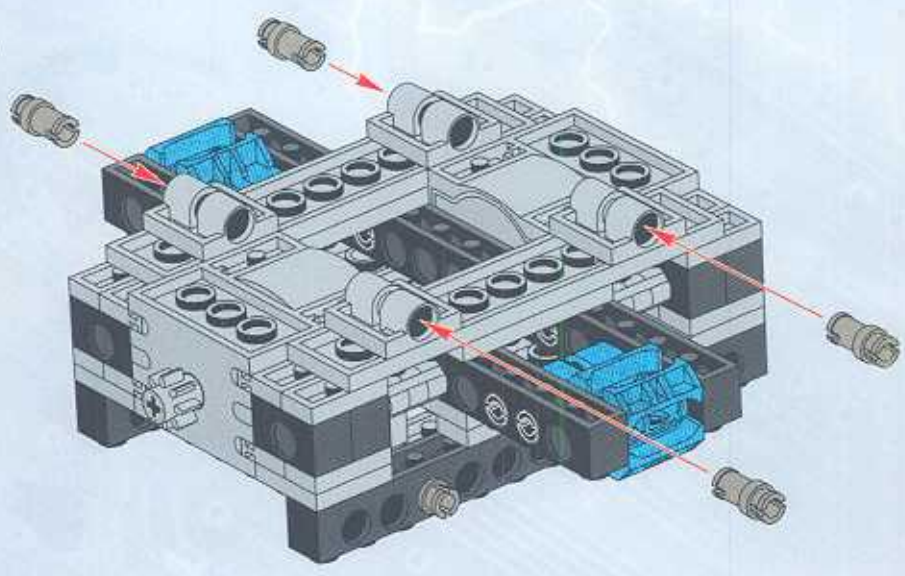




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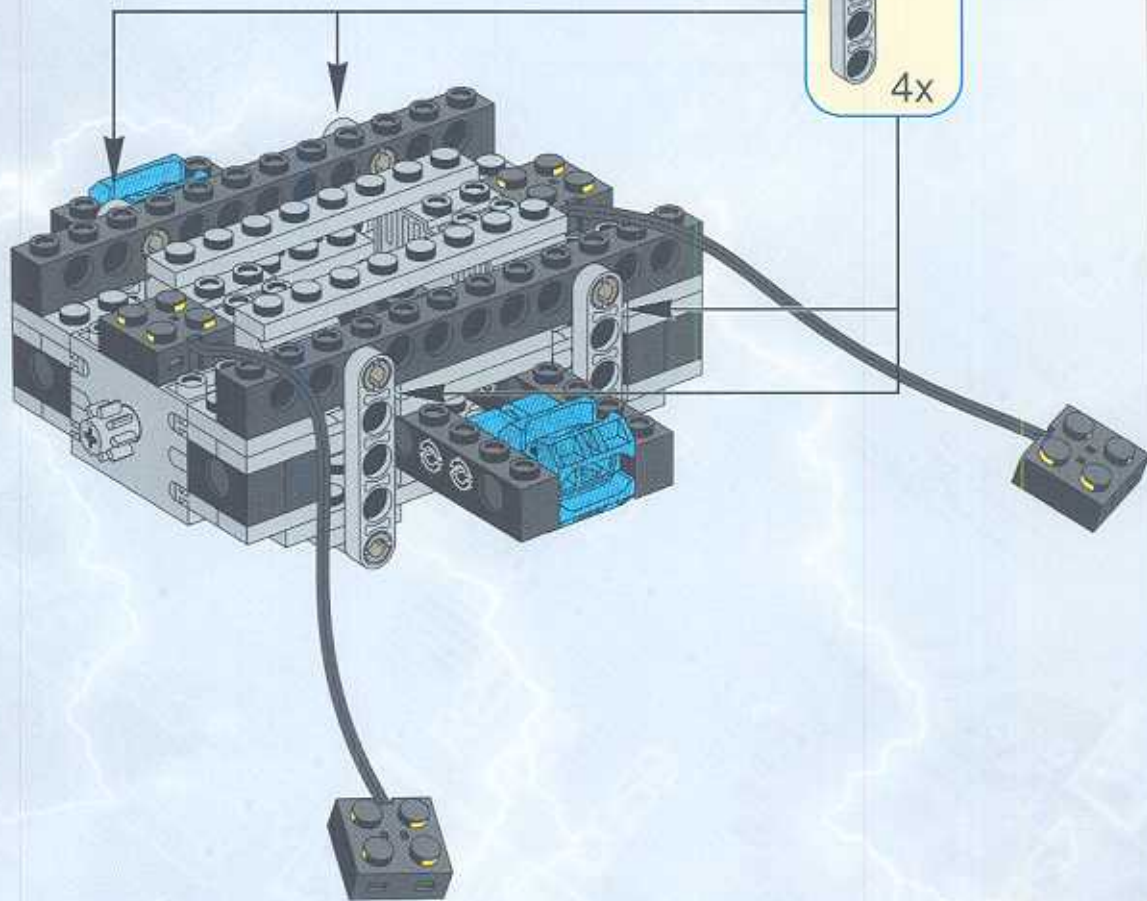


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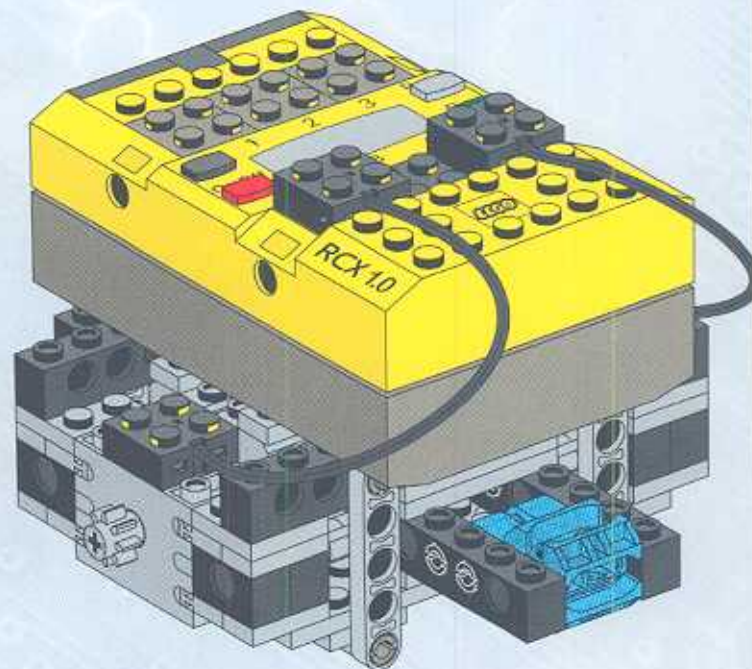
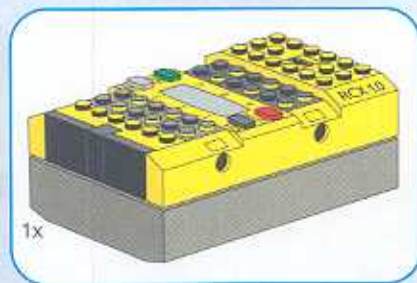




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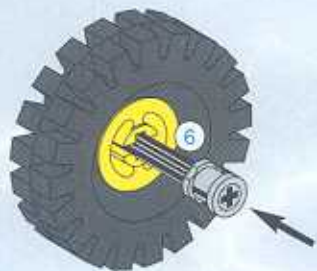


*This is the Driving Base for the Roverbot. Be sure to attach the wires as shown.*

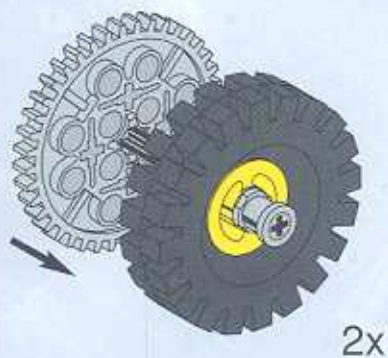


# Wheel Sets

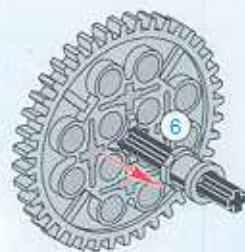
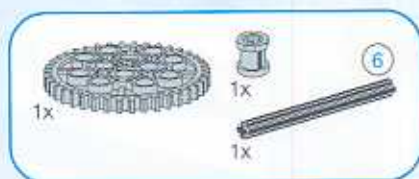
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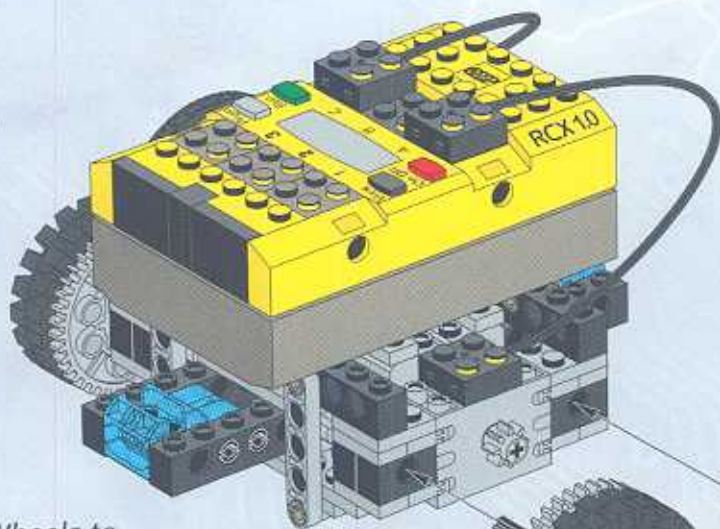
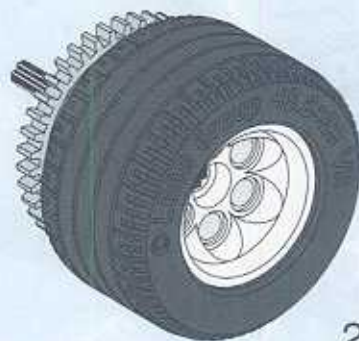
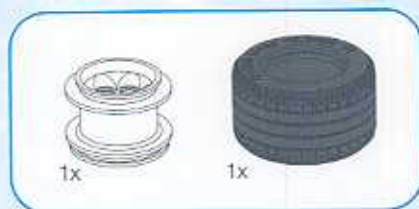
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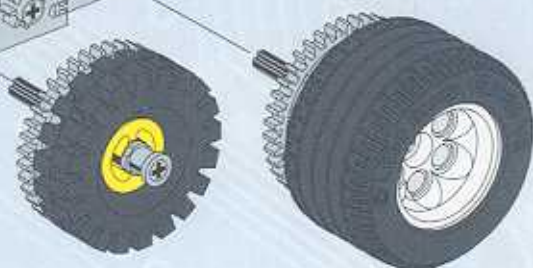


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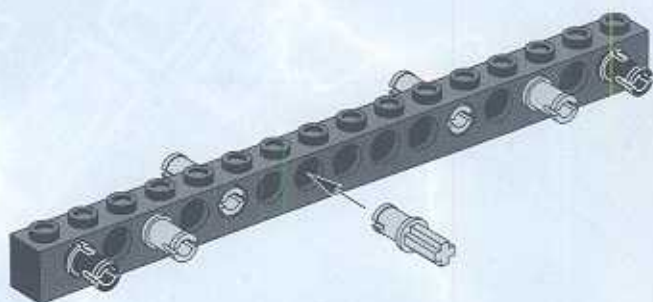
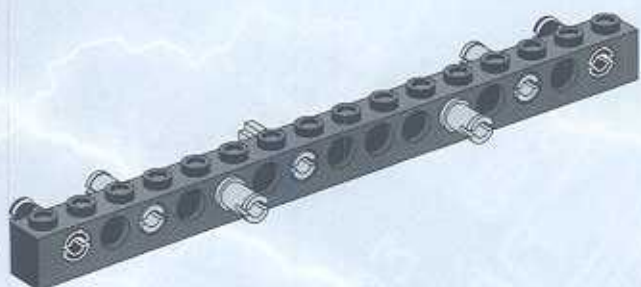
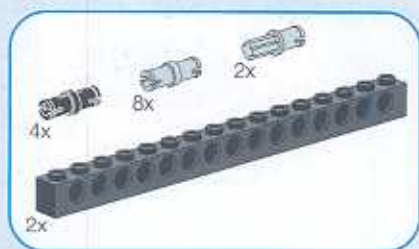
Attach the Wheels to the Driving Base like this.

If you have not yet built the Driving Base, go to page 12.

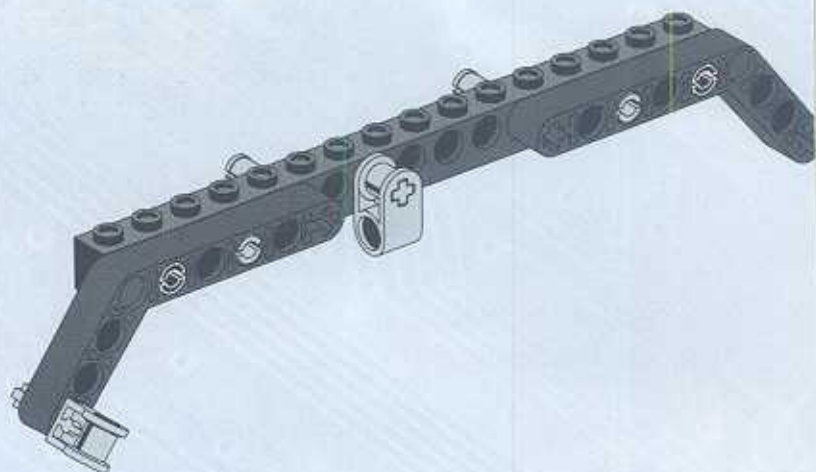
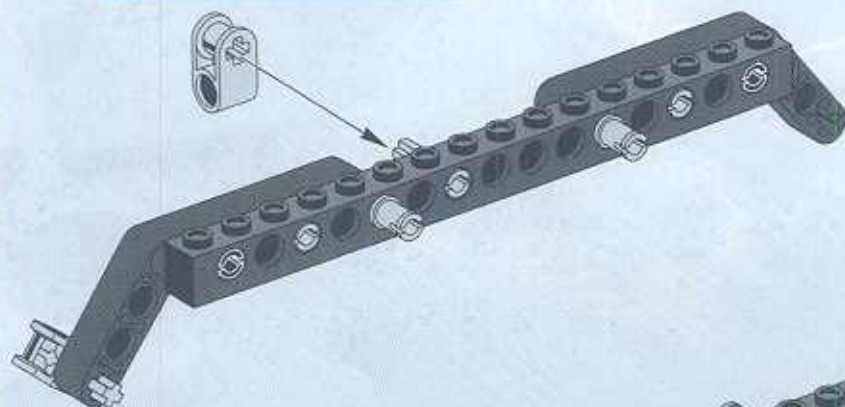
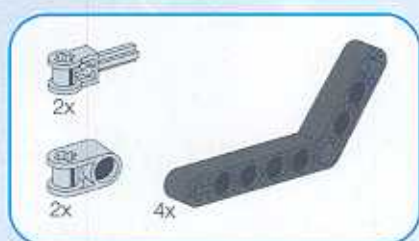


# Legs

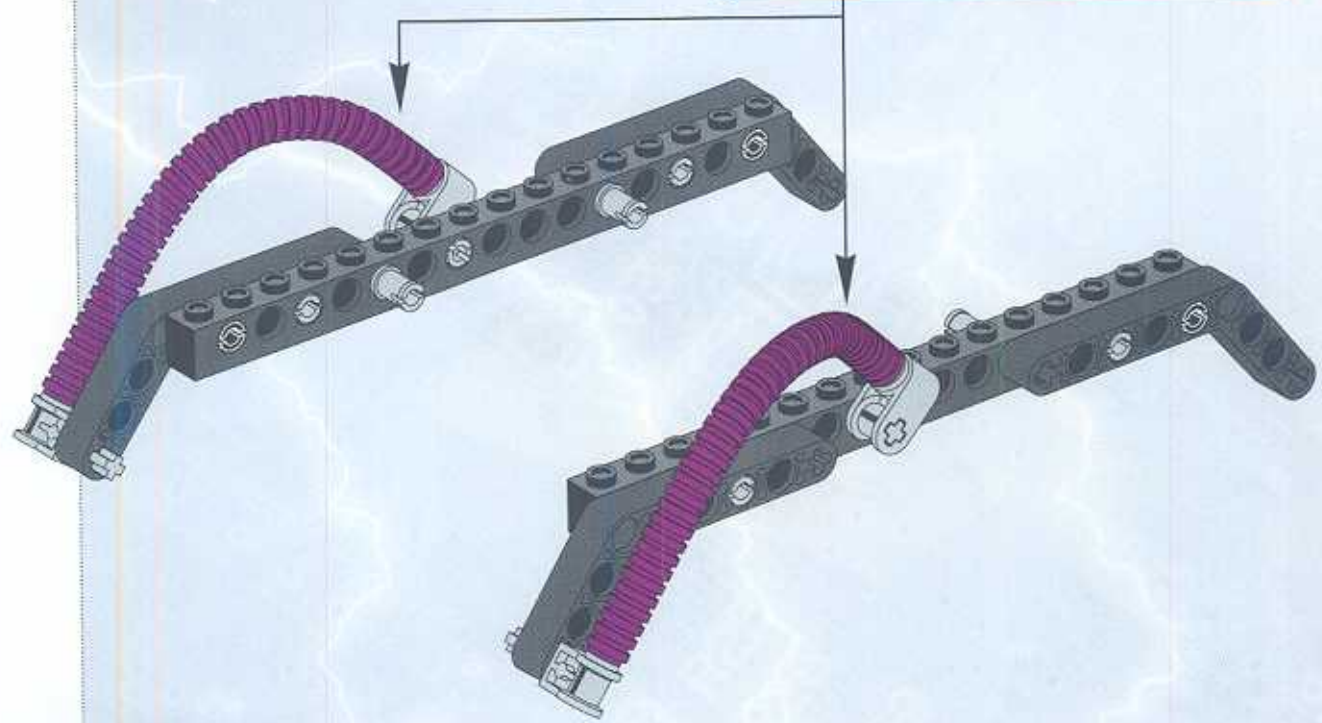
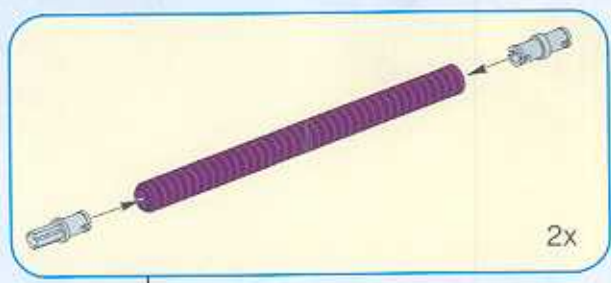
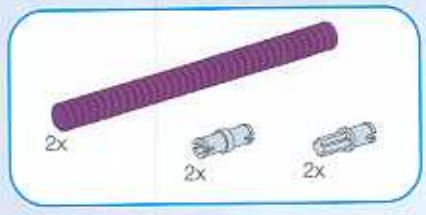
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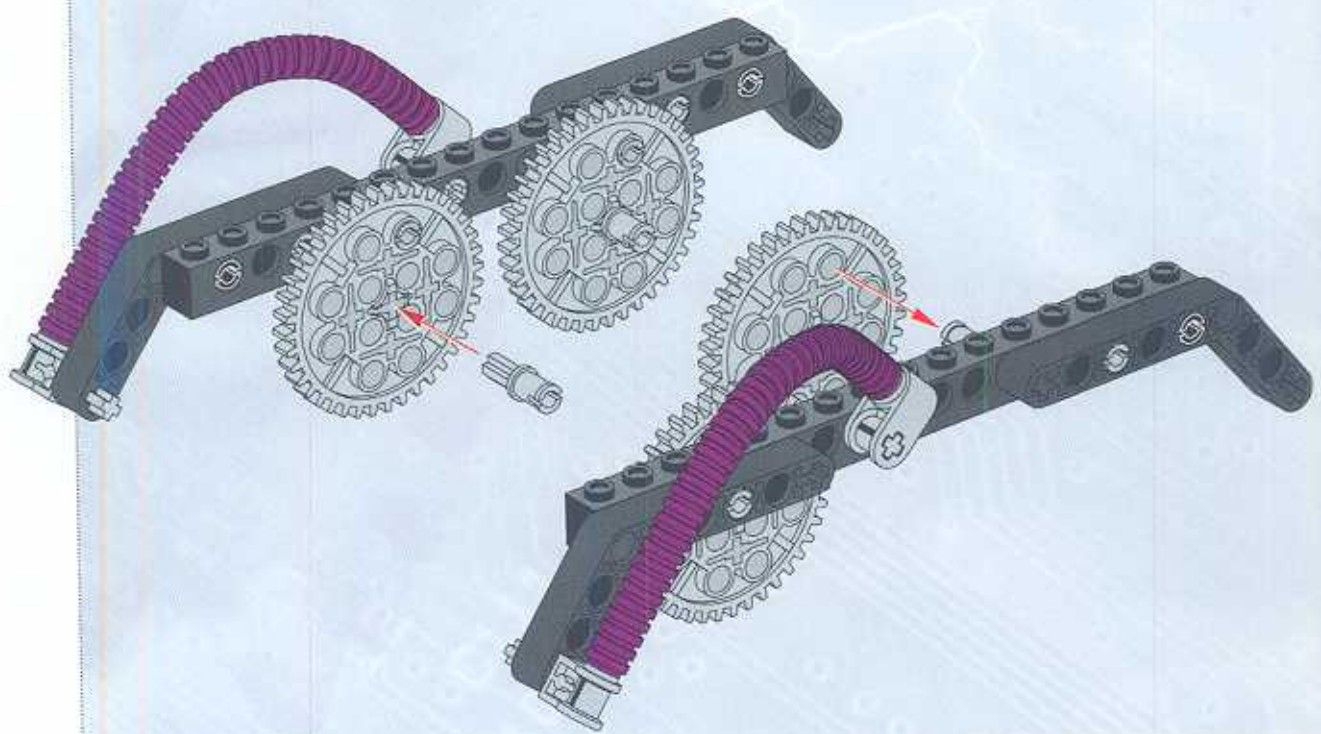
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4





5

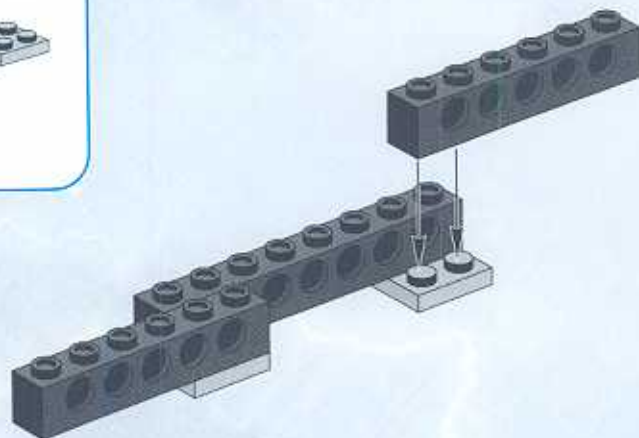
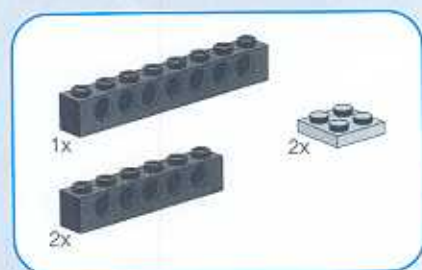
*Attach the Legs to the Driving Base like this.*

*If you have not yet built the Driving Base,  
go to page 12.*

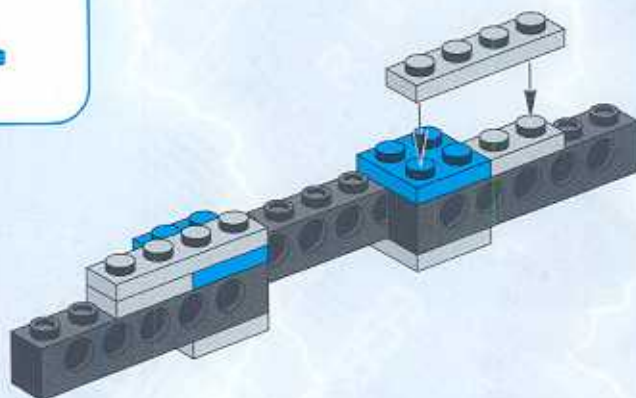
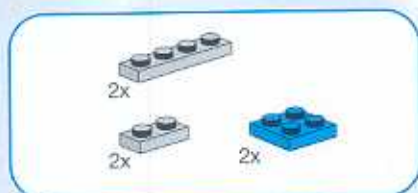
# Tracks

These building instructions show you how to make one of the two tracks. As you need two, do these building steps twice.

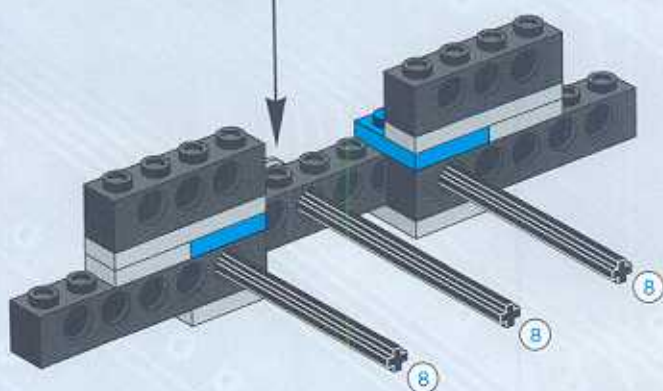
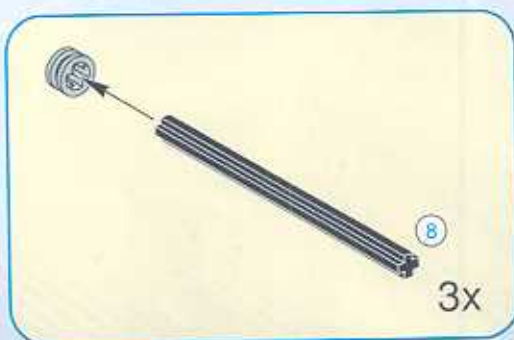
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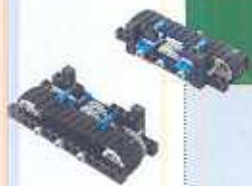


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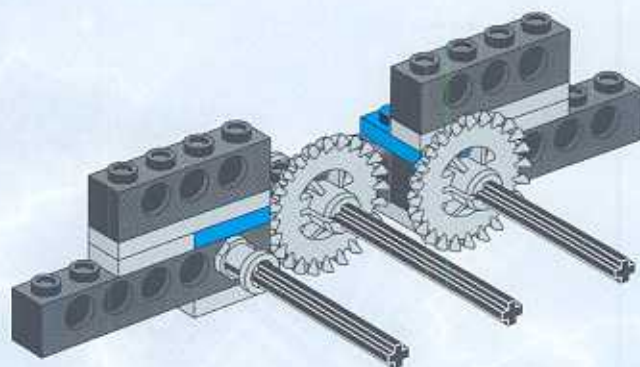
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2x



1x



5



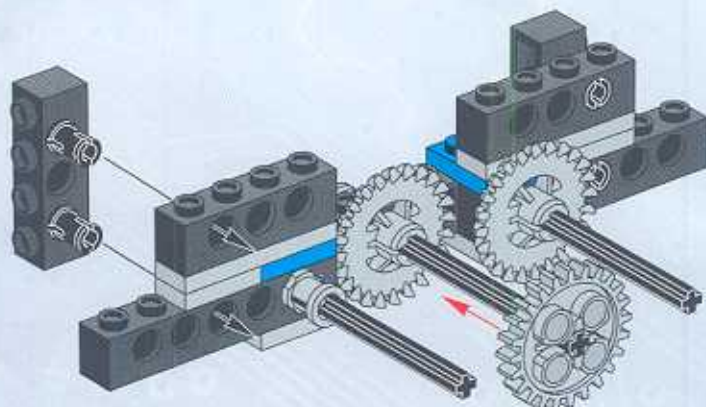
4x



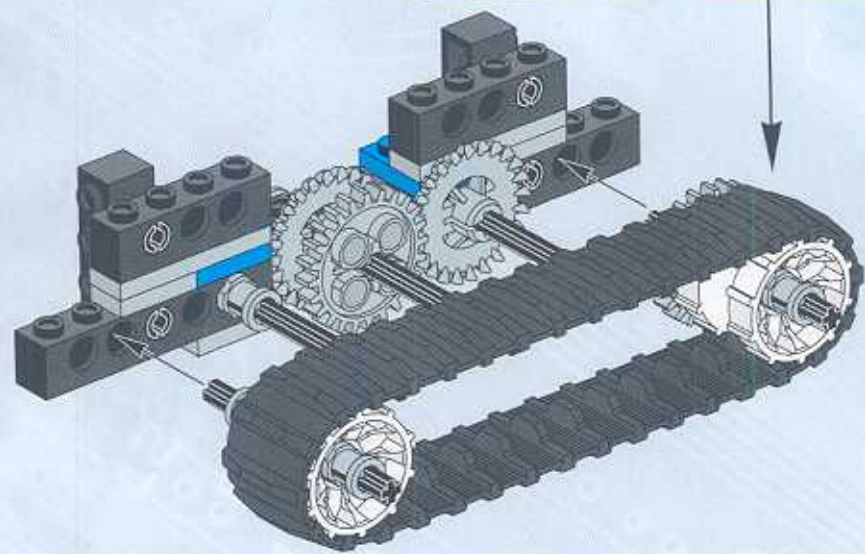
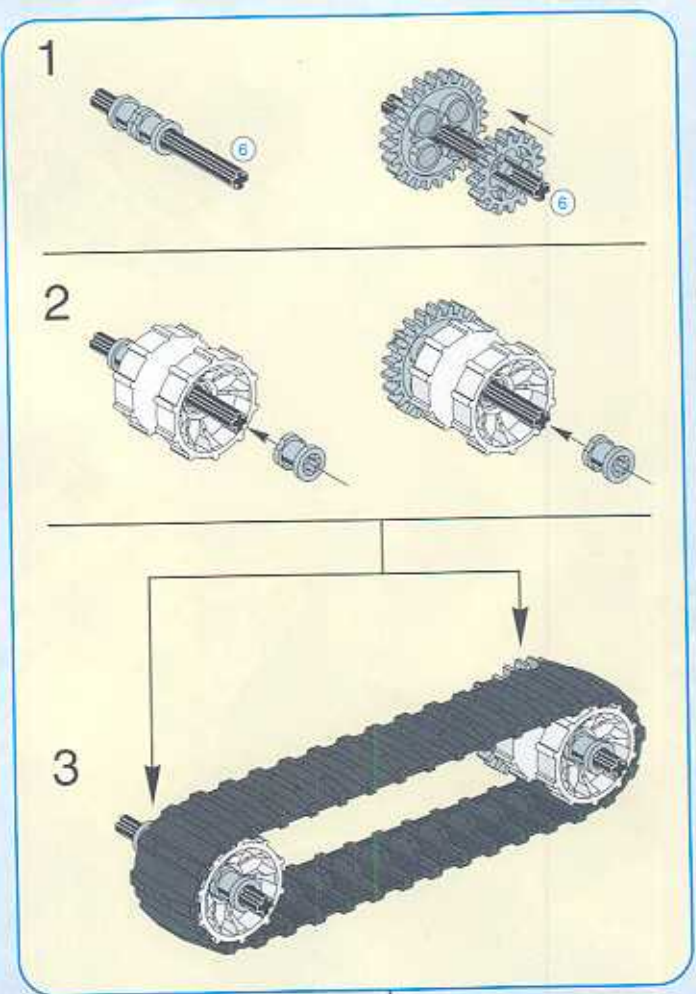
2x



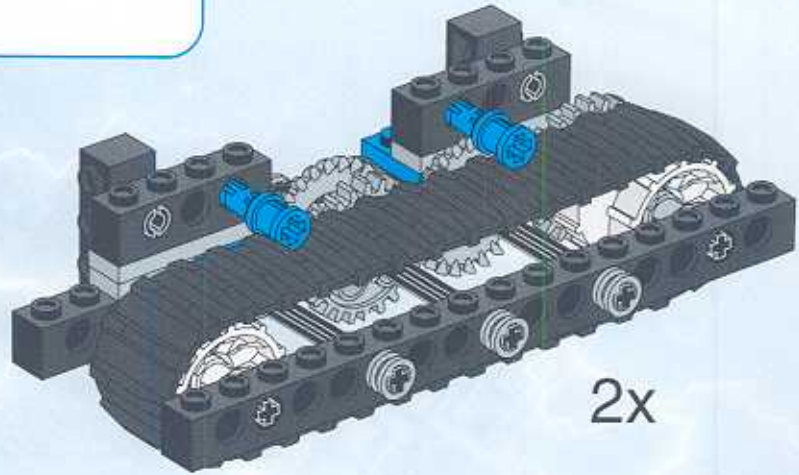
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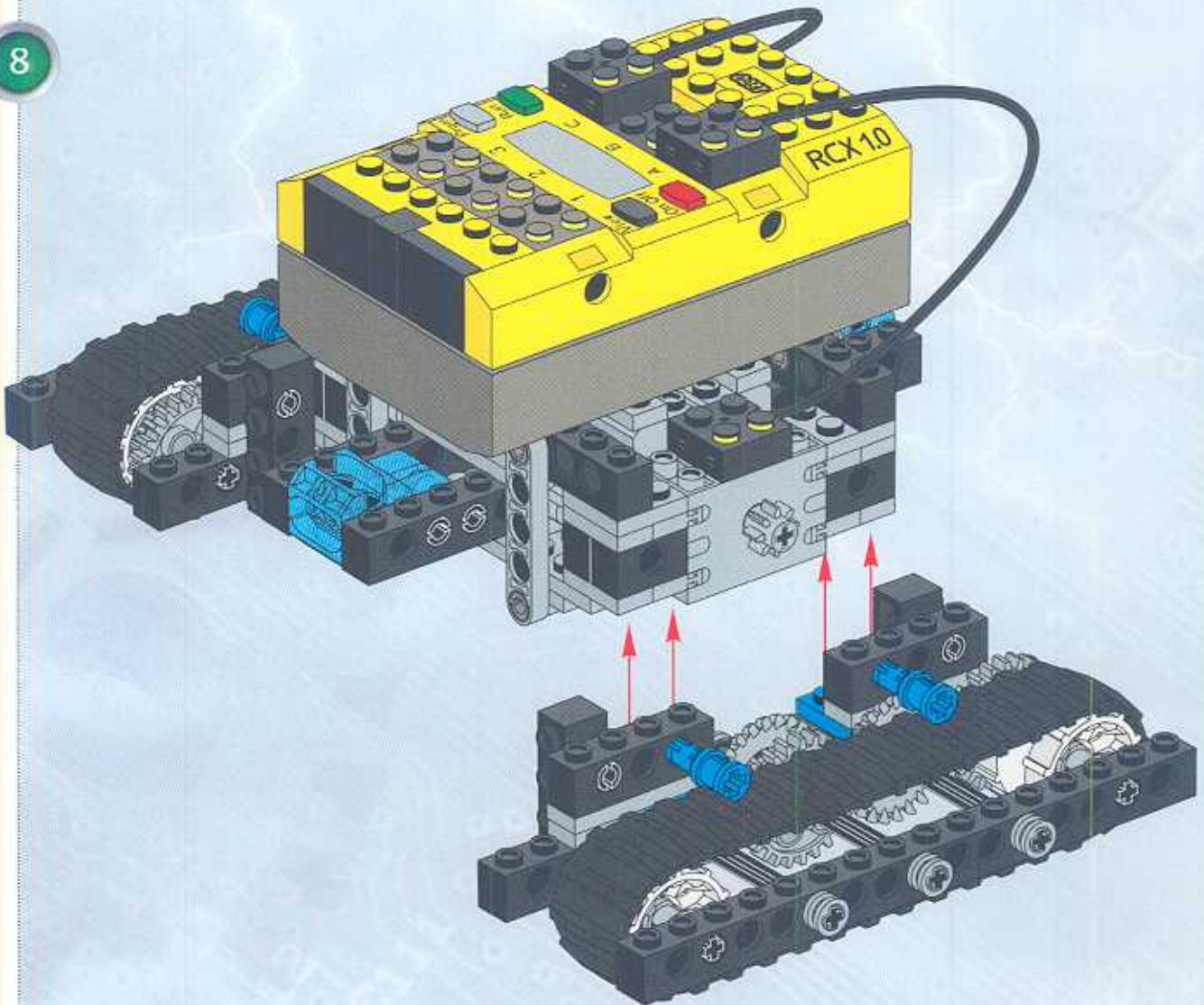
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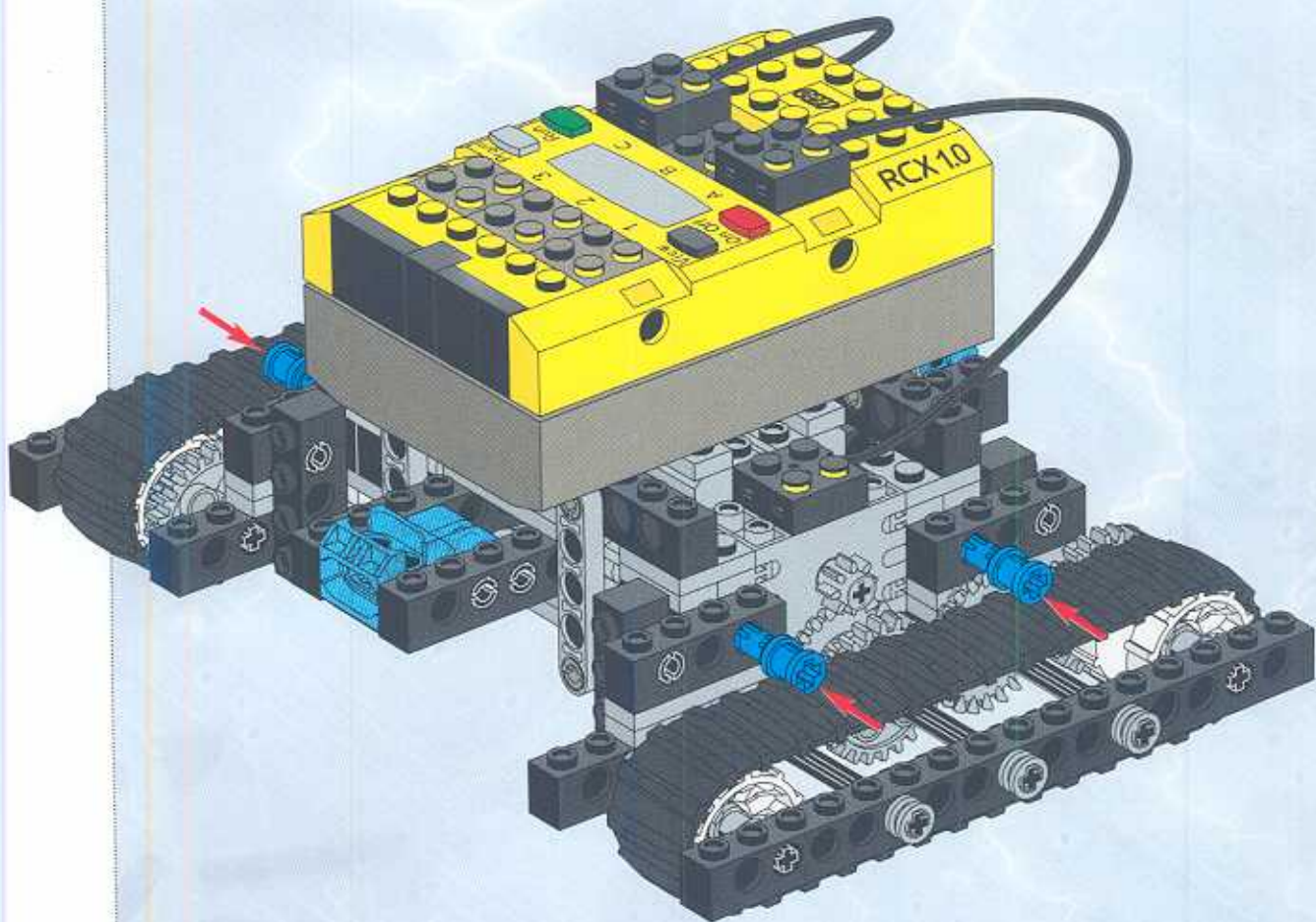


