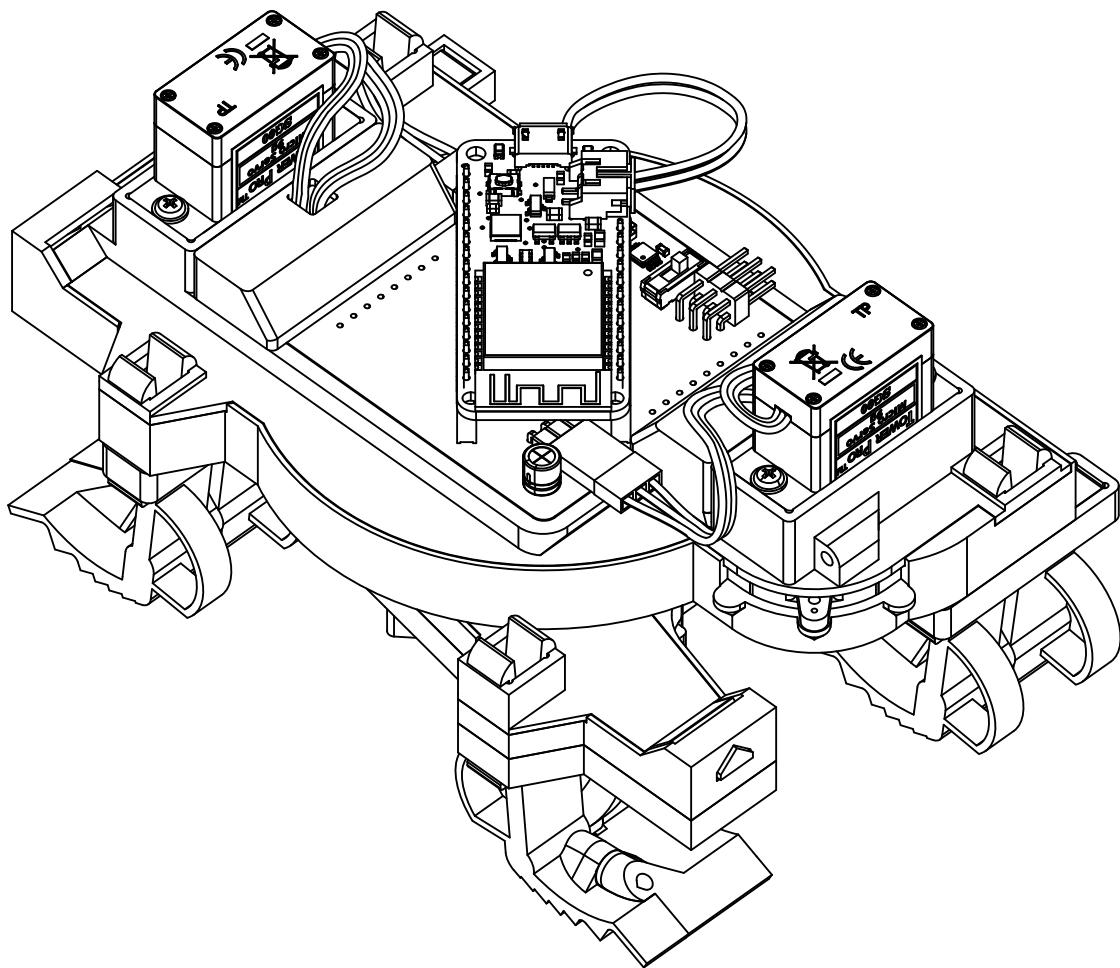


Tardygrade assembly manual

V 0.1



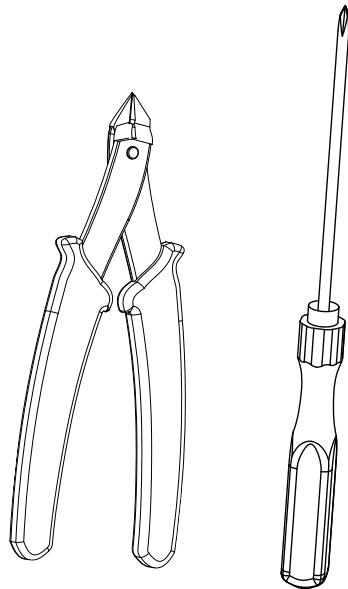
Section 0: Primer

This section goes through a few things that are useful to know before starting assembly of the robot, such as: The tools needed for assembly, how to distinguish between the two types of servo motor, and how 3D printing filament will be used to connect certain parts together.

Tools

The following tools will be used at different points during the assembly process:

- Flush wire cutters. (Or regular scissors as a second option.)
- Small Phillips head screwdriver.

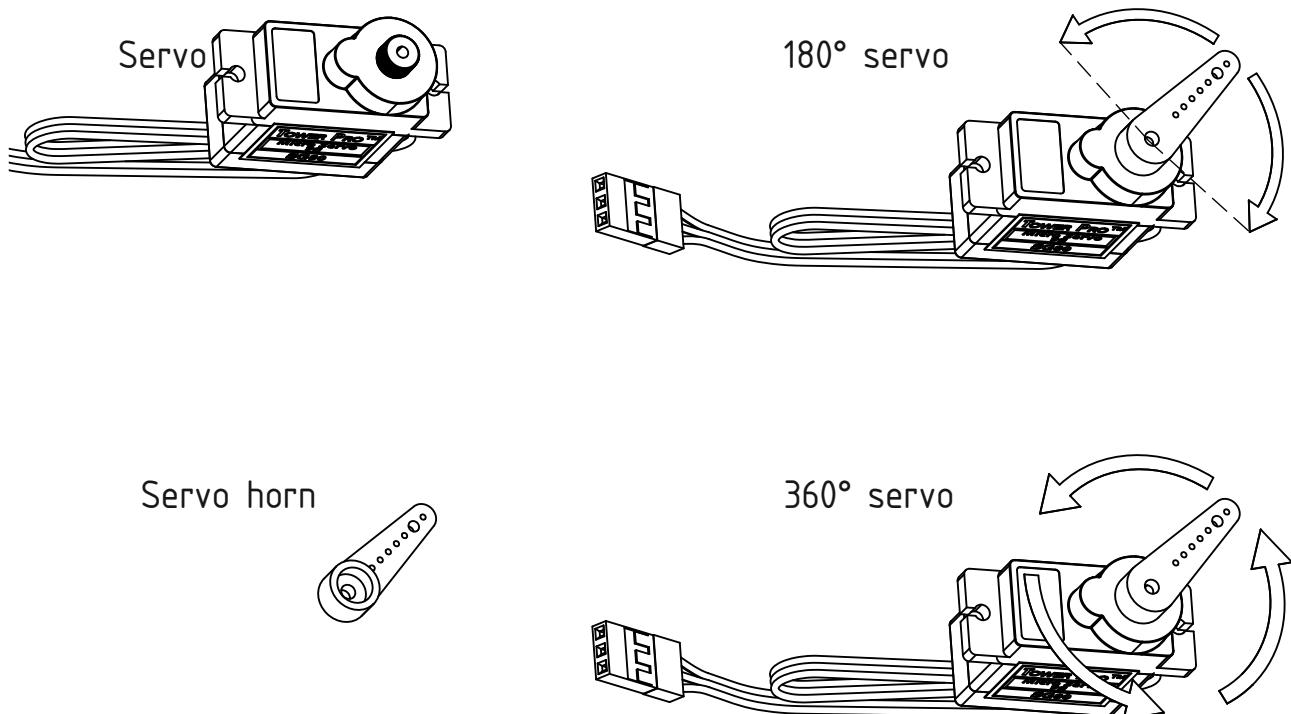


Servo types

The robot mechanics are controlled using two servo motors. These may look similar, but they differ in function. One servo only turns within a 180° arc, and is used for steering the robot. The other servo can turn continuously 360° , and is used for walking the robot forward or backward.

 Please identify and clearly mark which is which of these servos, to ensure they don't get mixed up in assembly.

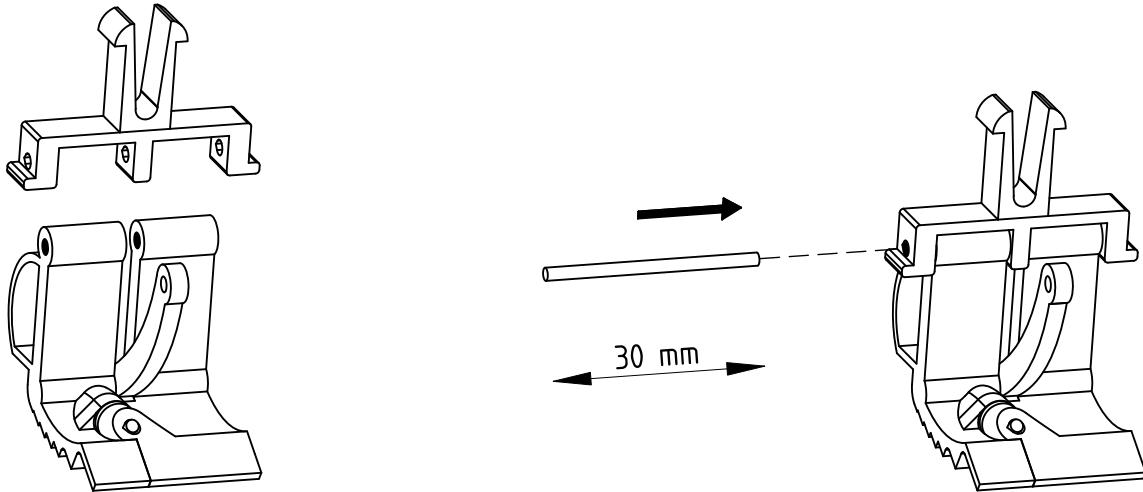
The servo type can be determined by attaching a servo horn and then slowly turning it by hand. If it can be turned past a full revolution, the servo is of type 360° .



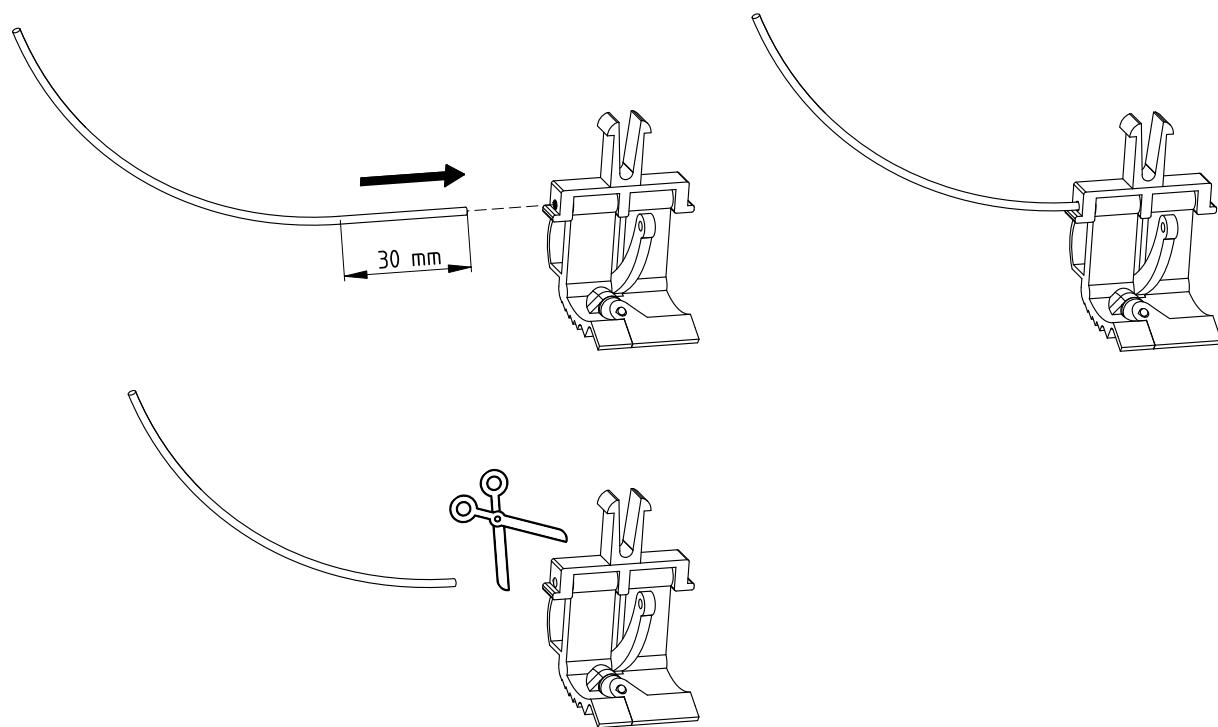
3D printer filament

Instead of attaching parts using screws or glue, the Tardygrade assembly relies mainly on 1.75 mm diameter 3D printer filament for connecting parts together.

The images below shows an example of this process. Two parts are joined together using a piece of filament that has been cut down to a length of 30 mm.



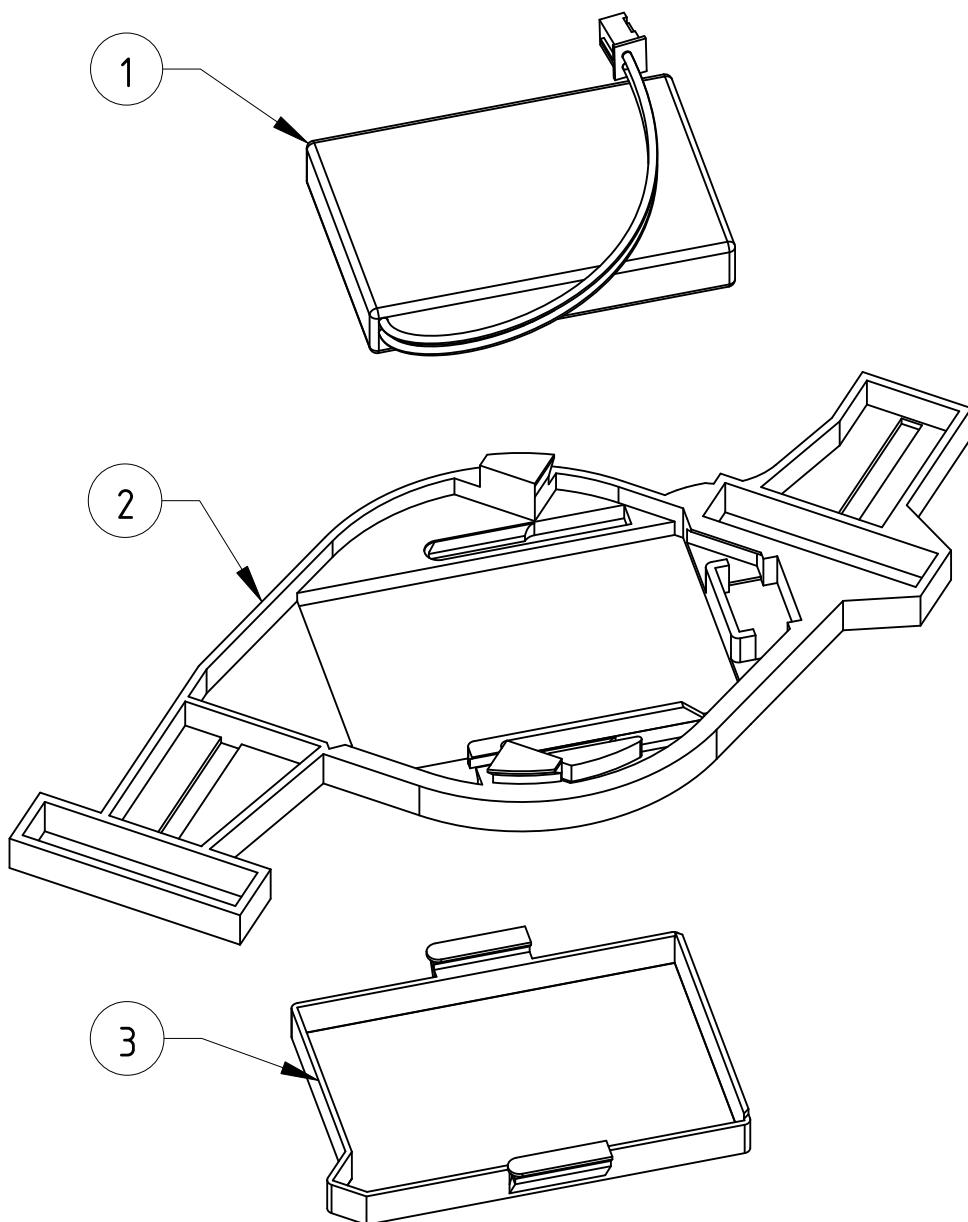
In some cases it might be easier to first insert an uncut length of filament, and then cut it down to size after it has been inserted. That method is illustrated below.



**Now you're ready to move on to Section 1 and begin assembly of the robot.
Good luck!**

Section 1:

Lower body, bottom deck

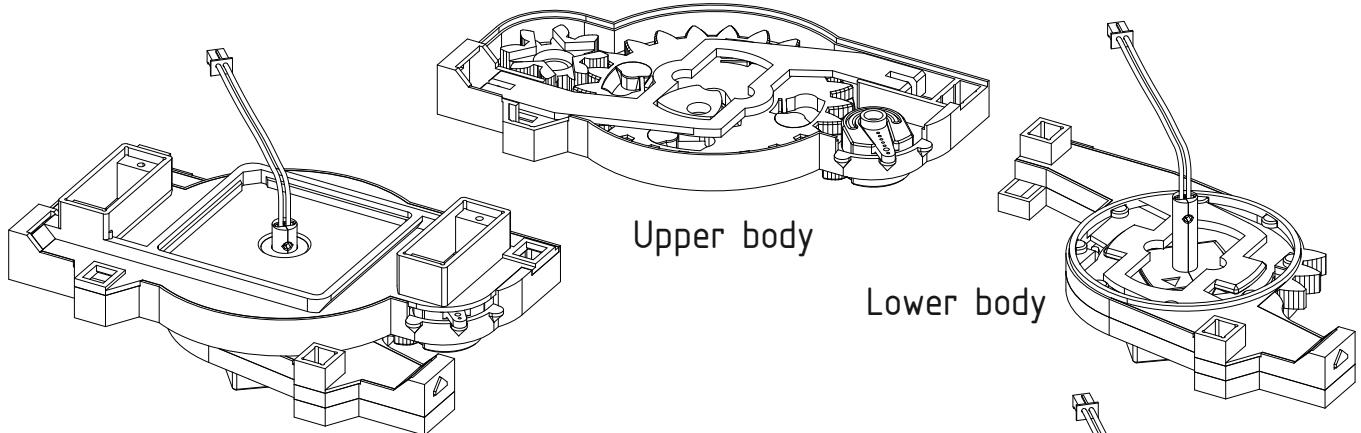


MATERIALS

- 1: Lithium-polymer battery
- 2: Bottom deck hull
- 3: Battery compartment

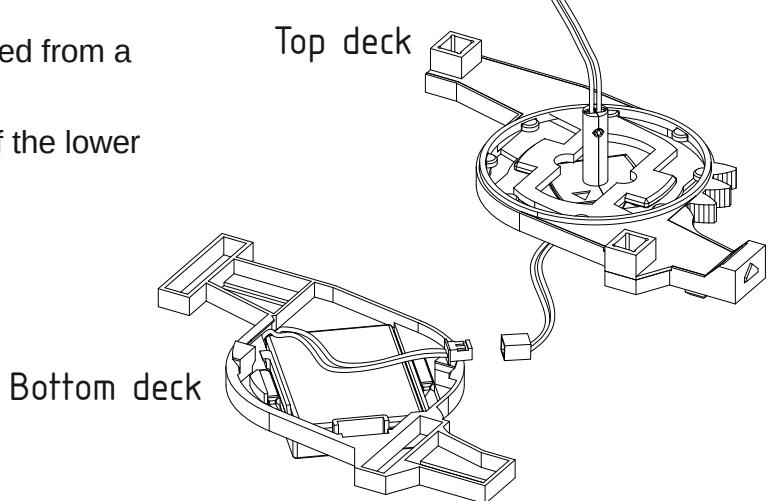
Looking ahead

For better understanding, here's an overview of how the main mechanical parts will fit together. The robot frame consists of two sub-assemblies: The upper body and the lower body. These two assemblies are connected in the center by a gear axle.



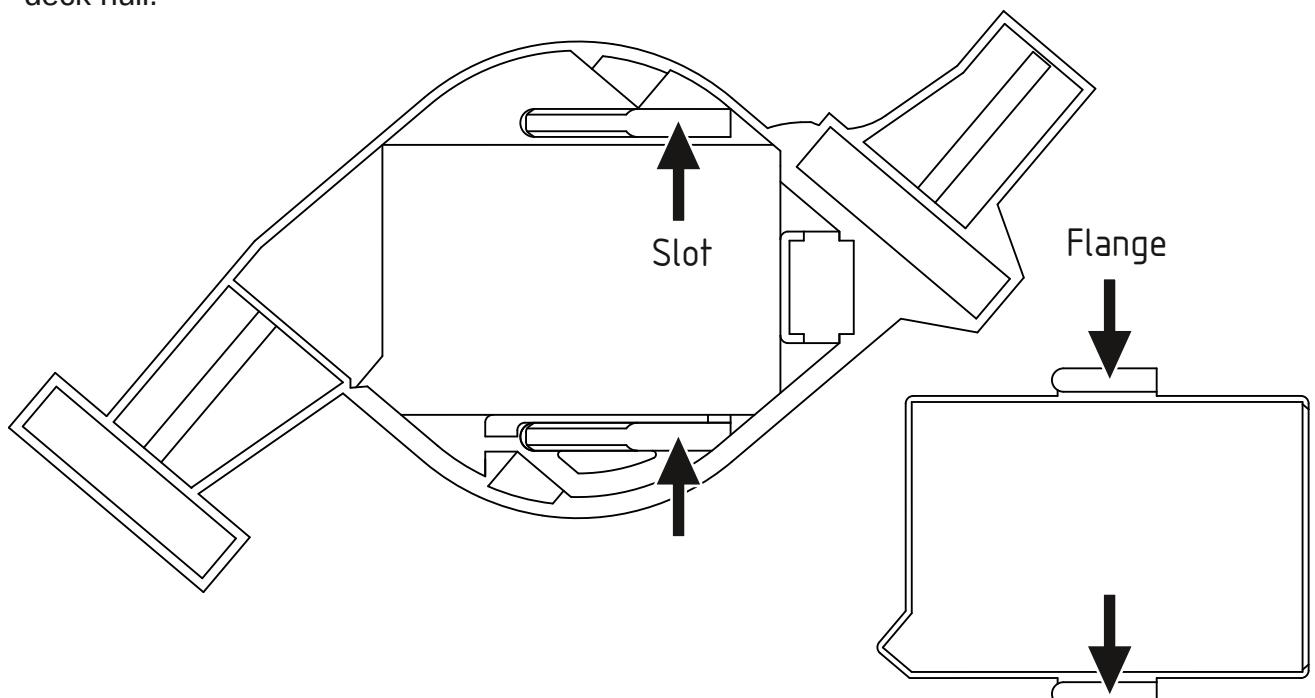
The lower body is in turn constructed from a top and a bottom deck.

In this section, the **bottom deck** of the lower body will be assembled.



Before starting

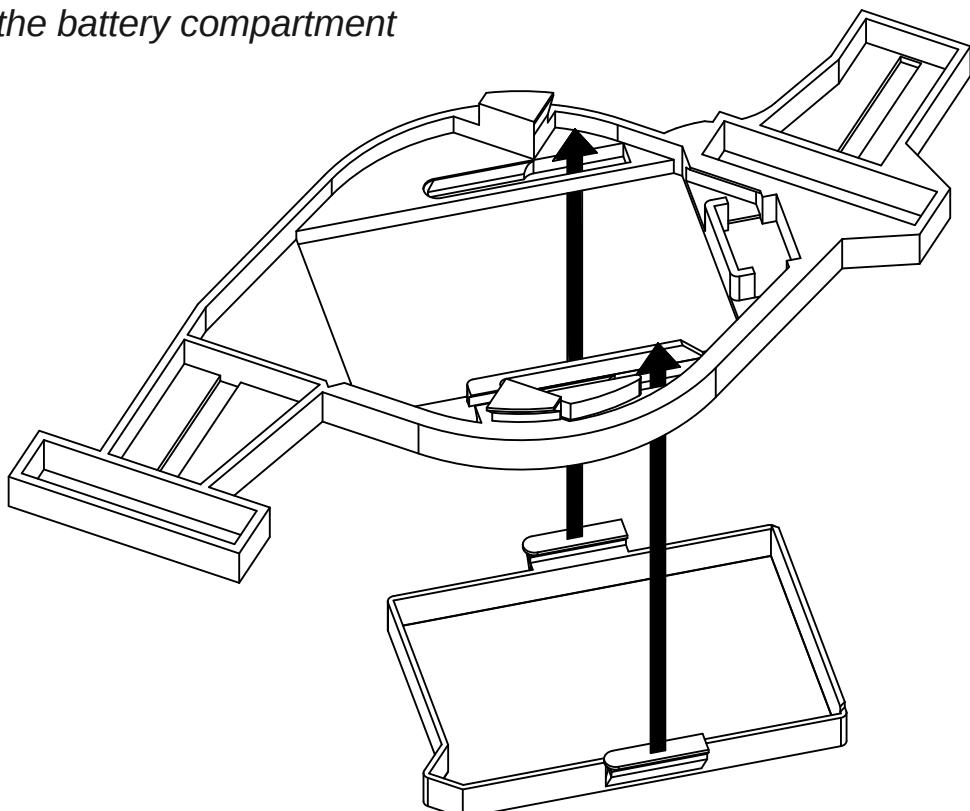
Note that the battery compartment has two flanges that fits into two slots on the bottom deck hull.



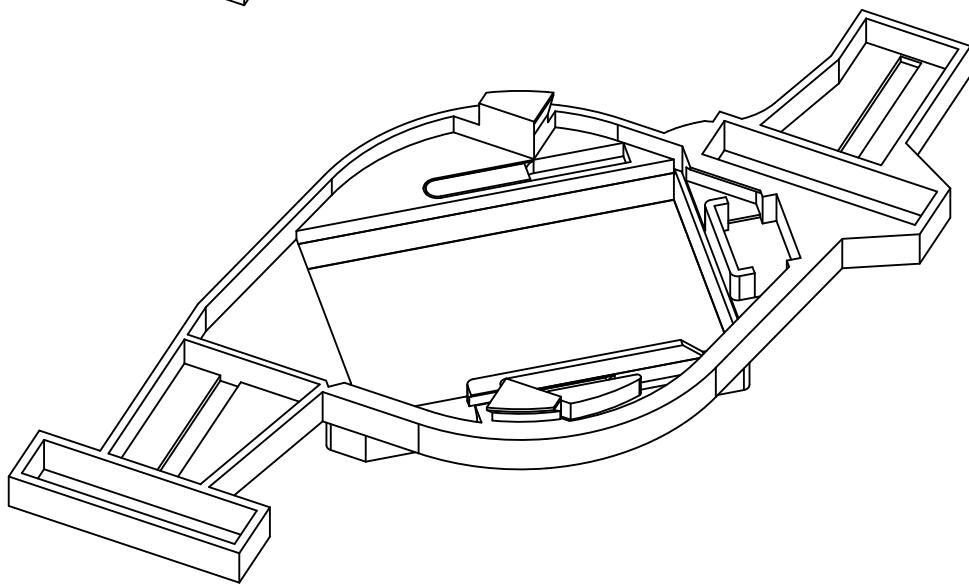
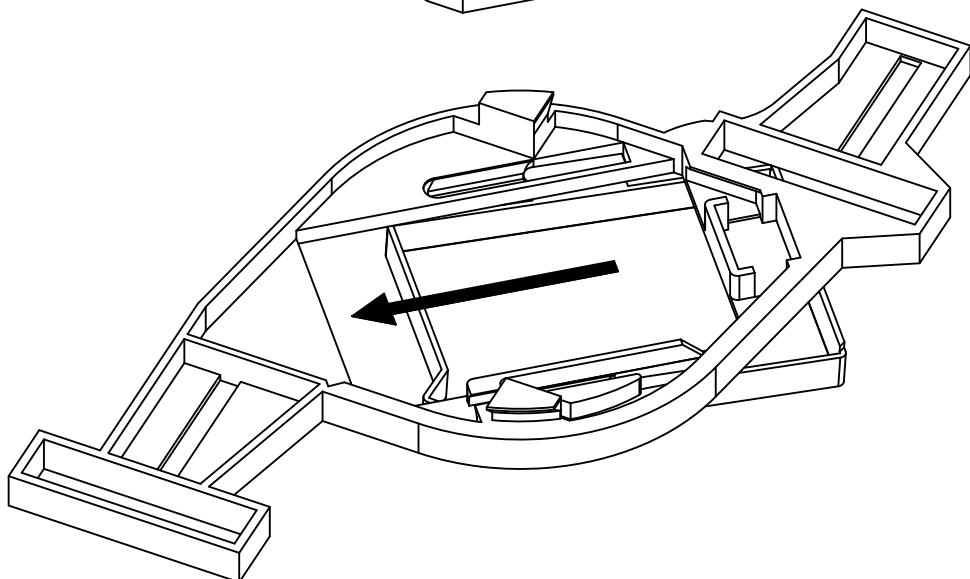
Step 1:

Attaching the battery compartment

1.1



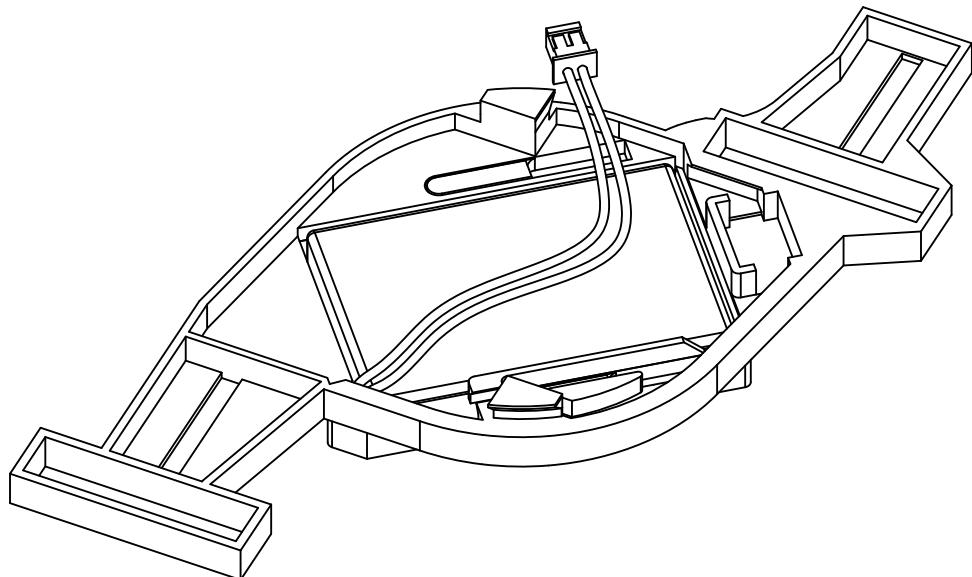
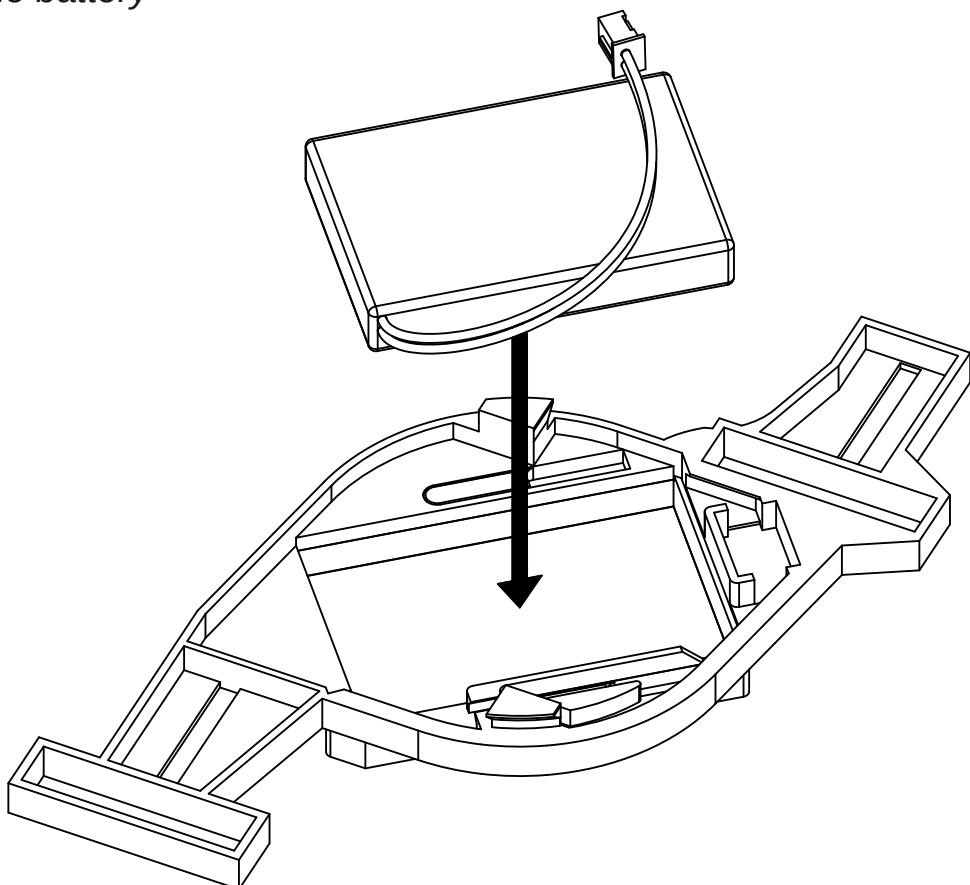
1.2



Step 2:

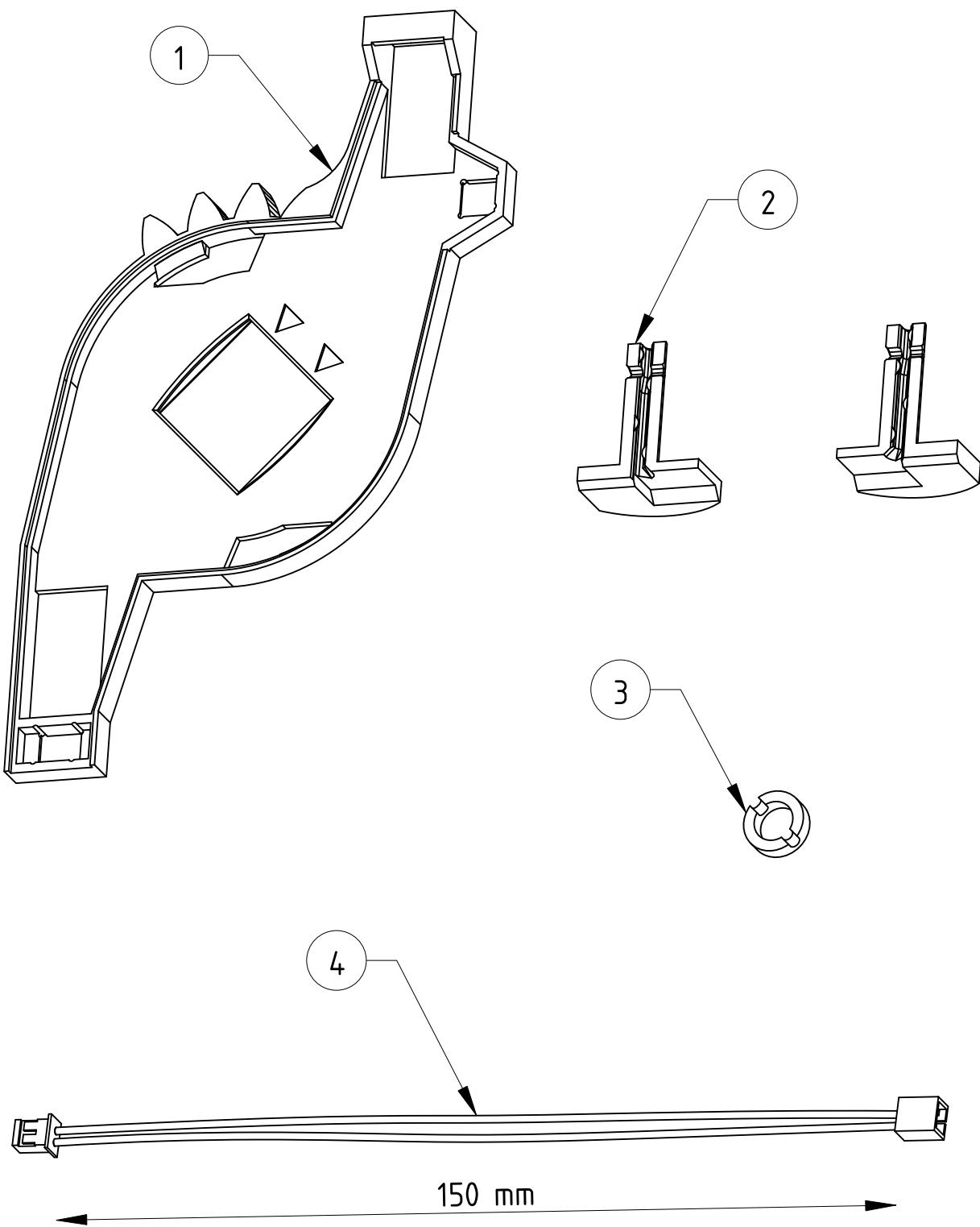
Placing the battery

2.1



Section 2:

Lower body, top deck

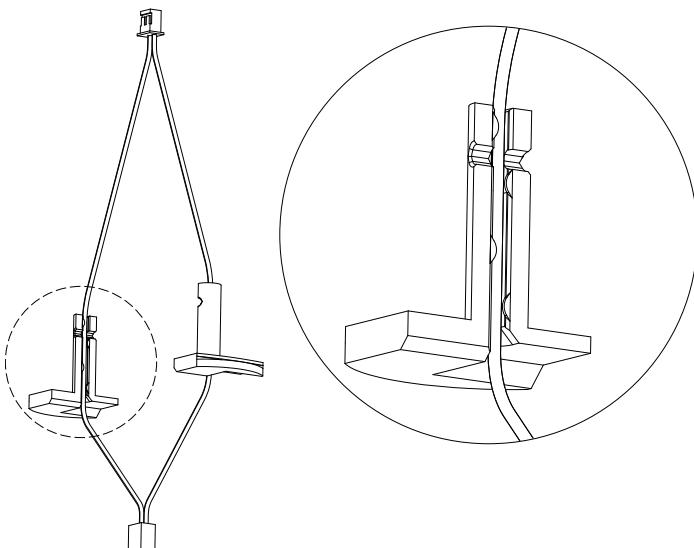
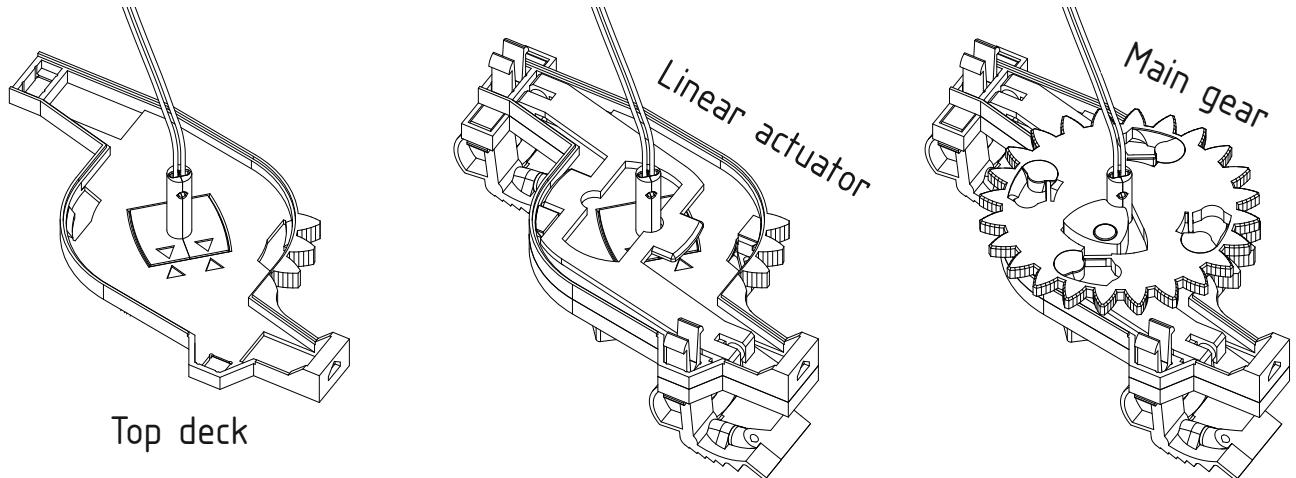


MATERIALS

- 1: Top deck hull
- 2: Main gear axle (two mirrored parts)
- 3: Ring nut
- 4: Battery extension cable, 150 mm in length

Looking ahead

In this section, the **top deck** of the lower body is assembled. It holds the axle around which the robot's main gear revolves. Later in assembly, it will also house a linear actuator which transfers motion from the main gear to two of the robot's legs.



