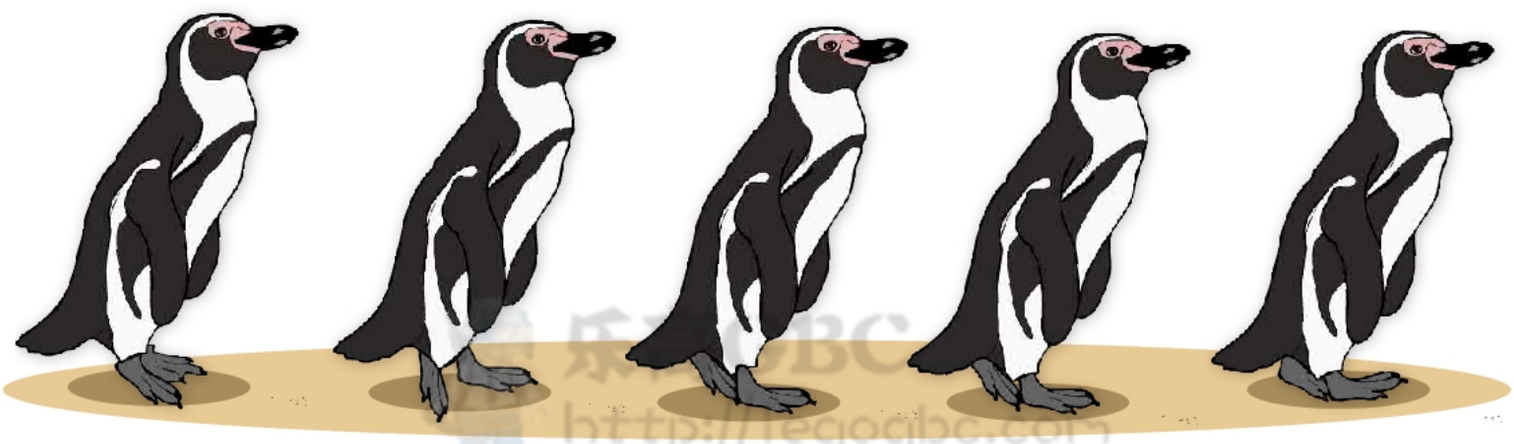
HUMBOLDT PENGUIN

Design phase: Out-phase motion

• Remember to have a **white paper** and a **pencil** to start drawing your ideas!

Looking for inspiration

• **Humboldt penguins** are South American penguins that live on the **"Ballestas Islands"** in the coastal region of Peru.
• They are **medium-sized** penguins, averaging **28 inches tall** and weighing about **9 pounds**.
• Their favorite food is **anchoveta**, a small fish that thrives in the cold waters of the South American coast.



How can I design a robot to replicate the two-leg walking motion of a penguin?

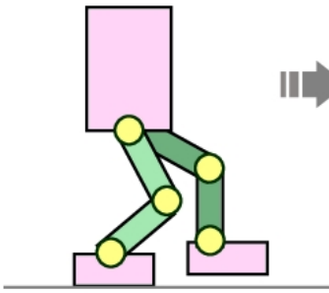
Biped robots

• They are robots that use **two legs** to perform a **walking motion**.
• There are two types of biped robots: **steady biped robots** and **balance shift biped robots**.
• **Balance shift** biped robots **do require** advanced programming using sensors to balance the center of gravity.
• **Steady** biped robots **do not require** the use of sensors or an advanced programming to balance. Given their structure, **steady biped robots** are **always balanced**, avoiding falling while they walk. In this book, we only focus on the development of **steady biped robots**.
• Biped robots **interlace** their legs to walk: one leg in front of another (**walk step**).

Out-phase motion

• An out-phase motion can be used to assure that **one leg is in front of the other** after a walk step.

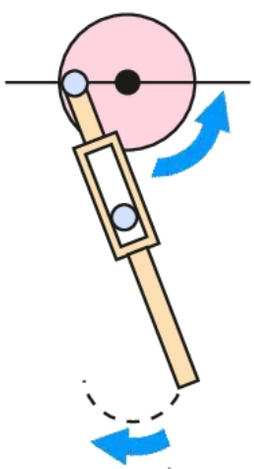
• An out-phase motion guarantees you that while **one leg** is moving **forward**, the **other leg** is moving **backward**.



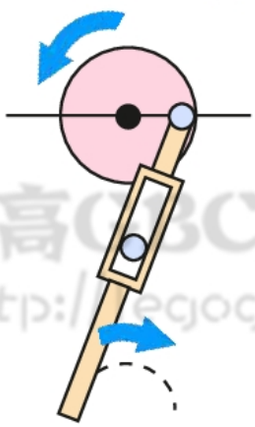
Inverted slider-crank linkage

• It is similar to a gear train; an inverted slider-crank linkage is used to **transmit rotational motion**.

• It consists of two phases: **stance phase** and **swing phase**.

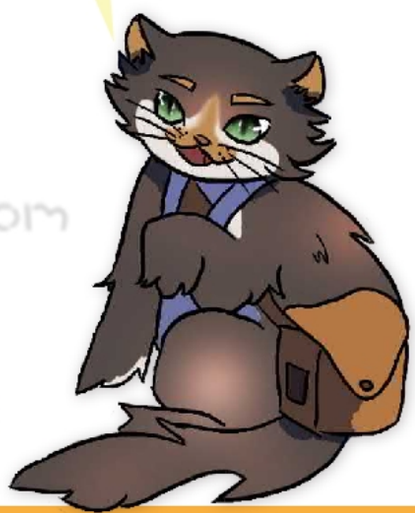


Stance phase



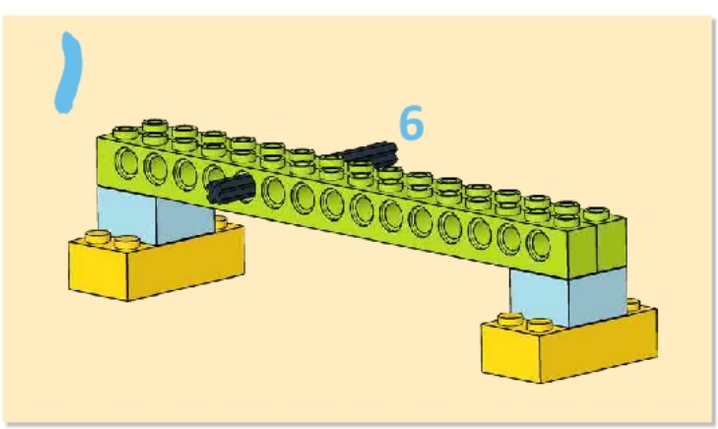
Swing phase

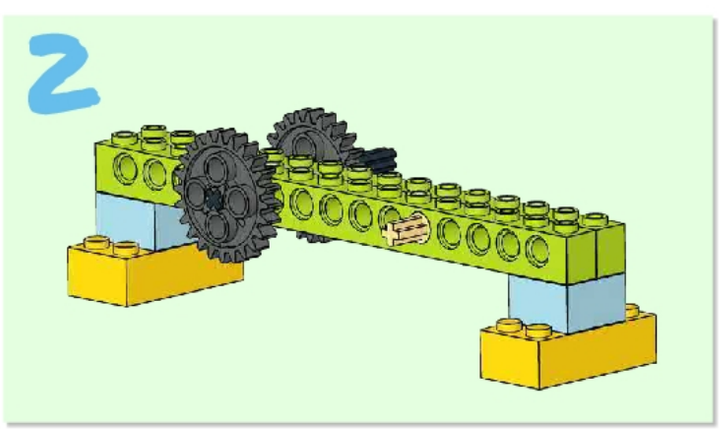
On a piece of paper, you can sketch some **ideas** to replicate the penguin walking motion!

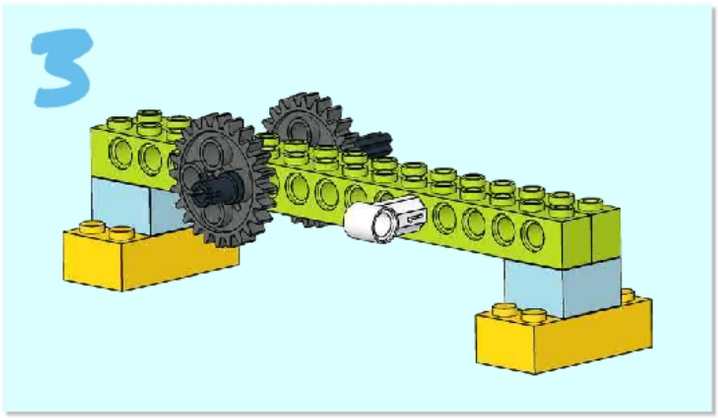


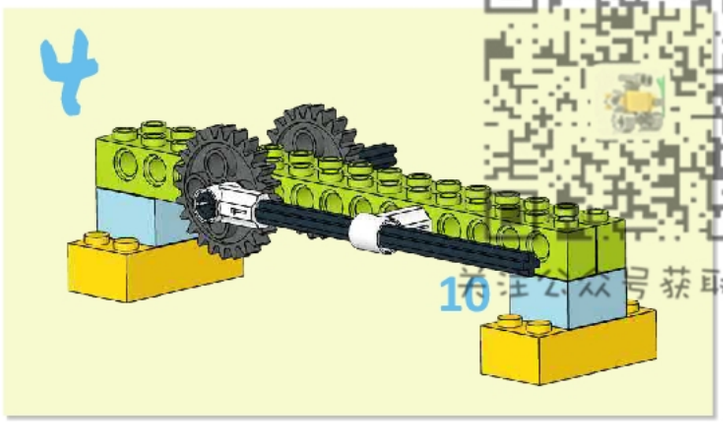
Build phase: Inverted slider-crank linkage

• Given the following building instructions, you can build your own inverted slider-crank linkage.



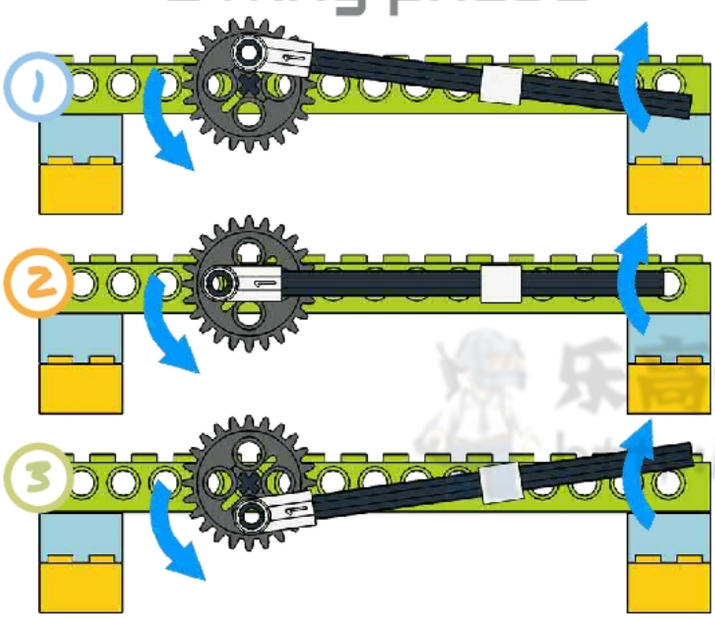




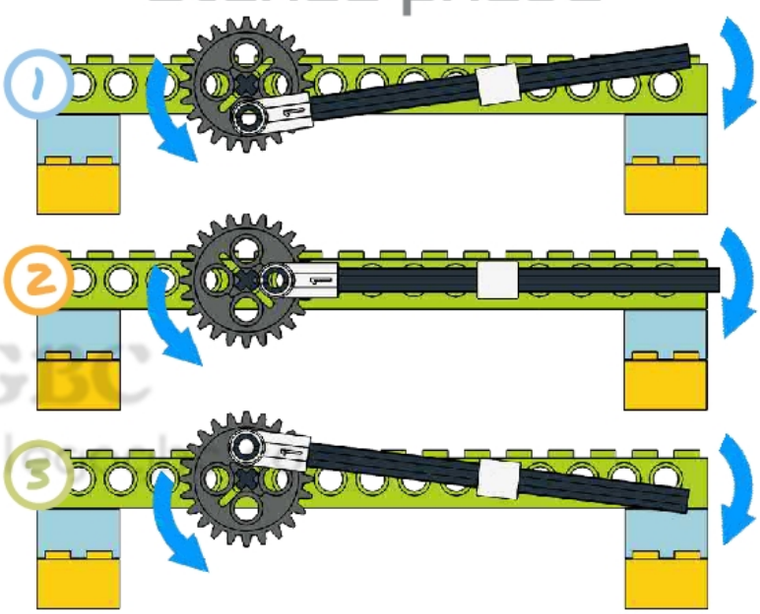


• Turn the gear to see how the axle tip of the opposite side moves.

