# 2024 MakeX Starter

## All-core Journey
## Technical Training of Competition

V1.0

Made by MakeX Organization Committee

2024/3/8

# CONTENTS

# Self-check list for junior instructors（Training goal）

1. Understand the use and debugging of core sensors in competition

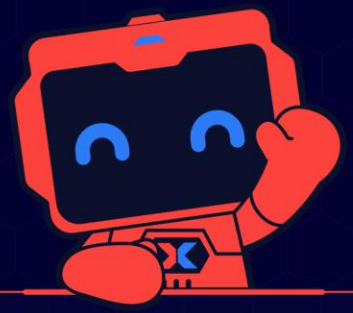
   （Ultrasonic Sensor、Quad RGB Sensor、Dual Color Sensor, etc.）

2. Be able to guide student solve critical programming problems

   （Cyberpi error code、Line follow issue、Firmware and common issues of the extension）

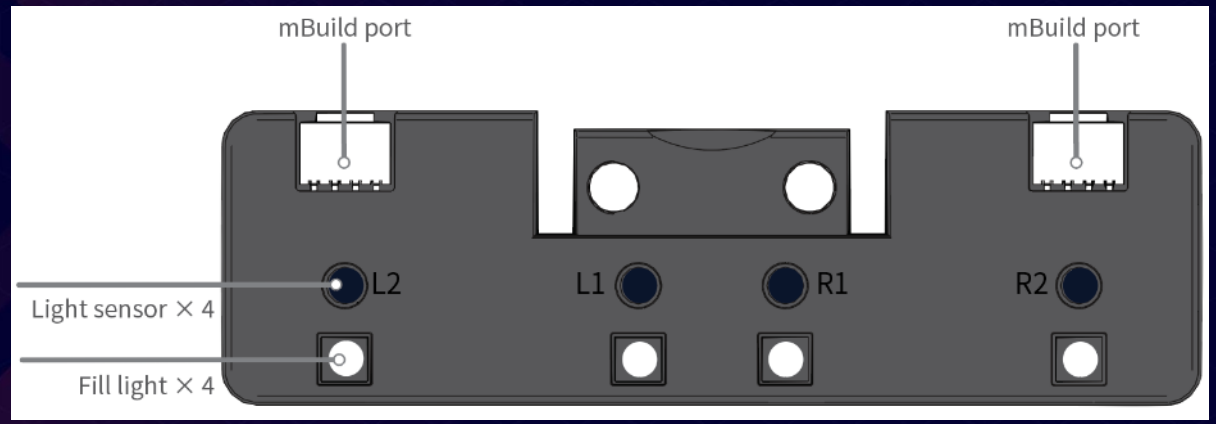
3. Understand and teach the core algorithms used in competition

   （Line follow with KP/PID algorithm、Manual control program design）



# 01 | Introduction to core electronic parts

# 01 | Quad RGB Sensor




Quad RGB Sensor

## Button Function:

1. Background learning
2. Switching fill light

## Scenarios:

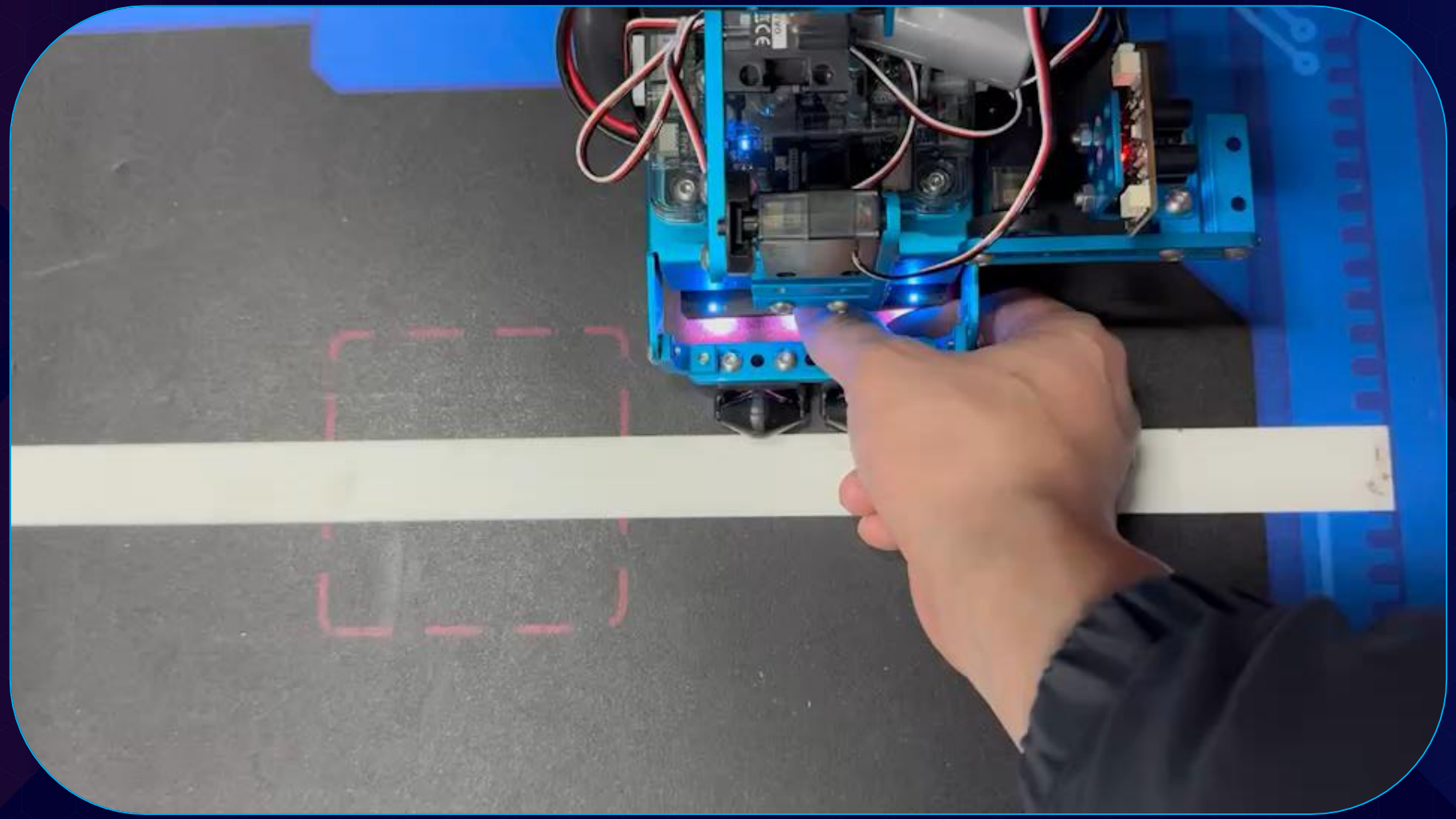
1. Line follow algorithm
2. Color detection algorithm

# What is the purpose of background learning and Switching fill light?

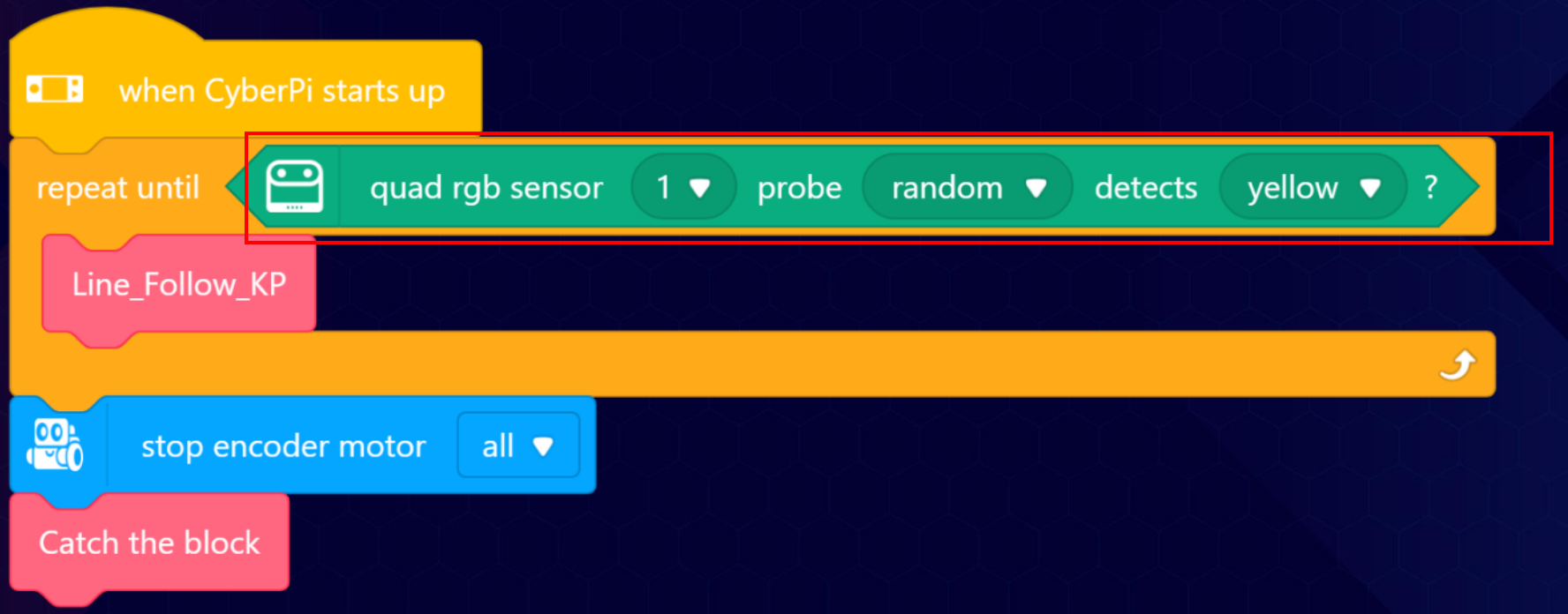
Reduce the interference of ambient light to the lin

e follow program

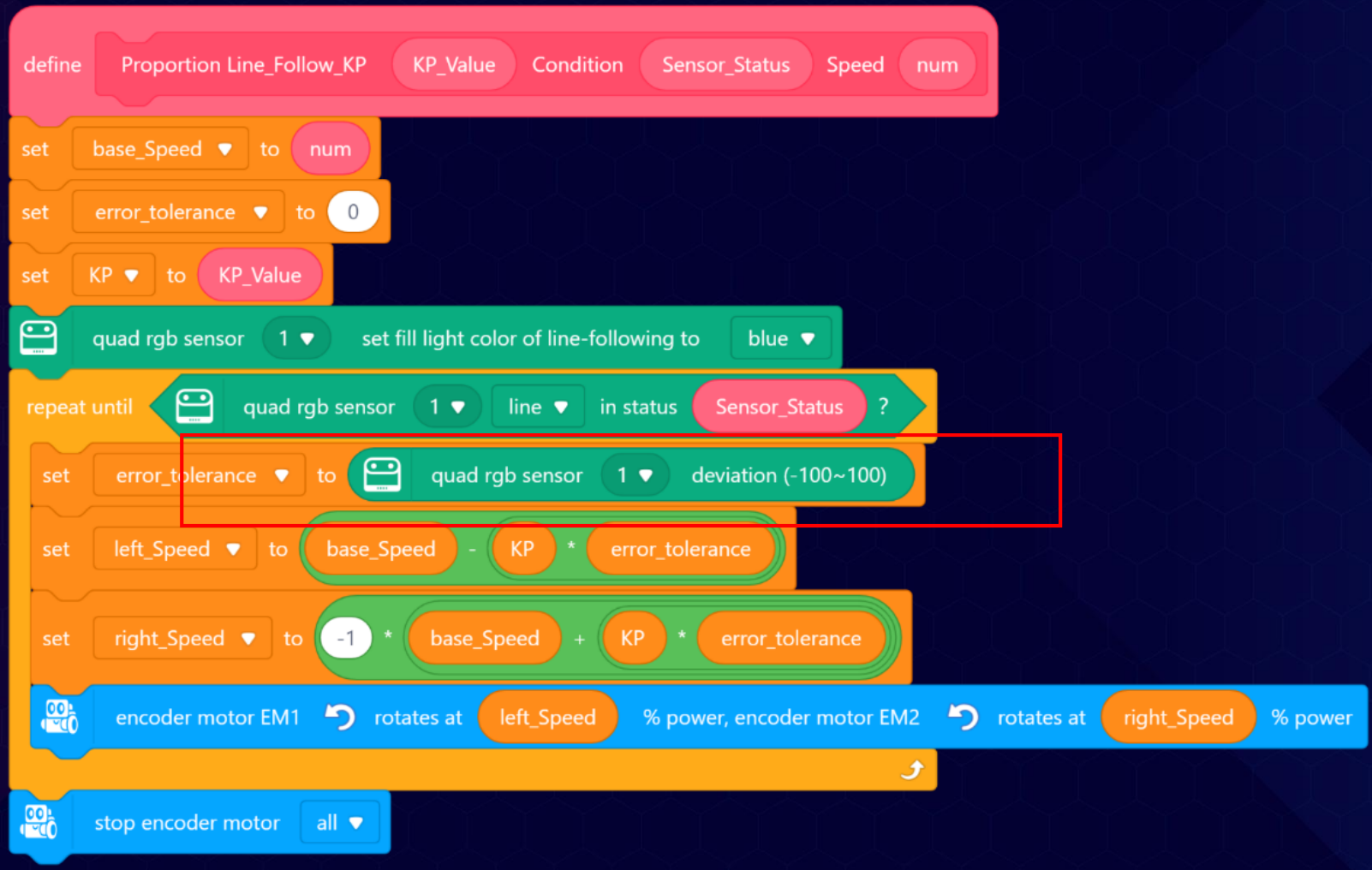
# 01 | Quad RGB Sensor – Guide of calibration



# 01 | Quad RGB Sensor – Color detection

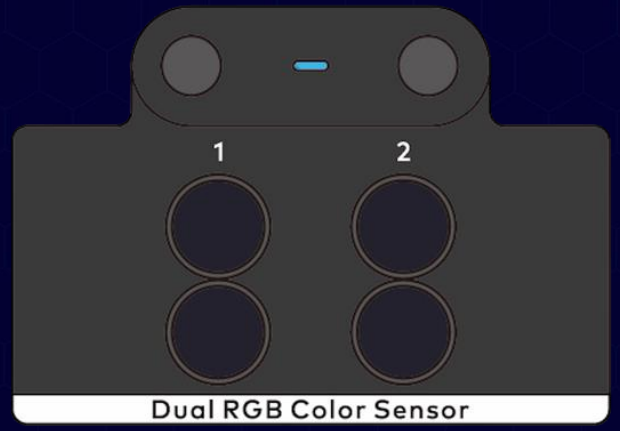


# 01 | Quad RGB Sensor – Line Follow algorithm(KP algorithm)



# 02| Dual RGB Color Sensor

Why do we need to add a dual RGB color sensor when we have Quad RGB sensor?