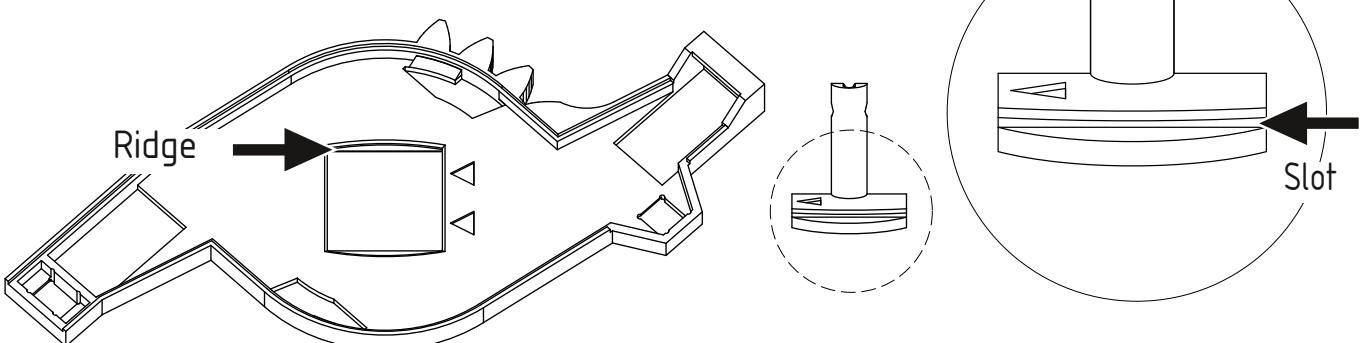
Before starting

The gear axle has the secondary function of leading the battery extension cable through the robot's upper body, to the electronics on top of the robot.

Note that each part of the gear axle has a channel running through it that fits one wire of the battery extension cable. The wire can be fitted by pushing it into the channel using your fingernail or the tip of a screwdriver. (Step 1.2)

The top deck hull has a square cutout in its base, which fits the two main gear axle parts.

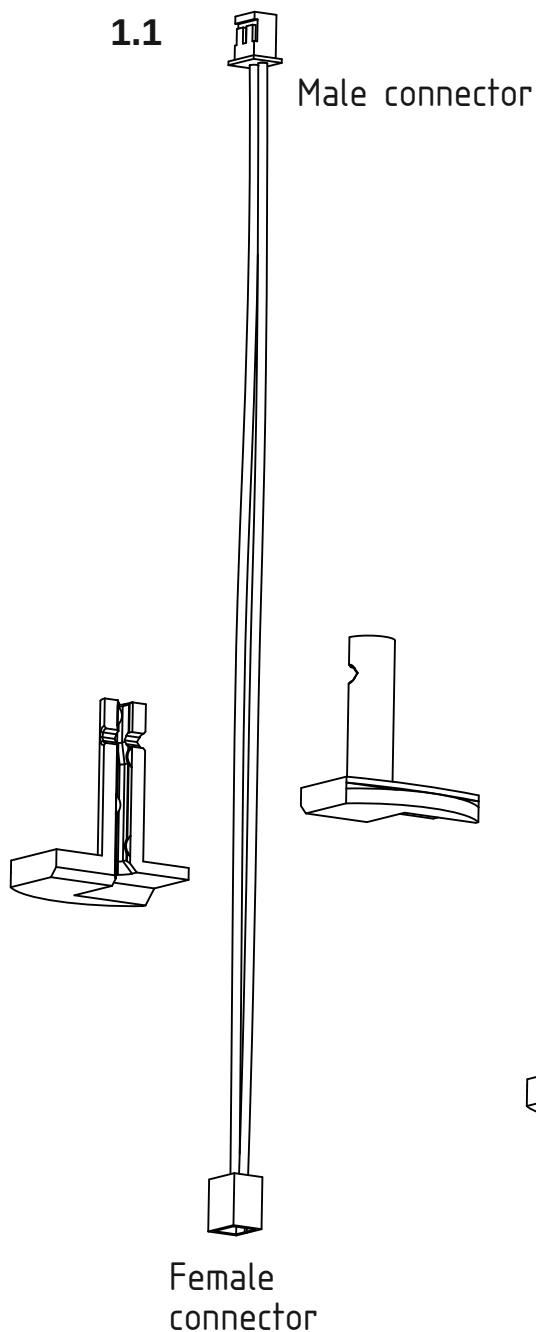
Two opposing sides of the cutout has a narrow ridge, which fits into a slot at the base of each axle part.



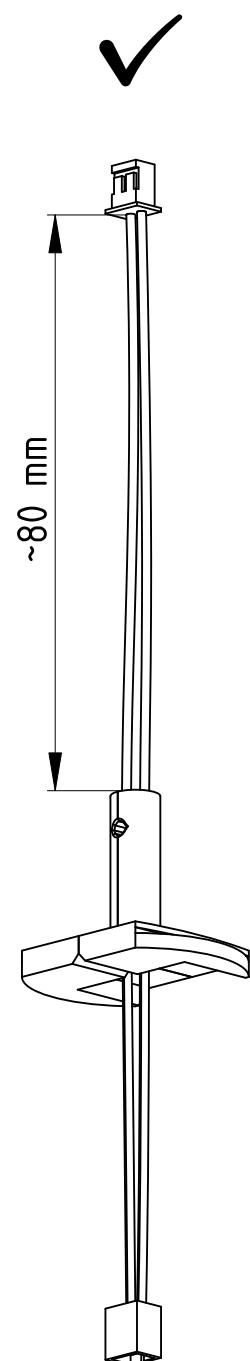
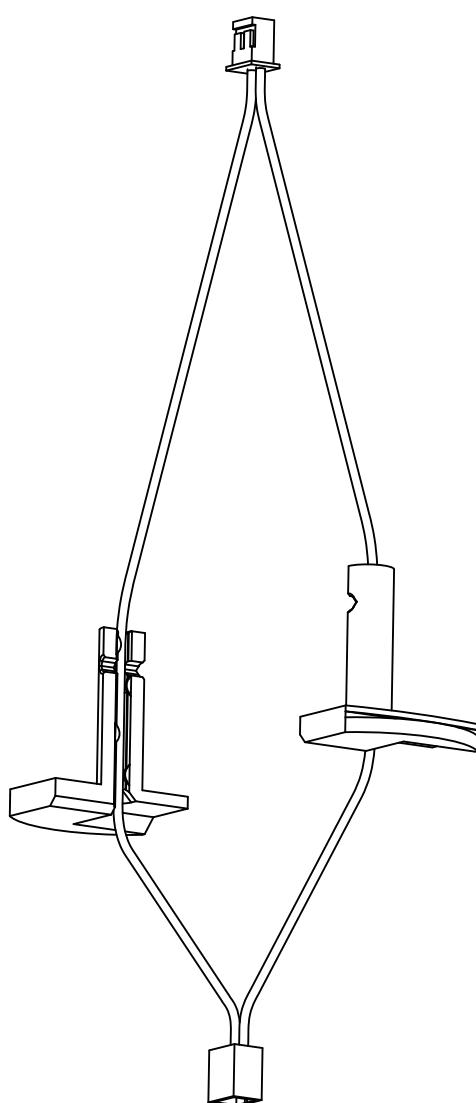
Step 1:

Inserting cable wires into axle parts

1.1

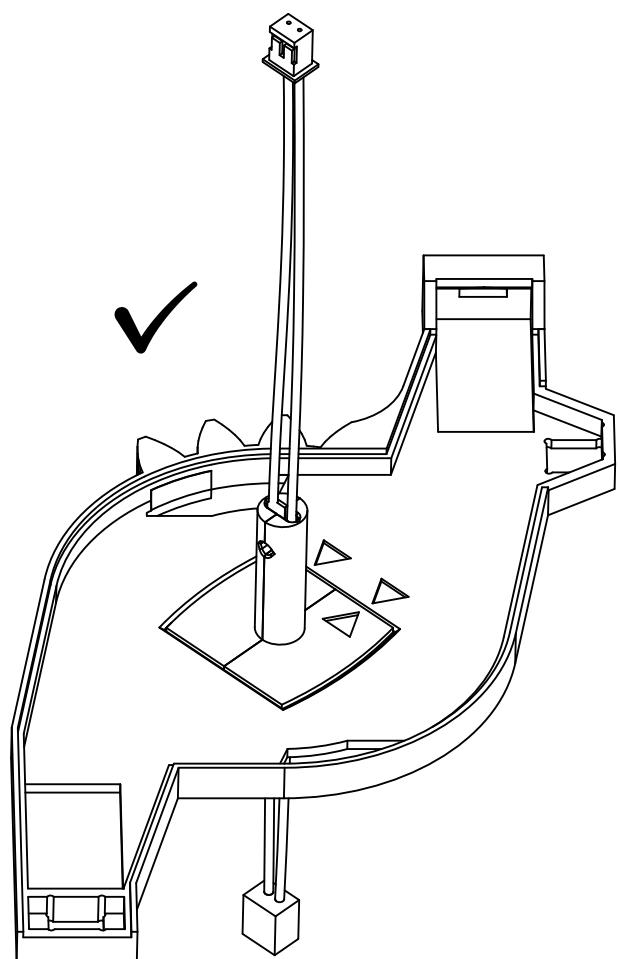
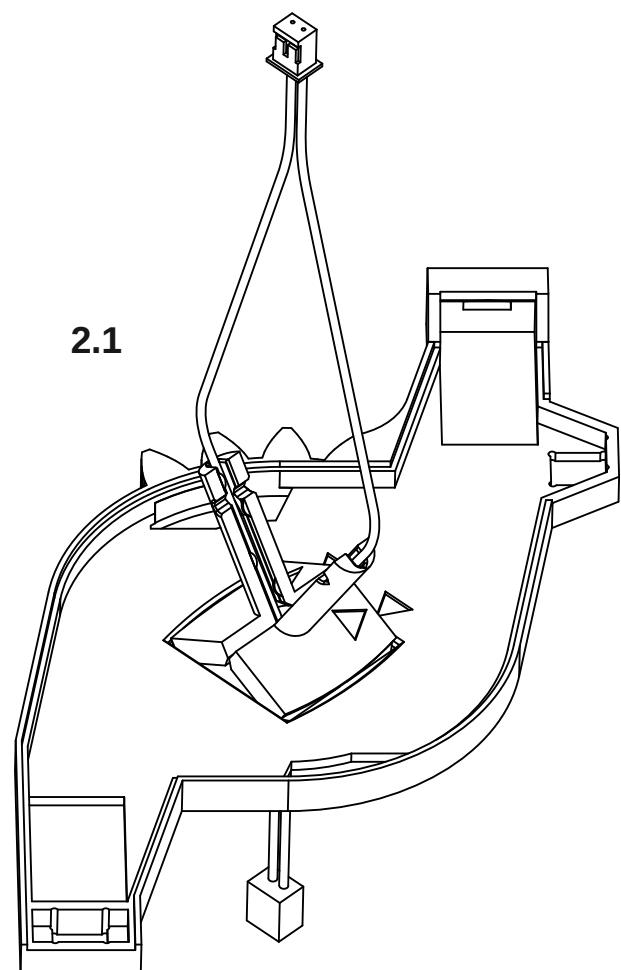


1.2



Step 2:

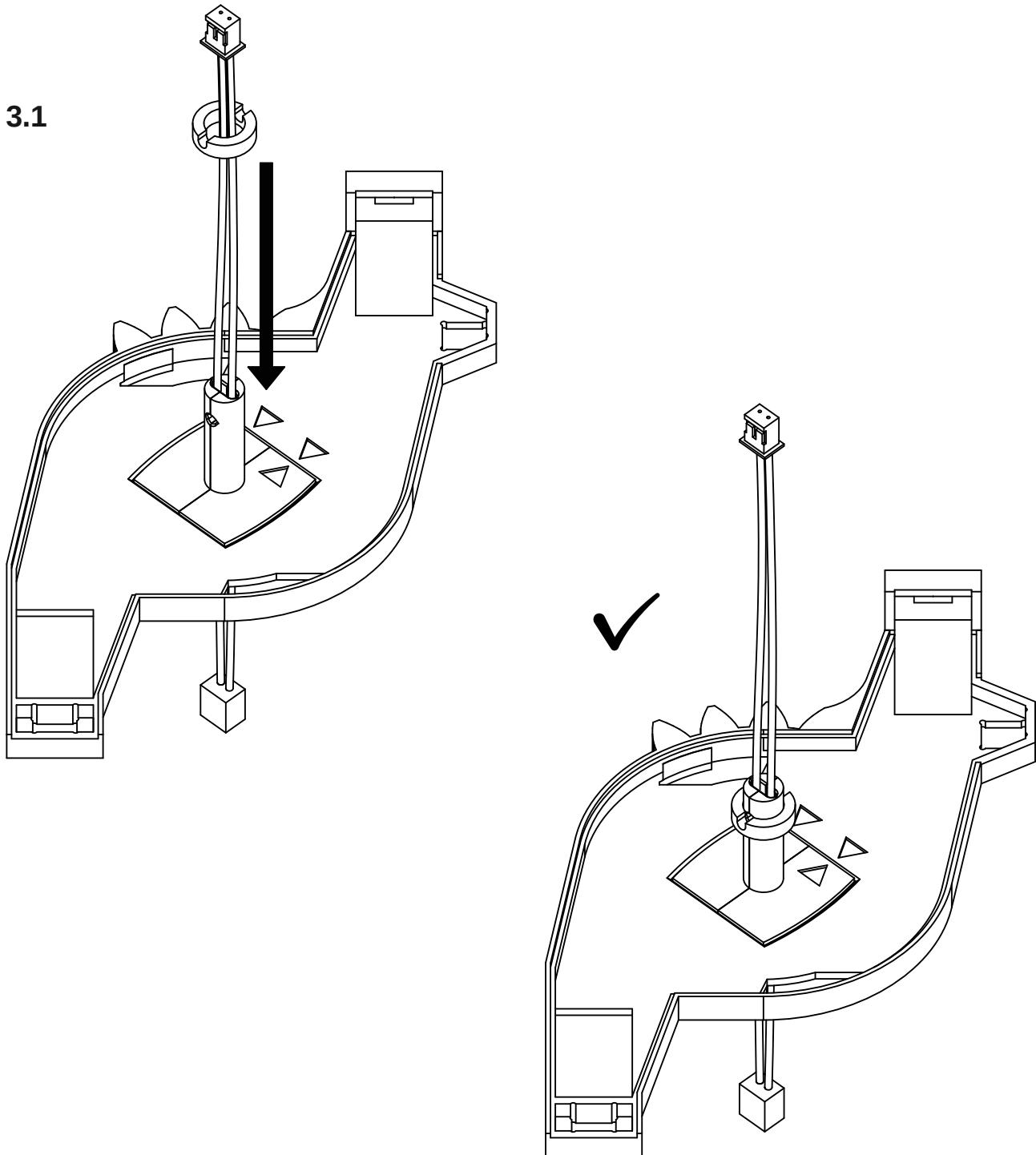
Slotting axle parts into deck cutout



Step 3:

Secure axle with ring nut

3.1

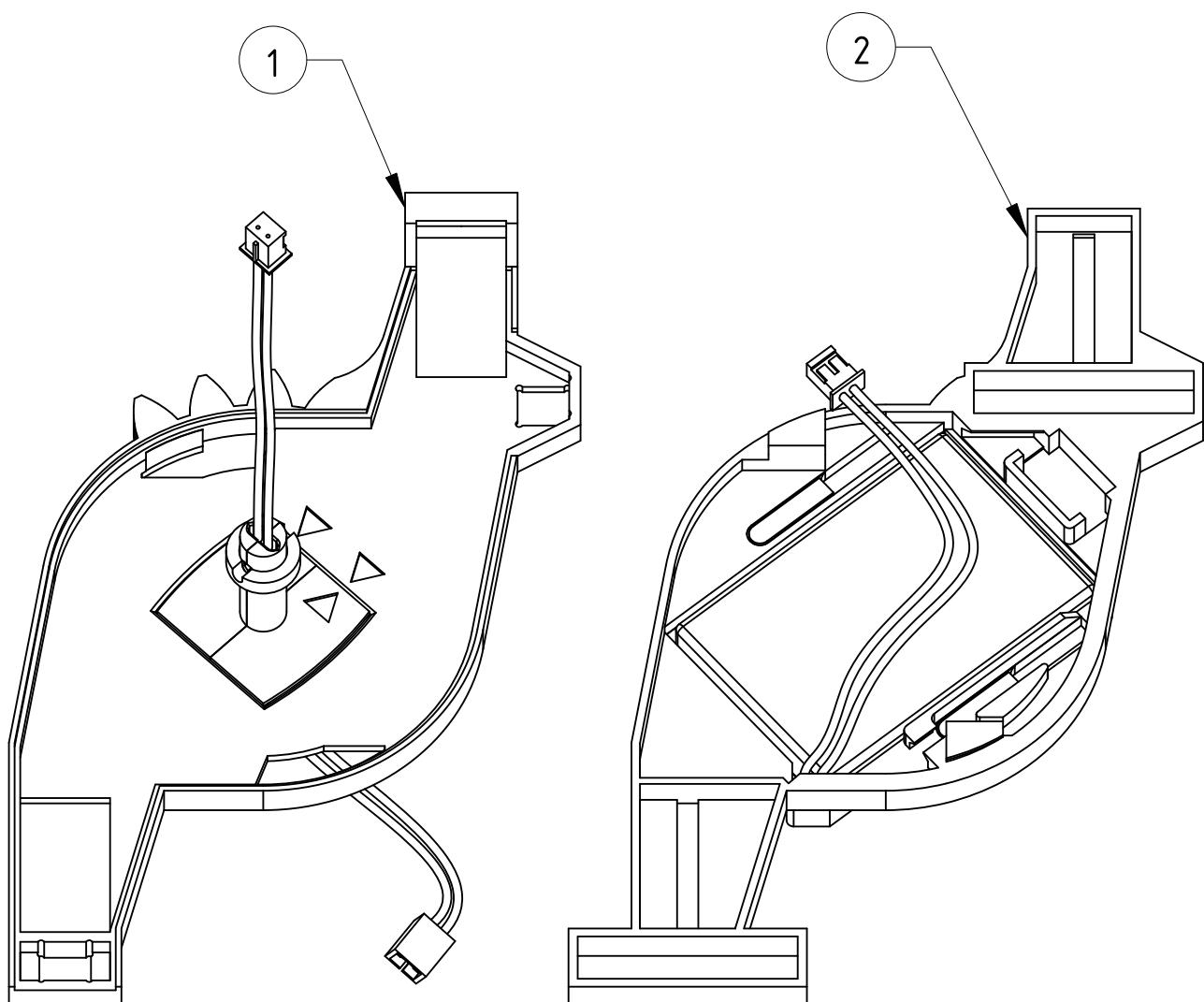


! The two parts of the gear axle must join together without any gap inbetween. Otherwise the ringnut will not fit around the axle. If the parts does not join properly, return to Step 1 and try pushing the wires further into the channels inside the axle parts.

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Section 3:

Lower body deck assembly



MATERIALS

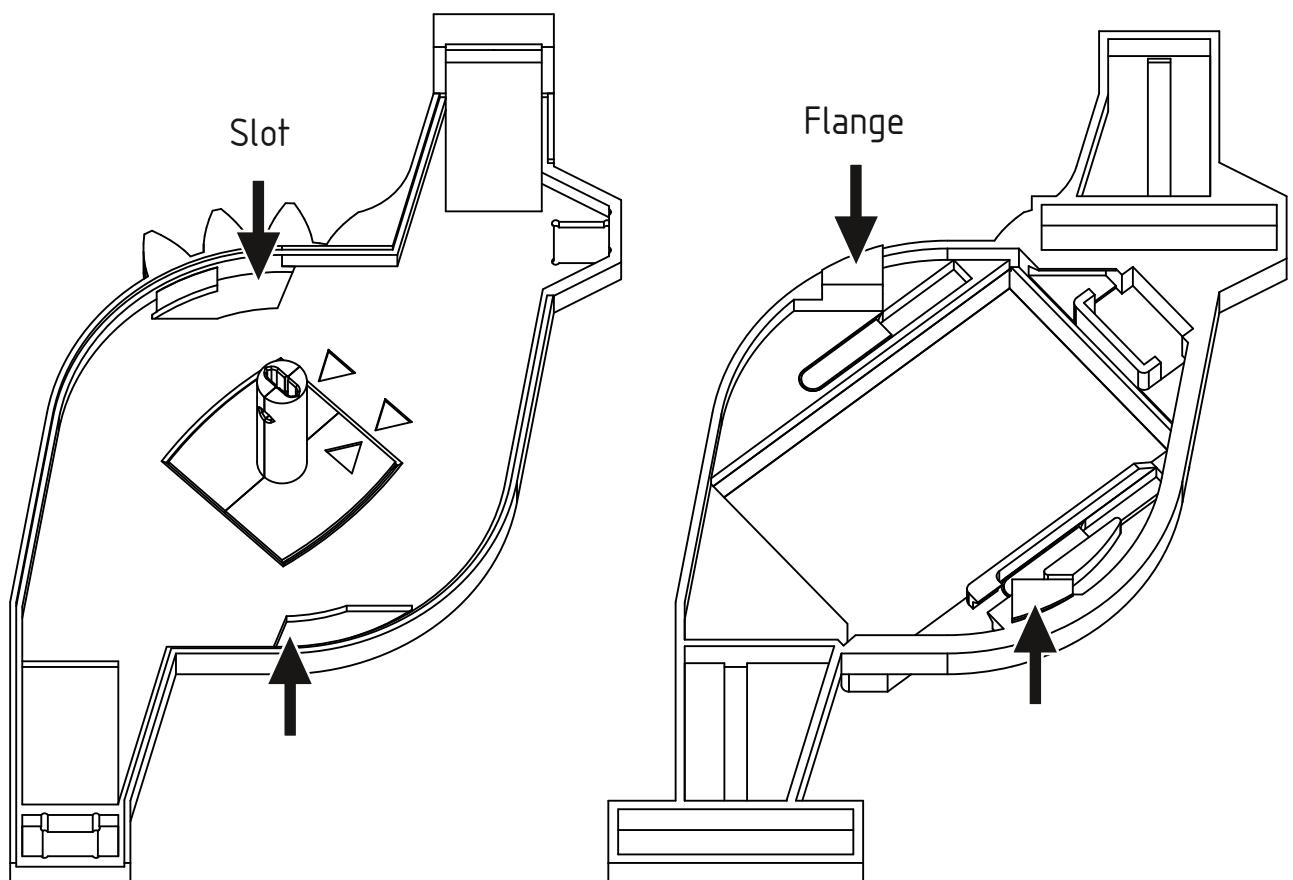
- 1: Lower body, Top deck
- 2: Lower body, Bottom deck

Purpose

In this section, the two previously assembled decks will be combined into one part. The bottom deck's battery will be connected to the top deck's extension cable.

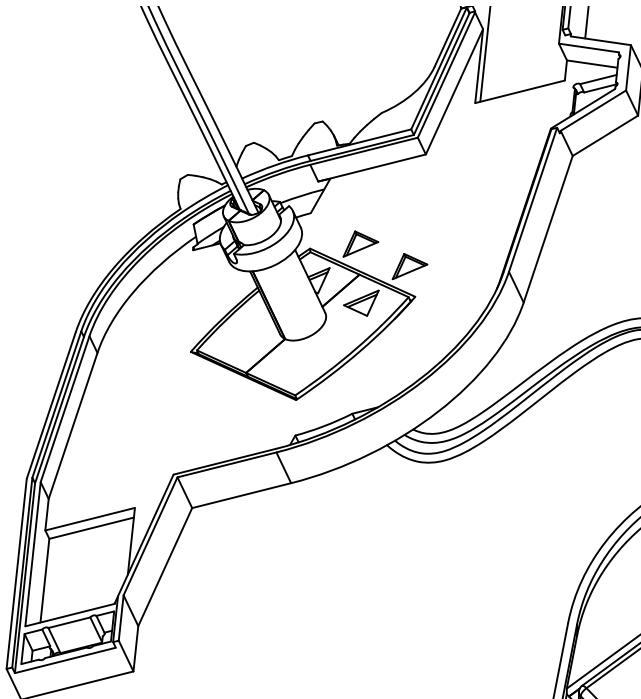
Before starting

Note that the bottom deck has two flanges that fits into slots in the base of the top deck. When the parts are twisted into position the flanges will lock the two parts together.

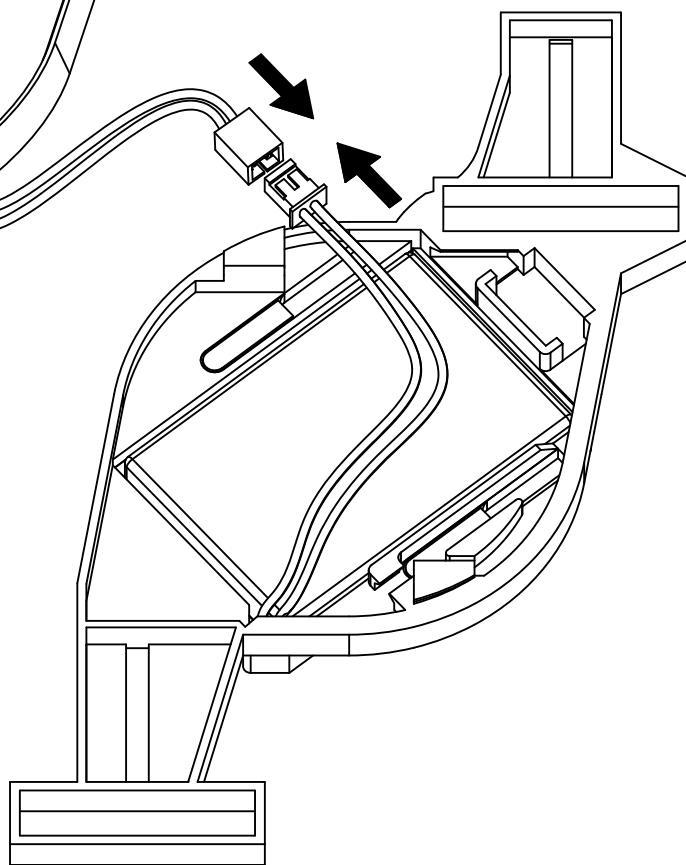


- i** In Step 2, it is important to make sure the two decks fit together properly. The bottom section of the battery extension cable must coil up within a narrow space between the battery and the base of the top deck.

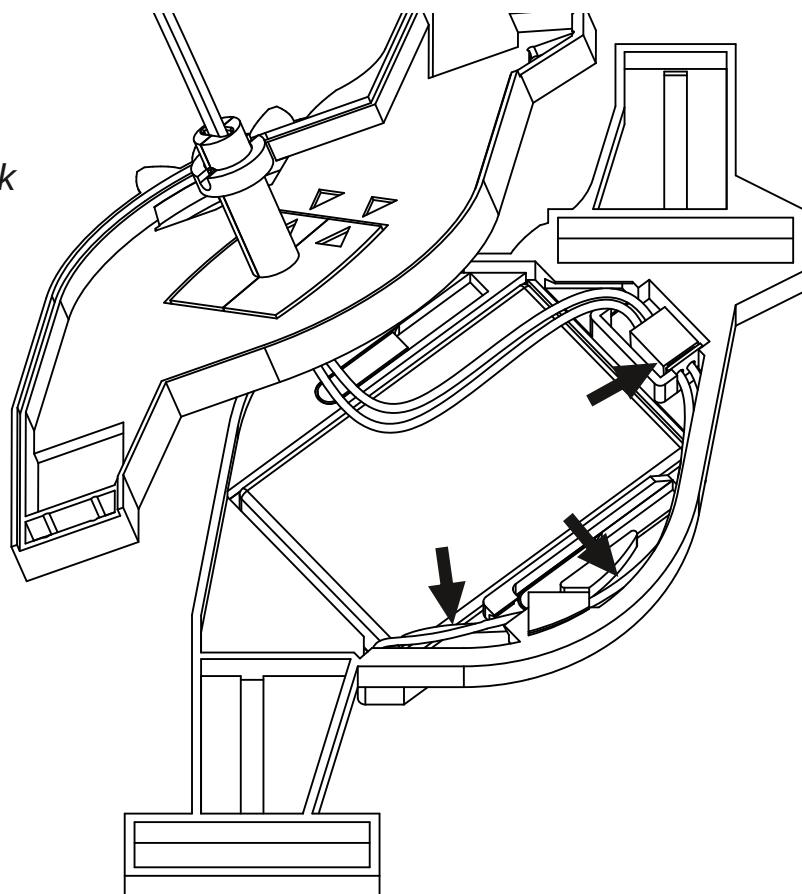
If you find it difficult to get the cable to fit, try using small pieces of thumbtack or scotch tape to fix the excess cable to the bottom deck.



