Promoting School-based Student Talent Pool: Nurturing Innovation and Technology Talents through Tier 1 Whole-class Project-based Learning

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Why does my school need Tier 1: STEAM Education Training?

Our Culture

Vision

- To gain recognition as one of the leading schools in Hong Kong in academic achievement, community service and extra-curricular activities.

School Motto

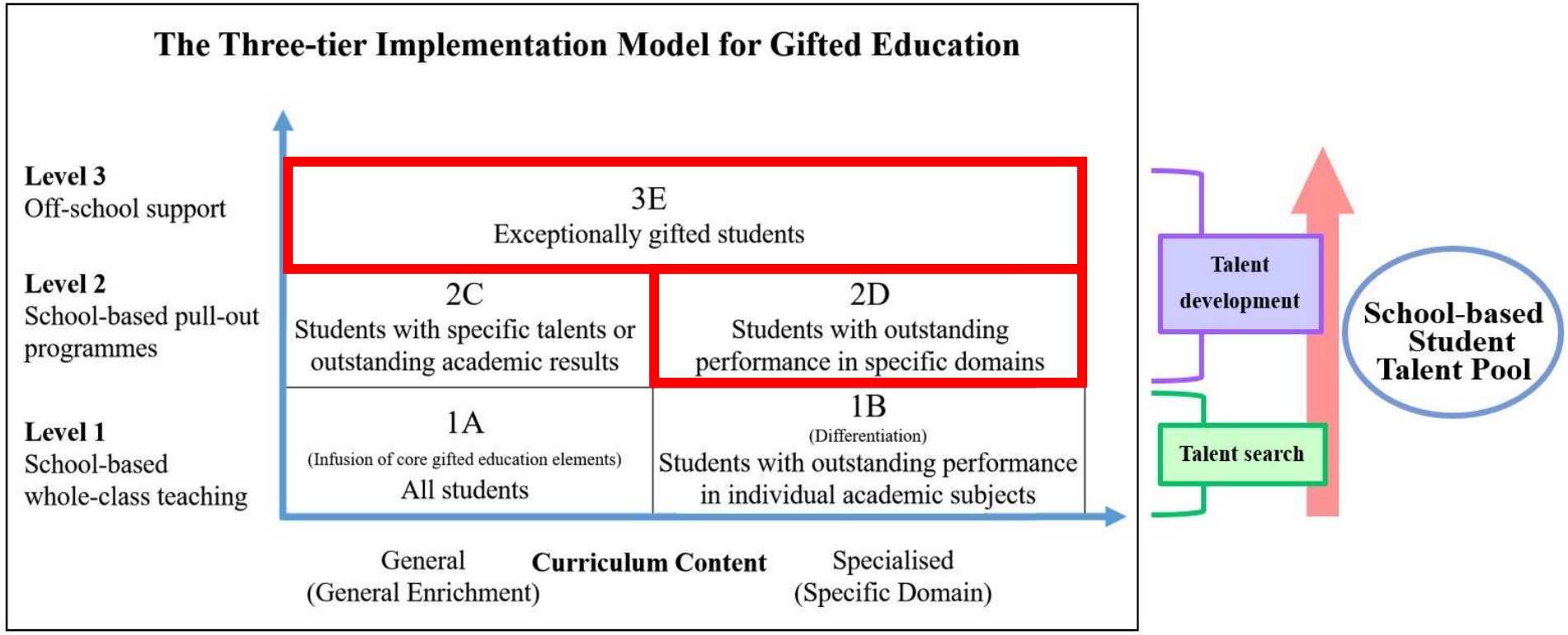
Self-strengthening and continuous improvement

自強不息

Students Love Competitions

Our Past Experience in Gifted STEAM Education

From Tier 3 to Tier 2



Tier 3: Hong Kong and International Competitions

- Meet and communicate with the highest ability students from other schools
- Our students know more about their ability and strength and hence able to set their goals

- Competitions we care:
  - Hong Kong Budding Scientists Award
  - RoboCup Junior

RoboCup Junior (International)

- 2008 Suzhou
- Heavy Weight:
- 1st Runner-up

- 2011 Istanbul
- Heavy Weight Arena A:
- 1st Runner-up
- Heavy Weight Arena B:
- 1st Runner-up

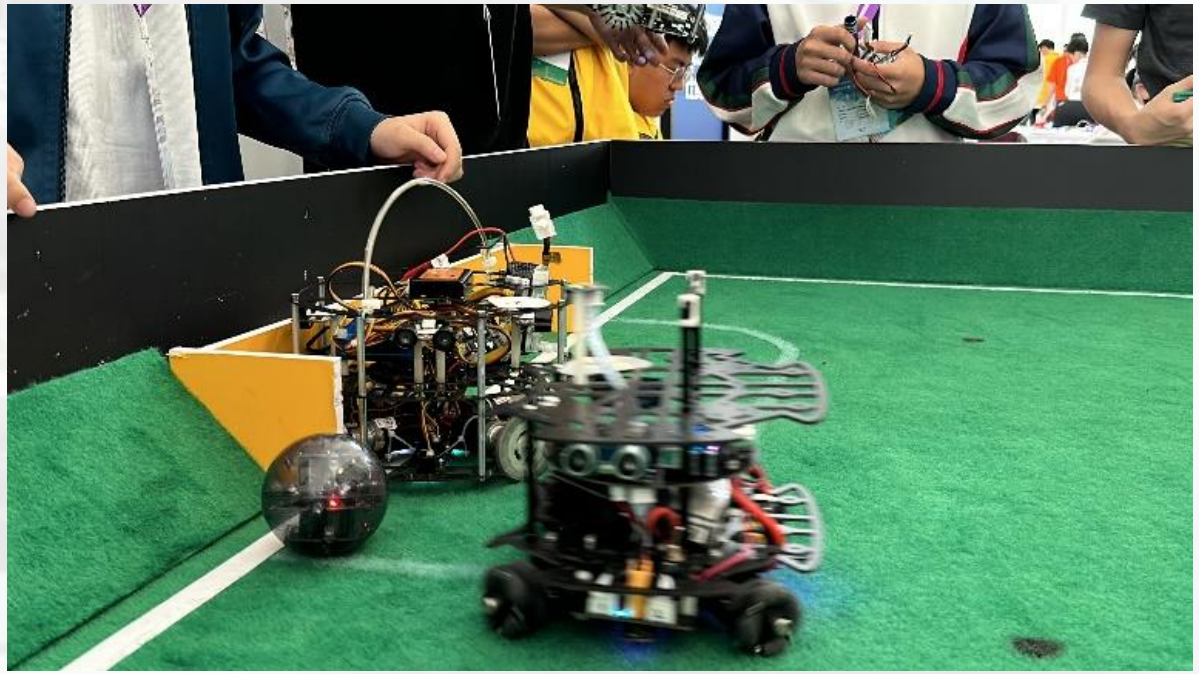
- 2021 Web-based
- Light Weight
- Champion