Dual RGB Color Sensor

## Button Function:

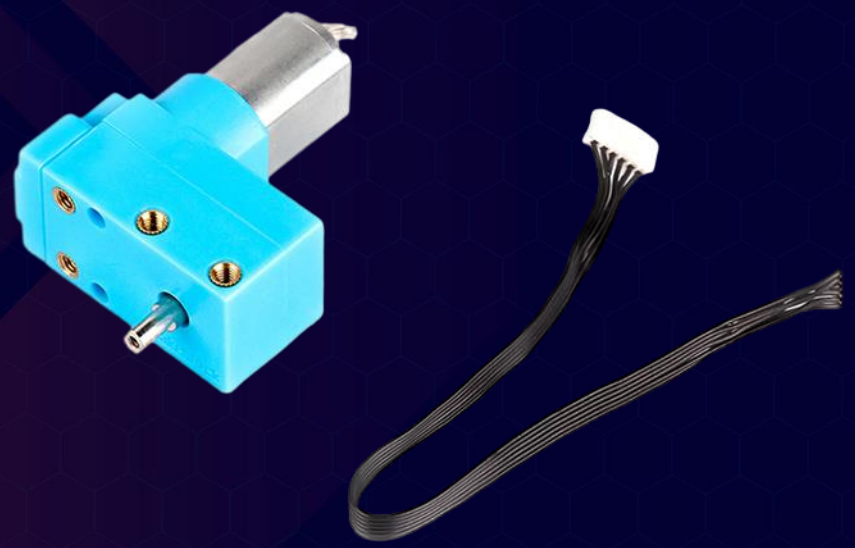
1. Background learning
2. Switching fill light

## Scenarios:

1. Line follow algorithm
2. Color detection algorithm

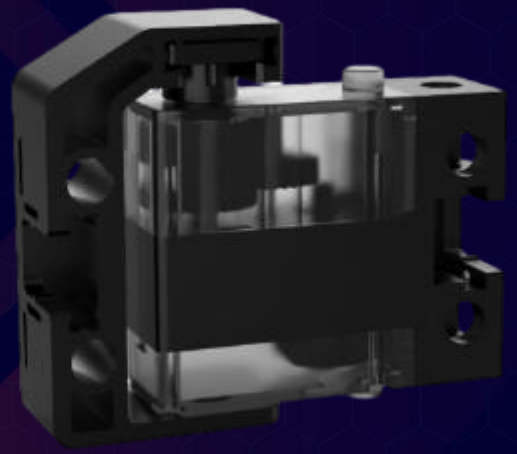
# 02| Dual RGB Color Sensor – Color detection

# 03 | 180 Optical Encoder Motor



180 Optical Encoder Motor

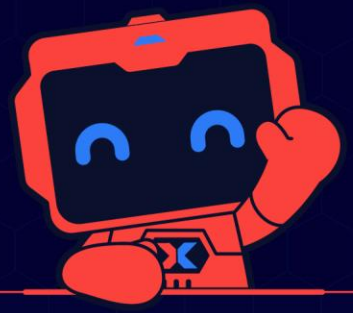
| Product Info | Description |
|---|---|
| SKU | 81340 |
| Gear ratio | 39.6 |
| Rated voltage | 7.4V |
| No-load current | 240mA |
| Full-load current | ≤750mA |
| No-load speed | 350RPM±5% |
| Starting torque | 5kg·cm |
| Rated torque | 800g·cm |



MS-1.5A Servo

## How to troubleshoot if the servo vibrates during operation?

1. Insufficient power supply voltage. Recharge the battery, and after incr easing the battery voltage, restart the robot.
2. Servo is defective. If servo defective is confirmed, replace the servo.
3. The weight of the objects carried by the servo is too heavy, so the wei ght needs to be reduced.
4. The control wire of the servo is too close to other motors, servos or ba ttery power lines, etc. Adjust the distance between them.
5. Unknown bug in the programming logic. Try adjusting the program to solve the problem.

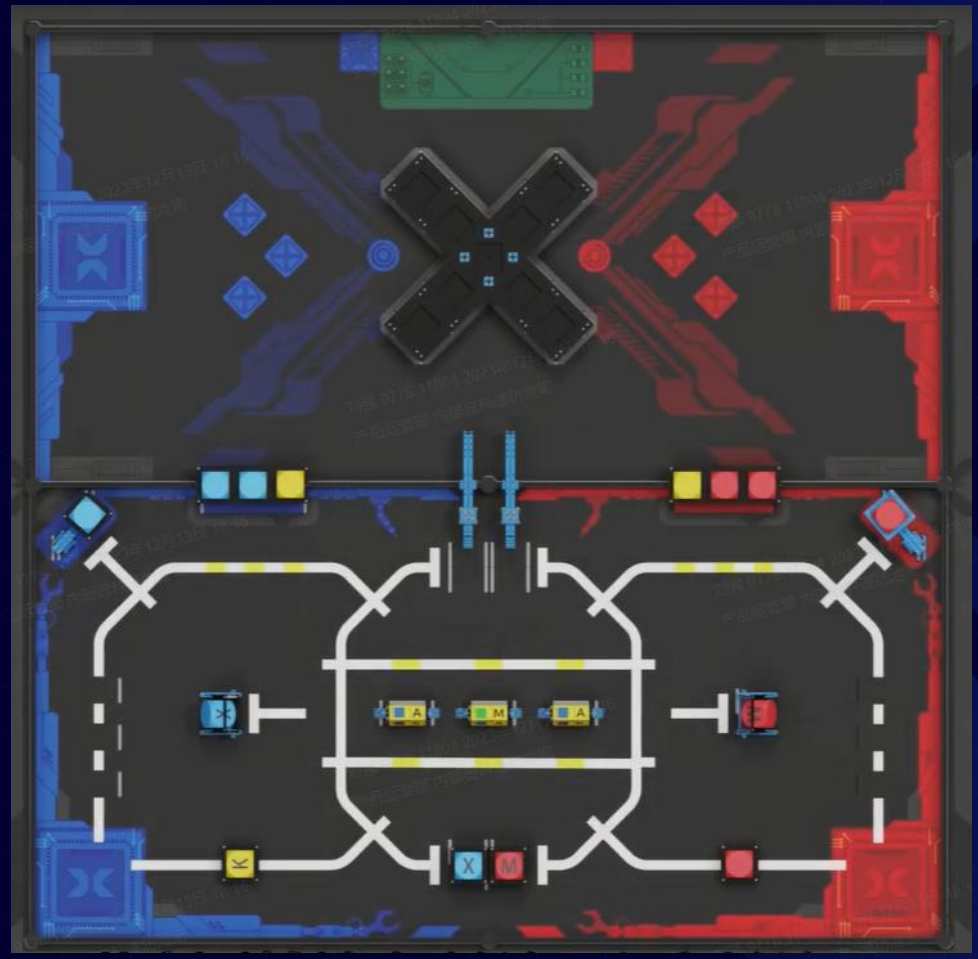


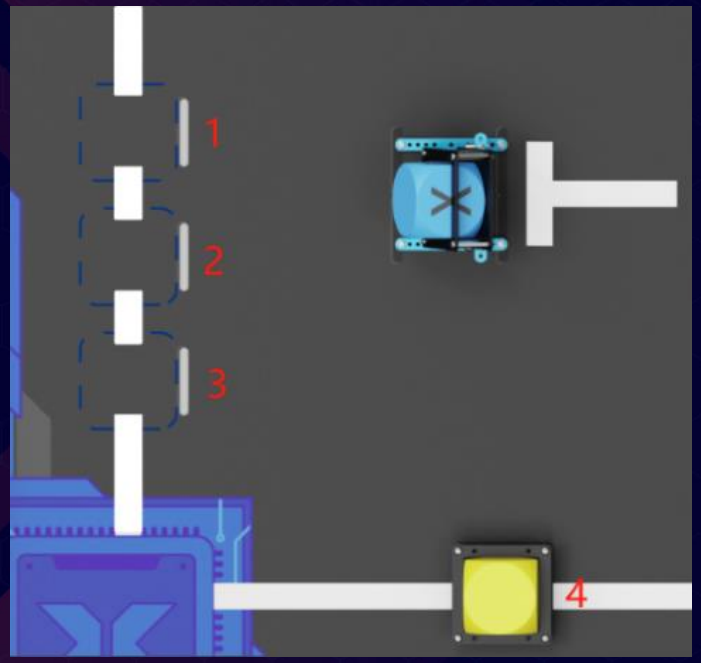
# 02

## Technical analysis of the competition

# 02| Analyzing Missions of the Competition

| Stage & Period | Mission Type | Mission Name |
|---|---|---|
| Auto control (x seconds，0<x ⩽240) | Independent Mission | M01 Capturing Quantum Chip |
| | | M02 Transiting Quantum Chip and Organic Crystal |
| | | M03 Capturing Alphabet cube |
| | | M04 Intelligent Manufacturing |
| | | M05 Processing of Contaminants |
| | | M06 Stacking Storeroom |
| | Alliance Mission | M07 Lighting the Antimatter Fuel Rod |
| Manual control (240s - end) | | M08 Operating Matrix Research Station |
| | | M09 Placing Team Marker |






## Mission Gameplay

### Mission Initial status:

This mission has two yellow cubes (quantum chip and organic crystal), one wit h the letter K (K should be upwards). Each team has four marking area close to starting area , where the cube placement is determined by a random draw.

*The yellow letter cube places in either the red or blue team's starting area, whi ch is negotiated by both teams before the competition.

### Gameplay:

The robot’ s target is to completely remove the yellow cube and their bases fro m the marking area.

## Scoring Judgment

a. The vertical projection of yellow cube（with base） must completely leave th e marking area

b. The yellow cube（with base） must completely inside the competition area

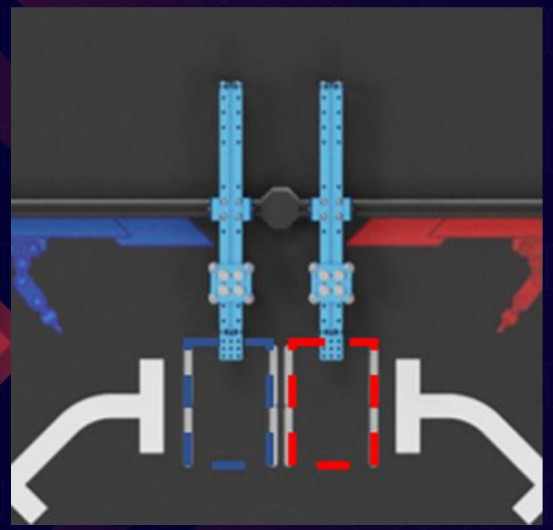
c. The yellow cube and base are not separated from each other;

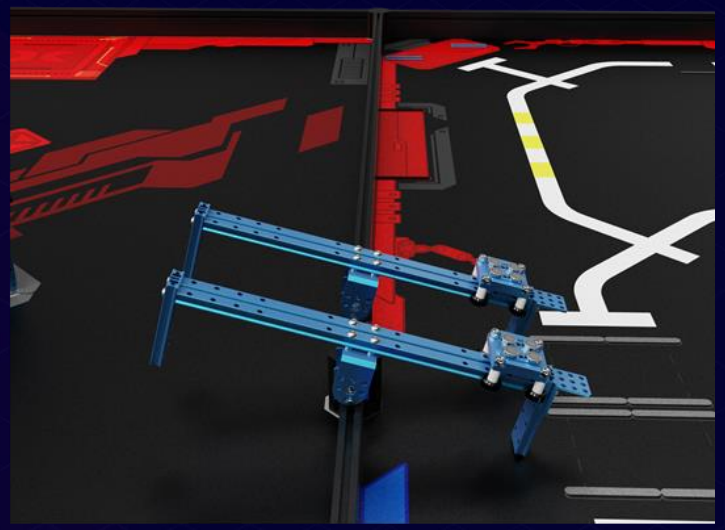
d. The yellow cube（with base） has no touch with the robot at the mission end

## Score of Mission

A successful move of the yellow cube earns 20 points

# 02| M02 Transiting Quantum Chip and Organic Crystal





## Mission Gameplay

**Mission Initial status：：**

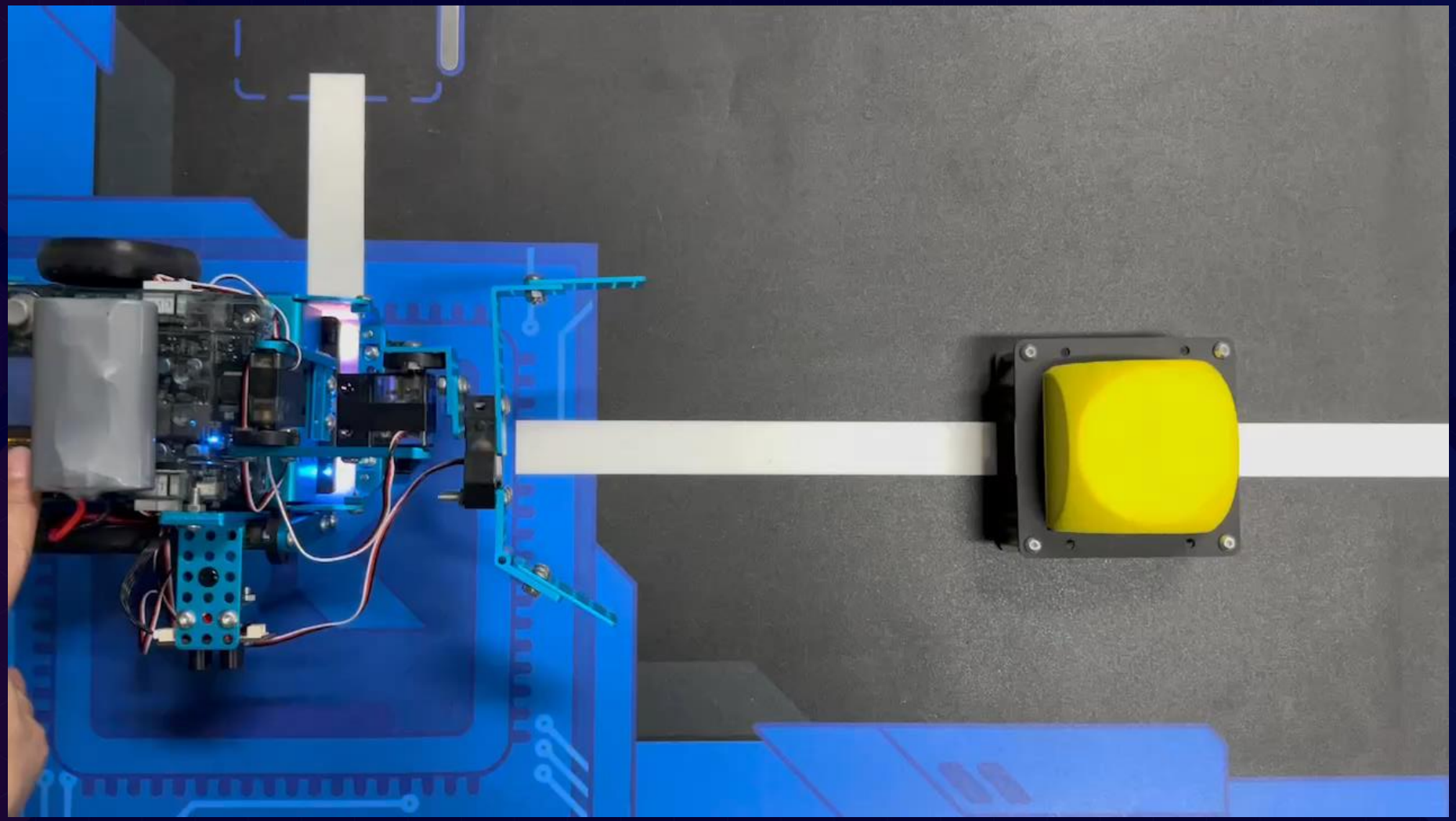
The scoring props of this Mission are derived from th e yellow alphabet cube or yellow cube (with base) of mission M01