Step 1:
Connecting extension cable to battery

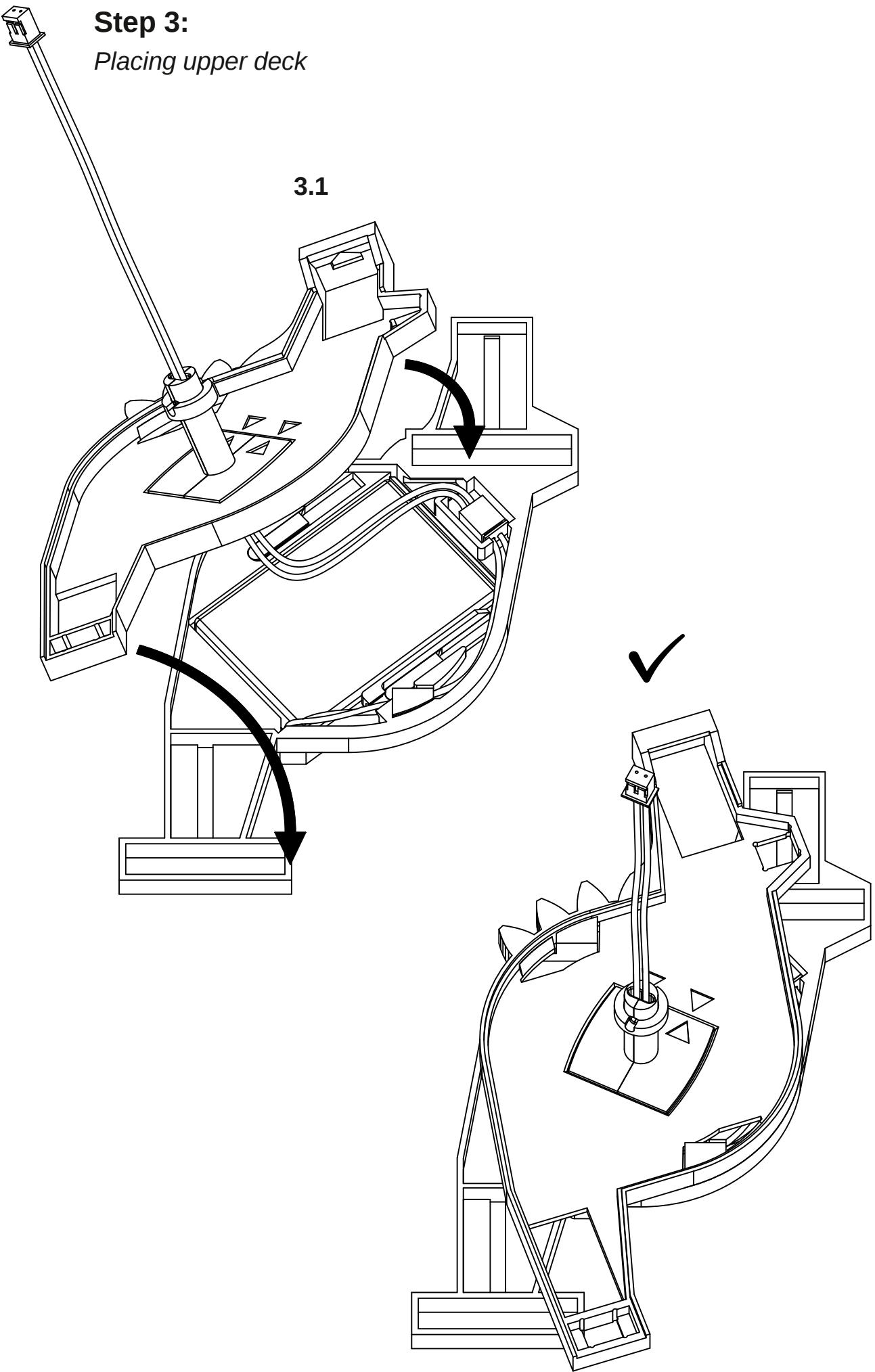


Step 2:
Arranging cable on lower deck



Step 3:
Placing upper deck

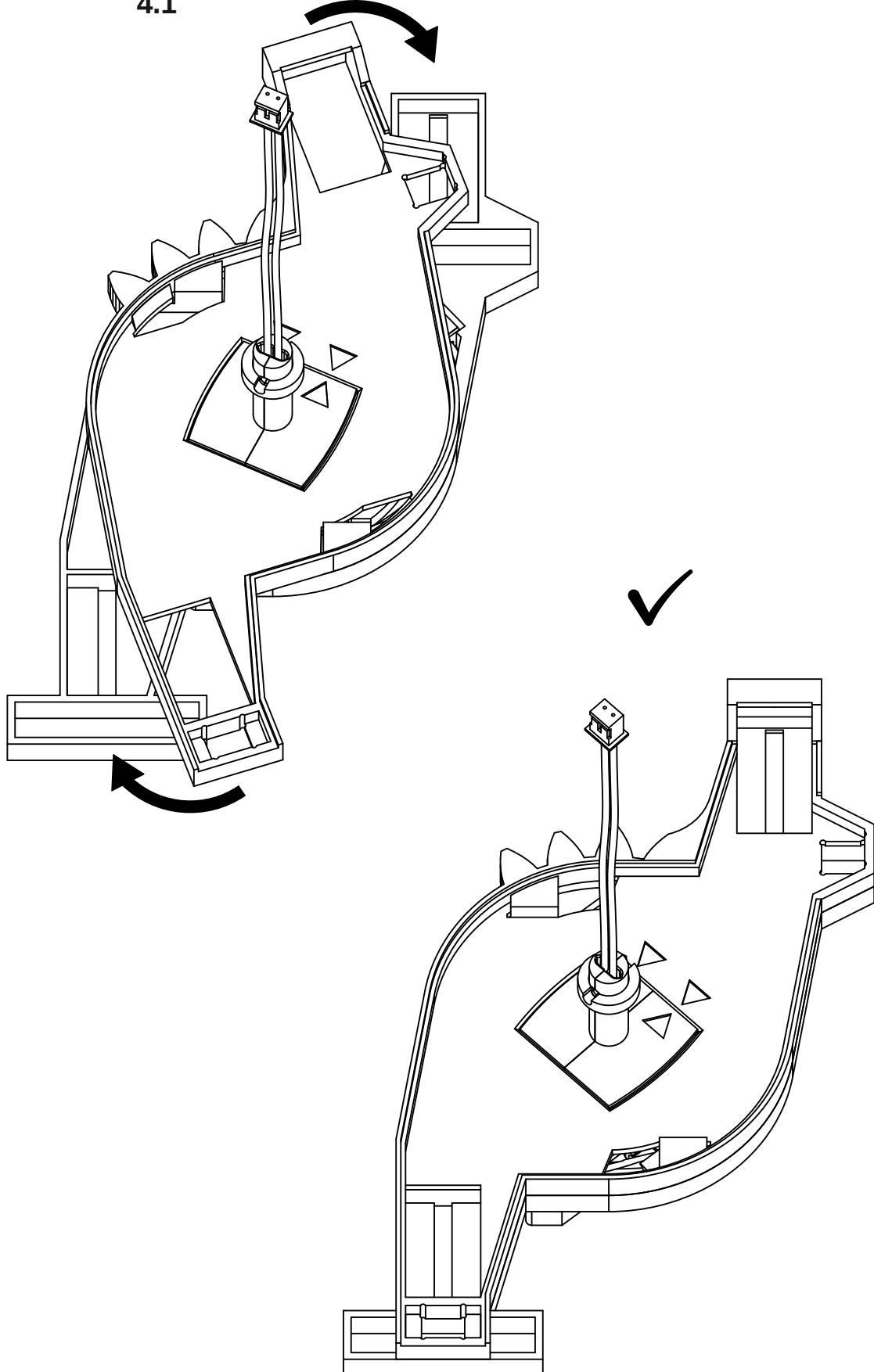
3.1



Step 4:

Locking decks together

4.1



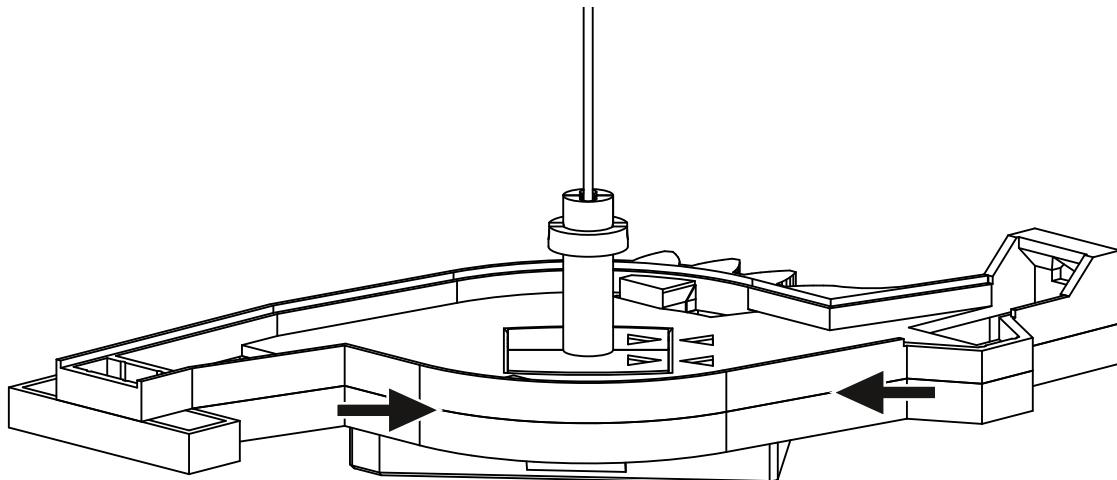


Final note

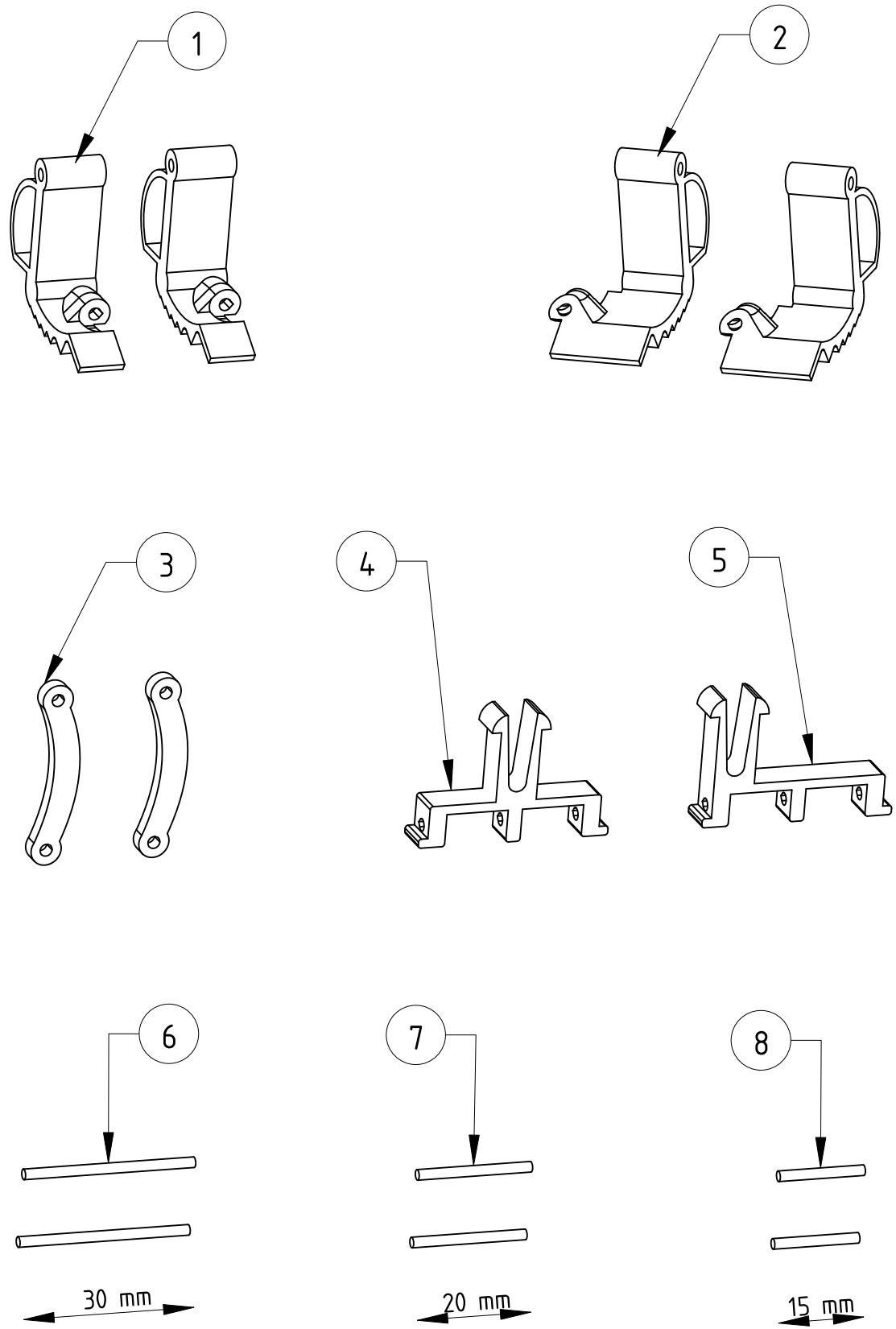
It's important that the top and bottom decks are joined closely together without any large gap inbetween.

A gap might be caused by the battery extension cable having gotten pinched between the two parts.

Inspect the seam of the assembly to ensure that the decks have been properly joined. If this is not the case, return to Step 2.



Section 4: Short legs assembly

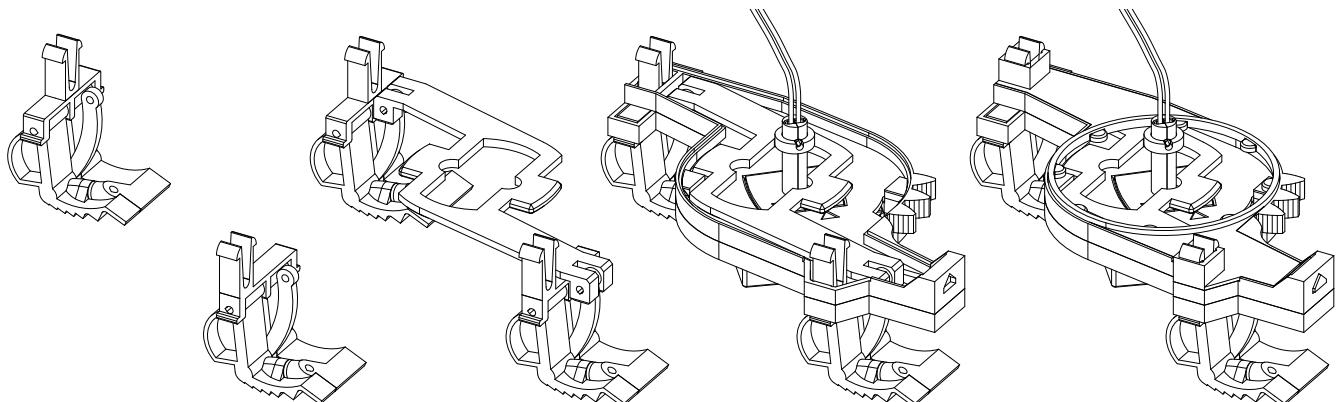


MATERIALS

- 1: 2x Short leg, left part
- 2: 2x Short leg, right part
- 3: 2x Short lever
- 4: Leg joint, center connector
- 5: Leg joint, side connector
- 6: 2x Leg joint sleeve
- 7: 2x Filament, 30 mm in length
- 8: 2x Filament, 20 mm in length
- 9: 2x Filament, 15 mm in length

Looking ahead

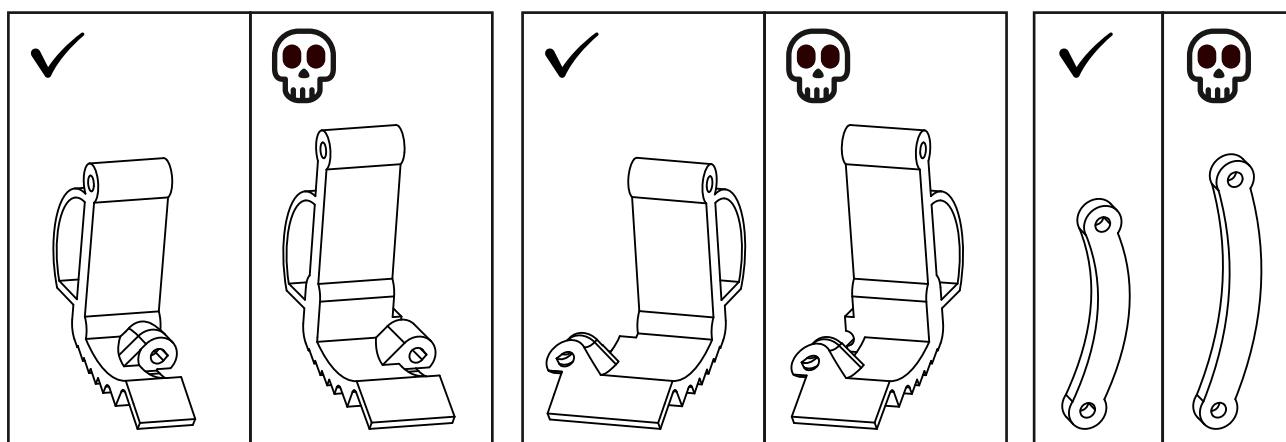
In this section, the robot's first pair of legs will be assembled. In Section 5, these will be connected to the lower body.



Before starting

Note that the Tardygrade kit contains two sets of similar looking leg parts for items 1, 2 and 3 in the materials list. The two sets of leg parts differs slightly in length and design.

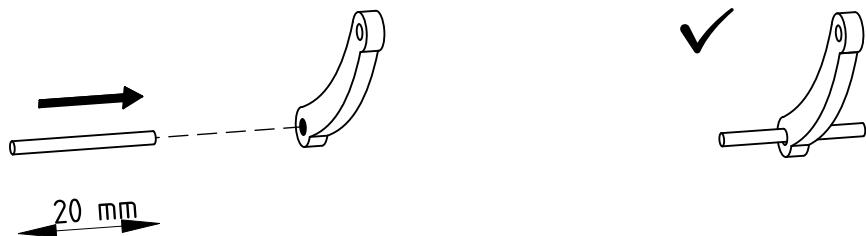
Make sure to select the correct parts for this section. The pictures below illustrates the difference between the two sets of leg parts.



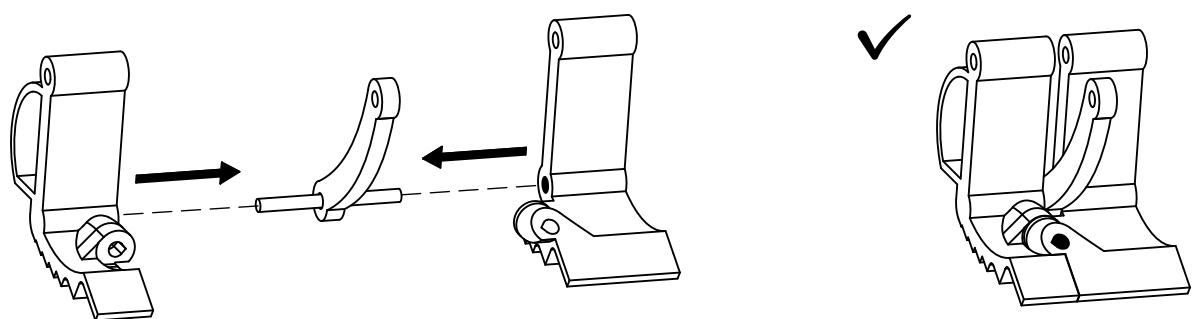
Step 1:

Assembling leg with center connector

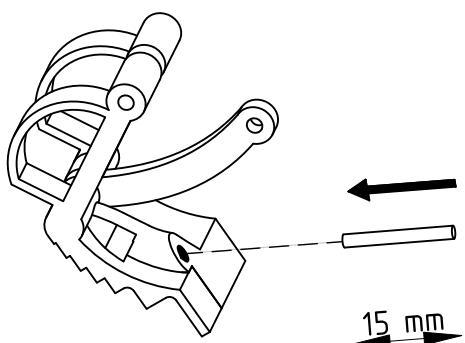
1.1



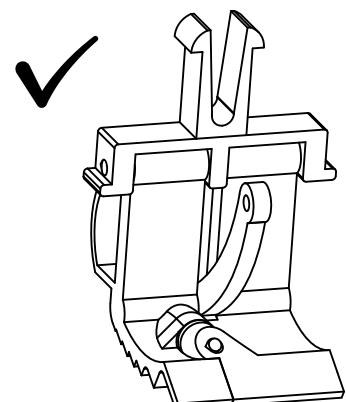
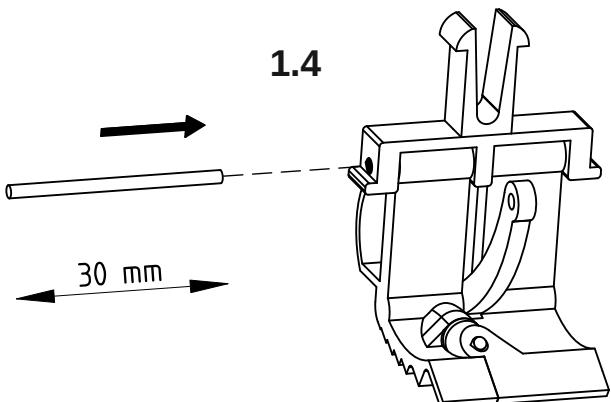
1.2



1.3



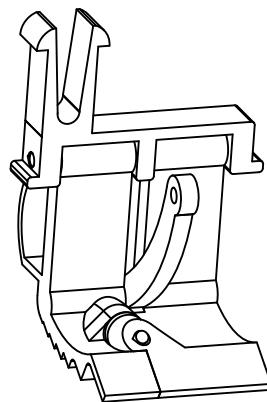
1.4



Step 2:

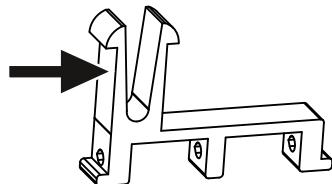
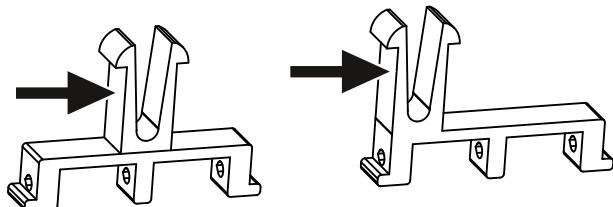
Assembly of leg with side connector

To assemble the second leg, repeat Step 1.1 through Step 1.4 using the remaining items in the materials list.



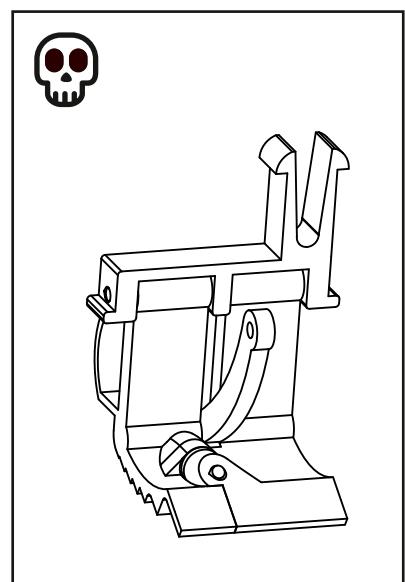
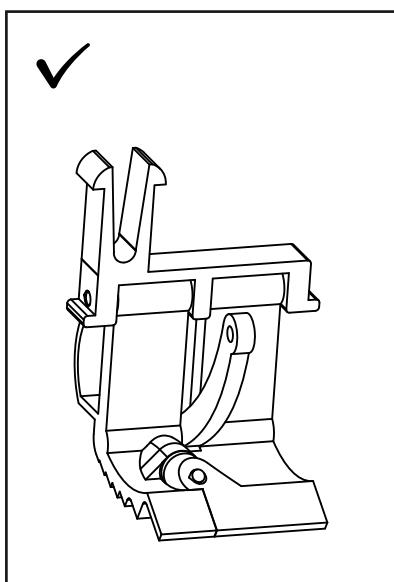
Final notes

- (i)** Each leg joint has a connector on top, that consists of two flexible arms with hooks. In the next section, these connectors will be used to snap-fit the legs into the lower body assembly.



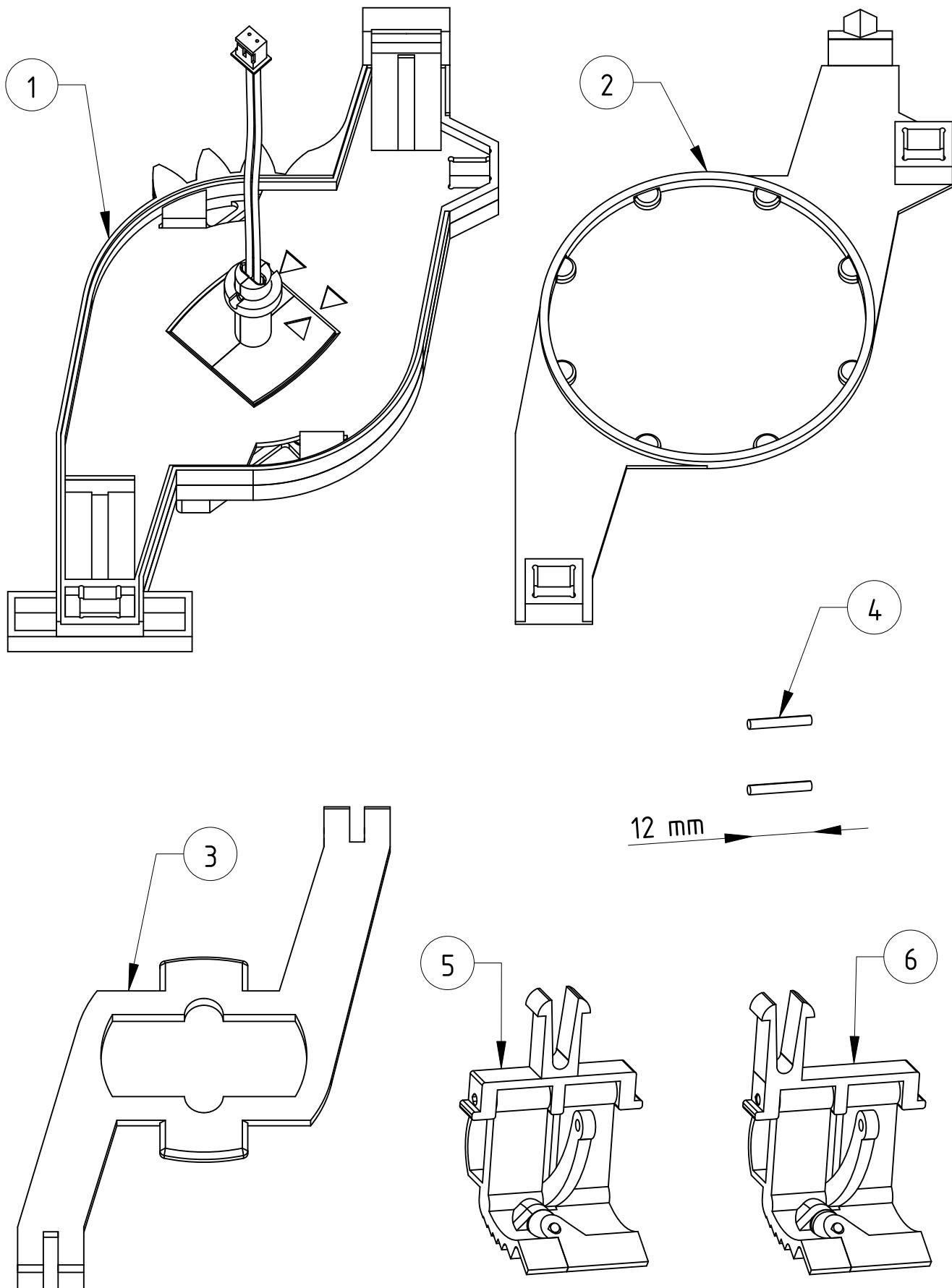
- !** The leg that was built in Step 2 has a joint with the connector oriented to one side. Double-check that the connector is oriented correctly, as illustrated below.

If the connector orientation does not correspond to the left image, return to Step 2.



Section 5:

Lower body final assembly



MATERIALS

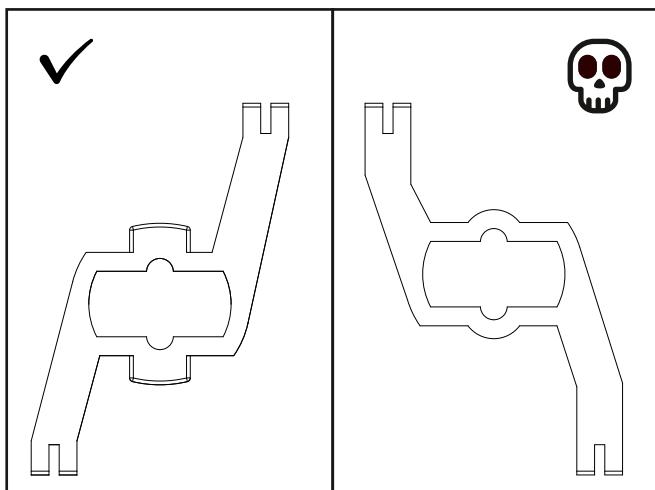
- 1: Lower body deck assembly
- 2: Lower body lid
- 3: Lower body linear actuator
- 4: 2x Filament, 12 mm in lenght
- 5: Short leg assembly, center connector
- 6: Short leg assembly, side connector

Purpose

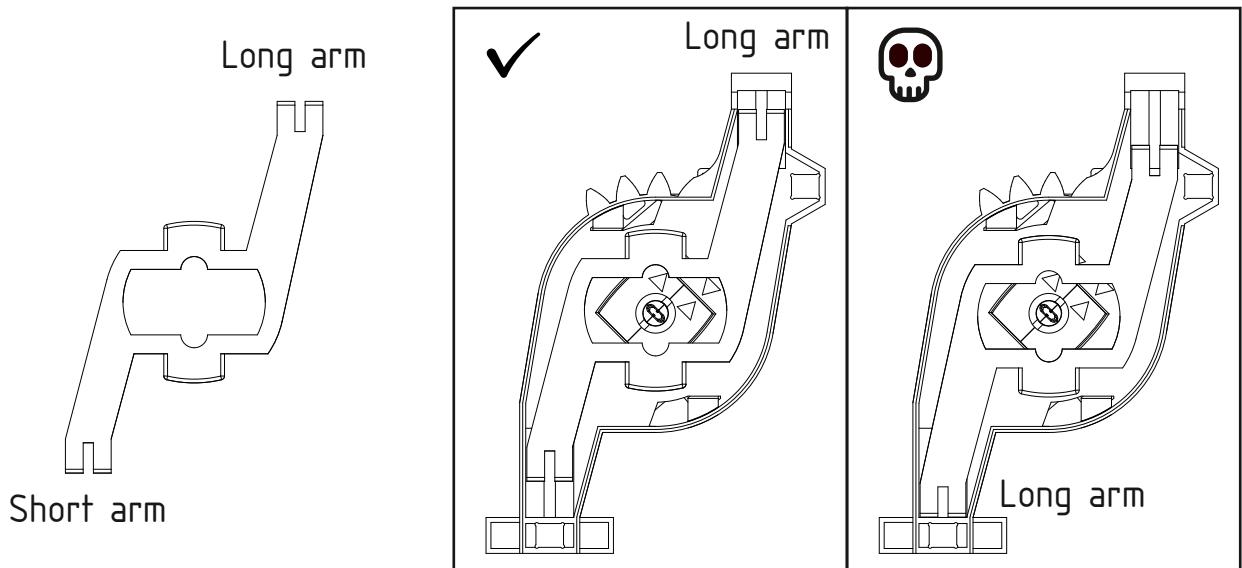
In this section, the assembly of the lower body will be finalized. The leg pair assembled in Section 4 will be fitted to the assembly from Section 3 and connected to a linear actuator. Finally a lid will be mounted onto the top deck of the body.

Before starting

- ! There are two similar looking linear actuators in the kit. Be sure to select the correct one for this assembly.

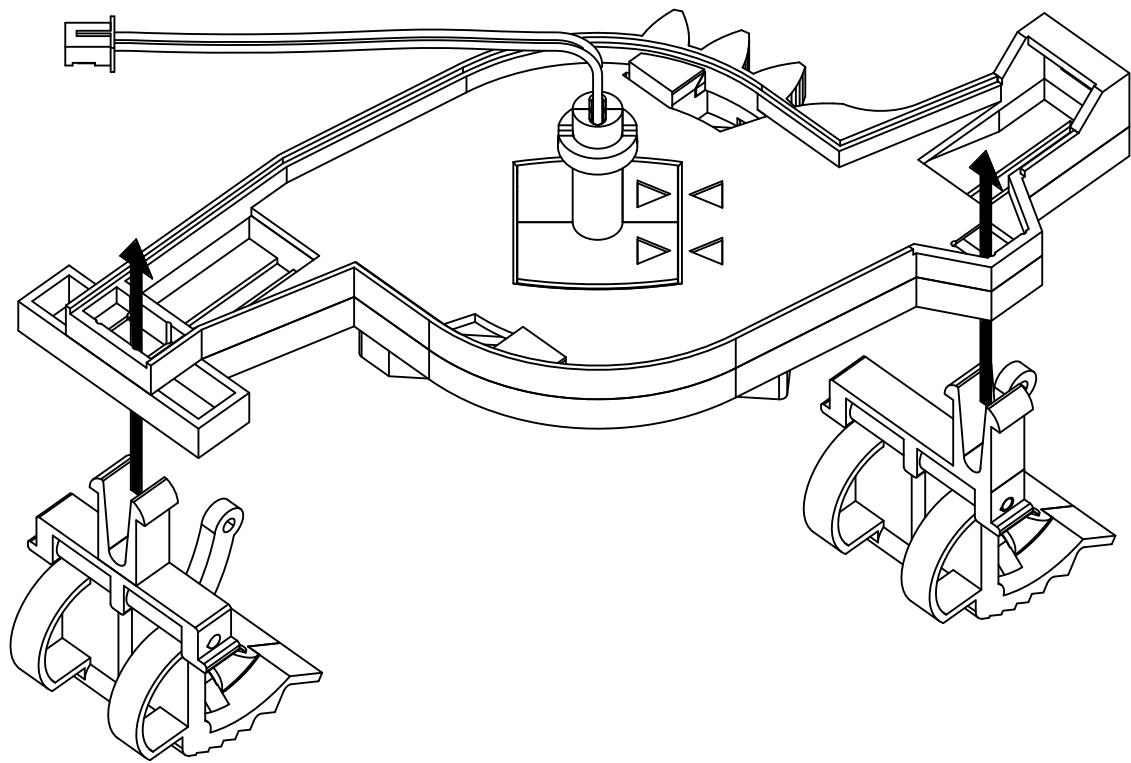


- ! The lower body linear actuator has two "arms" that differ in length. The actuator must be placed in the correct orientation, as illustrated below.



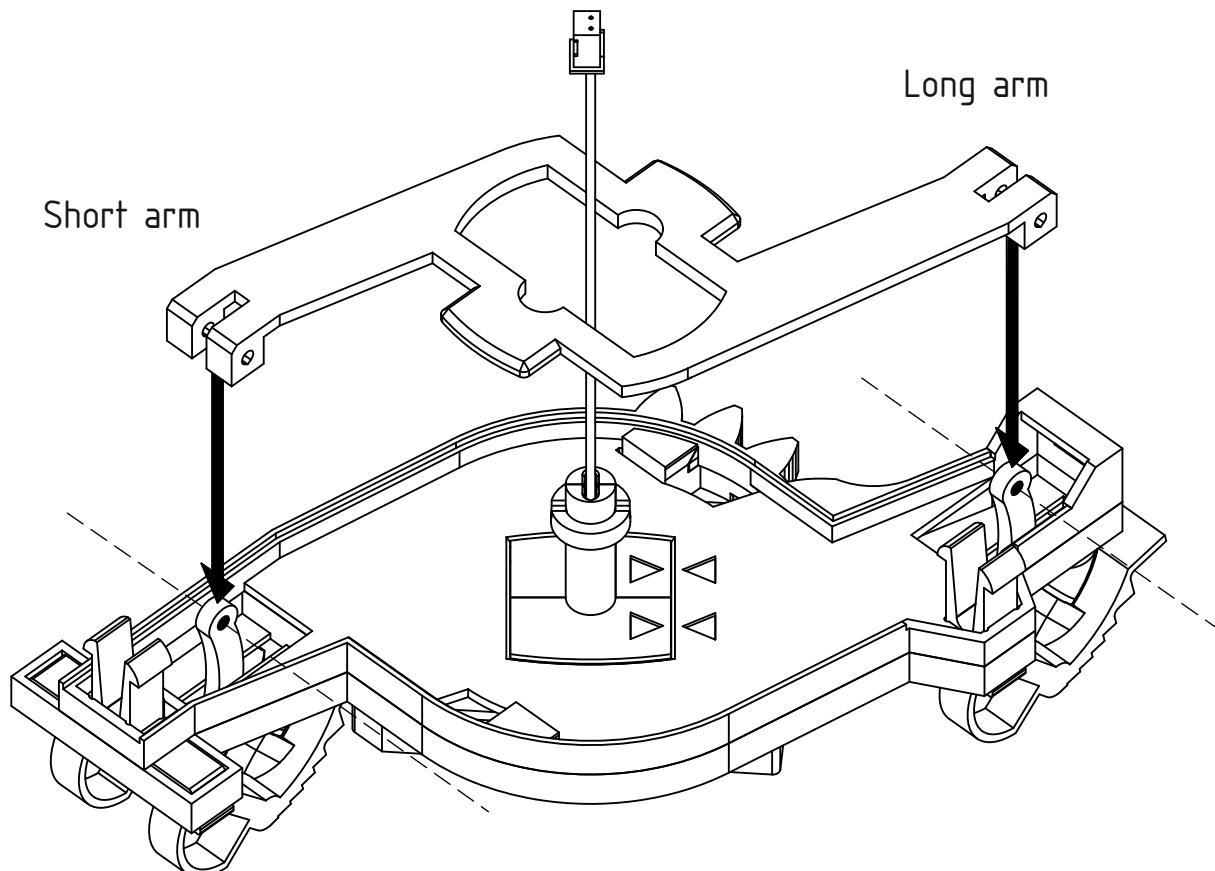
Step 1:

Attaching leg connectors



Step 2:

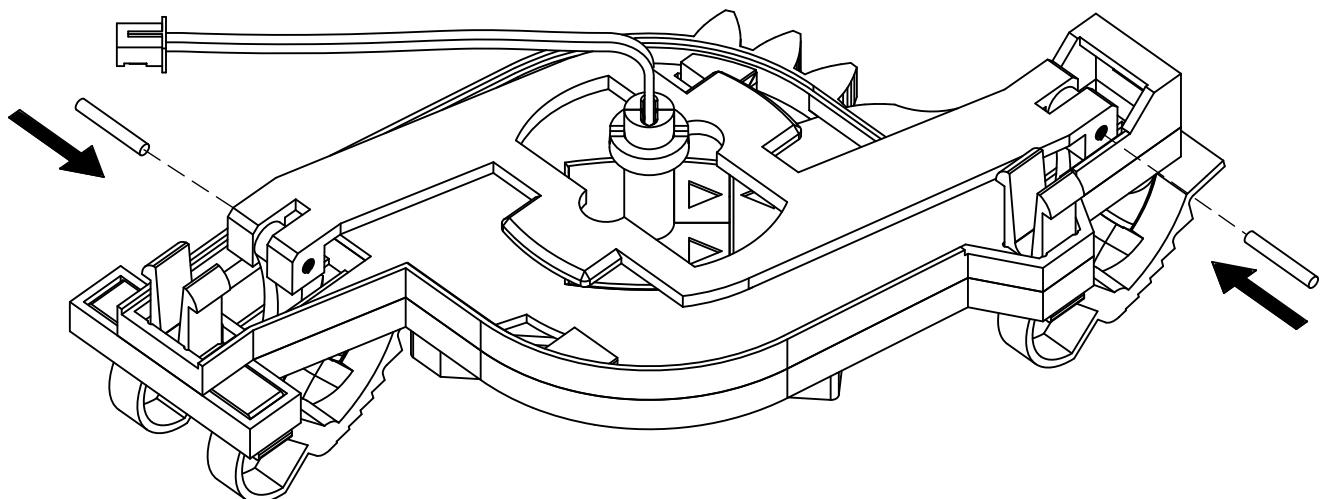
Lining up linear actuator with leg levers



Step 4:

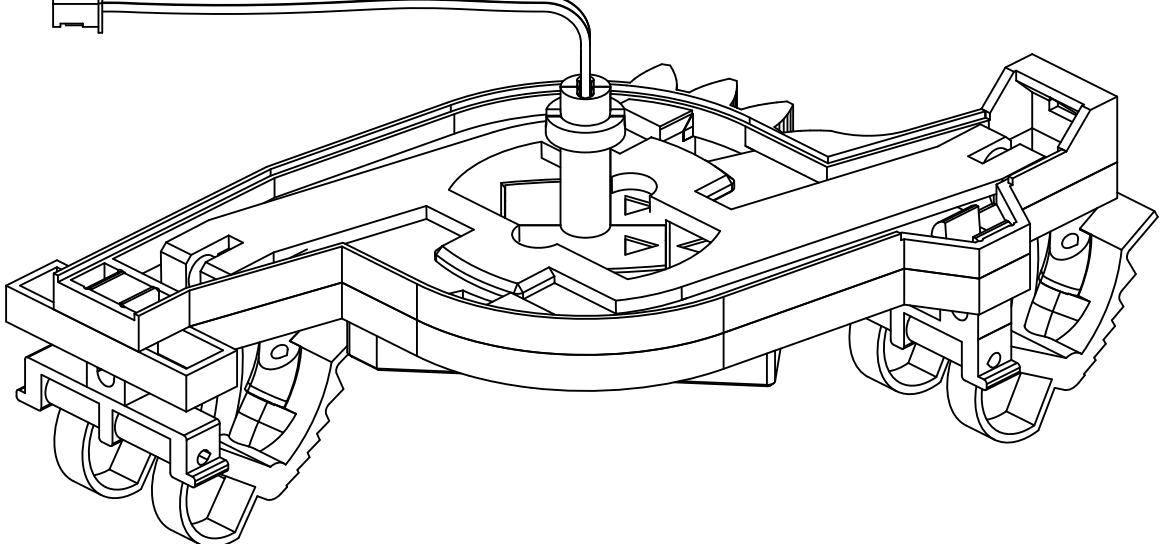
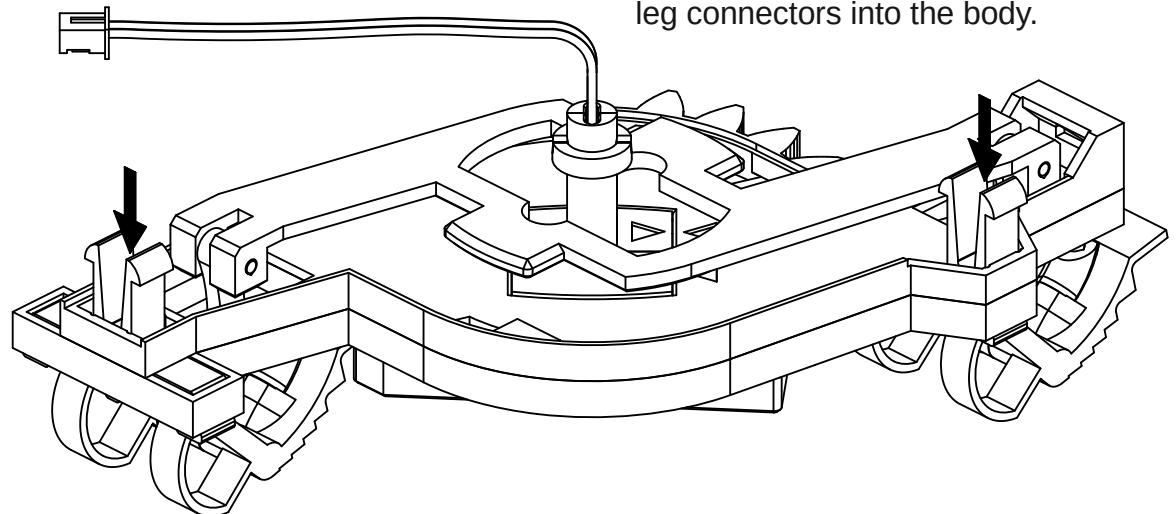
Joining legs and linear actuator using filament

3.1



Prior to Step 4, push back the leg connectors into the body.