Swing phase

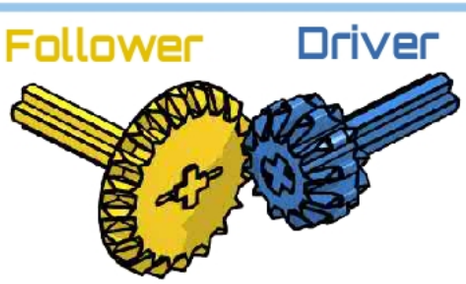


Stance phase



Bevel gears

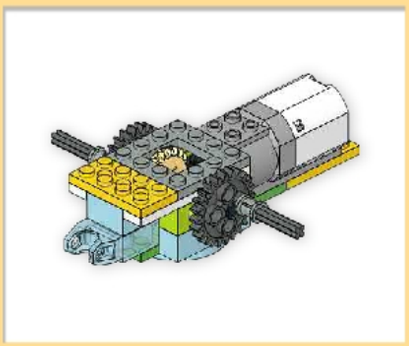
• Bevel gears operate in not parallel axles.
• They can be used as gearing down or gearing up mechanism when gears of different sizes are used.
• Usually, bevel gears are made for perpendicular axles (90 degrees); however, they can be also made for any other angle.

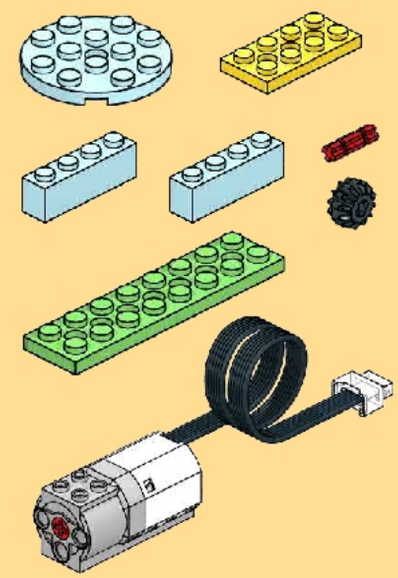


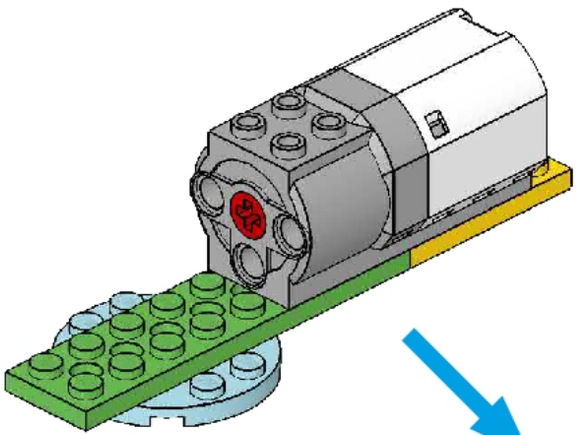
Gearing down mechanism using bevel gears

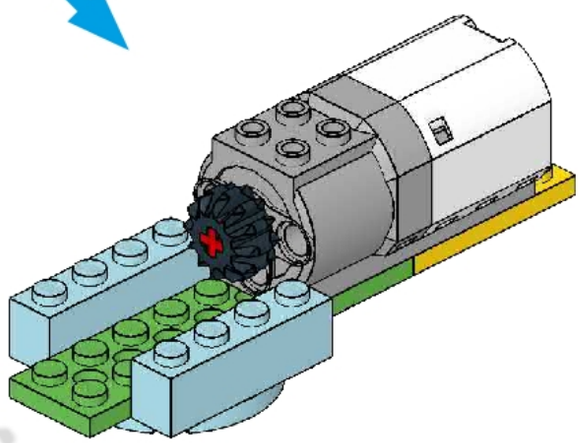
• Now you are ready to build your WeDo penguin prototype!
• Before you start building, prepare a suitable workspace.
• Keep in mind that the WeDo set has small pieces, so prepare a table with enough space to easily identify all the pieces and prevent them from getting lost.

Building instructions









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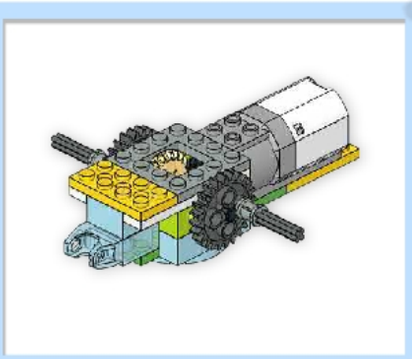

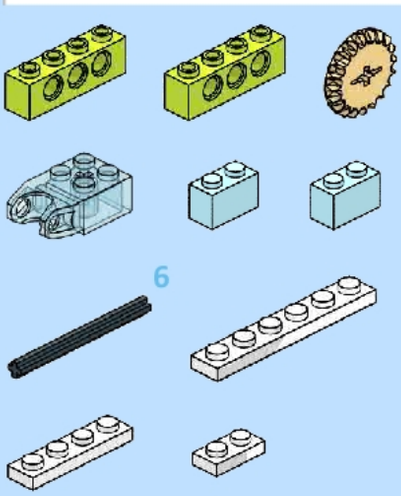

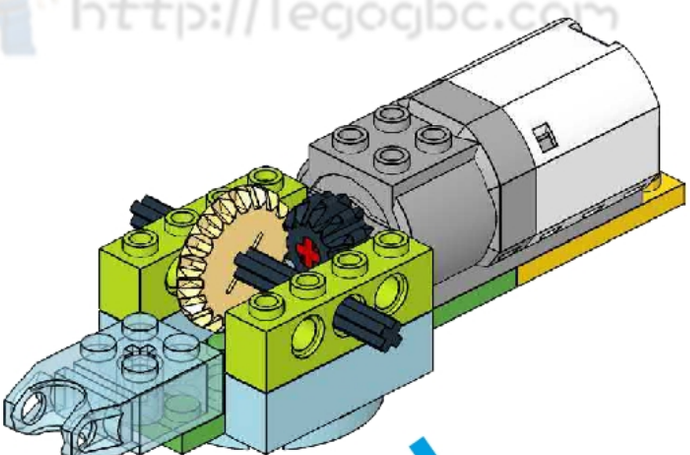

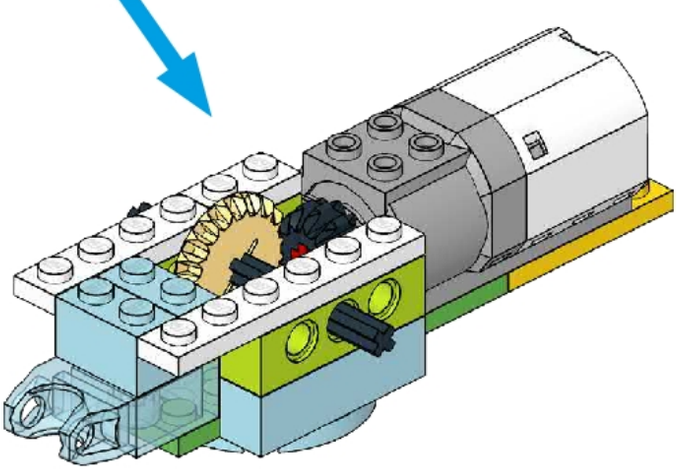

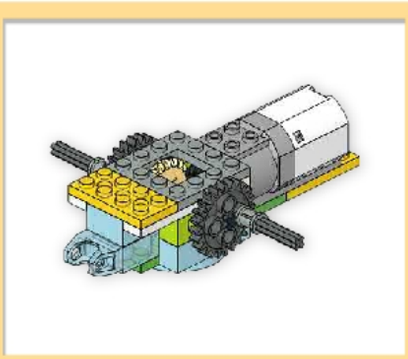

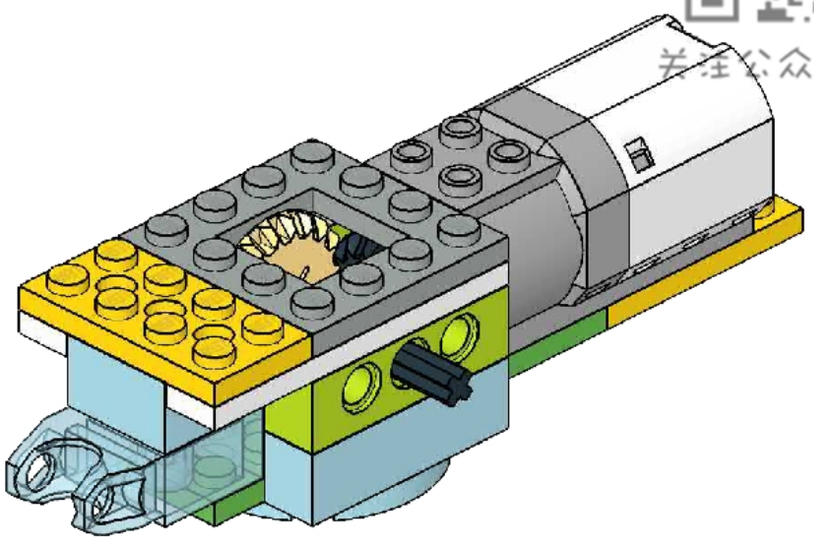

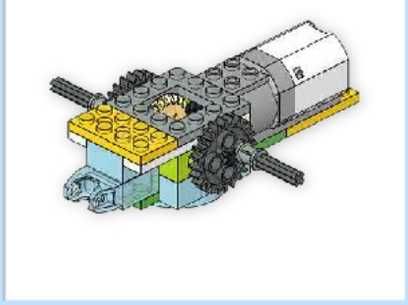

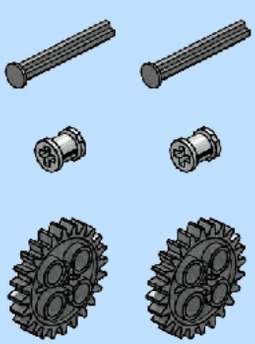

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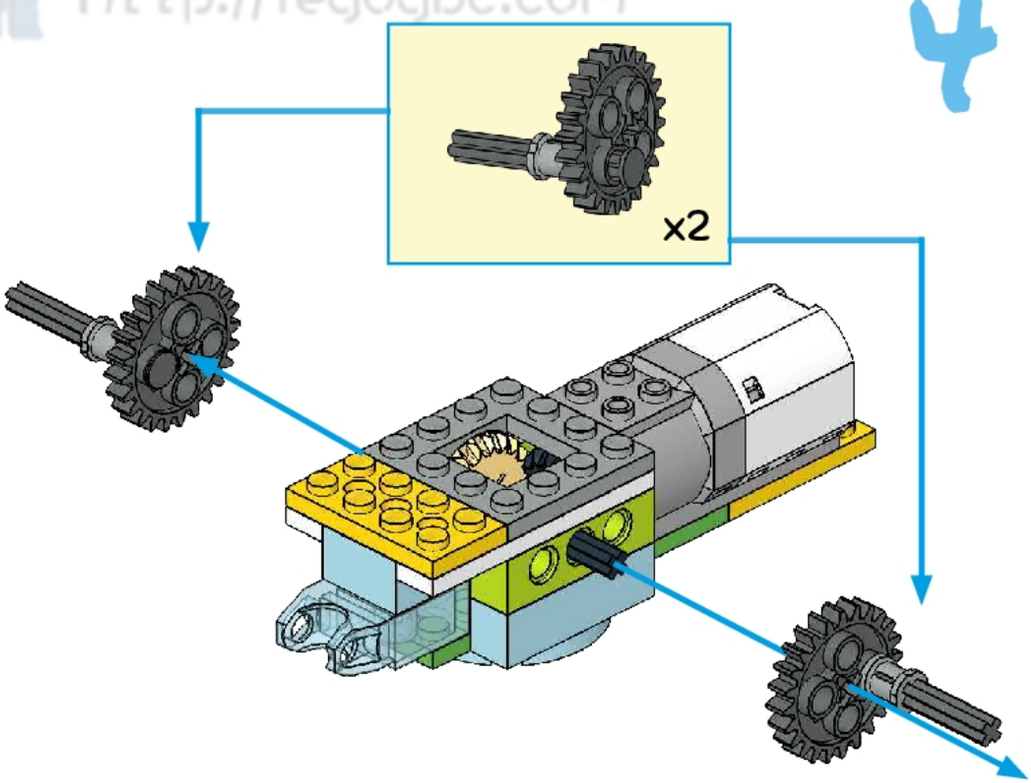

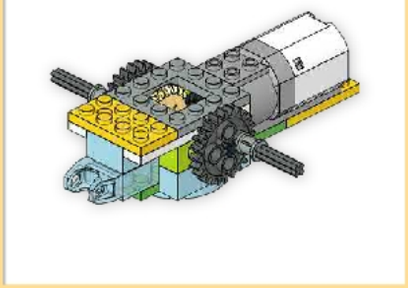

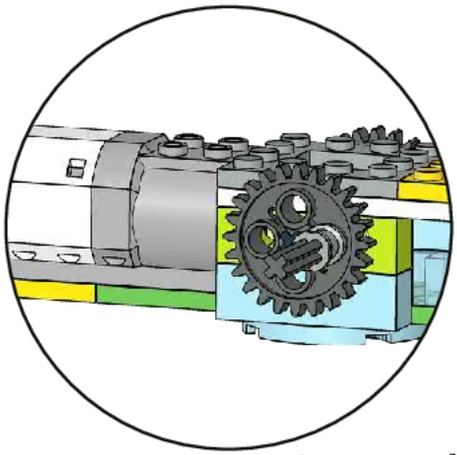

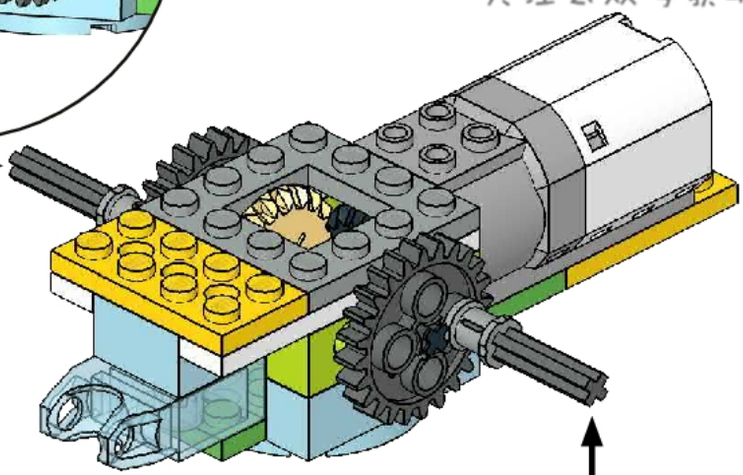

Be careful! The penguin uses an "out-phase" motion, meaning that one of the axles is in the opposite position of the other one.