**Gameplay:**

Transit the yellow alphabet cube or yellow cube (wit h their bases) to the manual loading area through th e slider. A successful transition of yellow cube earns 30 points

## Scoring Judgement

a. The vertical projection of yellow cube (with their bases) must be completely inside the manual loading area
b. The yellow cube (with their bases) must be adsorbed on the slider and does not fall off
c. The robot has no direct contact with the transfer slide and the yellow cube(and their base) at the mission end



## Key points:

1.Reasonably consider the amount and structure of servos/motors for moving or catching

Torque = Force x Distance

Where: Torque is in kg·cm, Force is in kg, Distance is in cm

Consideing the servo motor is with a maximum torque of 1.5 kg·cm

Plugging in the values you provided:
Force = 1.5 kg·cm / 5 cm
Force = 0.3 kg

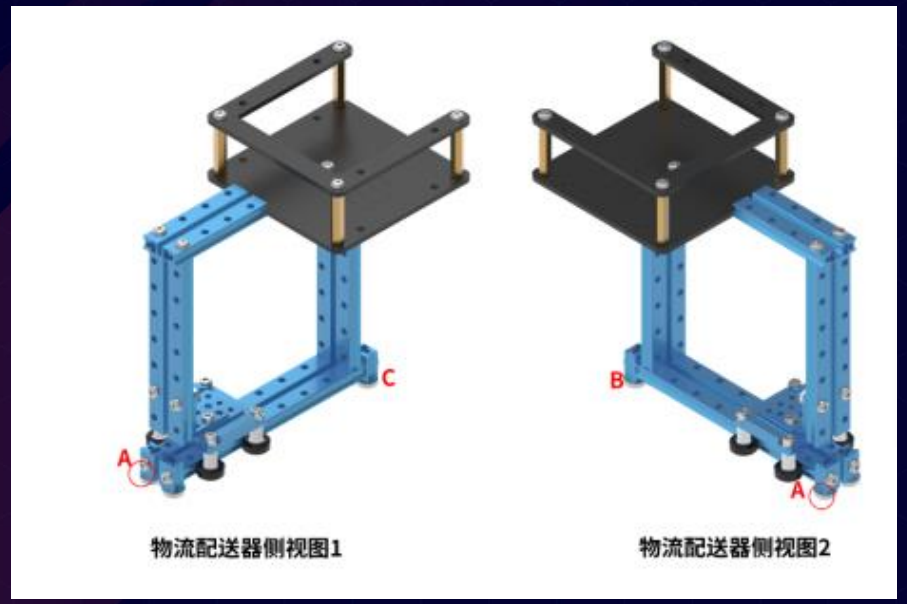
Therefore, the maximum load of this servo is about 0.3 kg at 5 cm.
Exceeding this load may cause the servo destabilize the servo's position.
However, this is theoretical and real-world factors like gear design and manufacturing quality also play a role.

2.How to improve the line follow efficiency (speed) at the intersections?

Intersection：made by two white lines intersects, it has T type or + type.

3. How to handle when the robot cannot recognize the intersections correctly?

# 02| M03 Capturing Alphabet cube




## Mission Gameplay

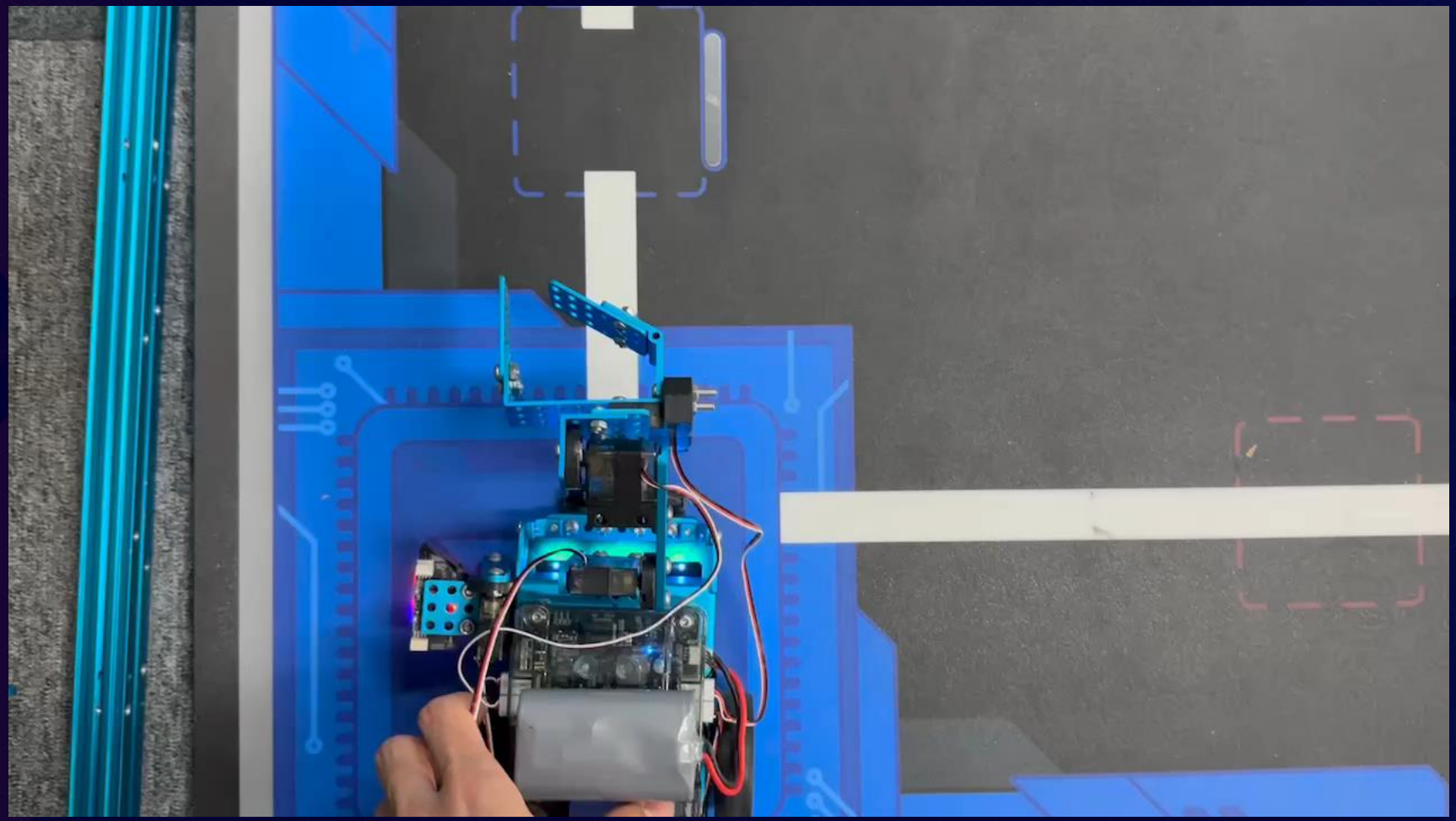
Remove the red or blue alphabet cube placed on the high cube placement table

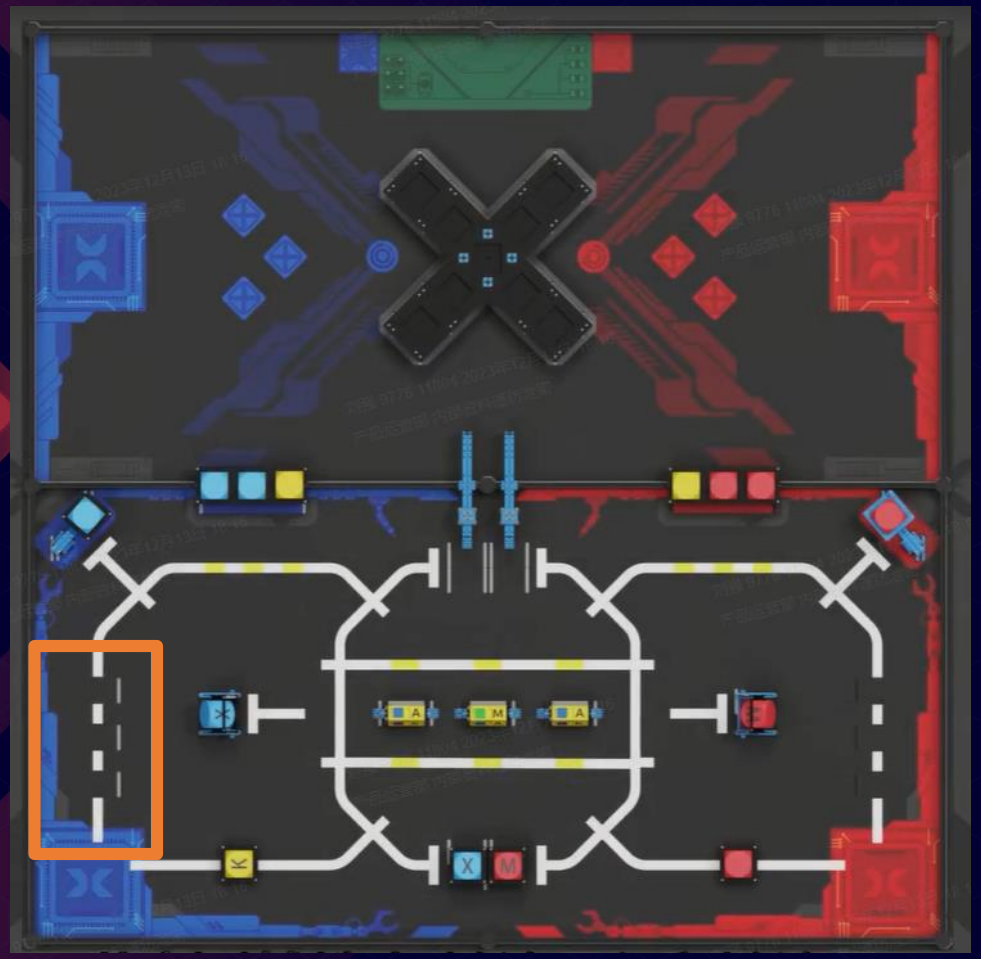
## Scoring Judgement

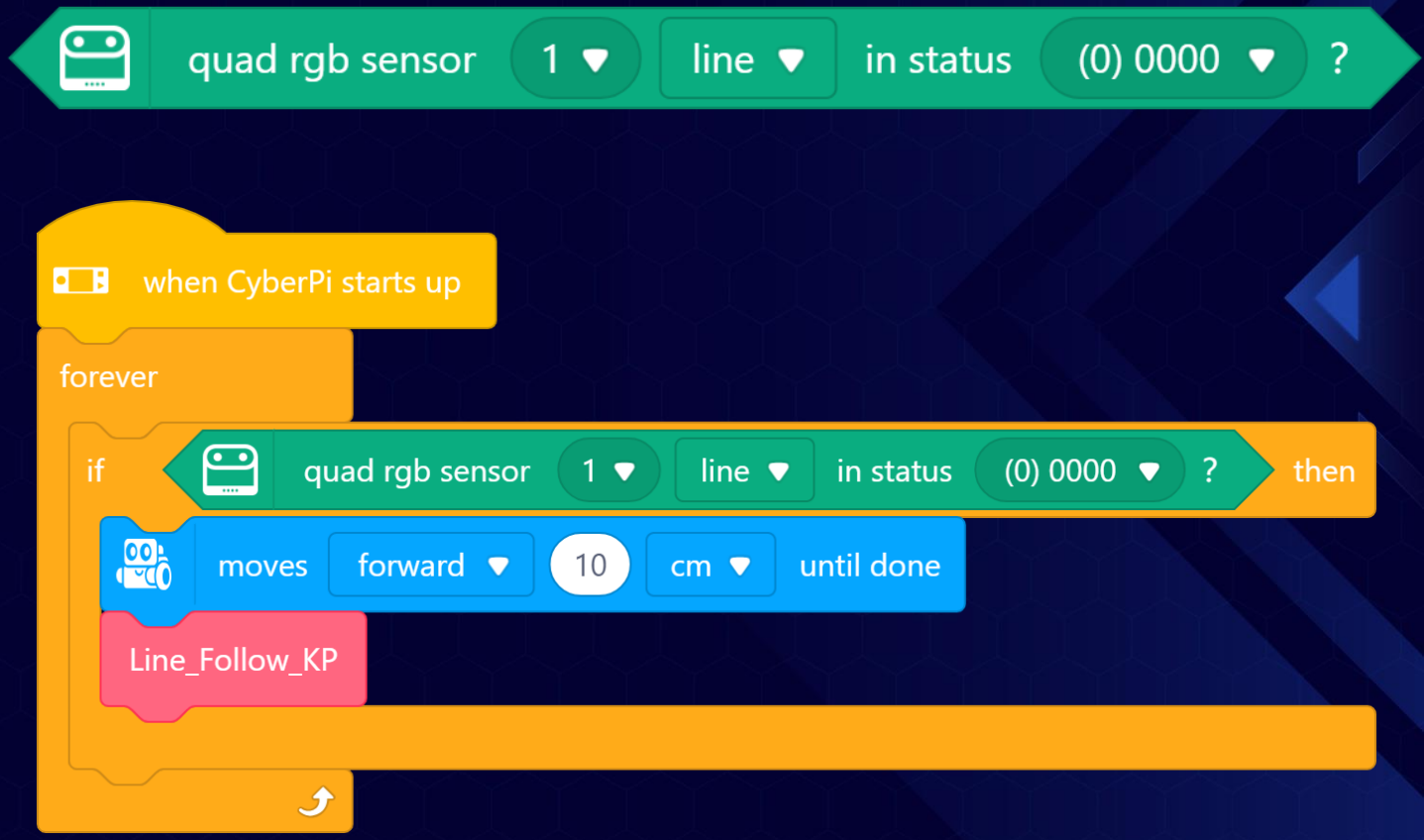
a. The vertical projection of red or blue alphabet cube must be completely inside the manual loading area
b. The Red or blue alphabet cube has no direct contact with the cube placement table
c. The Red or blue alphabet cube has no direct contact with the robot
d. The high cube placement table must remain upright