- 2023 Bordeaux France
- Light Weight
- 2nd Runner-up

RoboCup Junior (China Open)

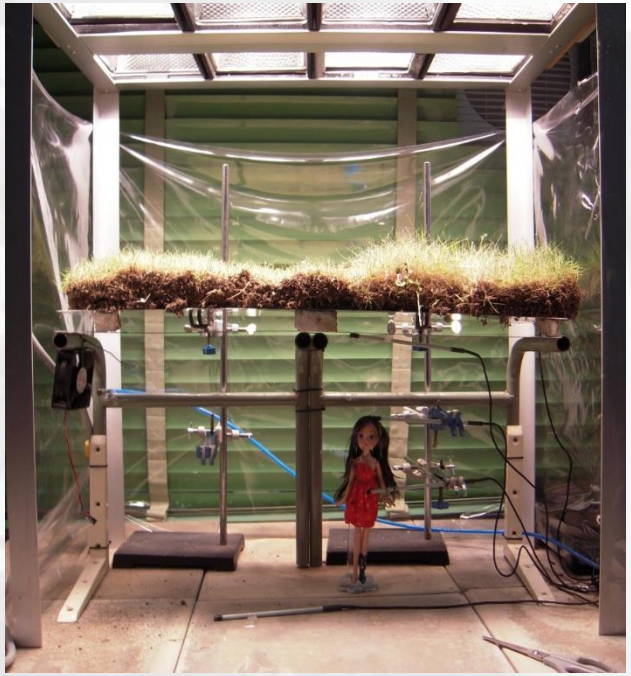
- 2019 Tianjin
- Light Weight Weight:
- 2nd Runner-up

- 2023 Tianjin
- Light Weight:
- Champion



Hong Kong Budding Scientists Award

- 2008: 1st runner up
- 2009: 1st runner up
- 2010: Champion
- 2012: Champion
- 2016: Champion
- 2017: 1st runner up
- 2020: Fourth
- 2023: Champion



In this environment, above average students have been given more chances….

From Tier 3 to Tier 2 School-based Pull-out Training

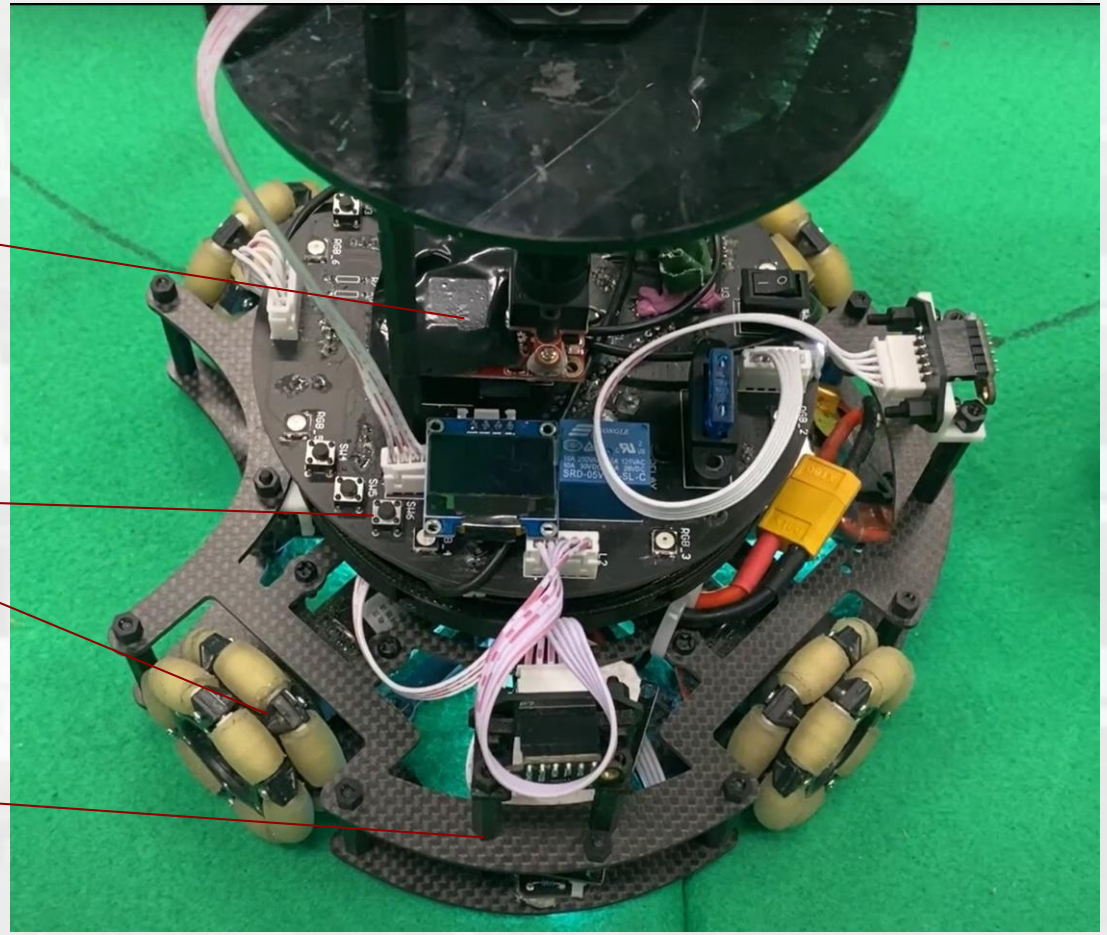
- To fill the knowledge gap between competitions and school curriculum, Students need proper pull-out training
- They need:
  1. Basic scientific knowledge
  2. Basic computing, electronics and design knowledge (that can be divided into 3 branches)
     A. Techniques that help them to perform scientific investigation
     B. Robotics and automatic control
     C. Invention and Innovation
  3. Effective communication skills (Presentation and Q&A)