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*Attach the Tracks to the Driving Base like this.*

*If you have not yet built the Driving Base,  
go to page 12.*

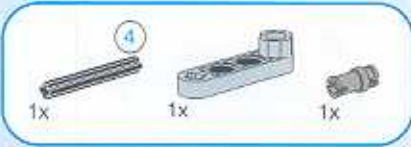


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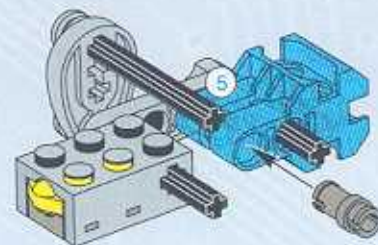
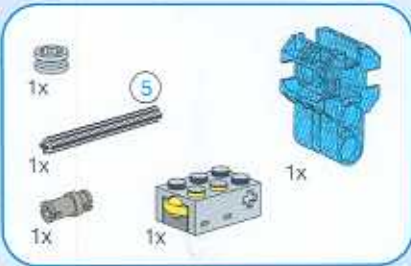
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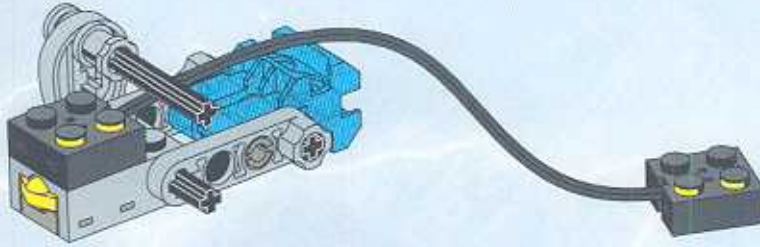
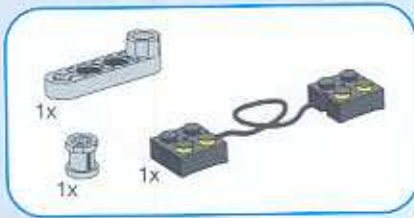
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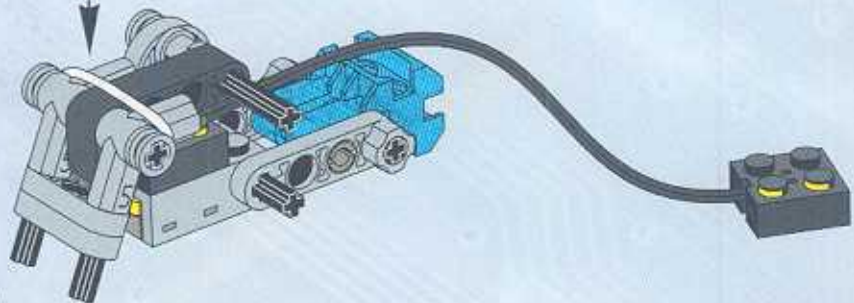
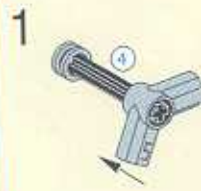
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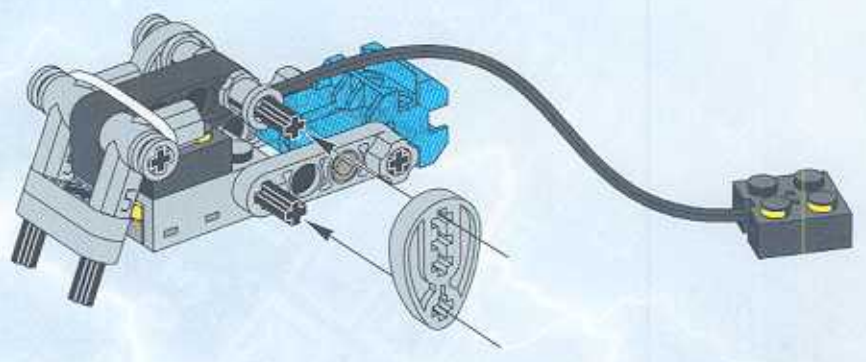


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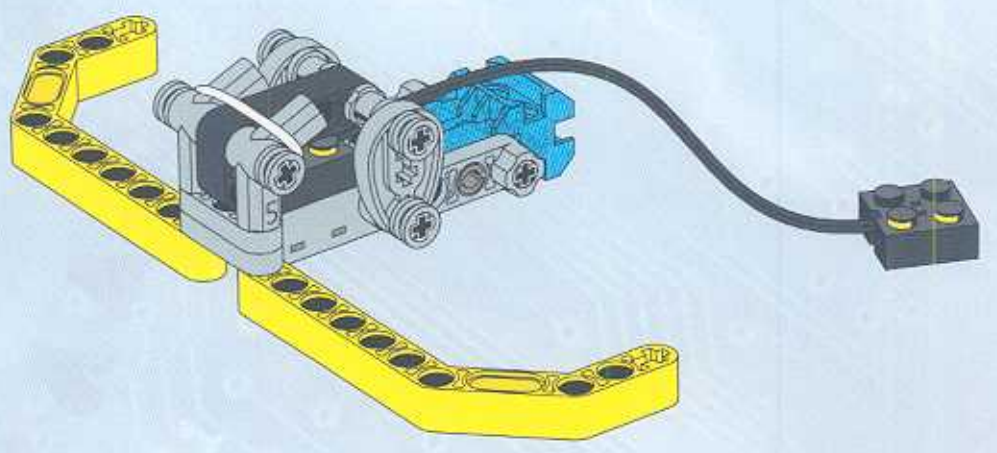
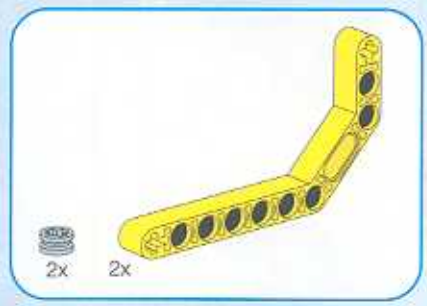




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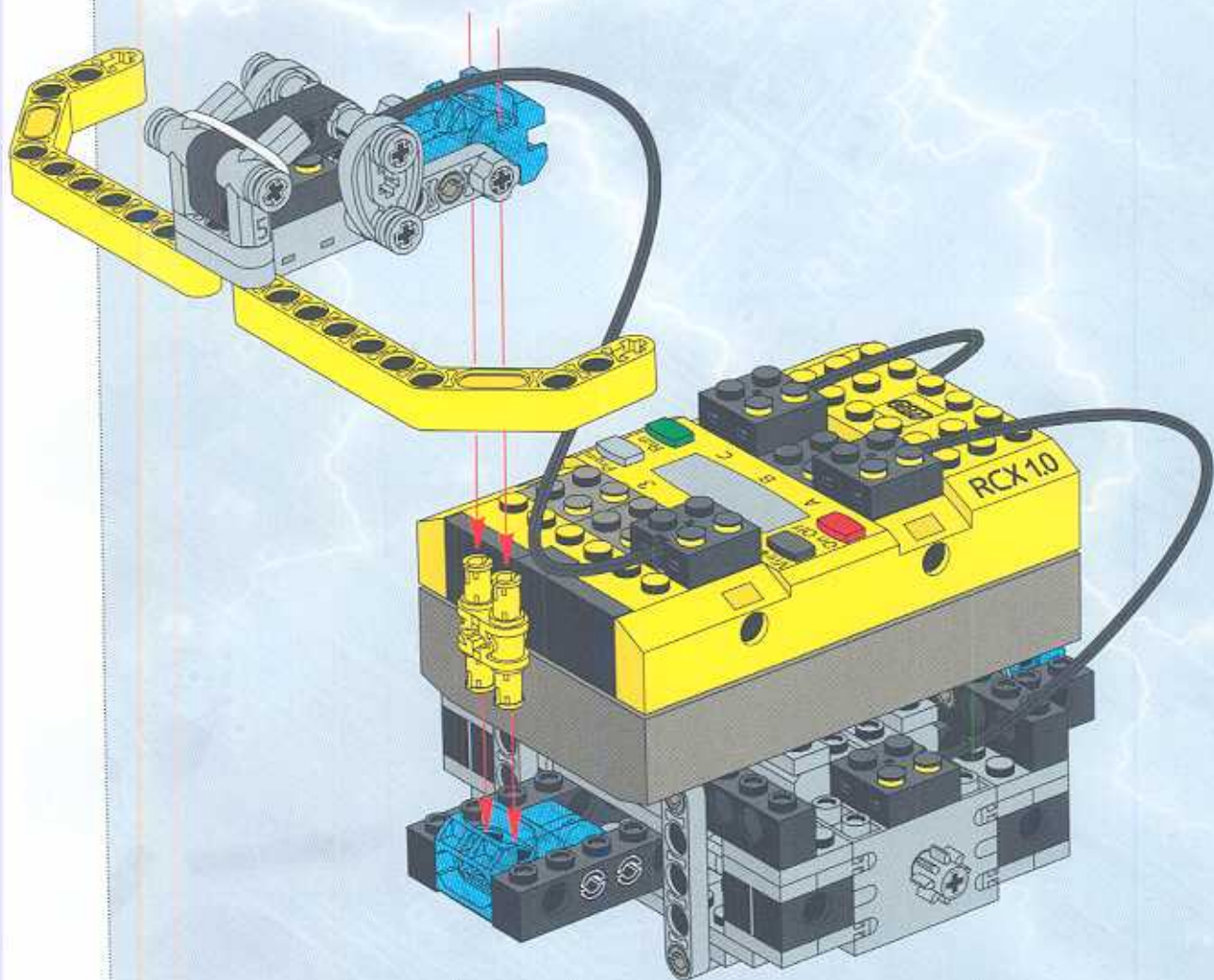
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8



1x

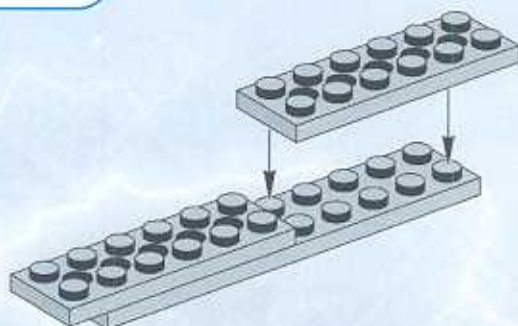
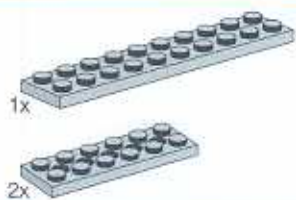


Attach the Single Bumper to the Driving Base like this.

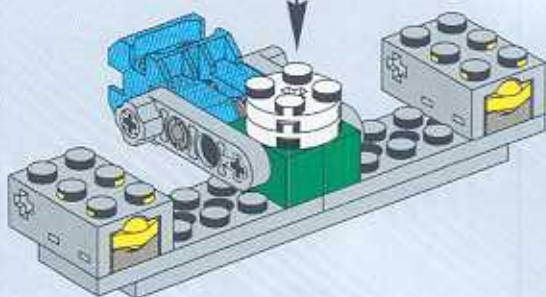
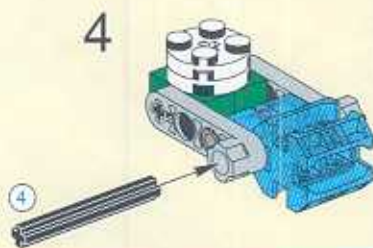
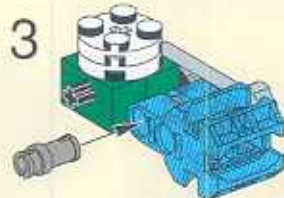
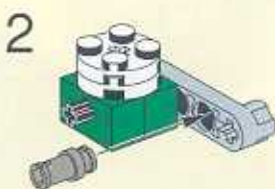
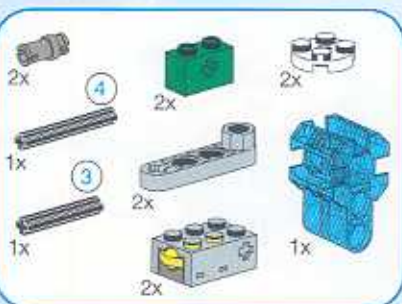
If you have not yet built the Driving Base, go to page 12.

# Double Bumper

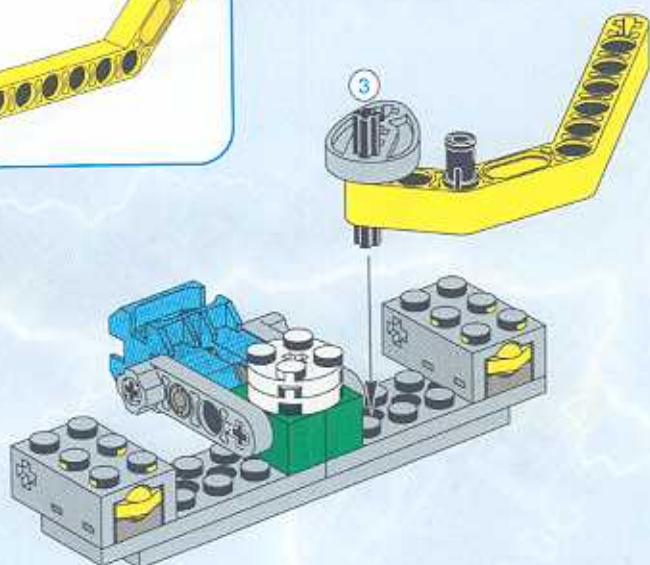
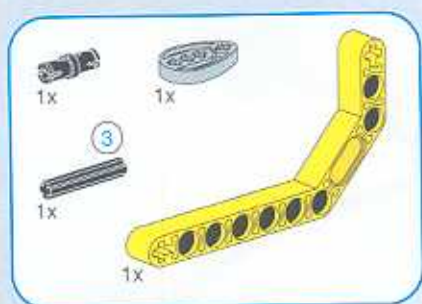
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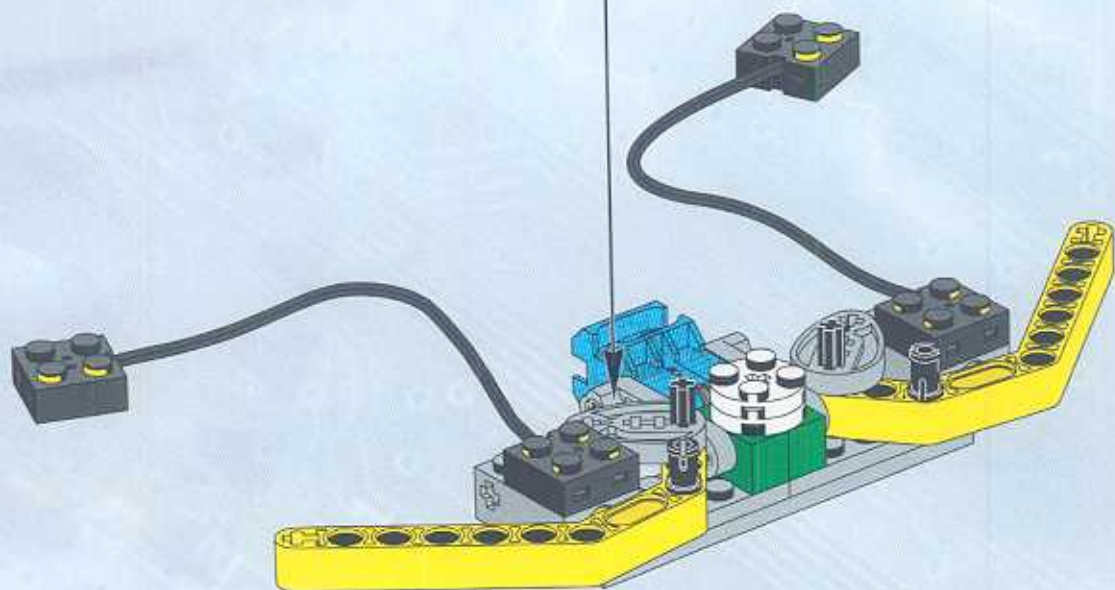
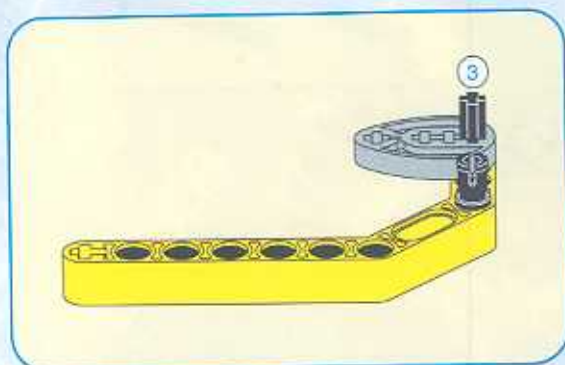
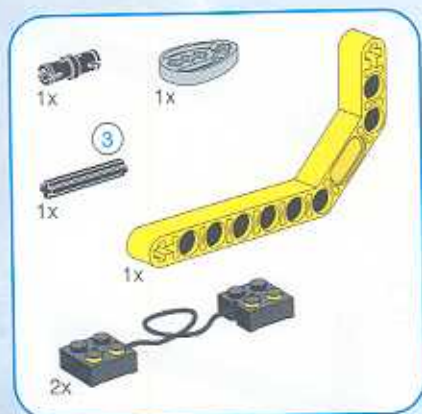
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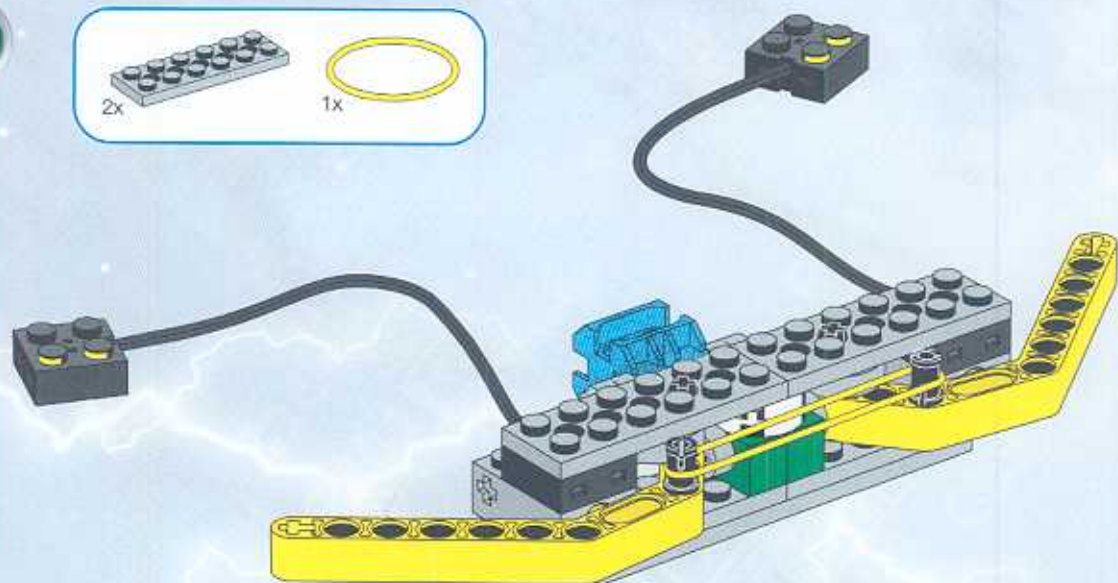
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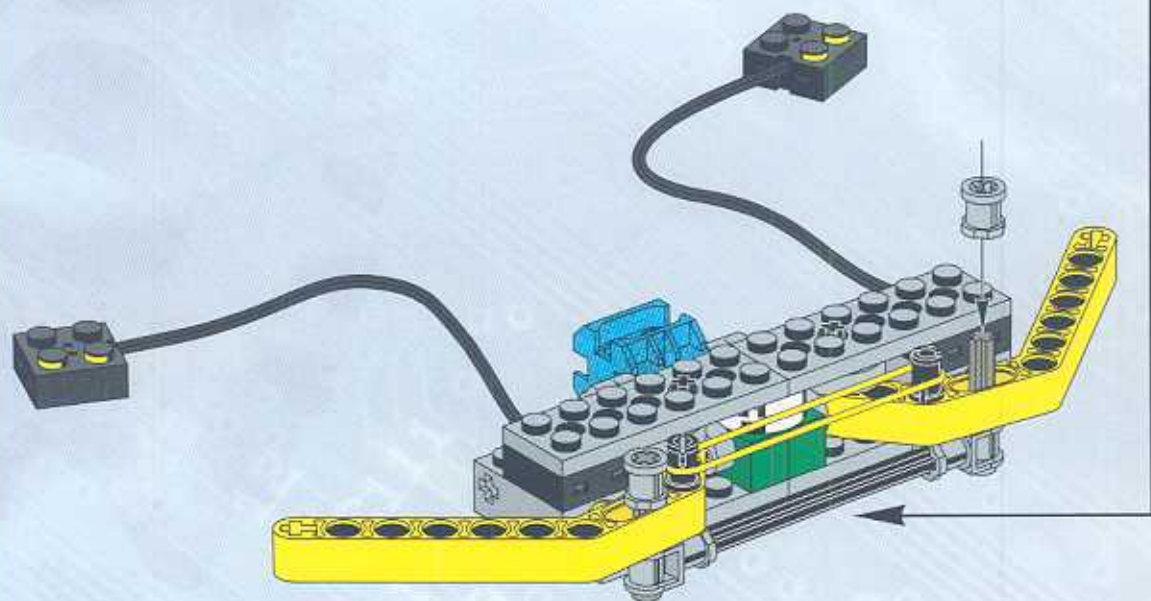
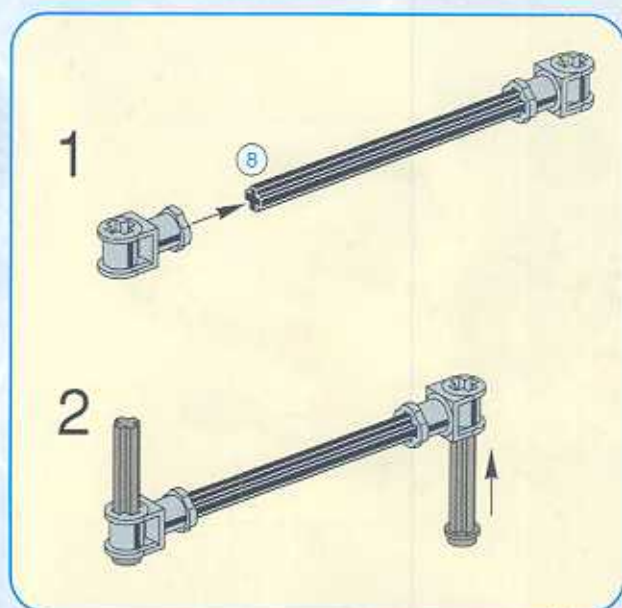
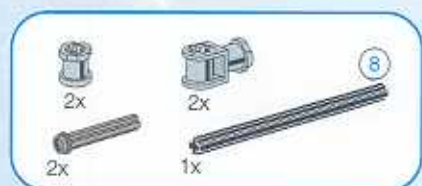
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5



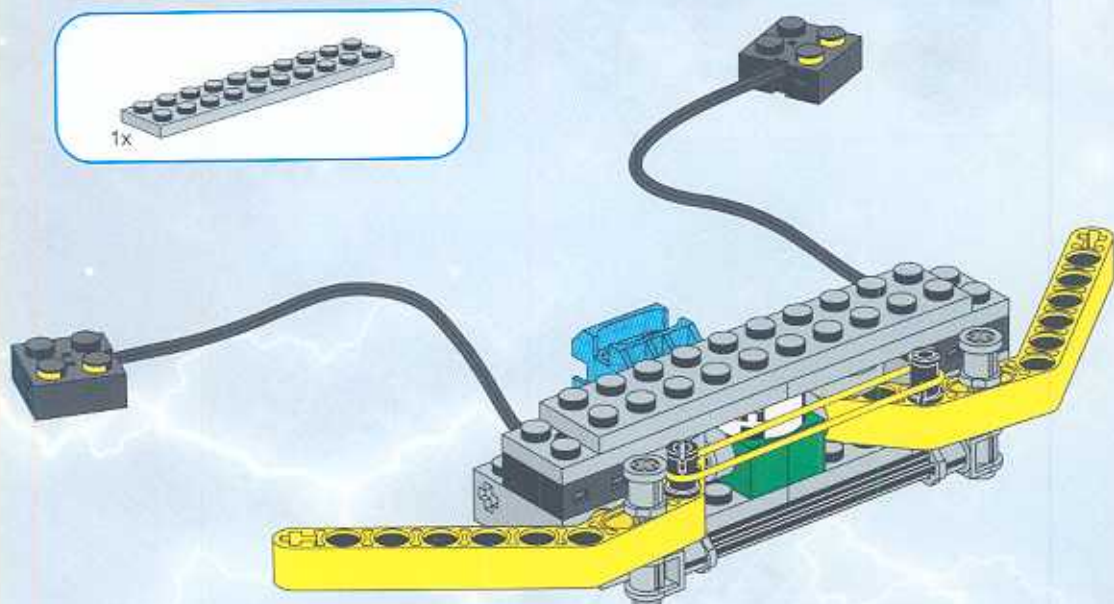
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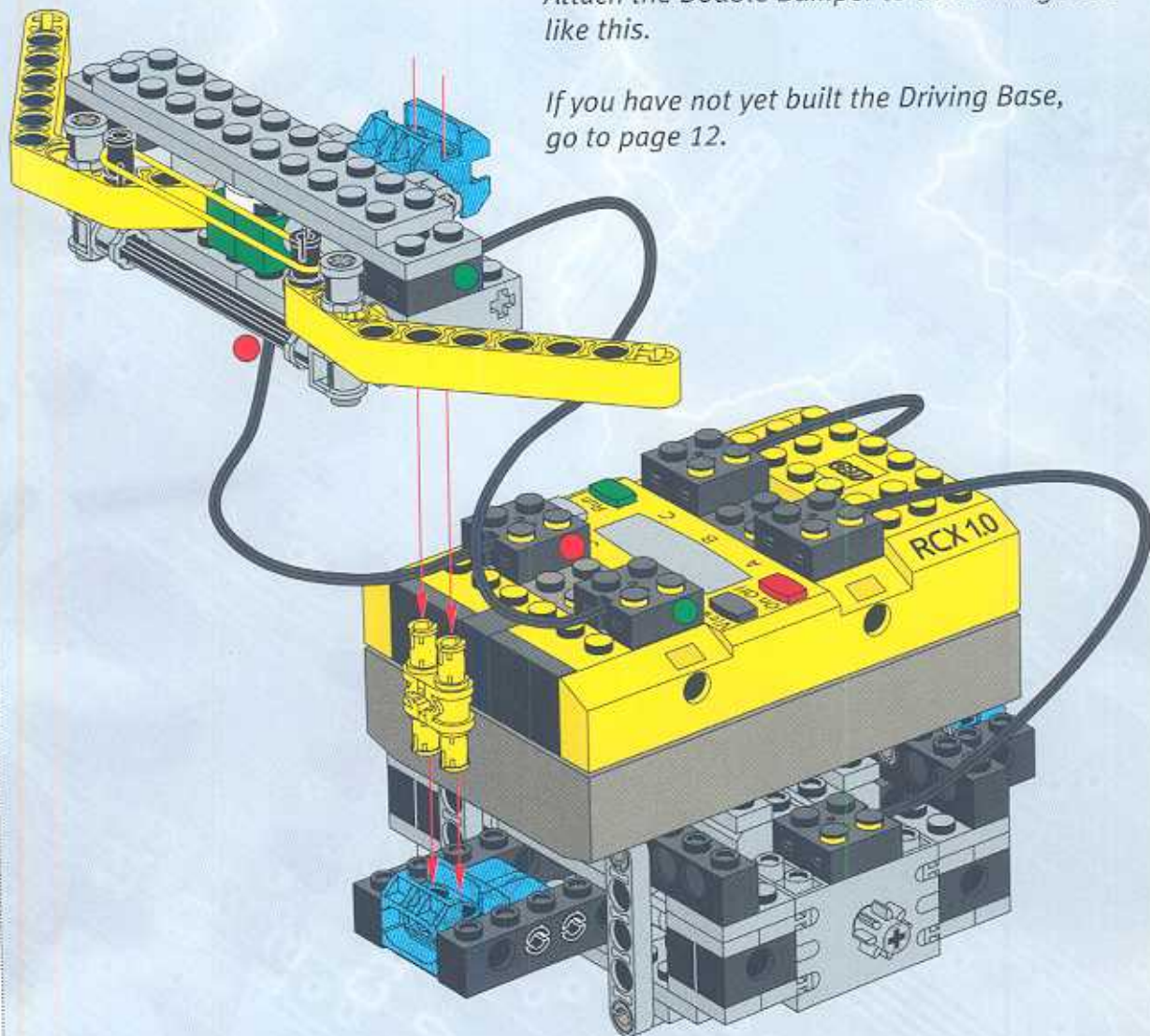
7

1x



8

1x

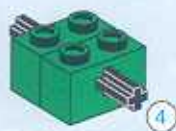


Attach the Double Bumper to the Driving Base like this.

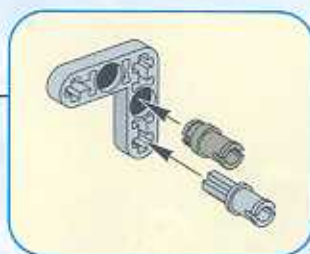
If you have not yet built the Driving Base, go to page 12.

# Light Sensor

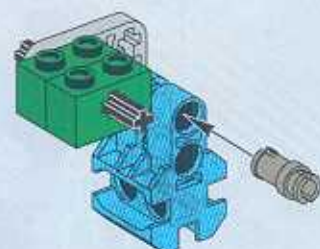
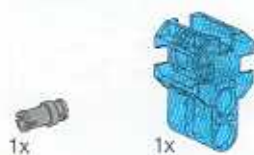
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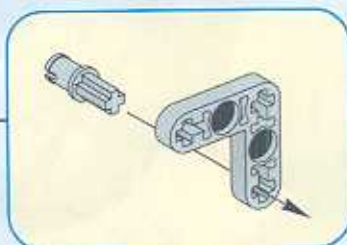
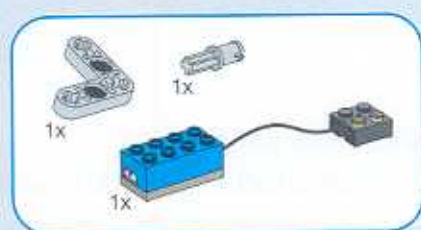
2



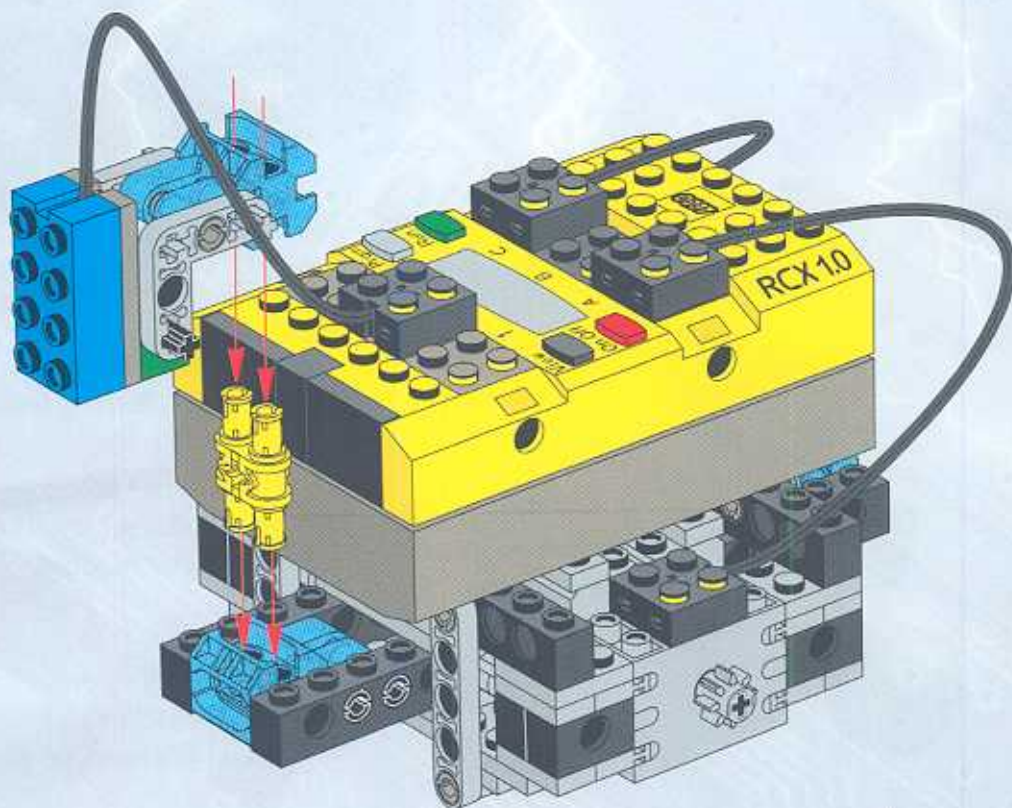
3



4



5



Attach the Light Sensor to the Driving Base like this.

If you have not yet built the Driving Base, go to page 12.



## ACROBOT SECTION

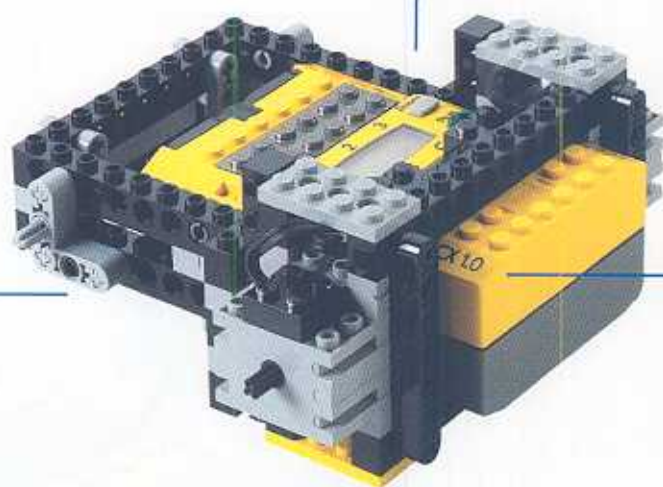
Here is an overview of the Acrobot.  
The following pages show building instructions for each part.  
Start by building the Driving Base, then choose which attachments you want to add.



**The Big Wheels**  
*page 45*



**The Pivot Wheel**  
*page 46*

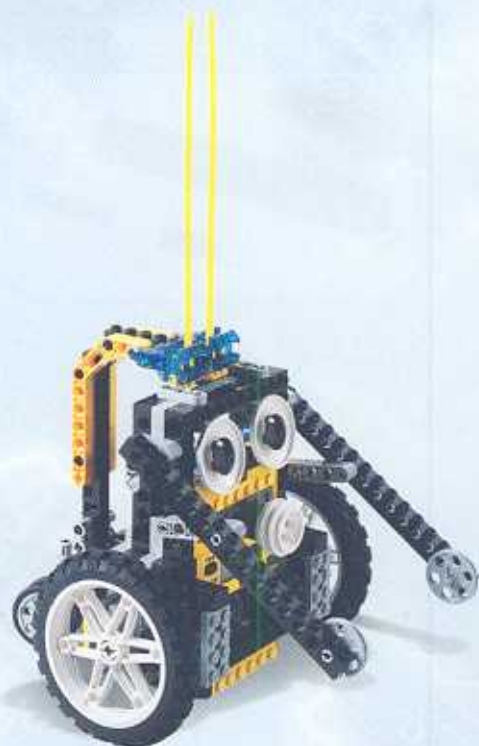


**The Driving Base**  
*page 38*

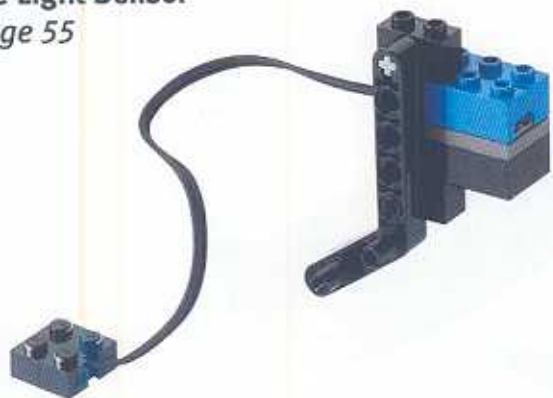
The Driving Base, together with the RCX forms the Acrobot.

Note: For additional attachments, as well as design suggestions, go to **Special Features** on *page 92*.

Examples of an Acrobot.



**The Light Sensor**  
page 55



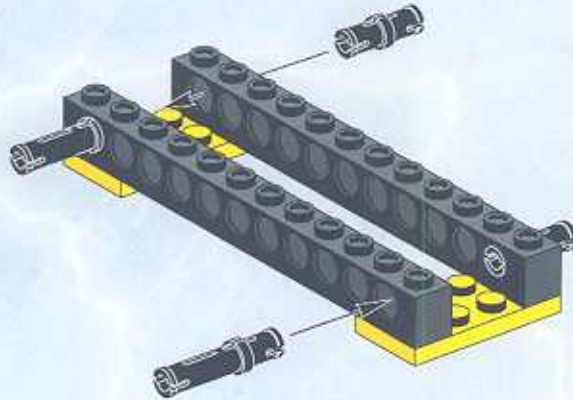
**The Single Bumper**  
page 49



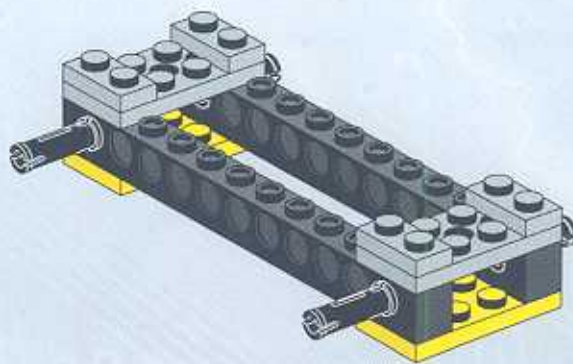
## Driving Base

Check that your RCX has working batteries before starting.