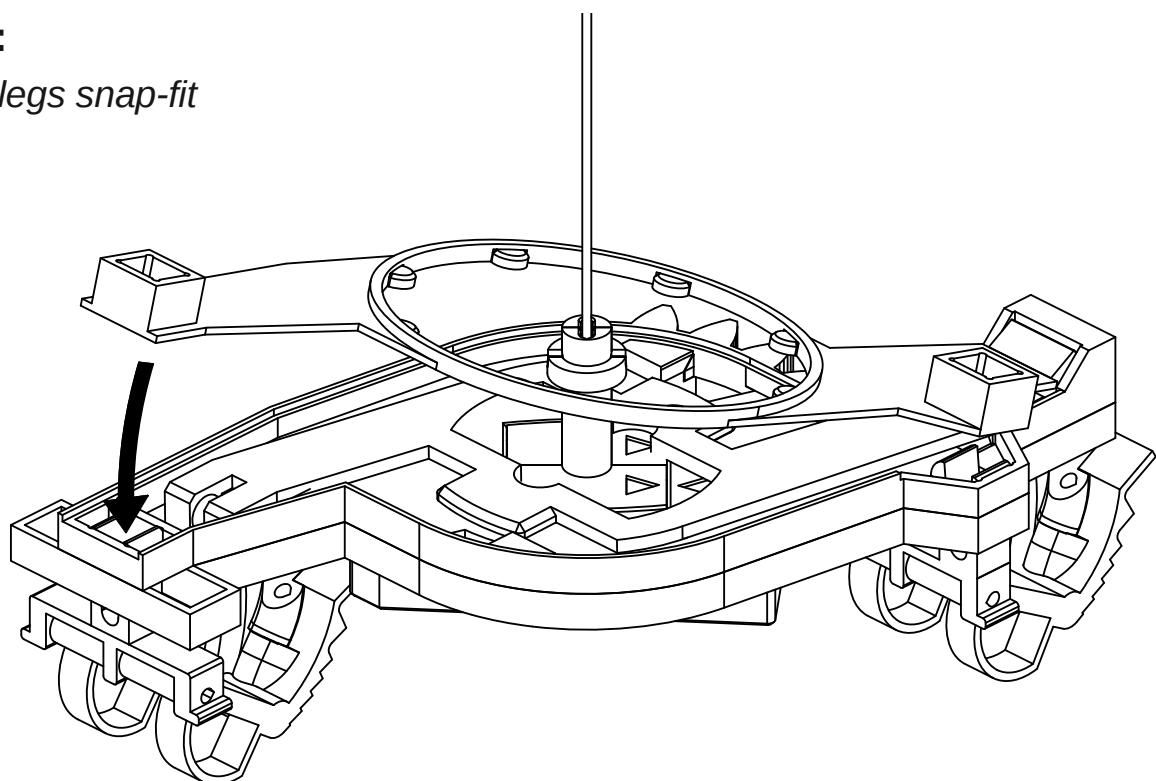
3.2



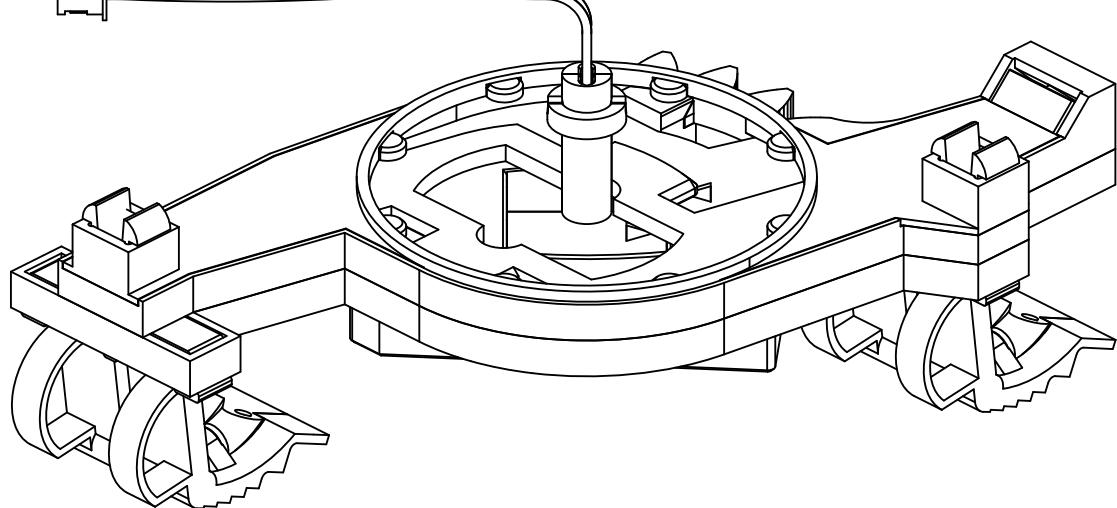
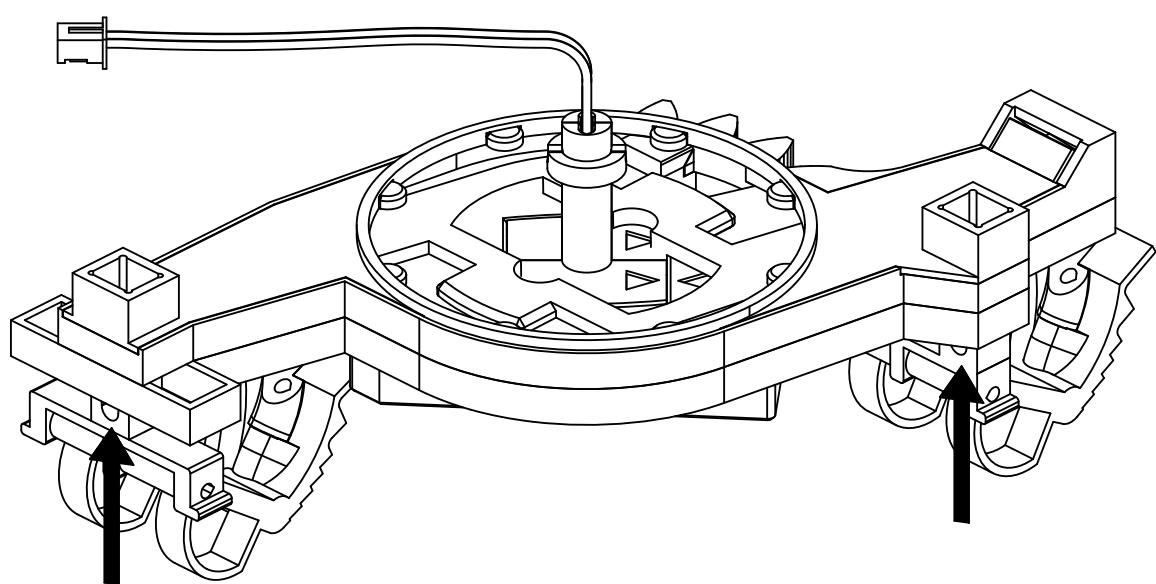
Step 4:

Lid and legs snap-fit

4.1

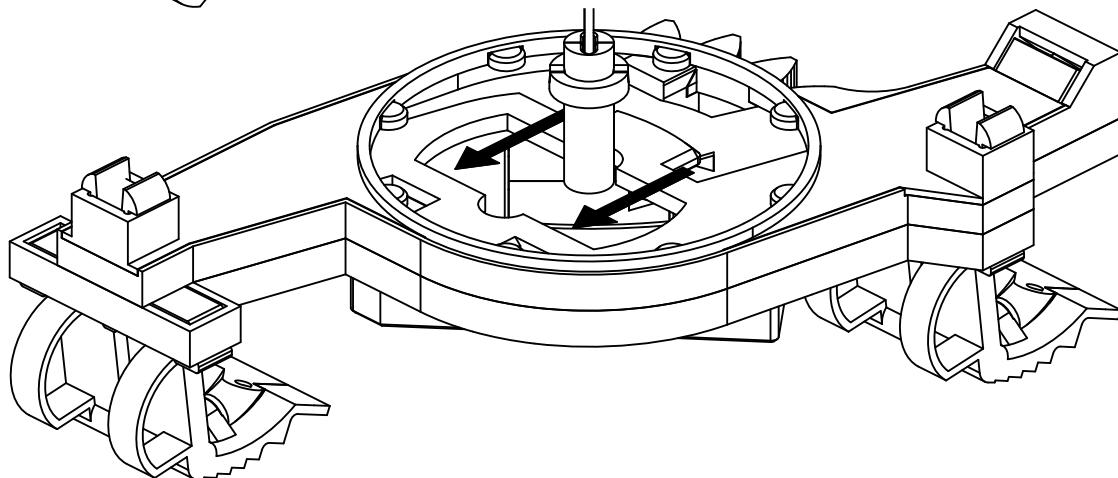
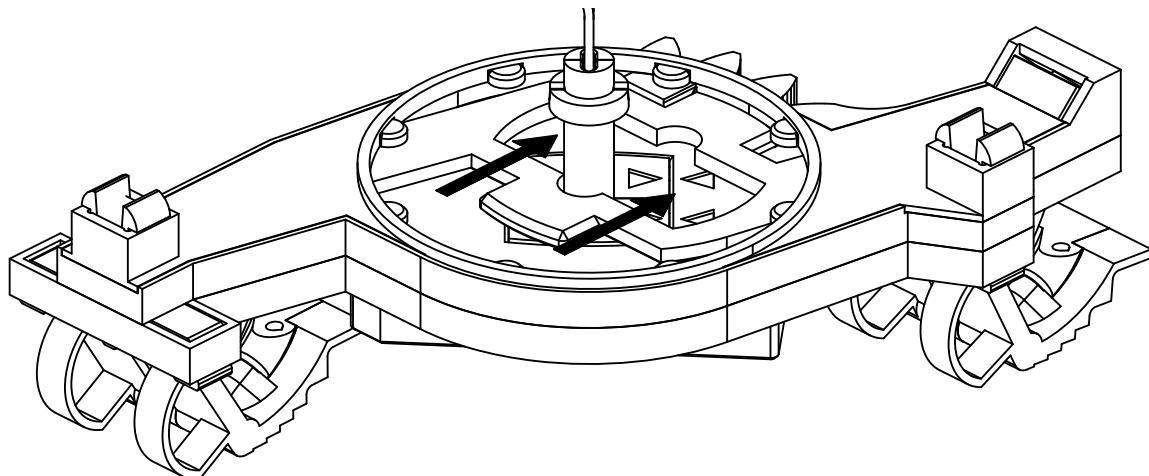


4.2



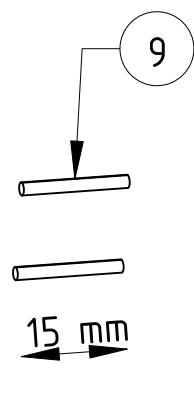
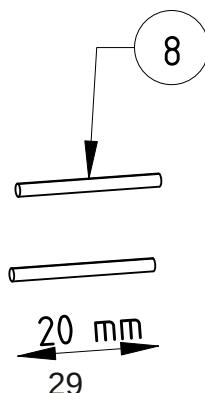
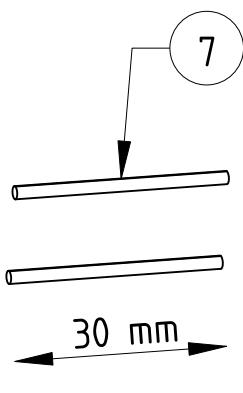
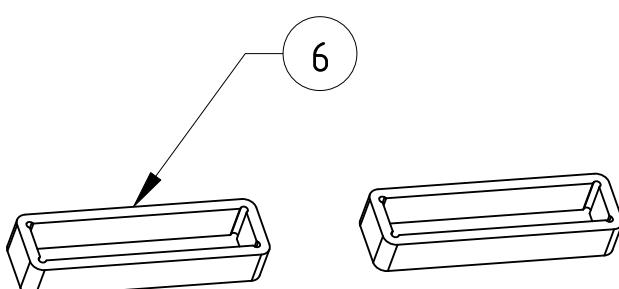
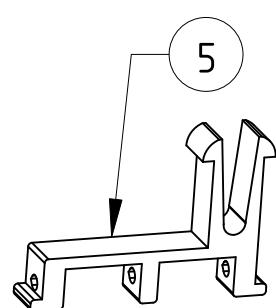
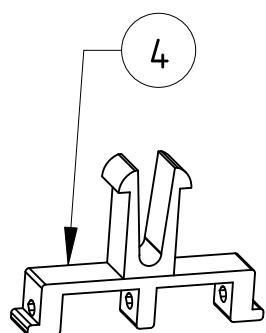
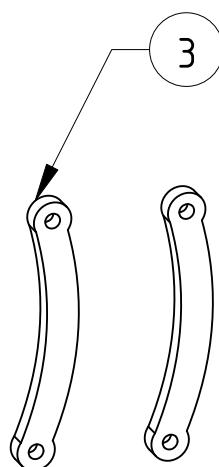
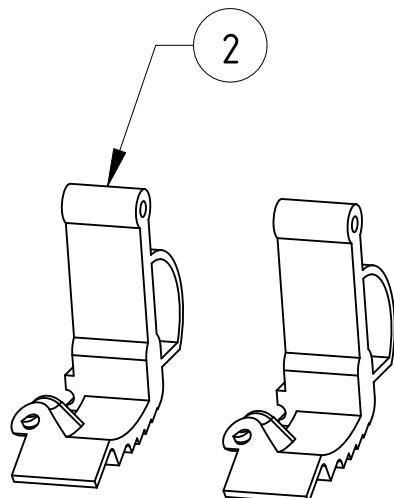
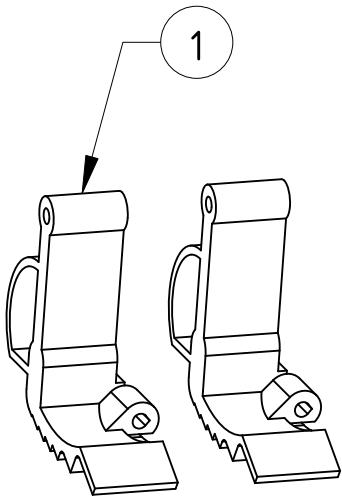
Final note

After assembly, ensure that the linear actuator can move freely. Push the linear actuator from side to side. If assembled correctly, the mechanism should move back and forth with very little friction.



Section 6:

Long legs assembly



MATERIALS

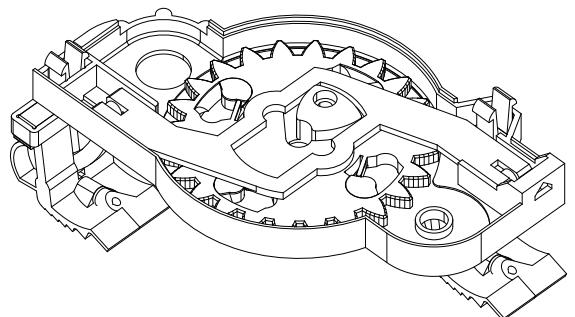
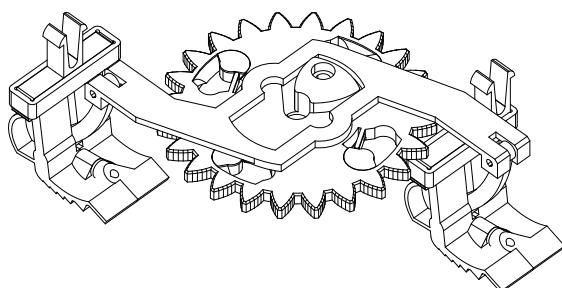
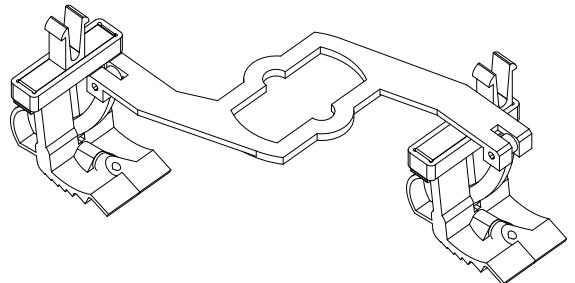
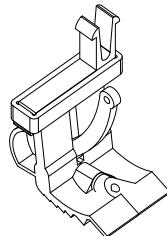
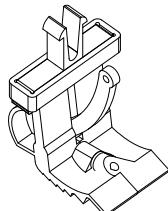
- 1: 2x Long leg, left part
- 2: 2x Long leg, right part
- 3: 2x Long lever
- 4: Leg joint, center connector
- 5: Leg joint, side connector
- 6: Leg joint sleeve
- 7: 2x Filament, 30 mm in length
- 8: 2x Filament, 20 mm in length
- 9: 2x Filament, 15 mm in length

Purpose

In this section, the remaining pair of legs will be assembled. Except for Step 1.5, the assembly process is the same as in Section 4.

Looking Ahead

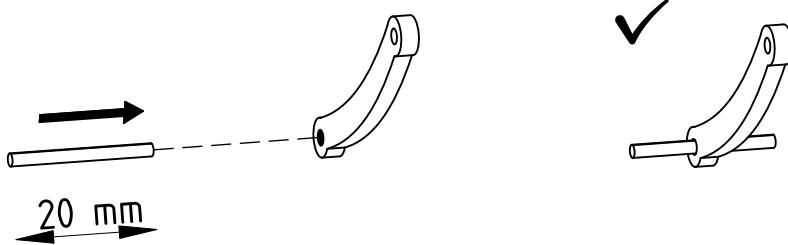
In Section 8, this pair of legs will be connected to the upper body.



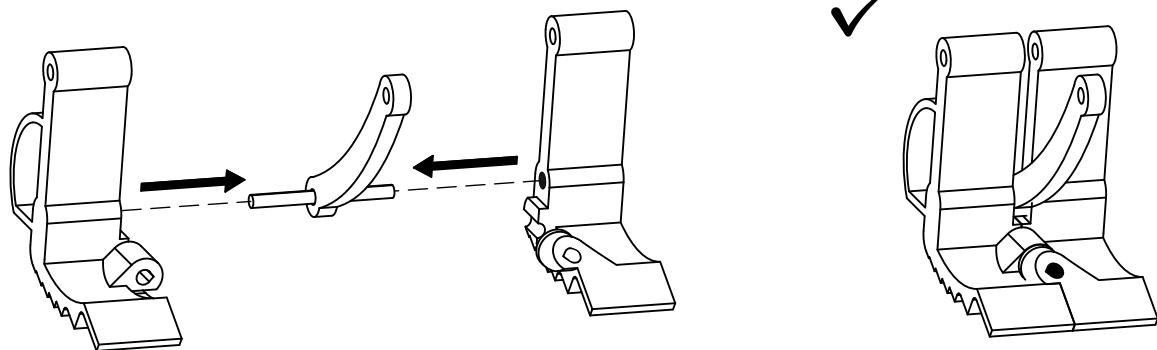
Step 1:

Assembly of leg with center connector

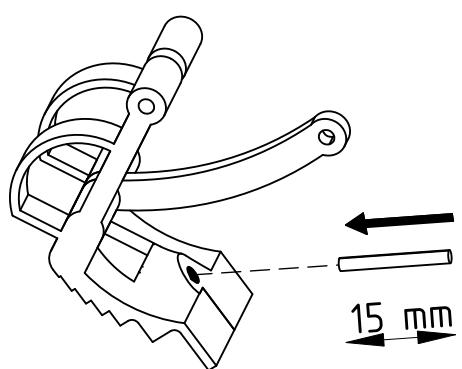
1.1



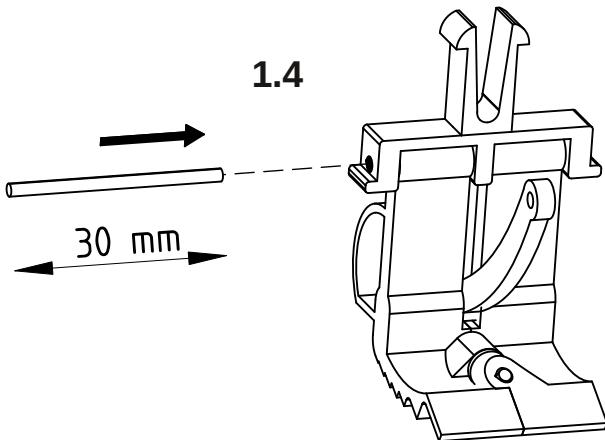
1.2



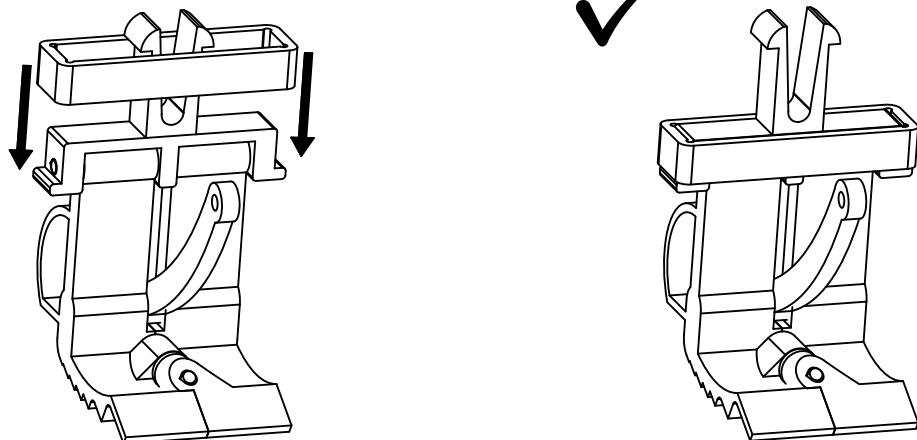
1.3



1.4



1.5

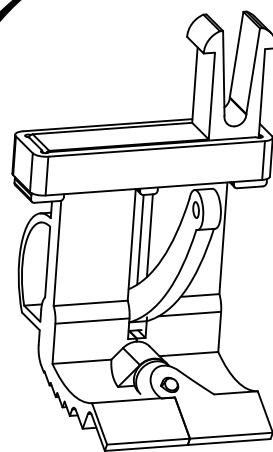


Step 2:

Assembly of leg with side connector

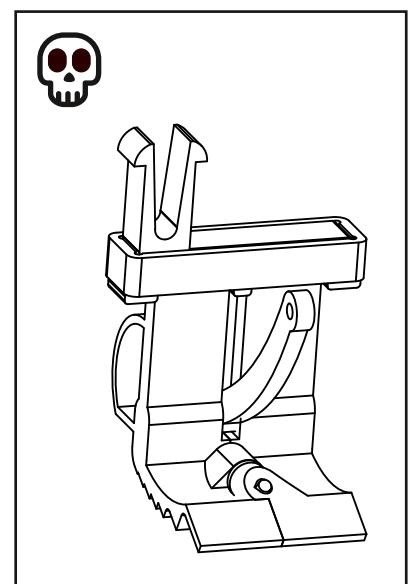
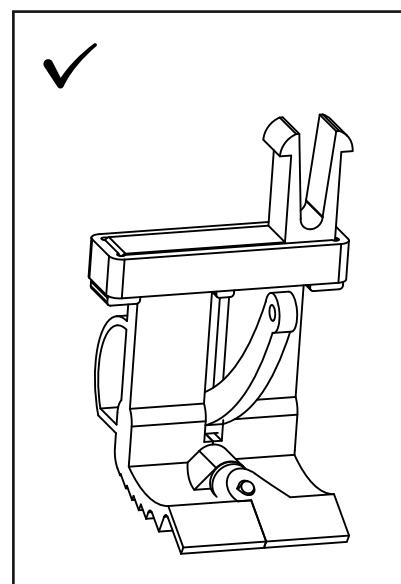


To assemble the second leg, repeat Step 1.1 through Step 1.5 using the remaining items in the materials list.

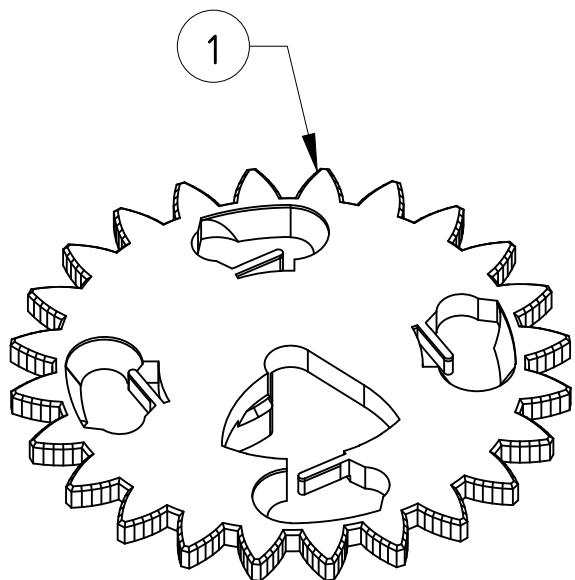


Final note

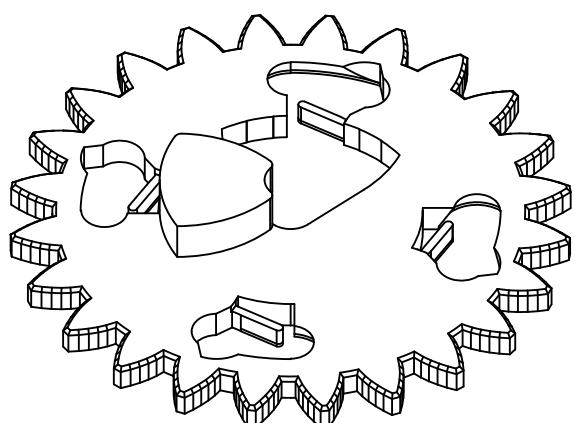
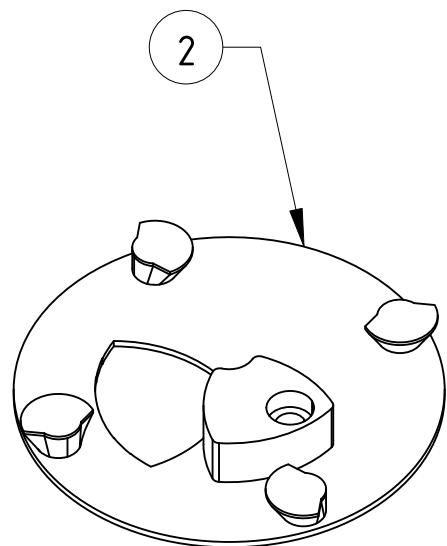
The leg that was built in Step 2 has a joint with the connector oriented to one side. Double-check that the connector is oriented correctly, as illustrated below.



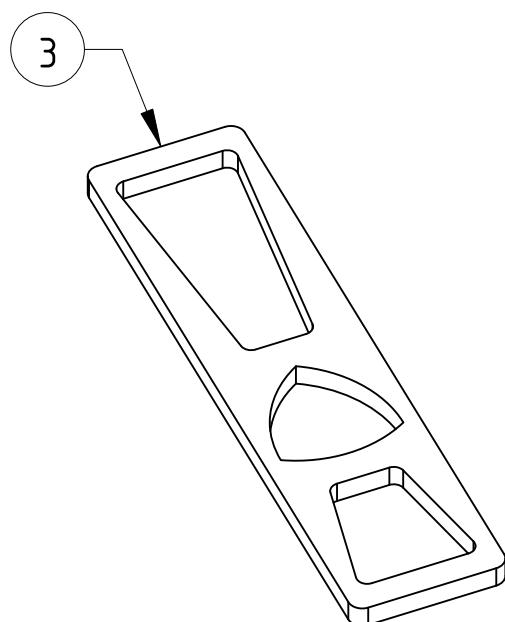
Section 7: Main gear



Top view



Bottom view



MATERIALS

- 1: Main gear, part A
- 2: Main gear, part B

TOOLS

- 3: Main gear wrench

Purpose

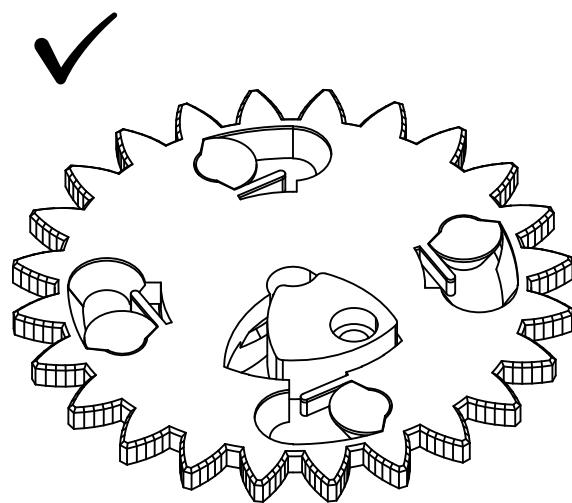
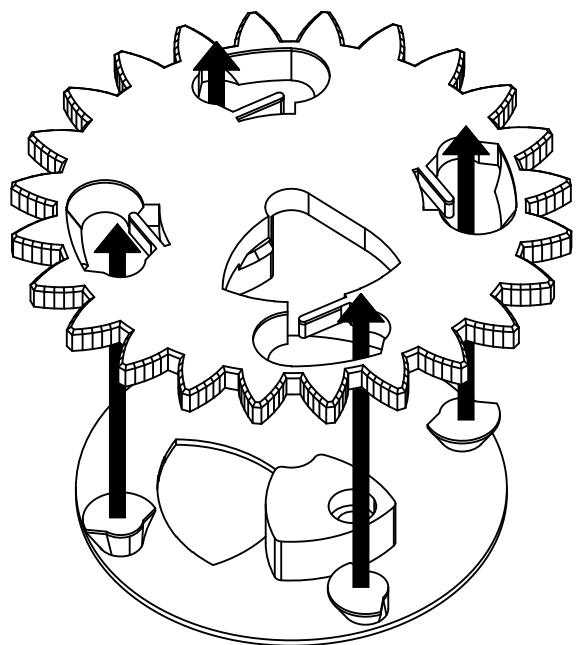
In this section, the main gear will be assembled. Its function is to transfer power from the robot's drive servo motor to the linear actuators in the upper and lower body.

The main gear will be mounted in Section 8.

The wrench (item 3) is only used as a tool for locking the top and bottom gear parts together. It's not part of the assembly.

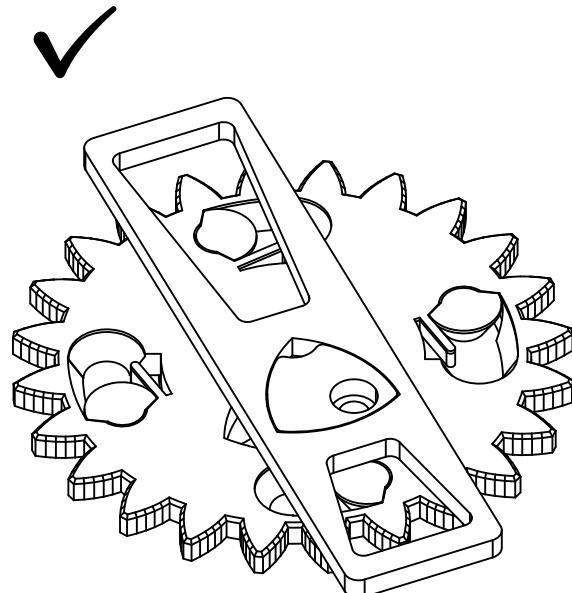
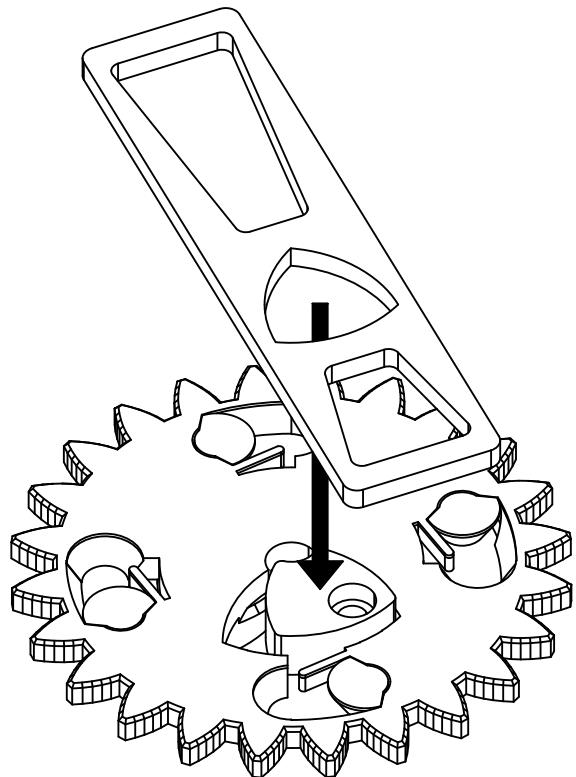
Step 1:

Gear pre-assembly



Step 2:

Fitting wrench on top cam

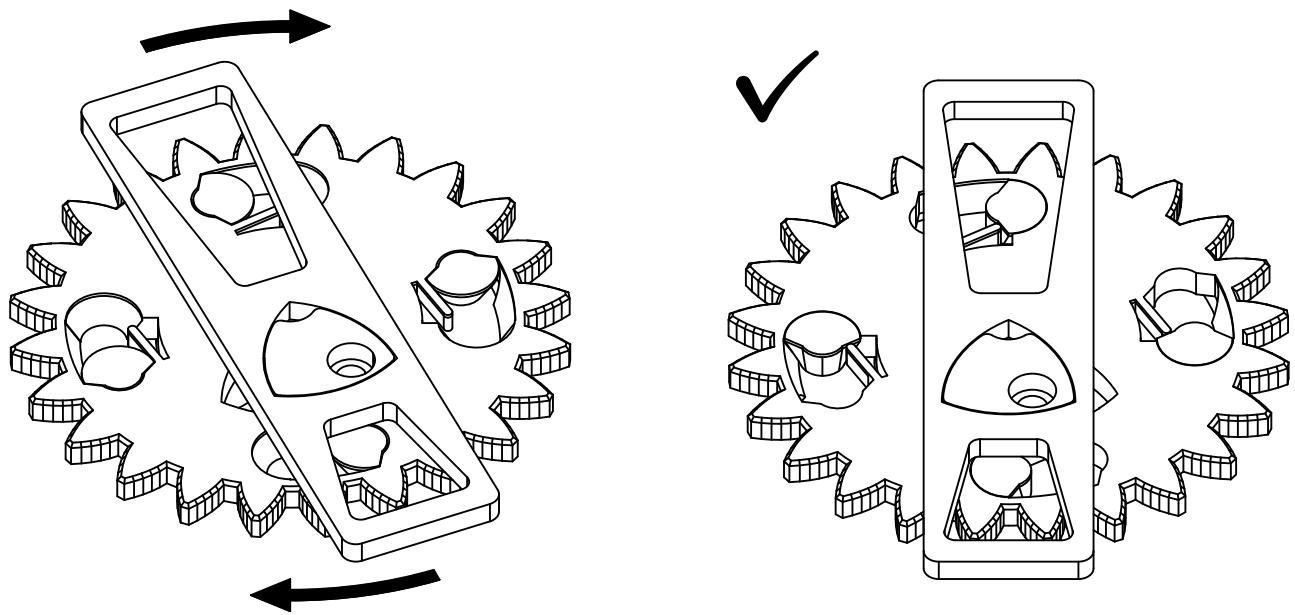


Step 3:

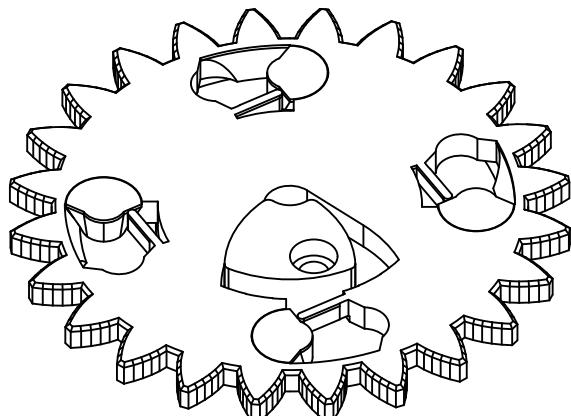
Locking gear parts

The gear is held in the palm of one hand.