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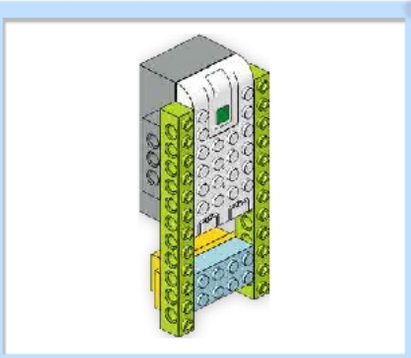

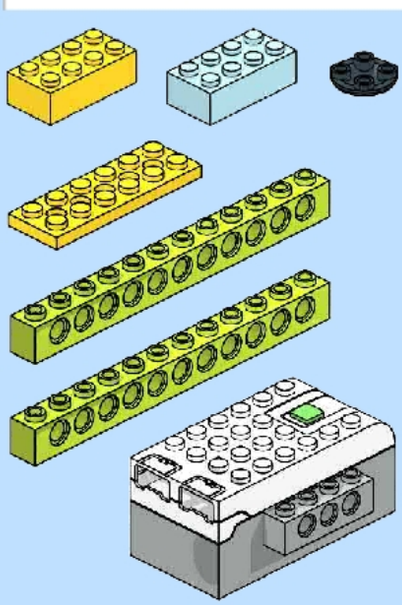

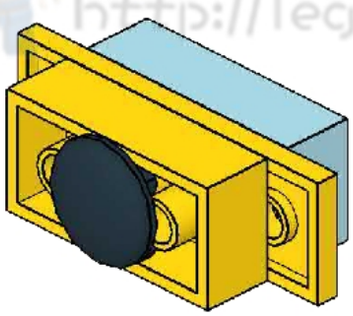

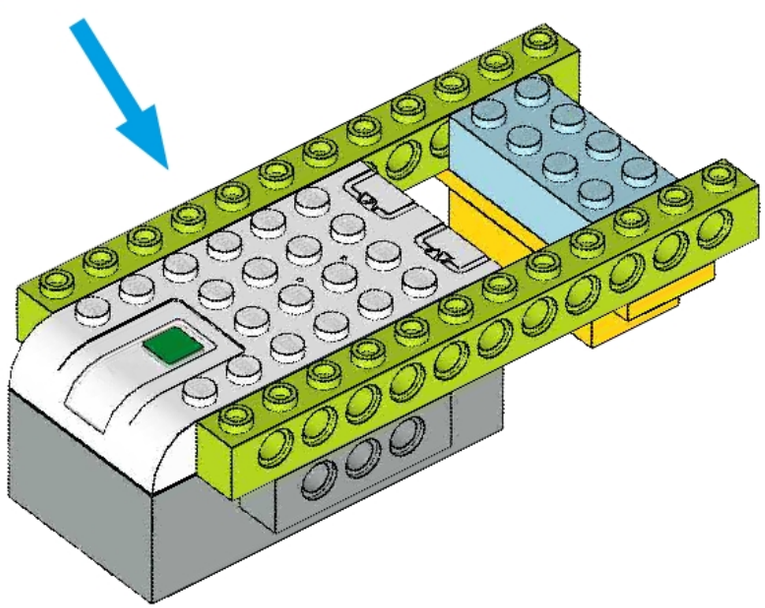

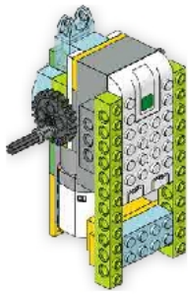

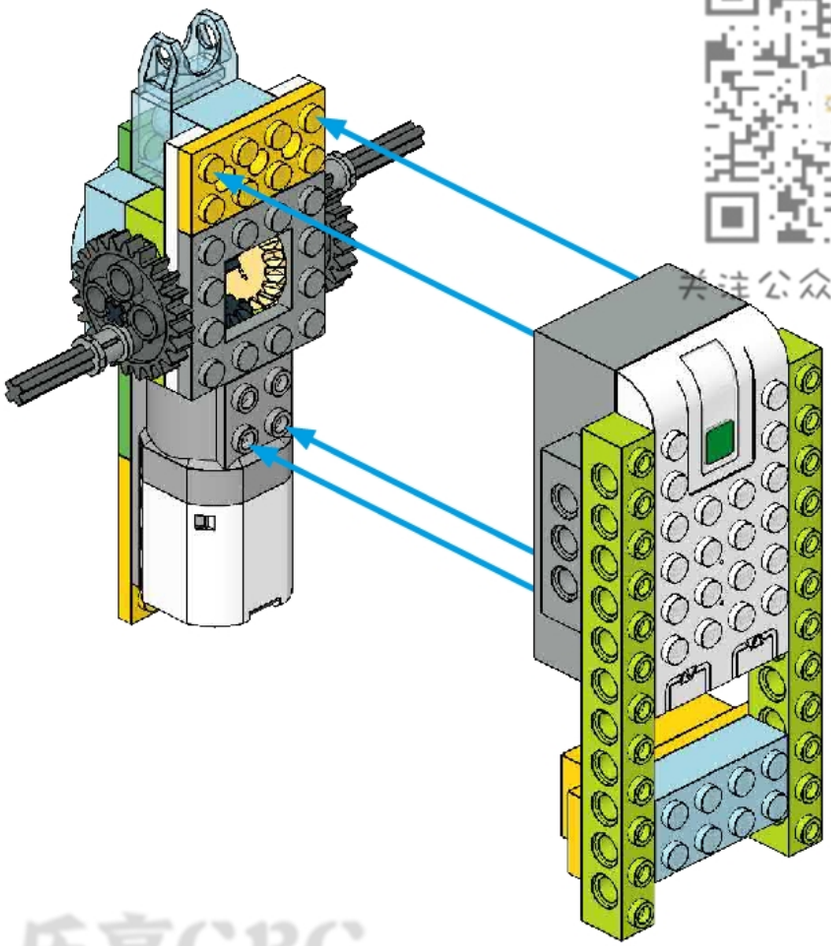

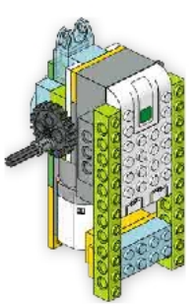

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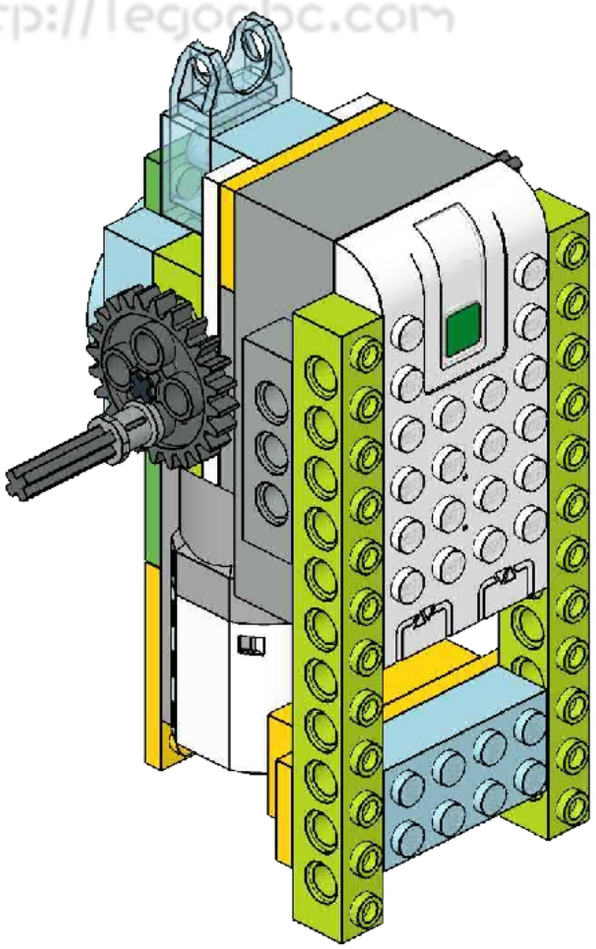

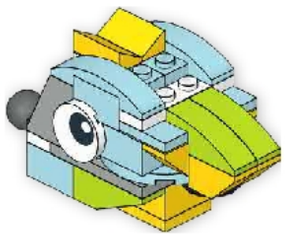

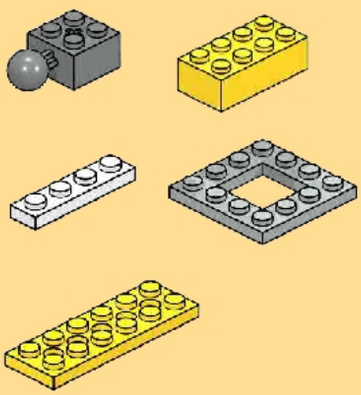

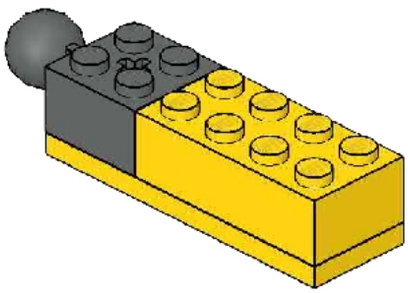

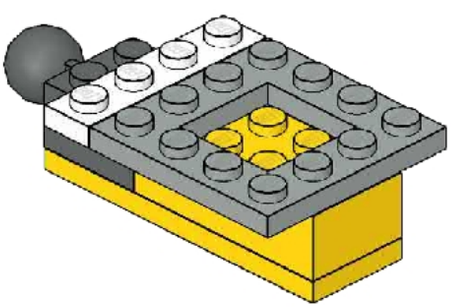

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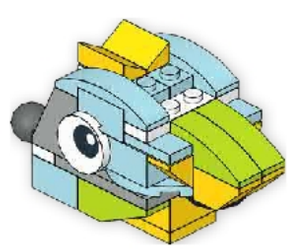