2. Basic computing, electronics and design knowledge

Microcontroller
Automation
Programming

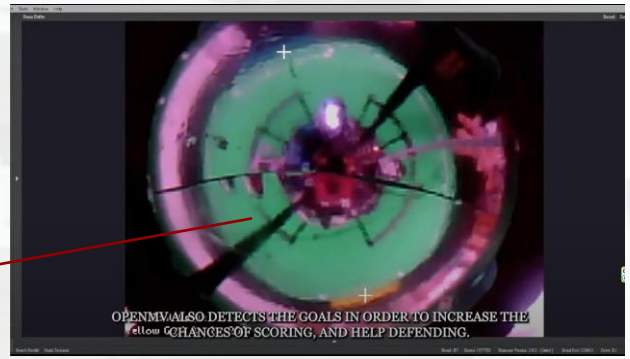
Use of sensors and performers

2D Technical Drawing for Laser Cutting



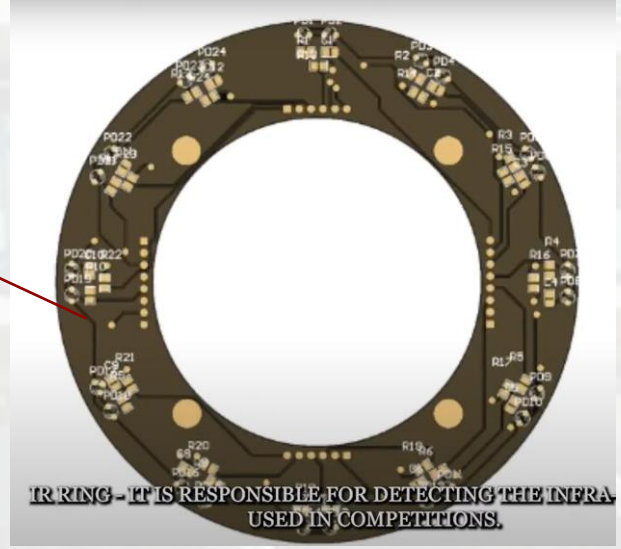
2. Basic computing, electronics and design knowledge

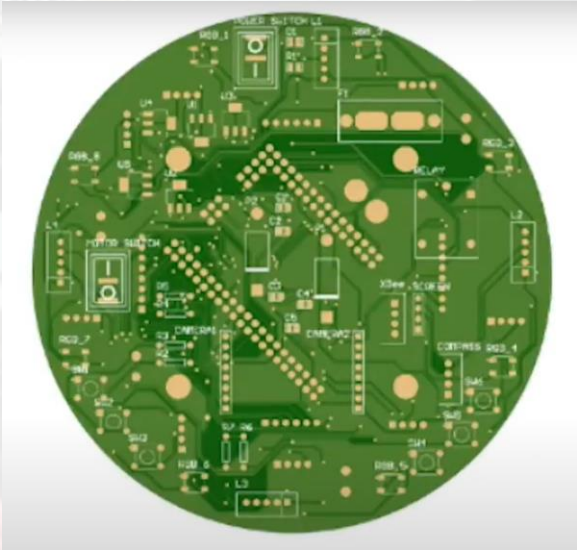
3D Technical Drawing for 3D printing



AI Camera

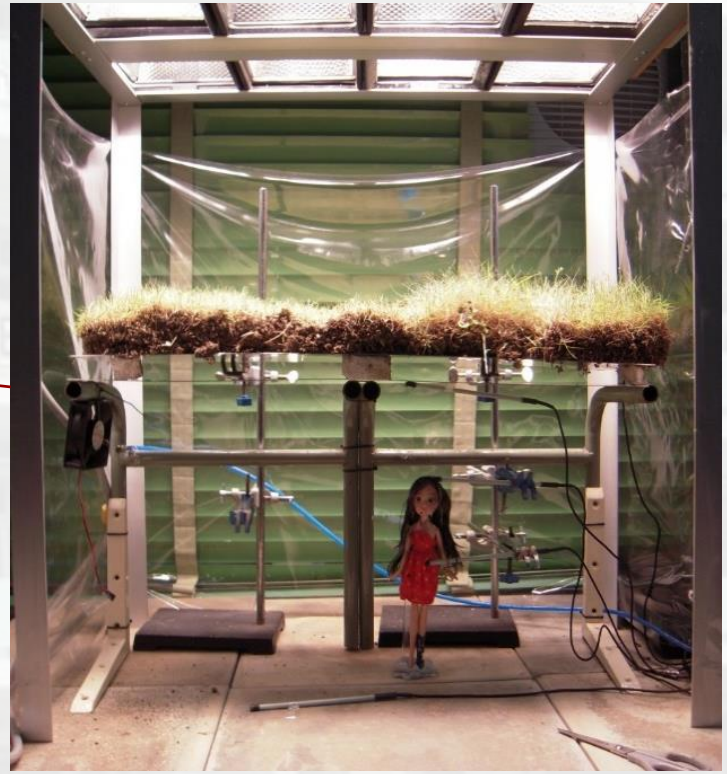
Circuit and Circuit Board Design





2. Basic computing, electronics and design knowledge

Scientific Investigation via Real-time Automated Data-logger System and Control



Tier 2: IJSO Training Course

- About 20-30 each form science students selected every year for in-school training programme(summer + school days)

Goal:

1. Junior form students are given a chance to learn senior form science.
2. Students are well trained in foundation and demonstrate excellence in senior form.

Tier 2: F1-2 VIP Enriched IT Class and F2-4 IT Innovation Lab

- Each year, about 20-30 F1 students select a 2 years programme called "Enriched IT Class" under the "School Vantage FIRST Potential Scheme" (盡展潛能計劃)
- F2-4 Students can also join various IT courses funded by the IT Innovation Lab in Schools, OGCIO.