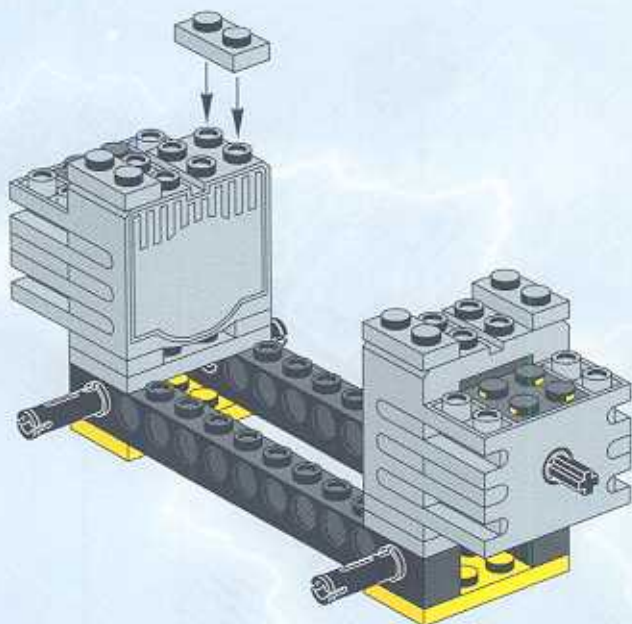
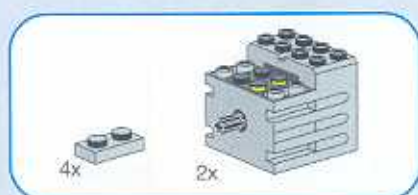
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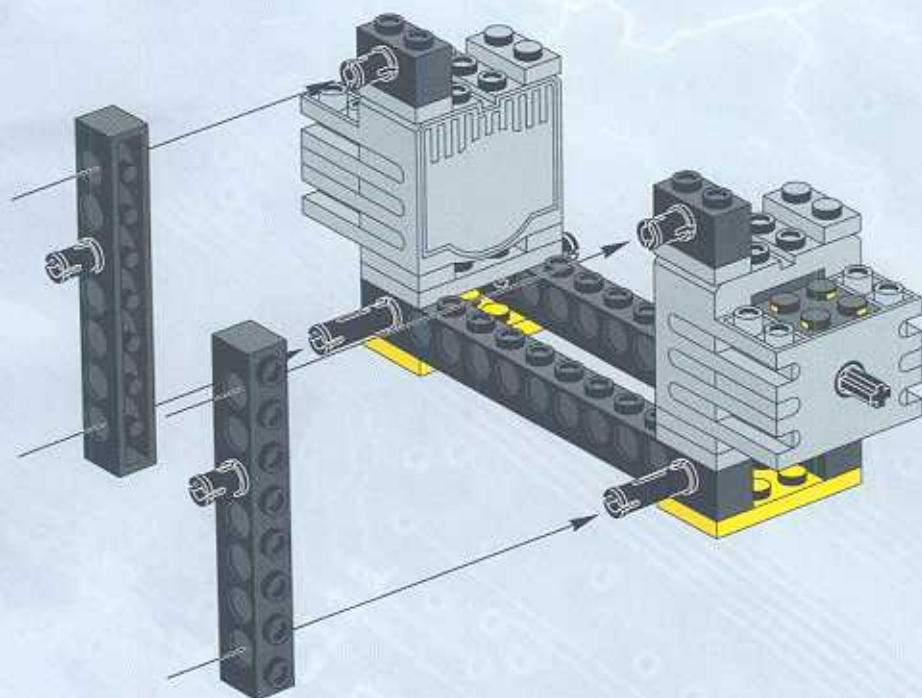
2



3

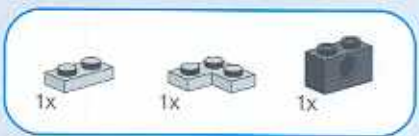


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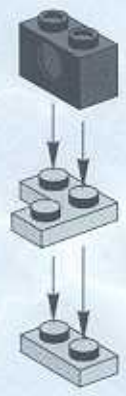




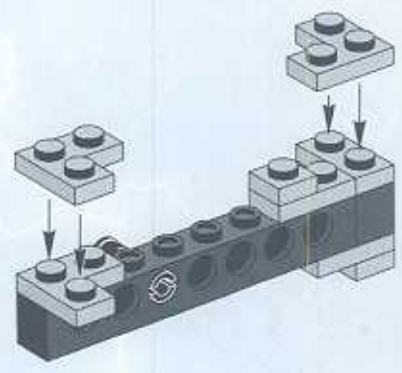
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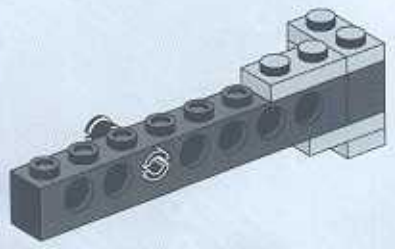
5.1



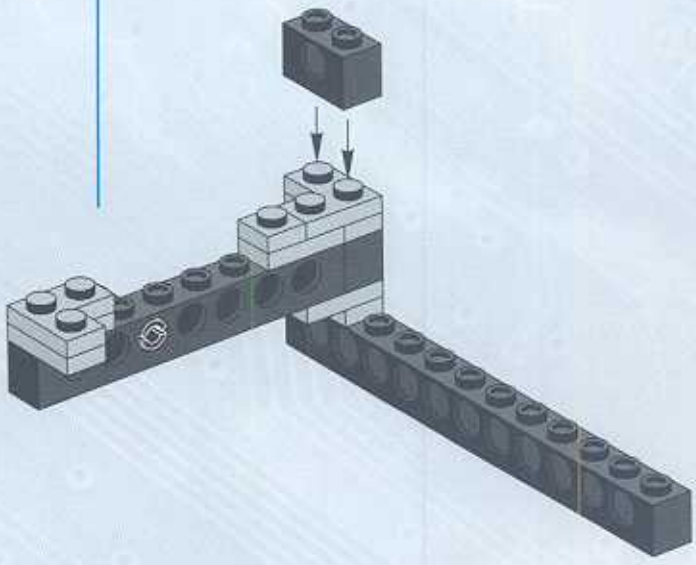
5.3



5.2



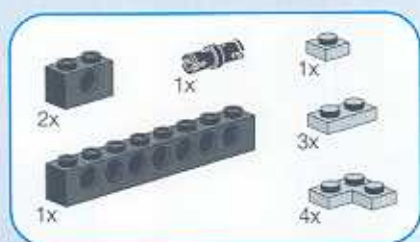
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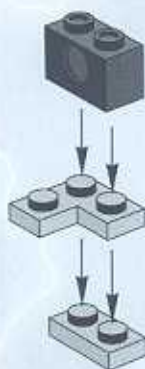




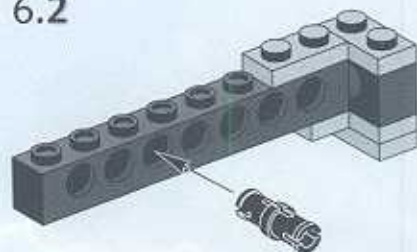
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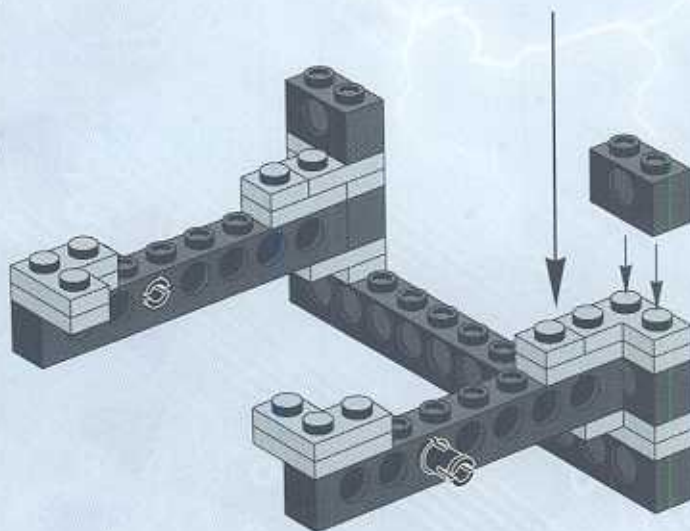
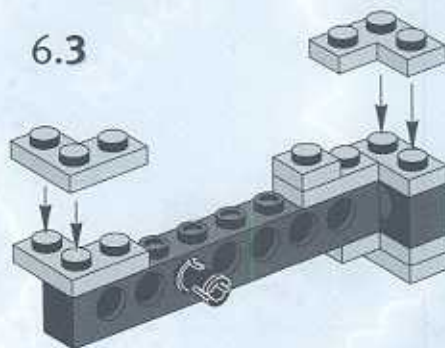
6.1



6.2

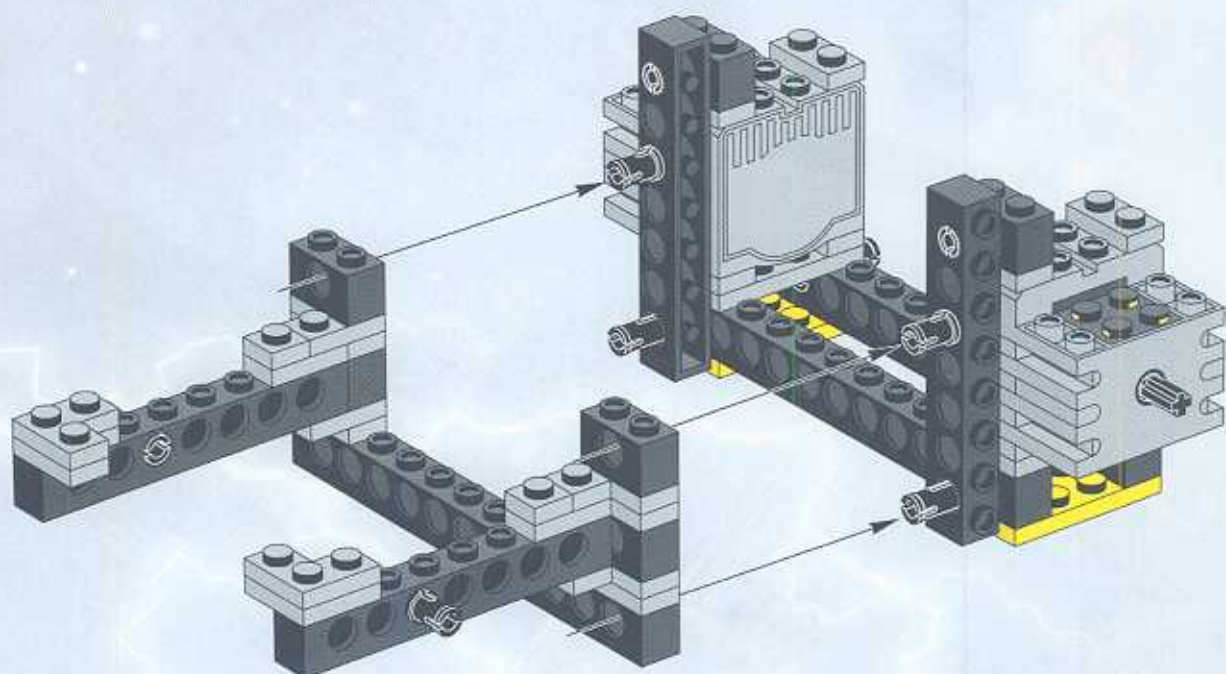


6.3

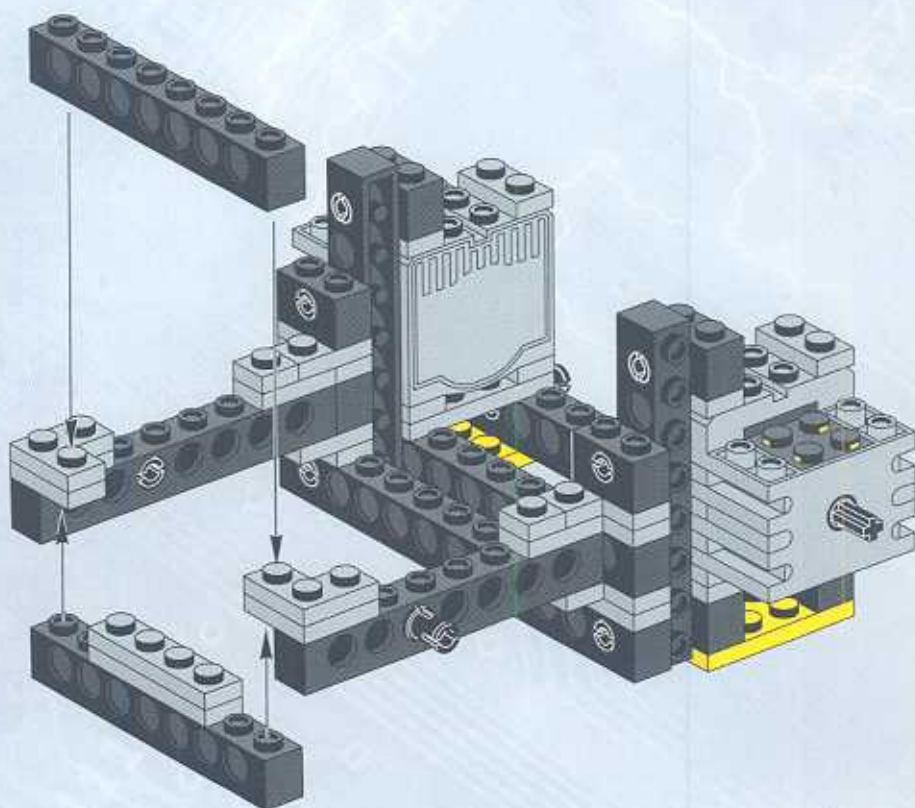




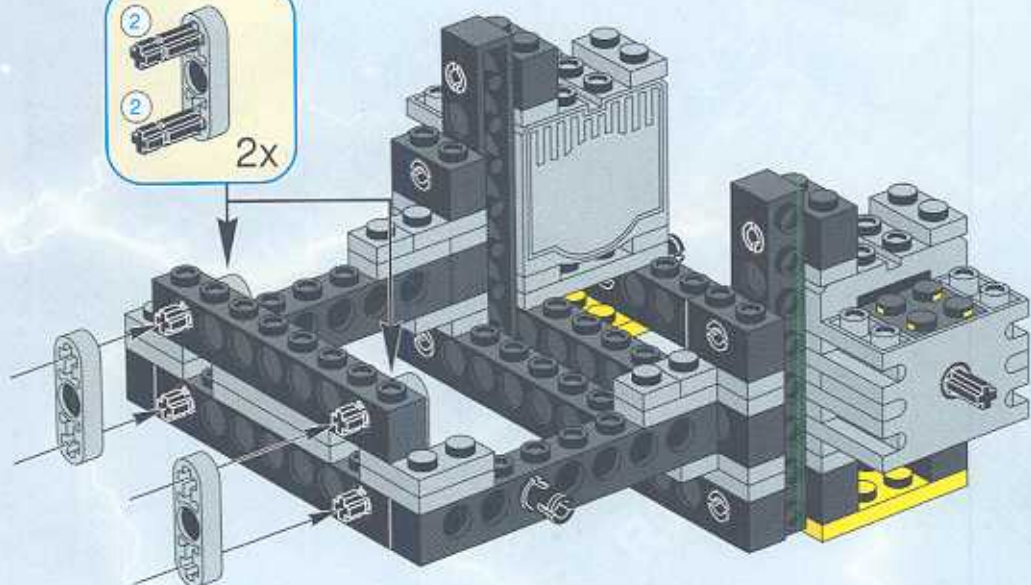
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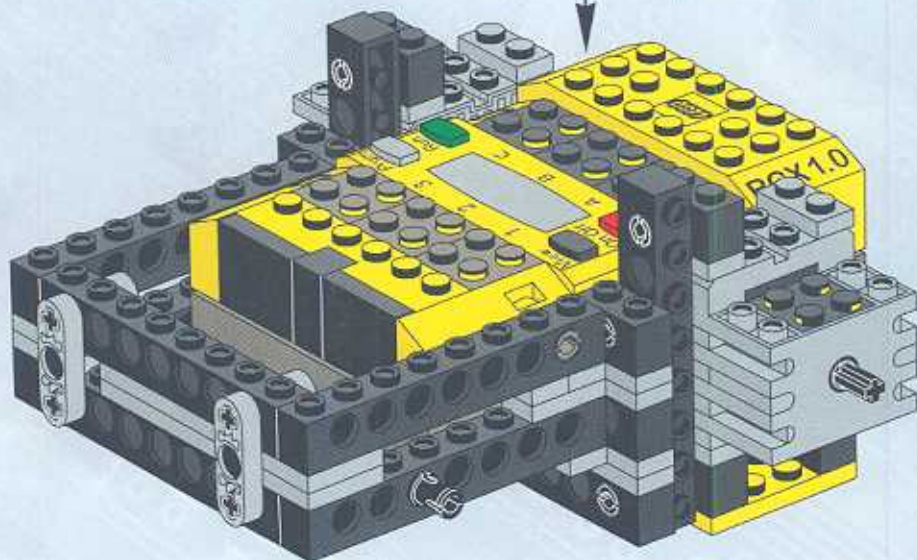
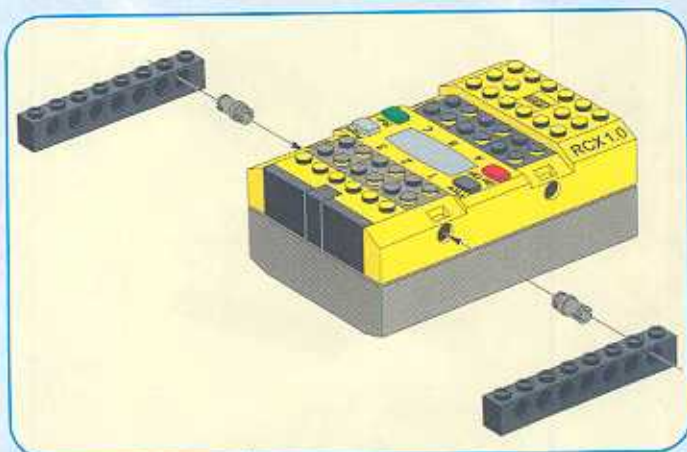
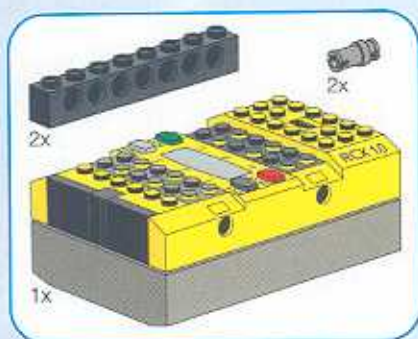
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9

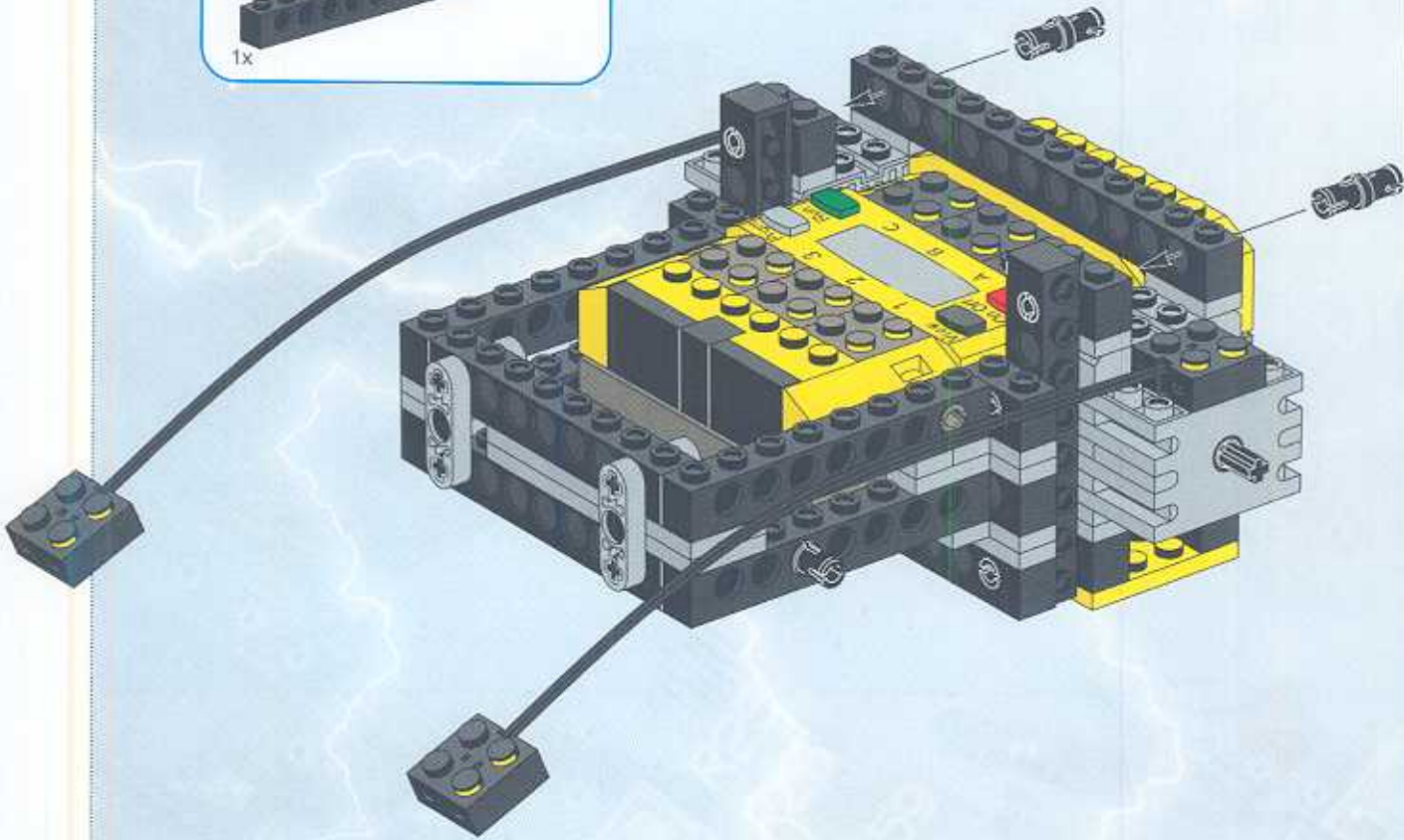
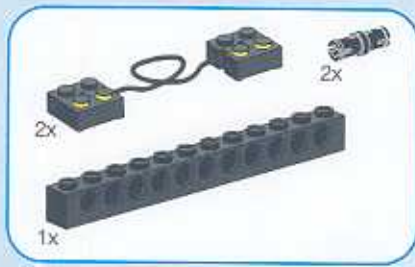


10

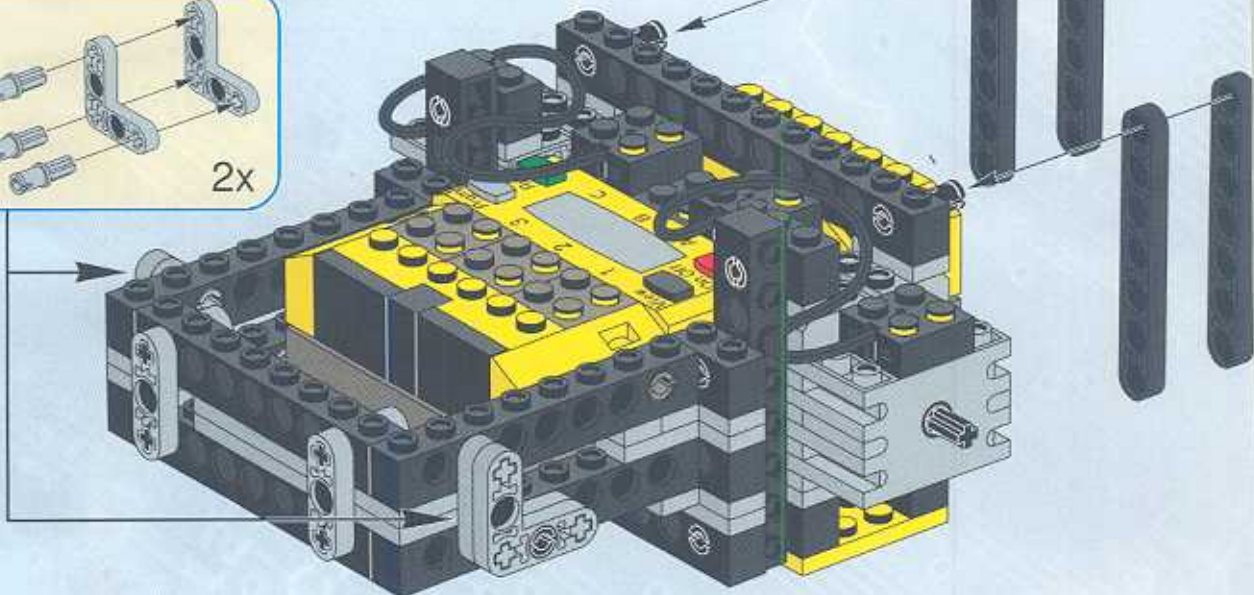
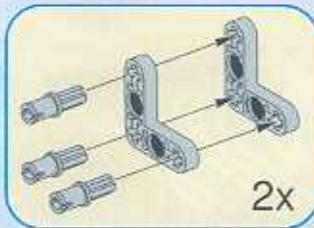




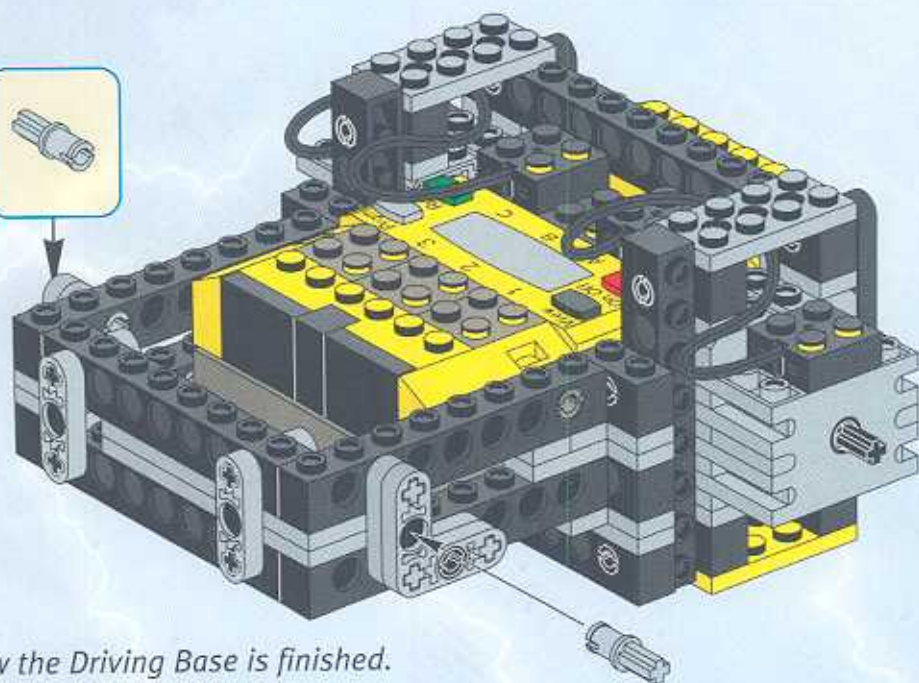
11



12

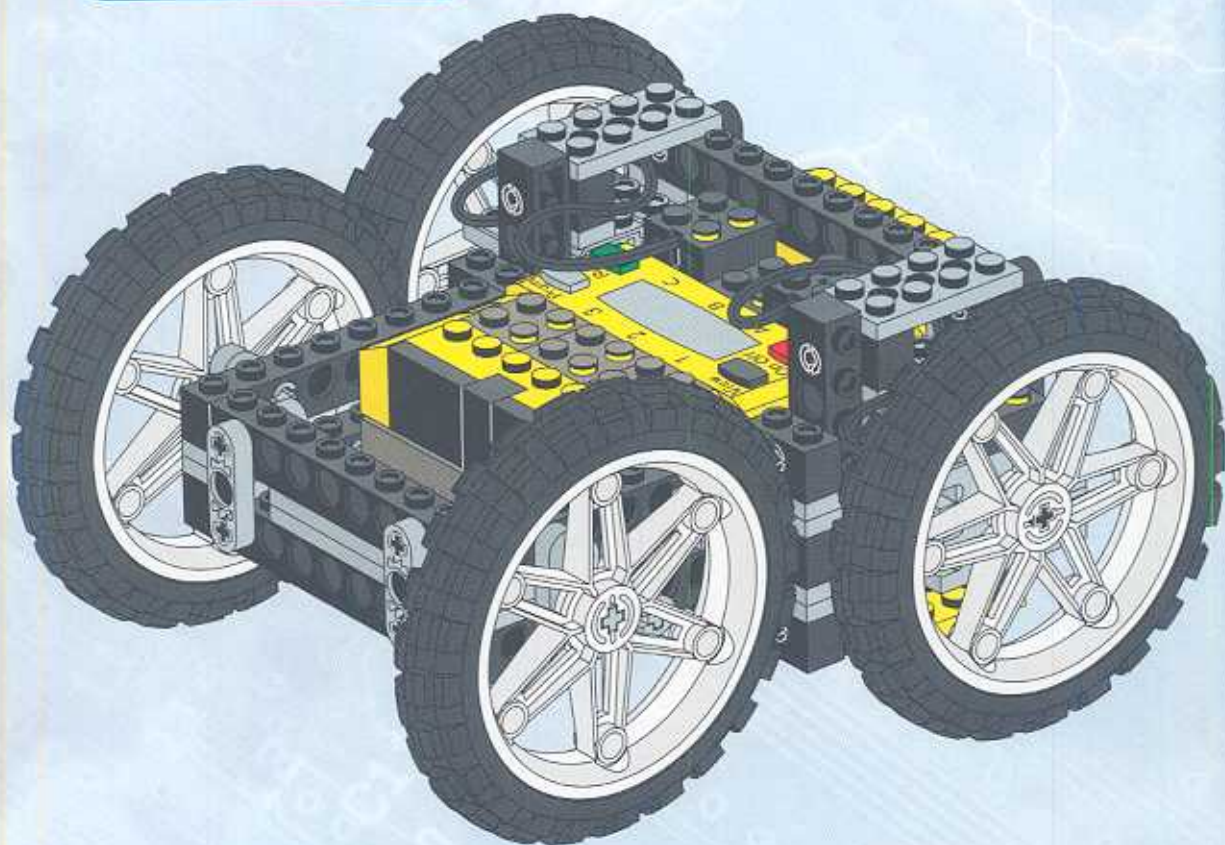


13



Now the Driving Base is finished.  
Add wheels to see it run!

1

**Big Wheels**

# Pivot Wheel



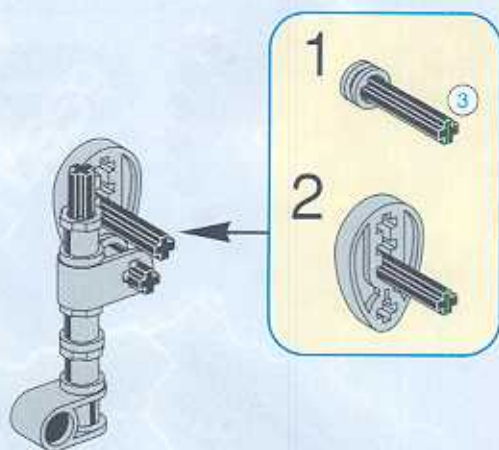
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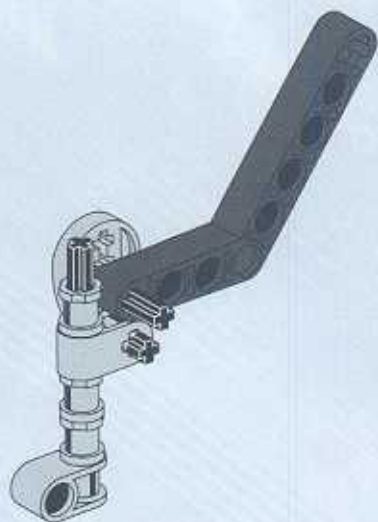
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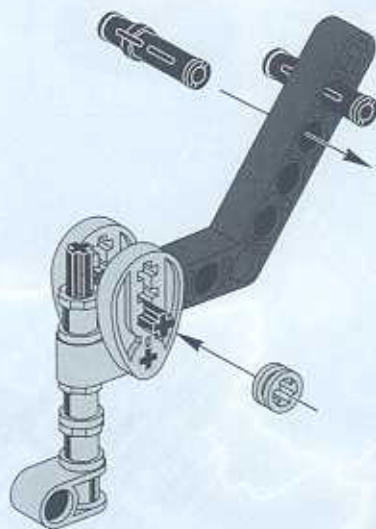
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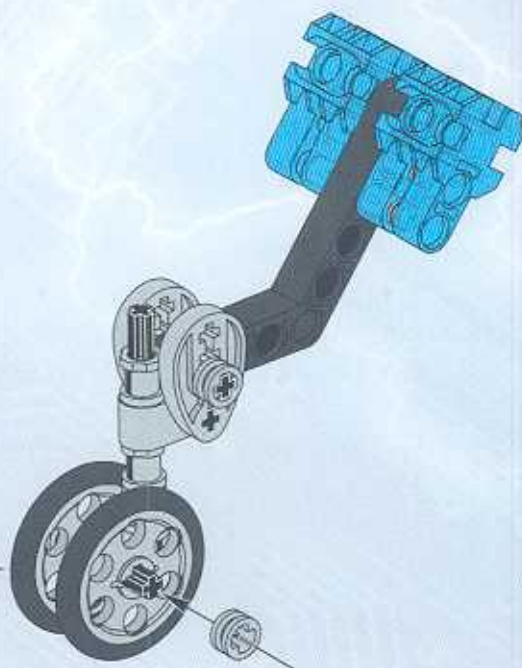
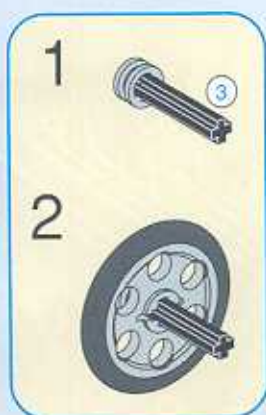
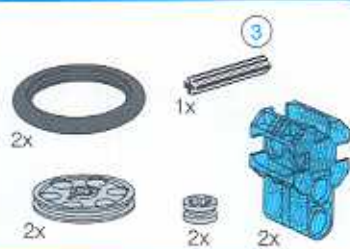
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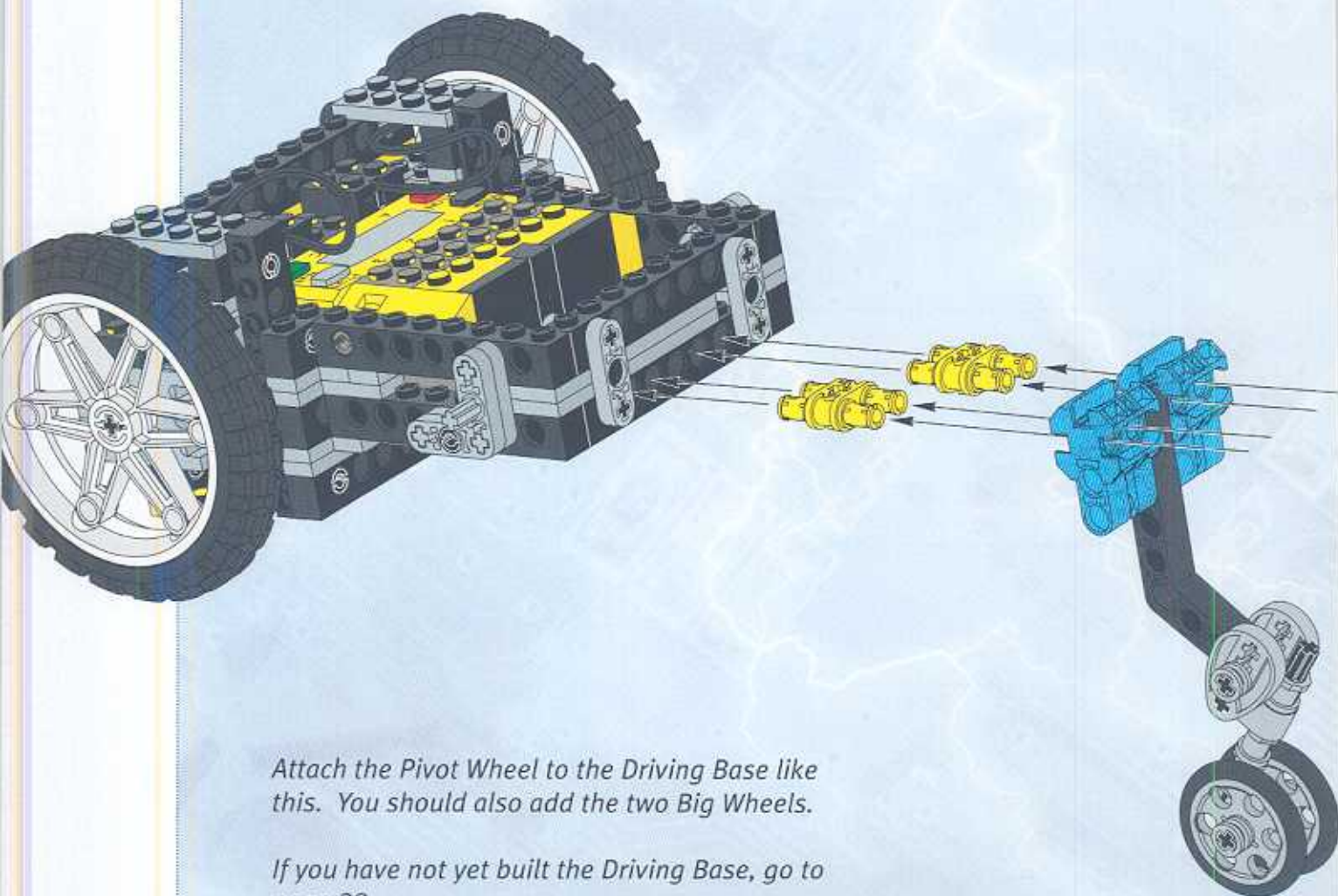
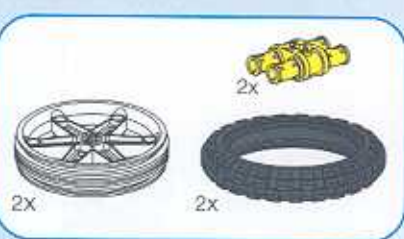
5



6



7



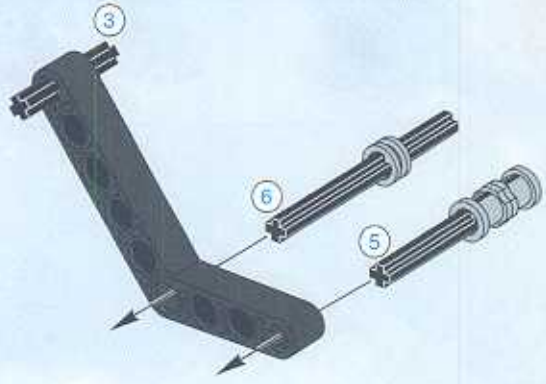
*Attach the Pivot Wheel to the Driving Base like this. You should also add the two Big Wheels.*