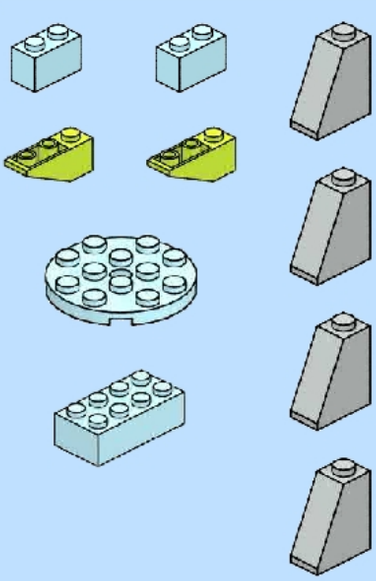

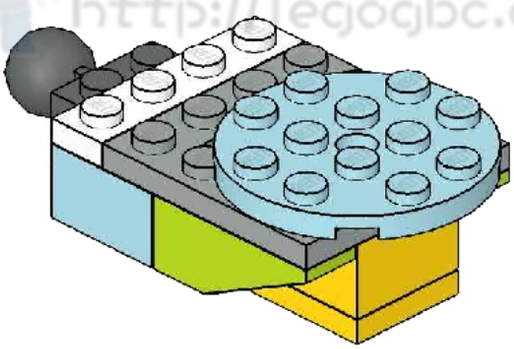

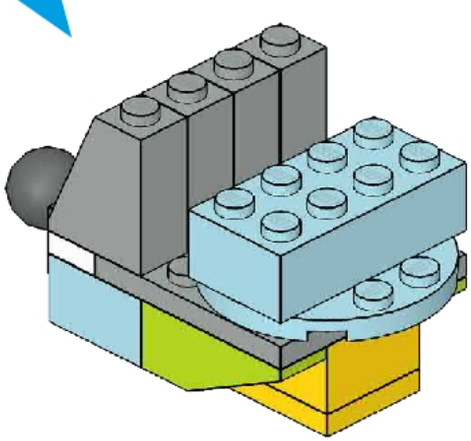

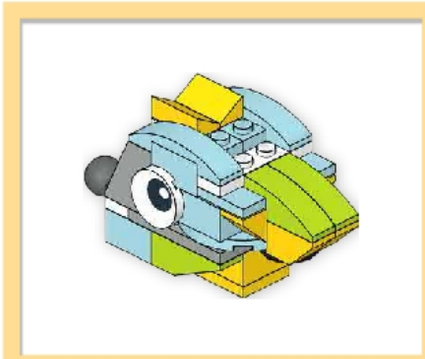

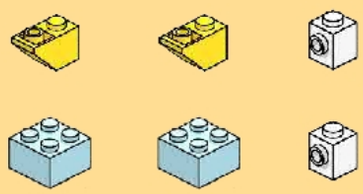

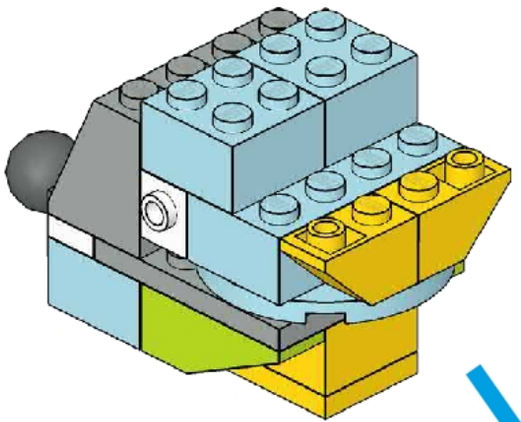

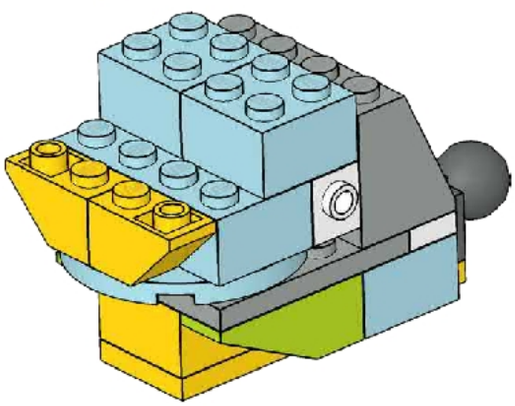

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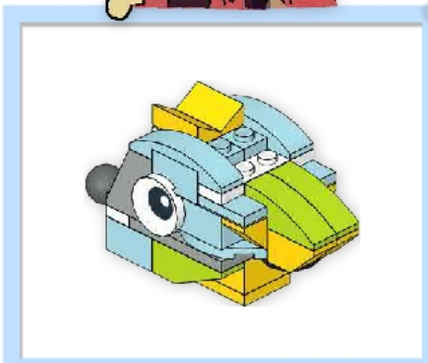

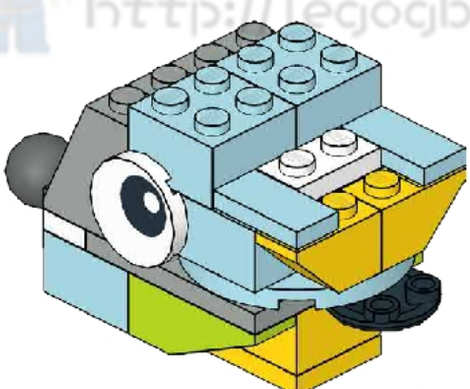

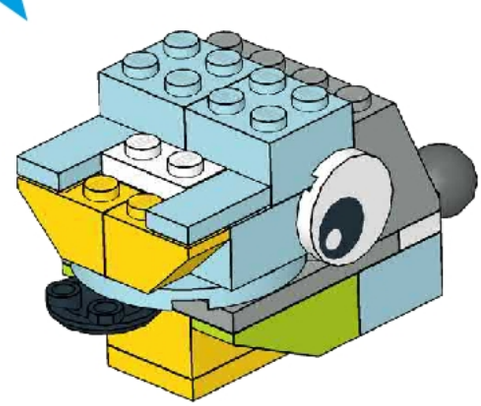

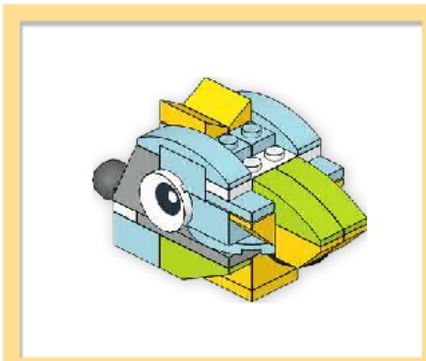

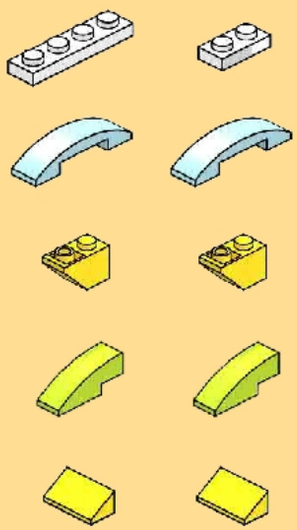

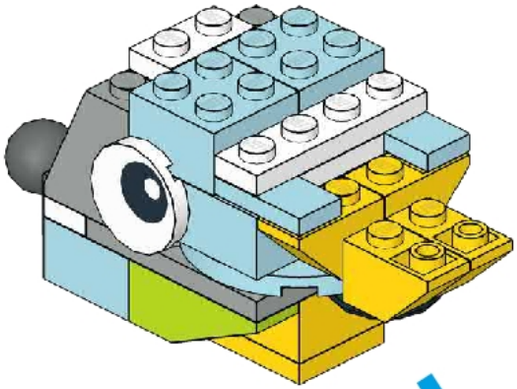

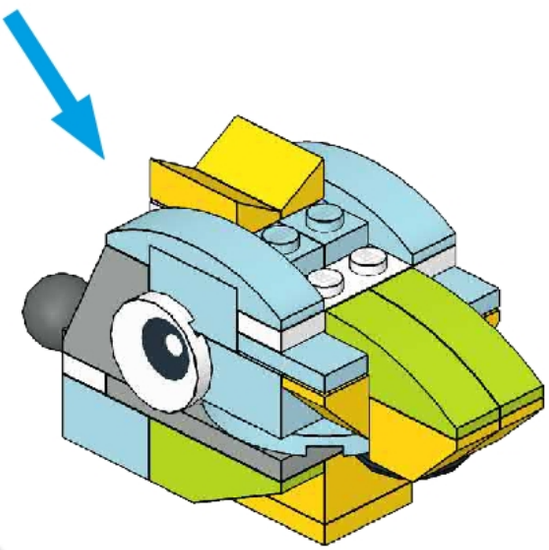

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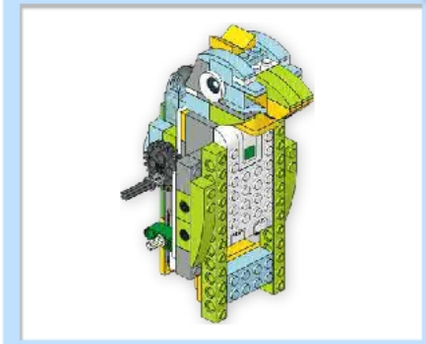

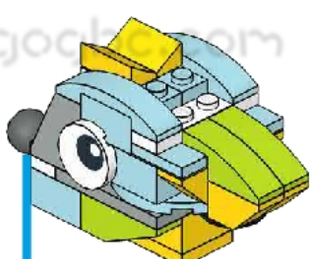

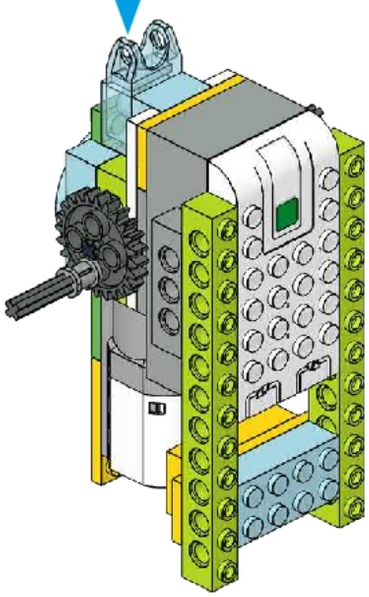

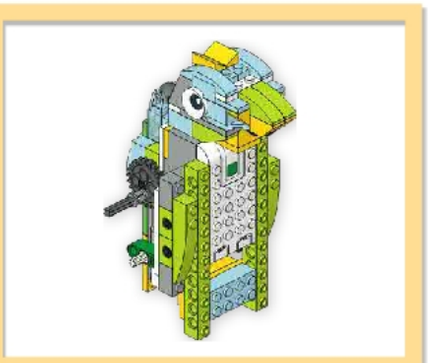

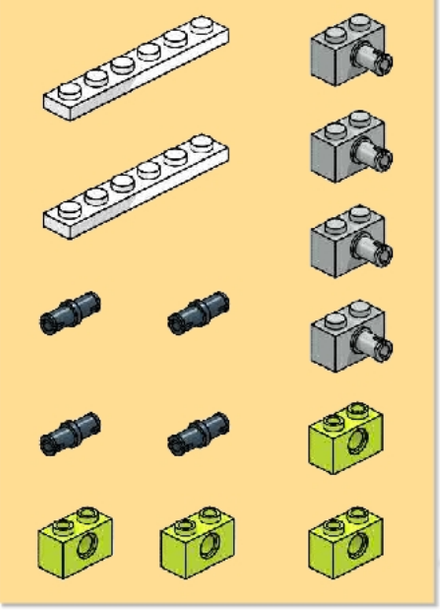

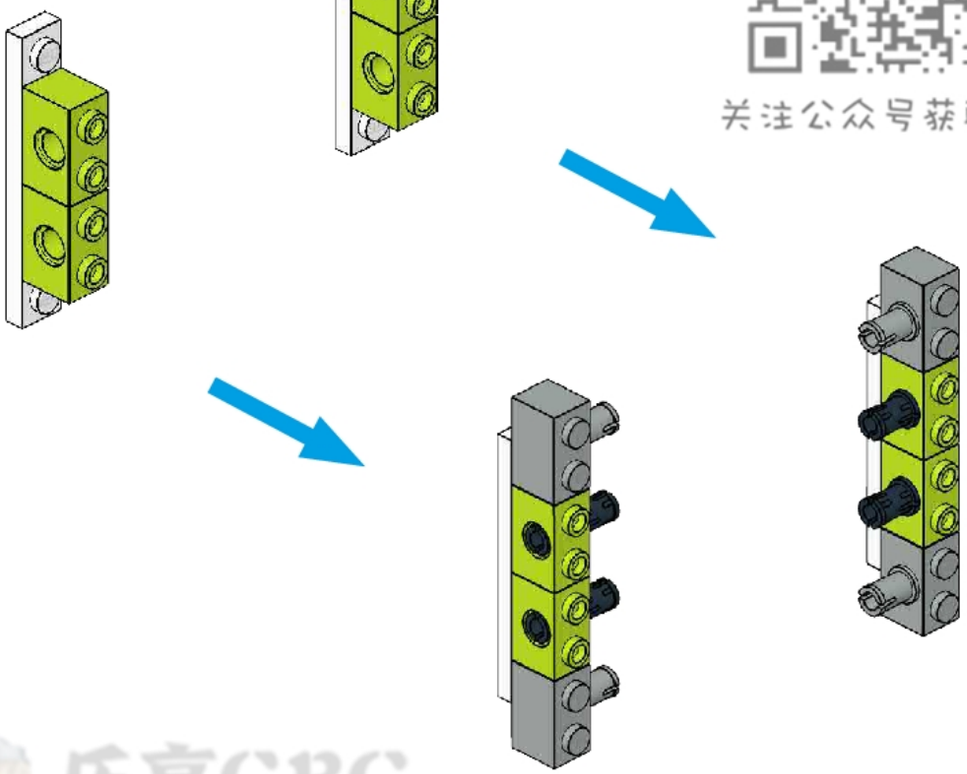

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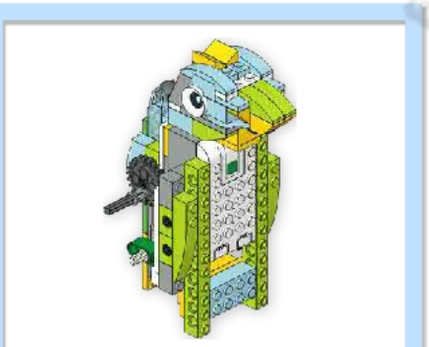