Tier2: Information Day

After the IJSO train course and Enriched IT Class, Students are allowed to use laboratories and decide their demonstration experiments with the guidance of teacher

Objective:

1. Autonomous Learning
2. Learn and practice presentation skills and Q&A

Why do we still need Tier 1: School-Based Whole-Class Training?

1. To promote STEAM Education Literacy through "Computer & Technology" Lessons
2. To enhance students interests' in STEAM Education
3. To strengthen students' ability to integrate and apply knowledge and skills in STEAM Education
4. To identify students gifted in STEAM Education and recommend them to join the school-based pull-out programmes
5. To fill the learning gap between the standard school curriculum and school-based pull-out prgrammes

What kind of learning strategy is suitable?

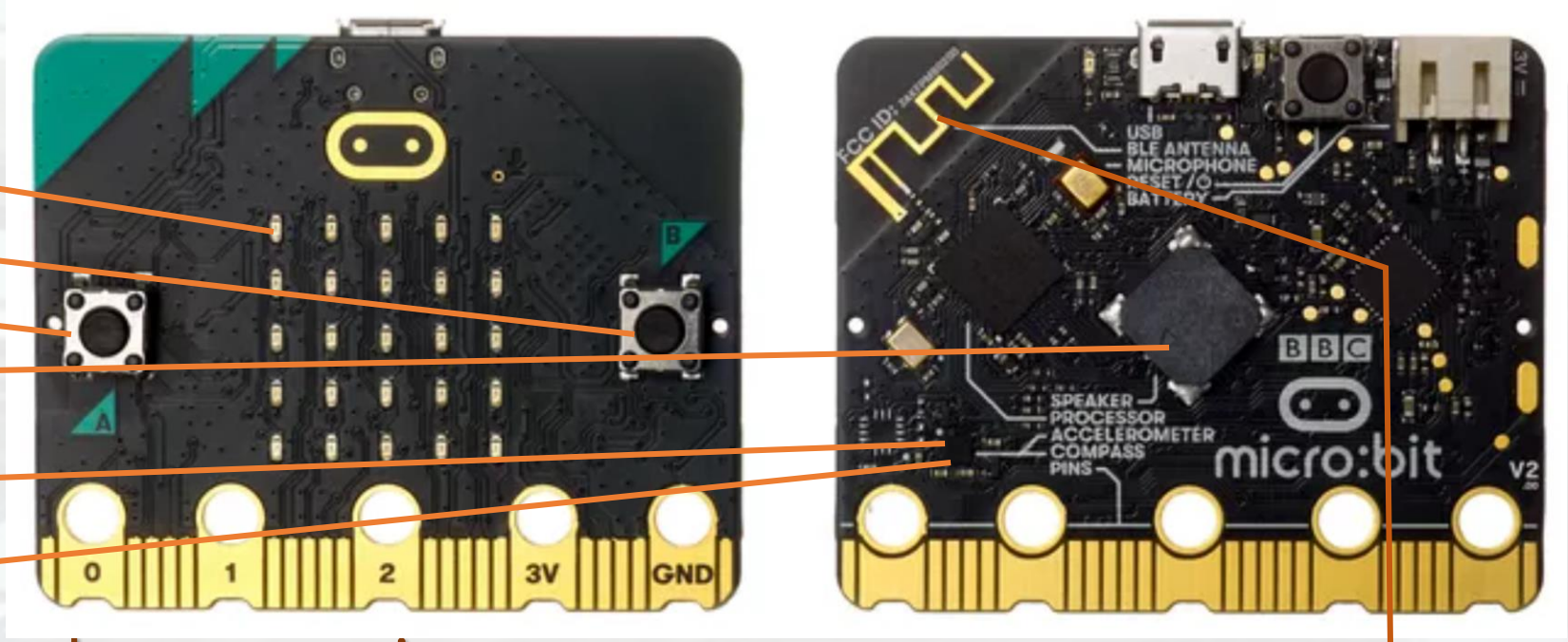
- Project-based learning that can be broken down into a series of small-scale task-based learning
  - "Students learn about a subject by working for an extended period of time to investigate and respond to a complex question, challenge, or problem. It is a style of active learning and inquiry-based learning." (https://en.wikipedia.org/wiki/Project-based_learning)
- Every students use the same standard kits to reduce complexity and difficulties
- Deal with learner's diversity: Students can modify the given program and/or deliver their reports in different depth.

Basic device 1: Micro:bit V2

Students can choose between simple blocks, JavaScript or Python for coding

Built in:

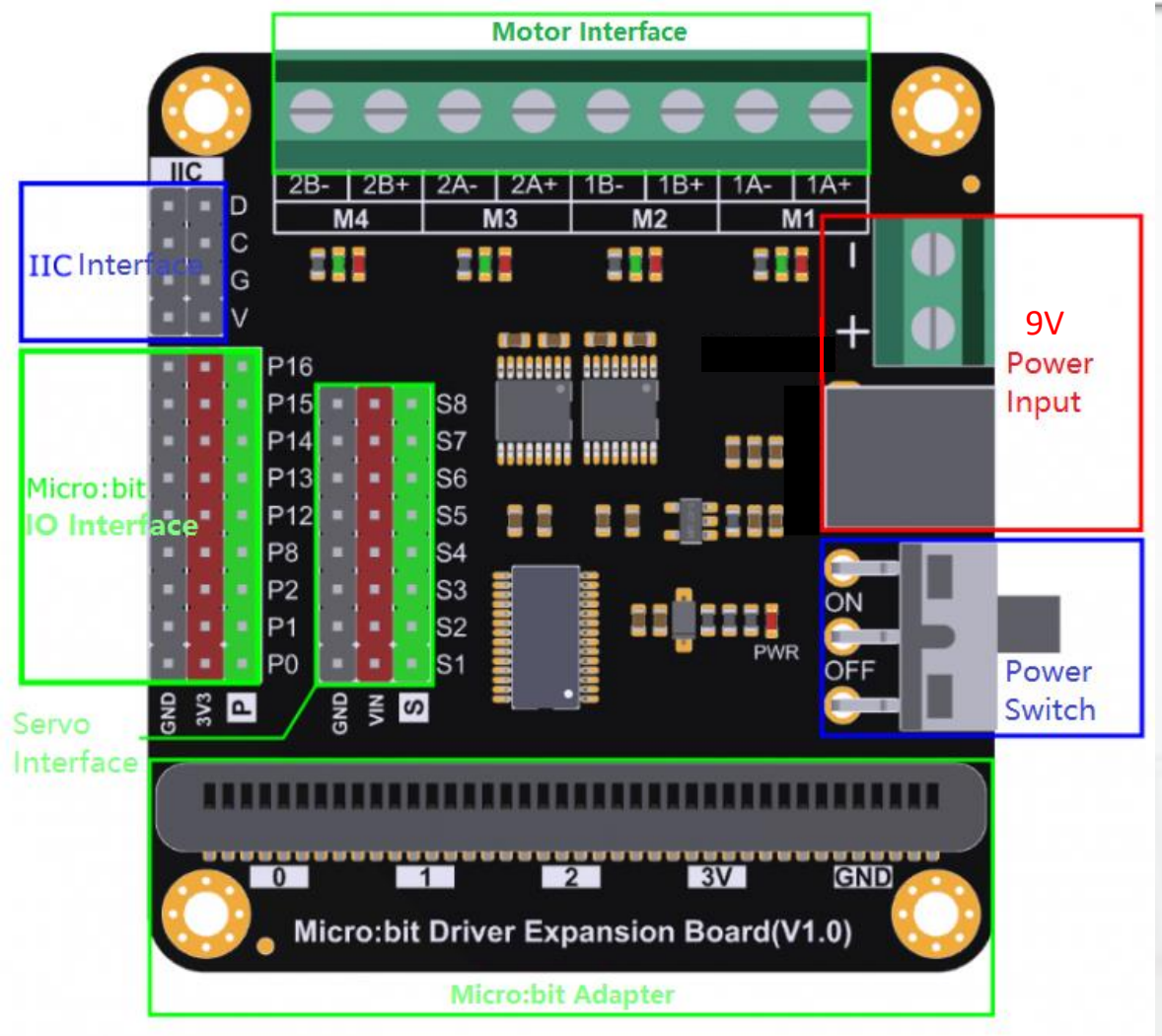
1. 5x5 LED
2. Button A and B
3. Speaker
4. Accelerometer
5. Compass
6. Radio or Bluetooth connection
7. Standalone Data logger (10 times / second)



Basic Device 2: PXT - Motor Extension Shield

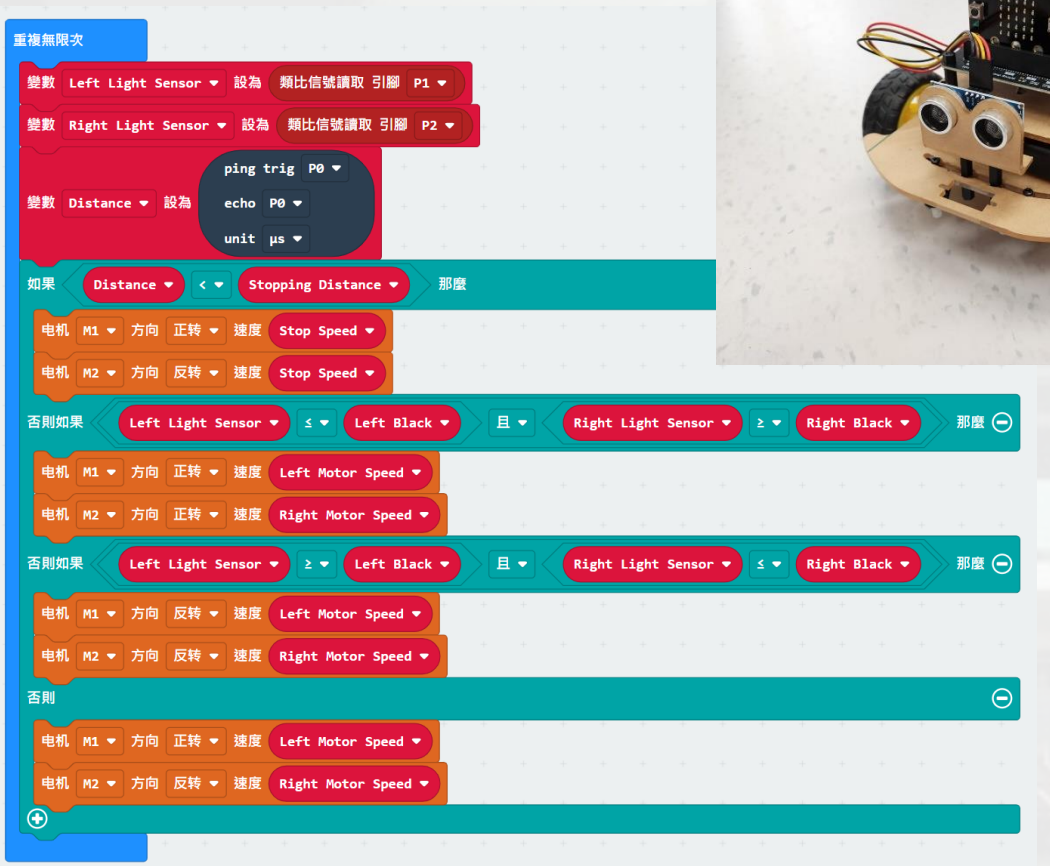
Unleash the power of the micro:bit

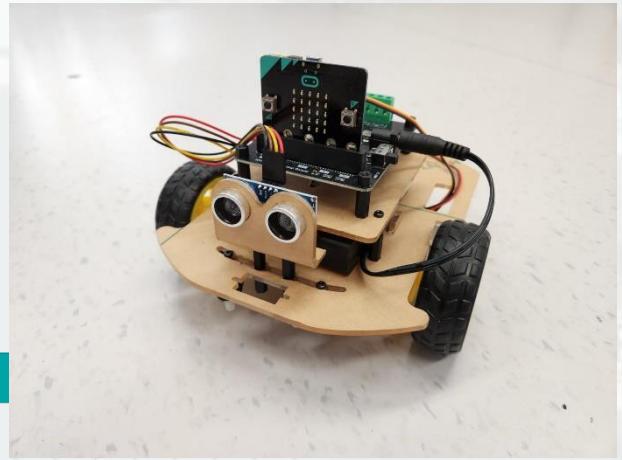
- 2 x IIC Interface
- 9 x IO Interface
  - (P0, 1, 2 can be set to analog)
- 8 x Servo Interface
- 4 x Motor Interface (0-9V)