*If you have not yet built the Driving Base, go to page 38.*

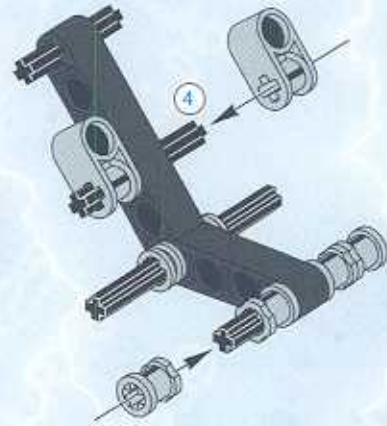
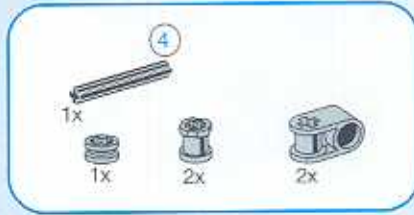


# Single Bumper

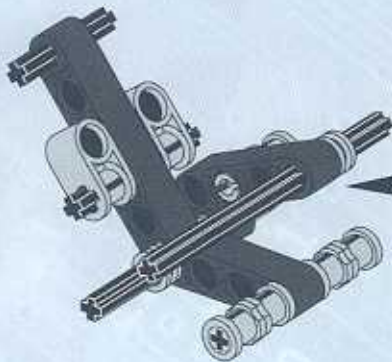
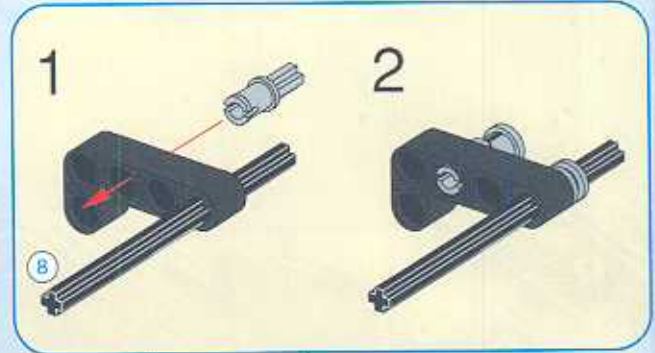
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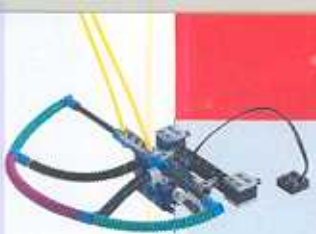


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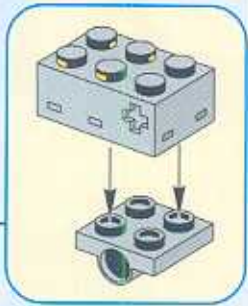
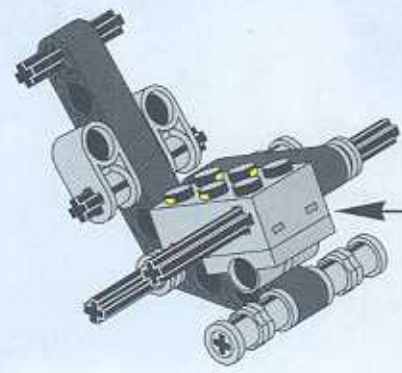


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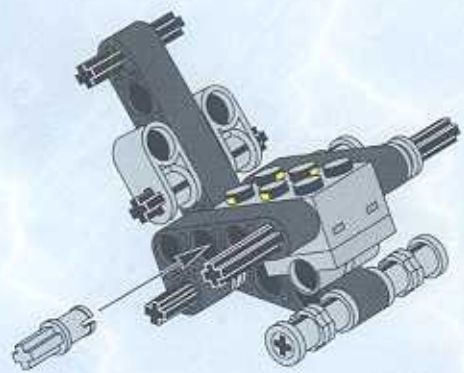




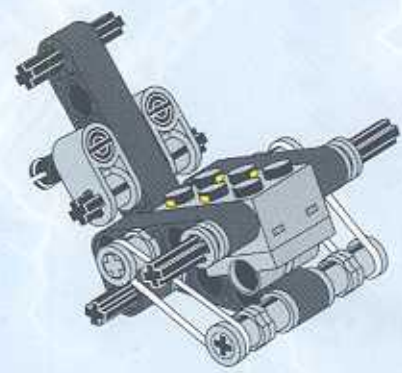
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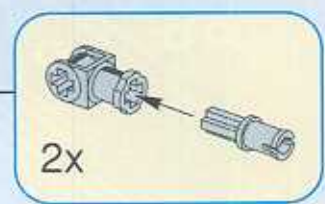
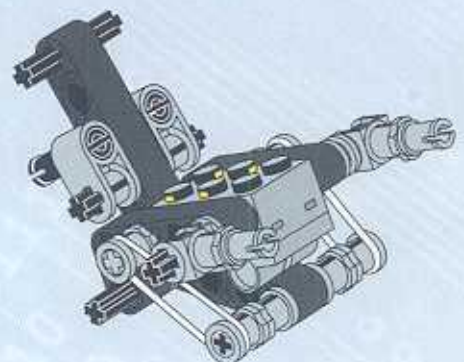
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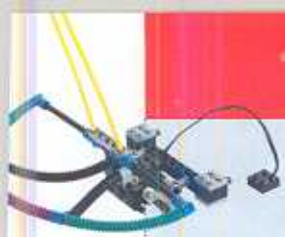


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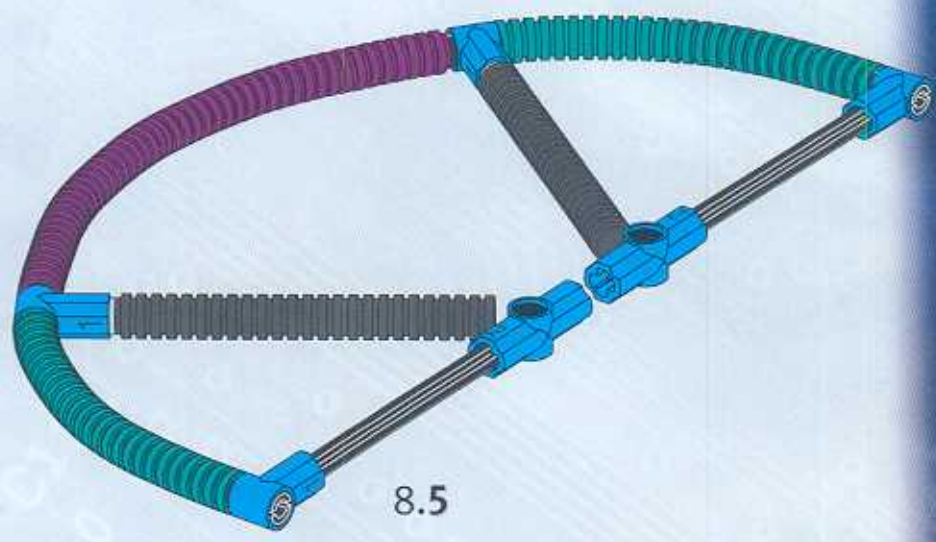
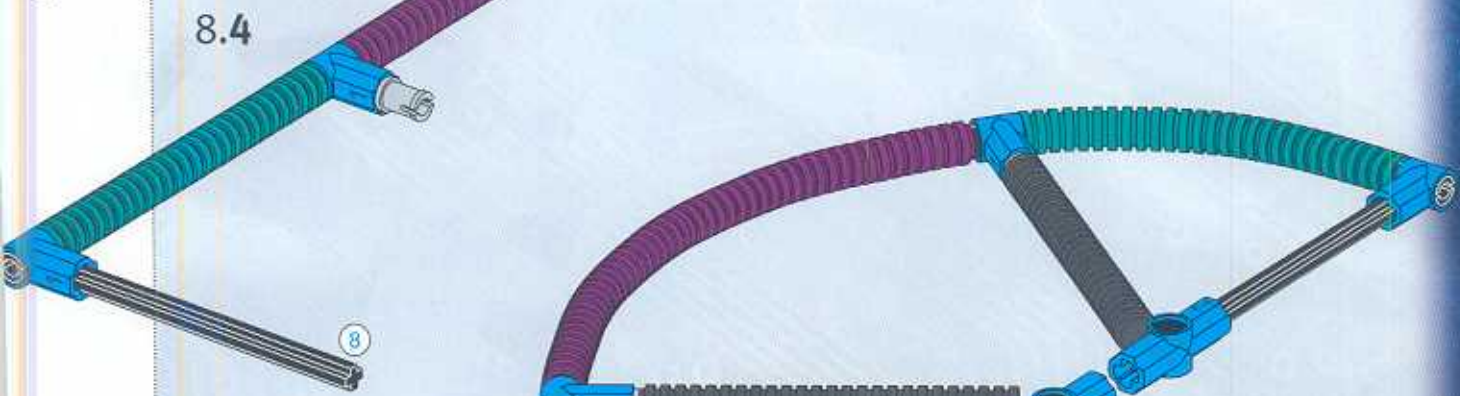
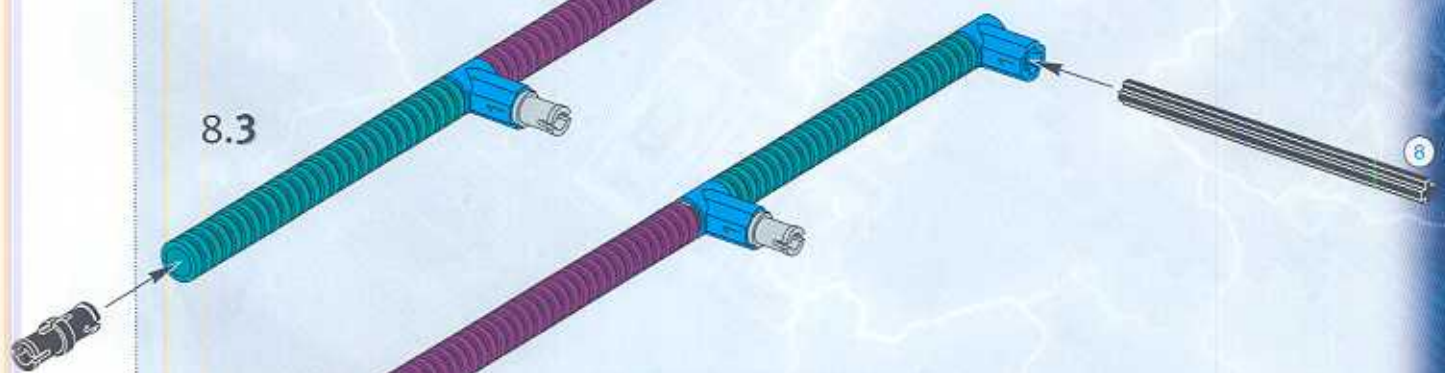
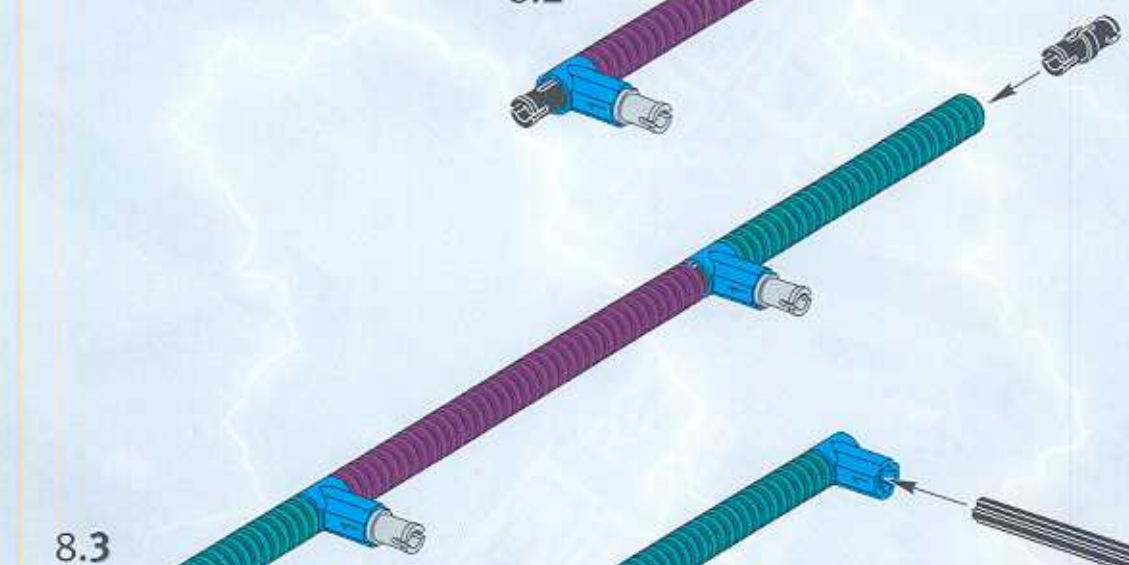
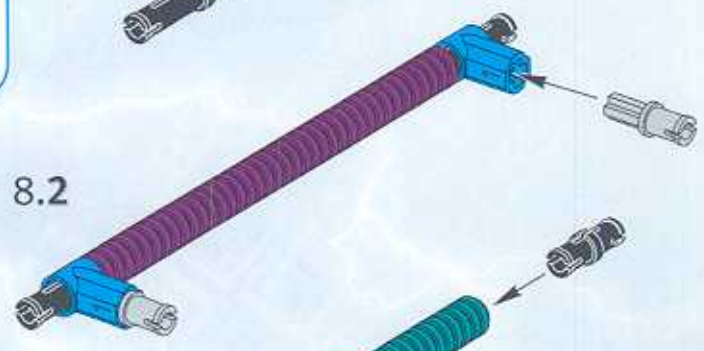
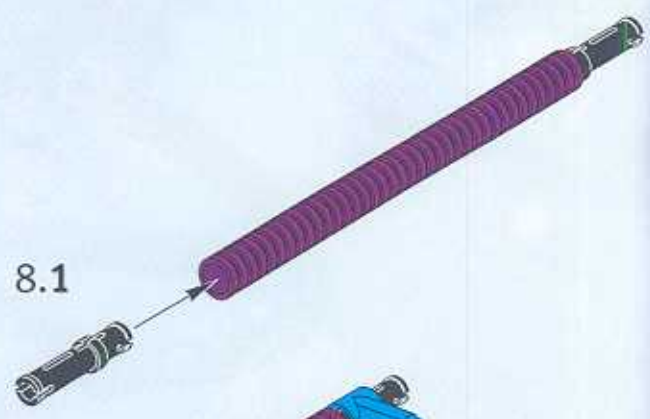


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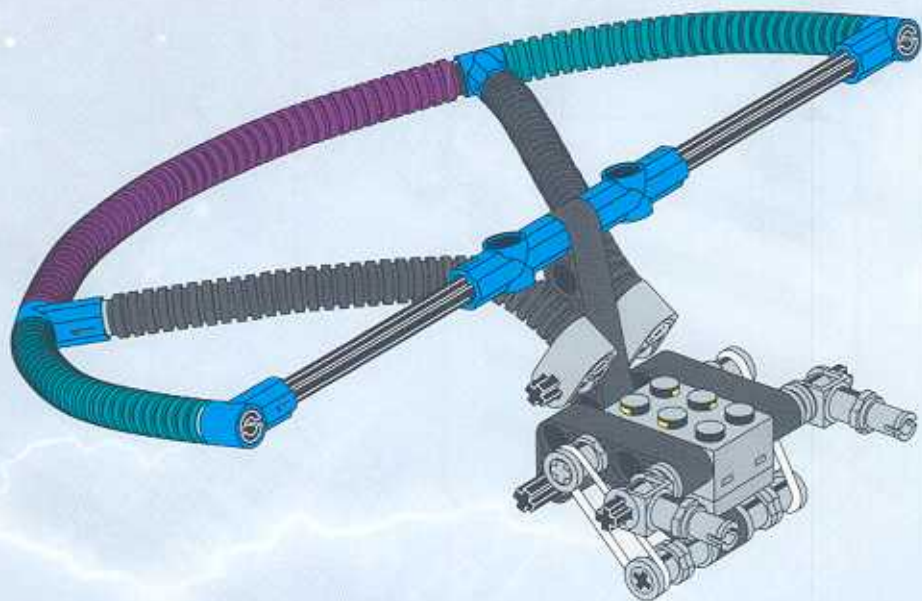




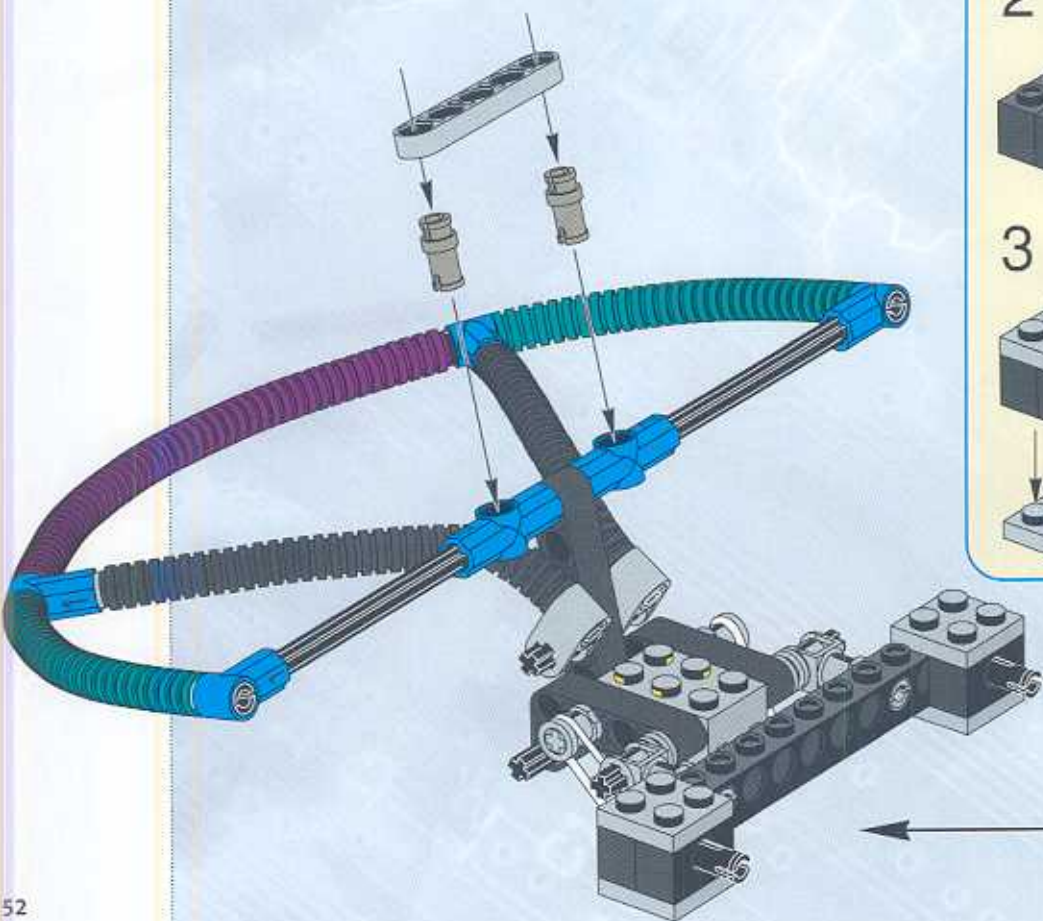
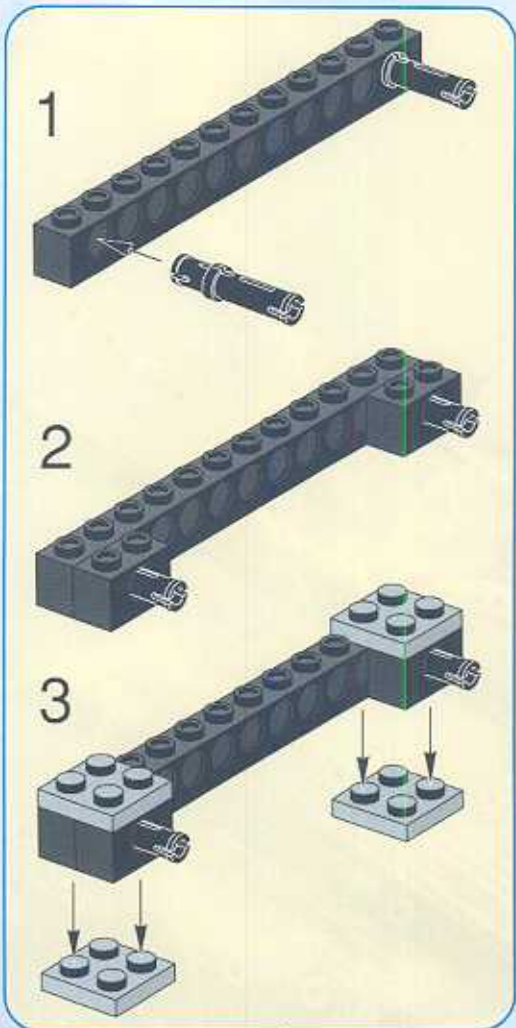
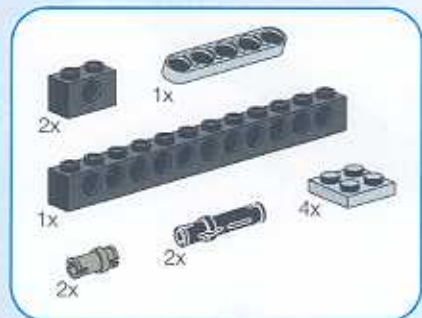
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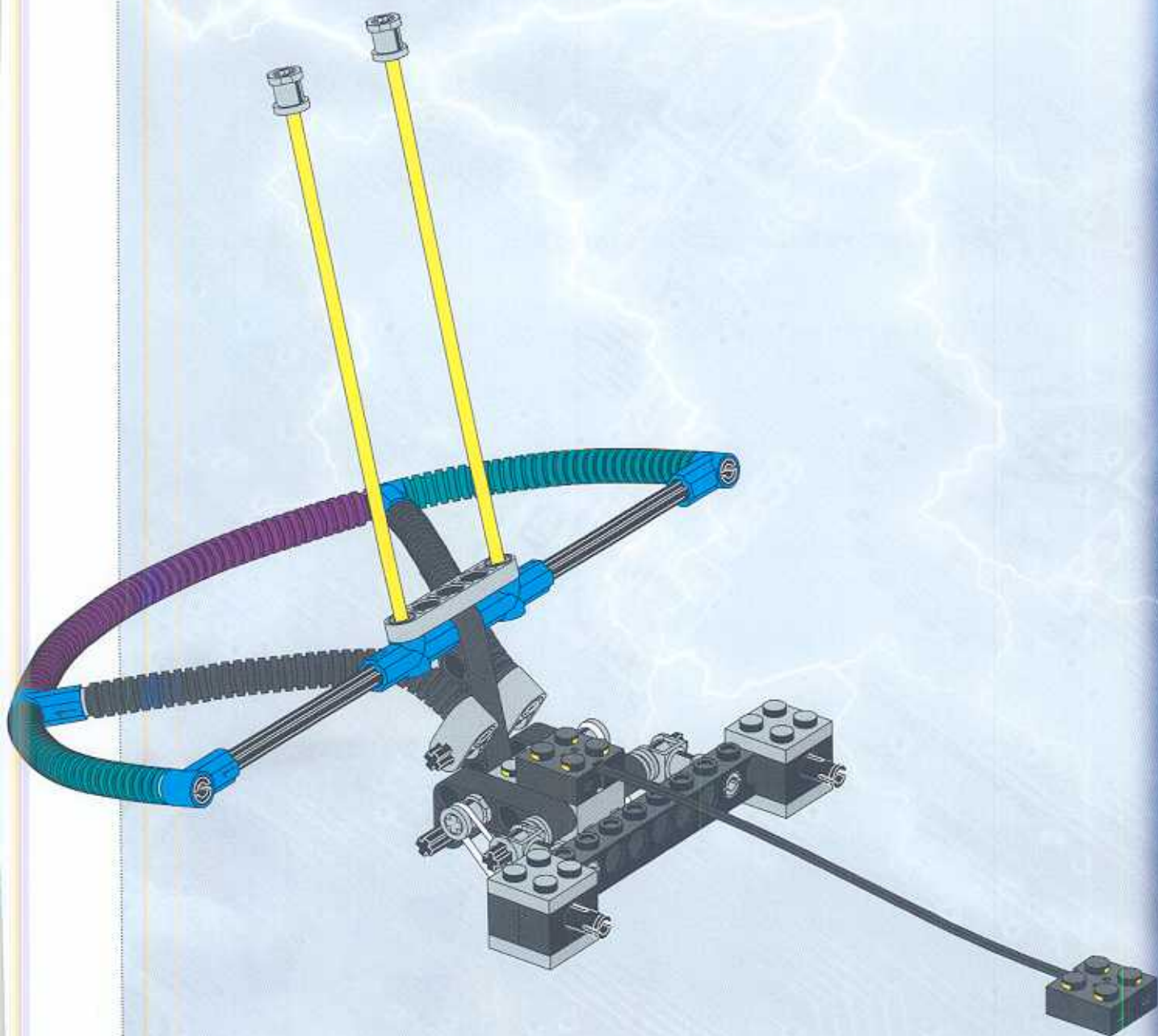
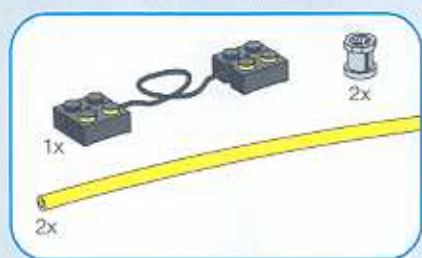
8.5



9

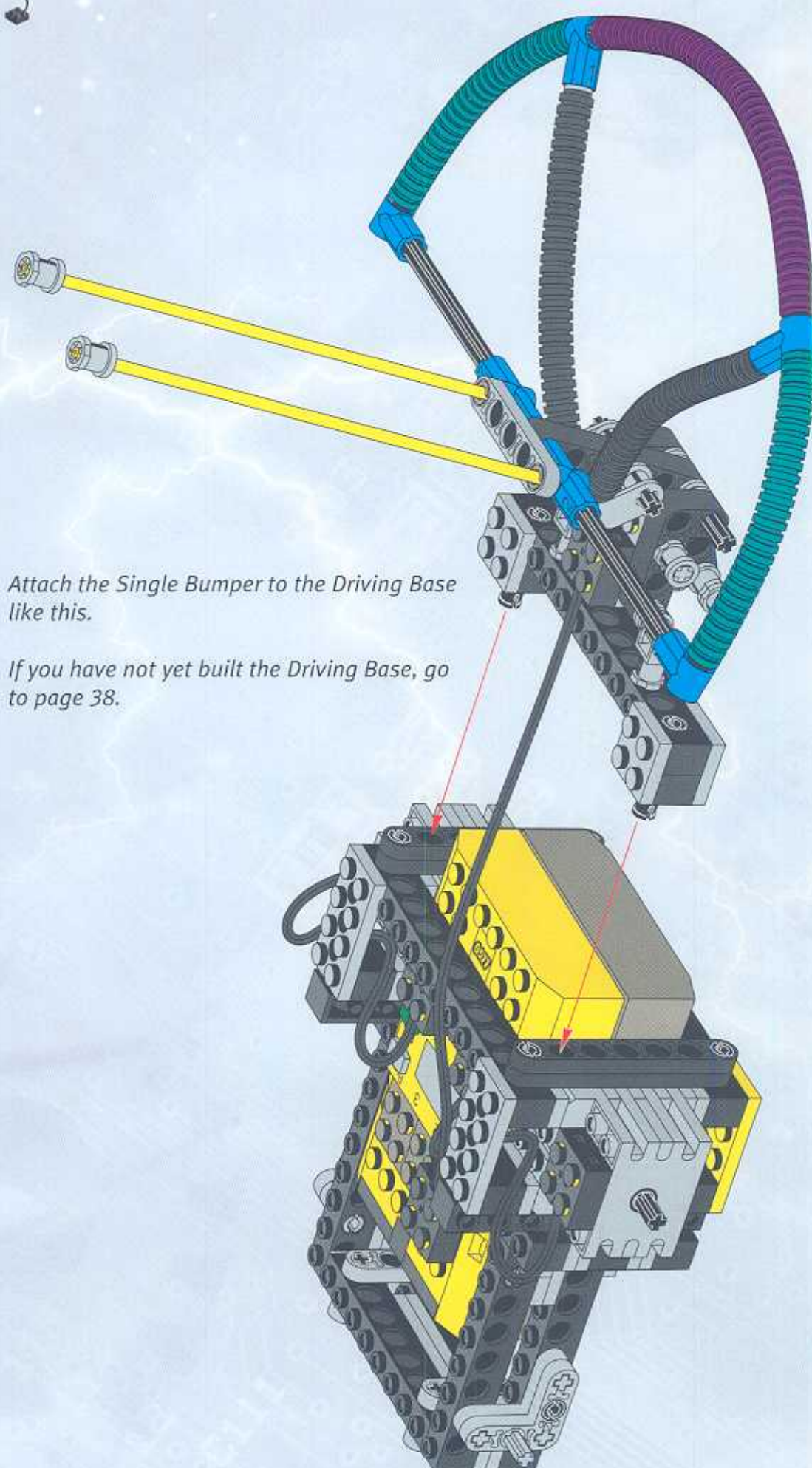


10





11

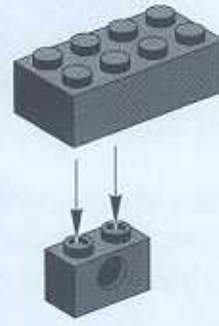


Attach the Single Bumper to the Driving Base like this.

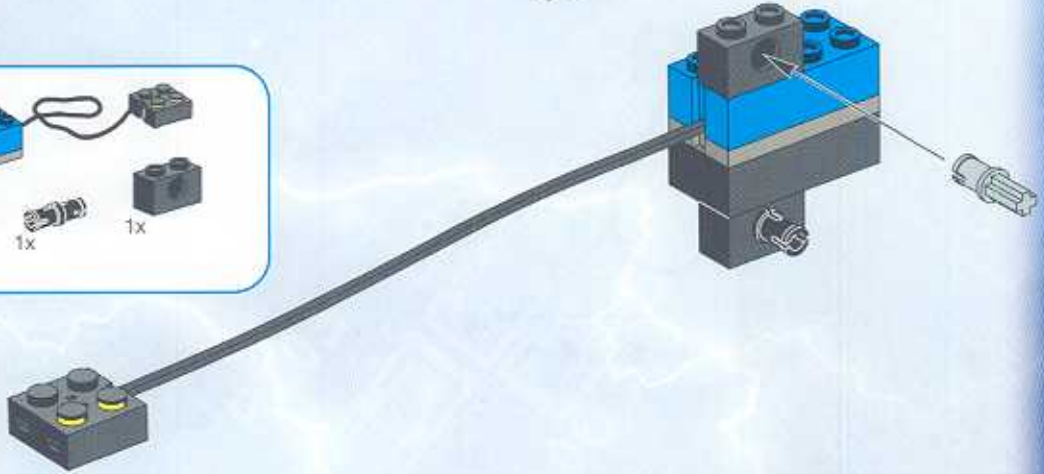
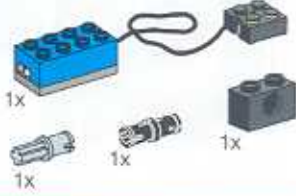
If you have not yet built the Driving Base, go to page 38.

# Light Sensor

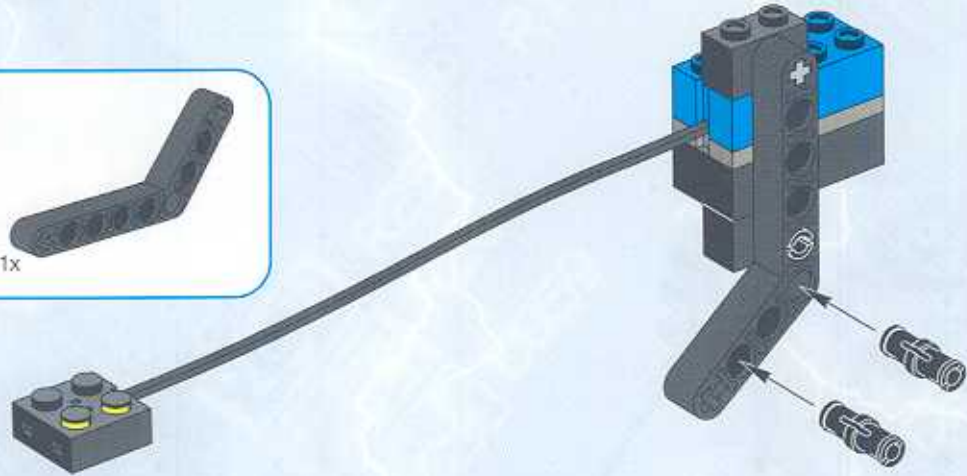
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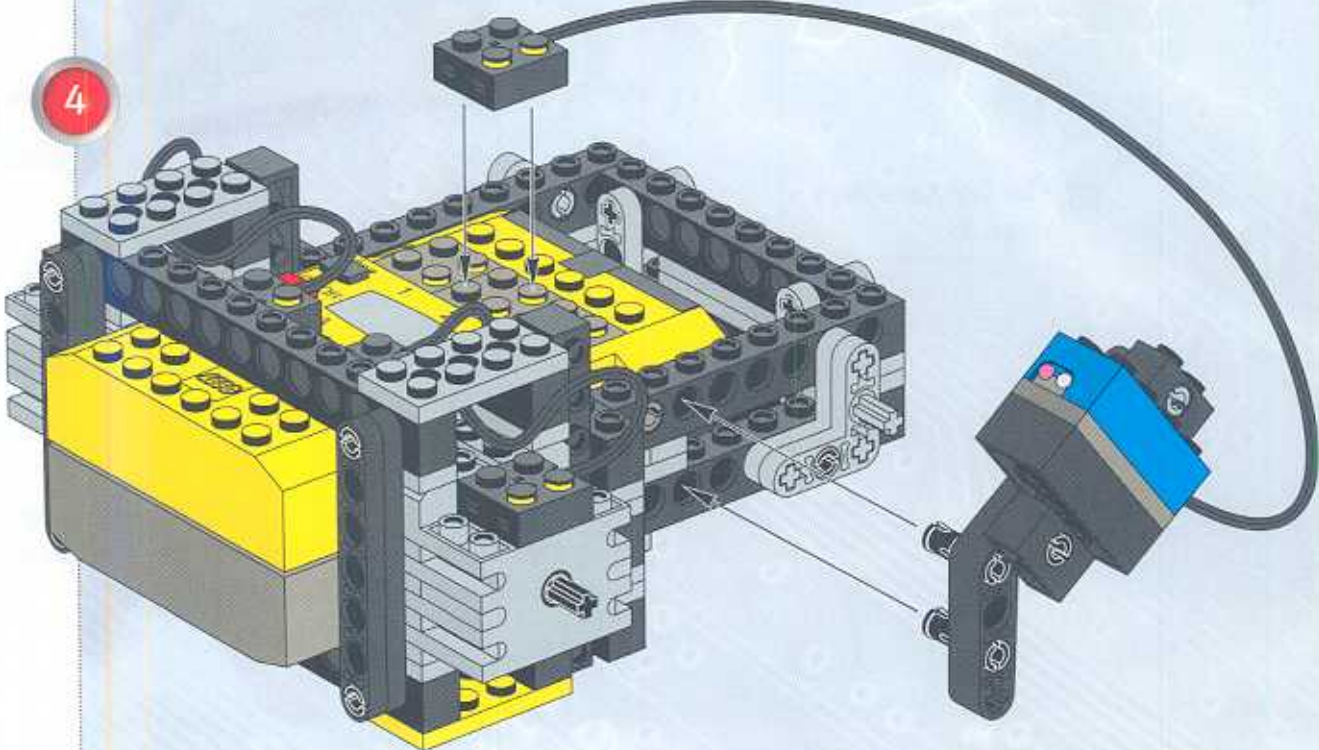
2



3



4





## INVENTORBOT SECTION

Here is an overview of the Inventorbot.

The following pages show building instructions for each part.

Start by building the Body and the Base, then choose which attachments you want to add.



**The Slap Arm**  
page 78



**The Squeeze Arm**  
page 81



**The Head** page 70



**The Body**  
page 58



**The Standing Base**  
page 64

The Body, the Standing Base, and the Head fit together to form the Inventorbot.

Note: For additional attachments, as well as design suggestions, go to **Special Features** on page 96.



**The Light Sensor**  
*page 86*



**The Hat Arm**  
*page 74*



**The Thrower Arm**  
*page 84*



Examples of an Inventorbot.

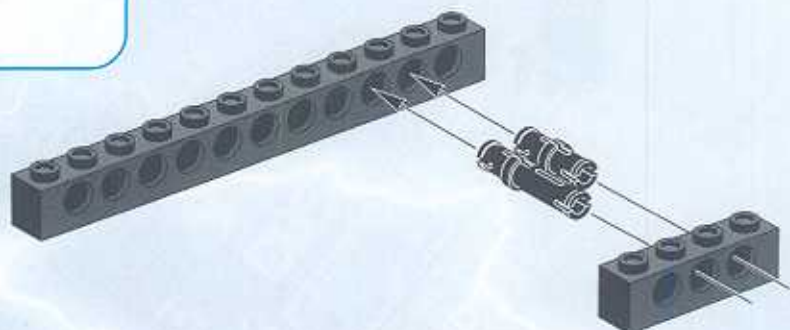
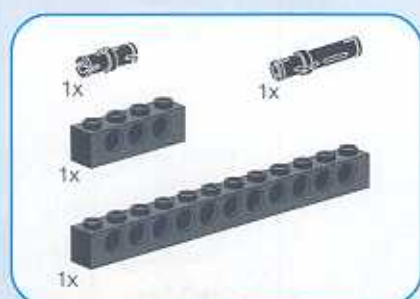




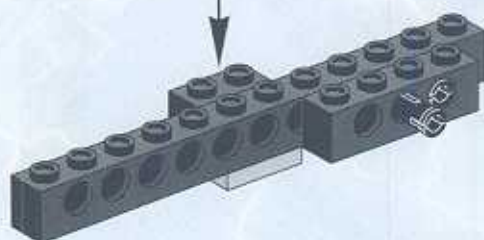
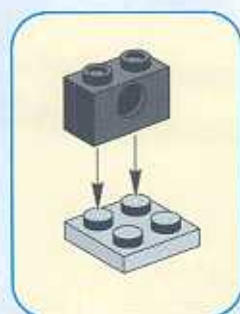
## Body

Check that your RCX has working batteries before starting.