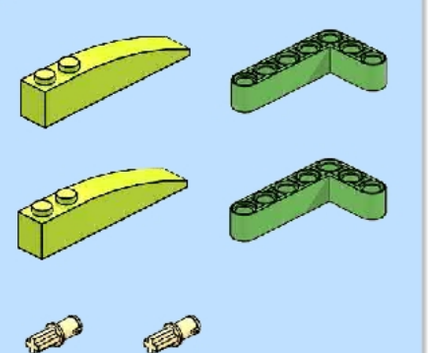

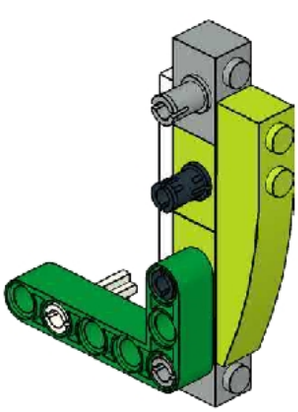

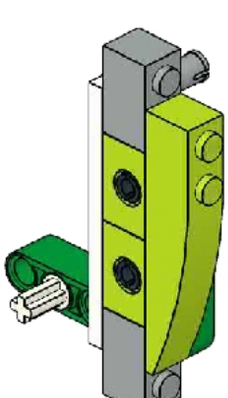

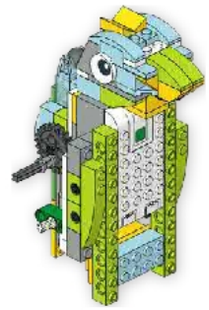

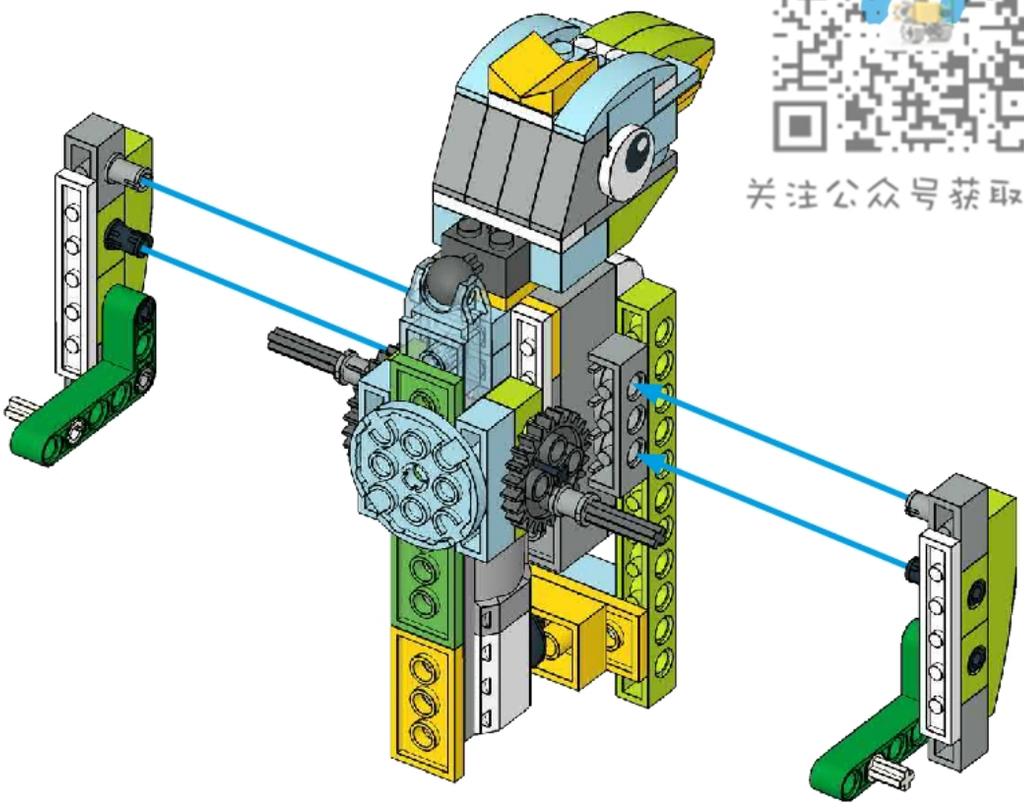

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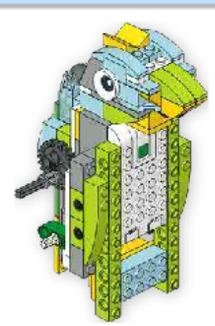

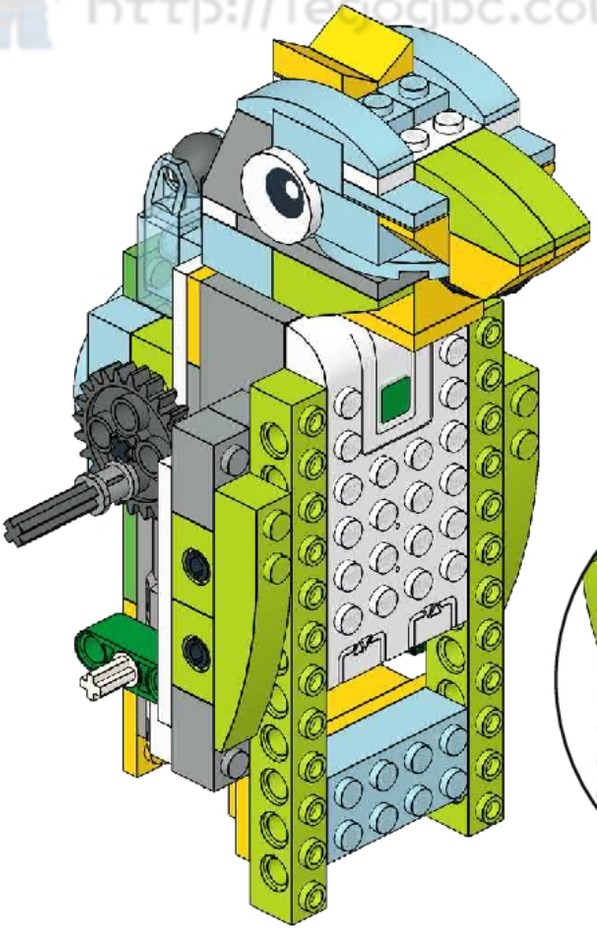

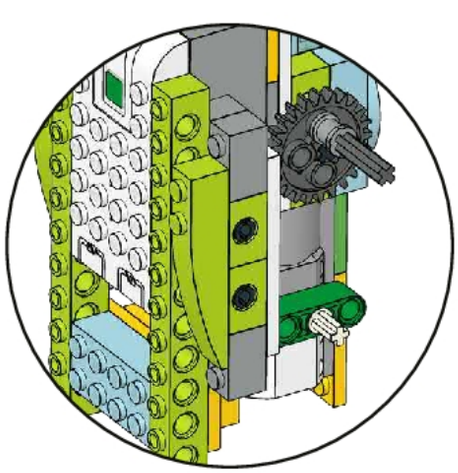

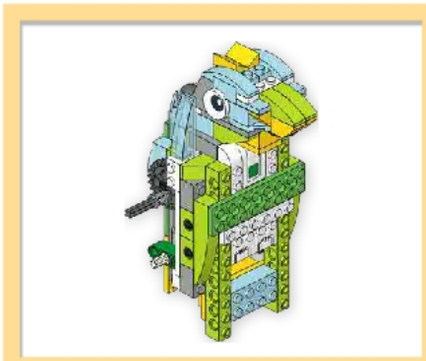

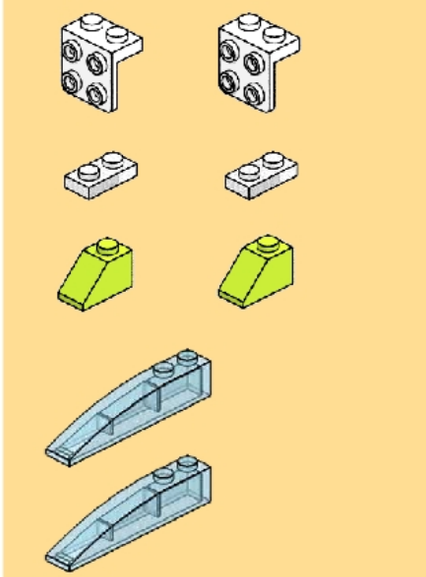

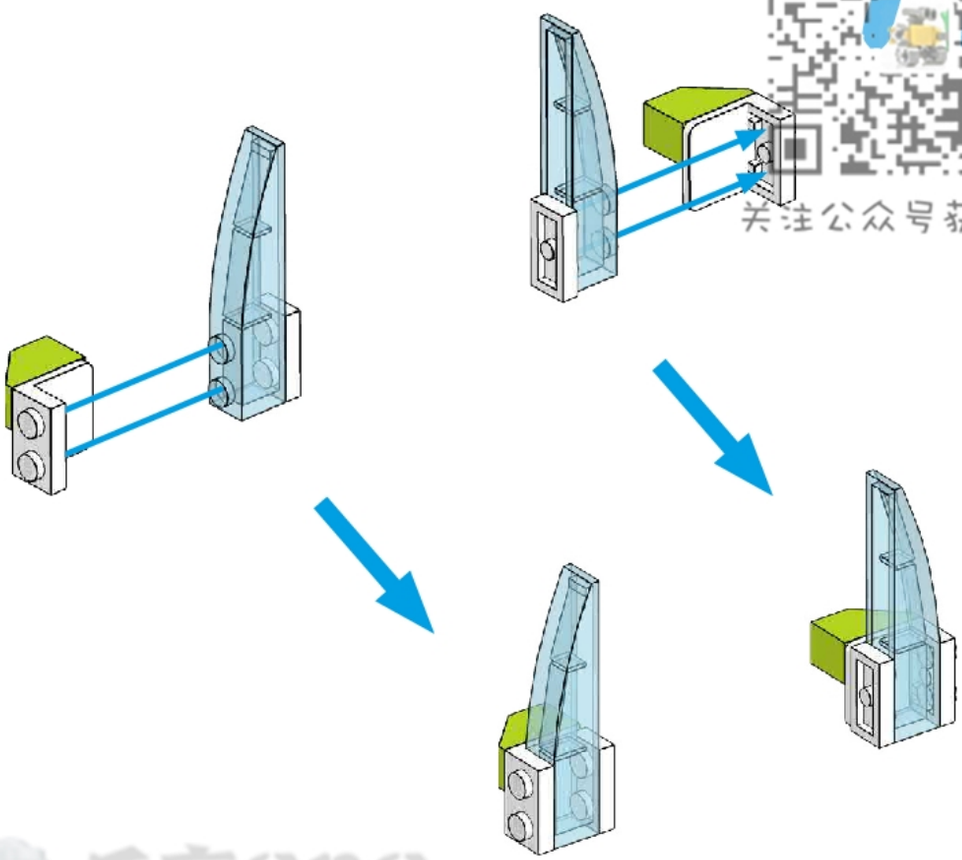

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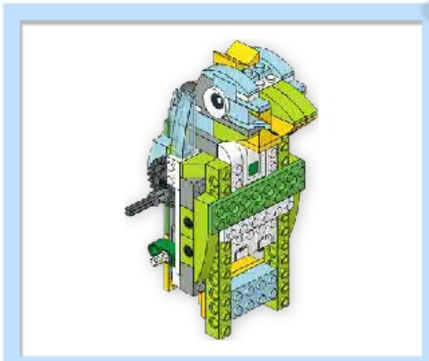