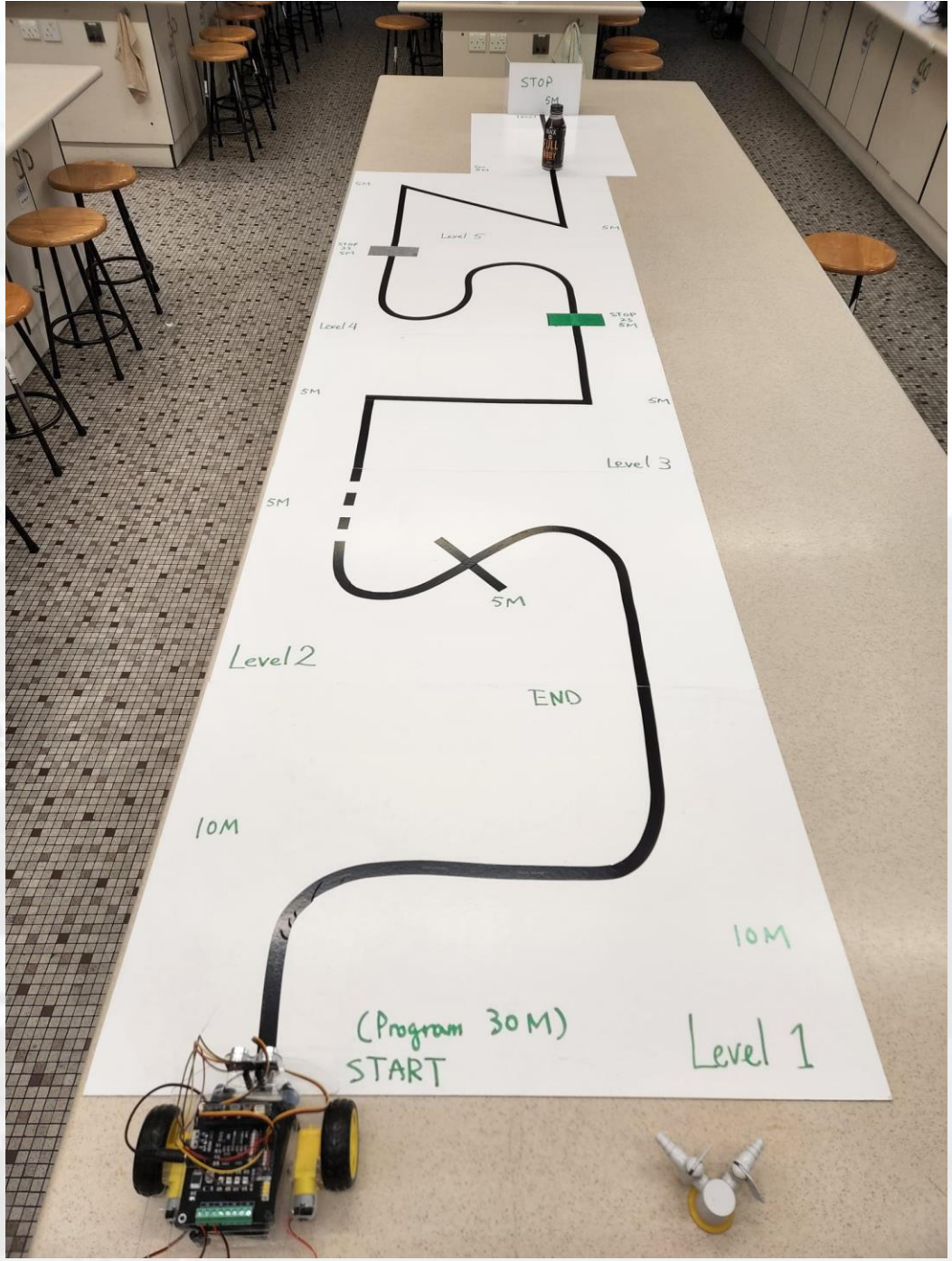


Project 1:
F1 Micro:bit Car

Robotics and automatic control



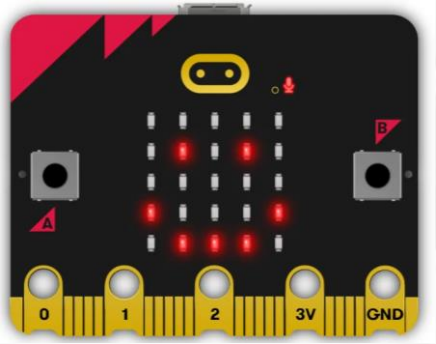




Task 0: Making of distance gauge Before assemble the car

- Devices

1. Micro:bit



2. PXT-Motor Extension Shield

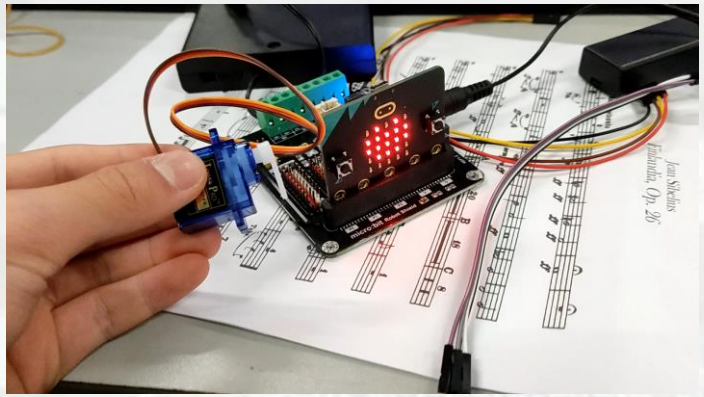
3. Servo Motor

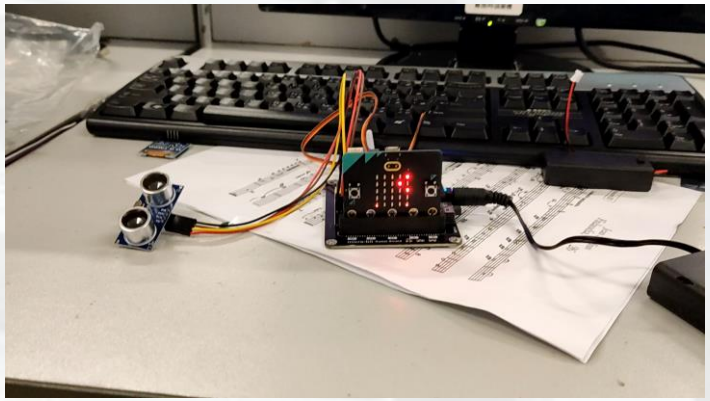
4. Sonar