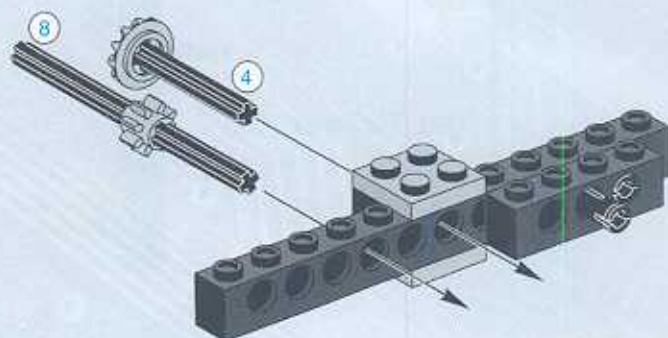
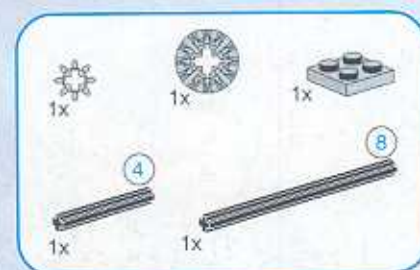
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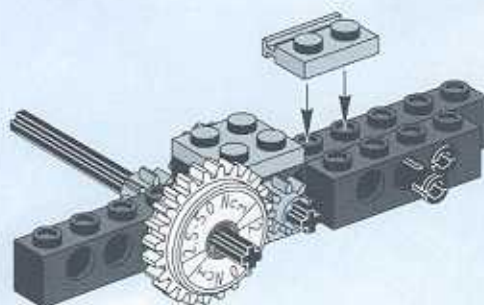
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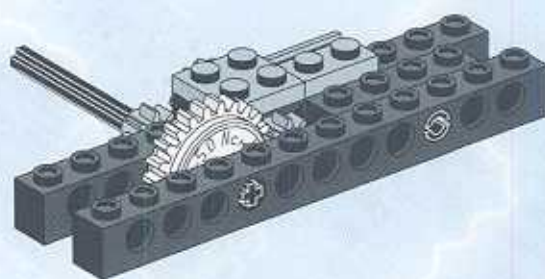
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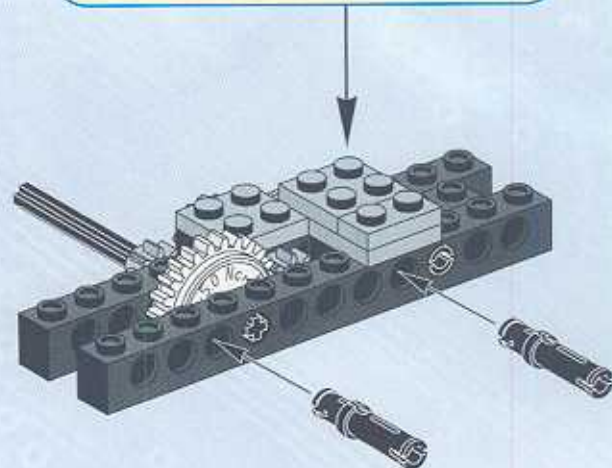
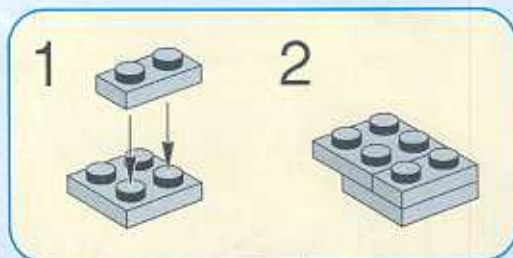
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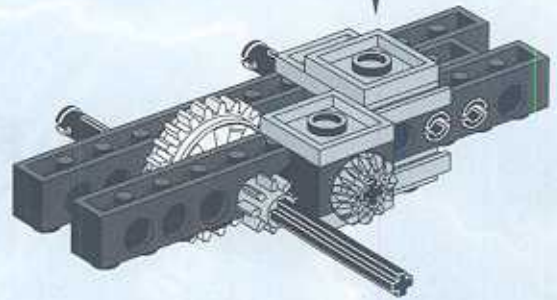
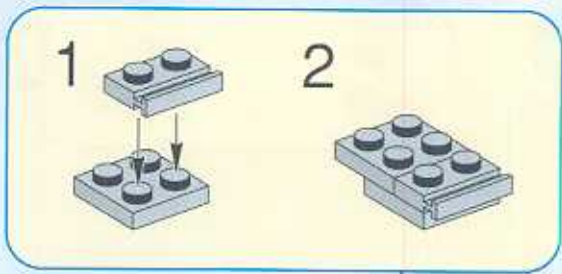


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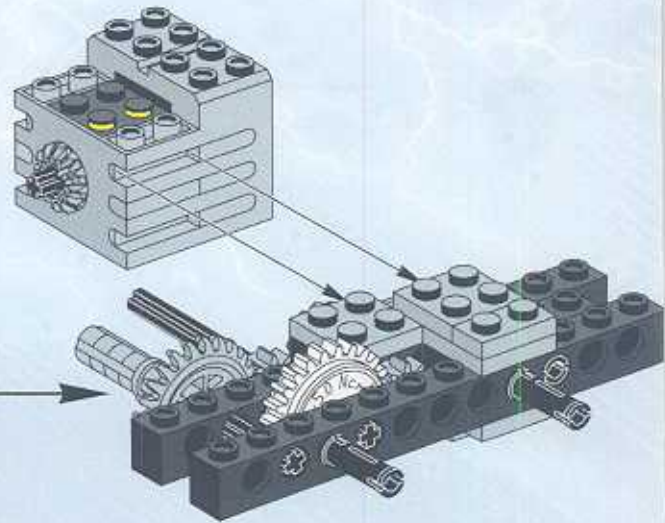
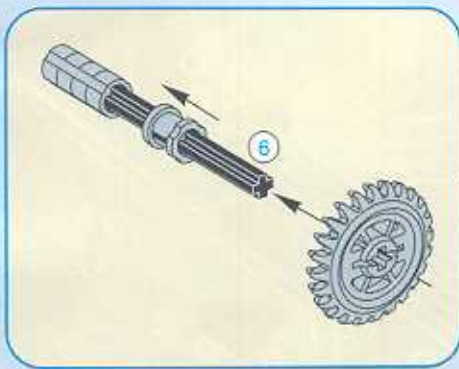
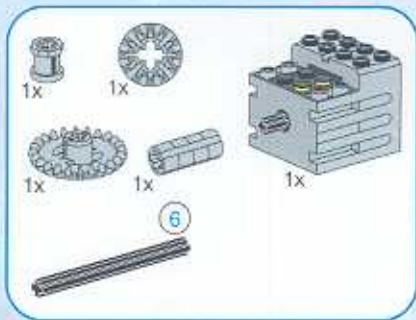




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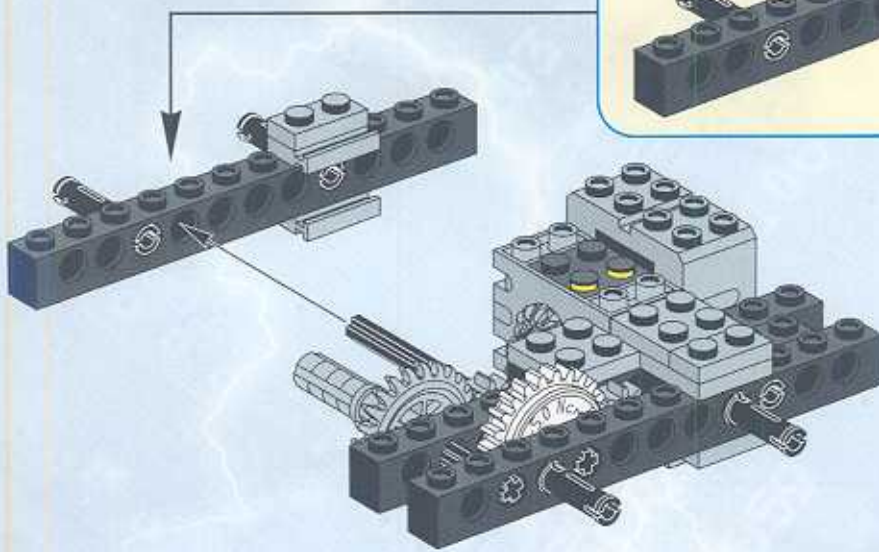
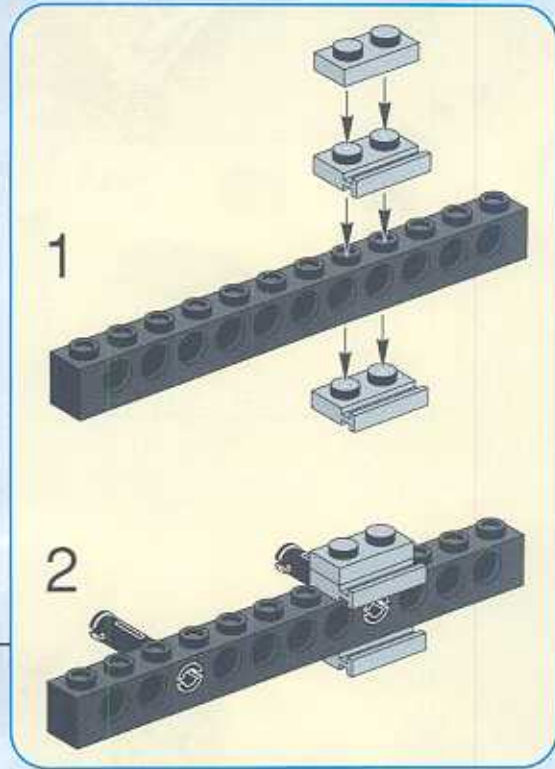
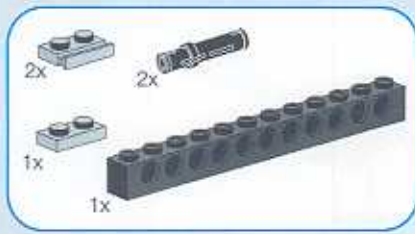


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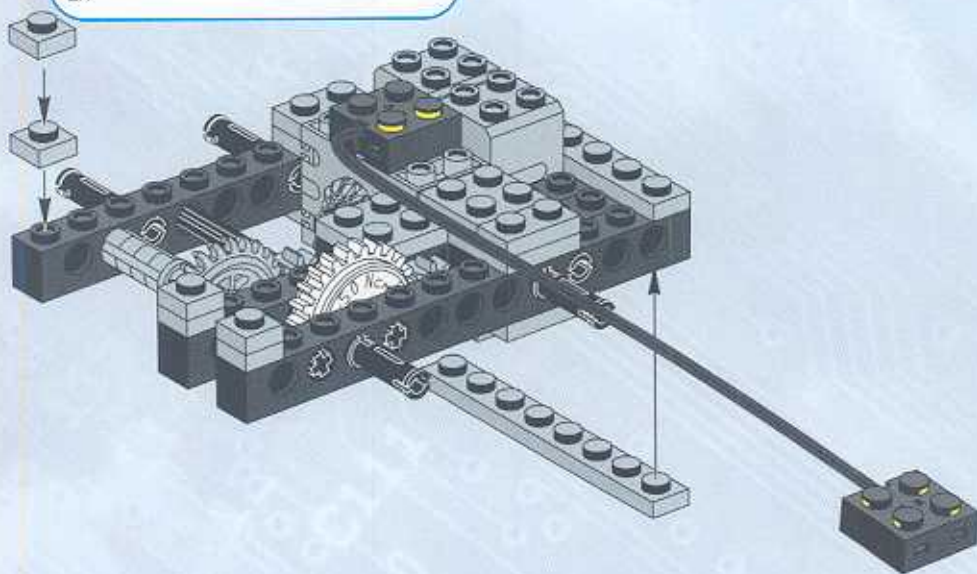
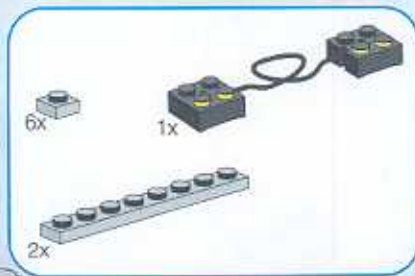




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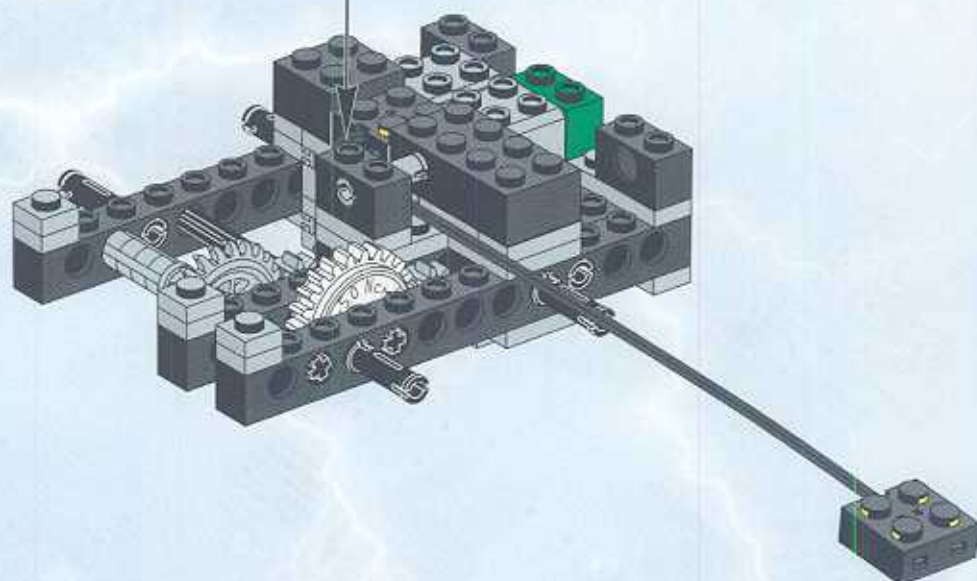
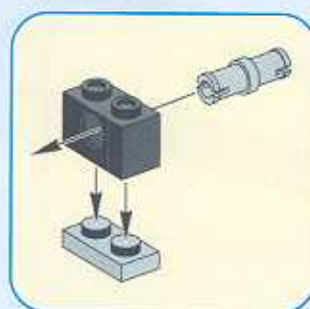
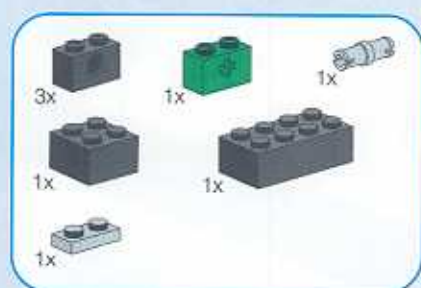


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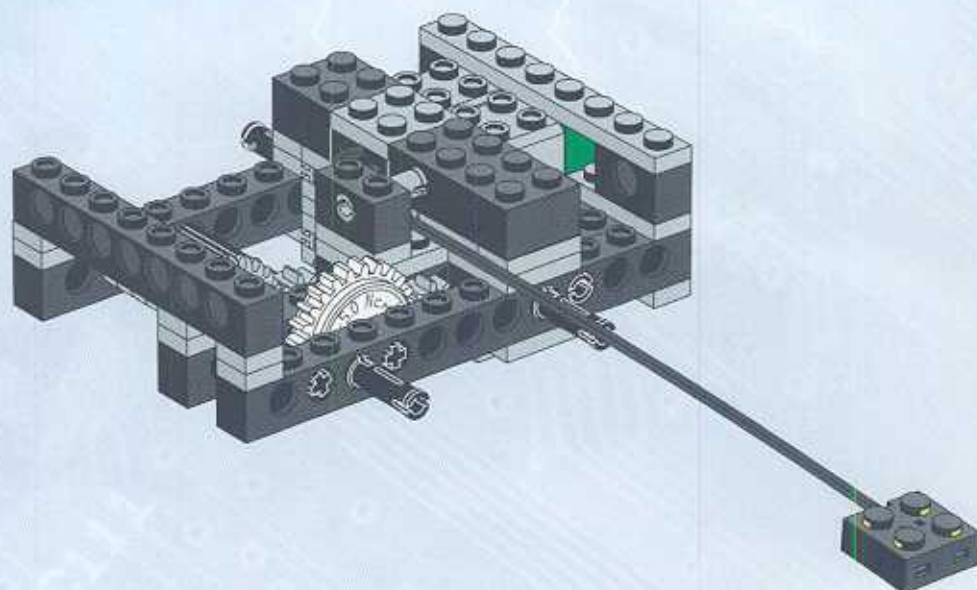
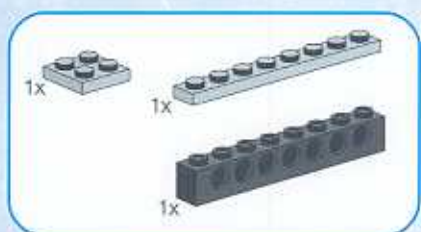




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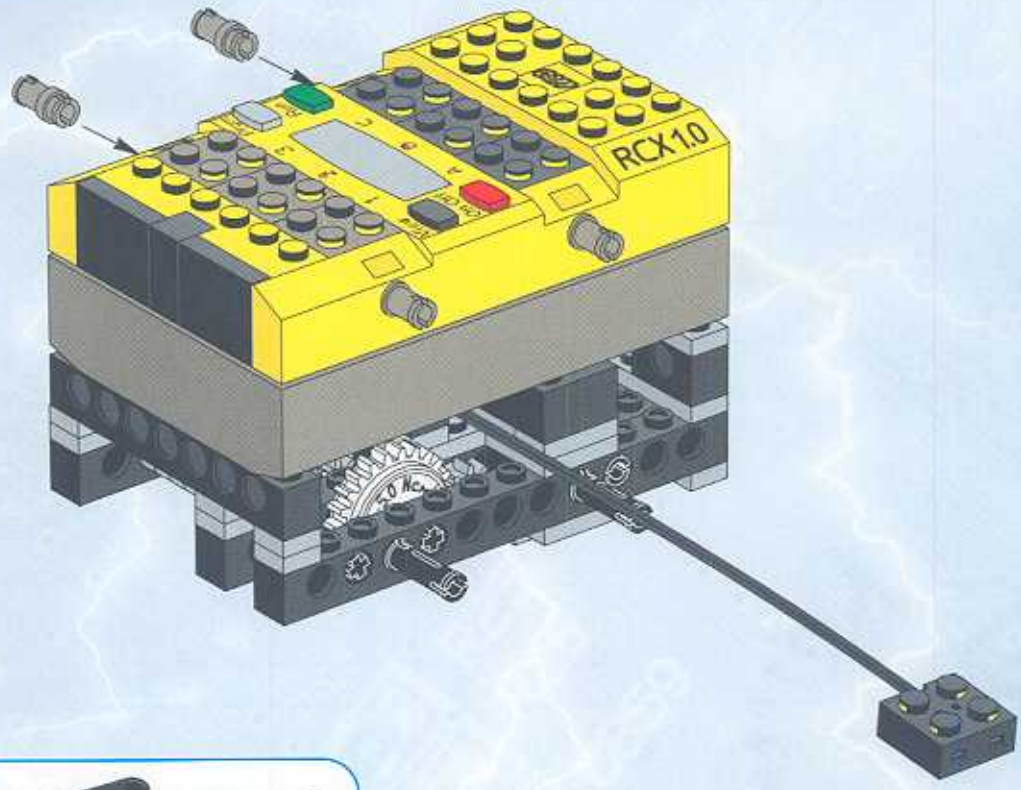
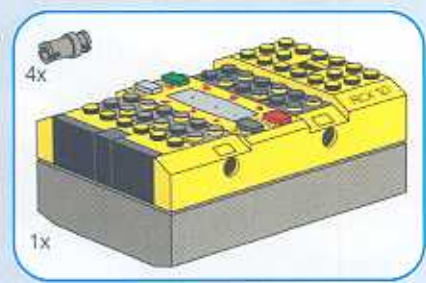


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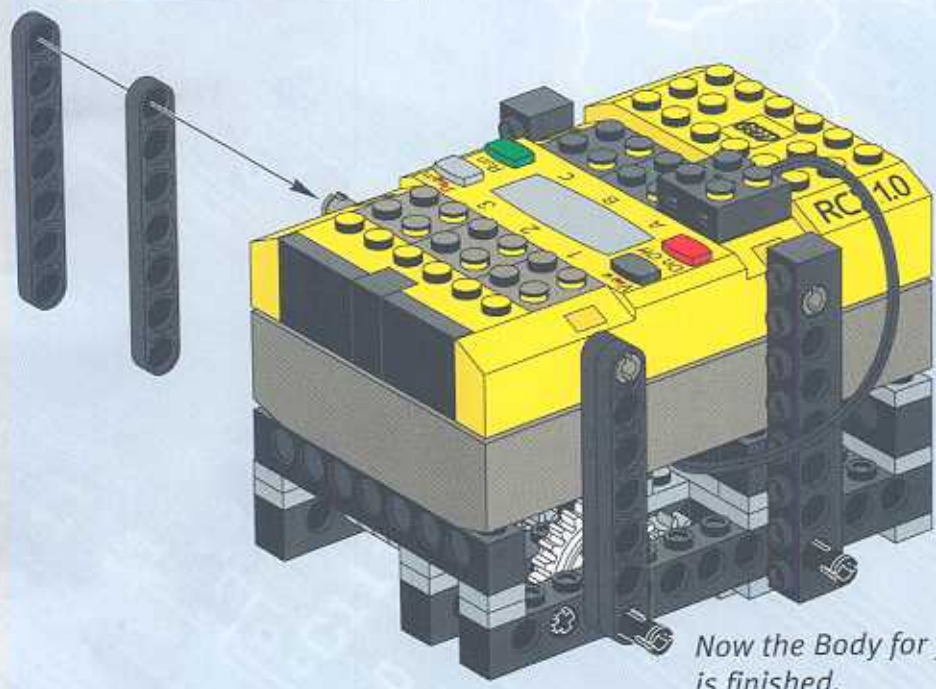
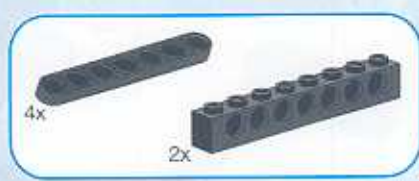




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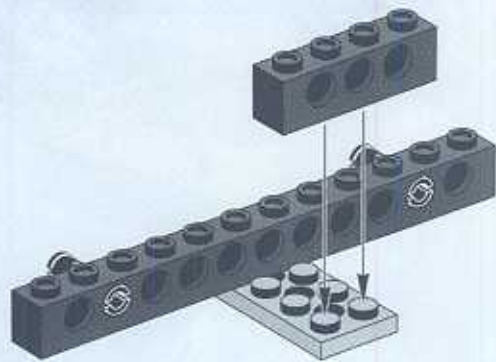
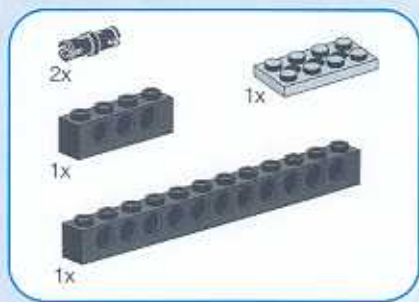
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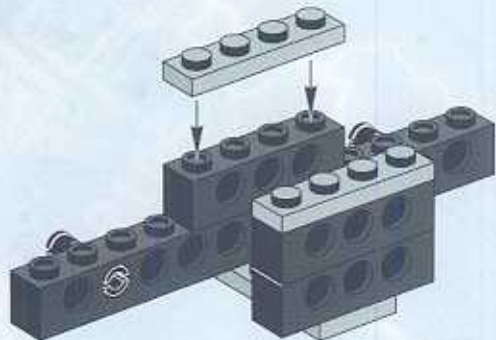
Now the Body for your Inventorbot is finished.

# Standing Base

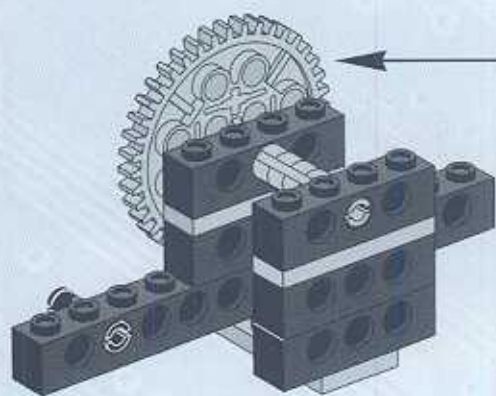
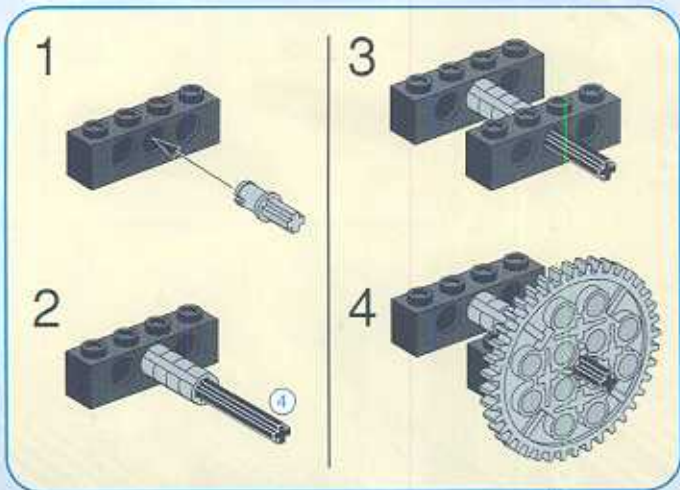
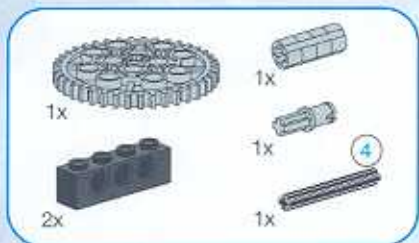
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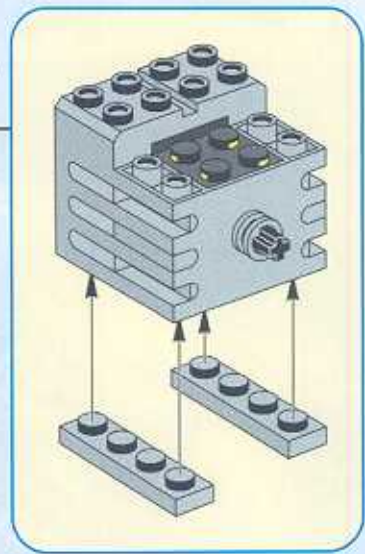
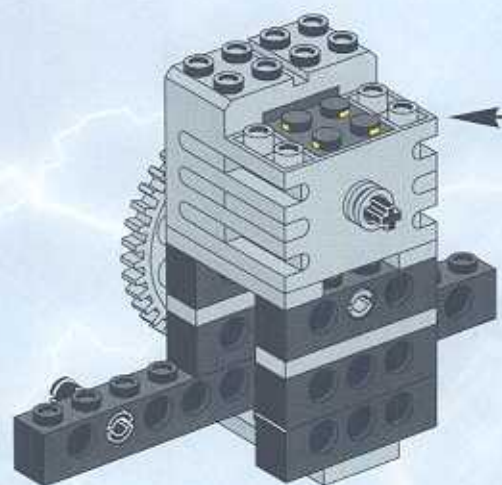
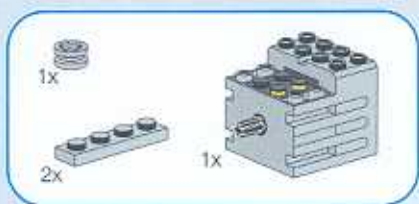


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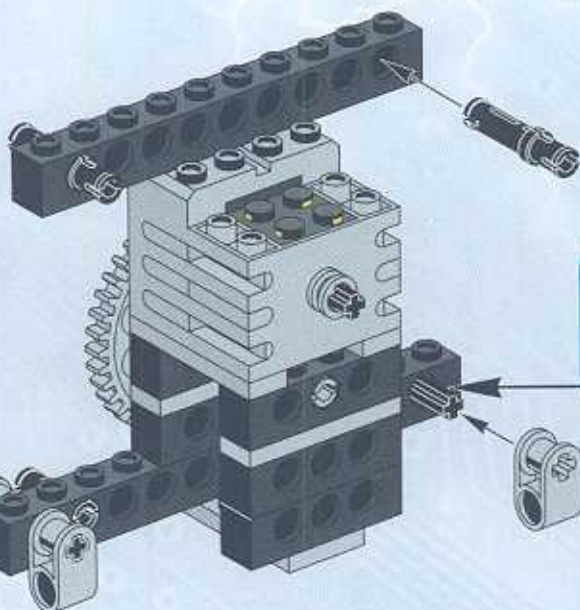




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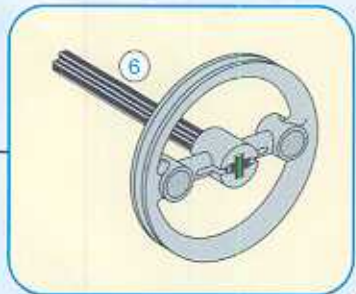
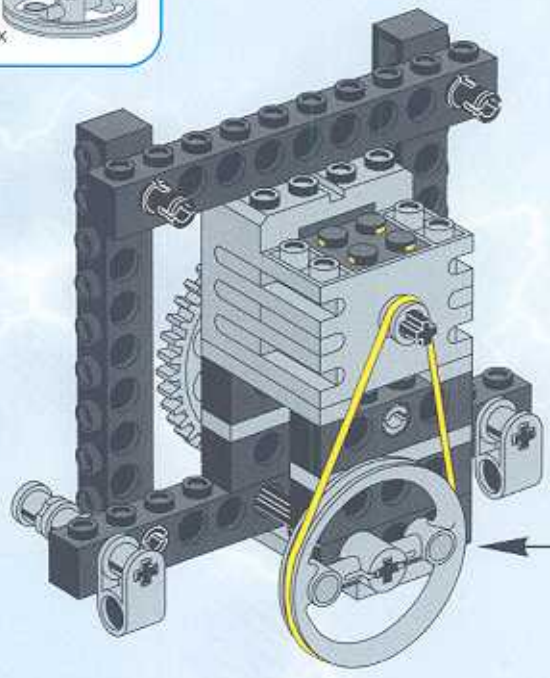
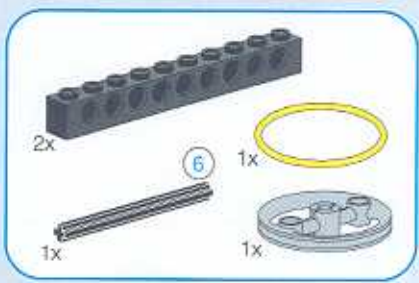


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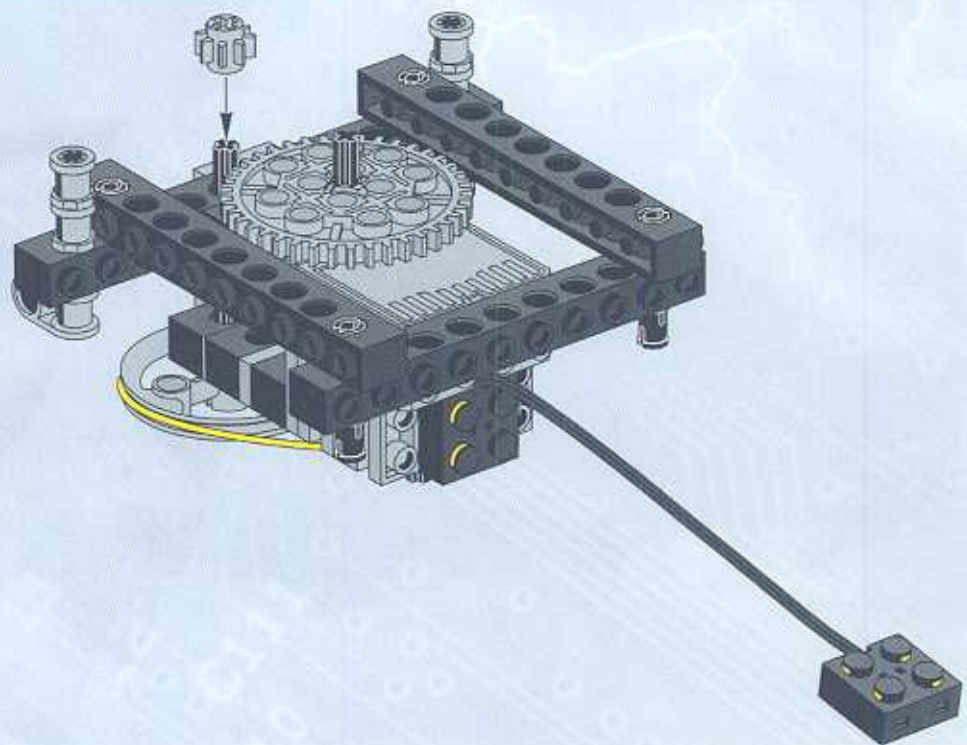




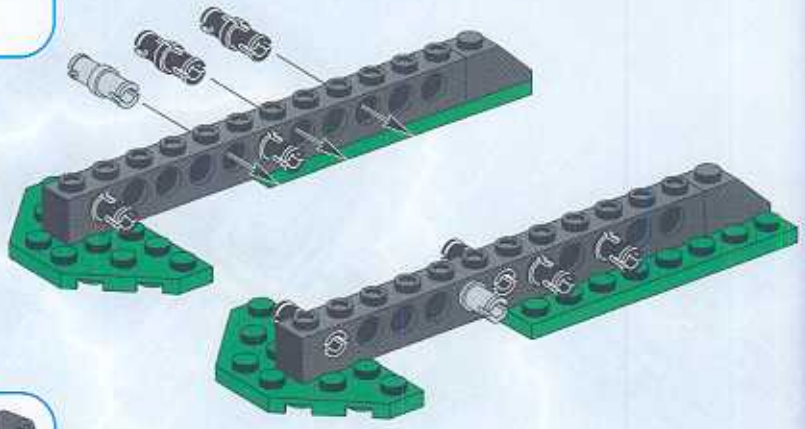
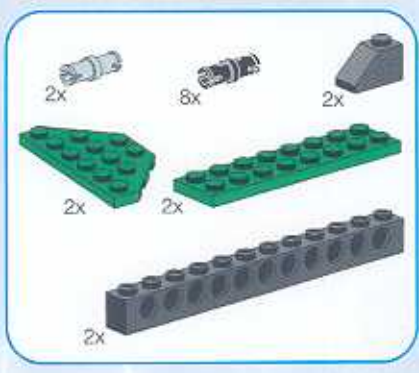
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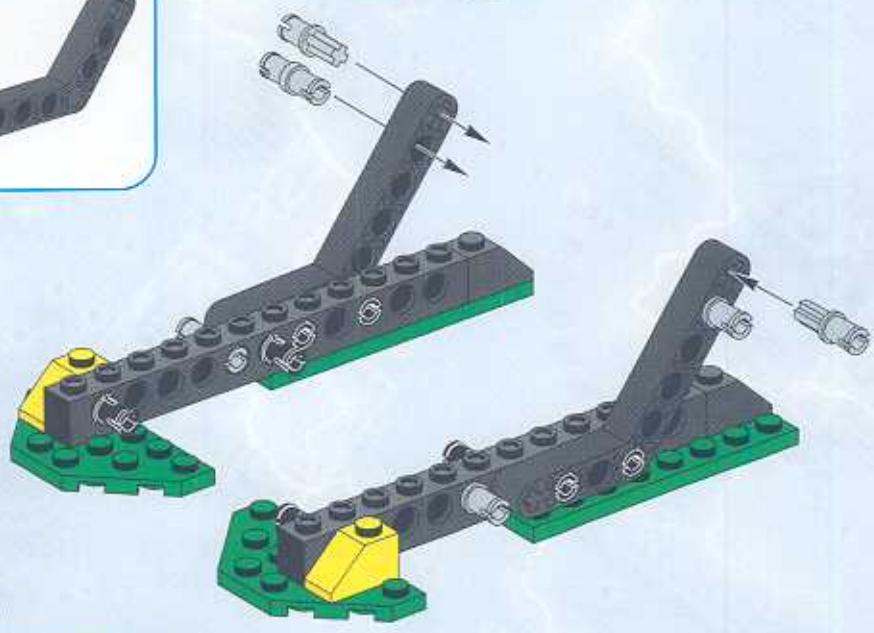
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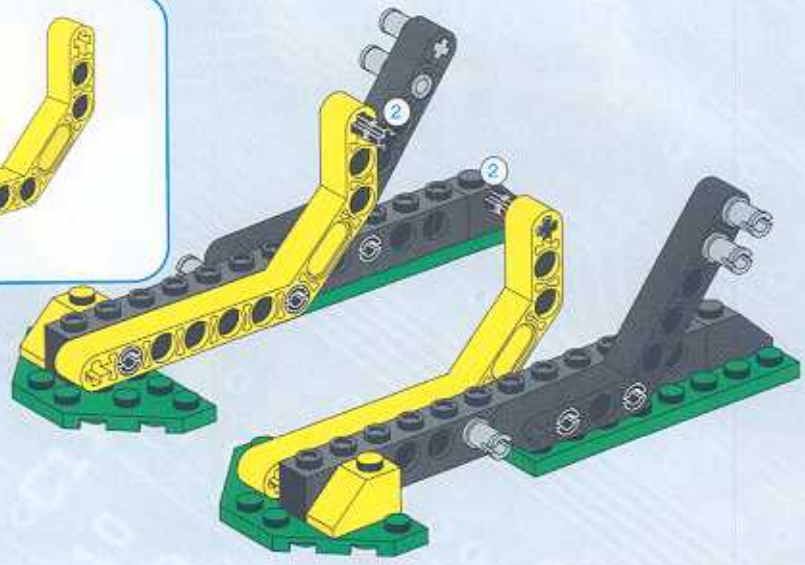
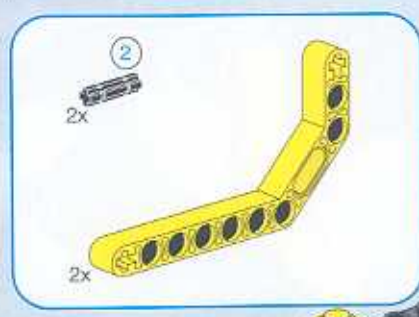
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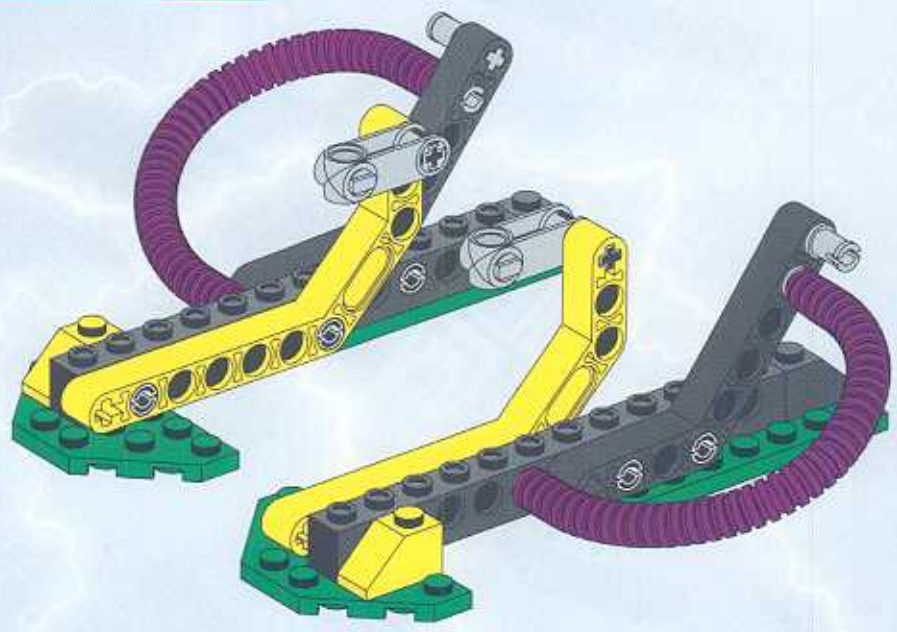
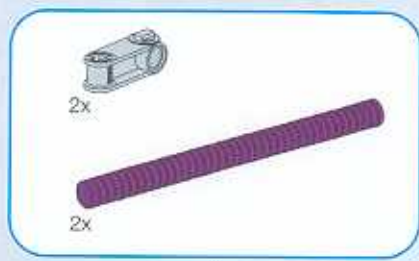