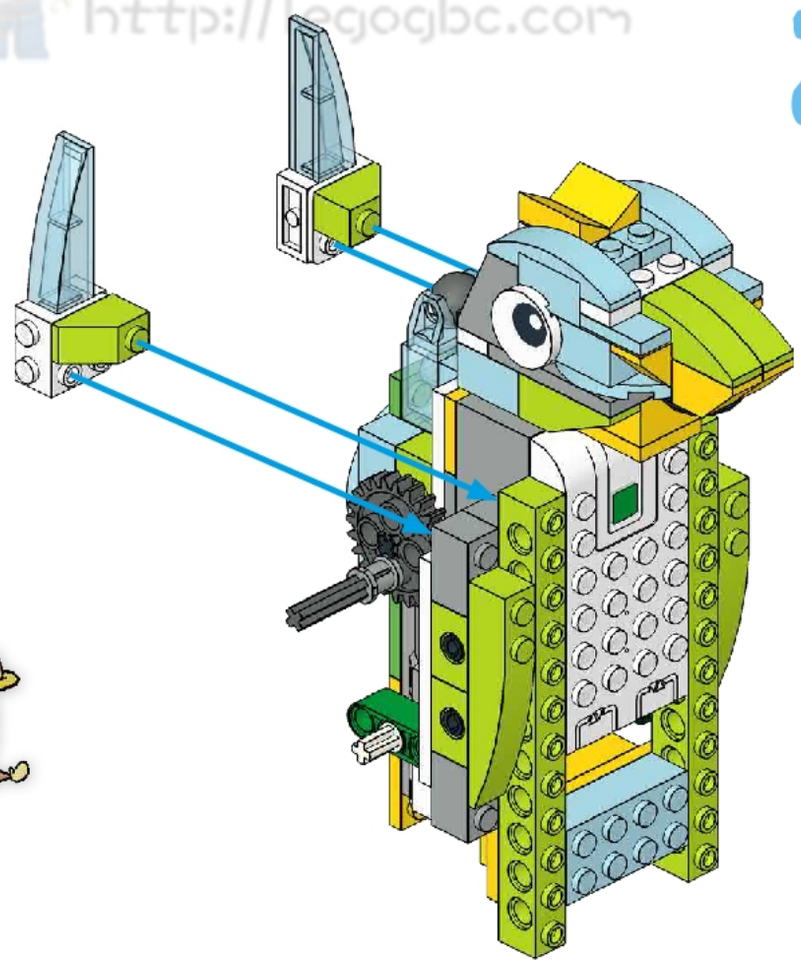

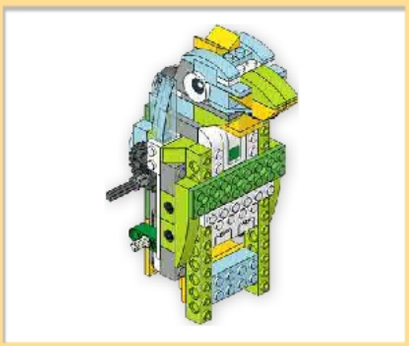

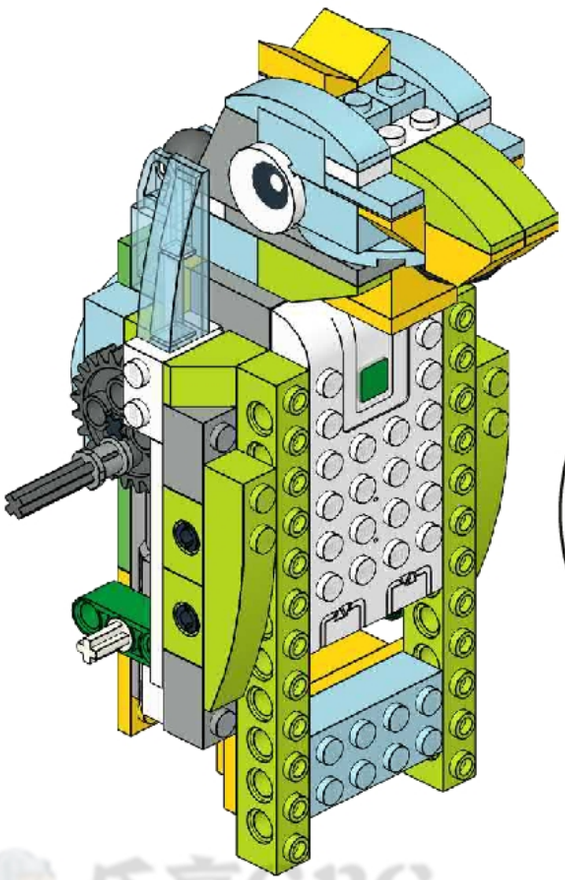

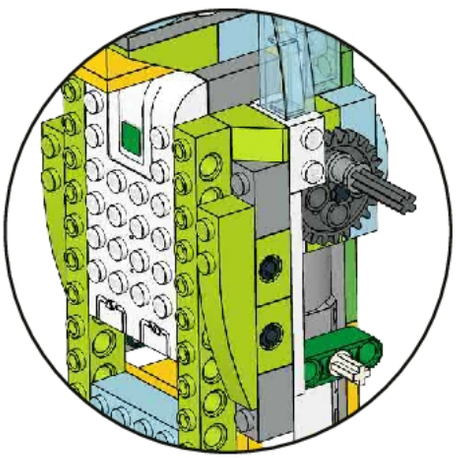

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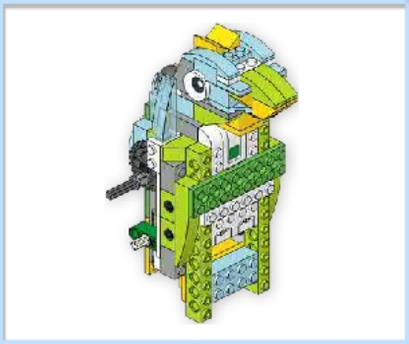

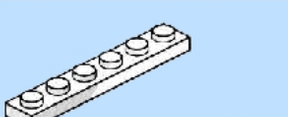

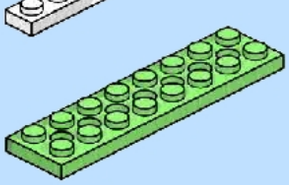

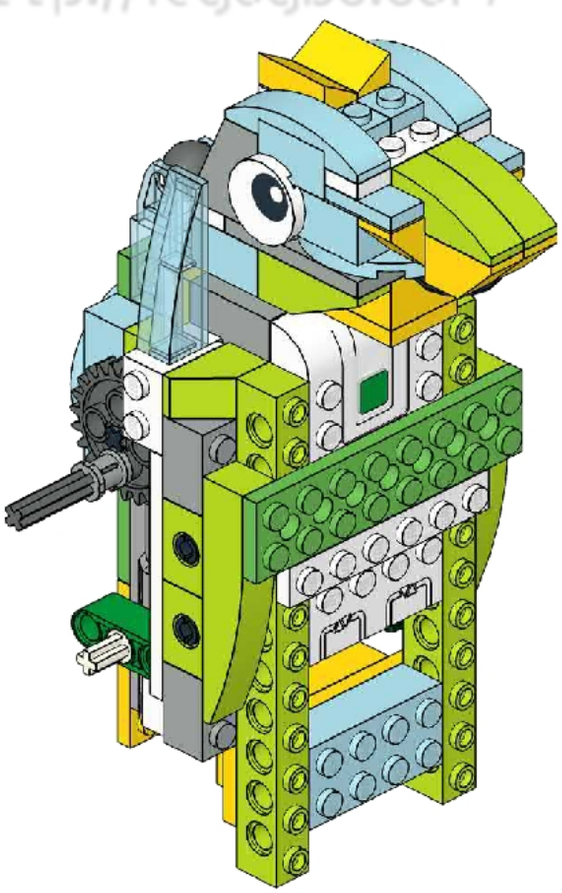

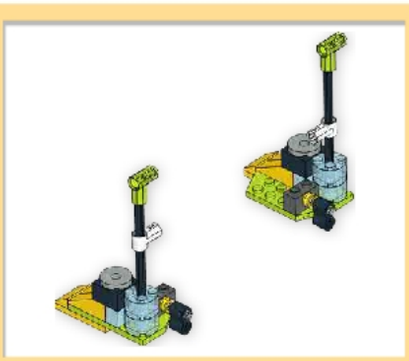

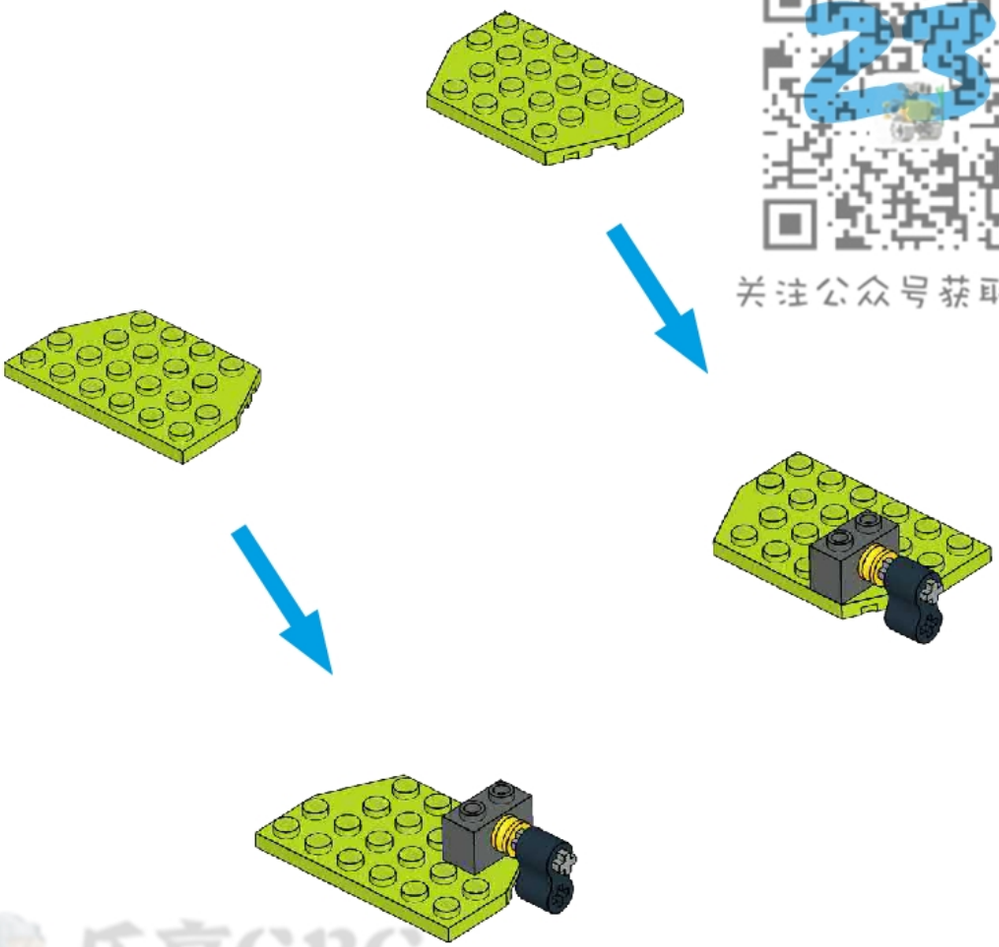

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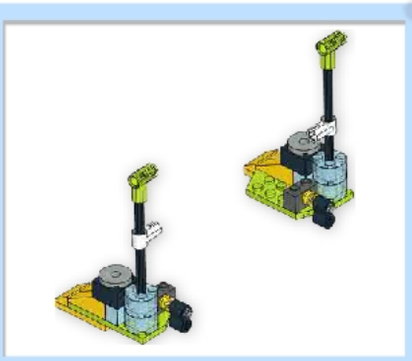