## Score of Mission

A successful remove of the red or blue cube earns 30 points








# How to decide the breakpoint?


## Scoring Judgement

a. The red or blue alphabet cube must completely leave the table
b. The vertical projection of red or blue alphabet cube must be co mpletely inside the competition area
c. The red or blue alphabet cube must have no direct contact with the robot and the manufacturing table at the end of mission

## Mission Gameplay

**Mission initial status:**

There are red or blue alphabet cube placed at the h igh manufacturing table of each team，the cubes a re embedded in the table，The direction of alphab et “M” or “X” are decided by a draw before the com petition

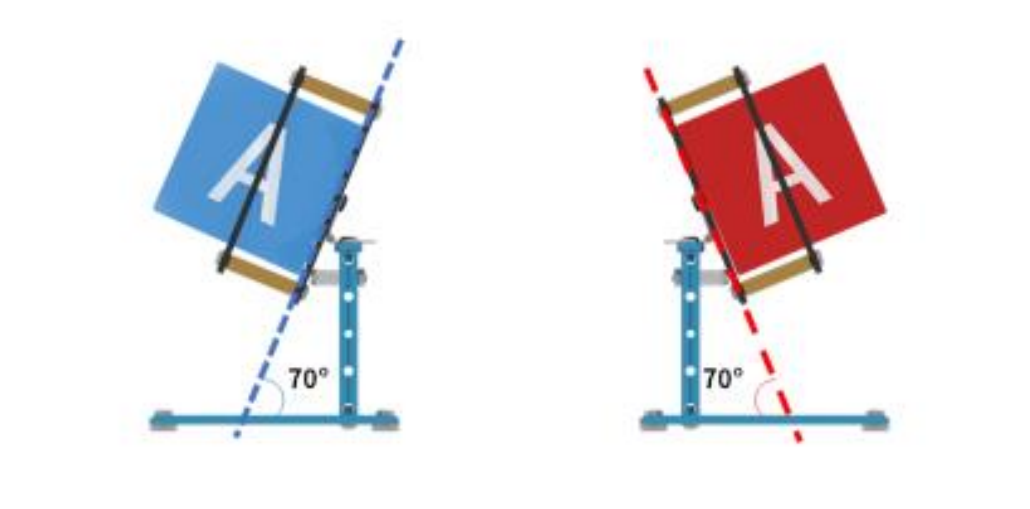
Gameplay:

Remove the cube from the manufacturing ta ble.

## Score of Mission

A successful remove of cube from the table ear ns 20 points

# 02| M05 Processing of Contaminants




## Mission Gameplay

Fill in the red or blue alphabet cube of M04 to the Password Filling Area and transit the original cube on the Resource Converter

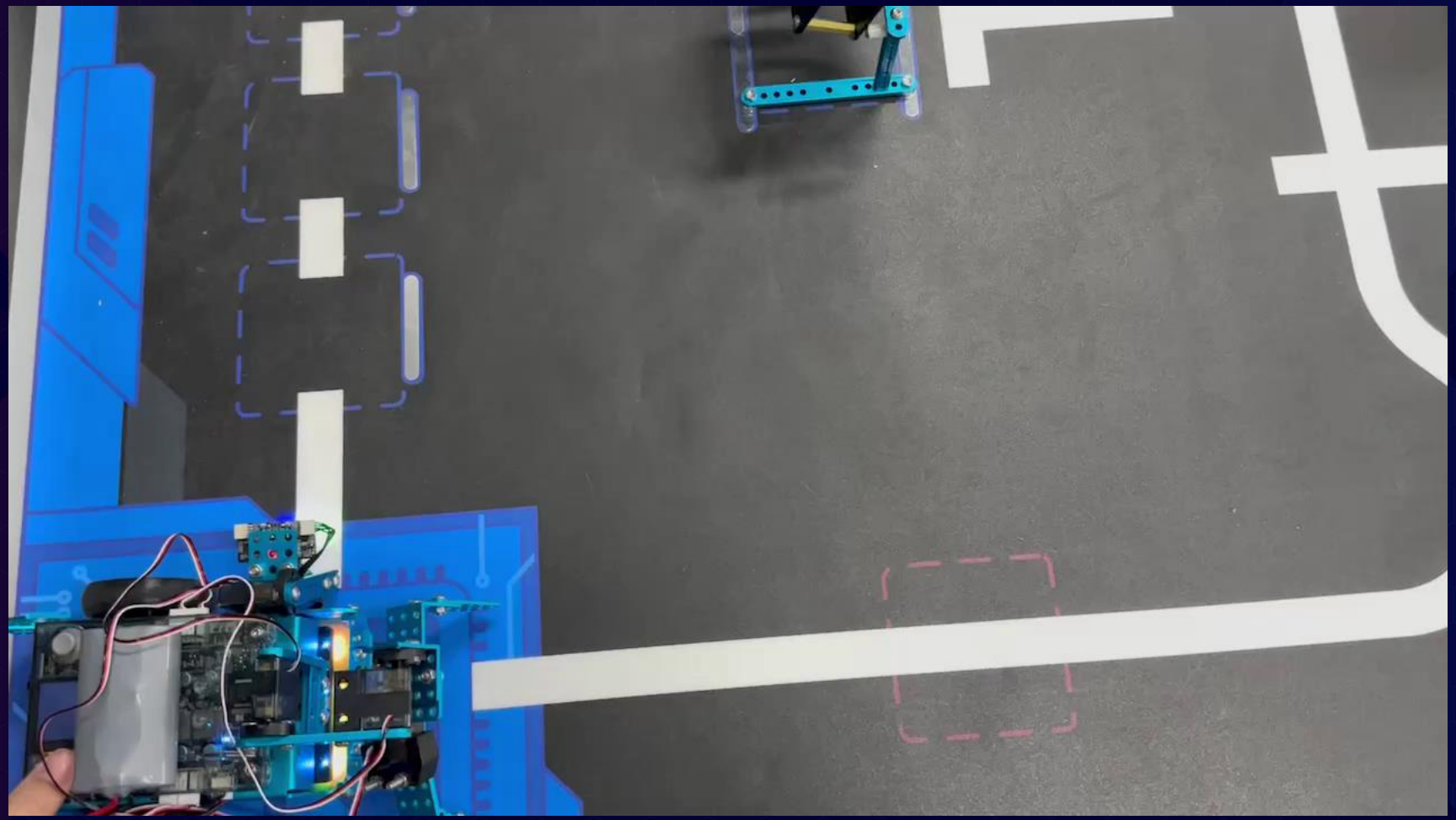
## Score of Mission

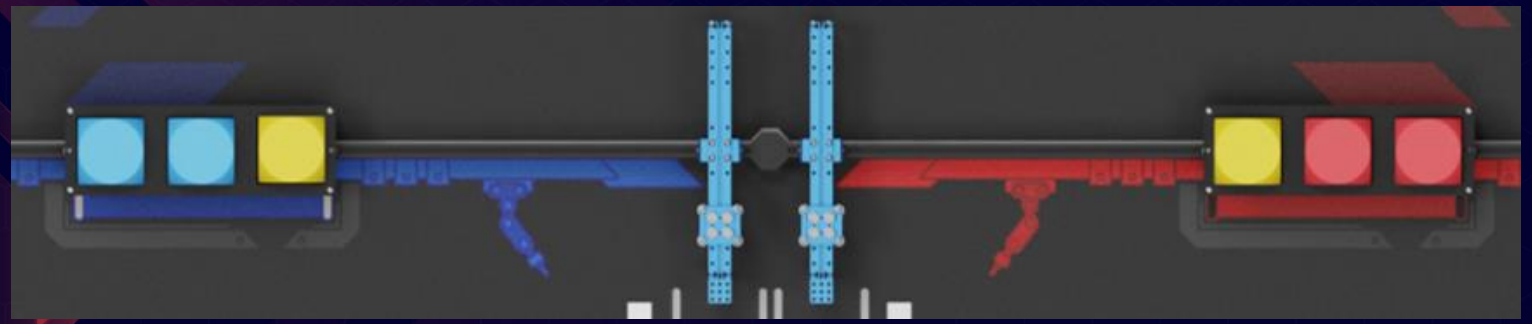
A successful filling of alphabet cube earns 10 points;
A successful transition of the original cube earns 30 points

## Scoring Judgement

1.a. The vertical projection of red or blue alphabet cube should at least be inside the password filling area and have direct contact with the baseplate
1.b. The red or blue alphabet cube must have no direct contact with the robot at the end of mission
1.c. The direction of alphabet “M” or “X” must be the same as the initial direction of M04 mission
If all requirements above are met, the corresponding red or blue team gets the score for password filling (10 points).
2. At the end of auto control stage， the vertical projection of the original cube from the Resource Converter must be completely inside the manual loading area
If requirement 2 is met， the corresponding red or blue team gets the score for transition(30 points)

# 02| Analyzing Missions of the Competition - M04 & M05





## Scoring Judgement

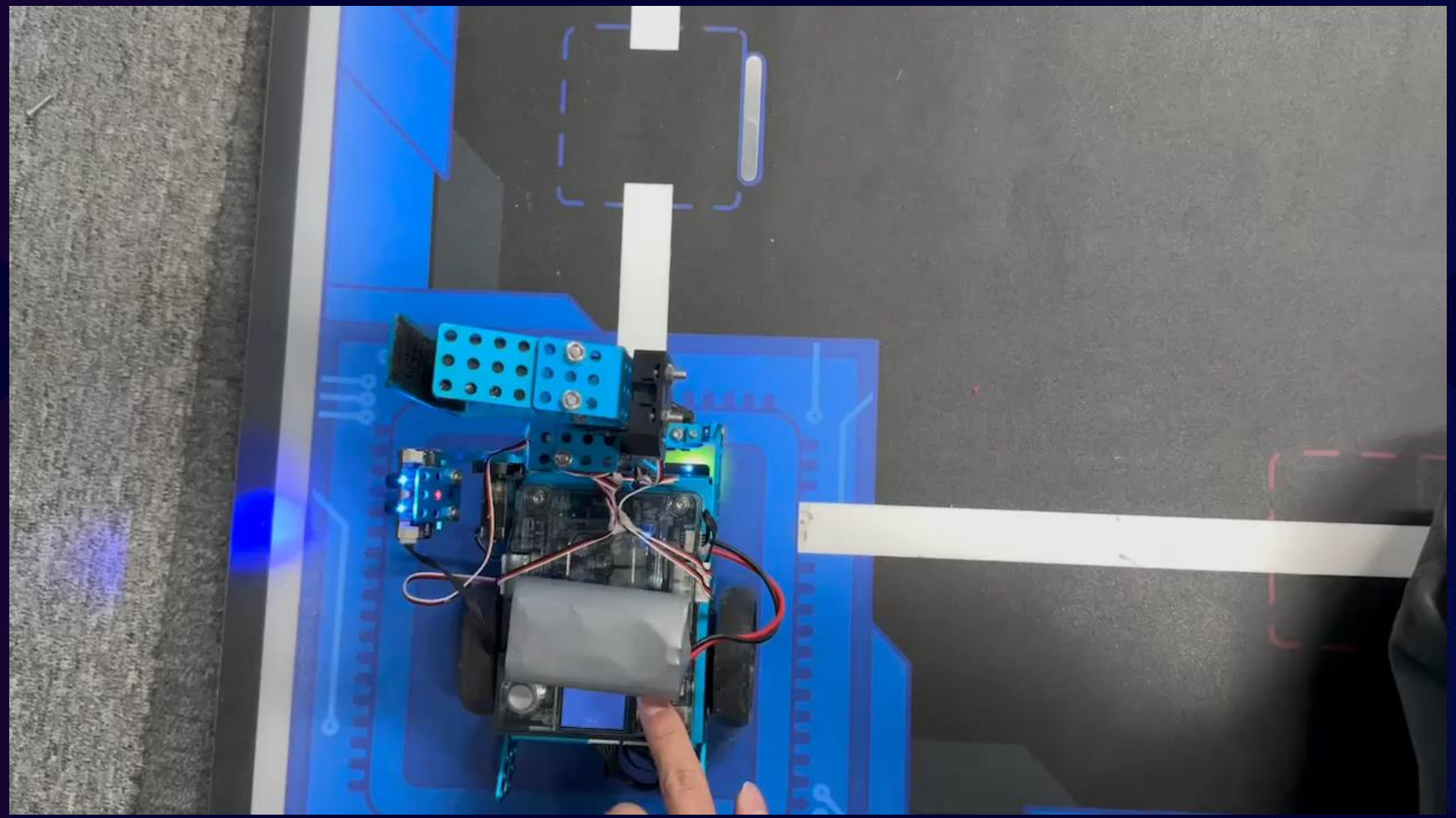
a. The vertical projection red or blue cube must be completely inside th e manual loading area
b. The vertical projection of yellow cube must be inside the storeroom
If requirements are met， the red or blue team gets the score correspo nding to each cube