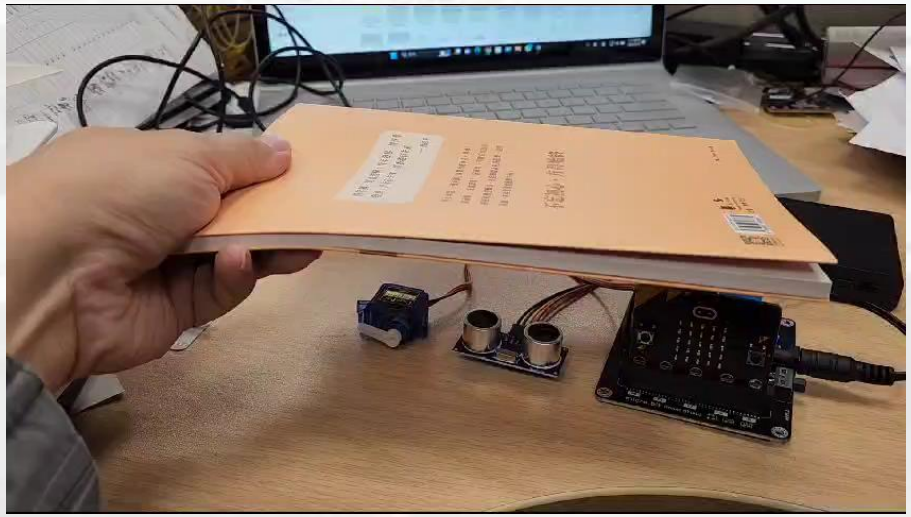
Task 0: Distance gauge

Tasks:

1. Call library
2. Control the movement of the servo motor
3. Collect data by Sonar
4. Indicate the collected data by a pointer







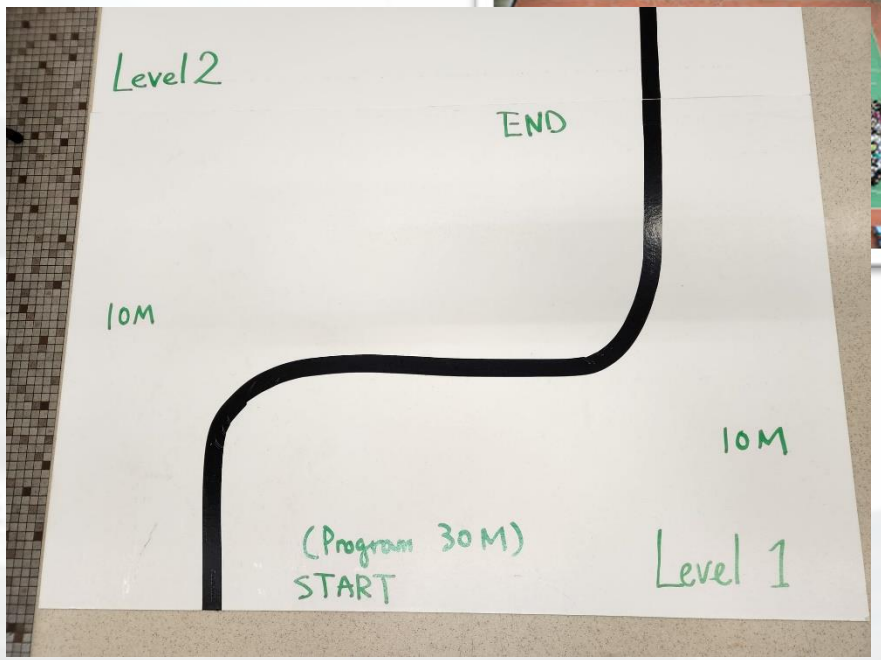
Level 1 and 2

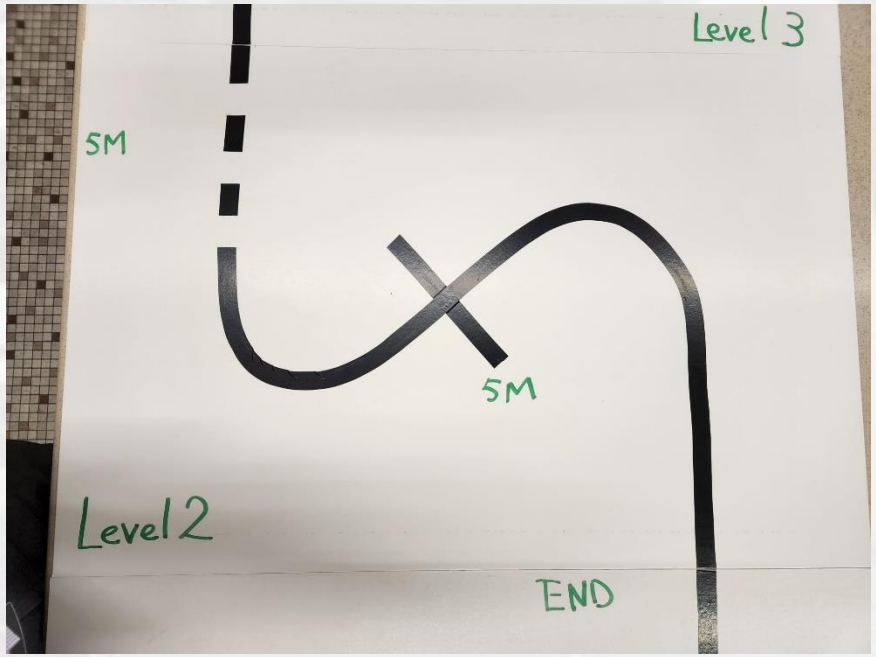
Level 1

- Basic program to follow the line
  - Left sensor dark, turn left
  - Right sensor dark, turn right