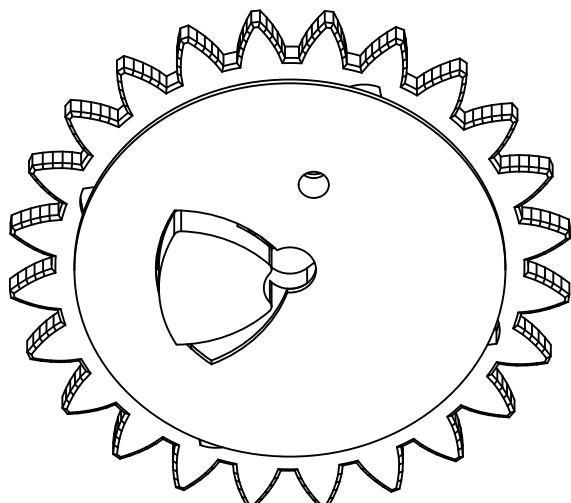
The wrench is turned clockwise until the parts locks in place.



Top view

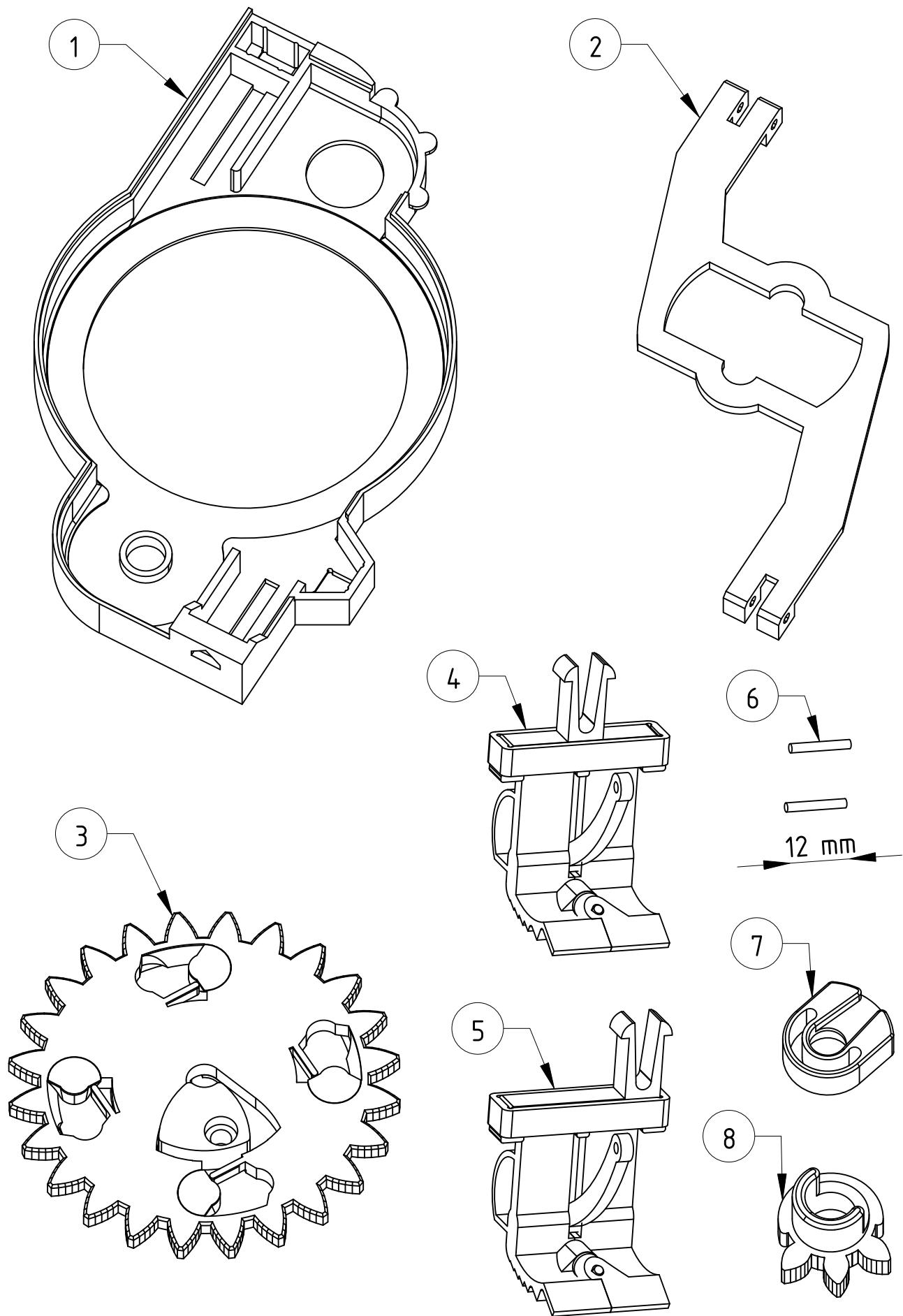


Bottom view



Section 8:

Upper body partial assembly



MATERIALS

- 1: Upper body hull
- 2: Upper body linear actuator
- 3: Main gear
- 4: Long leg assembly, center connector
- 5: Long leg assembly, side connector
- 6: 2x Filament, 12 mm in length
- 7: Steering gear, top part
- 8: Steering gear, bottom part

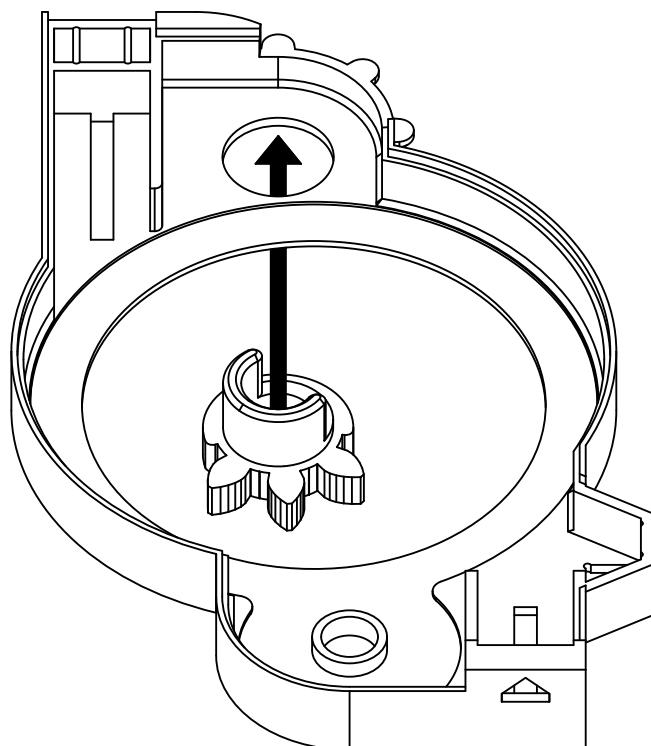
Purpose

In this section, assembly of the robot's upper body will be started. Like the lower body, it houses a linear actuator that is connected to two of the robot's legs. The upper body also houses the main gear, that transfers motion from the drive servo motor to both of the linear actuators.

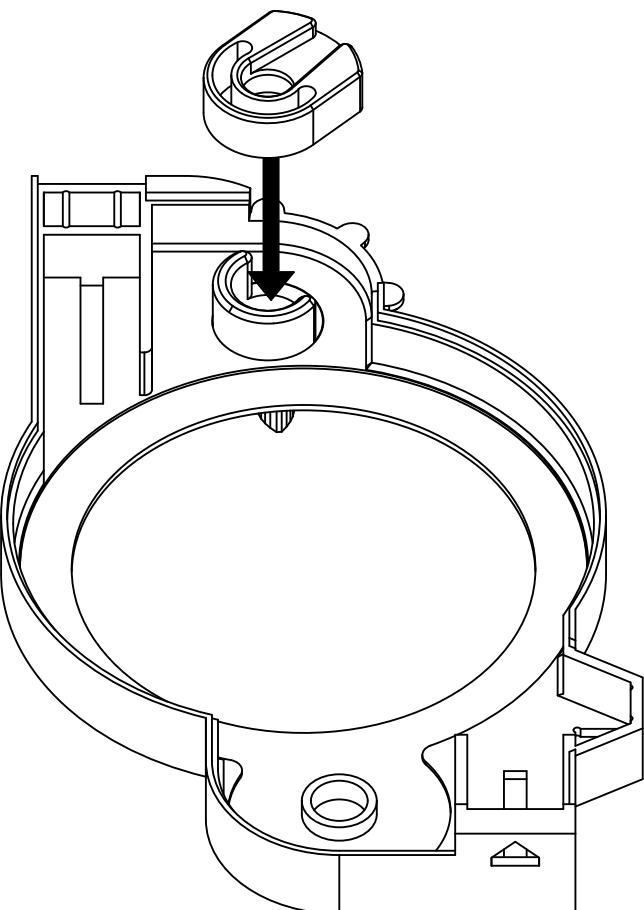
Step 1:

Steering gear assembly

1.1

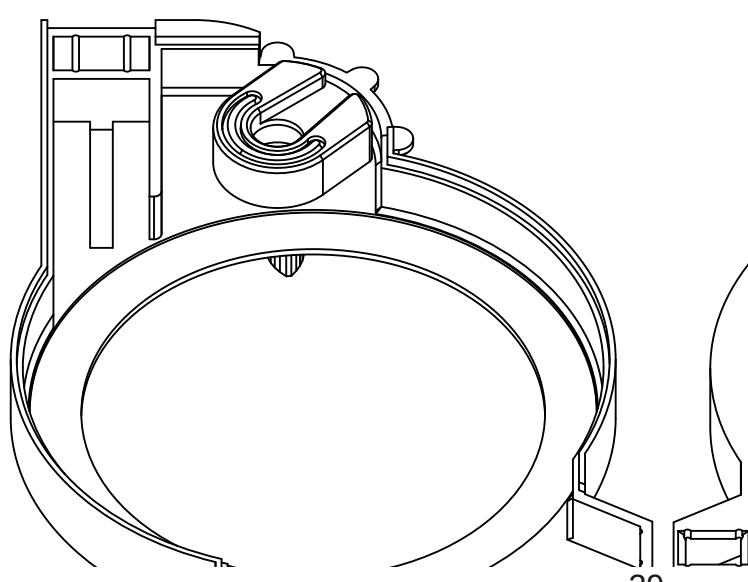


1.2



Top view

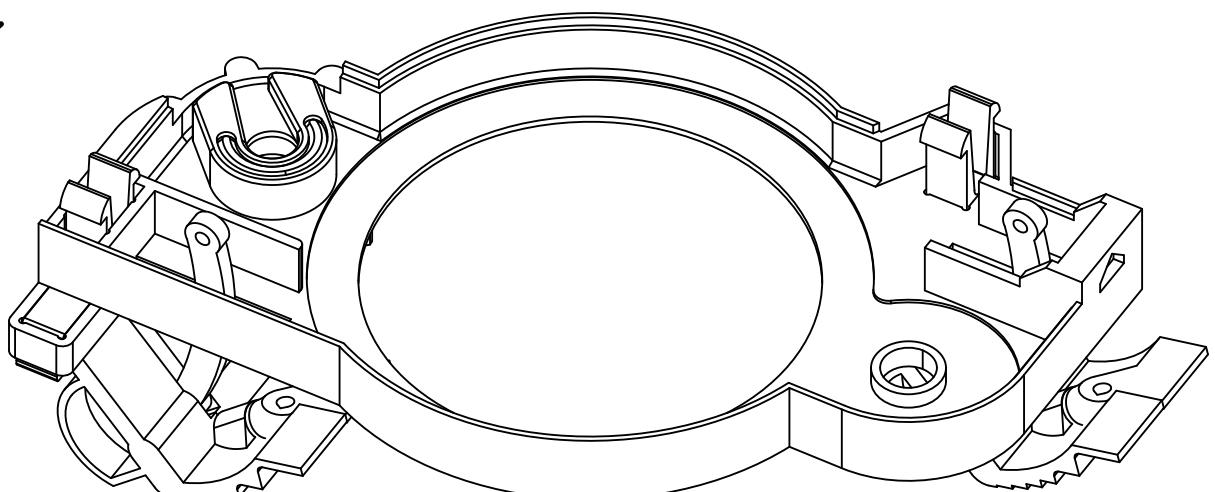
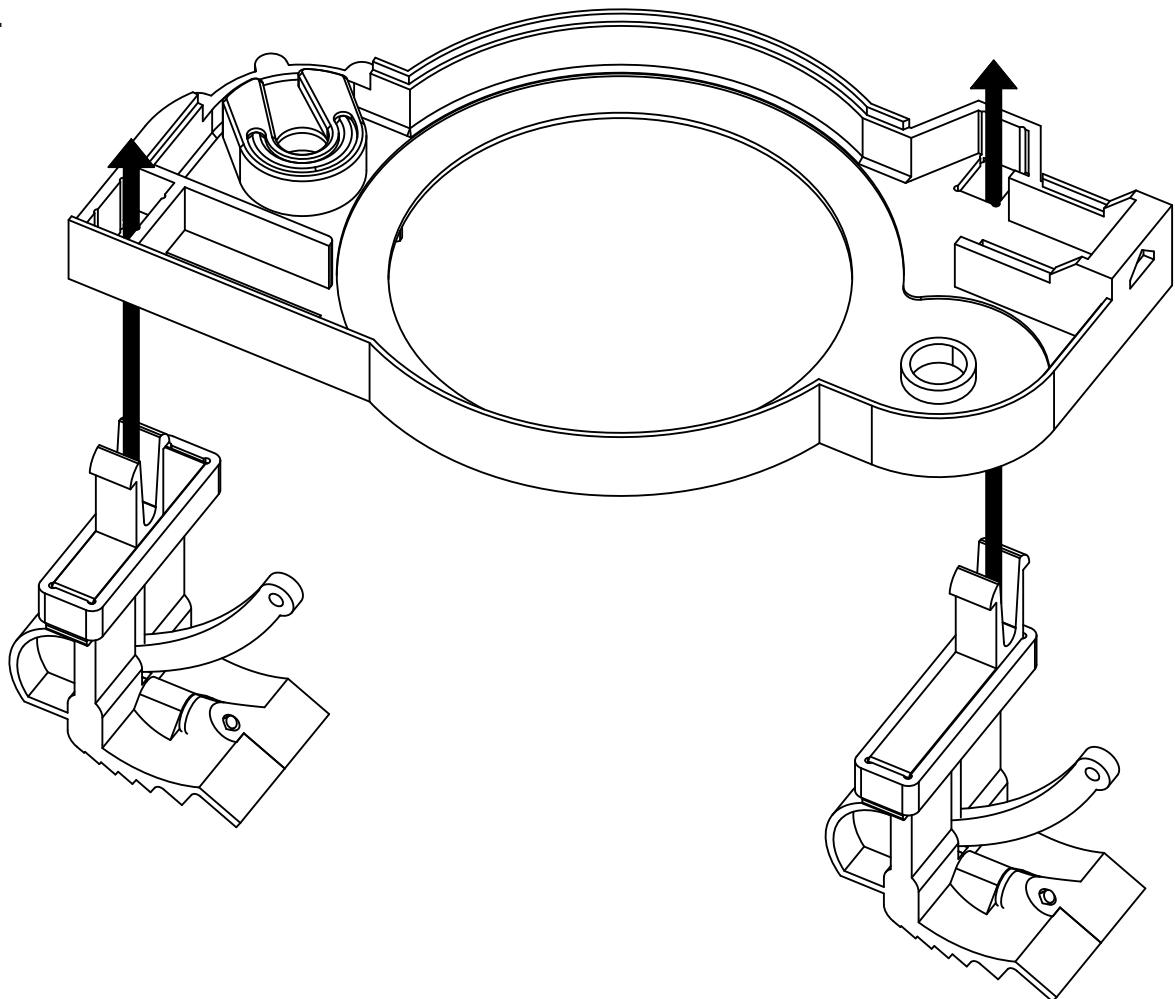
Bottom view



Step 2:

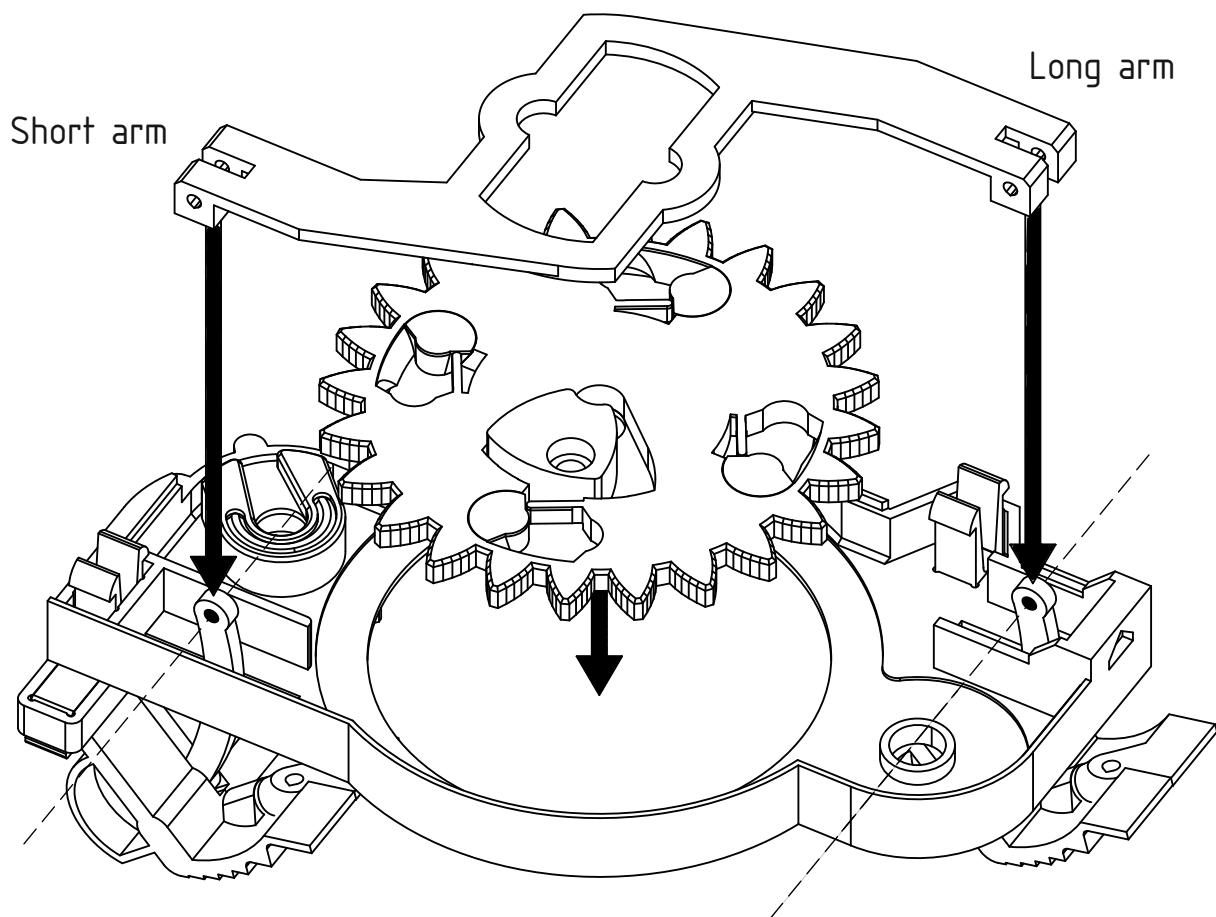
Attaching leg connectors

2.1



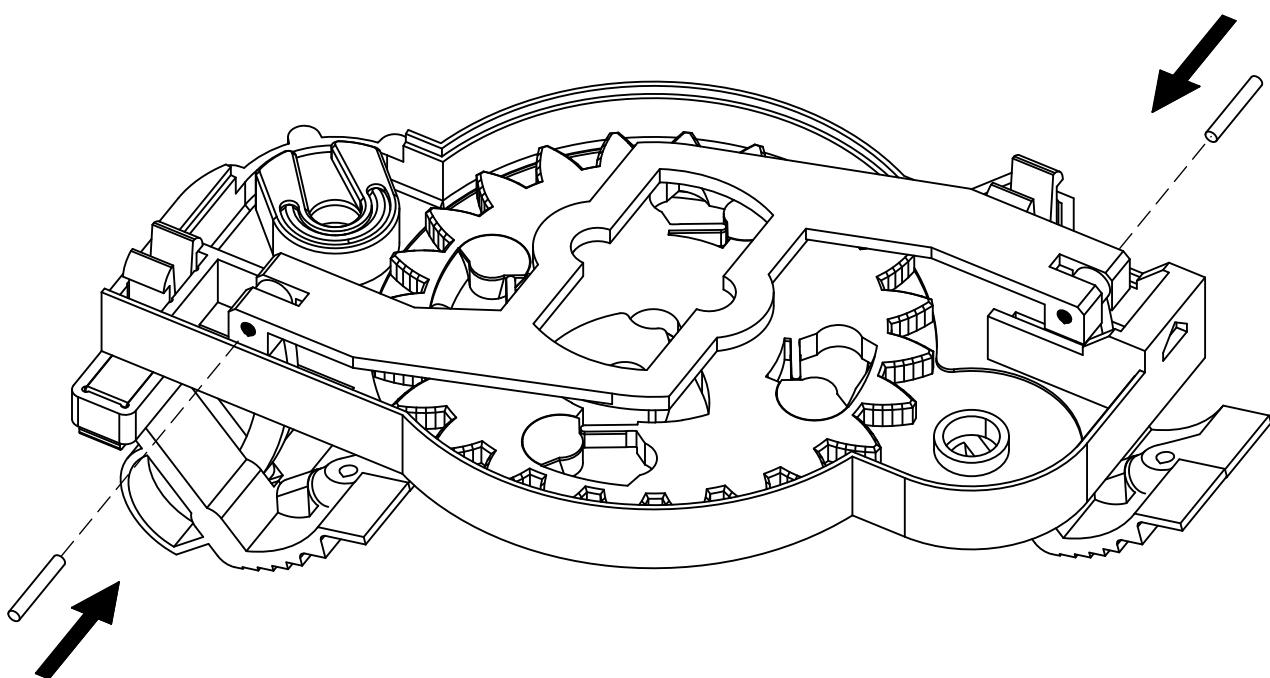
Step 3:

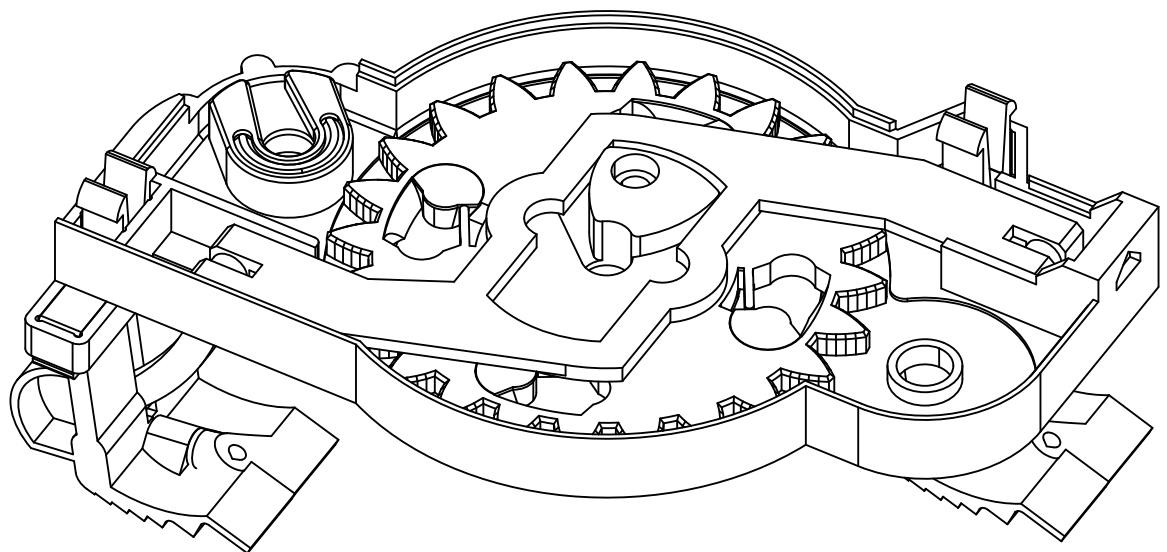
Placing main gear / Lining up linear actuator with leg levers



Step 4:

Joining legs and linear actuator using filament



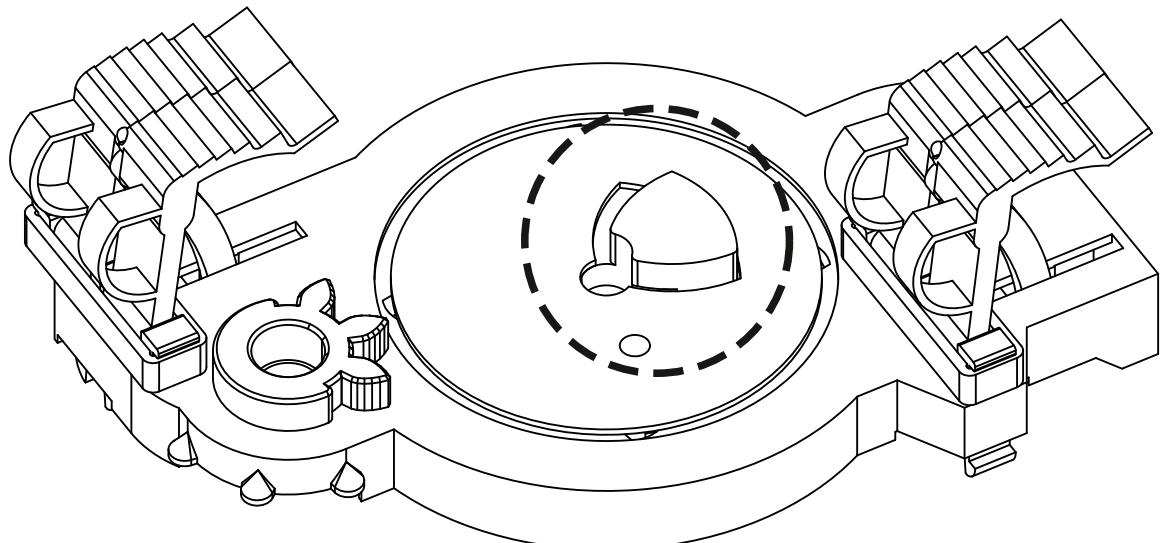


Final note

In the next Section, the upper and lower body will be connected by the main gear axle.

The function of the main gear is to drive both the linear actuator located in the upper body and the one located in the lower body.

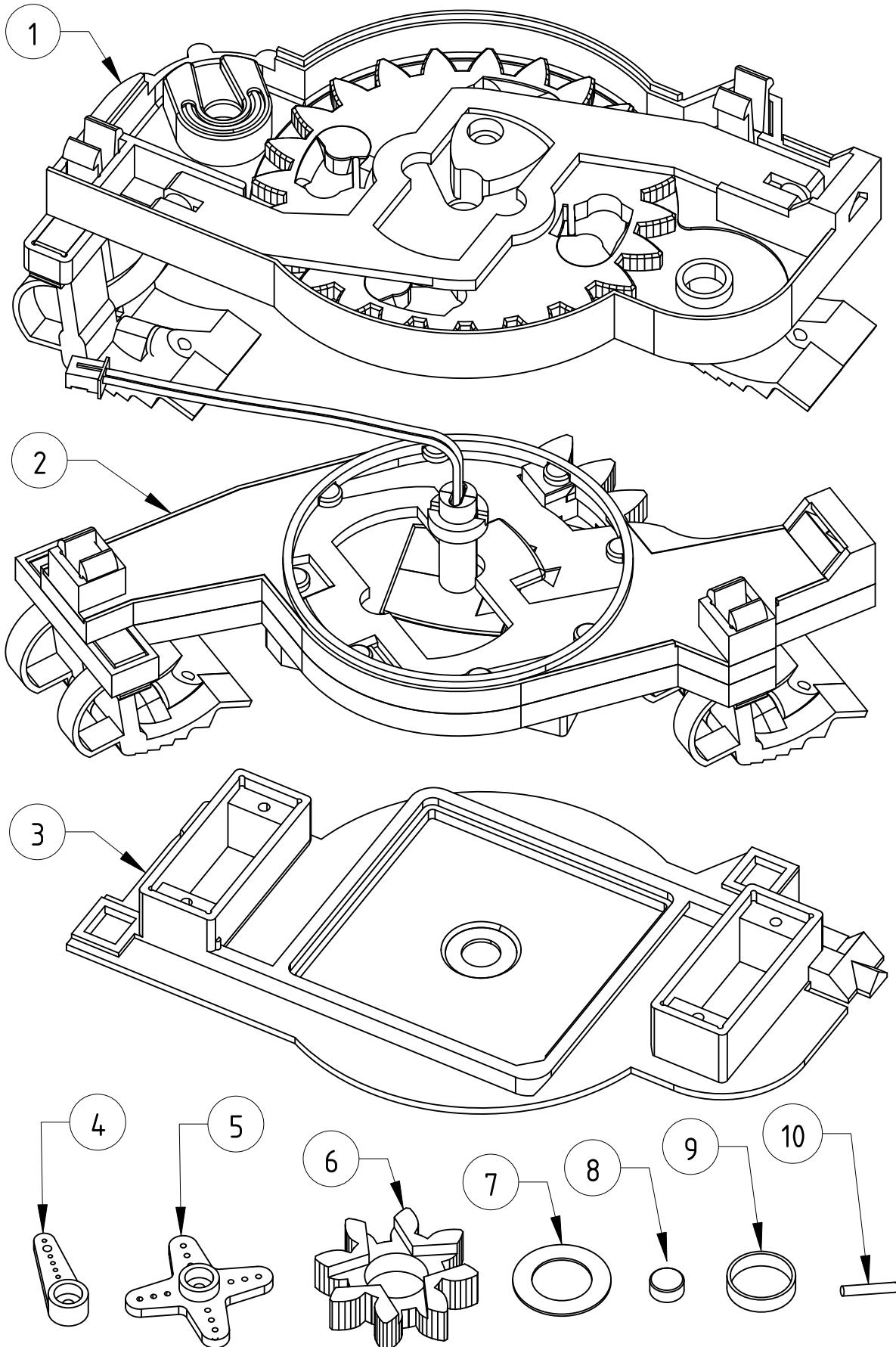
When viewed from below, one can see the bottom cam of the main gear, which will drive the lower body actuator.



Bottom view

Section 9:

Final mechanical assembly



MATERIALS

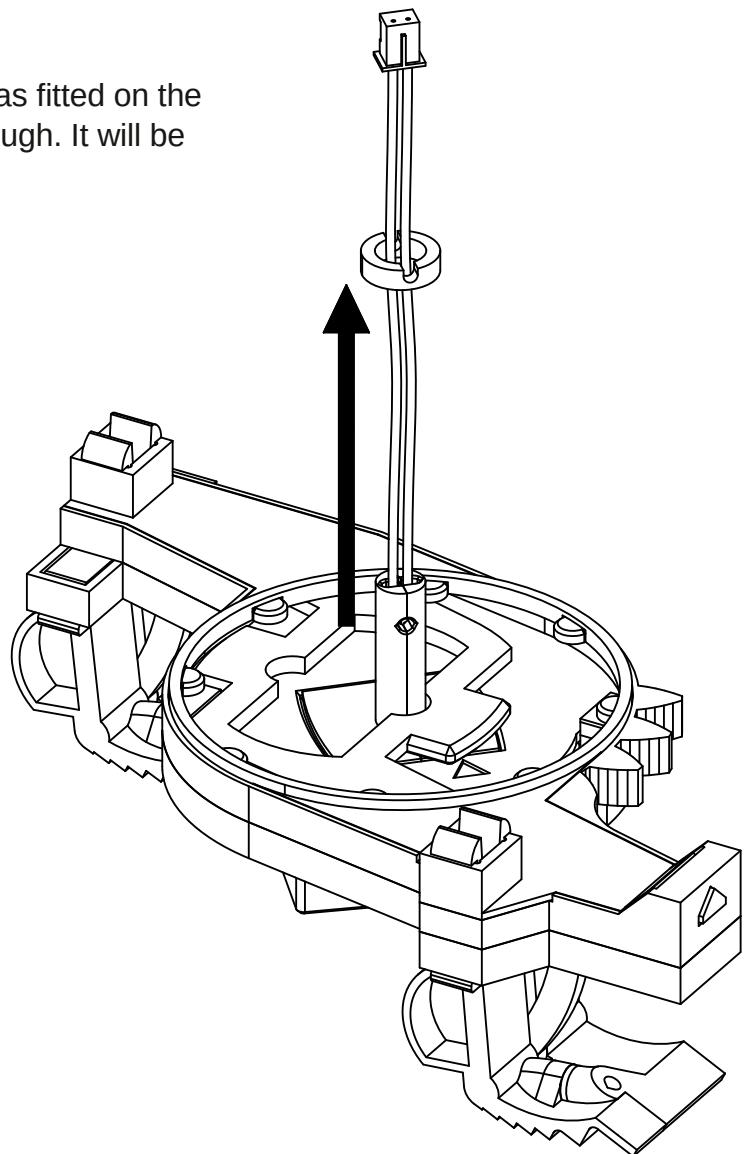
- 1: Upper body partial assembly
- 2: Lower body full assembly
- 3: Upper body lid
- 4: Servo horn
- 5: Servo horn, cross shape
- 6: Drive gear
- 7: Drive gear washer
- 8: Neodymium magnet, 6 mm in diameter
- 9: Ring nut sleeve
- 10: Filament, 10 mm in length

Purpose

In this section, the mechanical parts of the robot will be fully assembled.

Before starting

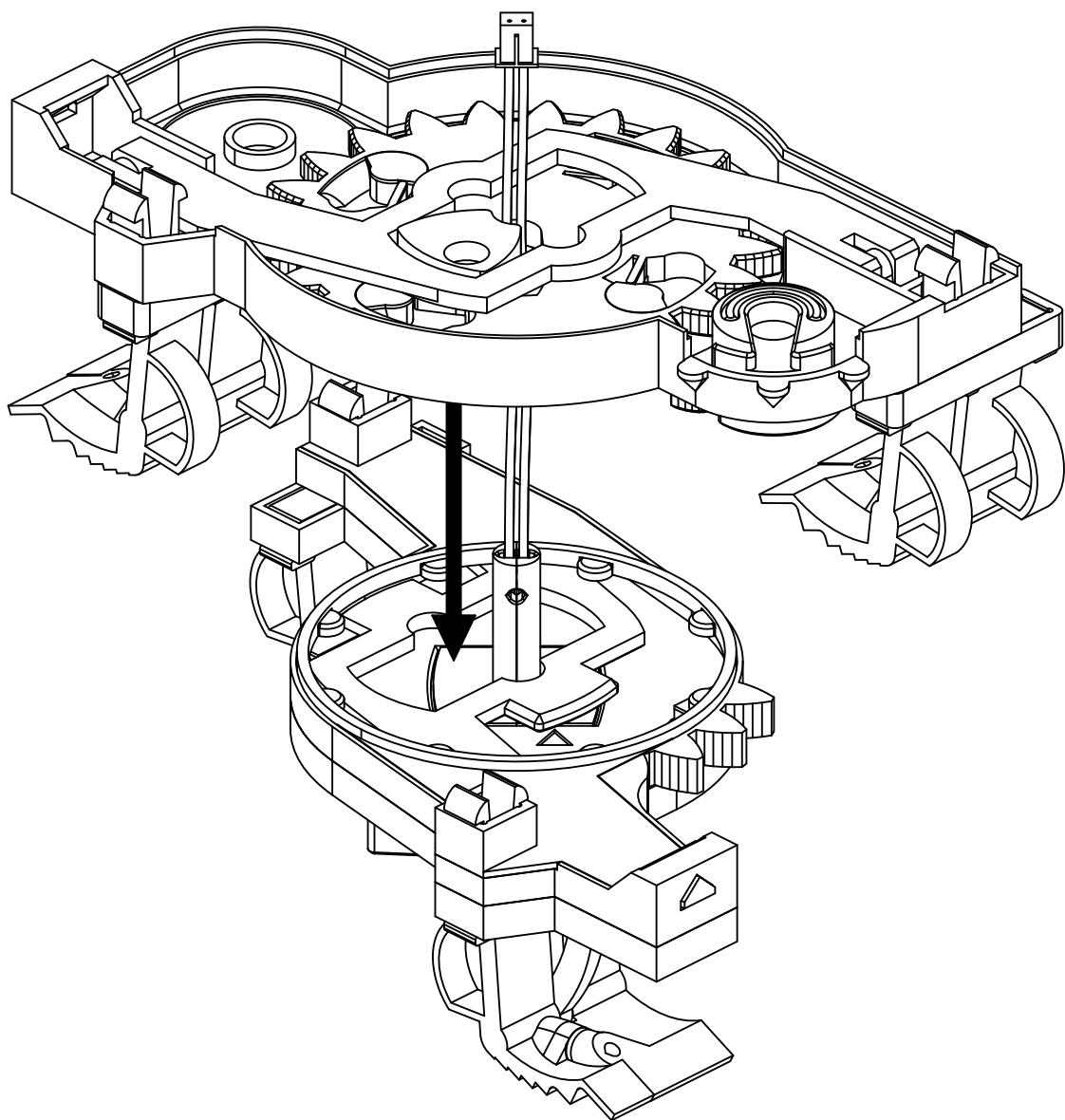
Temporarily remove the ring nut that was fitted on the lower body gear axle. Don't loose it though. It will be required in Step 4.