## Mission Gameplay

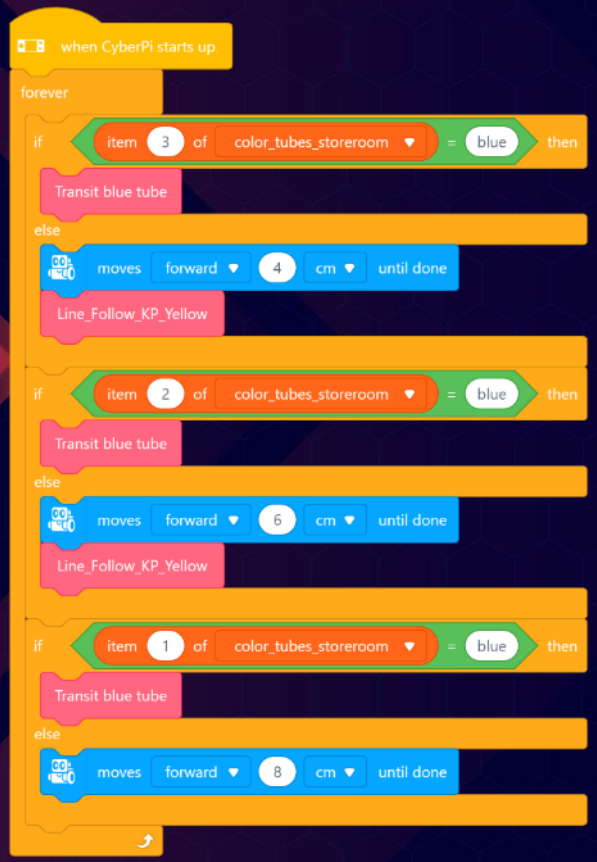
According to the color of cube inside the storeroom, transit the red or blue cube to the manual loading area and keep the yel low cube inside the storeroom

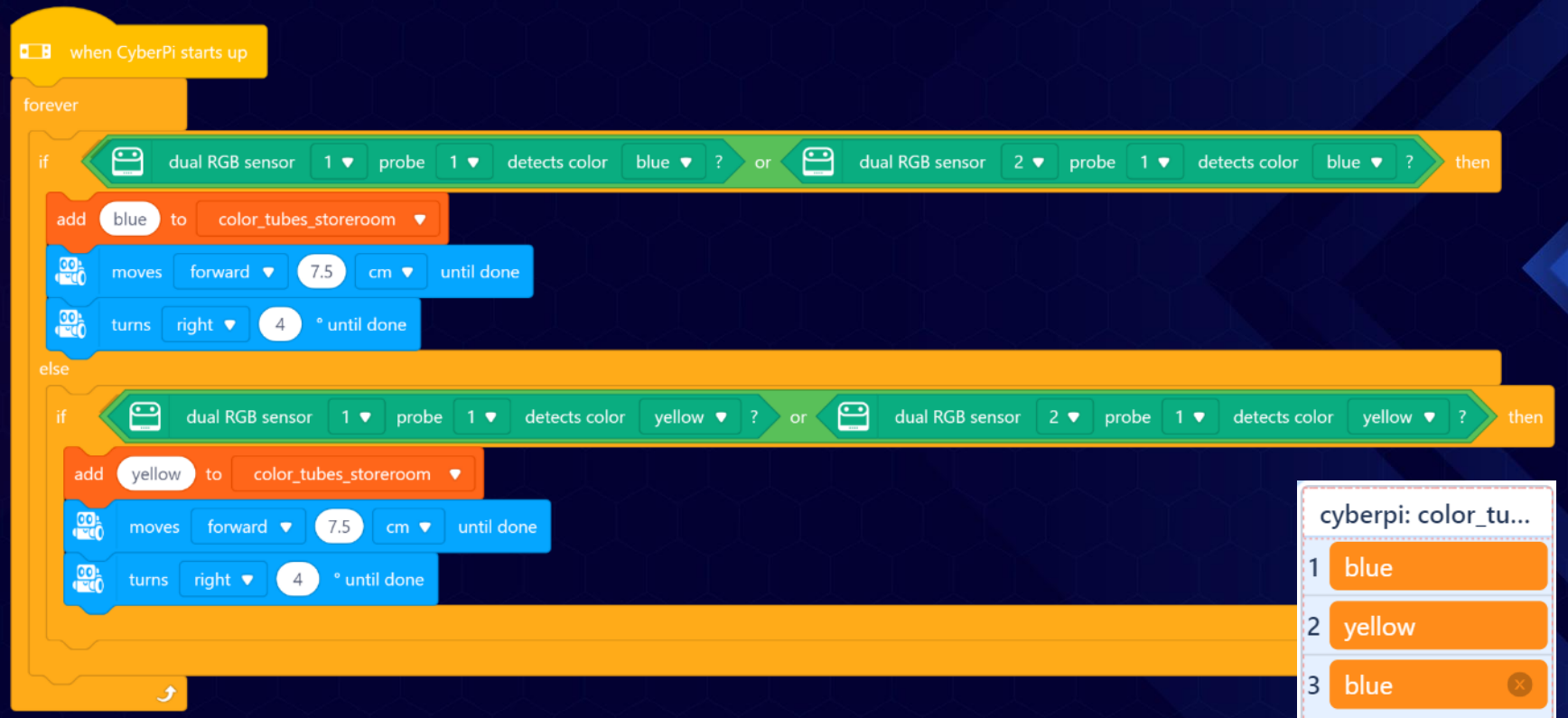
## Score of Mission

A successful transition of red or blue cube e arns 30 points
Keep the yellow cube at original location ea rns 10 points. No points will be deducted if t he yellow cube is transited.



# 02| Analyzing Missions of the Competition - M06 Solution 1

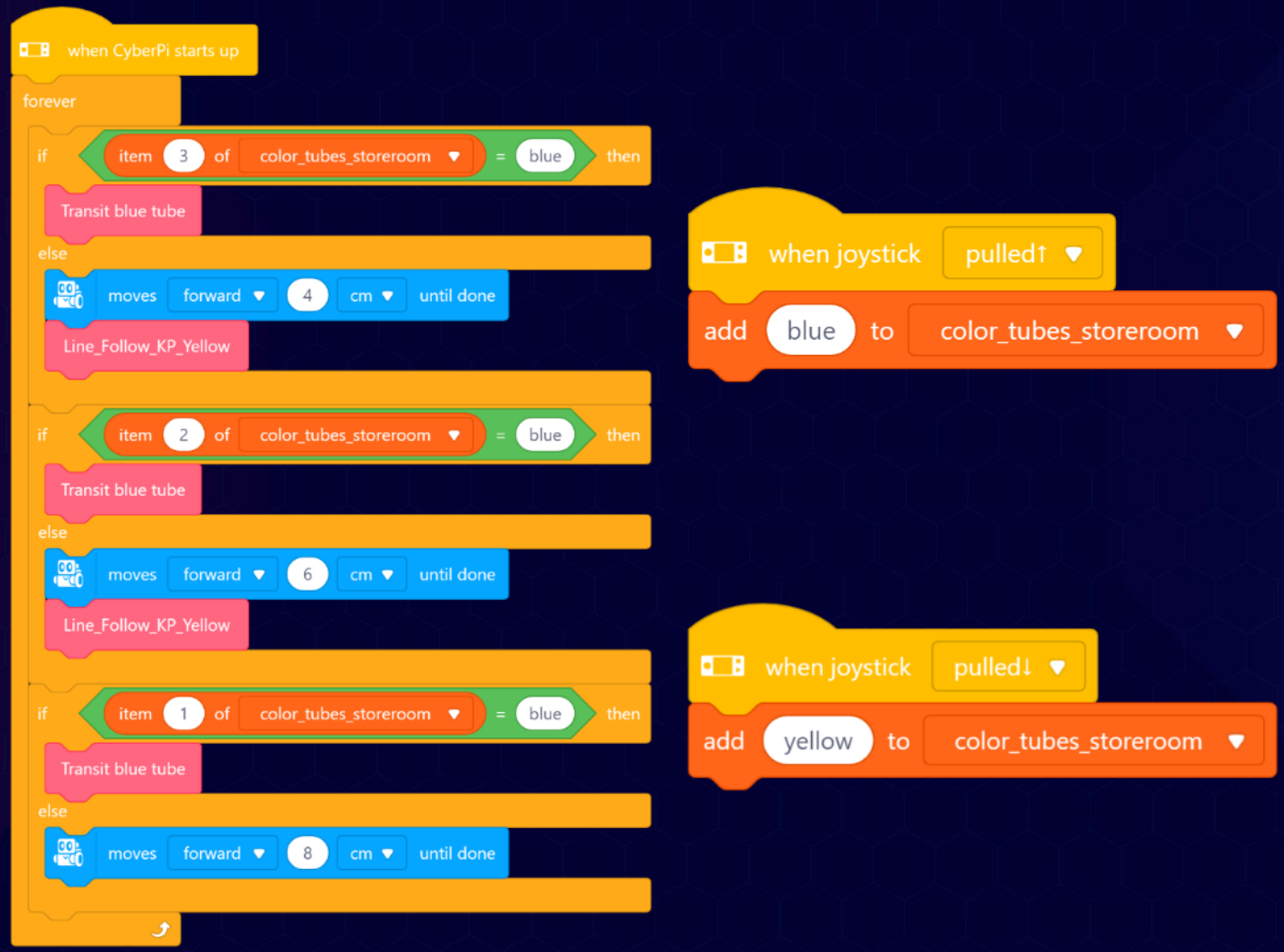


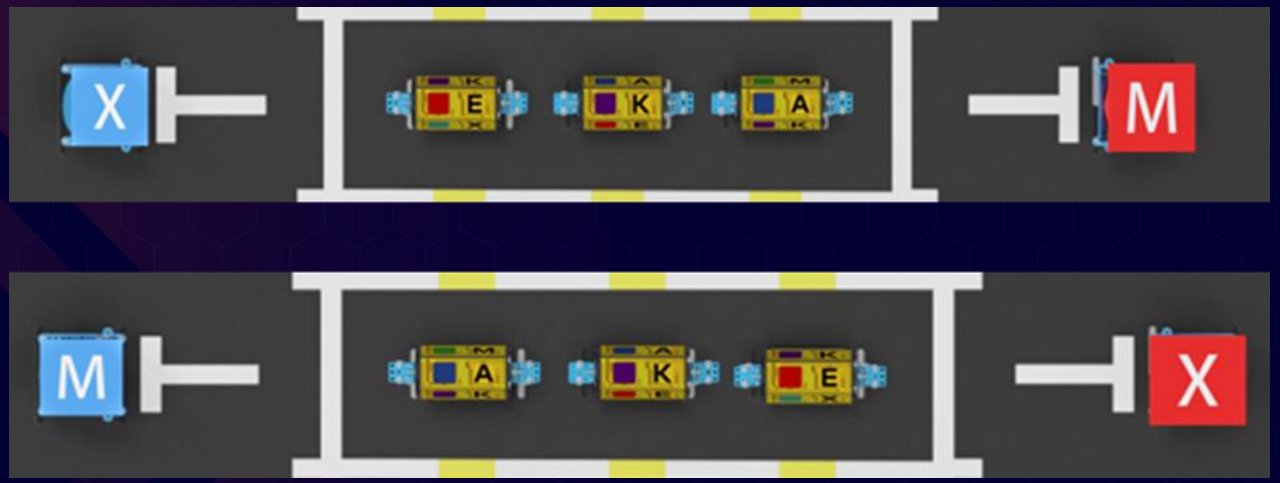




Is there any other solution?


when CyberPi starts up
forever
if item 3 of color_tubes_storeroom = blue then
Transit blue tube
else
moves forward 4 cm until done
Line_Follow_KP_Yellow
if item 2 of color_tubes_storeroom = blue then
Transit blue tube
else
moves forward 6 cm until done
Line_Follow_KP_Yellow
if item 1 of color_tubes_storeroom = blue then
Transit blue tube
else
moves forward 8 cm until done
when joystick pulled↑
add blue to color_tubes_storeroom
when joystick pulled↓
add yellow to color_tubes_storeroom

# 02 | M07 Lighting the Antimatter Fuel Rod (Alliance Mission)




## Mission Gameplay

Turn the color-mark on Decoding rotary c ylinder to correct order.

## Score of mission

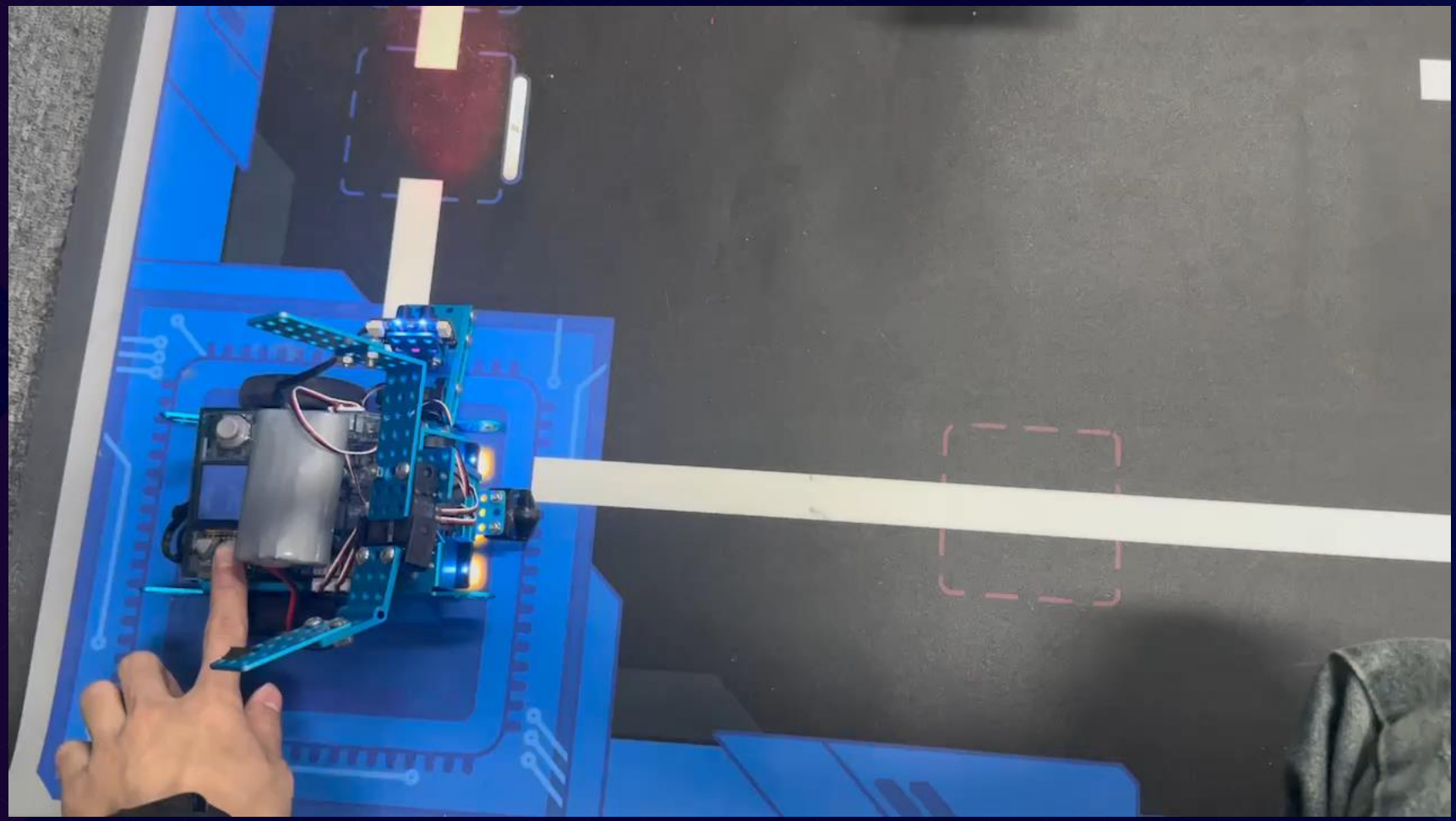
A successfully turned color-mark in corre ct order earns 30 points