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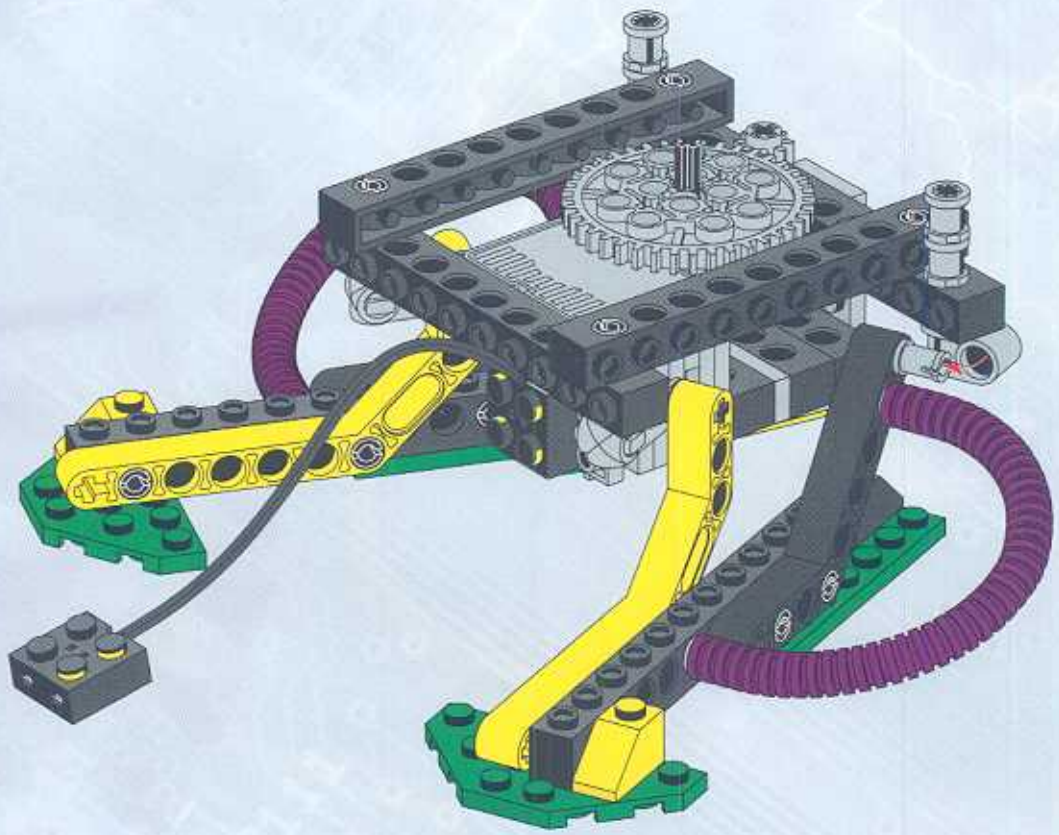




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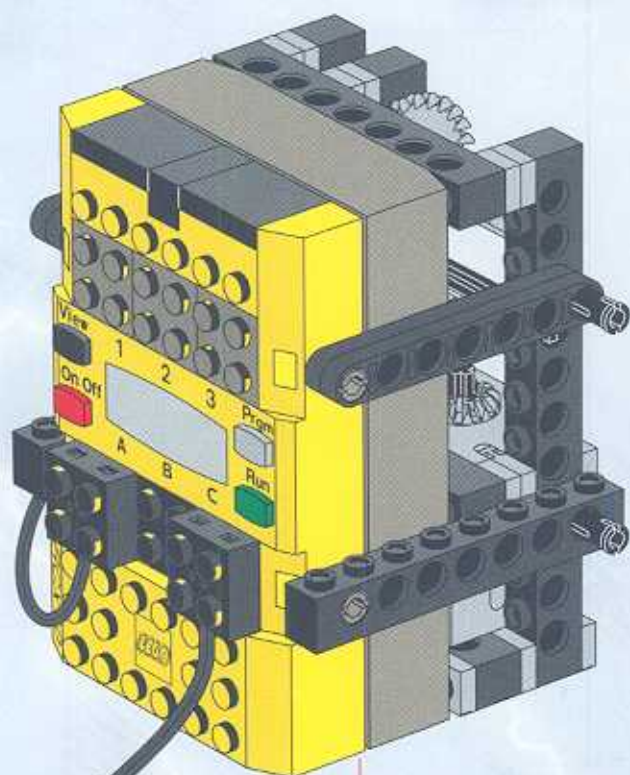
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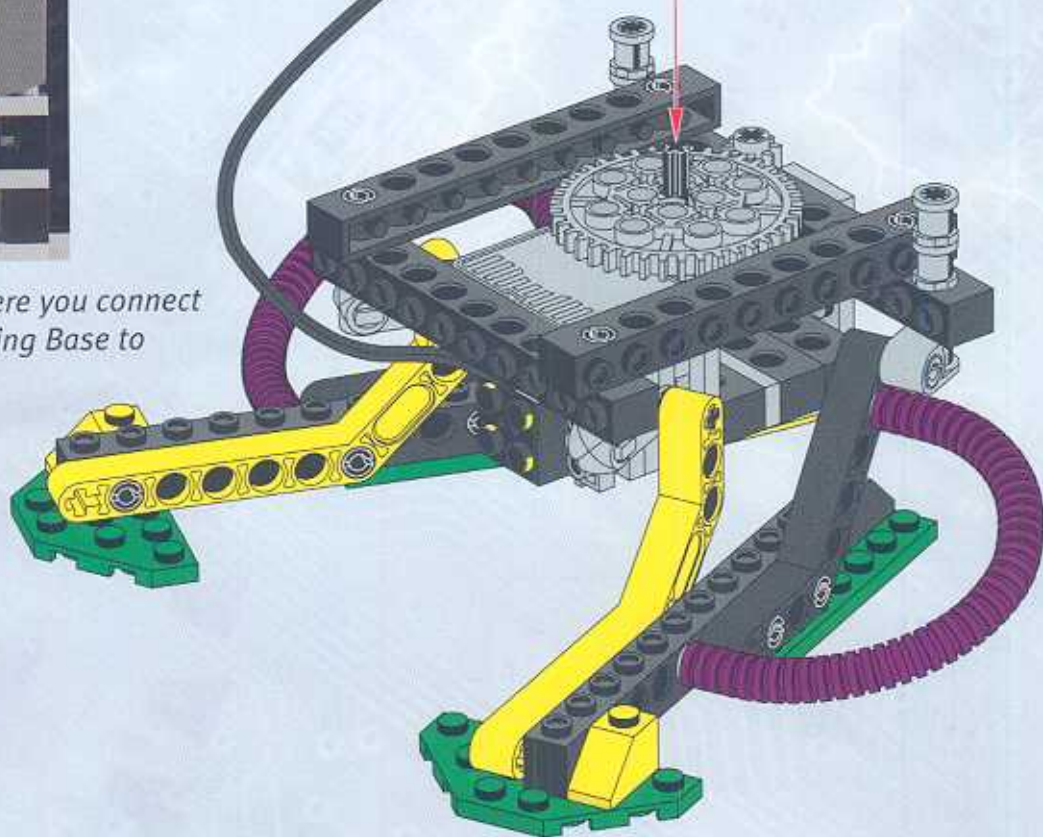
6

Attach the Standing Base to the Body like this.

If you have not yet built the Body, go to page 58.



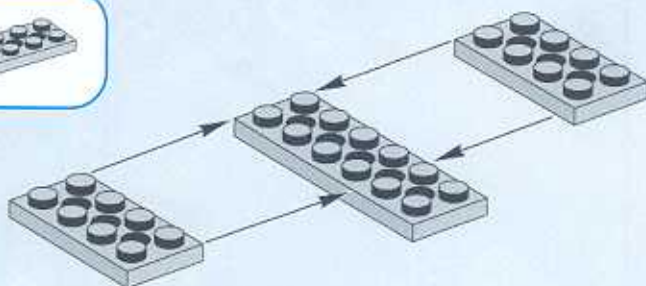
This is where you connect the Standing Base to the Body.



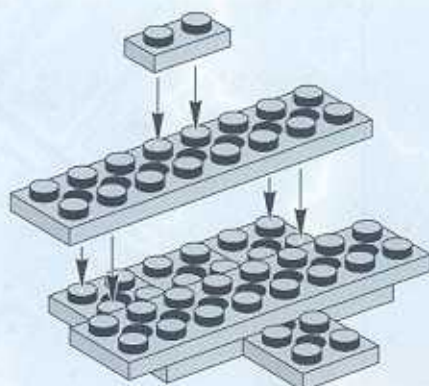


# Head

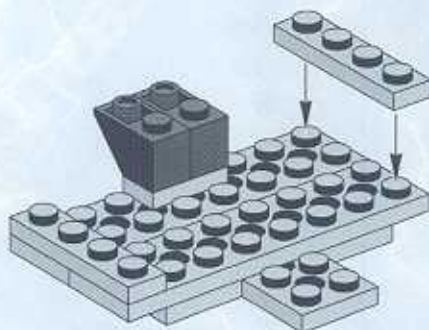
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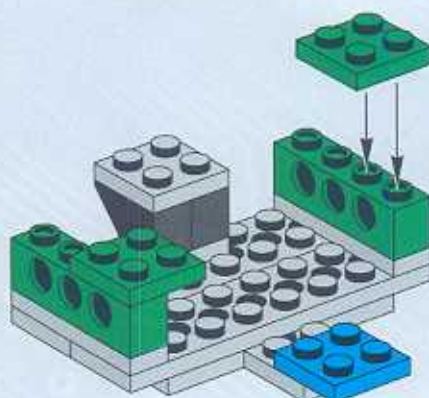
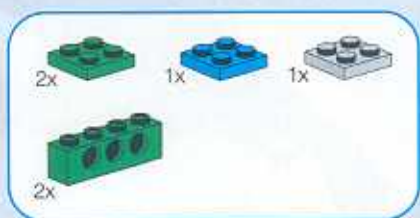
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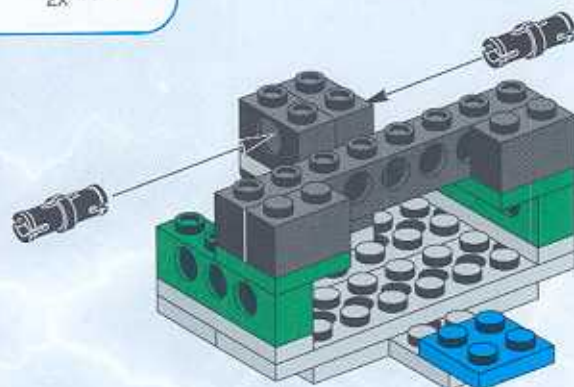
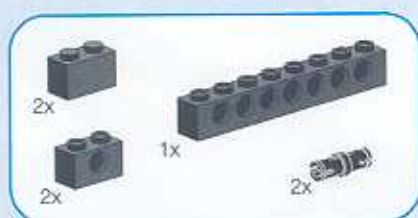
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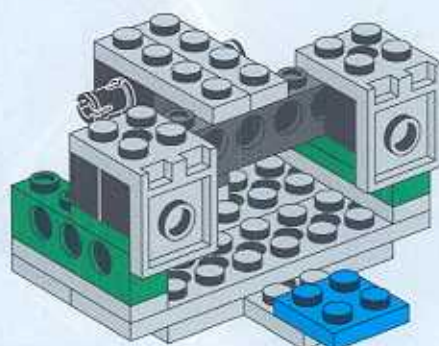
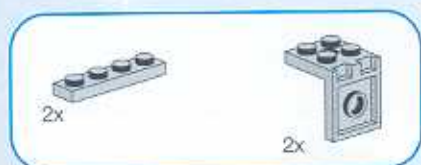
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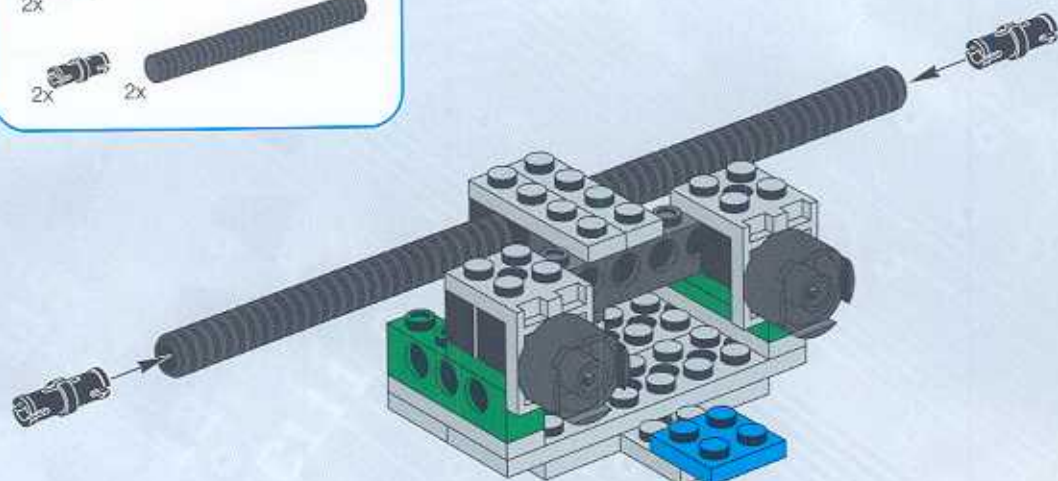
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6

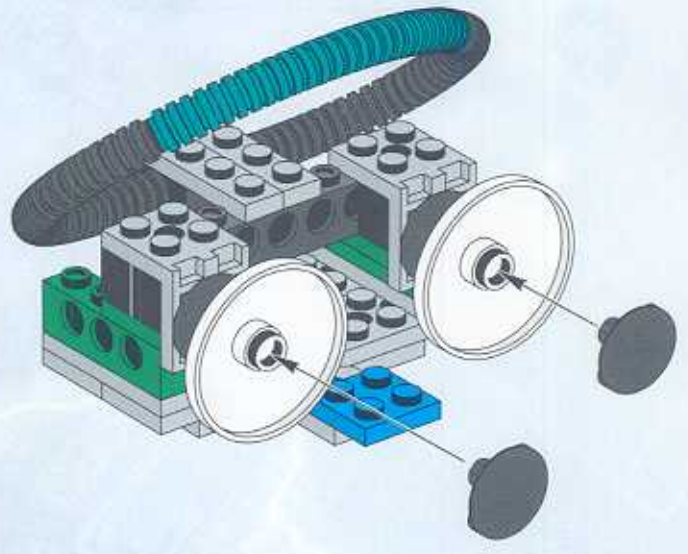
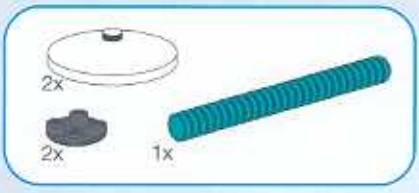


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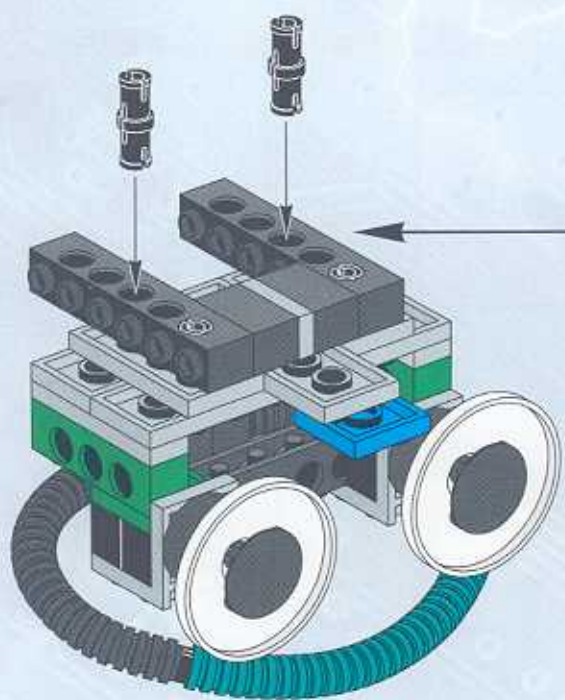
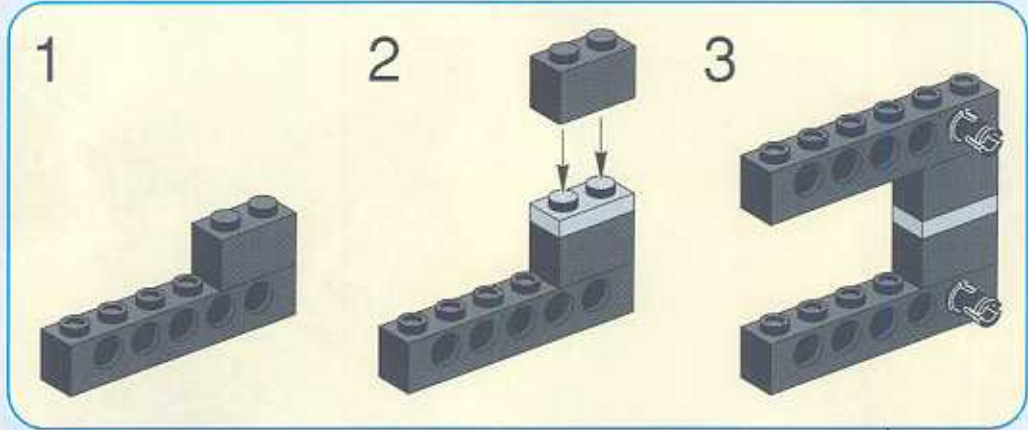
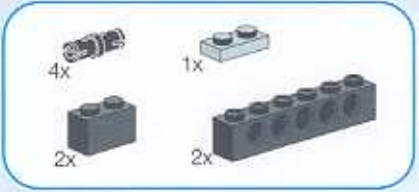




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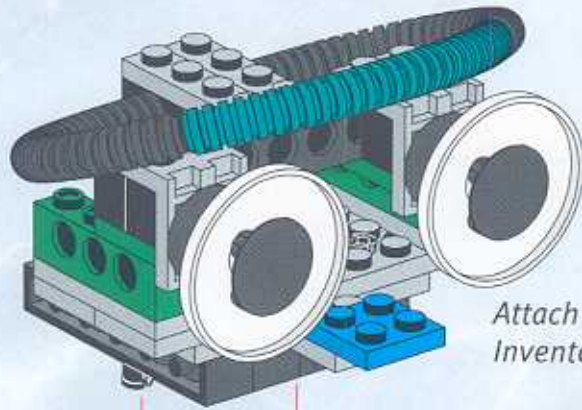


9





10



Attach the Head to the Inventorbot's Body like this.

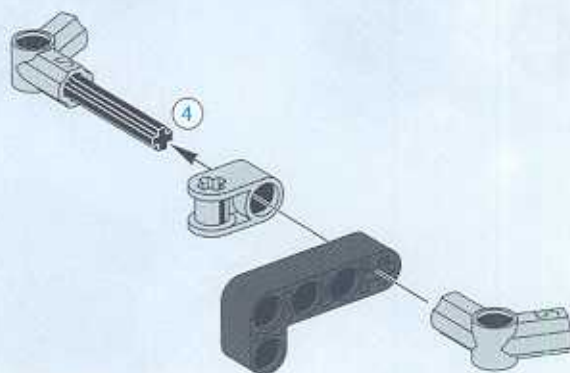
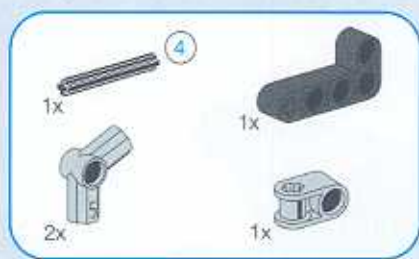
If you have not yet built the Body and the Standing Base, go to page 58.



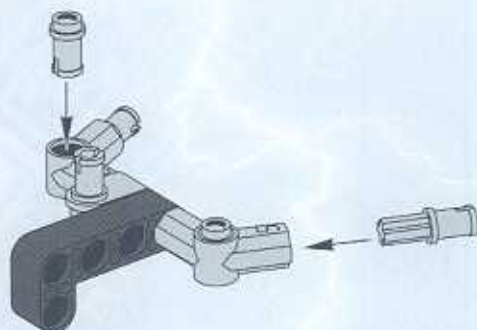
Now you are ready to build some arms for your Inventorbot.

# Hat Arm

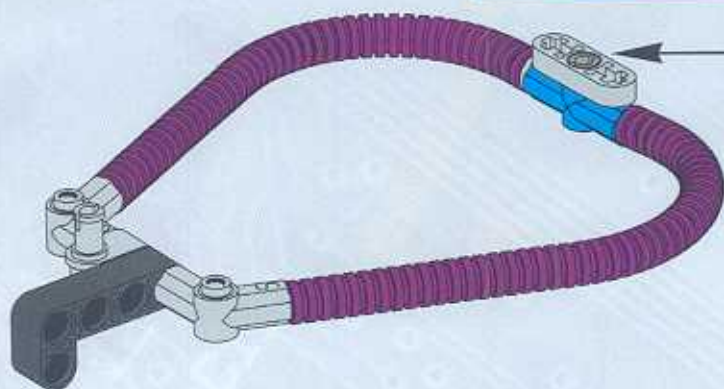
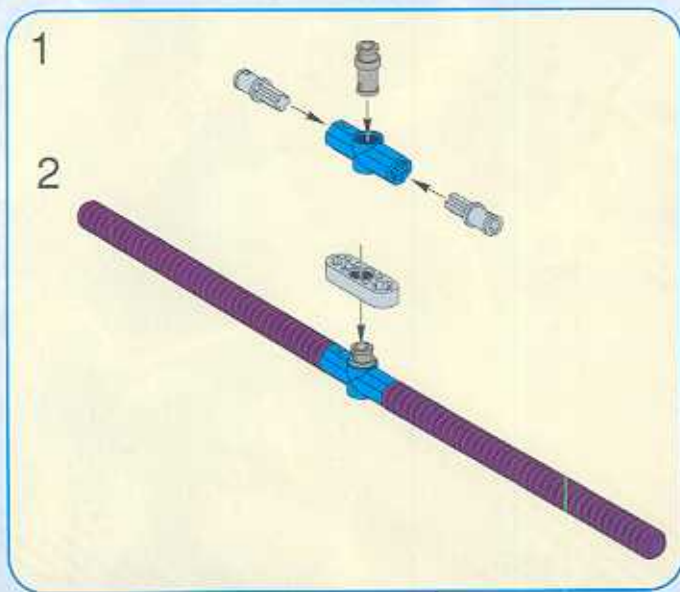
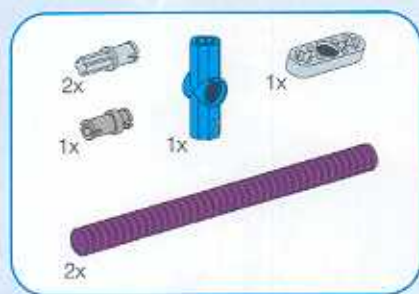
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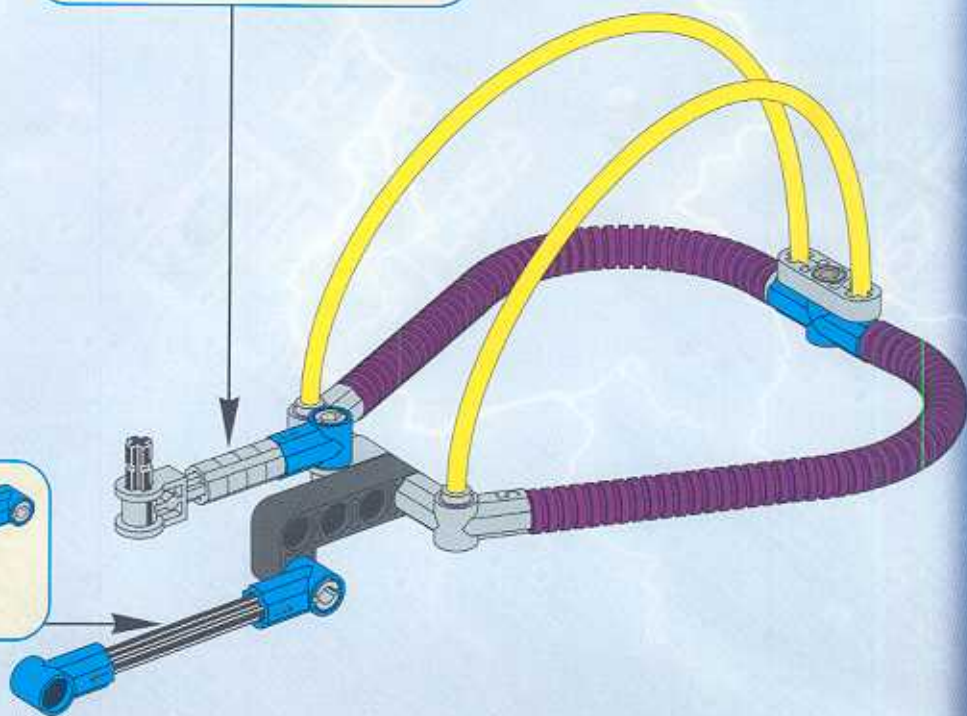
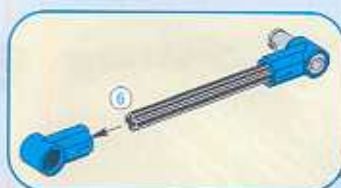
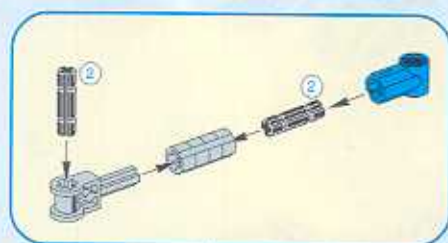
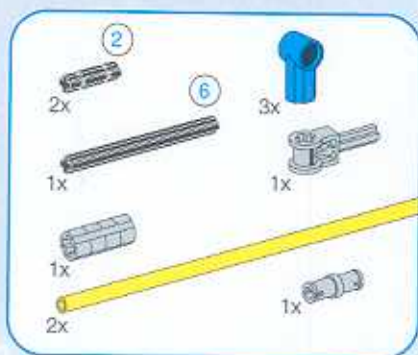
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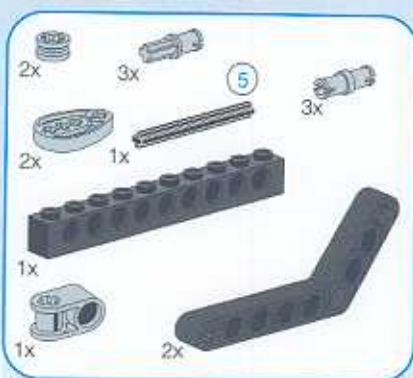
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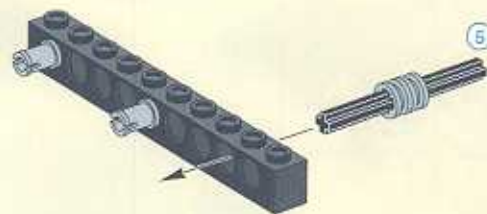
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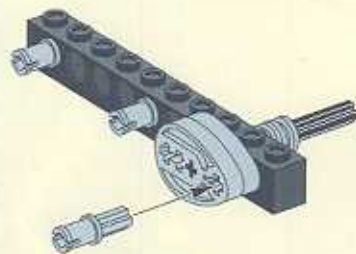
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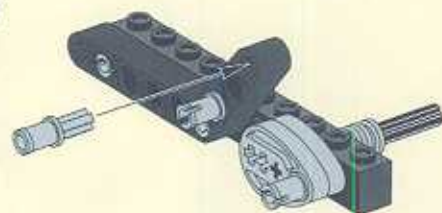
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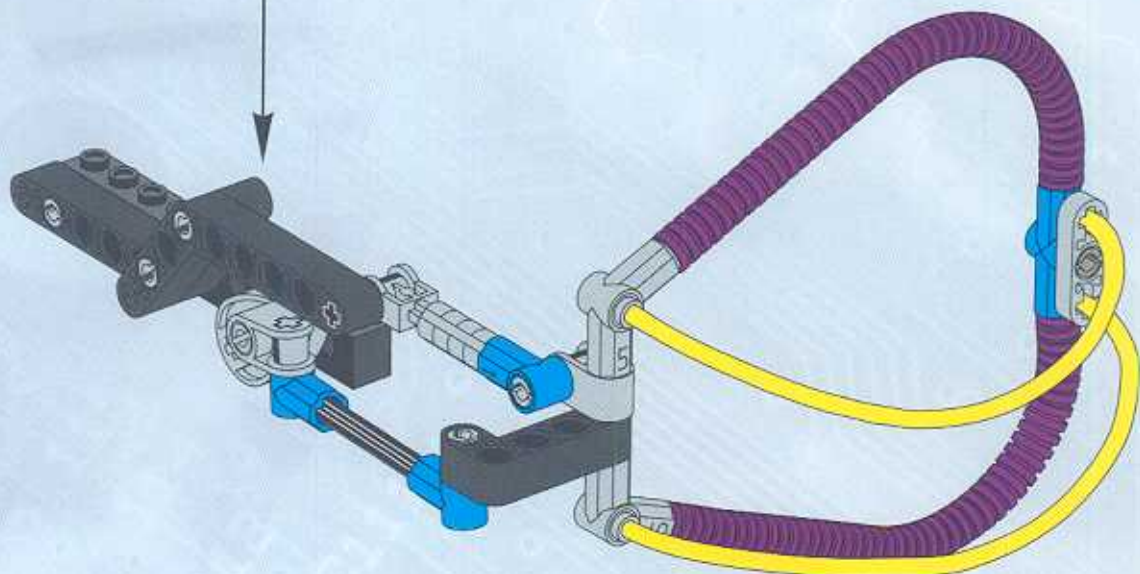
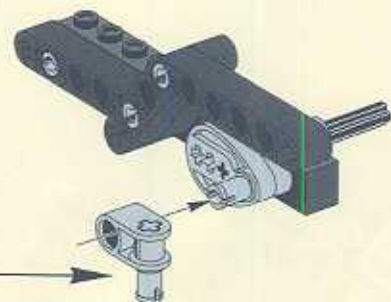
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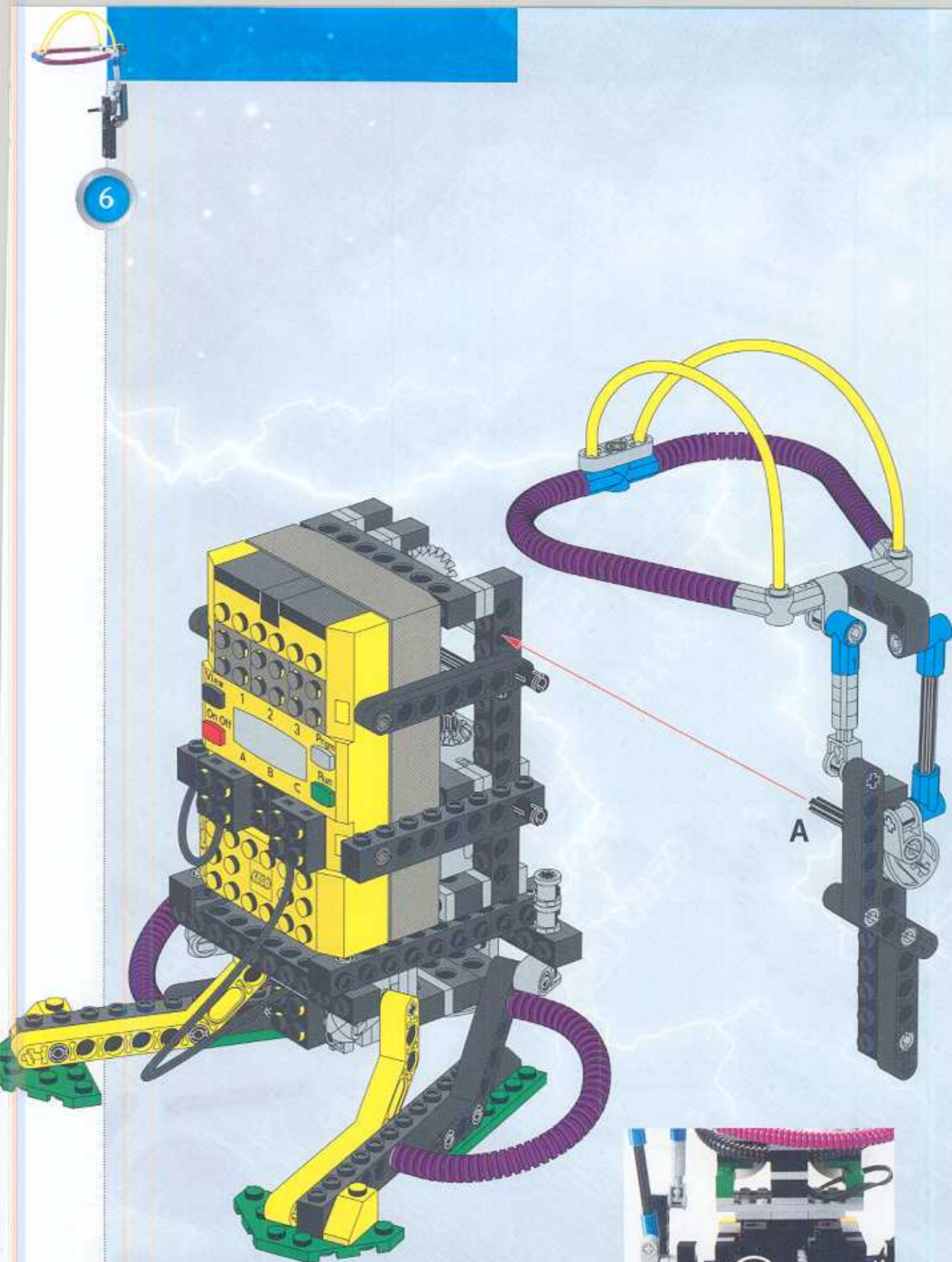


3



4

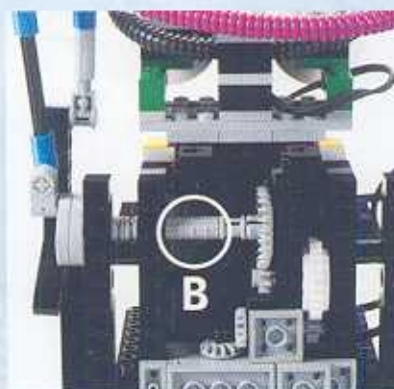




*Attach the Hat Arm to the Inventorbot like this.*

*Make sure piece A fits into piece B.*

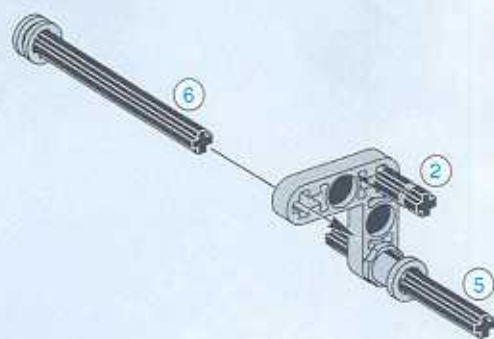
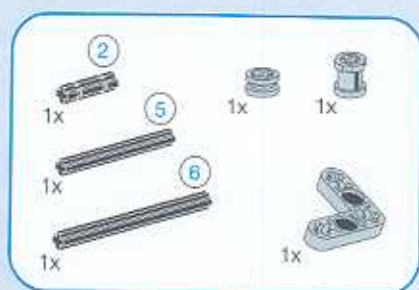
*If you have not yet built the Body and the Standing Base, go to page 58.*



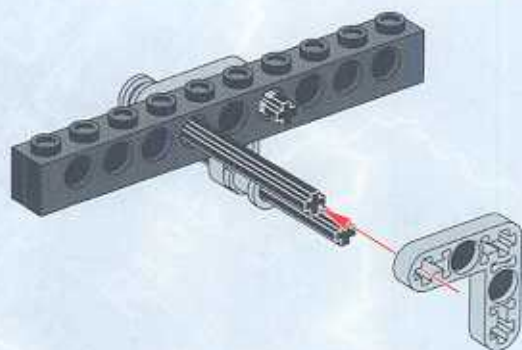
# Slap Arm



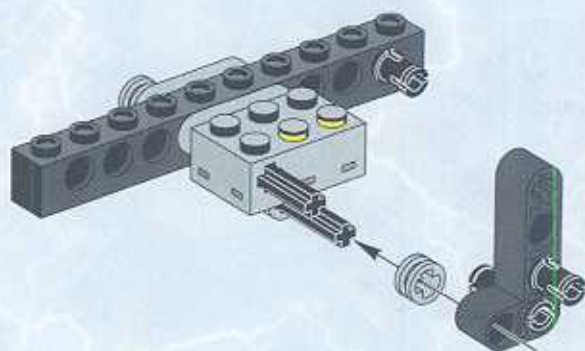
1



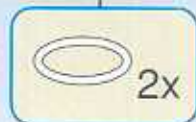
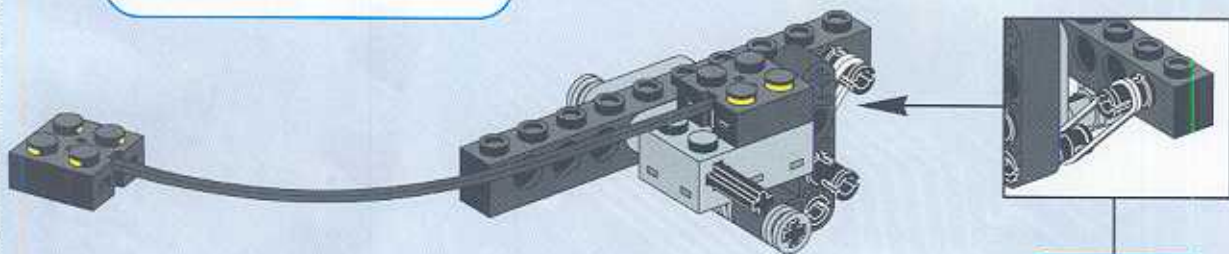
2