Step 1:

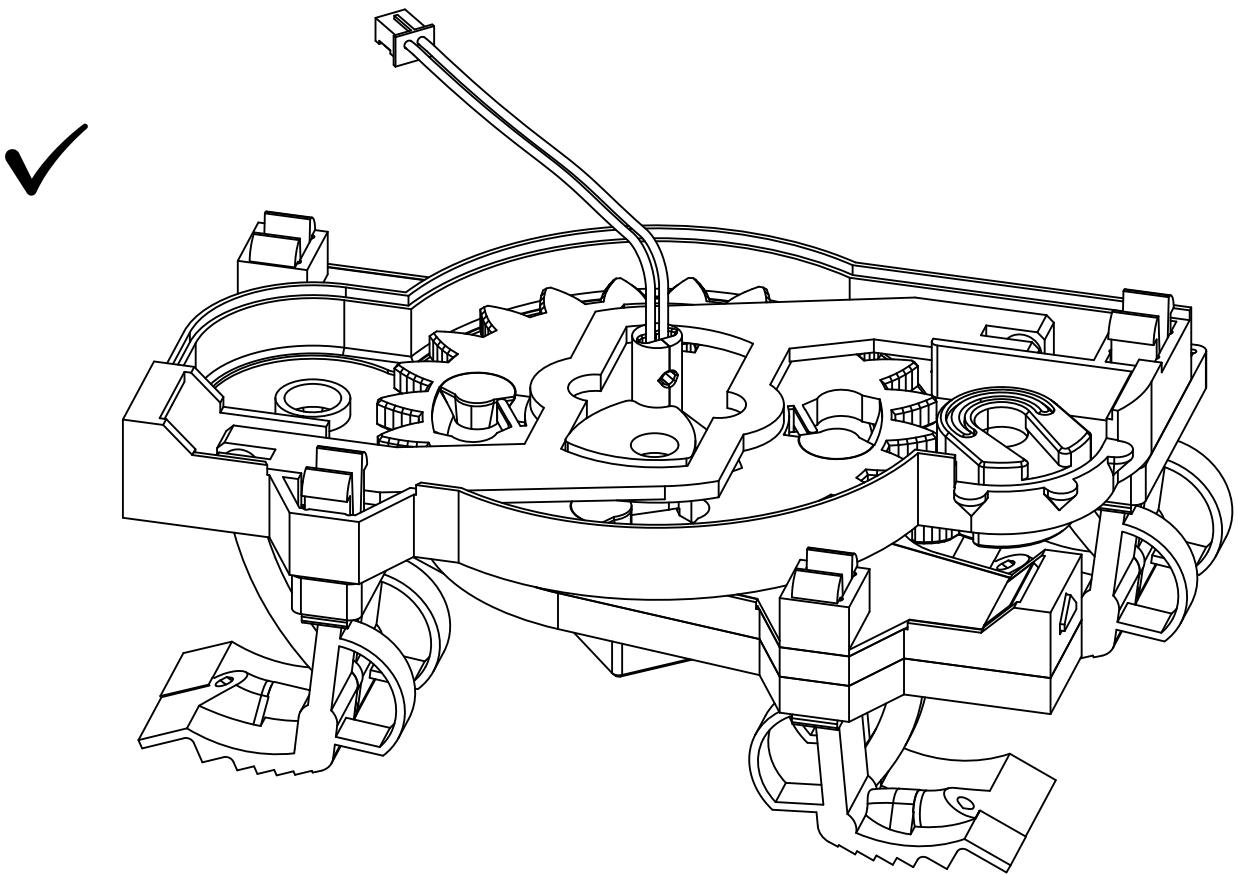
Connecting upper and lower body

1.1



Note the orientation of the main gear and the position of the lower body linear actuator. When positioned like this, the bottom cam of the main gear will slot into the linear actuator cutout.

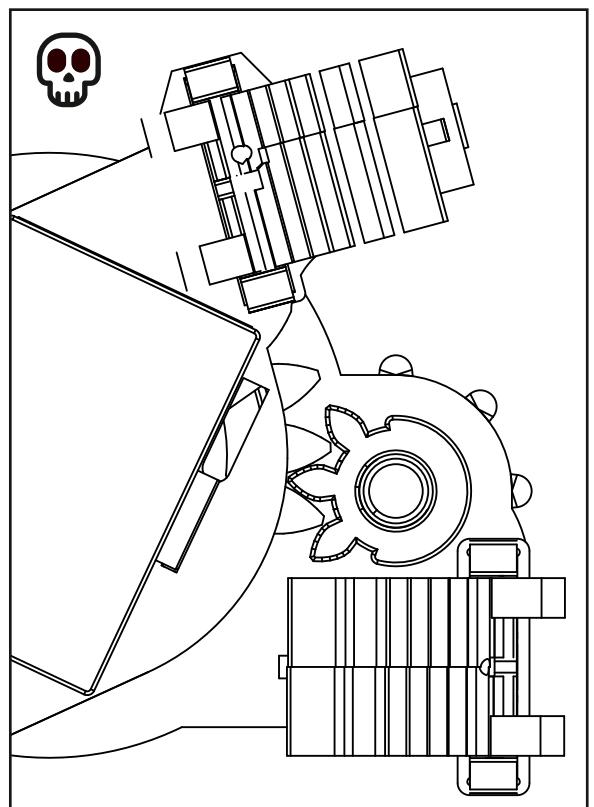
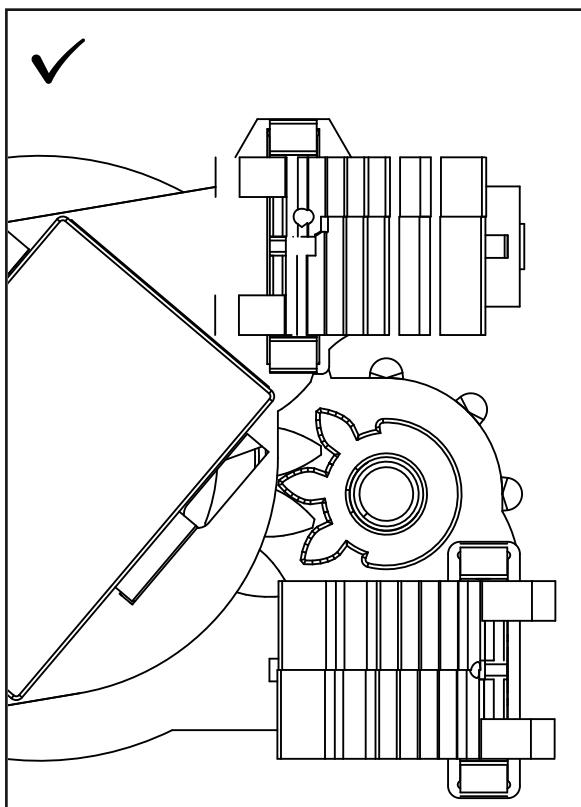
Otherwise, try turning the main gear by hand to make the pieces fall into place.



! **Before proceeding:**

The steering gear must interlock correctly with the gear rack on the lower body. Study the two images below carefully. The image on the left illustrates the correct interlock position of the gear teeth.

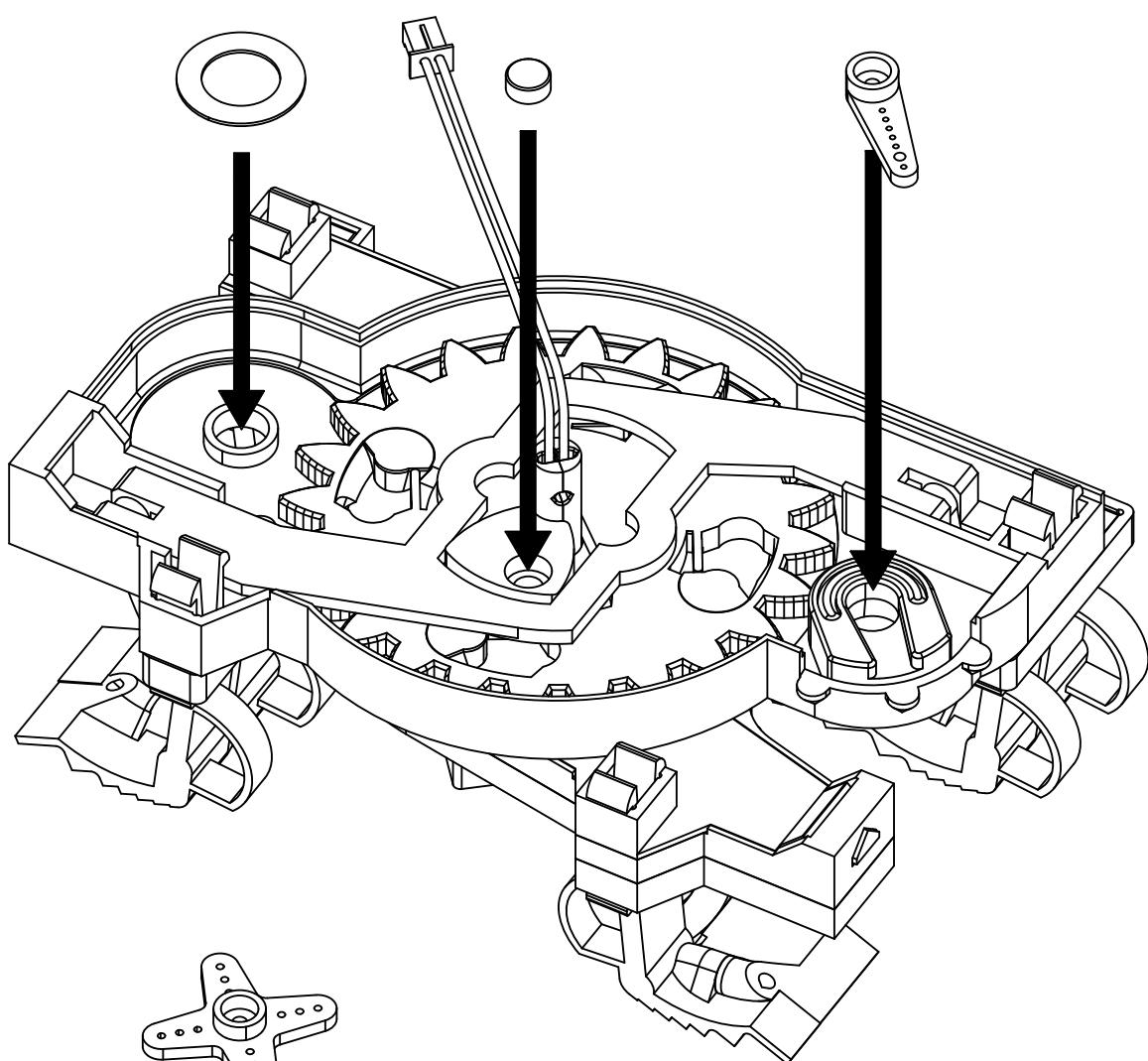
If the assembled parts does not correspond to the left image, return to Step 1.1.



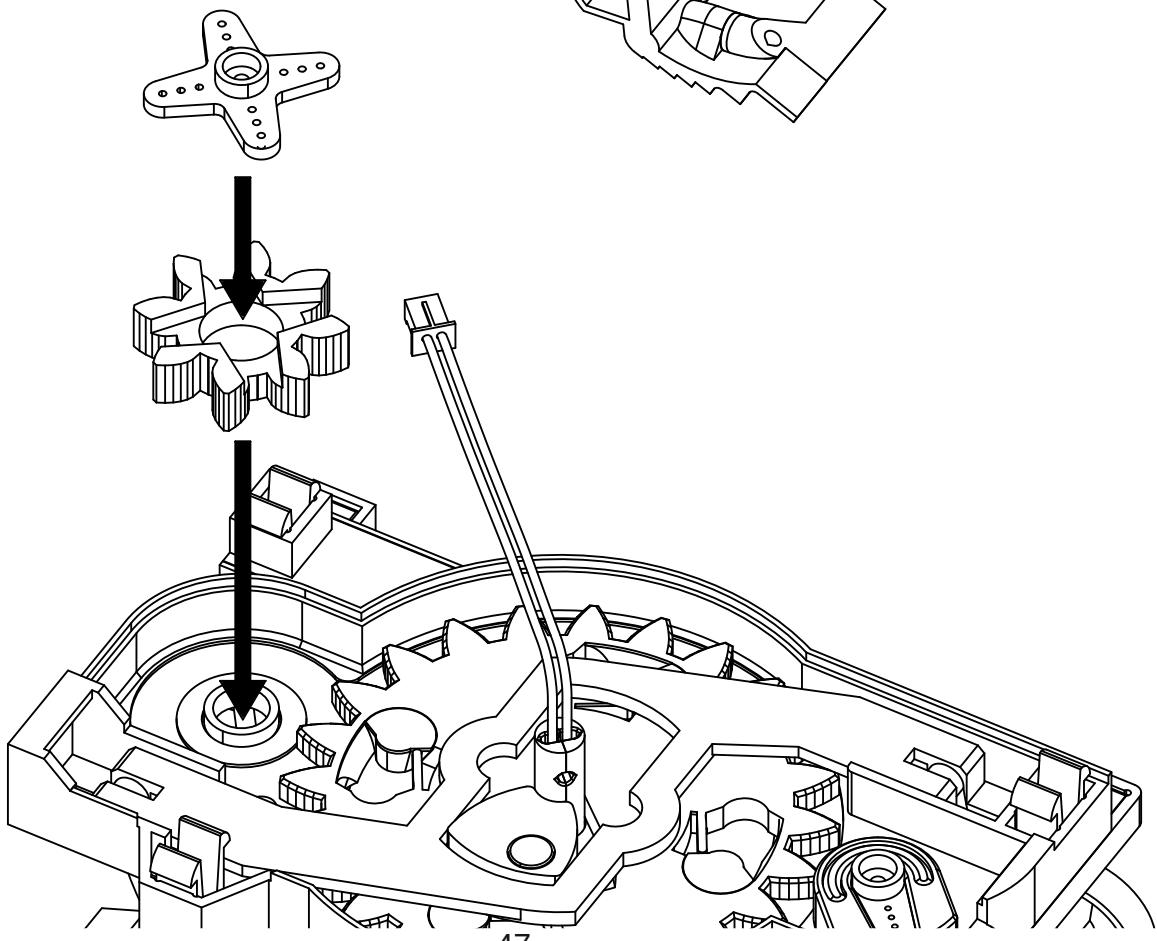
Step 2:

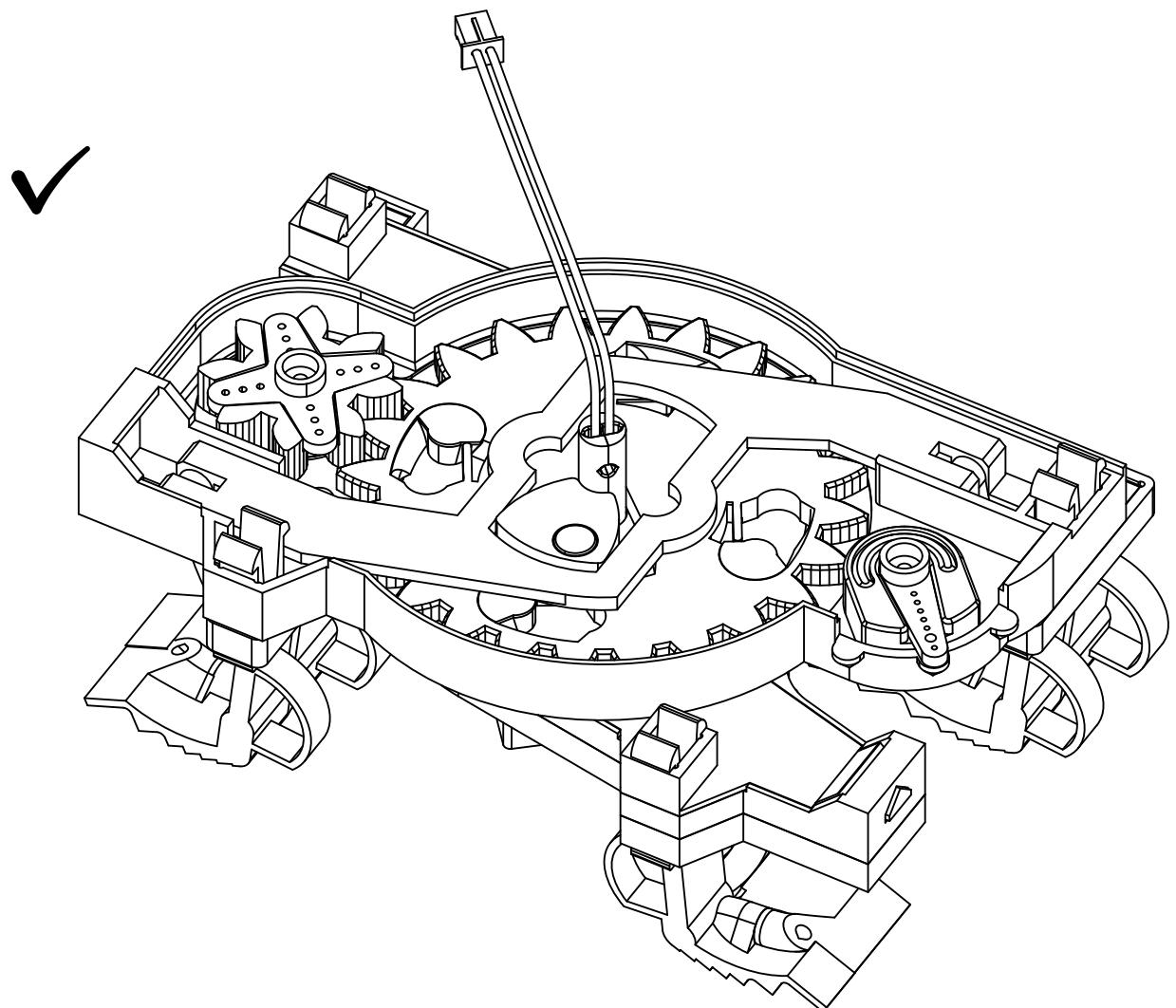
Placing washer, magnet, servo horns and drive gear

2.1



2.2

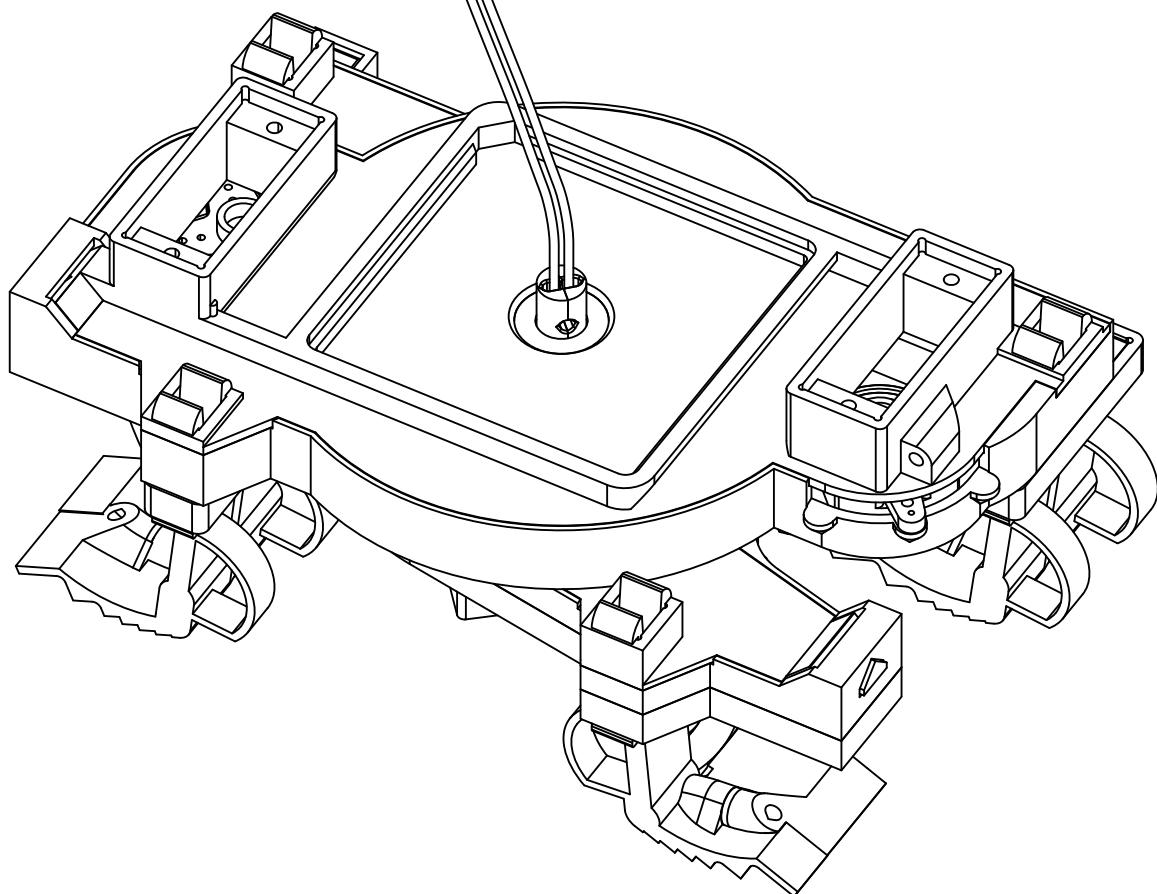
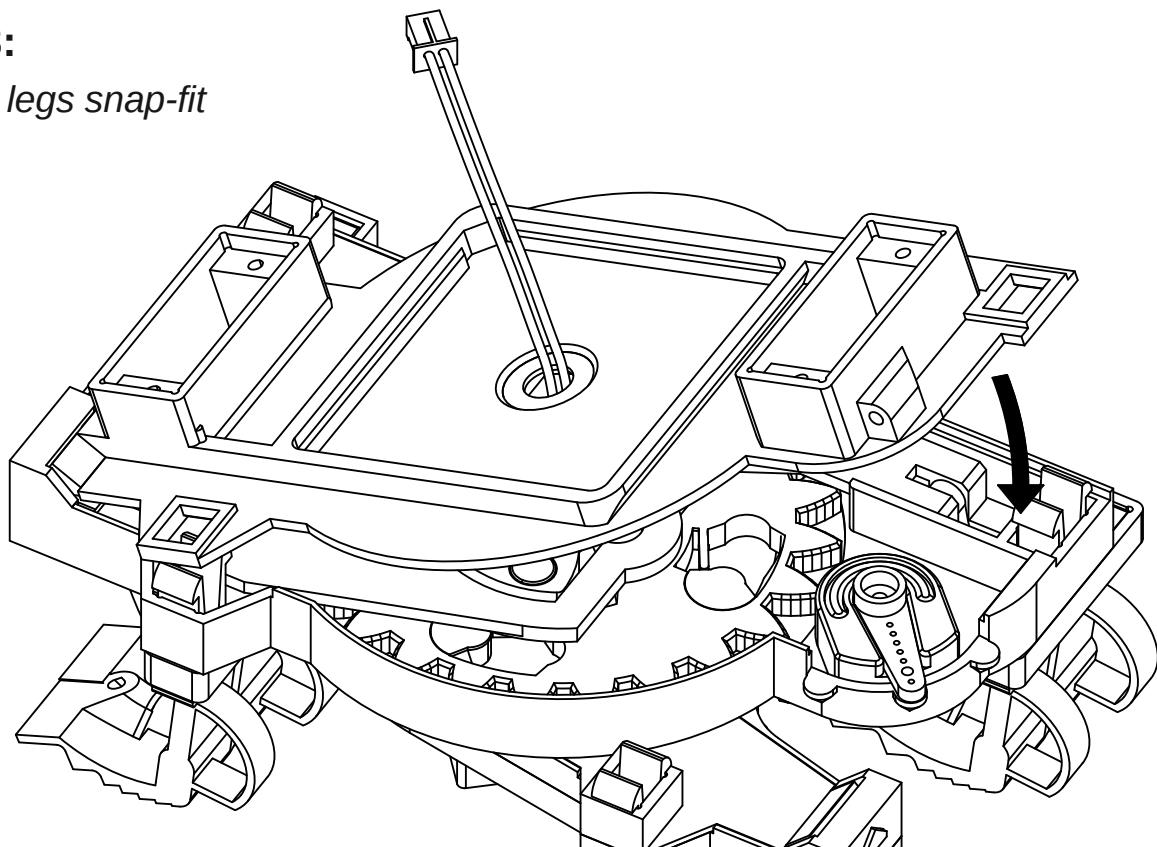




Step 3:

Lid and legs snap-fit

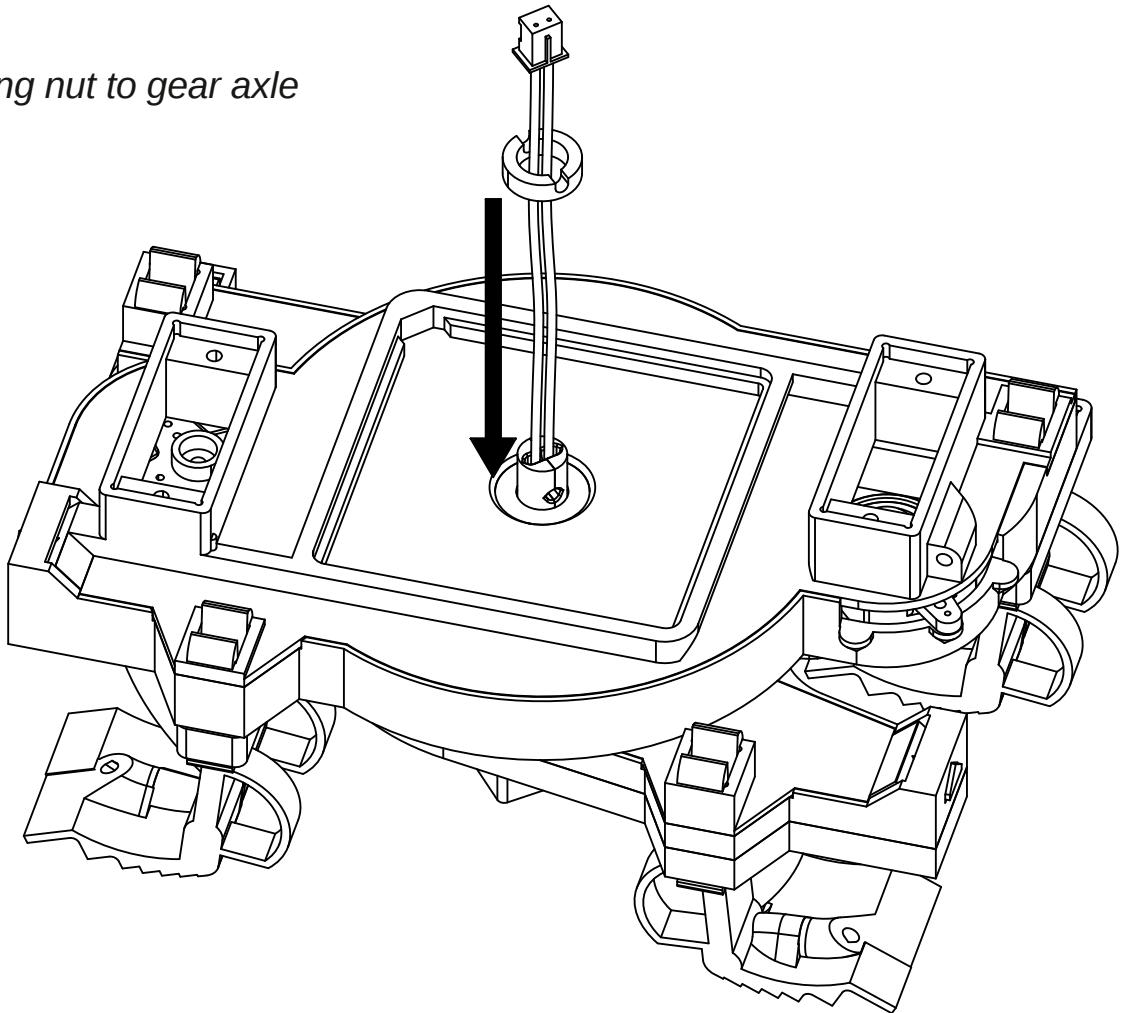
3.1



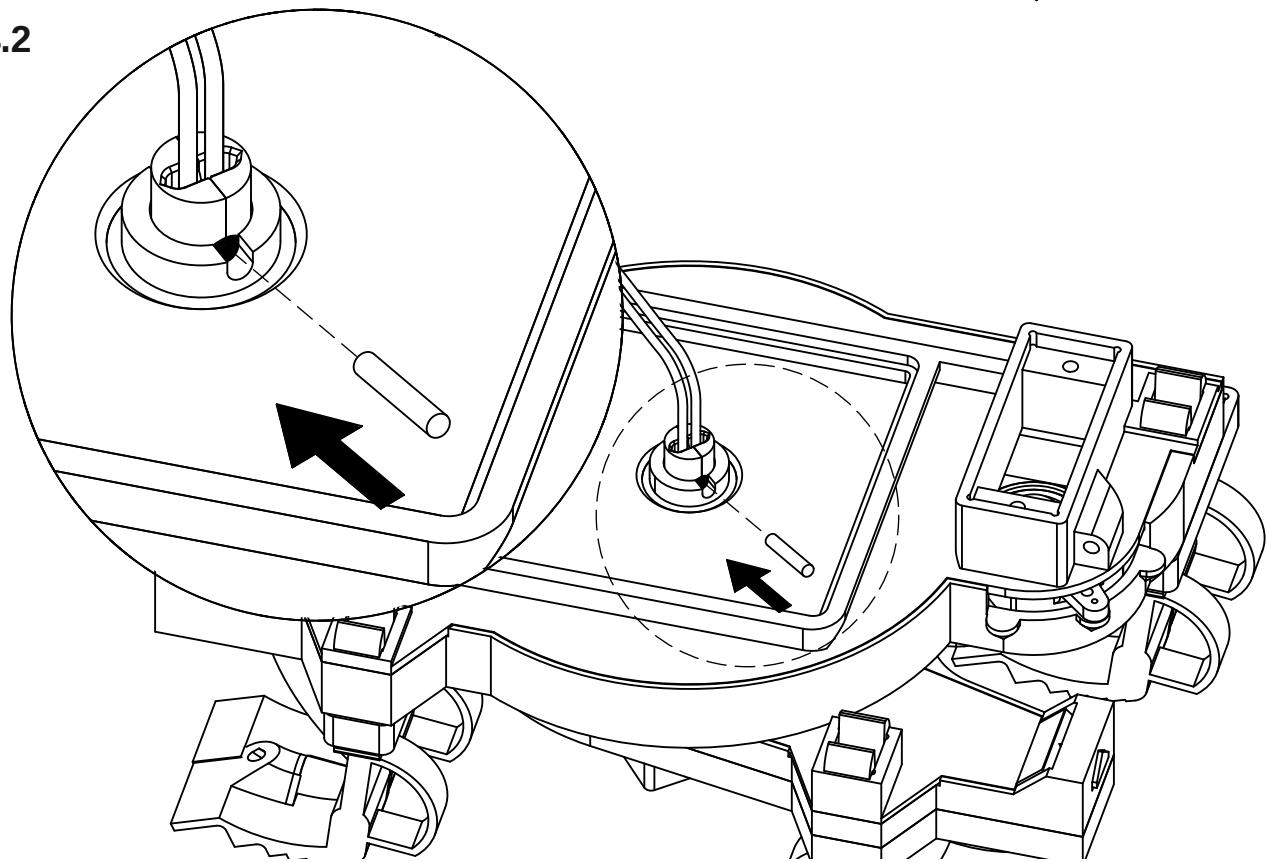
Step 4:

Locking ring nut to gear axle

4.1

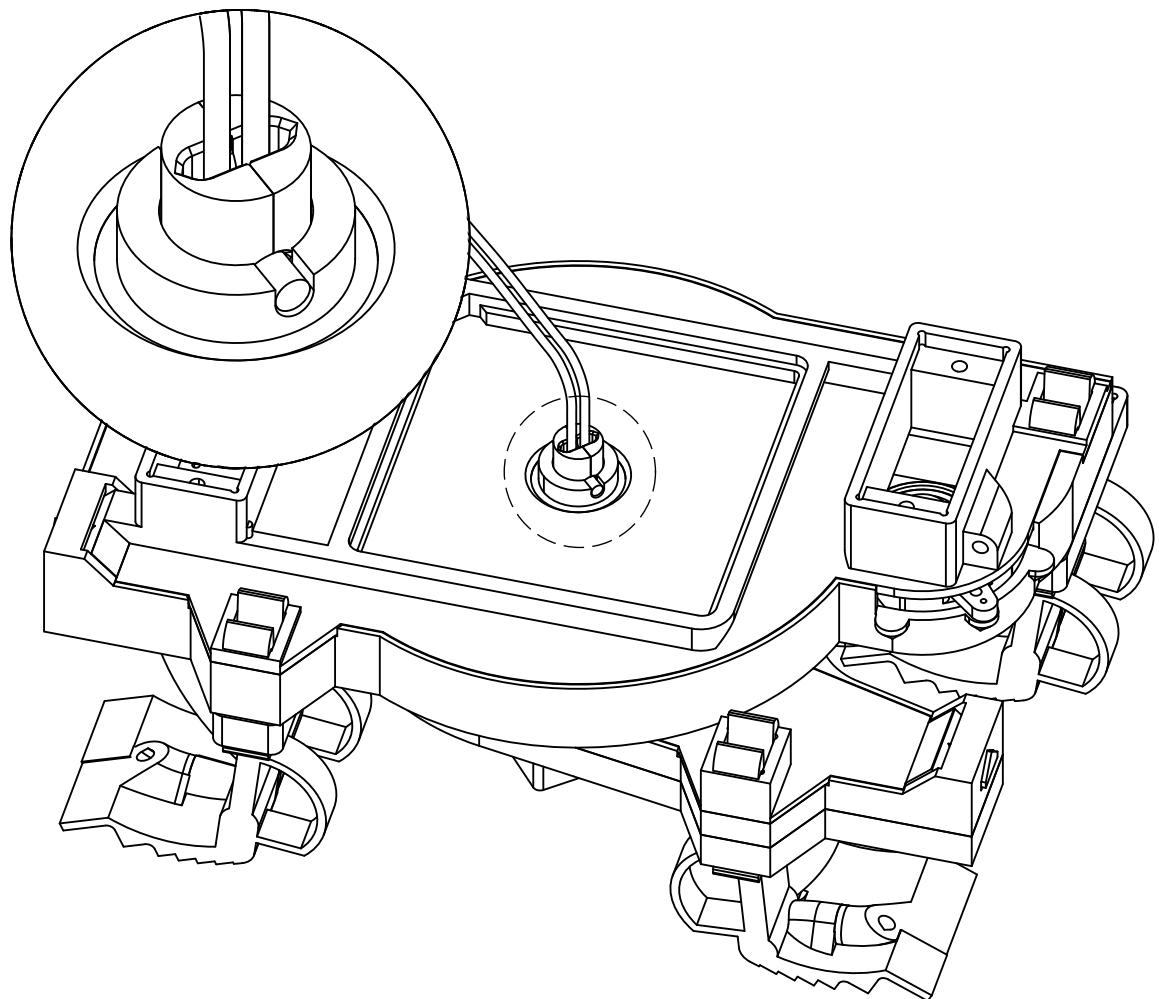


4.2



It might be somewhat difficult to insert the filament through the gear axle. If this is the case, try cutting the filament at an angle so that it forms a sharp point.