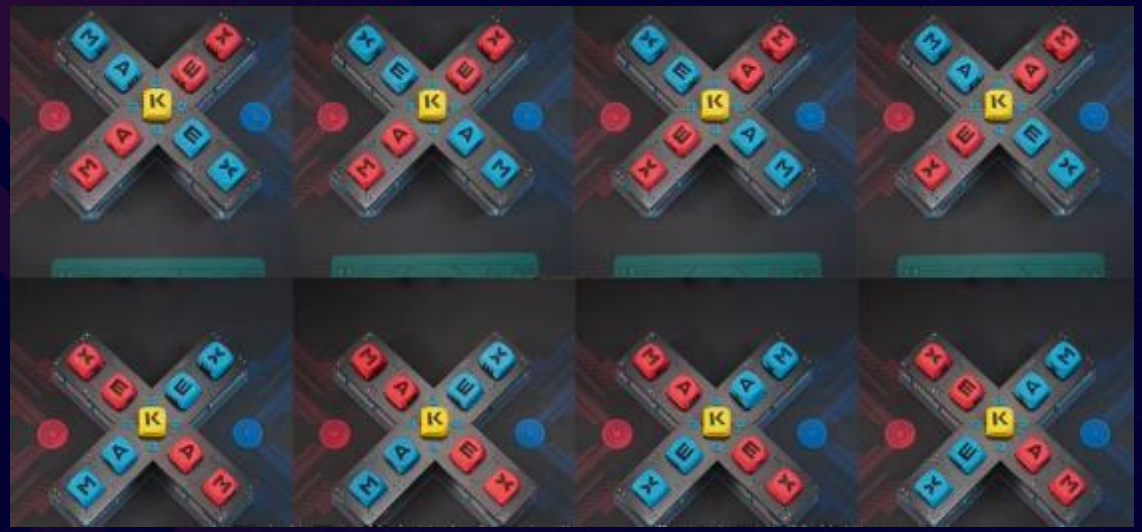
## Scoring Judgement

a. The order of decoding rotary cylinder must be combined with cubes in M05 to form a positive sequenc e of “MAKEX” or reverse sequence “XEKAM”.
b. The robots must have no direct contact with the Decoding rotary cylinder device
c. The color-mark that meets the correct order must be upwards
If all requirements above are met, both team gets the score for mission M07

Note:

a. If neither team scores the password filling (10 points) in M05, neither team scores for this mission also no matter the order of color-mark on Decoding rotary cylinder.
b. If there is only one team gets the score for password filling(10 points) in M05, the correct order of color-marks for mis sion M07 must start from this team’ s cube and form "MAKEX" or "XEKAM" for points to be awarded in M07.





## Mission Gameplay

Fill in the same color (blue or red) alphabet cube and yellow alphabet cube(K face upwards) into t he same line of the Matrix Research Station. If the cubes are put at the correct order, extra points wi ll be awarded.

## Score of Mission

A successful filling of alphabet cube earns 20 point s;

If any order of the cube in same color combined to form the sequence of “MAKEX”, extra 50 points w ill be awarded to both team

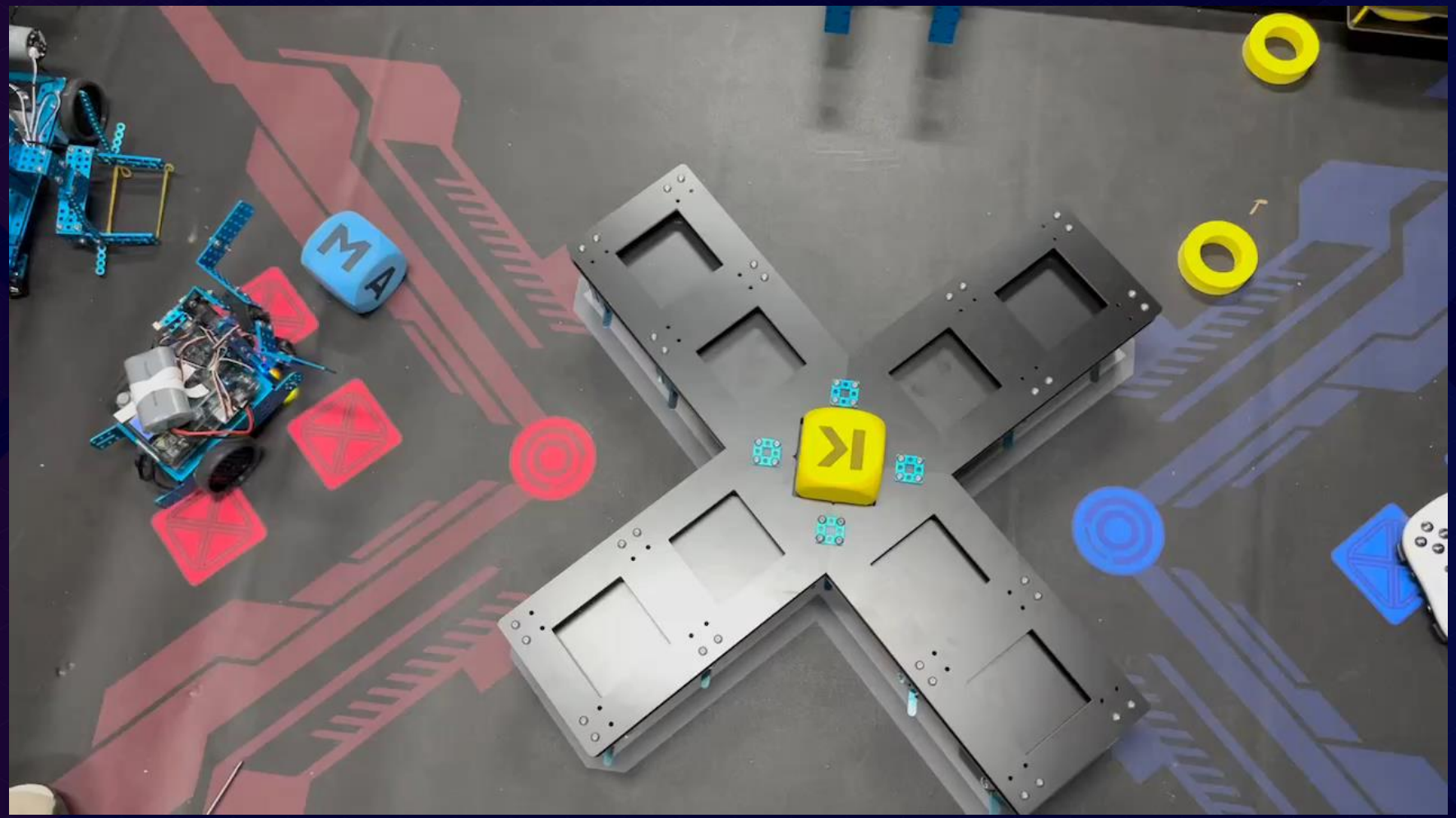
## Scoring Judgement

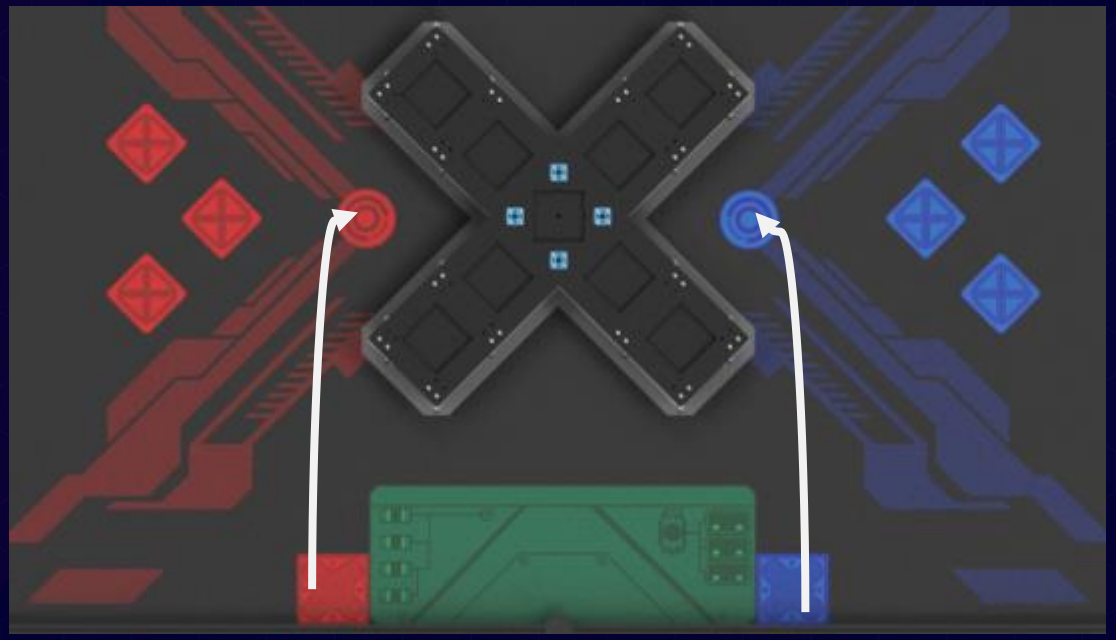
a. Any cubes in the same color must be filled in the same line as above photo shows

b. The robots must have no direct contact with any color cubes and the structure of t he Matrix Research Station at the end of mission.

c. The color cube must be completely inserted into the grooves with no part hanging

If all requirements above are met, the points of corresponding cube will be awarded

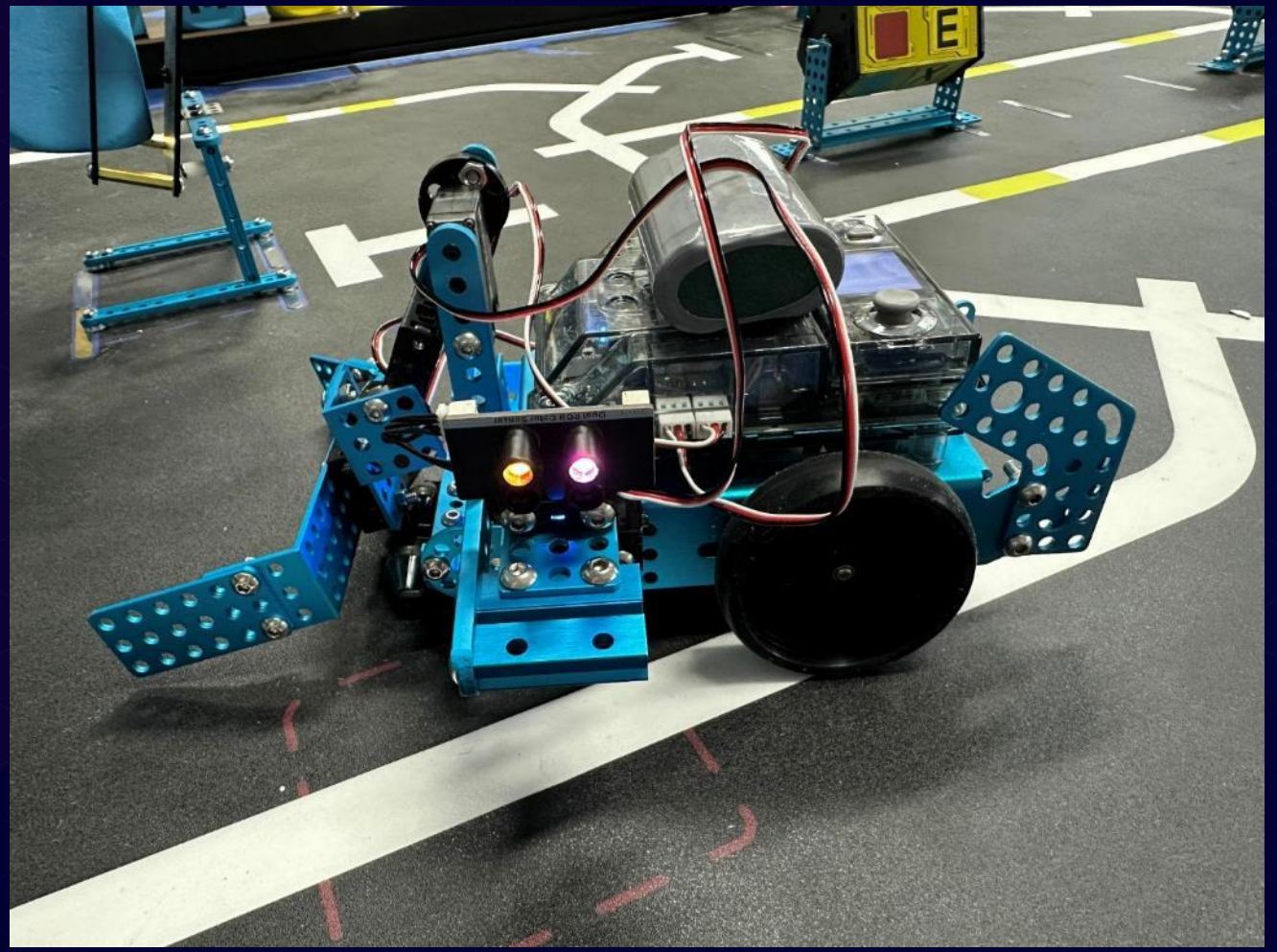

MA

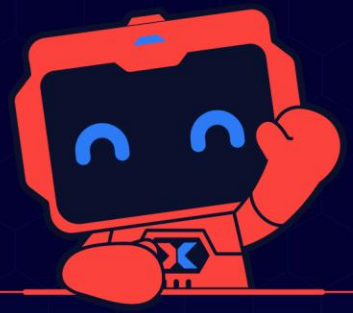


## Scoring Judgement

a. The vertical projection of team marker must be completely inside the circle area
b. The team marker must remain upright and have no direct contact with the robot at the end of mission
c. The team marker must have direction contact with the baseplate without lifting
If all requirements above are met, the points of corresponding marker will be awarded