3



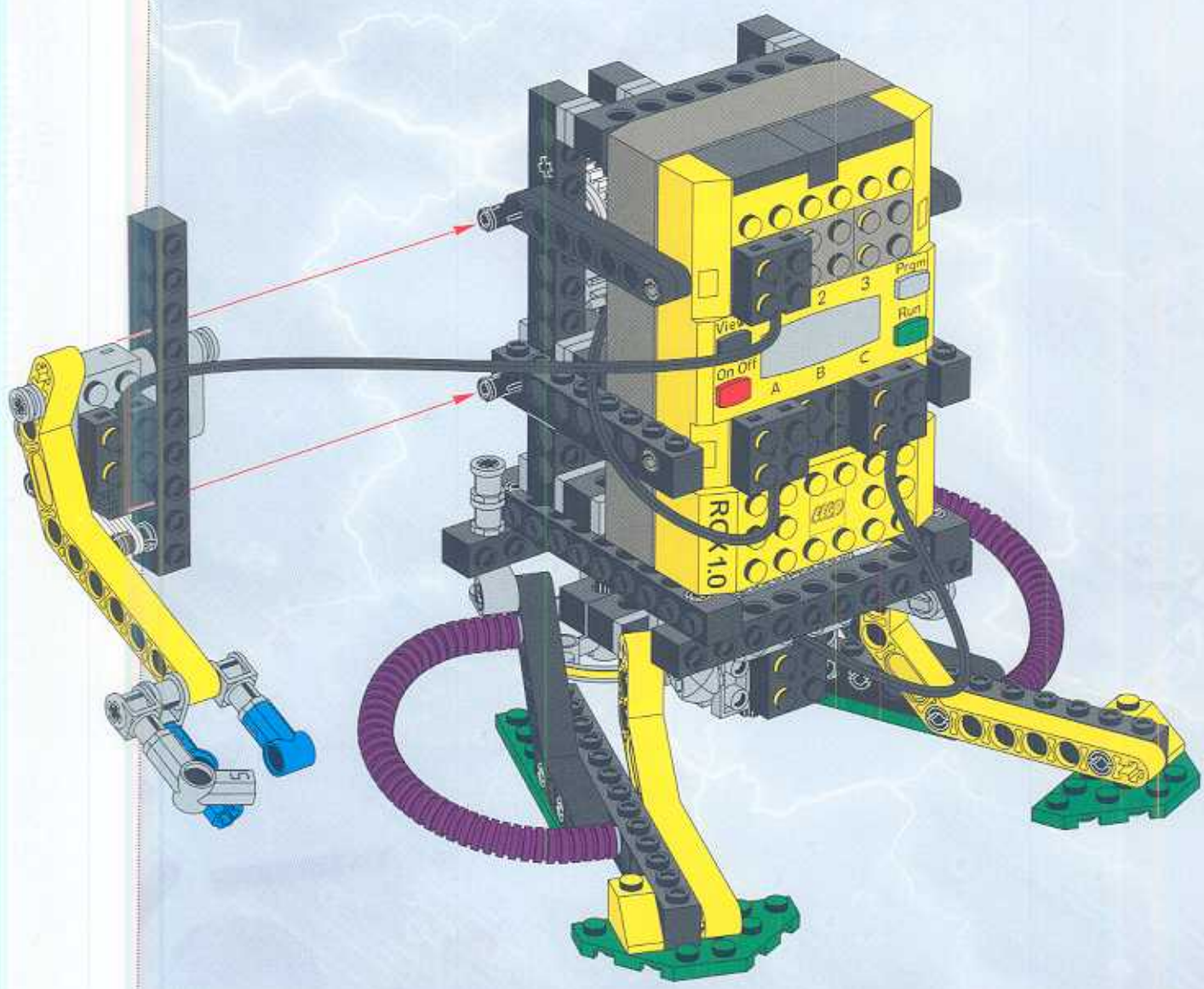
4







6



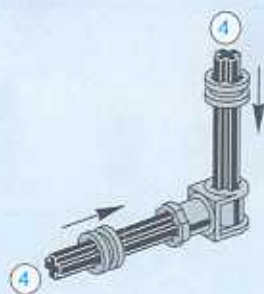
*Attach the Slap Arm to the Inventorbot like this.*

*If you have not yet built the Body and the Standing Base, go to page 58.*

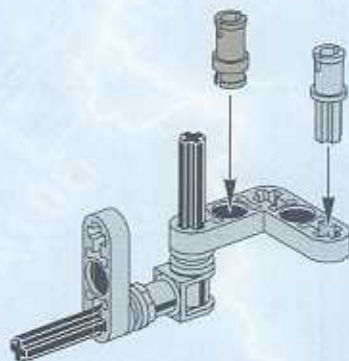
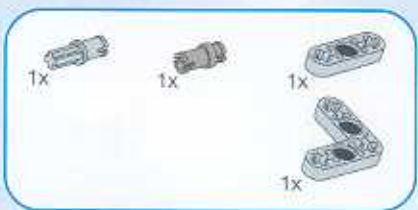


# Squeeze Arm

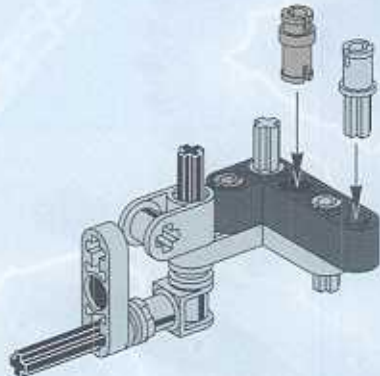
1



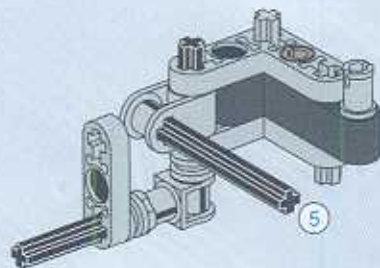
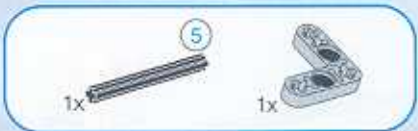
2



3

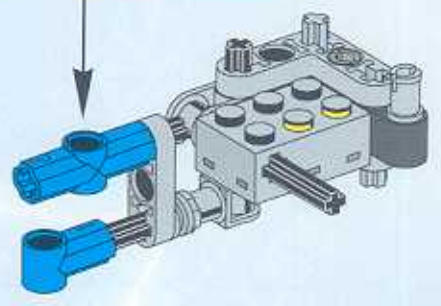
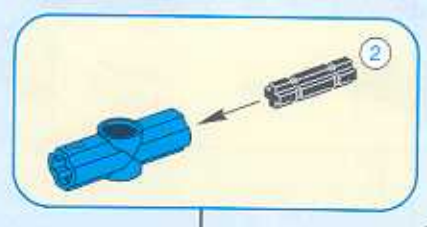
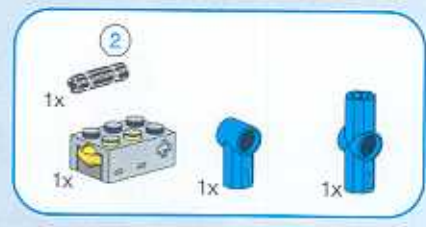


4

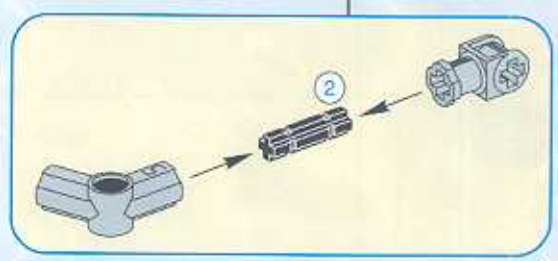
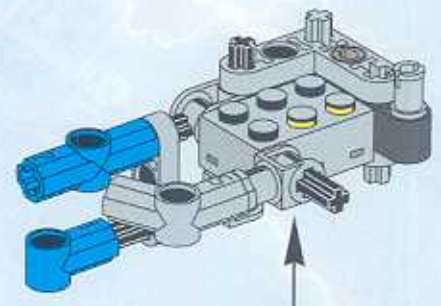
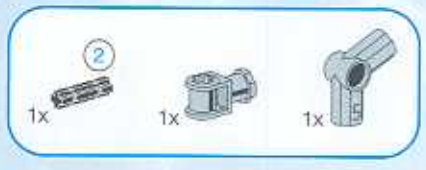




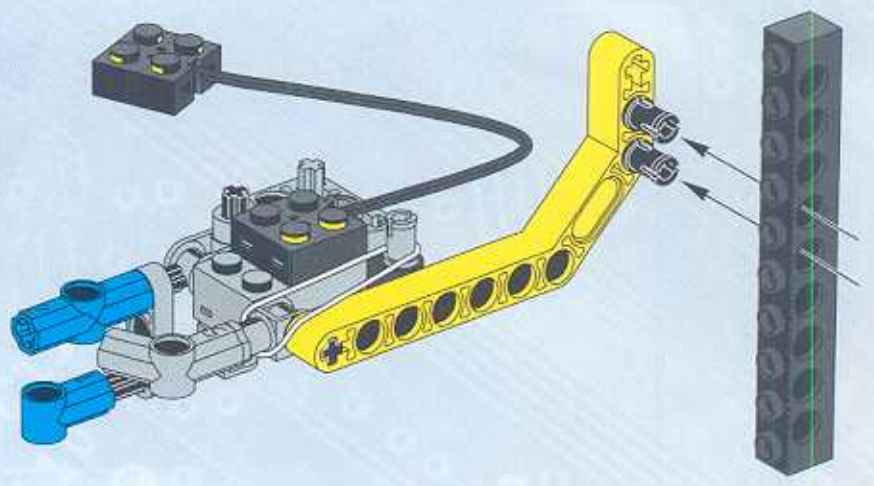
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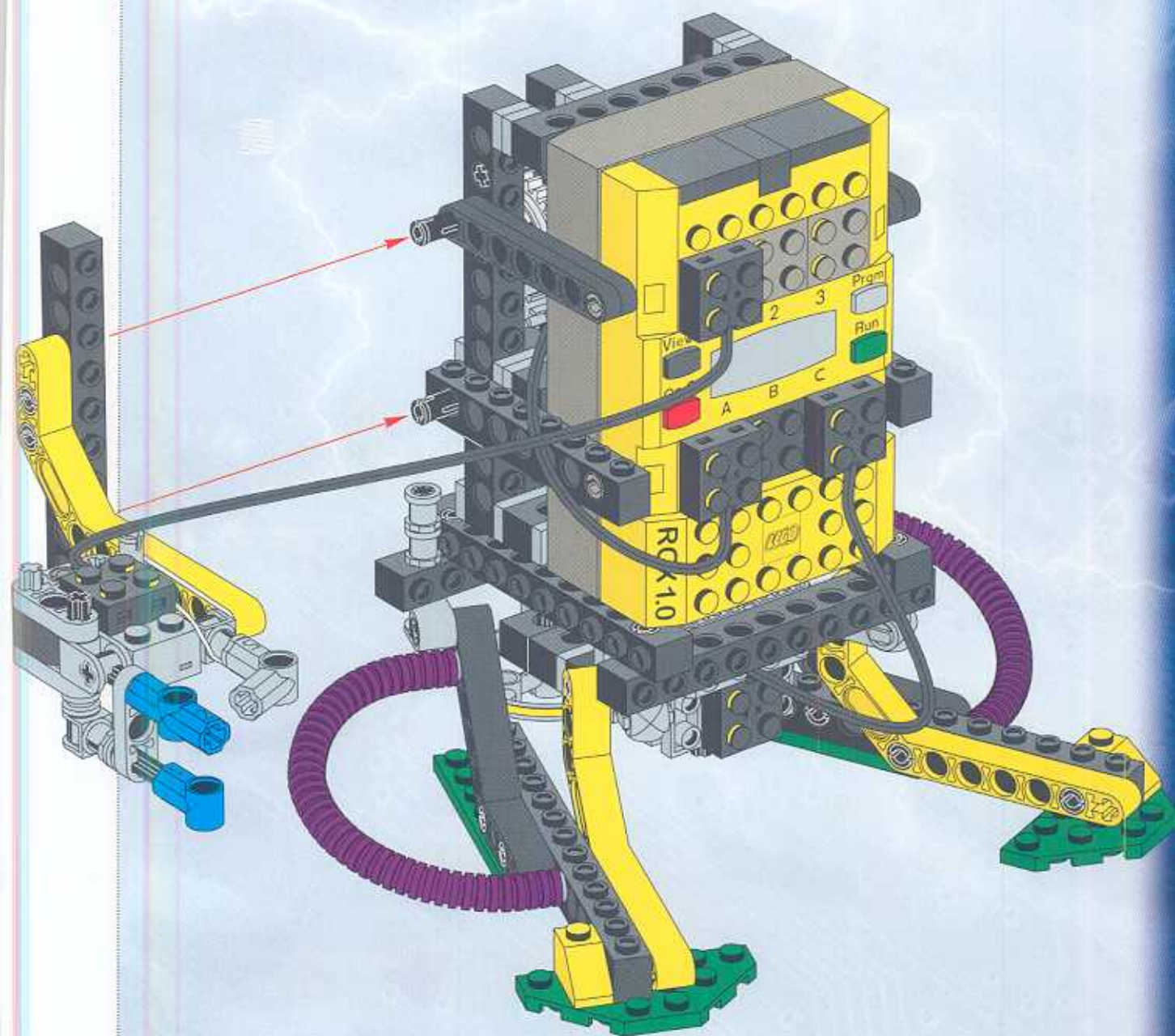
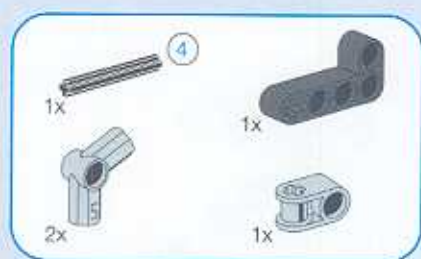
6



7



8



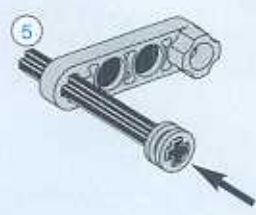
Attach the Squeeze Arm to the Inventorbot like this.

If you have not yet built the Body and the Standing Base, go to page 58.

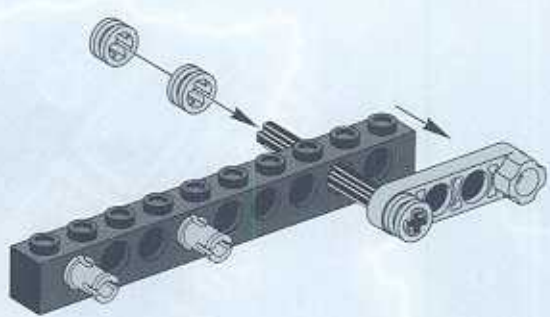
# Thrower Arm



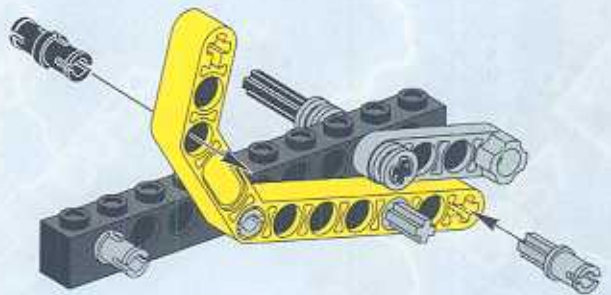
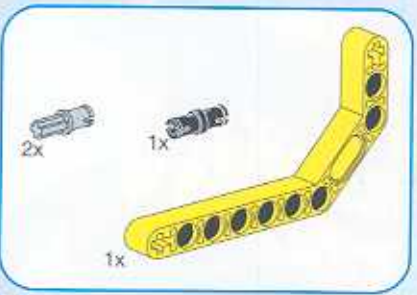
1



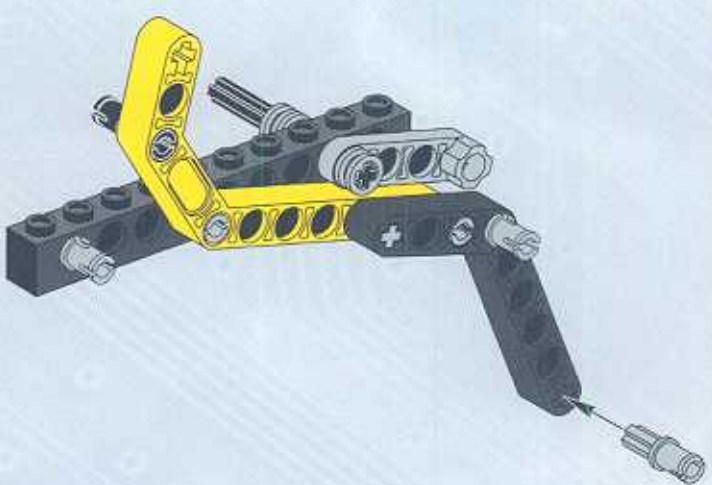
2



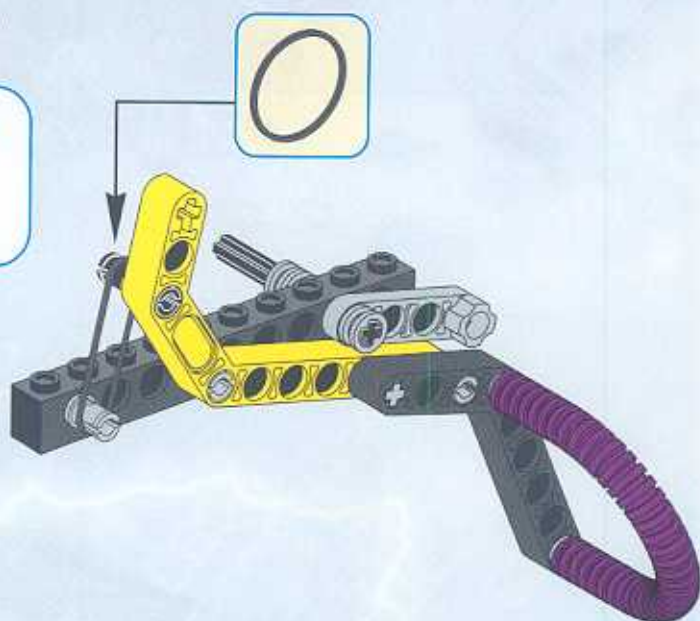
3



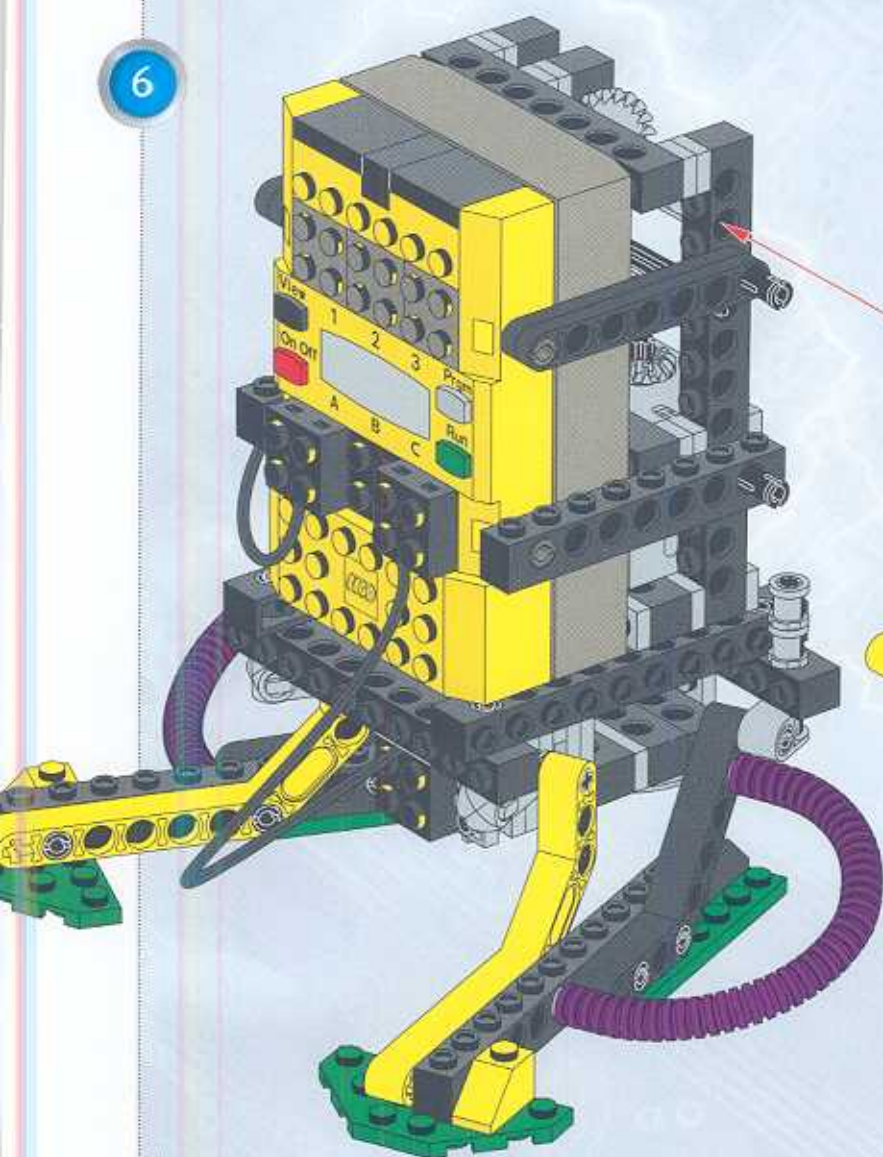
4



5



6



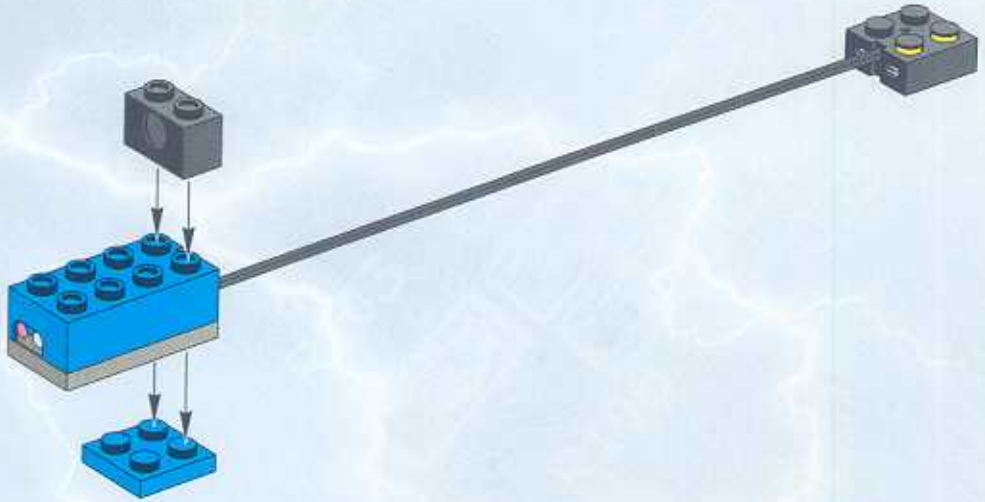
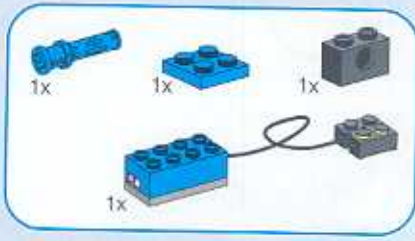
Attach the Thrower Arm to the Inventorbot like this. Make sure that piece A fits into piece B.

If you have not yet built the Body and the Standing Base, go to page 58.

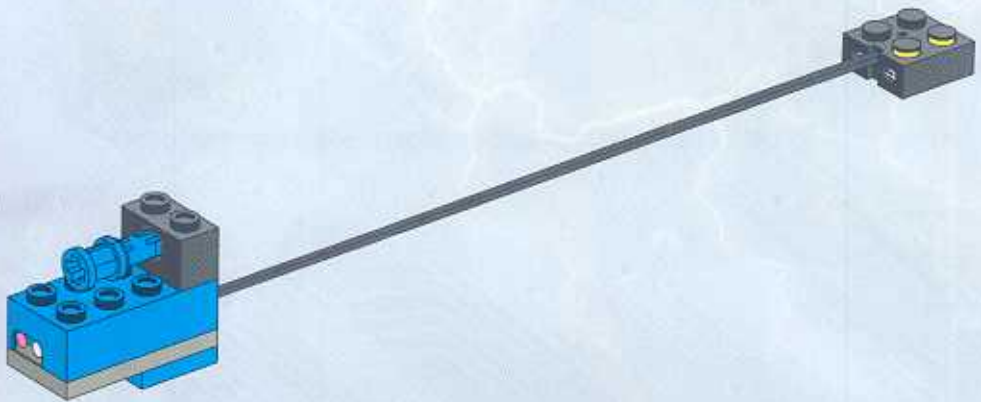
# Light Sensor



1



2



3



Attach the Light Sensor to the Inventorbot's Body like this.

If you have not yet built the Body and the Standing Base, go to page 58.

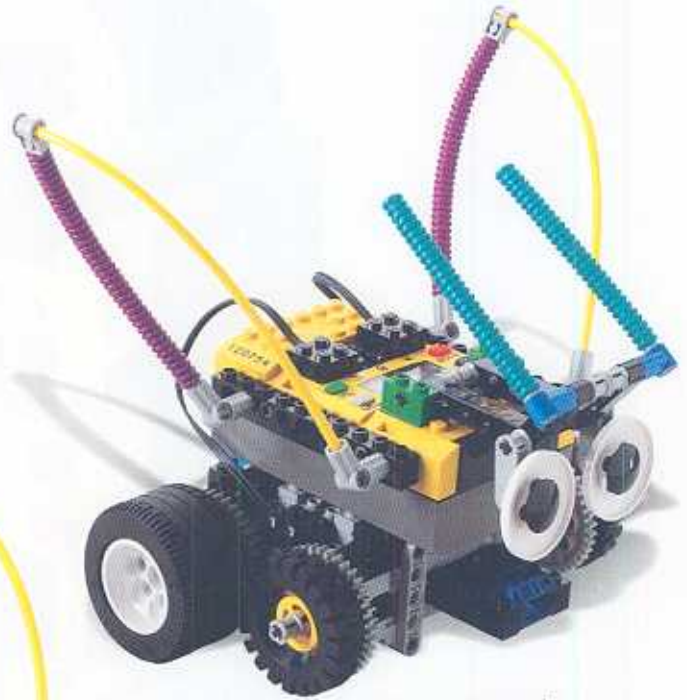


## SPECIAL FEATURES

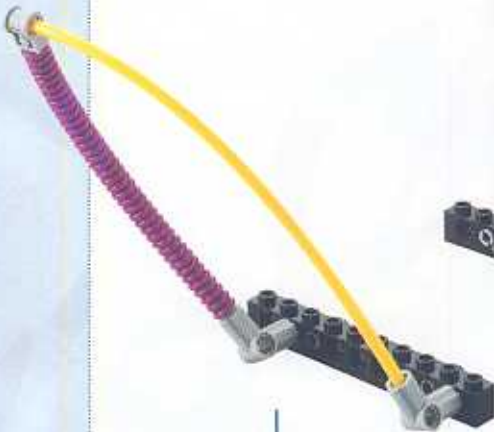
The following four pages show ideas and suggestions for dressing up your Roverbot.



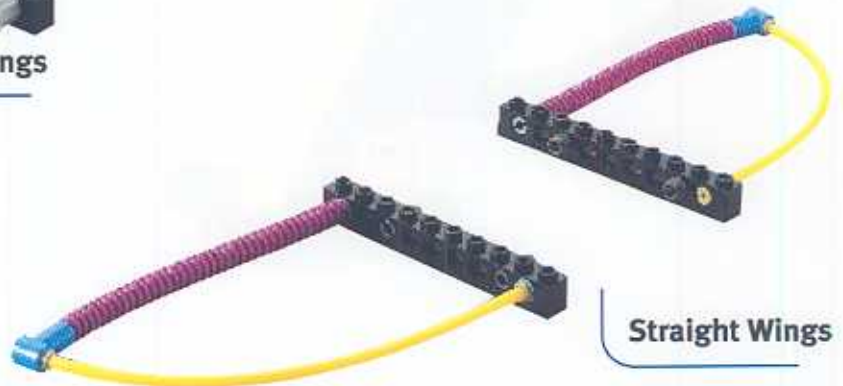
Bug Eyes



*example*

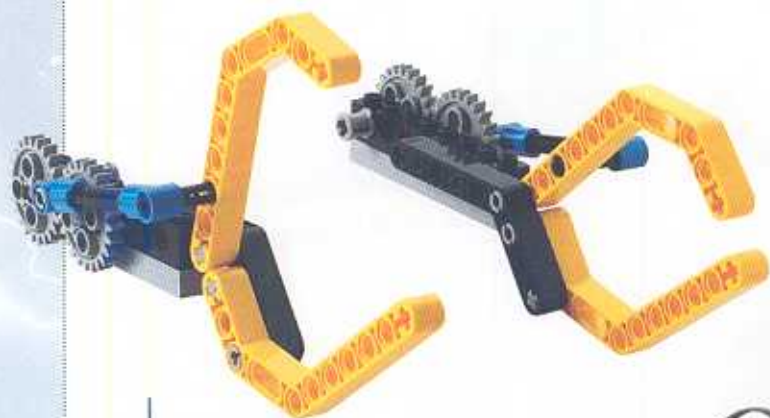


Angled Wings



Straight Wings



**Claws***example***Parrot Head***example*

With this head you can program your robot to react when you stroke its “head feathers”

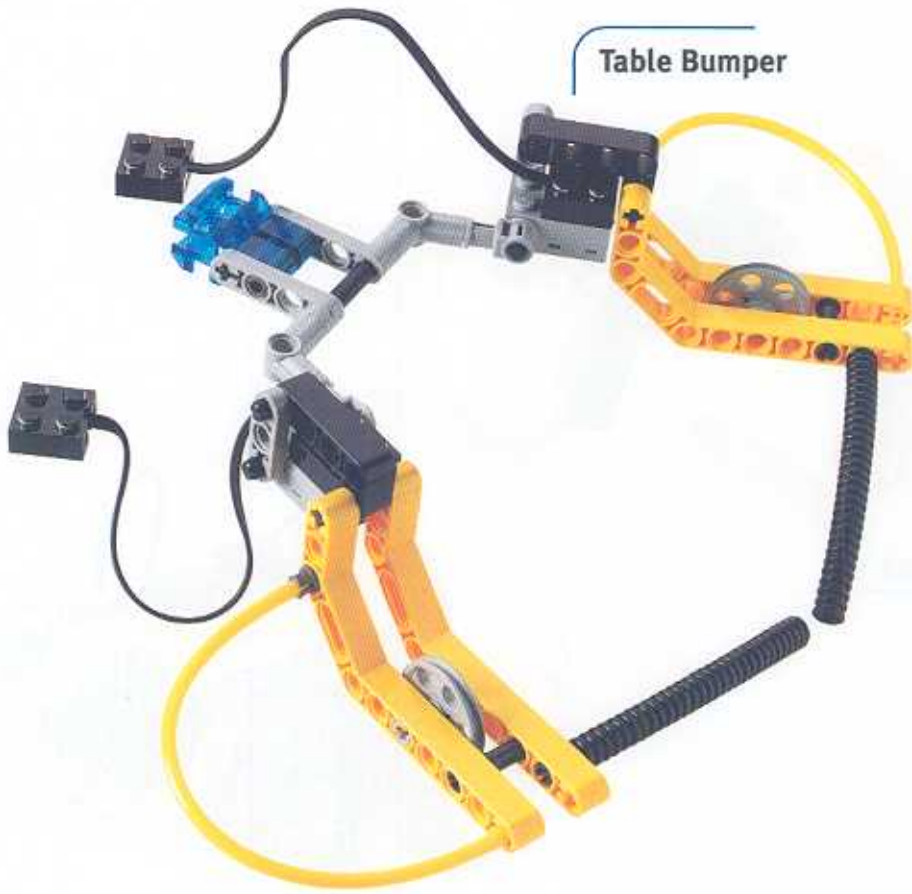
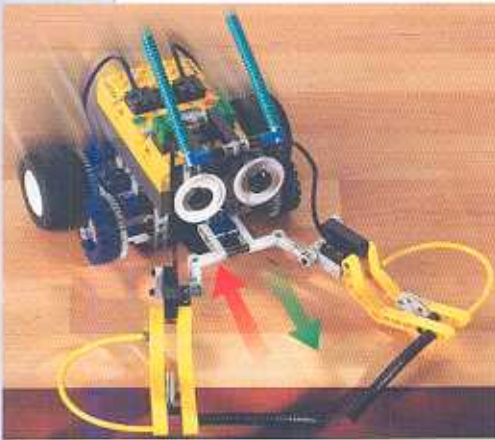


Table Bumper



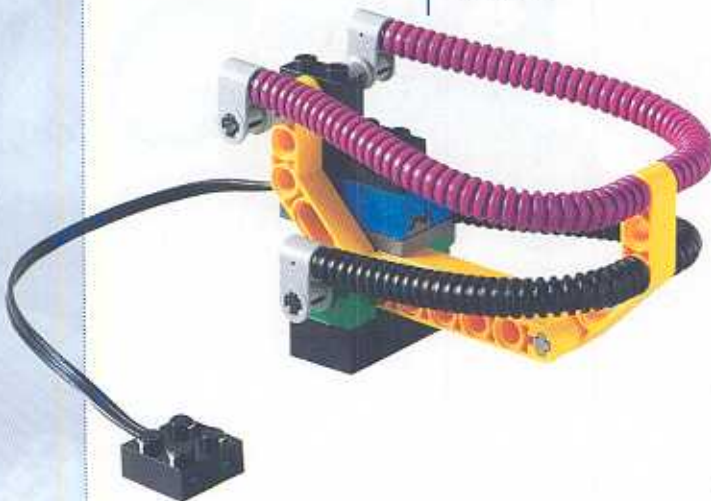
*This bumper can make the Roverbot sense the edge of a table and then avoid falling off.*

*Hint: The Touch Sensors will be pressed when the bumper goes over the edge.*

*Warning: Make sure bumper works before trying it on a table.*



Basket



example

Tail Sensor



Cyclops



*You can attach the Tail Sensor or the Cyclops like this.*

Cable Control



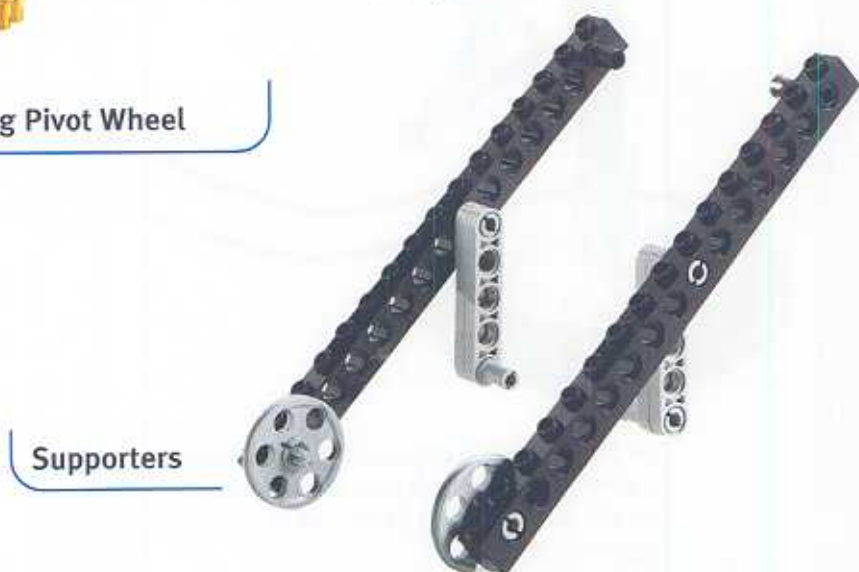
detail

*The Cable Control can be used as a remote control to steer your robot. It uses two Touch Sensors. Use the longest wires in the set to get the maximum distance for control.*



## SPECIAL FEATURES

The following four pages show ideas and suggestions for dressing up your Acrobot.

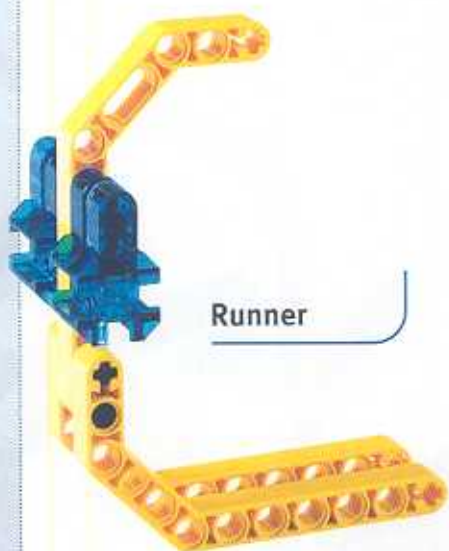


Big Eyes



example

Wheel Pinchers



Runner



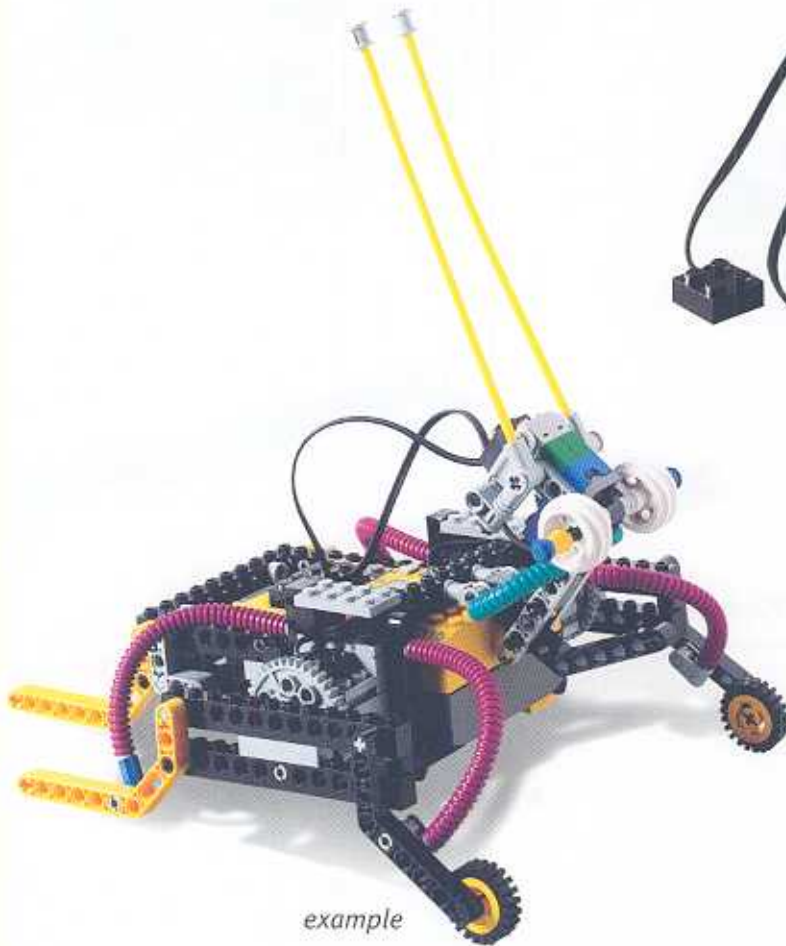
example



Hind Legs

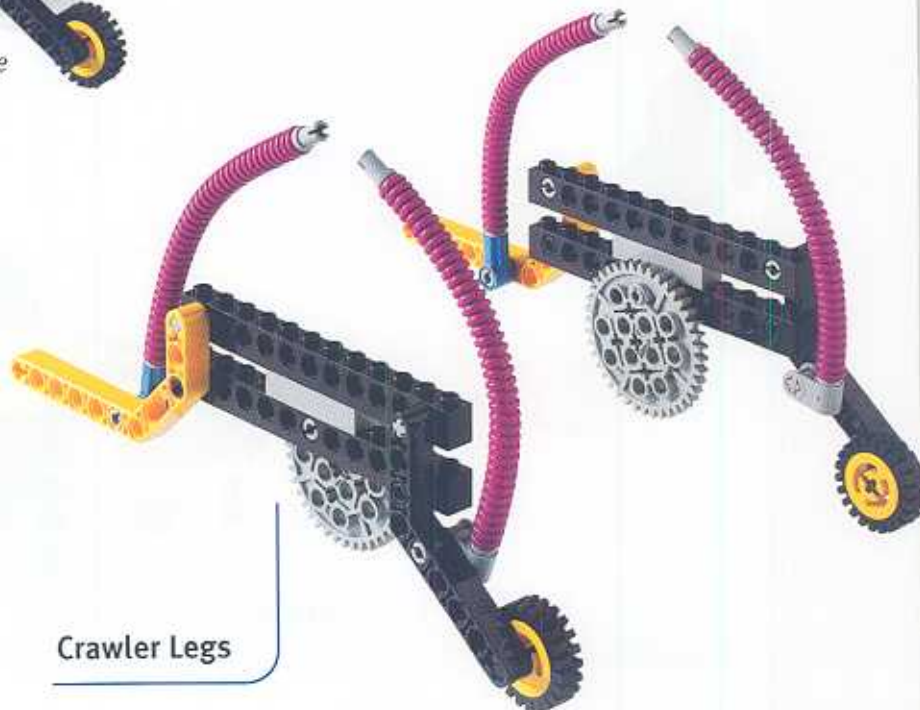


Bug Head



example

*The Bug Head has a Touch Sensor that should be activated when the feelers bump into something. It also has a Light Sensor so it can follow a bright light.*



Crawler Legs



Power Bumper

*This bumper can make the Acrobot react when the bumper hits an object. The robot is so fast, it needs Support Wheels to keep it from falling over.*



detail



Support Wheels



example



## SPECIAL FEATURES

These two pages show ideas and suggestions for dressing up your Inventorbot.