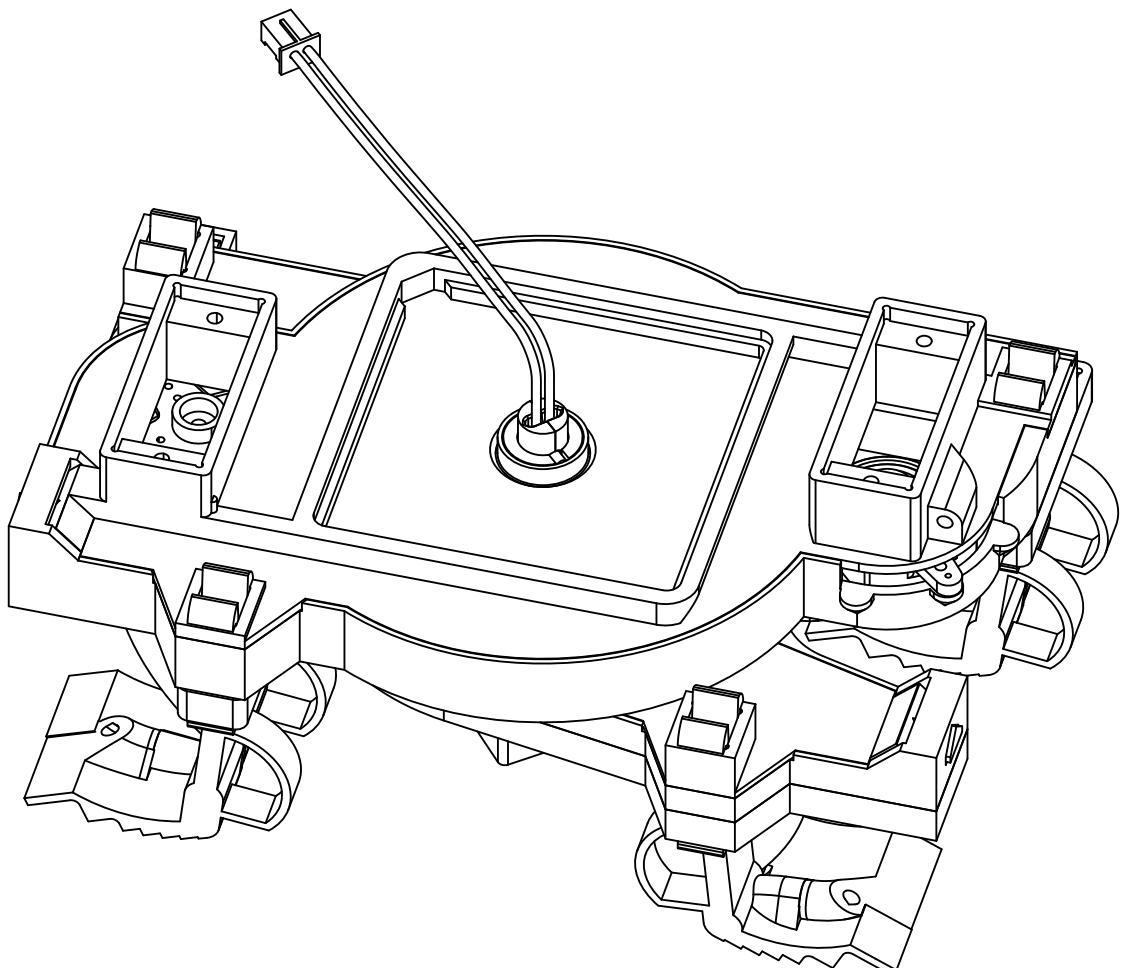
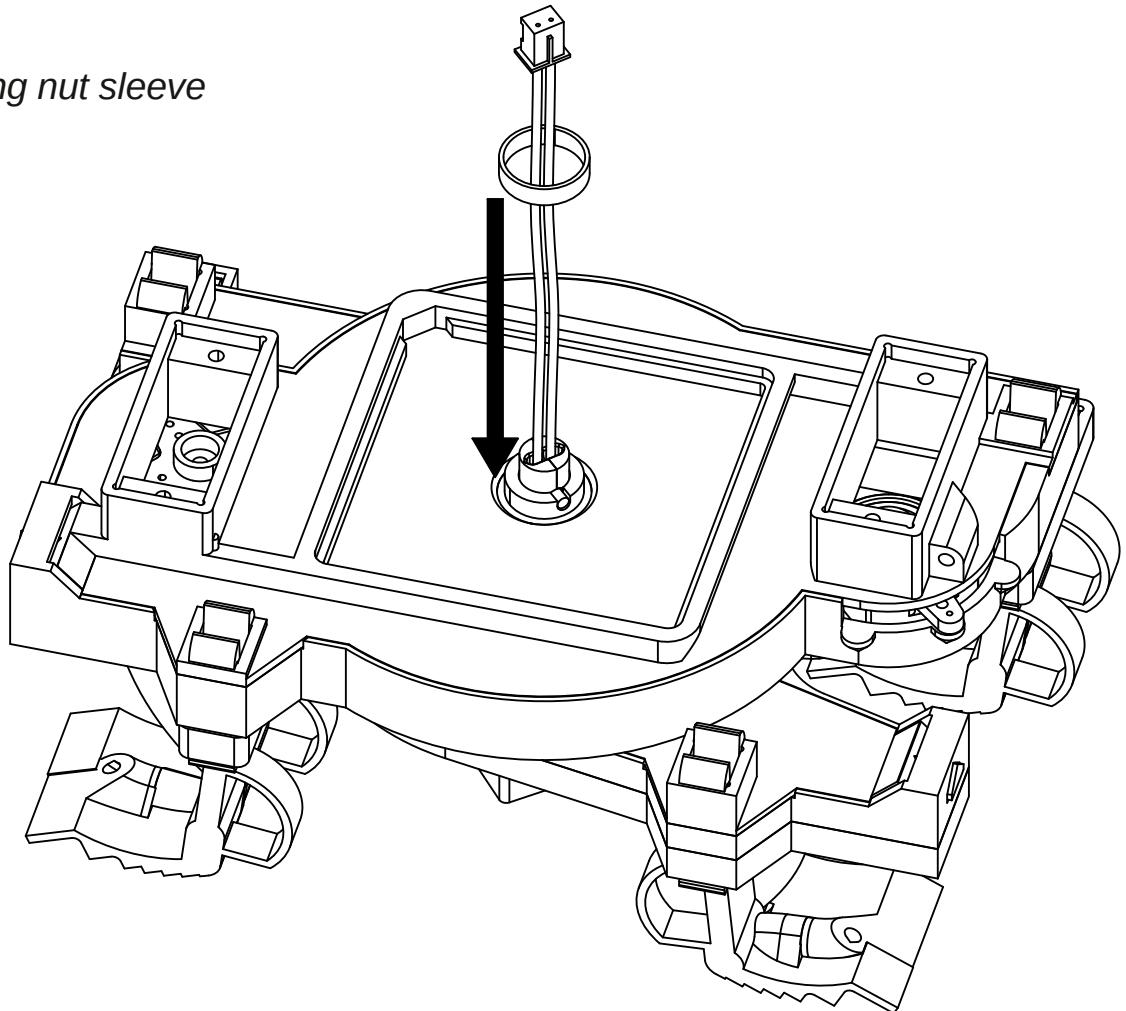
✓



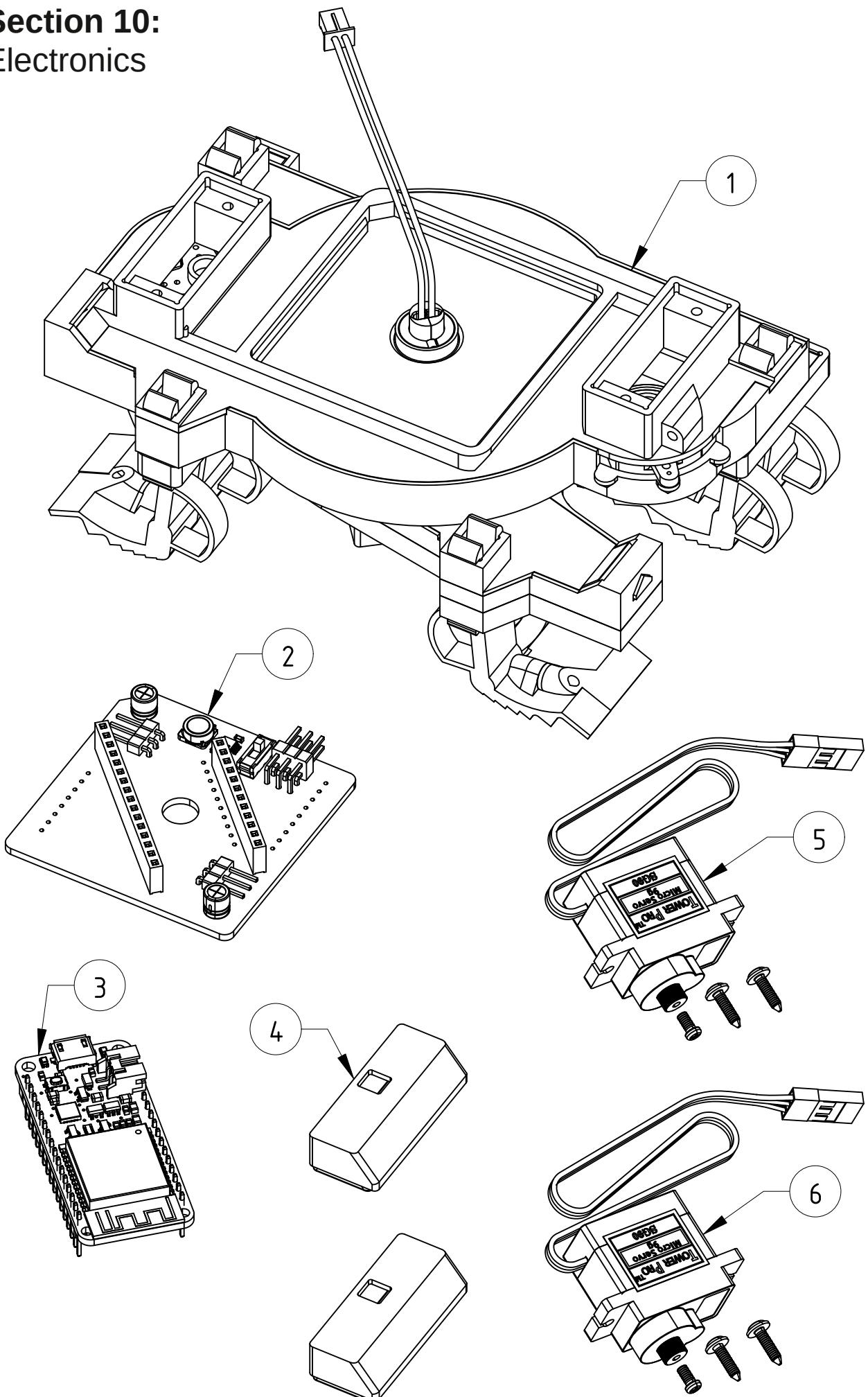
Step 5:

Placing ring nut sleeve

5.1



Section 10: Electronics



MATERIALS

- 1: Tardygrade mechanical assembly
- 2: Tardygrade motherboard PCB
- 3: "Adafruit HUZZAH 32" microcontroller board
- 4: 2x Slider blocks
- 5: Micro servo, 360° continuos rotation
- 6: Micro servo, 180° rotation

Purpose

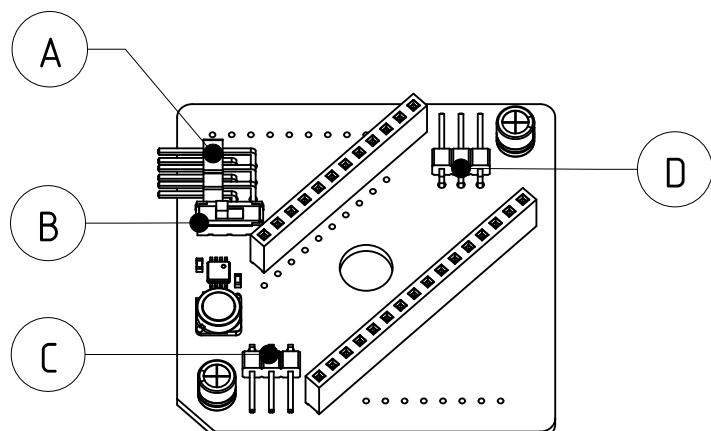
In this section, the electronics and servo motors will be fitted to the robot's mechanical frame. This is the final part of the assembly process.

Electronics boards

The robot's control electronics consists of two printed circuit boards:

The motherboard (item 2) provides physical interface and power regulation for two servo motors. It also has four magnet sensors for determining the position of the robot's main gear.

The microcontroller board (item 3) provides WiFi connectivity and acts as the robot's "brain". It has circuitry for charging the robot's battery via a usb port. The microcontroller board connects to the Tardygrade motherboard by two parallel pin sockets.

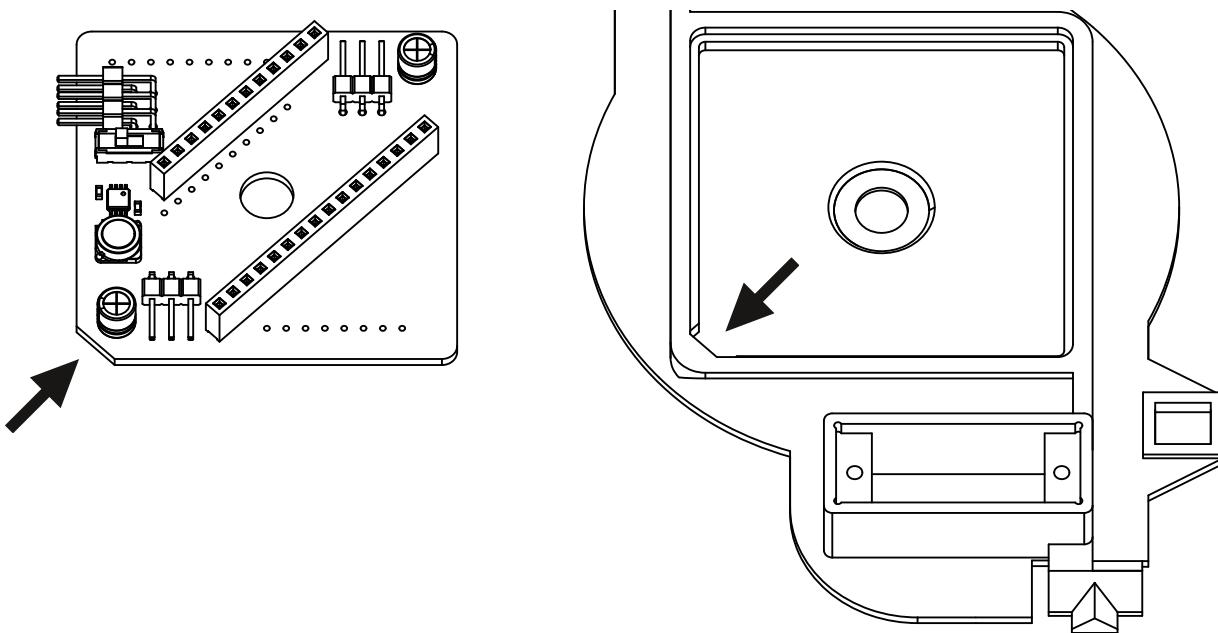


MOTHERBOARD PCB

- A: Connector for distance sensors (Not covered in this document)
- B: Power switch
- C: Connector for 360° servo
- D: Connector for 90° servo

Motherboard PCB orientation

In Step 1 of this section, the motherboard PCB will be fitted inside the square socket on the top lid of the robot. Note that the PCB and the PCB socket has one chamfered corner each. This is to prevent the PCB from being mounted at an incorrect orientation.

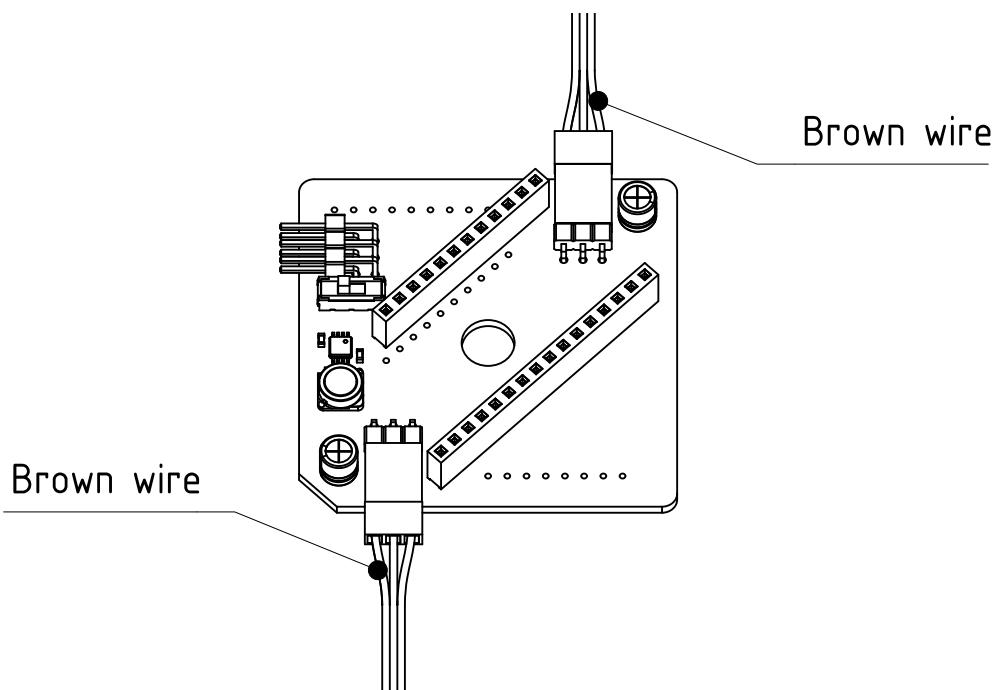


Connecting servo motors

Each servo motor has a cable that terminates in a 3-pin socket. The socket connects to a pin header on the motherboard PCB. The cable wires are colored yellow (signal), red (5V) and brown (ground).

Note that it is possible to connect a servo cable with the socket turned "upside down", in which case the servo will not work.

The left image below shows the correct orientation of the connectors. On both servo cables, the brown (ground) wire faces outward.

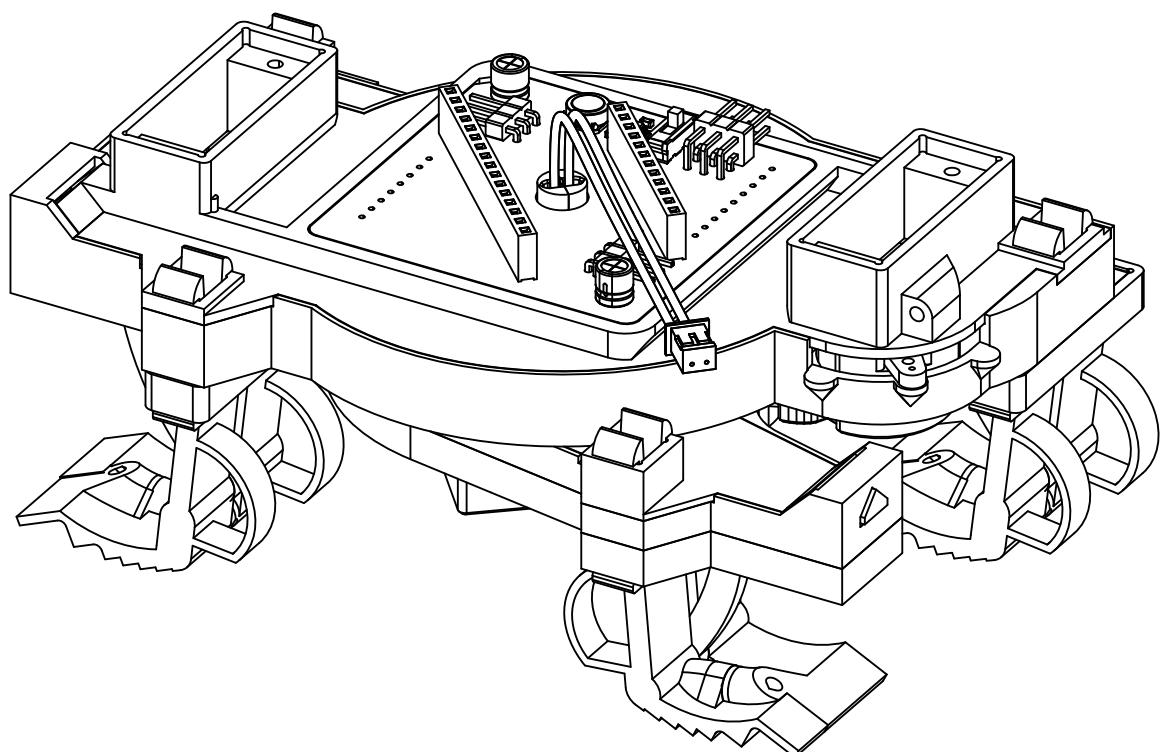
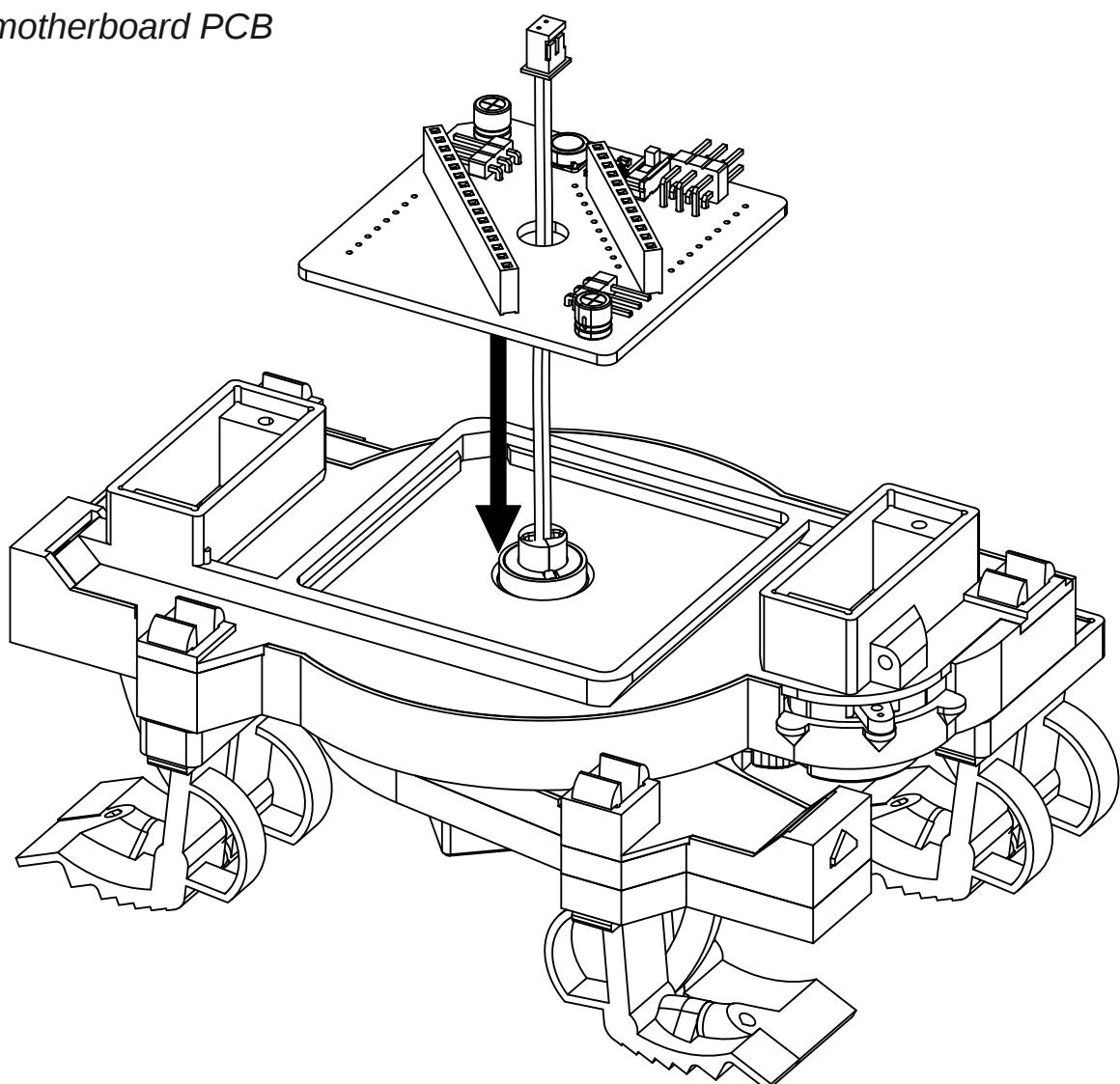


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Step 1:

Mount motherboard PCB

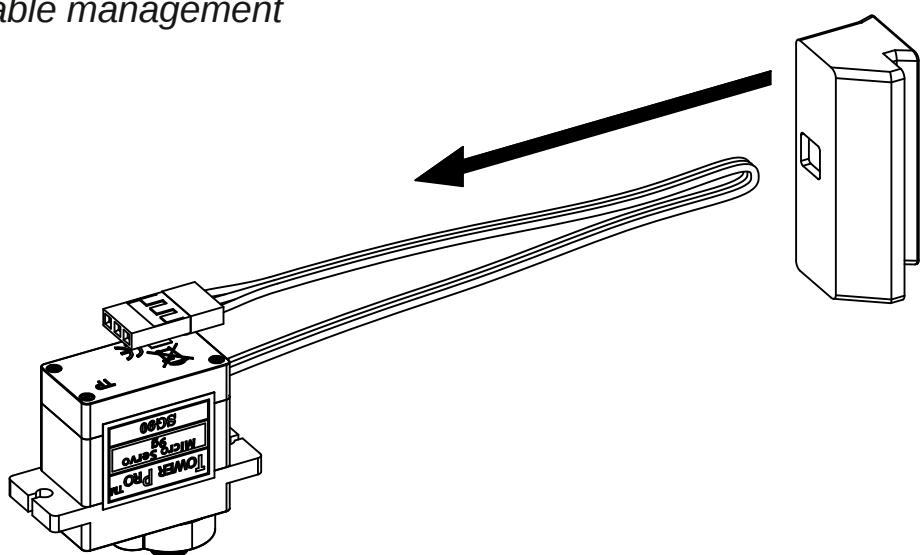
1.1



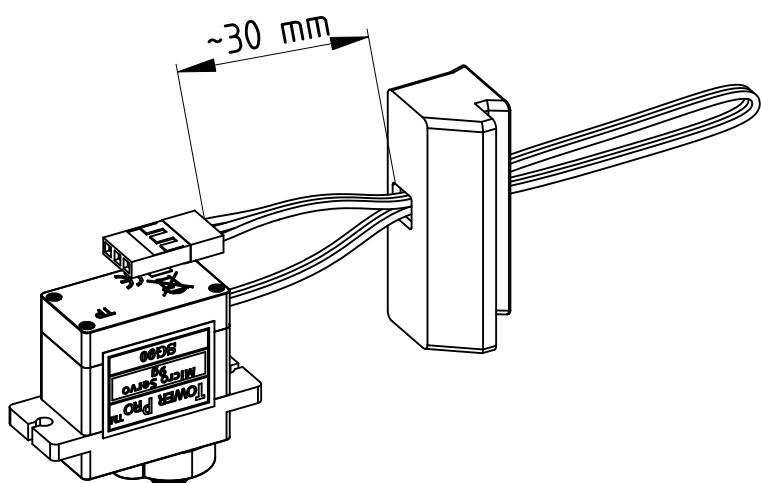
Step 2:

Servo cable management

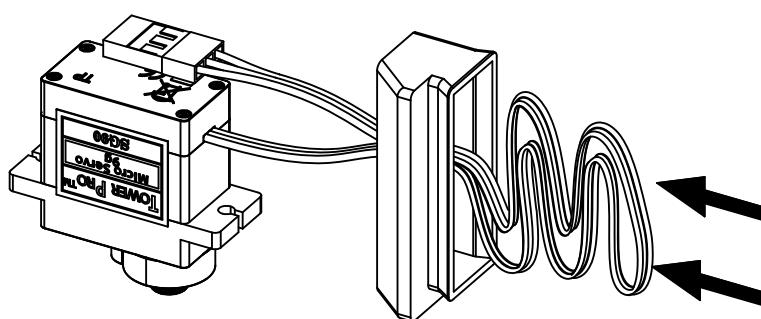
2.1



2.2



2.3



Fold the excess cable
into the slider block.

Step 3:

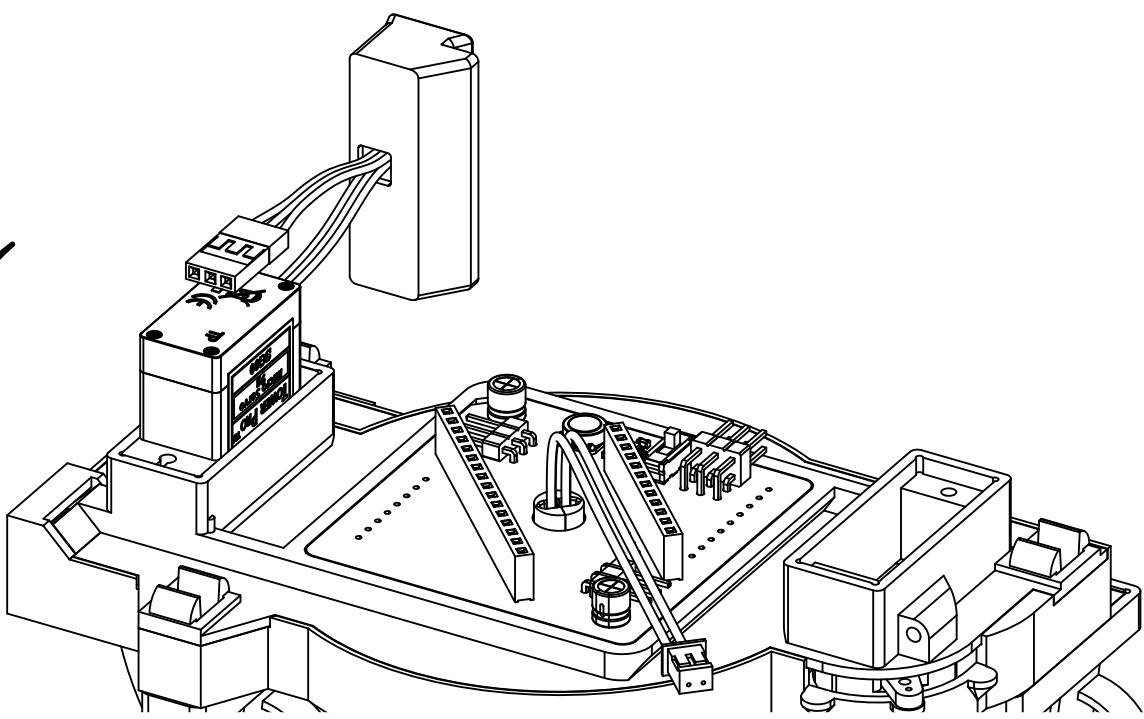
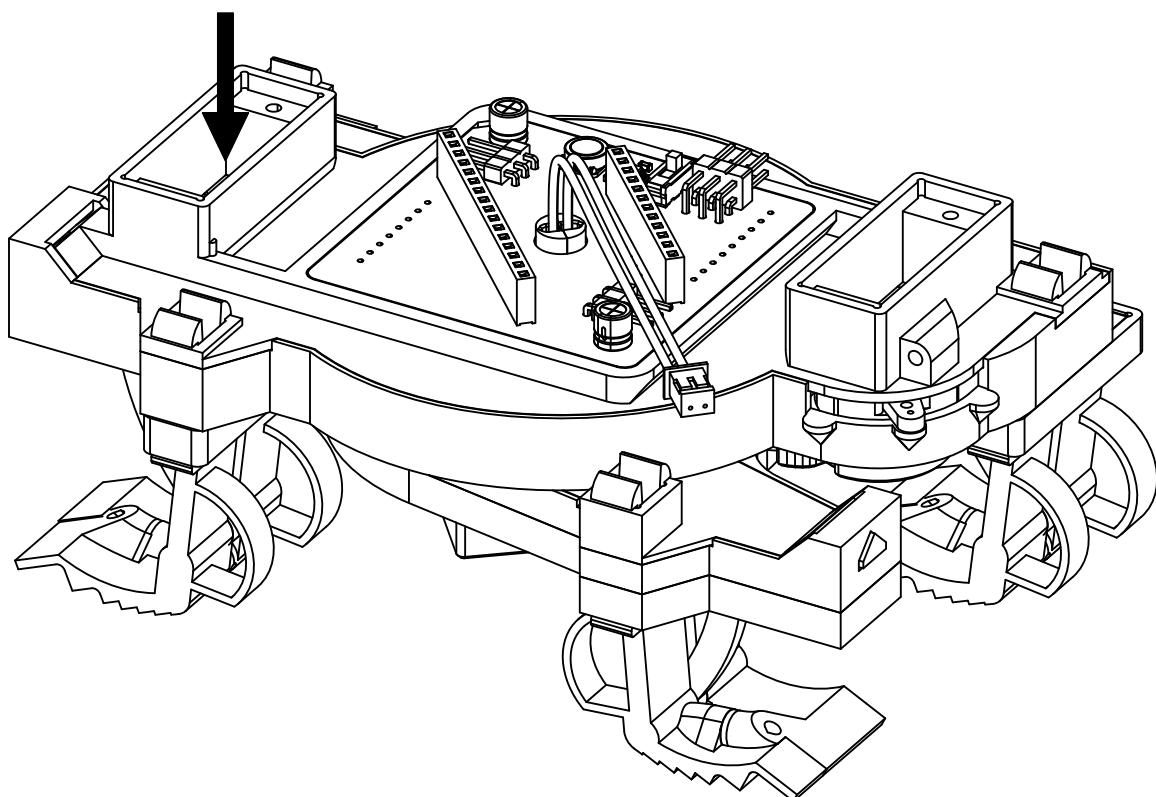
Seating 360° servo in drive gear socket



Important note

For this step, make sure to use the 360° continuos servo.