# 03 Analyzing the demo robot of the Competition





# 03

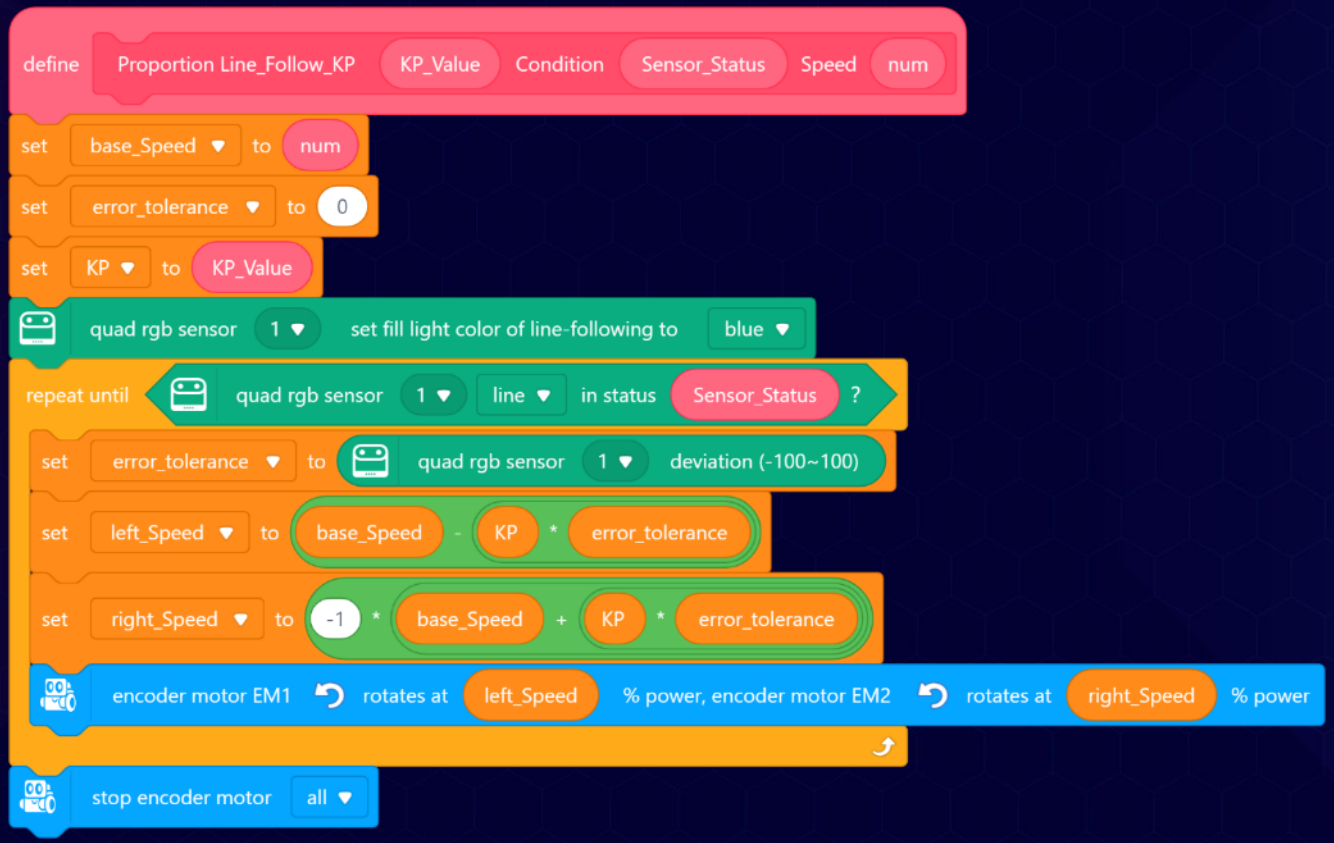
## The core algorithm of the competition

# What are the necessary algorithms in the competition?

Line Follow; Intersection Detection;

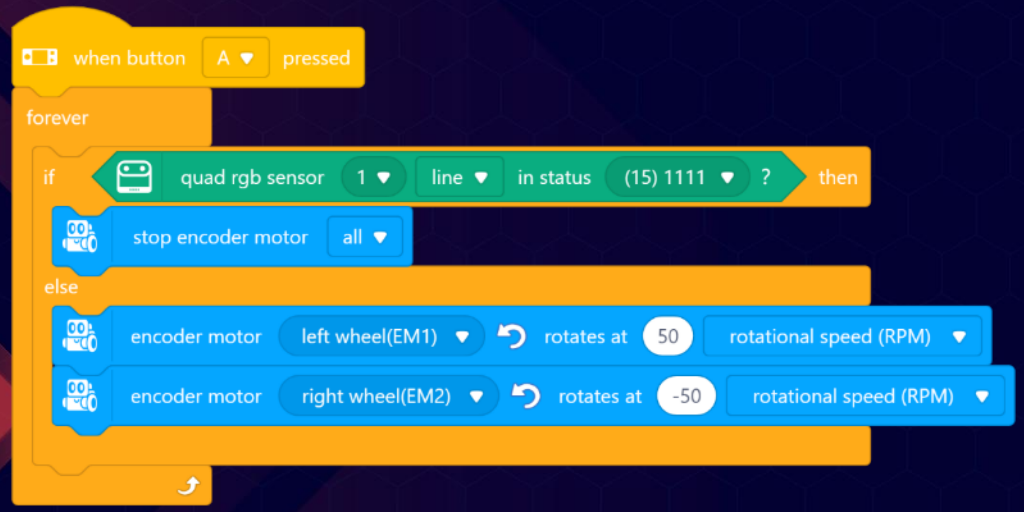
Breakpoint Detection; Color Detection

# 03 Core algorithm of the competition - KP (Proportion Line Follow)




How to let students understand the algorithm of Proportion Line Follow clearly?

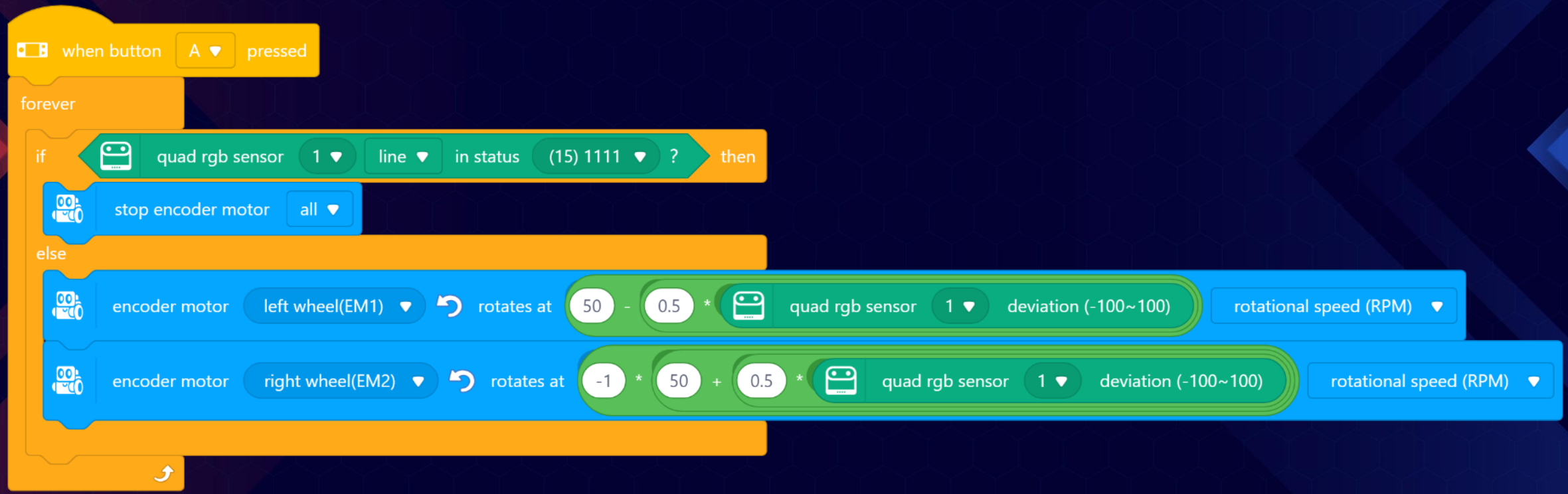
# 03 Core algorithm of the competition - KP (Proportion Line Follow)




Oscillation is certain if the speed isn't set smoothly
How to make improvement to the osc illation

# 03 Core algorithm of the competition - KP (Proportion Line Follow)

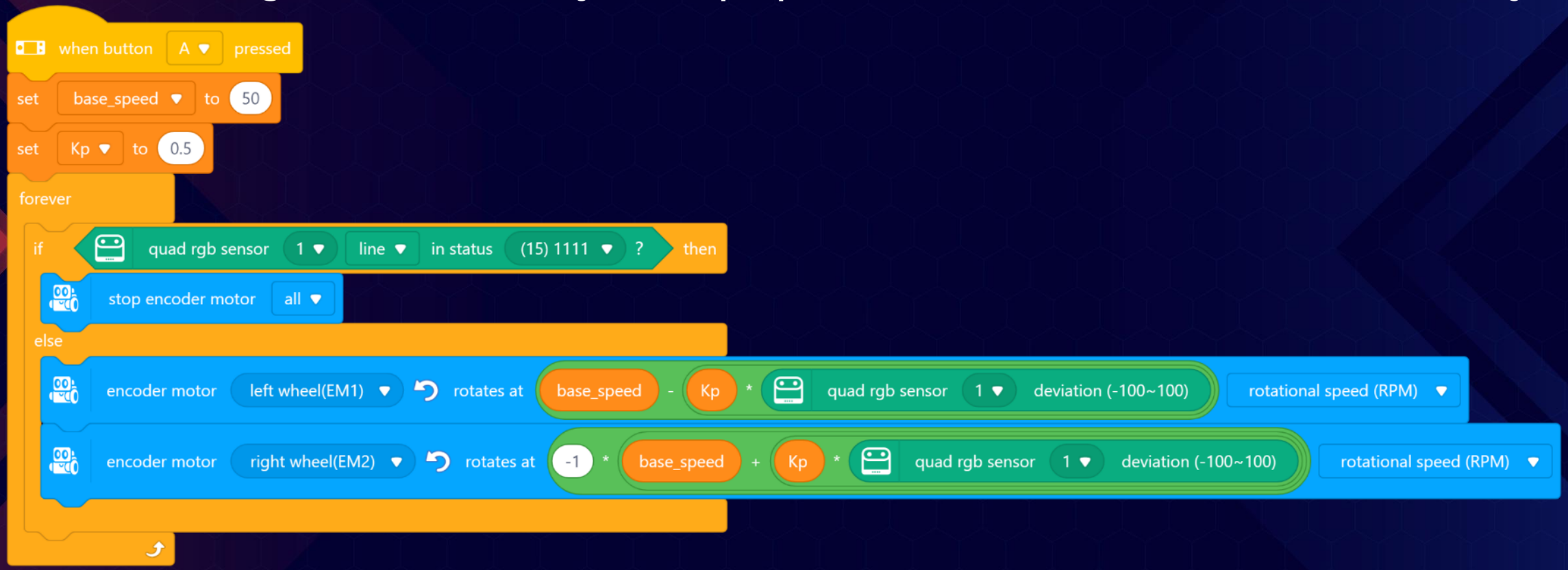
Adding the factor can adjust the proportion of oscillation, which is the sensitivity



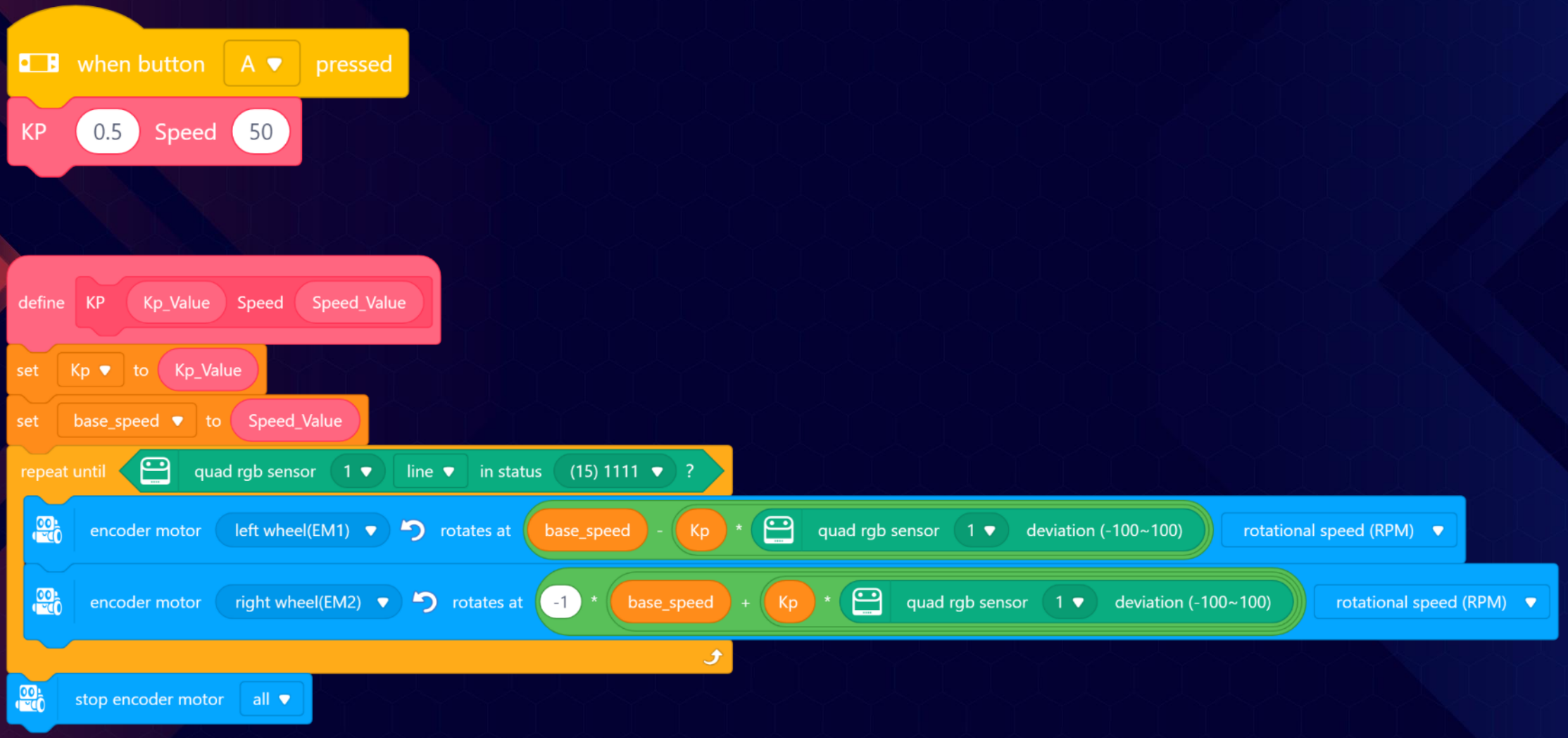
# 03 Core algorithm of the competition - KP (Proportion Line Follow)

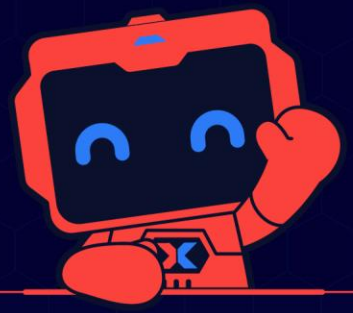
MAKEX 童心制物 makeblock

Adding the factor can adjust the proportion of oscillation, which is the sensitivity



# 03 Core algorithm of the competition - KP (Proportion Line Follow)





# 04 | Advanced Competition T echnology

# Why PID Auto Control is required?

The PID (Proportional–integral–derivative controller) algorithm is essentially to stabilize the encoder value (or speed) at a specific value.