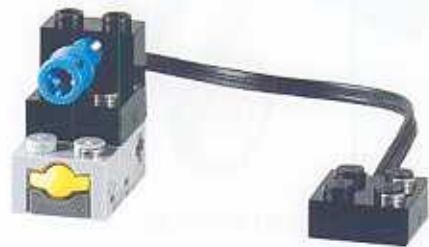
Waving Arm

*The Waving Arm is attached to the Inventorbot like the Hat Arm in the Challenges.*



example

Touch Sensor Nose



Head





### Head Shaker Attachment

*When motor A is running, the robot will shake its head.*



*detail*



*example*

### Target Bumper



*Can you program your robot to throw an object at the Target Bumper and make it sense when it hits? Use the longest wire to connect the Target Bumper to the Inventorbot.*

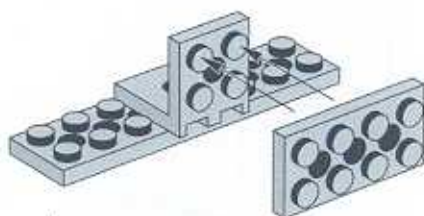


*example*

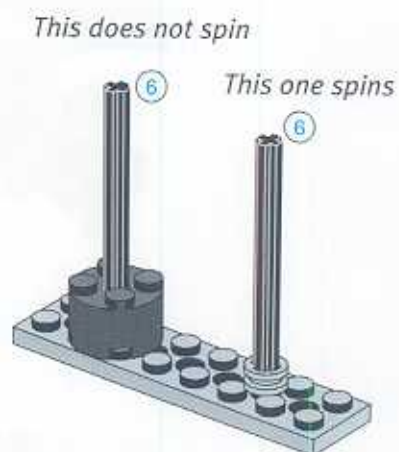


## TIPS & TRICKS

On the following four pages you can find tips and tricks to make your inventions bigger, stronger, and faster.



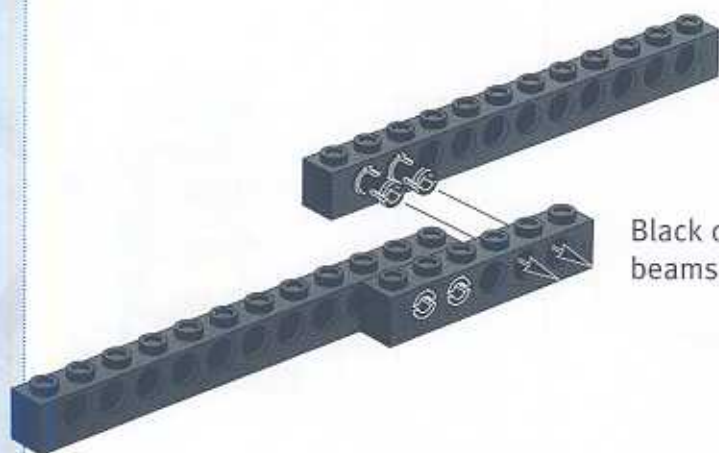
Making angles



Adding axles

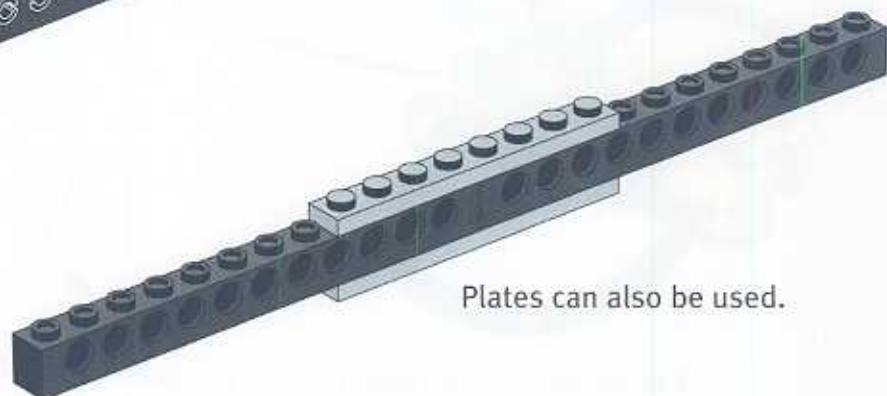


Gray connector pegs allow moveable connections.

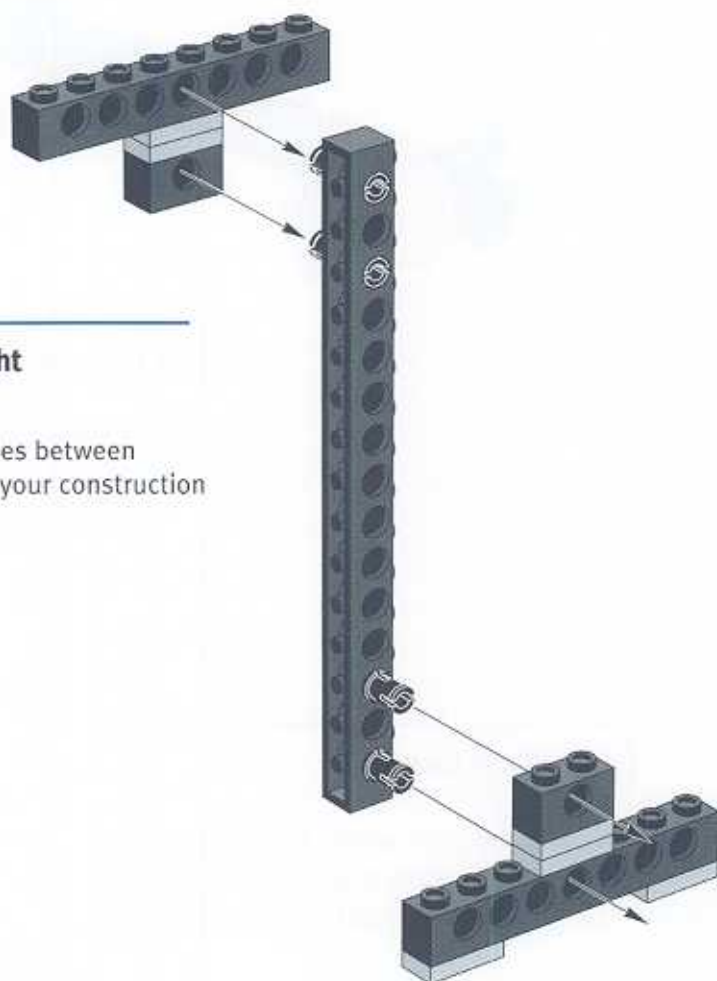


Black connector pegs lock beams firmly.

Connecting two beams

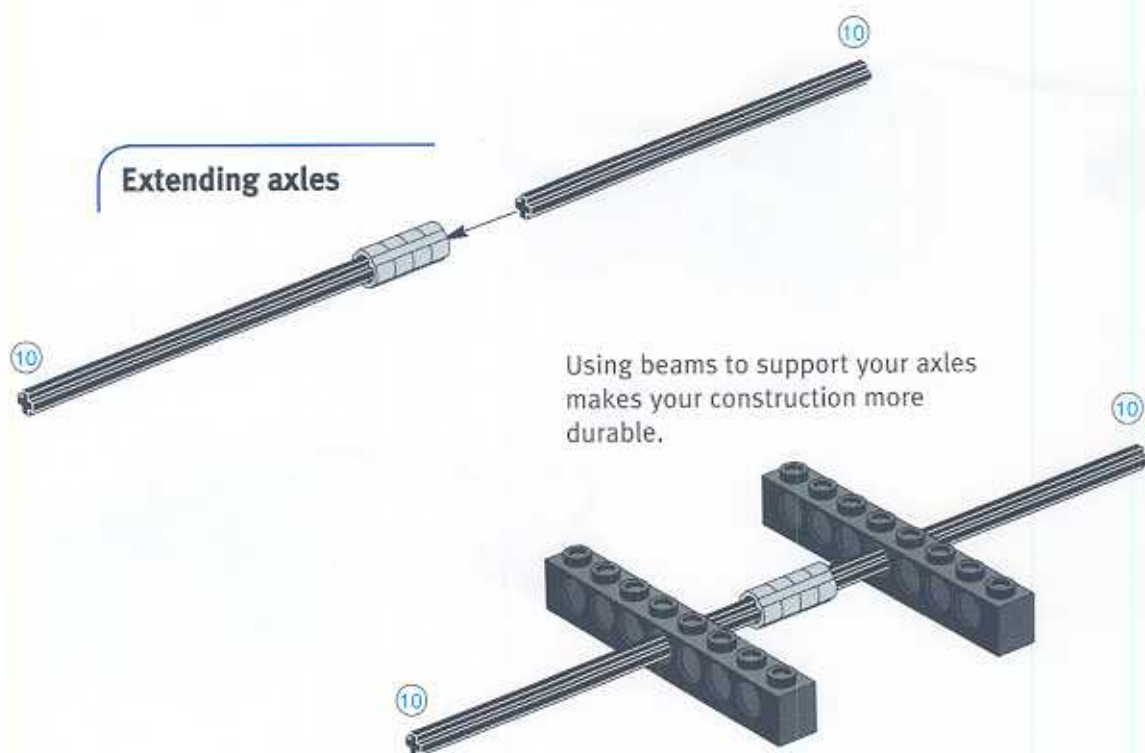


Plates can also be used.



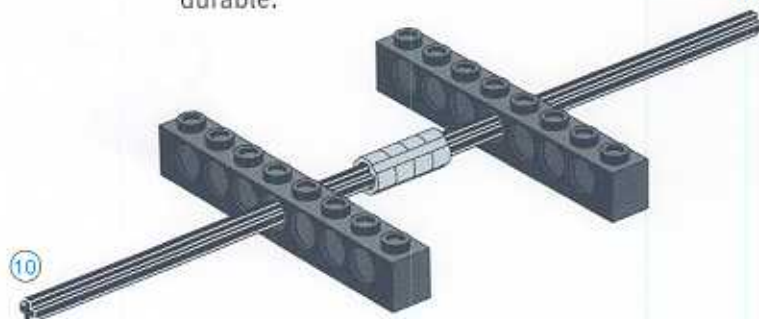
### Adding height

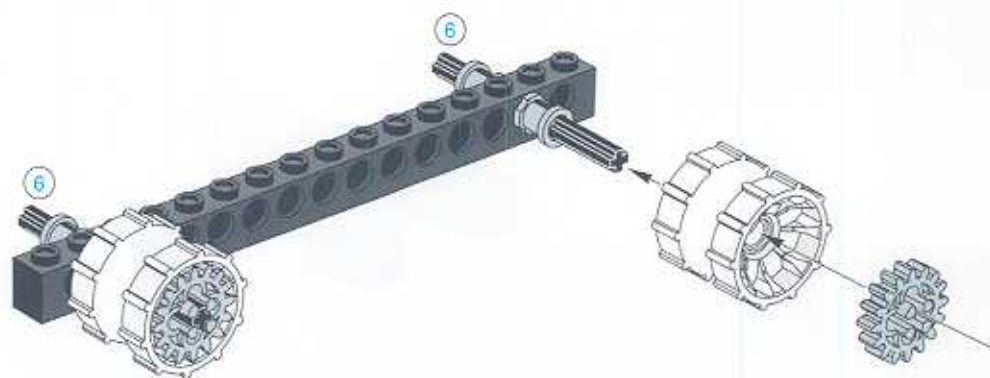
Using two plates between beams makes your construction more durable.



### Extending axles

Using beams to support your axles makes your construction more durable.



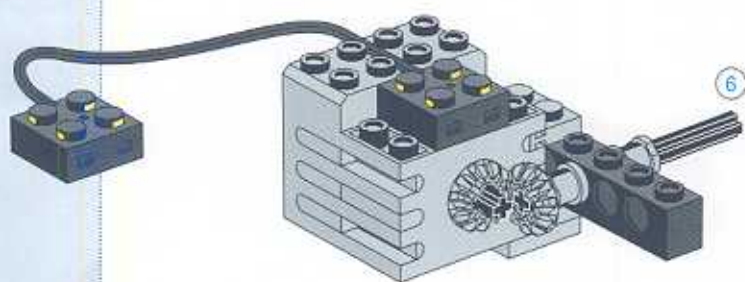
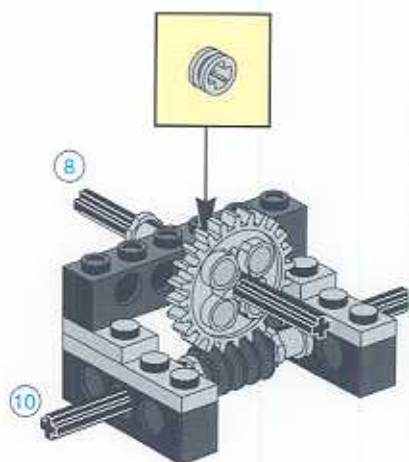


**Adding hubs for caterpillar treads**

The gears allow the hubs to revolve.

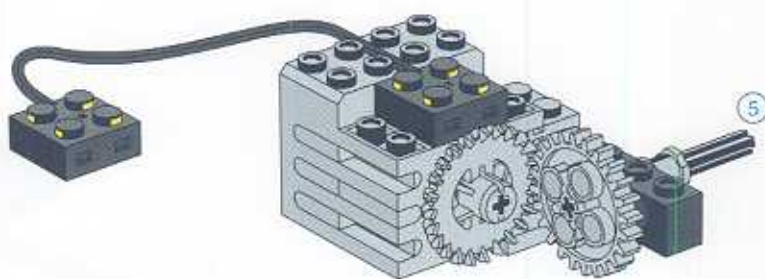
**The Worm Gear**

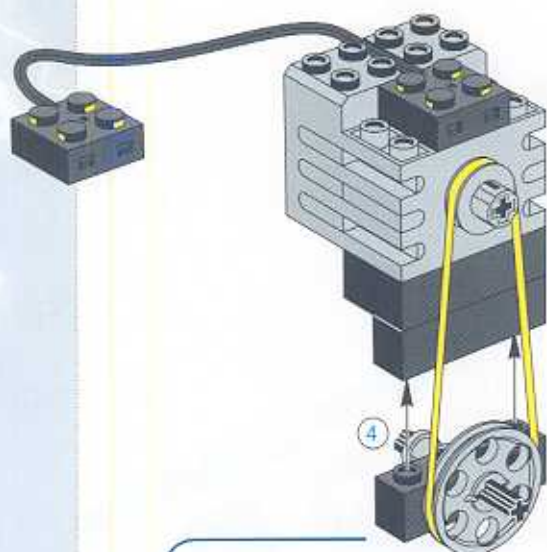
Connecting the worm gear axle to a motor will cause the 24-tooth gear to turn very slowly, but with lots of power.



**Angle gearing**

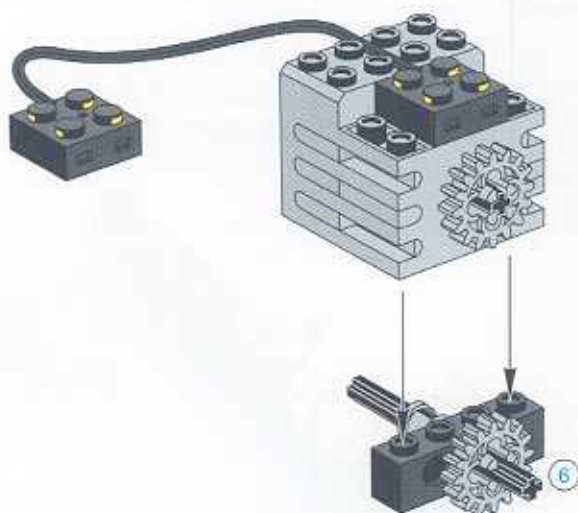
Making a gearing at an angle.





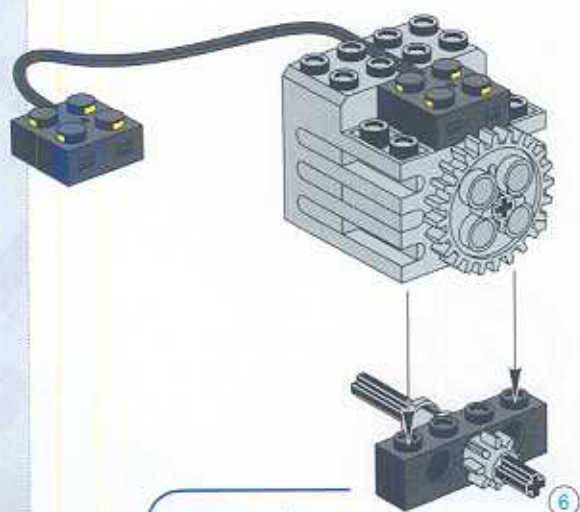
### Belt Drive

By using a belt drive, you can transmit power over long distances.



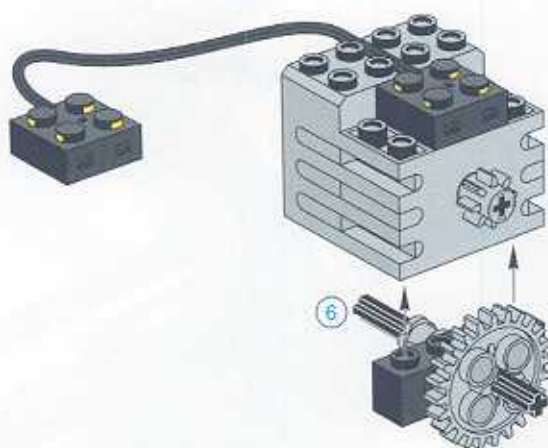
### 1:1 gearing

Using the same size gears makes the attached axle move at the same speed as the motor.



### 1:3 gearing

Using 1 to 3 gearing causes your axle to spin fast.



### 3:1 gearing

Using 3 to 1 gearing causes your axle to turn slow, but with power.



# TOP SECRET

CODE: NU-INV9747-A

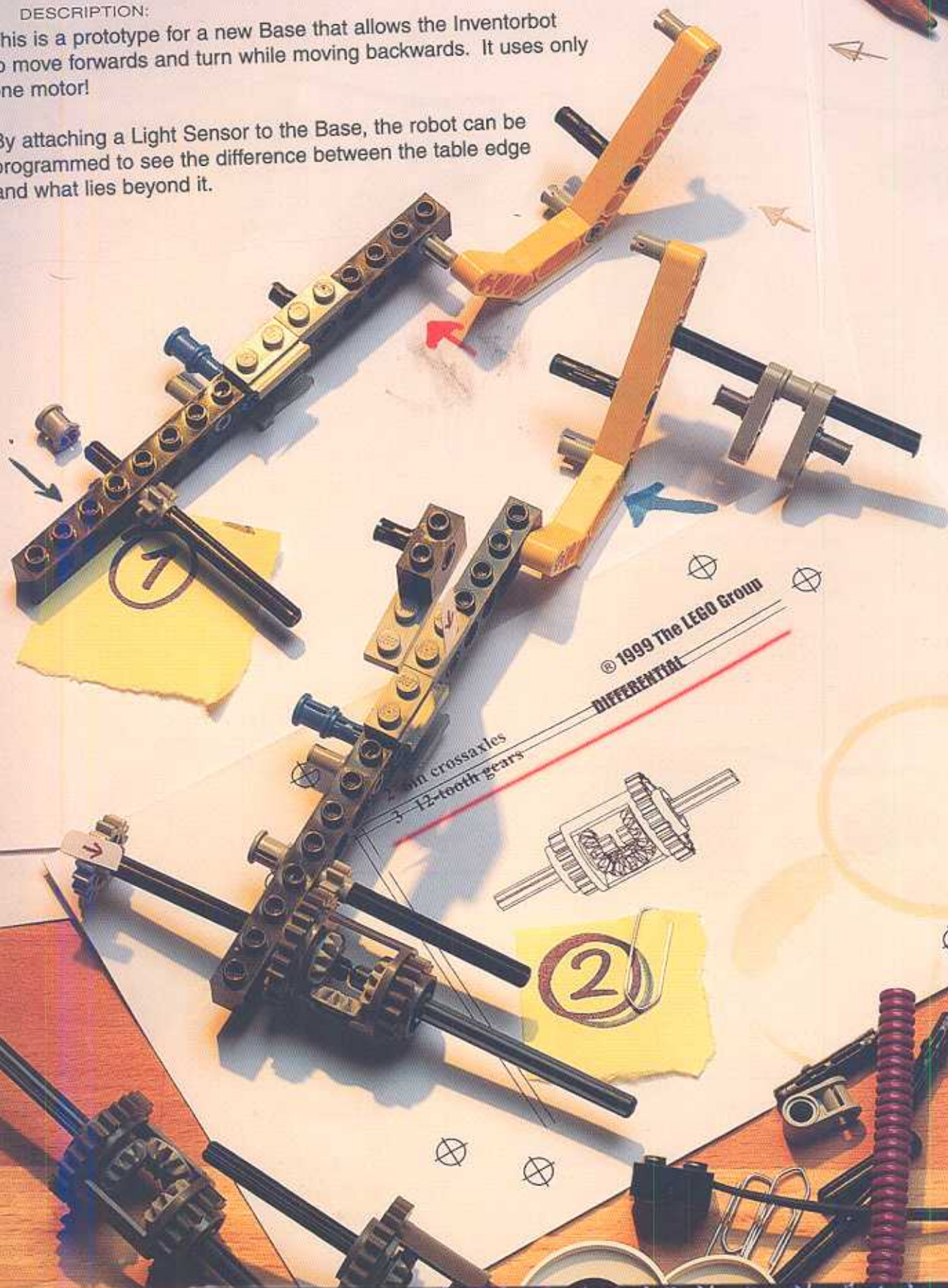
DEP.: MINDSTORMS

REF: INVENTORBOT PLANS RCX 11/99

## DESCRIPTION:

This is a prototype for a new Base that allows the Inventorbot to move forwards and turn while moving backwards. It uses only one motor!

By attaching a Light Sensor to the Base, the robot can be programmed to see the difference between the table edge and what lies beyond it.



© 1999 The LEGO Group  
DIFFERENTIAL

2 crossaxles  
12-tooth-gears

2

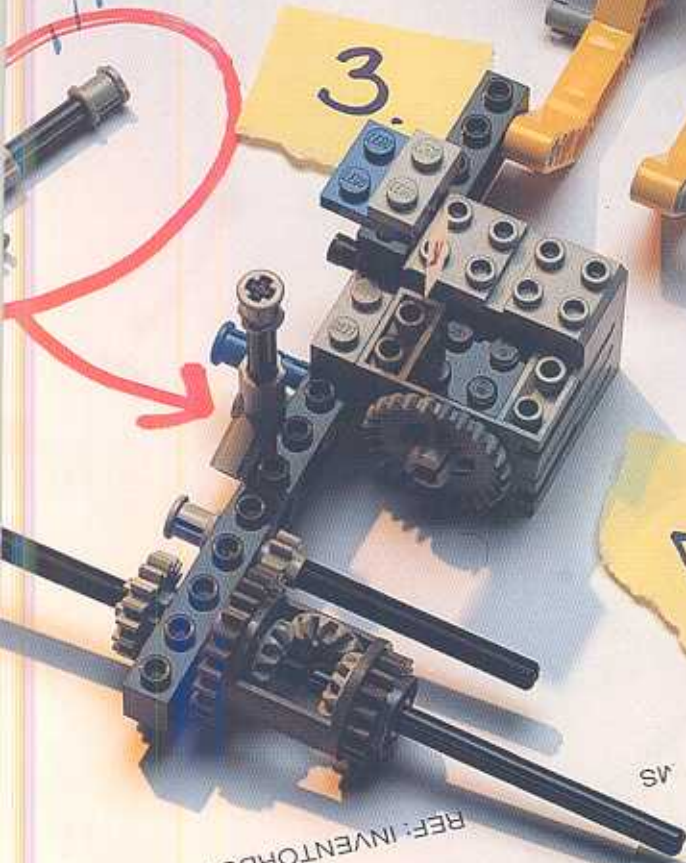


1 2 3 1 0 6 V K V K U

# MINDS STORMS

LEGO 0937

THIS PIECE LOCKS THE GEAR  
CAUSING ROBOT TO TURN WHEN  
MOTOR REVERSES DIRECTION



3



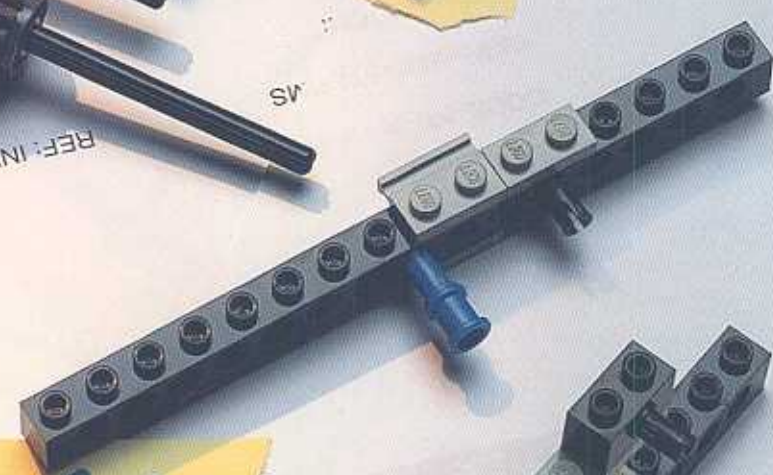
2



4

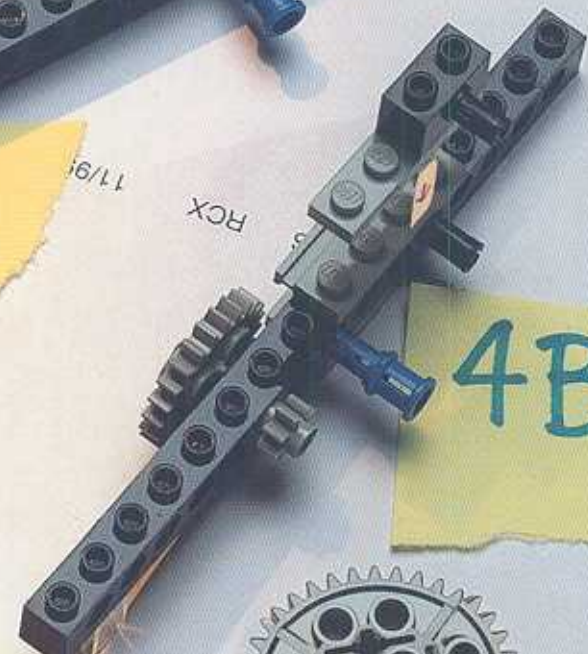
REF: INVENTORBOT PLANS

4A



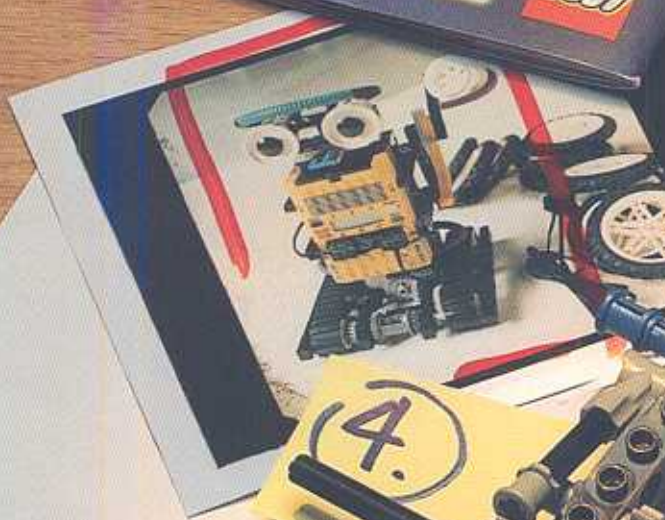
RGX

4B



MINDS STORMS  
NV9747-A

MINDSTORMS  
LEGO 6937



4.

2

5.

CODE: NU-INV9747-A  
DSTORMS

LEGO MINDSTORMS



6.

THESE ARE USED  
TO LOCK YELLOW BEAMS

REMEMBER!  
SPECIAL RELEASES TO COME ON  
[WWW.LEGOMINDTORMS.COM](http://WWW.LEGOMINDTORMS.COM)

7.

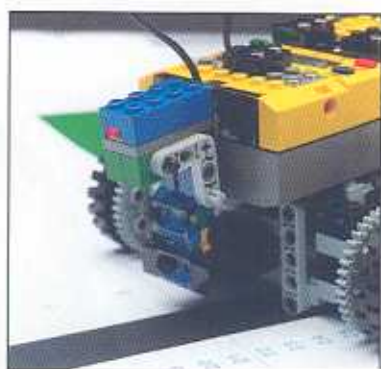
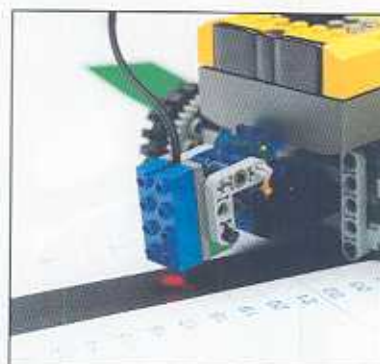




## LIGHT SENSOR/TEST PAD

The Light Sensor can be used with the Test Pad.

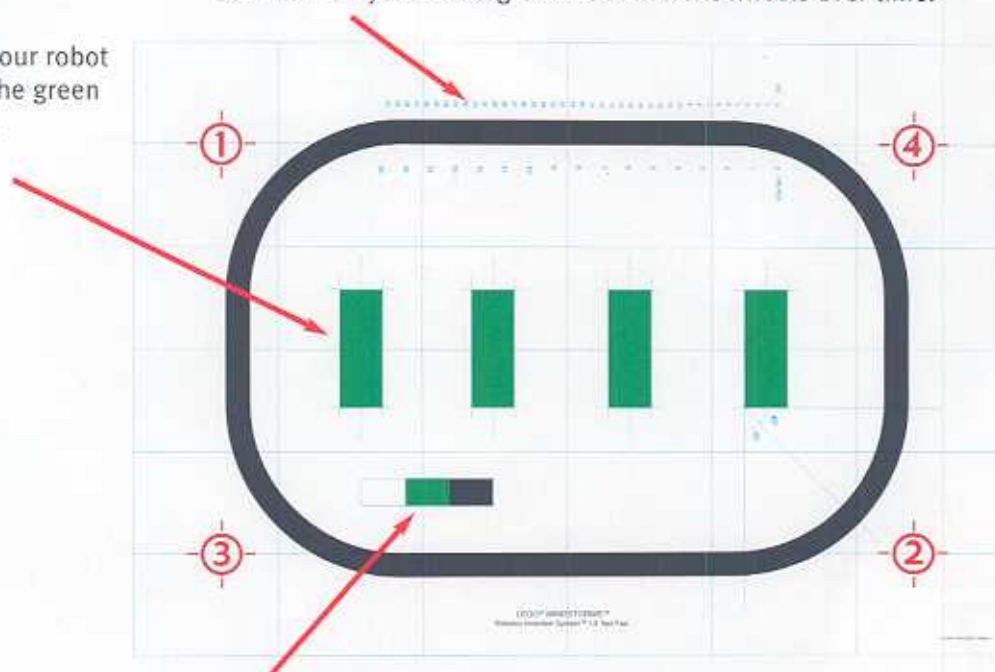
With the Light Sensor pointing down, you can make your robot follow a black line.



With the Light Sensor pointing forwards, you can make your robot follow or avoid light.

Use the numbers to measure distance.  
See how far your robot goes with different wheels over time.

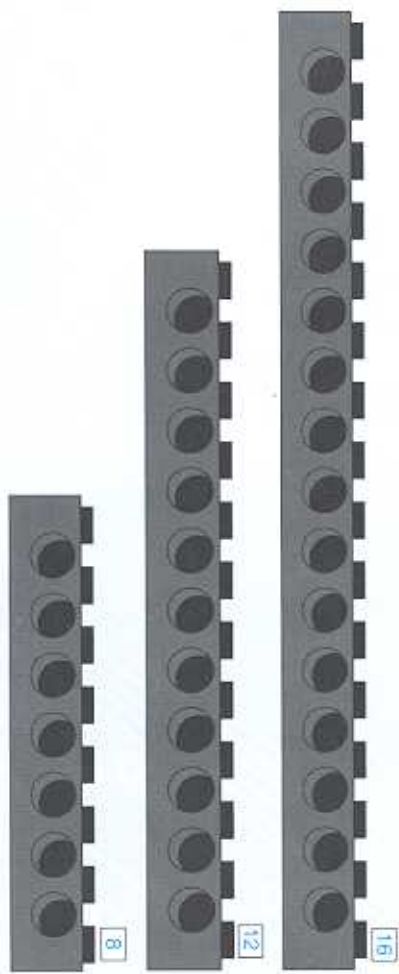
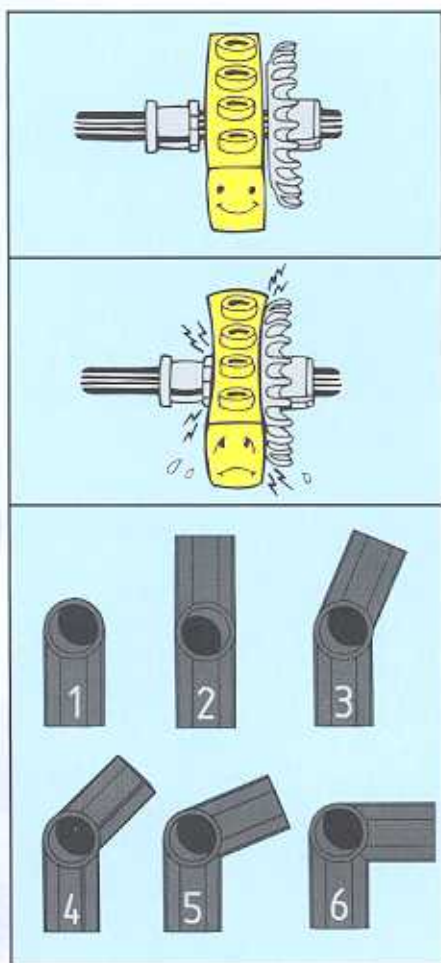
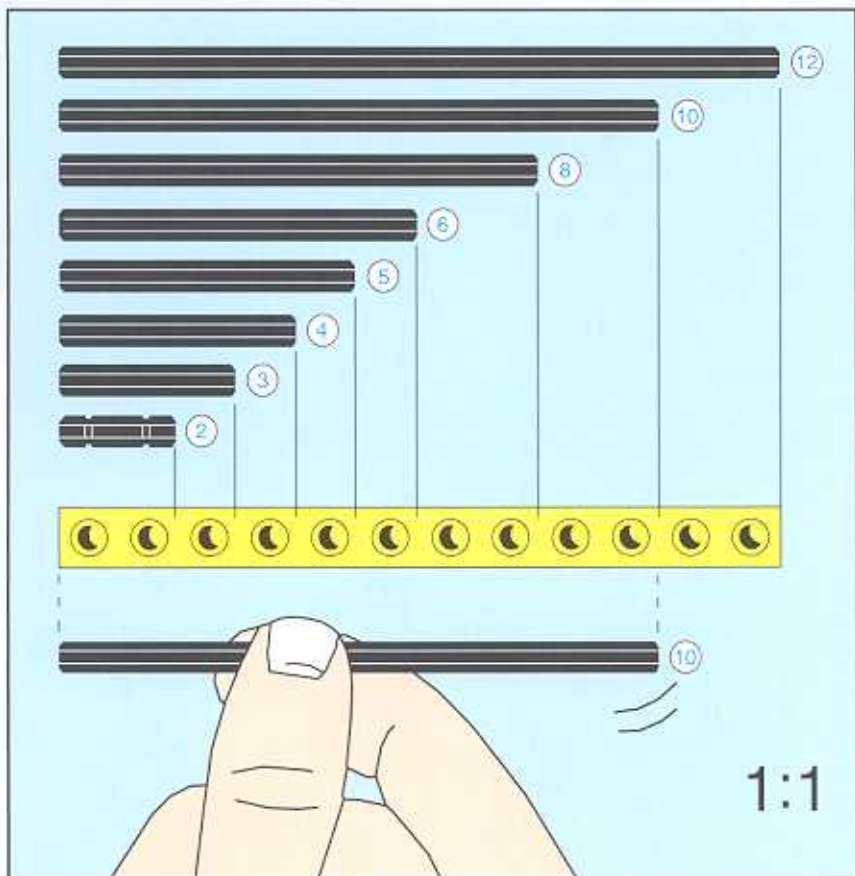
Make your robot count the green blocks.



This color strip can be used to find out an individual color's numerical value as measured by the RCX. Use the View button (as explained on page 9 in the User Guide) or the Try-Out function (User Guide, page 19) to see the Light Sensor's readings.

*Note: The light in your room will effect the reading.*





The background of the advertisement is a close-up, artistic view of a LEGO MindStorms Technic assembly. It features a central grey gear, various grey Technic bricks and connectors, and a blue printed circuit board (PCB) with intricate patterns and component labels like 'R230', 'R231', 'R225', and 'R226'. The lighting is dramatic, with a strong blue glow emanating from the center, creating a sense of depth and highlighting the mechanical details.

**LEGO** MINDSTORMS™