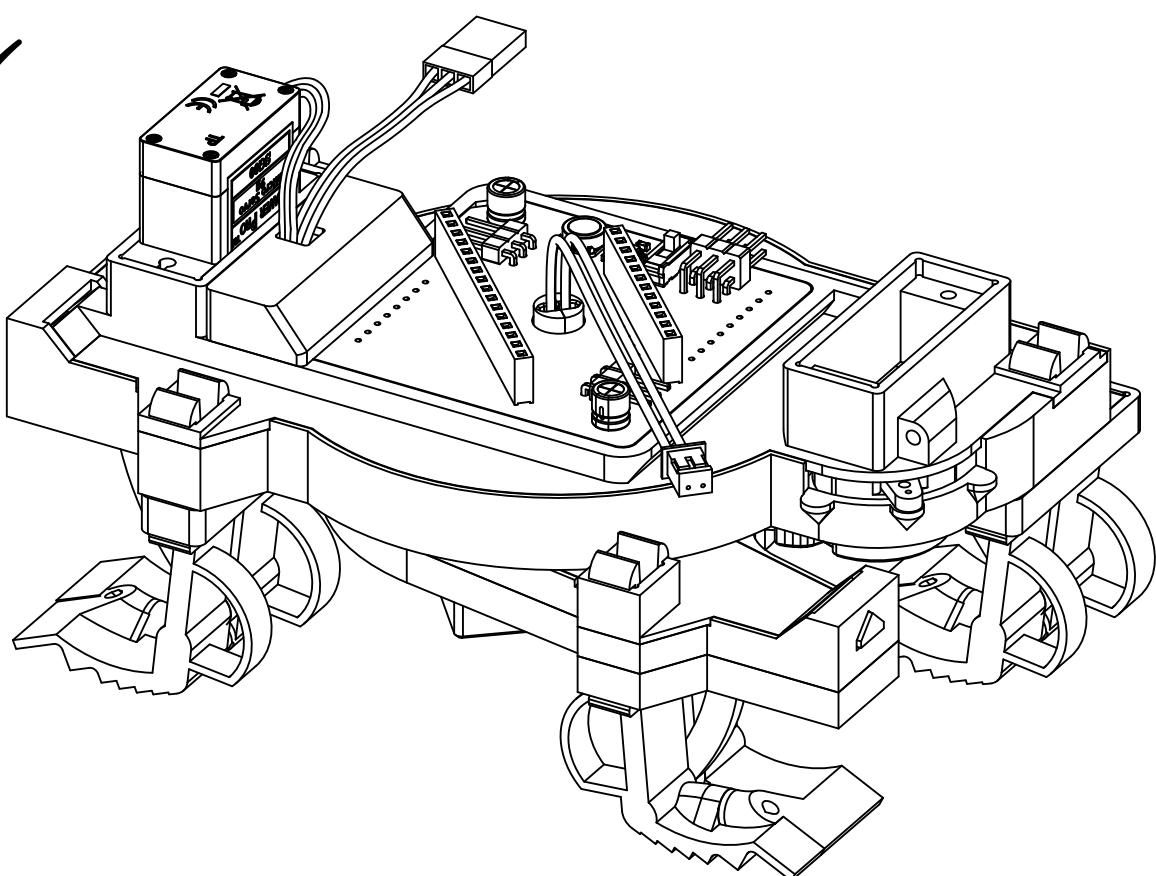
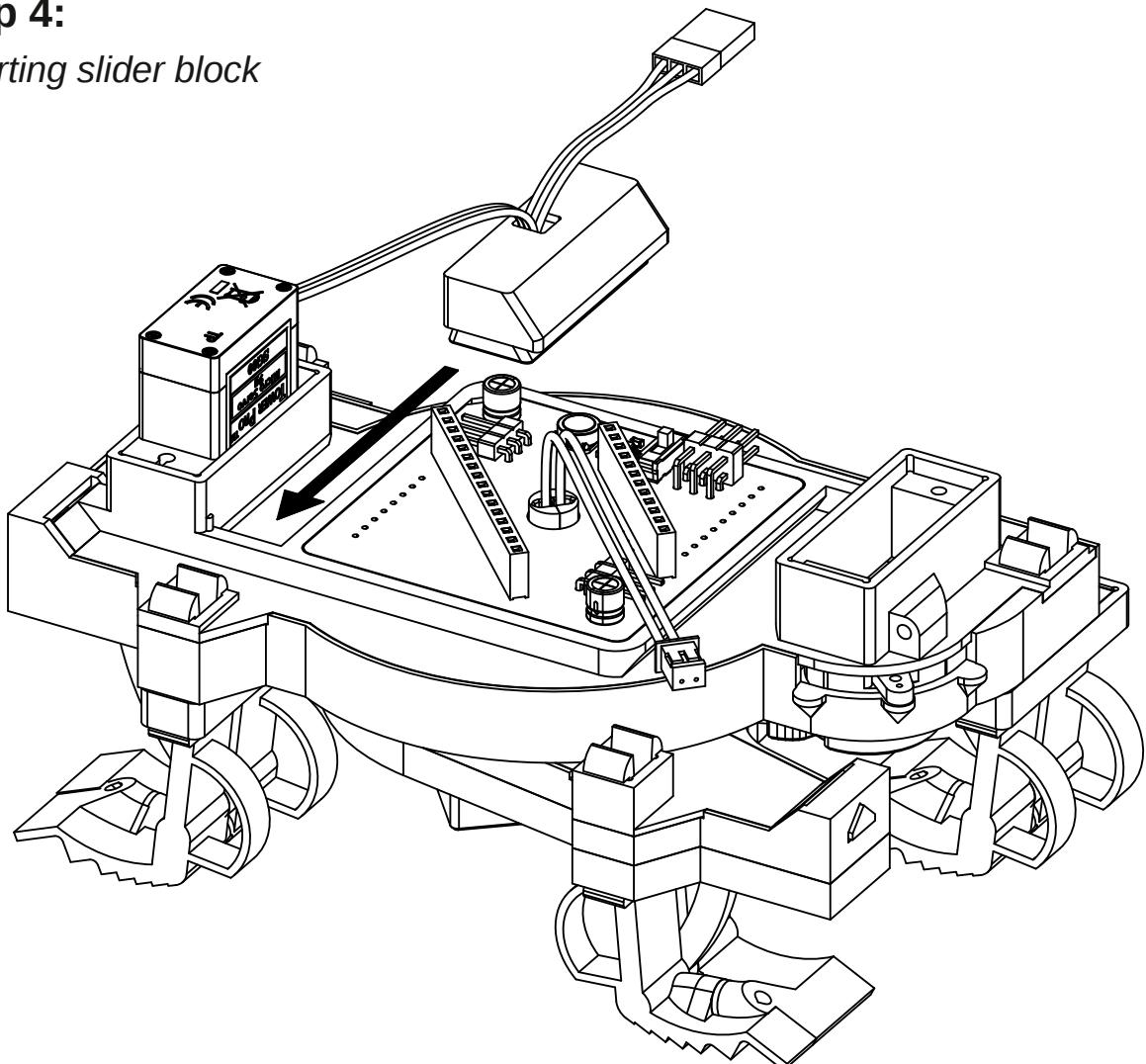
3.1



Step 4:

Inserting slider block

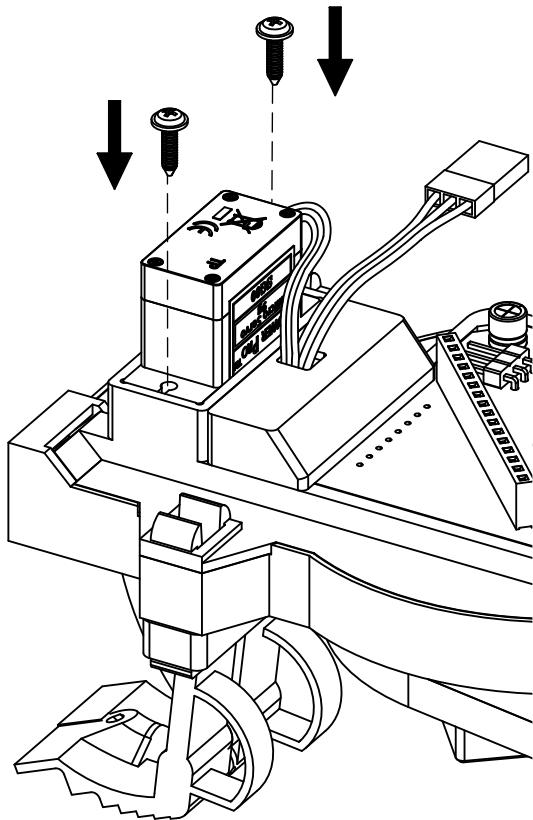
4.1



Step 5:

Securing servo with two screws

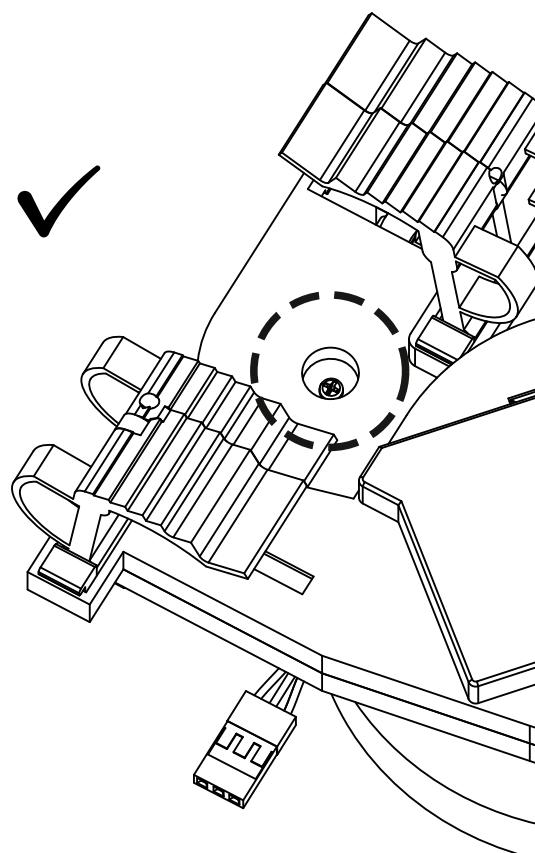
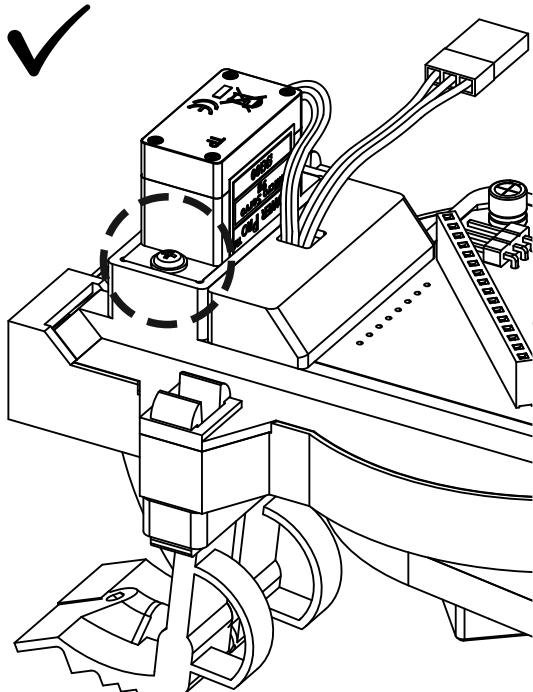
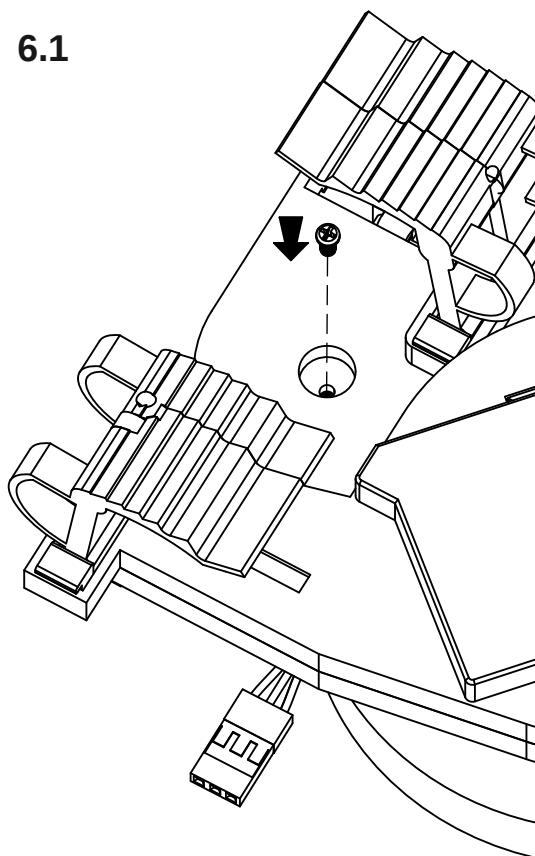
5.1



Step 6:

Securing servo horn with one small screw

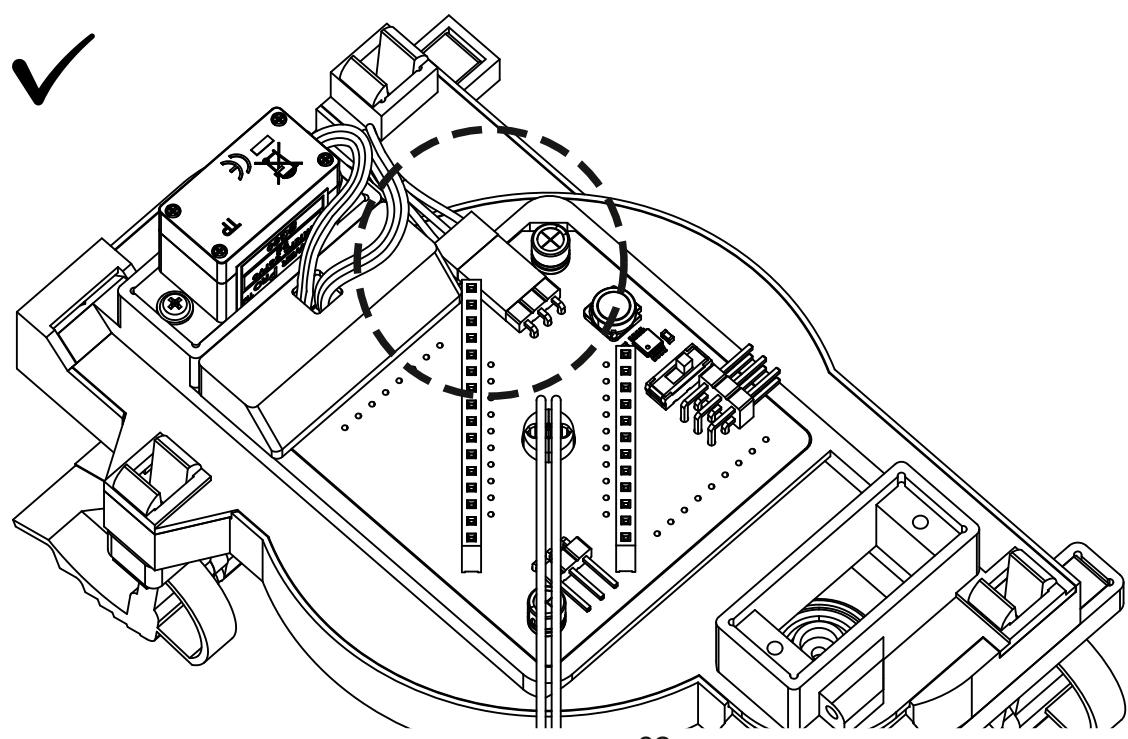
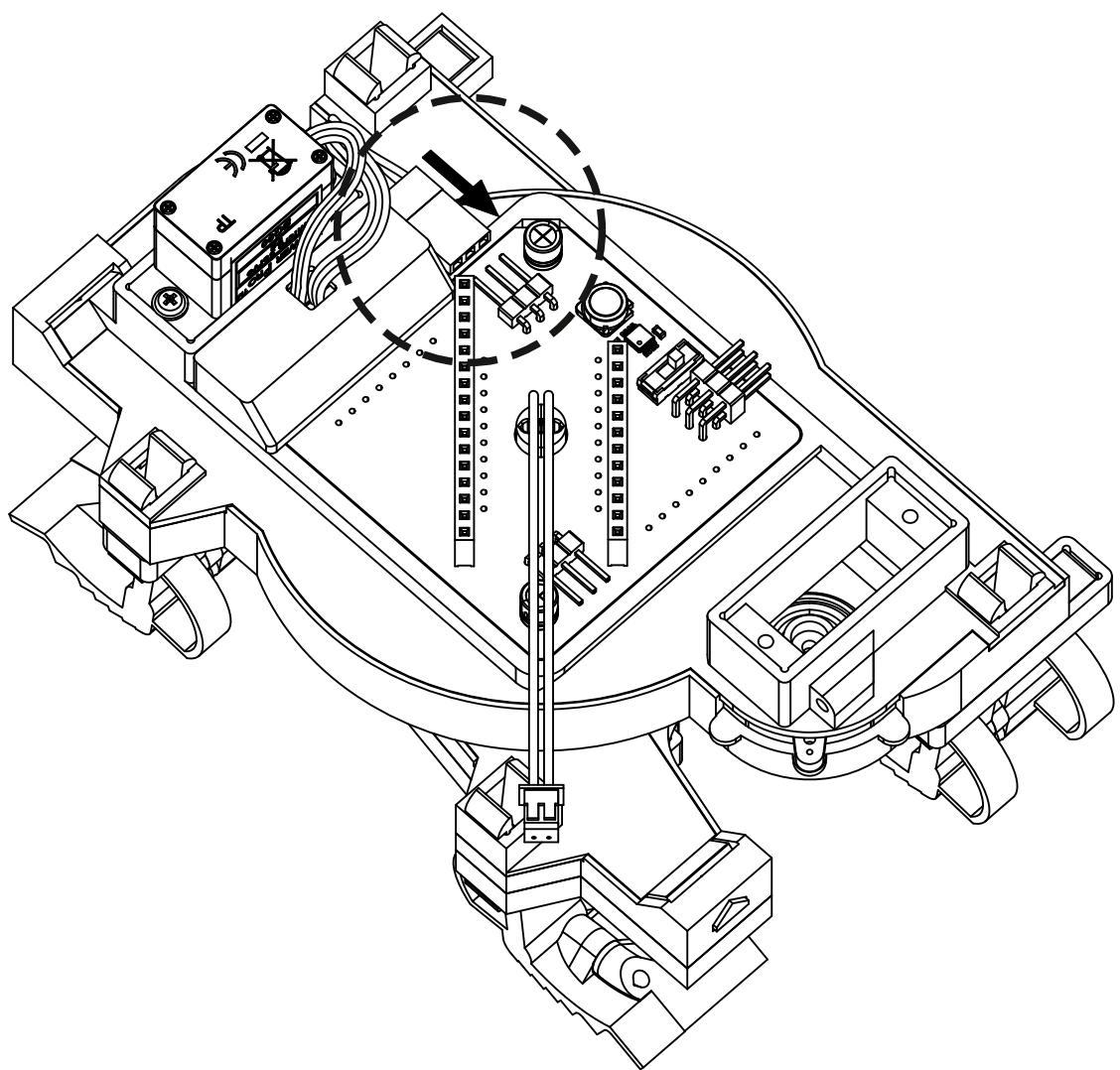
6.1



Step 7:

Connecting servo cable to motherboard pin header

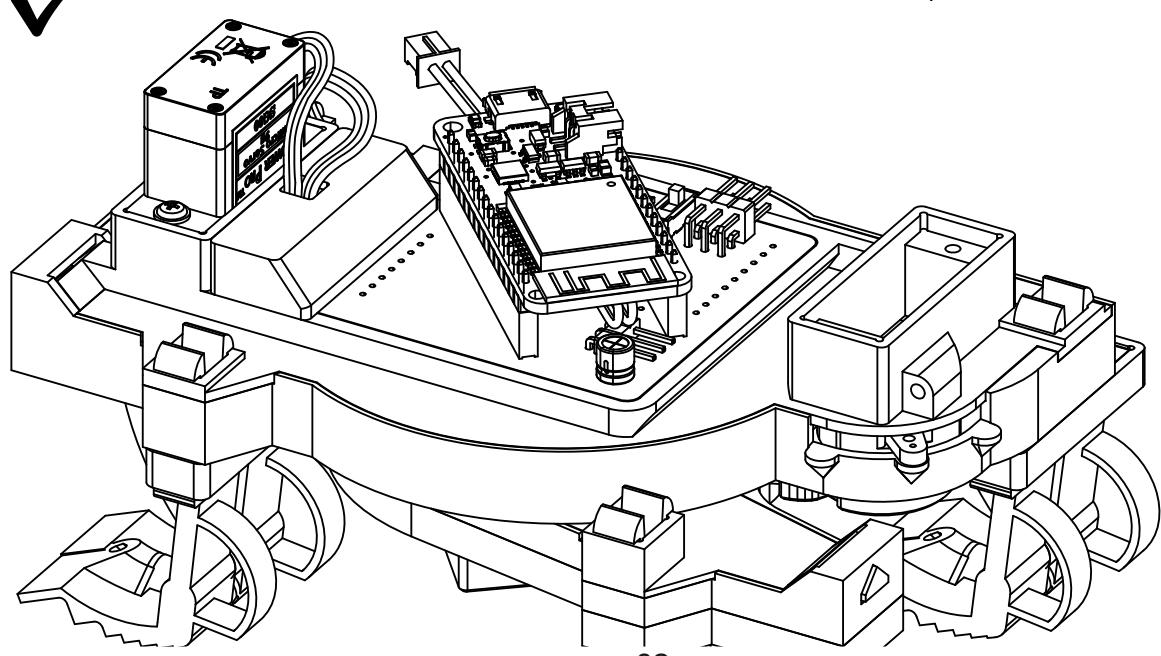
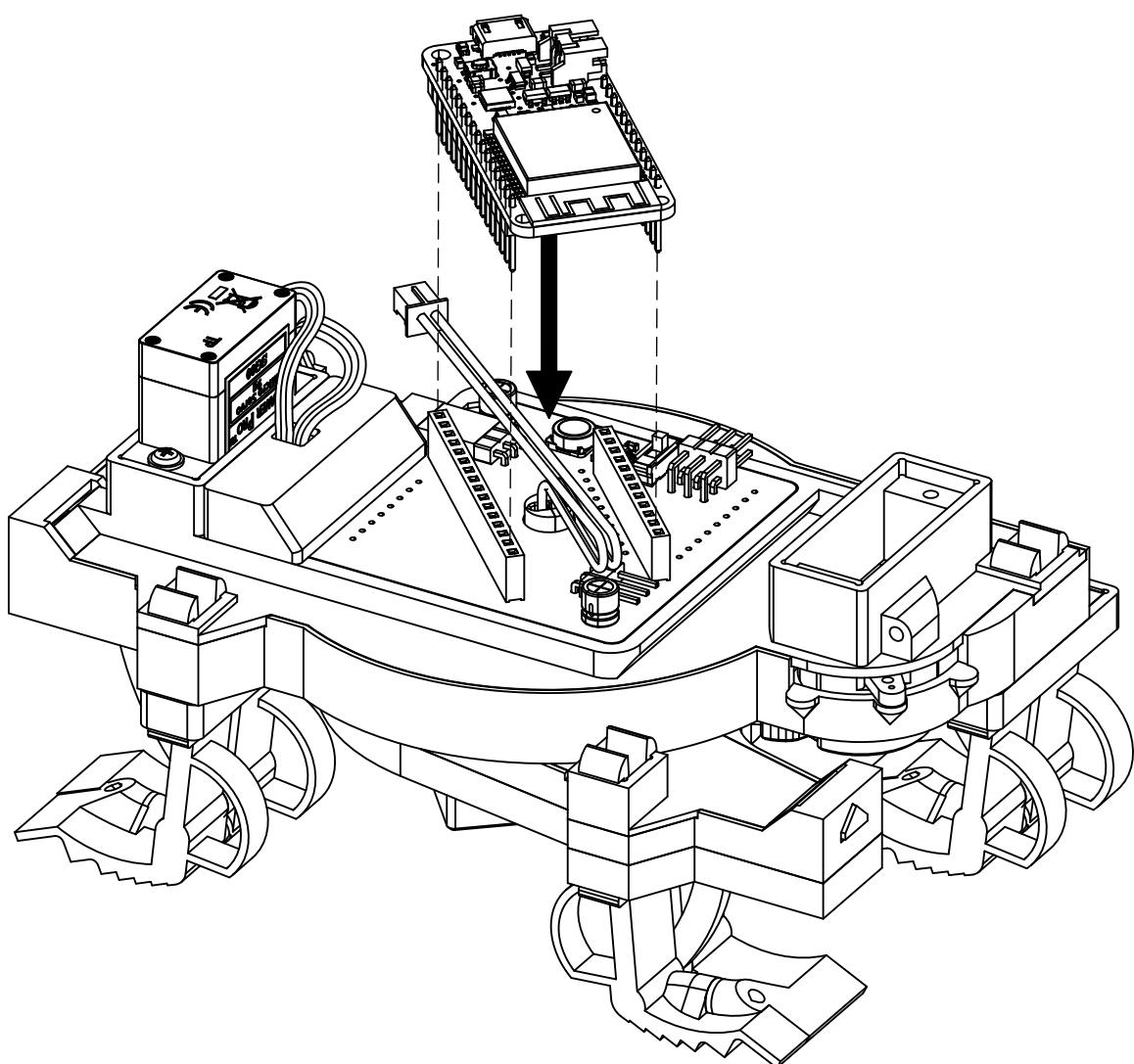
7.1



Step 8:

Seating the microcontroller board in motherboard pin sockets

7.1



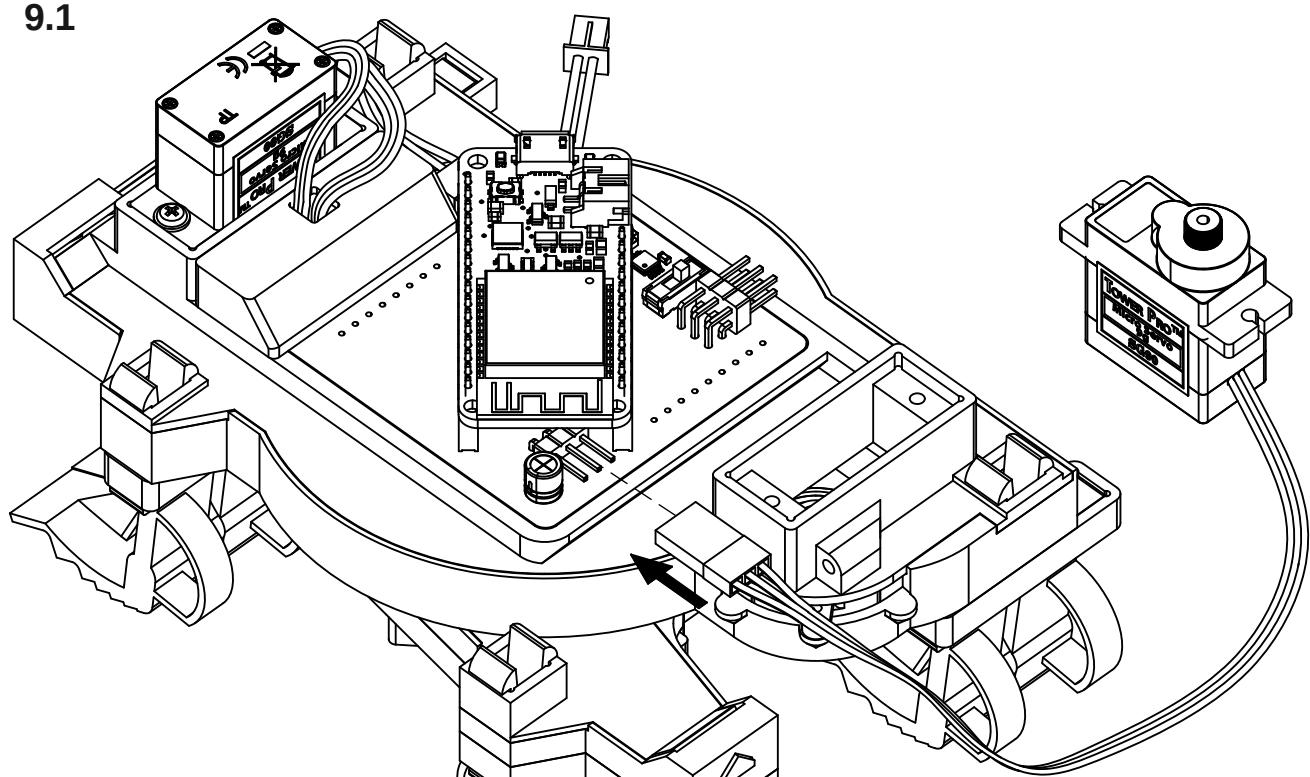
Step 9:

Powering on the electronics to center the 180° servo

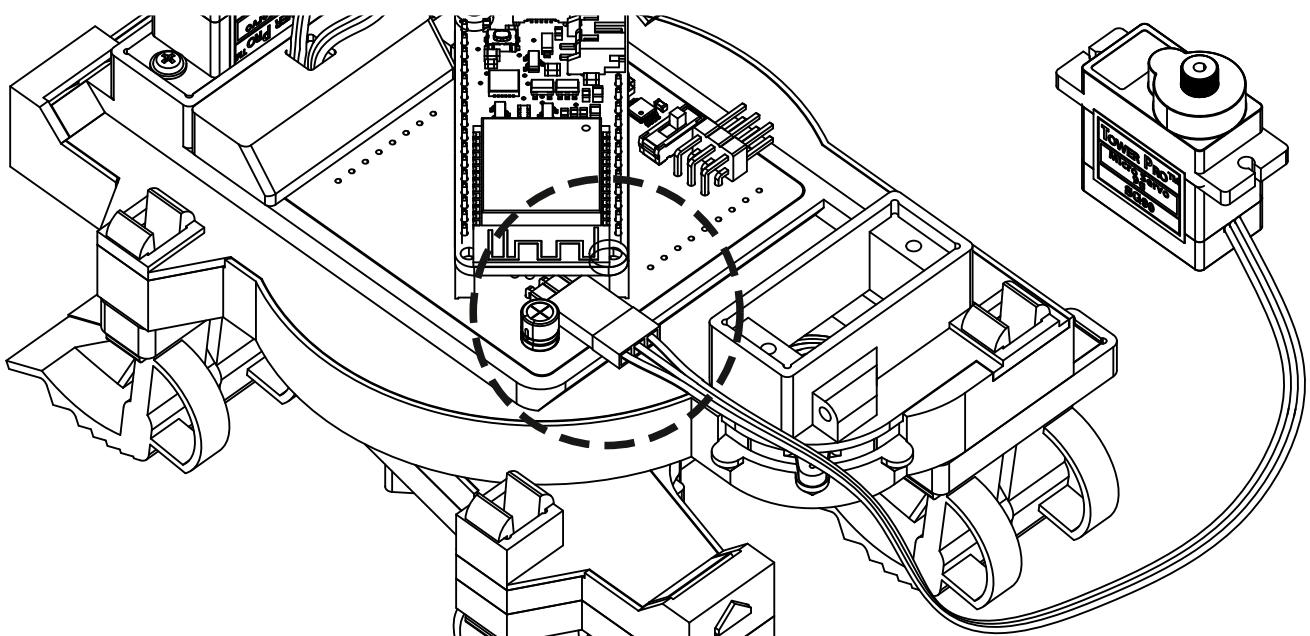
Note

Before being permanently seated, the 180° servo gear needs to be in center position. This will happen automatically when powering on the microcontroller. Prior to that, the 90° servo temporarily needs to get connected up to the motherboard.

9.1

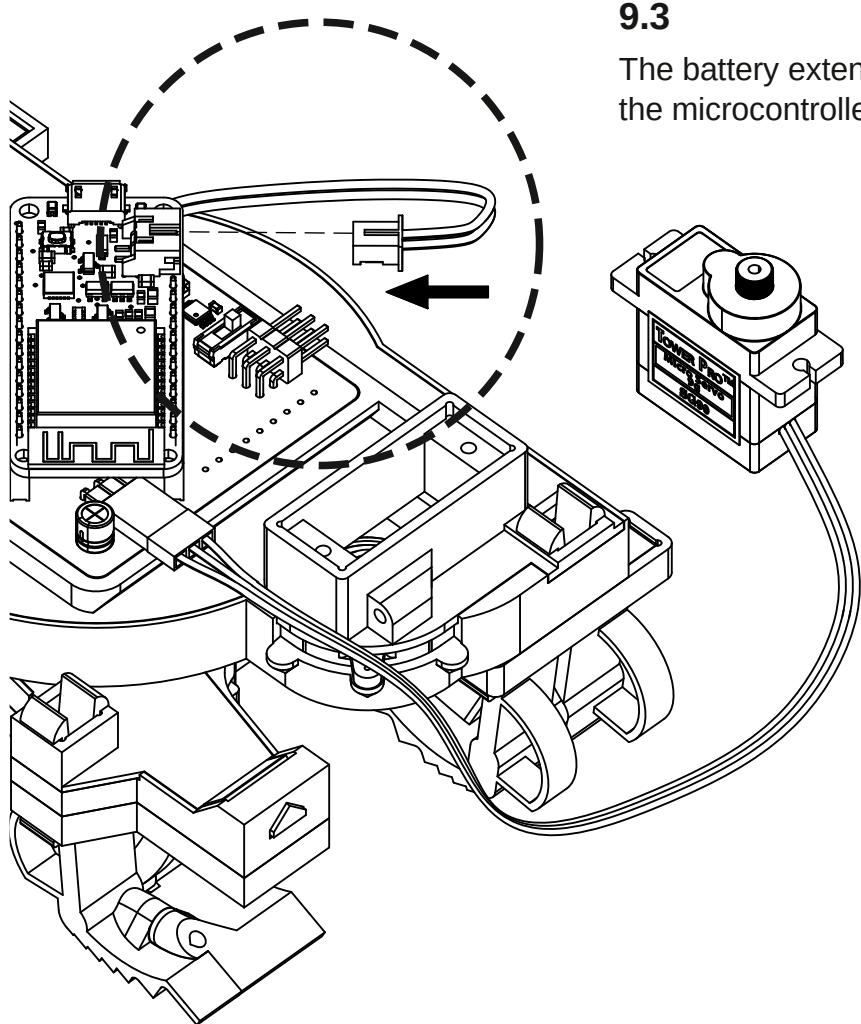


9.2



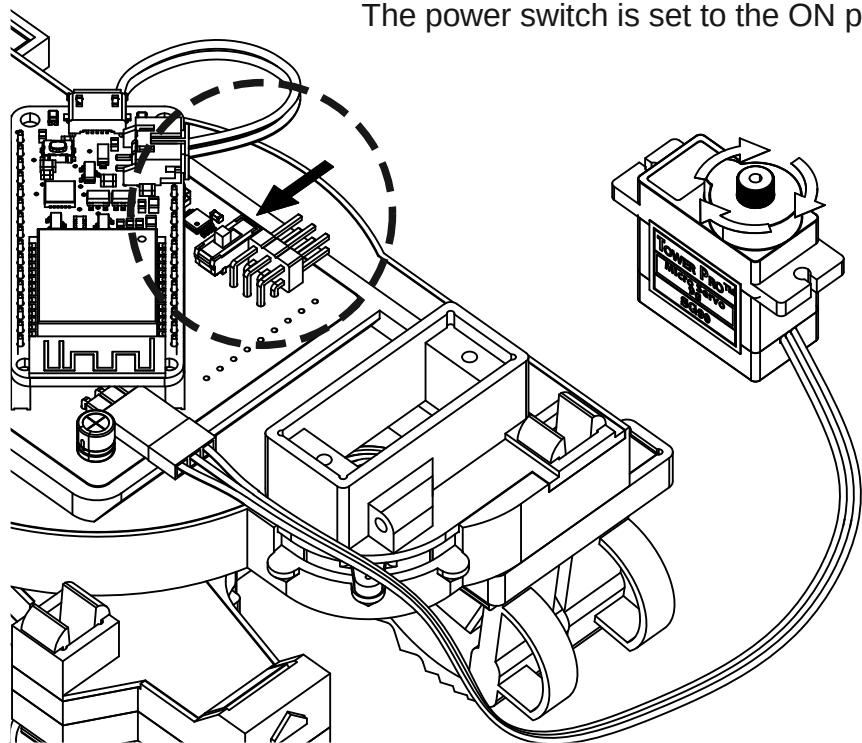
9.3

The battery extension cable gets connected to the microcontroller board.



9.4

The power switch is set to the ON position.



Note

The servo should turn on within a few seconds, indicated by a short whirring noise.

The servo is now centered, and the power switch can be set to the OFF position.

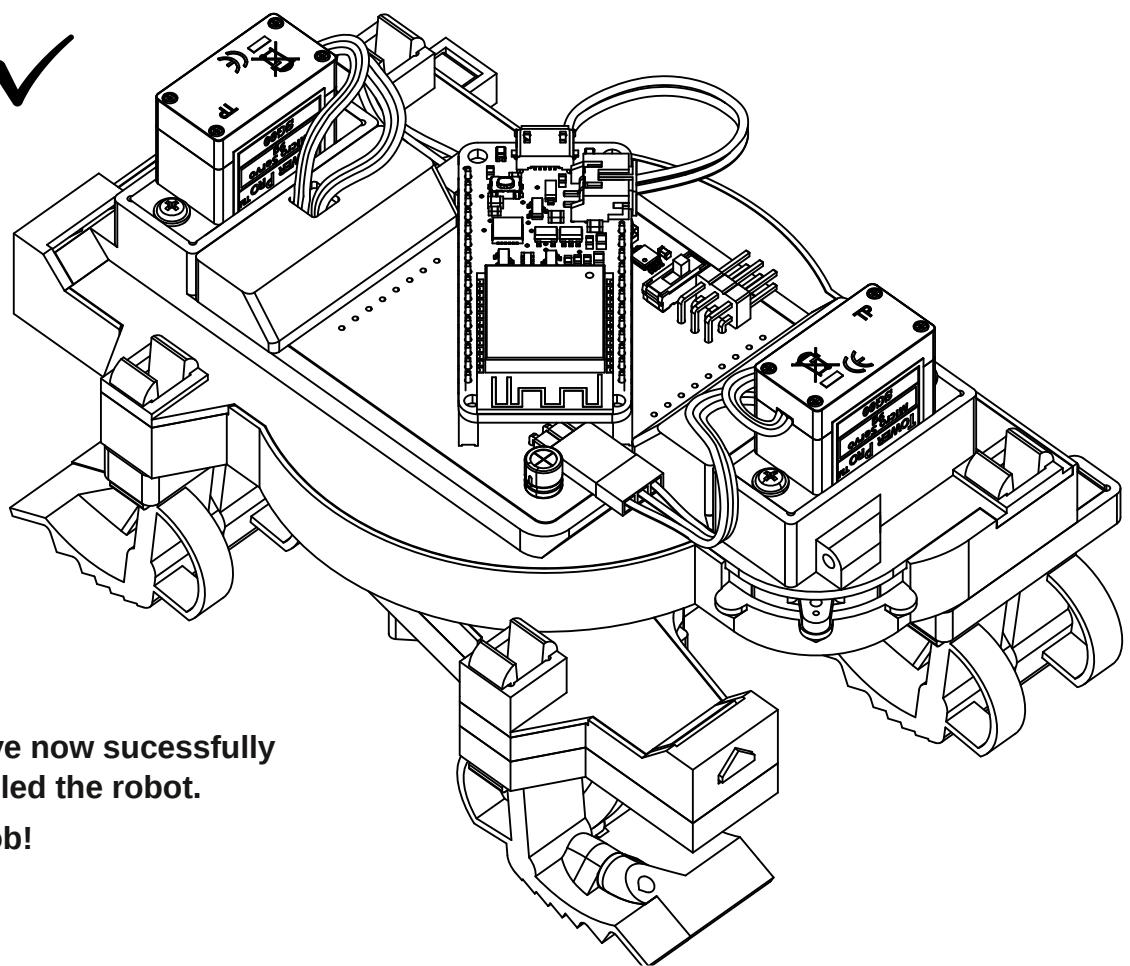
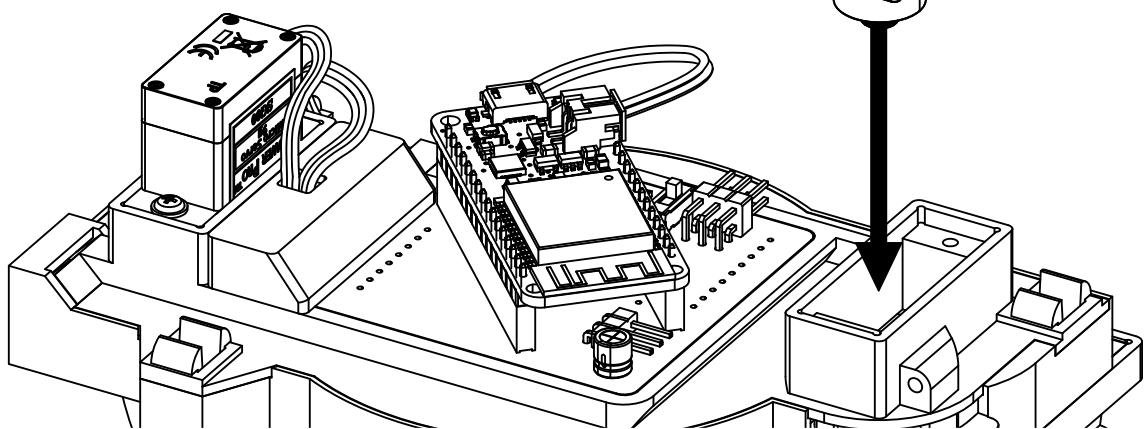


Step 10:

Seating the 180° servo in steering gear socket



Follow the procedure described in Steps 2 - 6
when mounting the 180° servo.



You have now sucessfully
assembled the robot.

Good job!