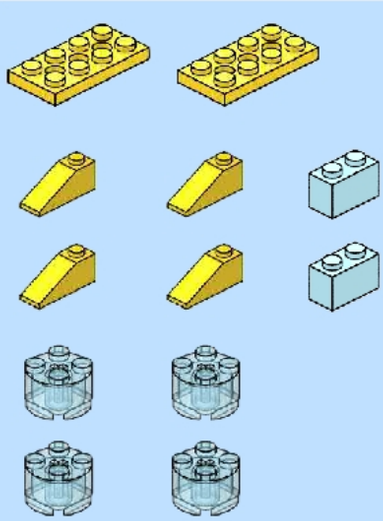

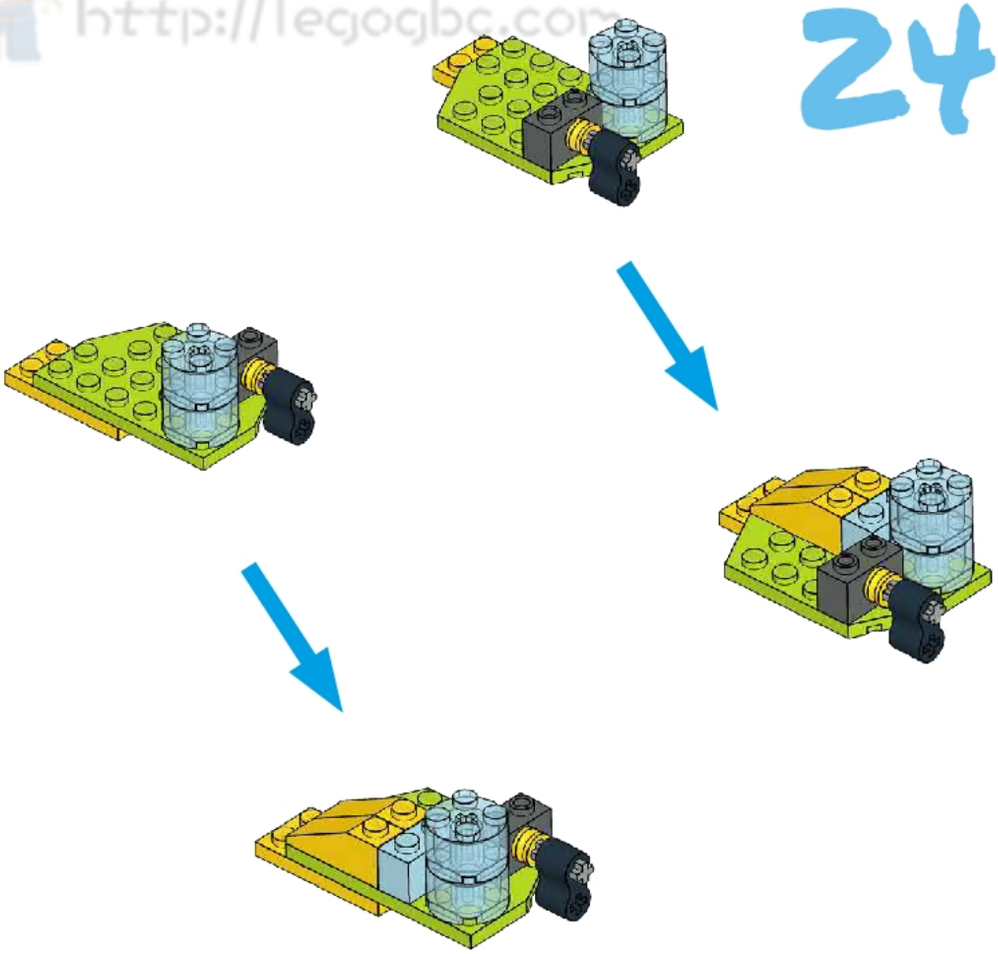

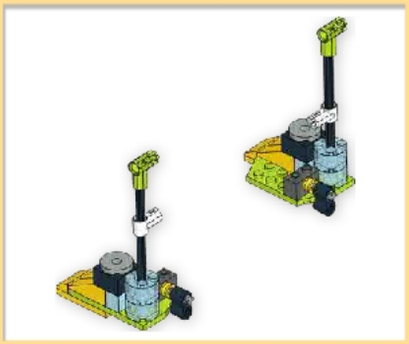

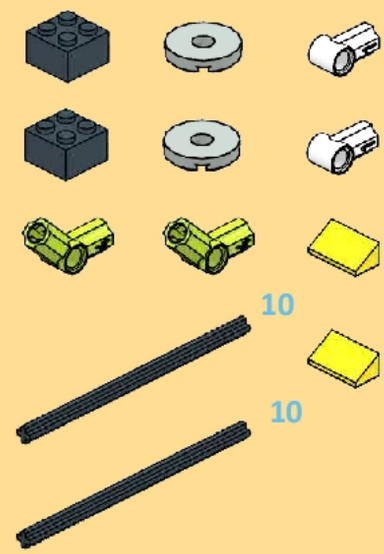

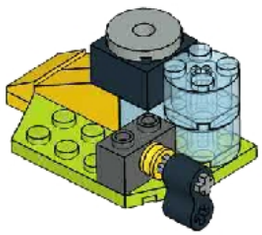

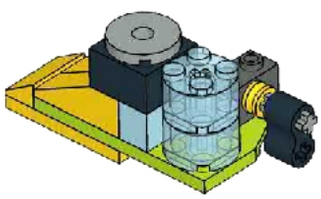

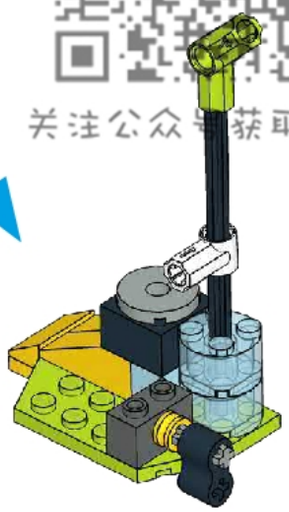

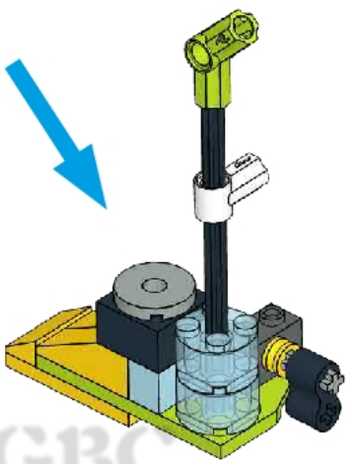

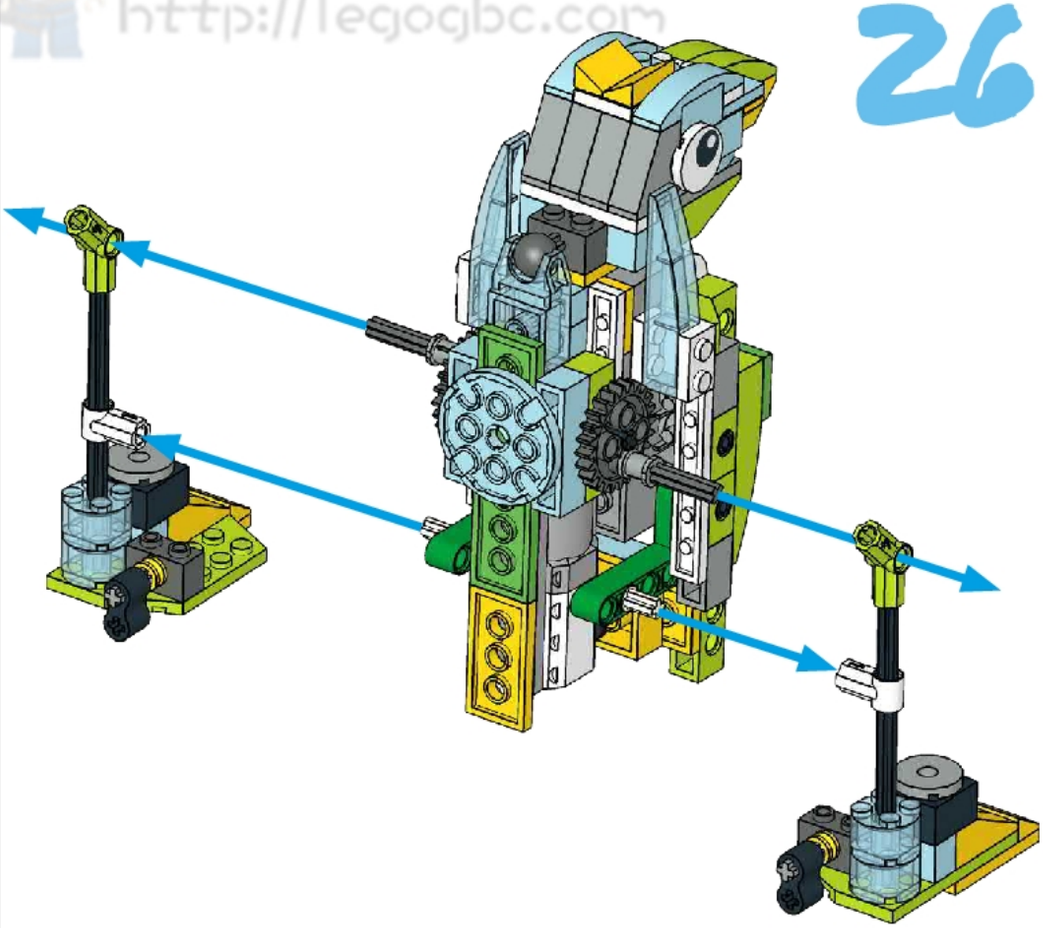

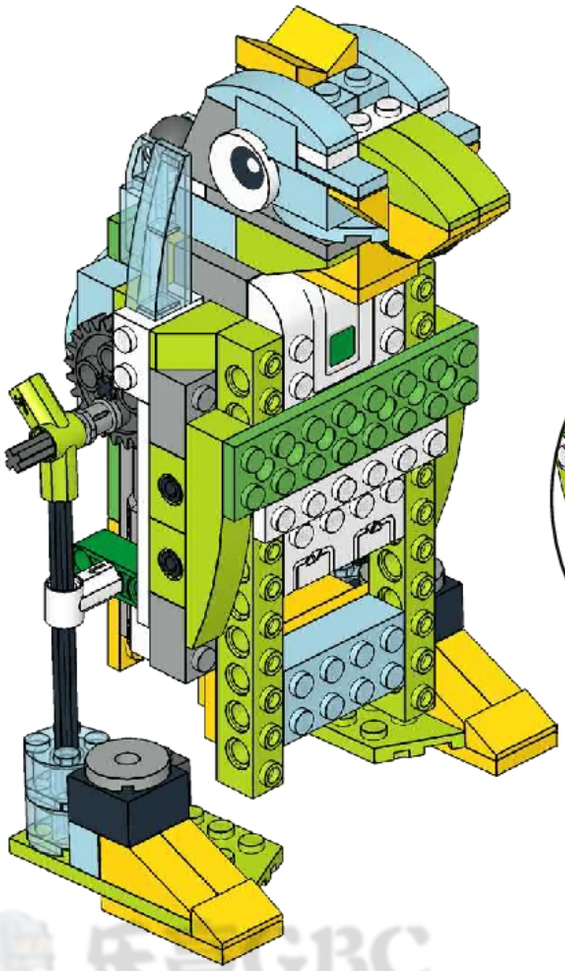

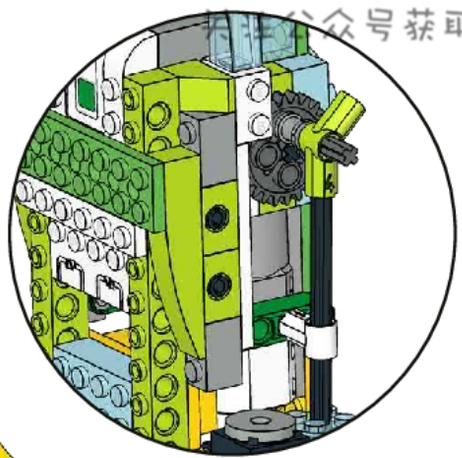

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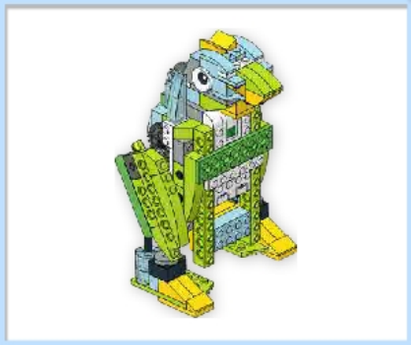

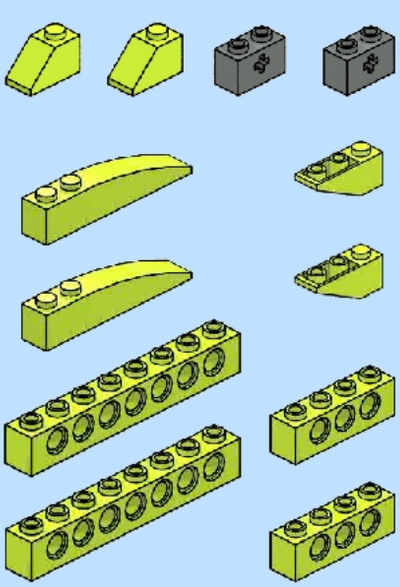

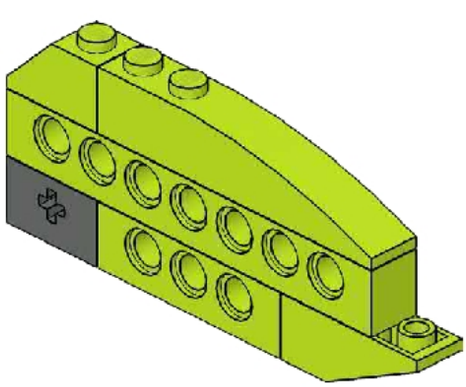

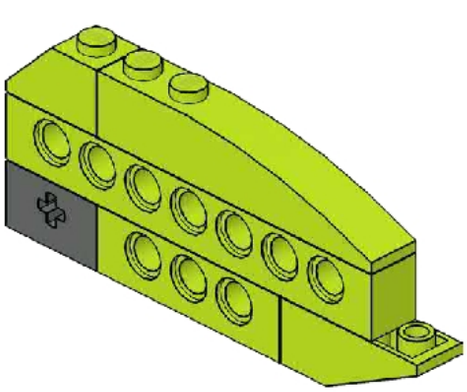

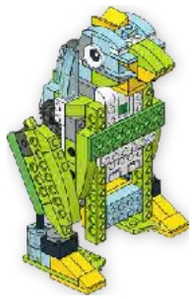

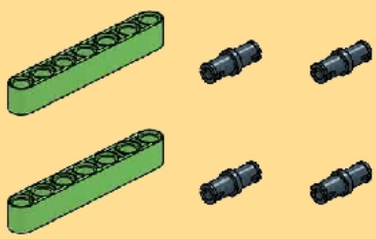

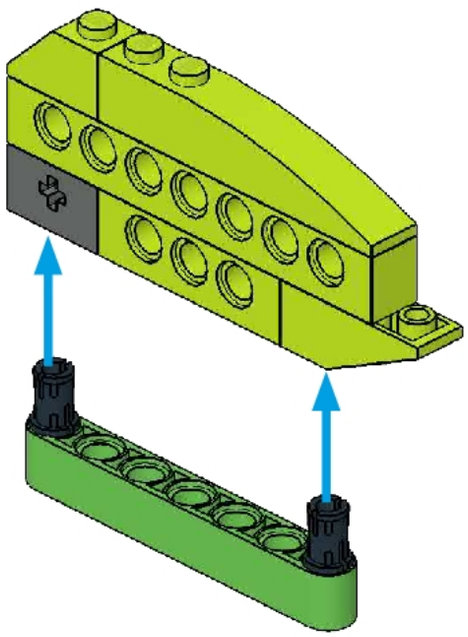

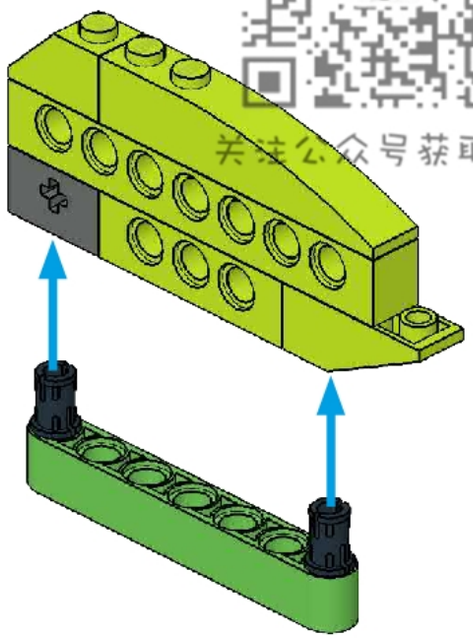

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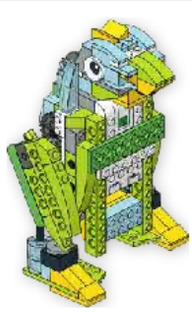