# 03 Core algorithm of the competition - PID Auto Control

When the value of P factor is small, the response speed becomes slower.
When the value of P factor is large, though the response speed is relatively fast, the oscillation is more serious

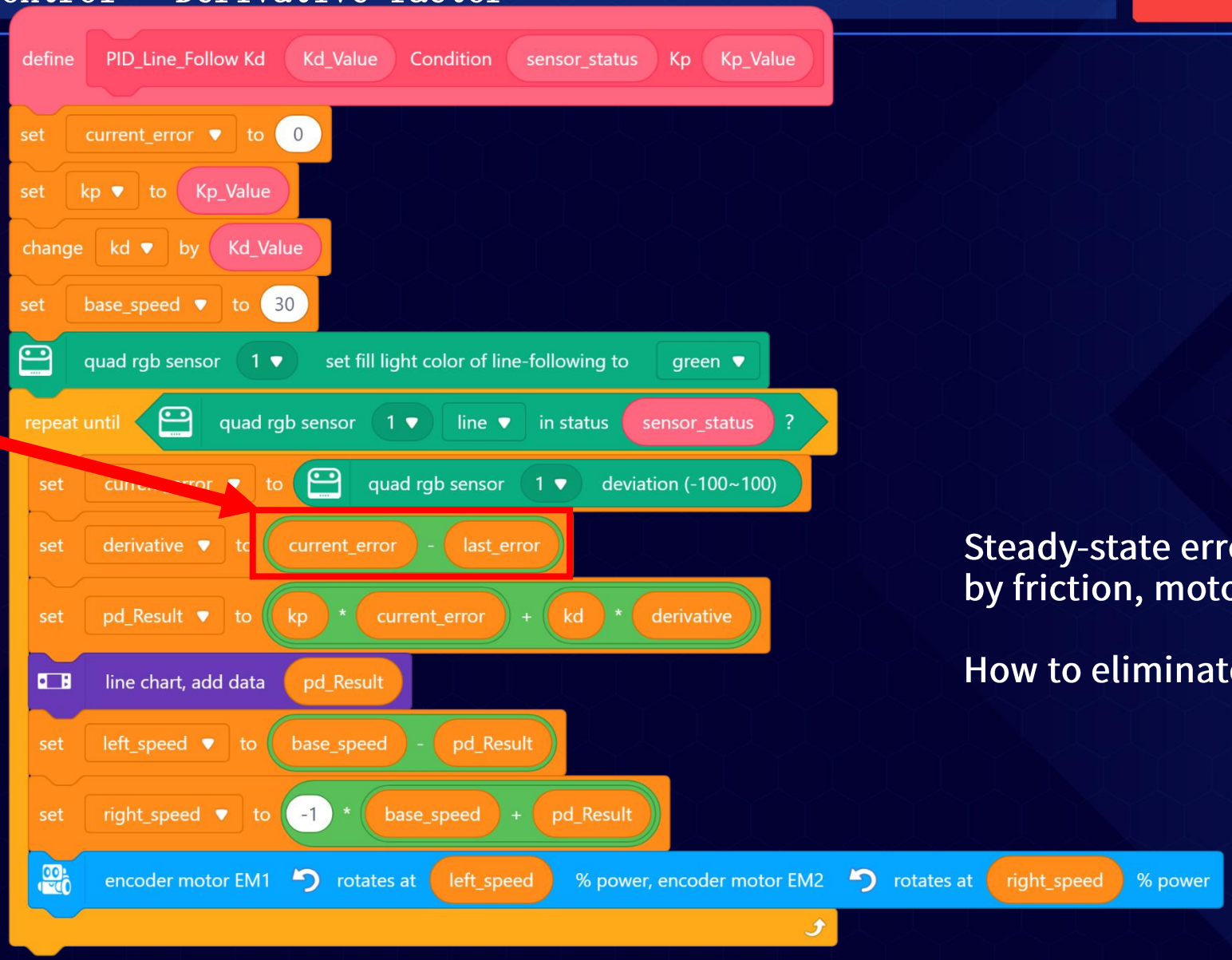
1、Proportional factor：*Increase the speed difference between wheels and increase the responding speed of system*

2、Integral factor：*Eliminate the residual steady-state error*

3、Derivative factor：*Predict error changes and counteract them before they can occur to reduce the oscillation*

# 03 PID Auto Control - Derivative factor

Decrease the deviation value to make it close to the target value




Steady-state errors are caused by friction, motor wear, etc.

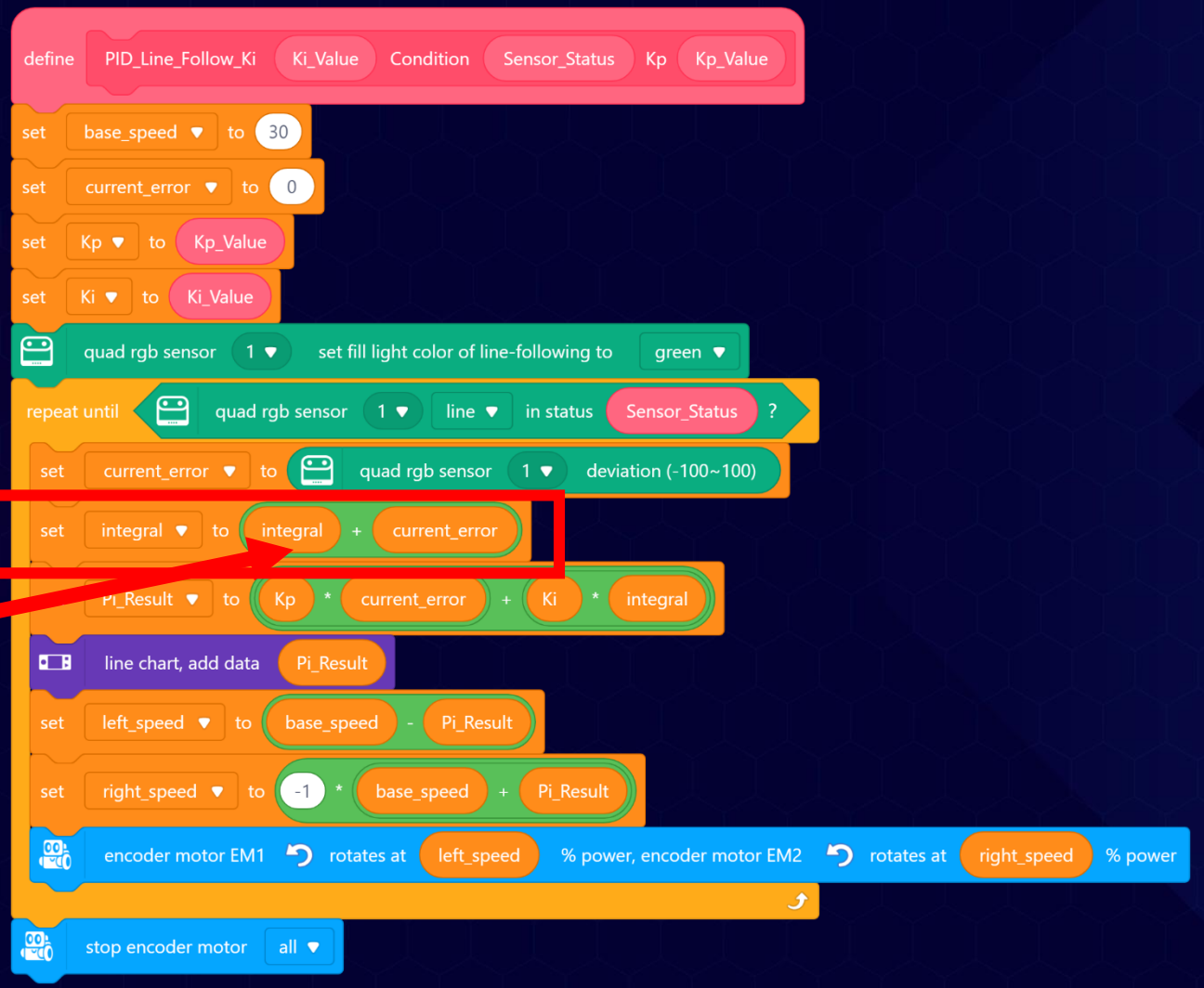
How to eliminate them?

## What is steady-state error?

When the wheel speed is very close to the expected value, the Error difference will be very small, which will cause the power given by the motor to become smaller. When there is friction in the environment, it may cause the motor power equals to friction in force. Although the controller keeps requesting force, due to balancing of the friction, the wheel speed cannot be increased ,so it stabilizes in an embarrassing situation where the target has not been reached.

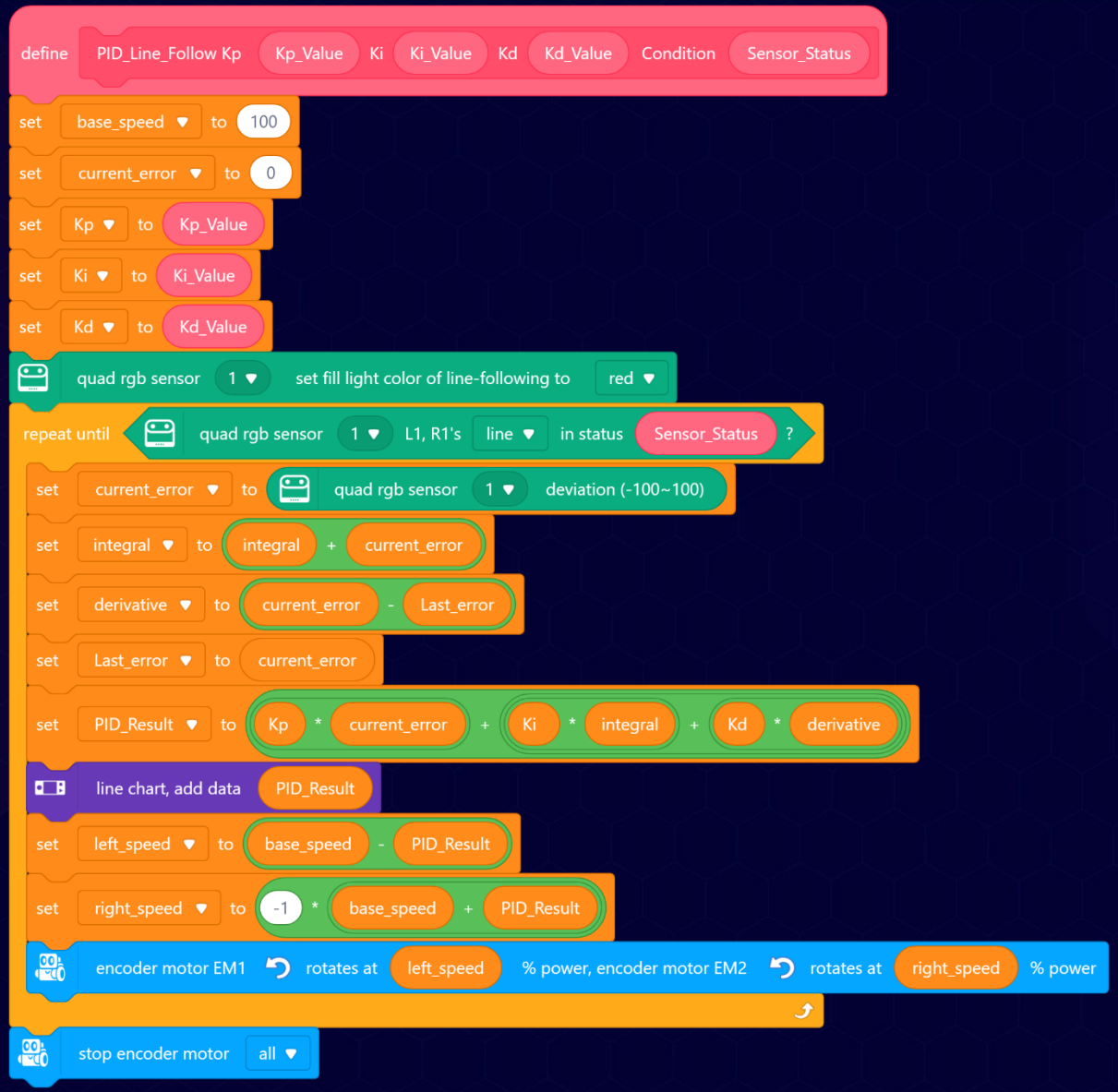
In order to solve this problem of steady-state error, we introduce the integral factor. If the equipment doesn't reach the expected speed value for a long time, the I controller will continue to accumulate errors and add the errors to the output force. In this way, as time accumulates, the output of the controller becomes bigger and bigger. Until the new high power allows the machine to overcome the balancing interference and reach the expected value.

# 03 PID Auto Control - Integral factor




Accumulate the error values to get them out of the steady state error

# 03 PID Auto Control - Demo Version



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# THANKS

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