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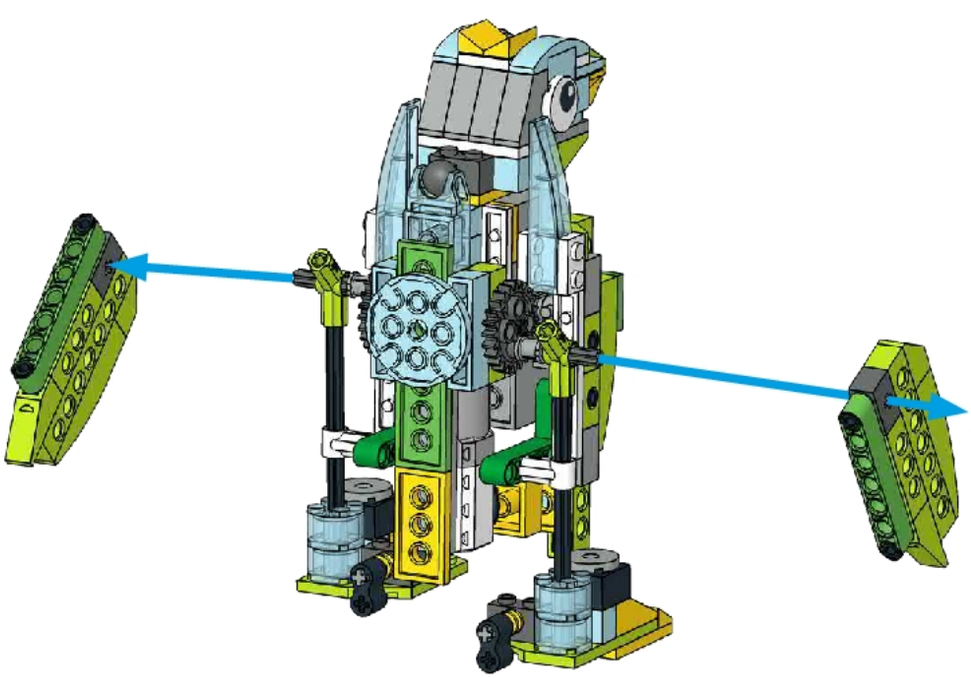

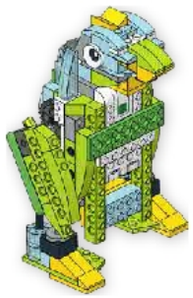

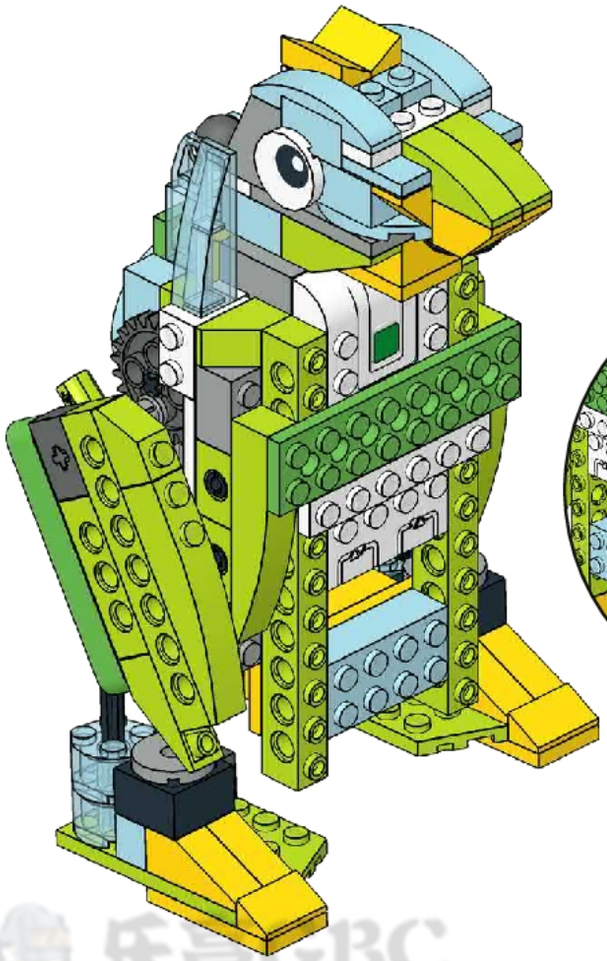

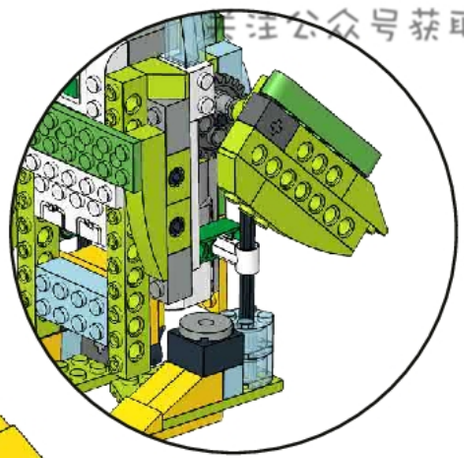

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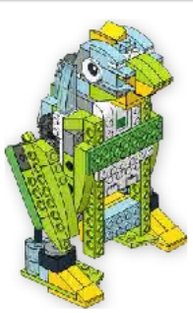
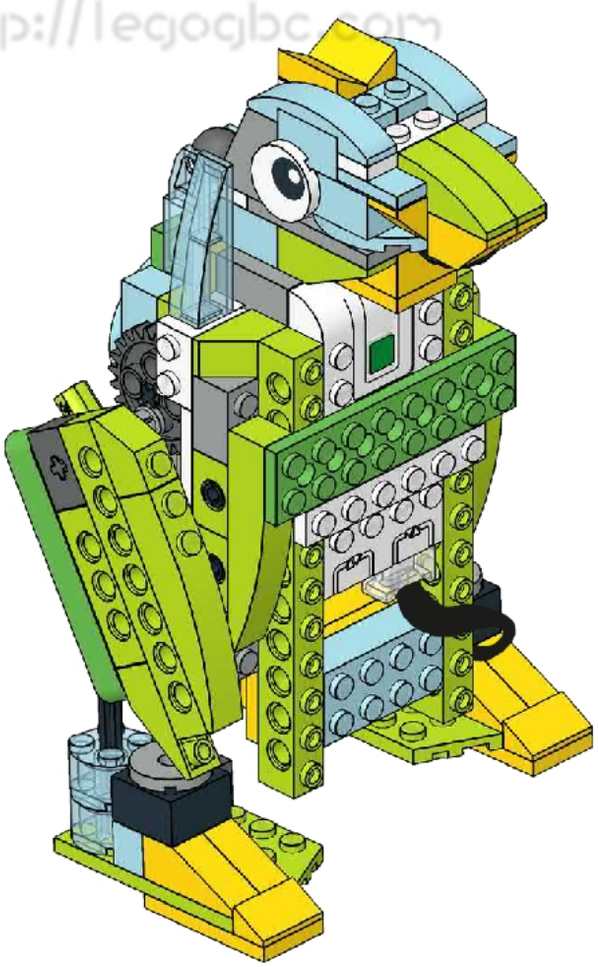




• Before going to the next phase, you can identify the mechanisms you are using in your penguin prototype.

• Can you predict how your penguin prototype will move by only seeing the model?

• How many gears are you using in your penguin prototype?

• How many legs does your penguin prototype have?

Design features

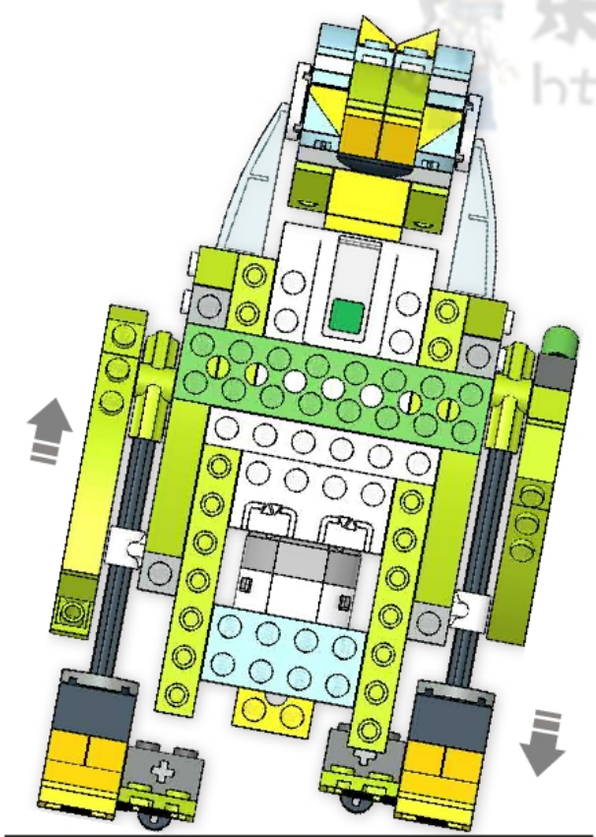
• Your penguin uses the motor to drive the two legs.

• Can you identify the bevel gears and the inverted slider-crank linkage?

• Can you identify the driver gear and the follower gear in the bevel gear mechanism?

• Are the two legs in an out-phase motion? You can check this by the position of the legs. One leg should be in the opposite direction of the other one.

Gearing down mechanism using bevel gears



Out-phase motion

Inverted slider-crank linkage

Program phase: Finite loop

- In this section, you will explore the use of finite loop to perform repetitively tasks.
- The program idea consists of moving your penguin back and forth.
- In a more detailed way, your penguin will move forward for 4 seconds, then backward for another 4 seconds, then forward again for 4 seconds, and finally backward for another 4 seconds.

Flowchart

1. Start the program
2. Set motor power
3. Penguin moves forward
4. Wait for 4 seconds
5. Penguin moves backward
6. Wait for 4 seconds
7. Penguin moves forward
8. Wait for 4 seconds
9. Penguin moves backward
10. Wait for 4 seconds
11. Penguin stops

1. Start the program
2. Set motor power
3. Penguin moves forward
4. Wait for 4 seconds
5. Penguin moves backward
6. Wait for 4 seconds
7. Penguin stops

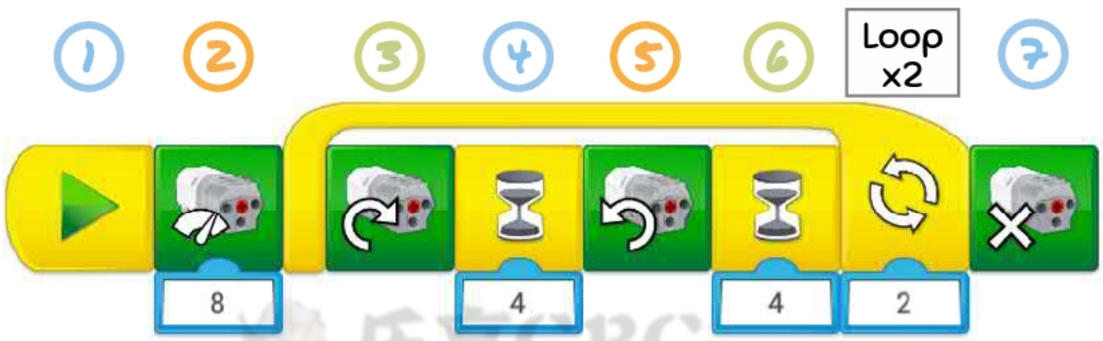
Loop x2

You can use finite loops to avoid repetition of programming blocks! In the example, both flowcharts list the same tasks, but using a finite loop we can reduce the number of tasks from 11 to 7!

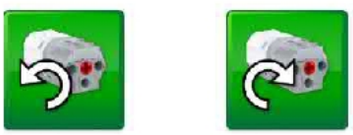
• The first flowchart indicates 11 tasks. Therefore, we can assign a programming block for each task:

Using a finite loop

• The number of tasks can be reduced from 11 to 7 using a finite loop block:



• Task 3 indicates that your penguin should go forward. Which of these blocks will make your penguin go forward?



• You will find out the answer to this question on the test phase!

Test phase: Controlling motor direction

• Remember to verify the communication between your WeDo software and your WeDo Hub before you start testing your prototype.

• Start testing your prototype by executing the program developed in the program phase by clicking the "Start" block.

TEST 1: Finding the right motor direction

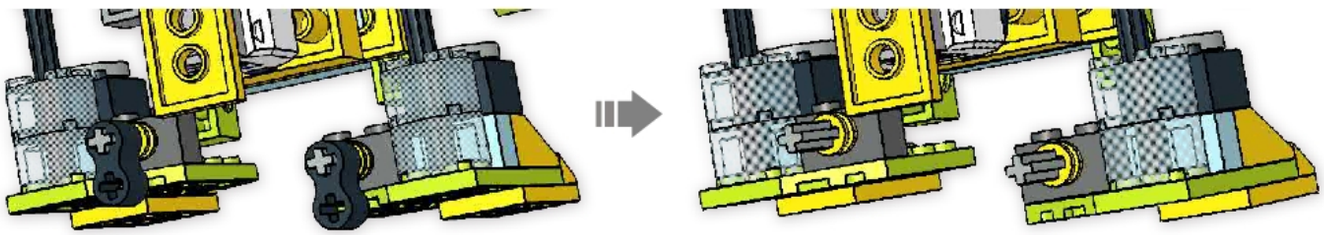
• Identify in which direction your motor has to rotate to make your penguin move forward and backward.

TEST 2: 11-block program vs. 7-block program

• Do you find any difference between the program using 11 programming blocks and the program using 7 programming blocks?

TEST 3: Friction to walk

• Remove the rubber parts located at the bottom of your penguin legs:



• Execute your program and test how your penguin moves without the rubber parts. Does it walk better or worse?

Friction: Why is it useful?

• **Friction** is the force that resists the sliding of one solid object over another. Thanks to friction, you can walk without slipping.
• **Rubber materials** present higher friction than **plastic materials**, which makes your penguin walk better when it is using a rubber piece.

Document & share phase

• Remember to collect all your **notes**, **videos**, and **photos** to report your **findings and results**.
• Record a video of your penguin moving with and without the rubber parts and make a comparison.
• Write your findings and results obtained from the **three tests** performed in **the test phase**.

Enhancing the experience

• **Build:** You can try to build different legs for your penguin and see if it can walk.
• **Programming:** Program different motor power when your penguin is moving back and forth.