Level 2

- Priority of decision making
  1. Cross the cross: Both sensors dark first
  2. Passing through dotted line





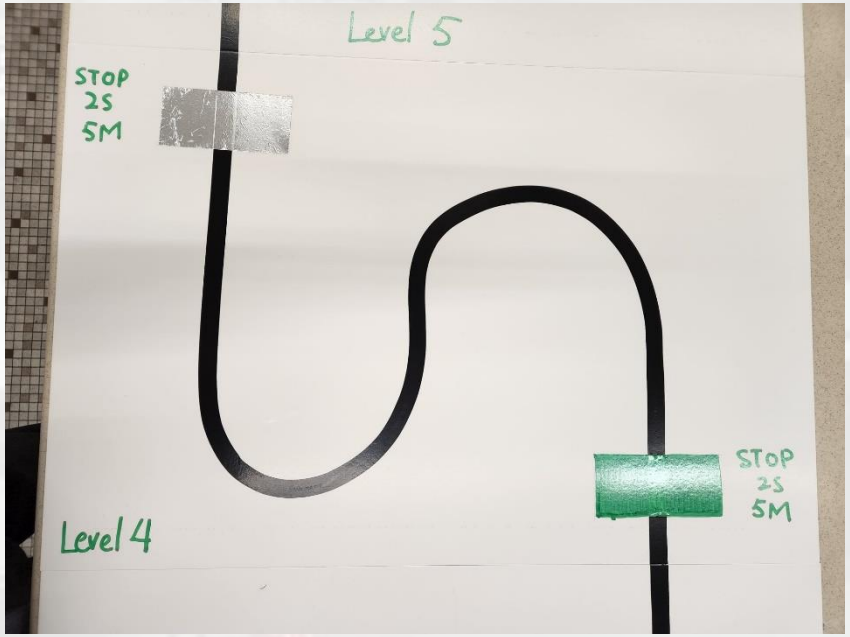
Level 3 and 4

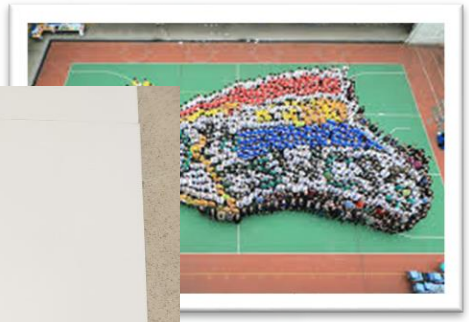
Level 3

- Adjust the position of light sensors or you need to find a method to find out the car is on a right angle track

Level 4

- Avoid misinterpretation: Double check reading
  1. between black and white, and
  2. brighter than white





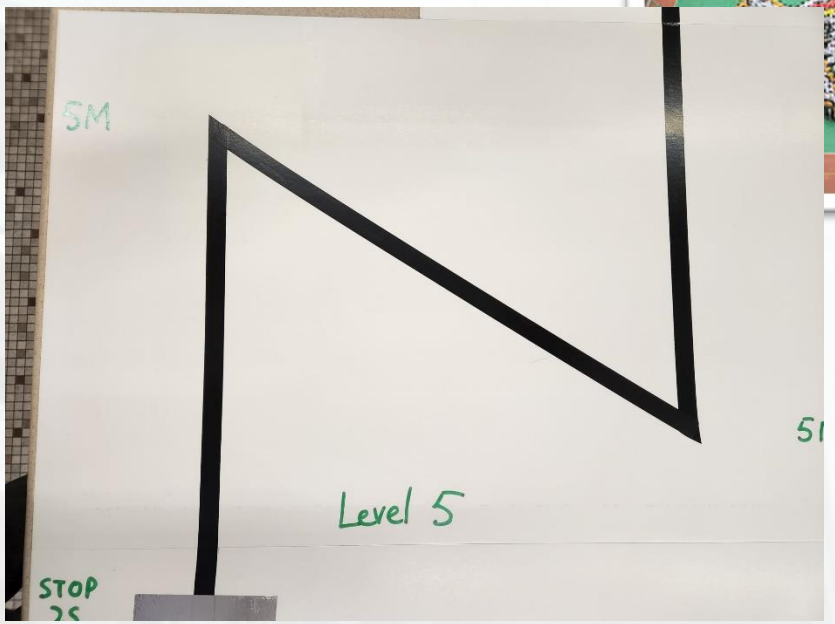
Level 5 and 6

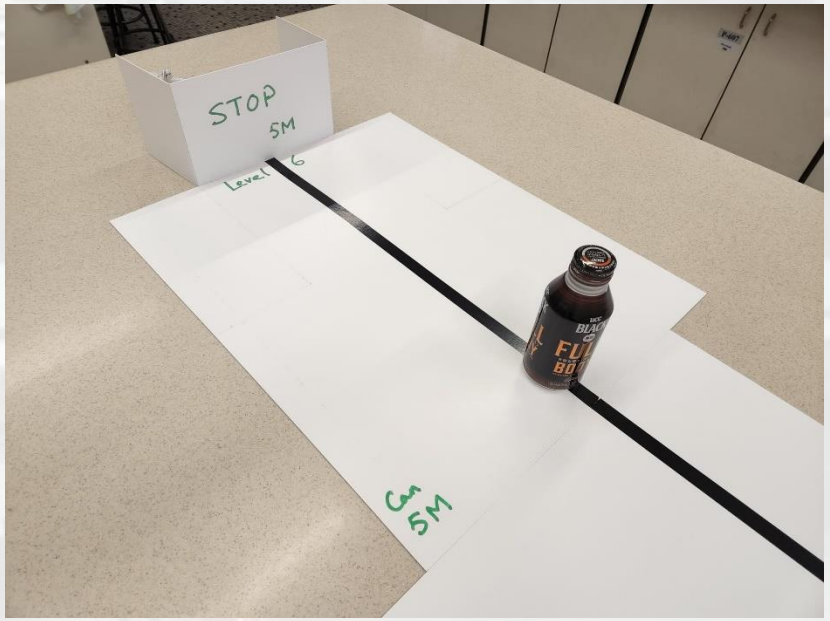
Level 5

- Unavoidable. Recognise the acute angle, leave the track, sharp turning and return to the track.

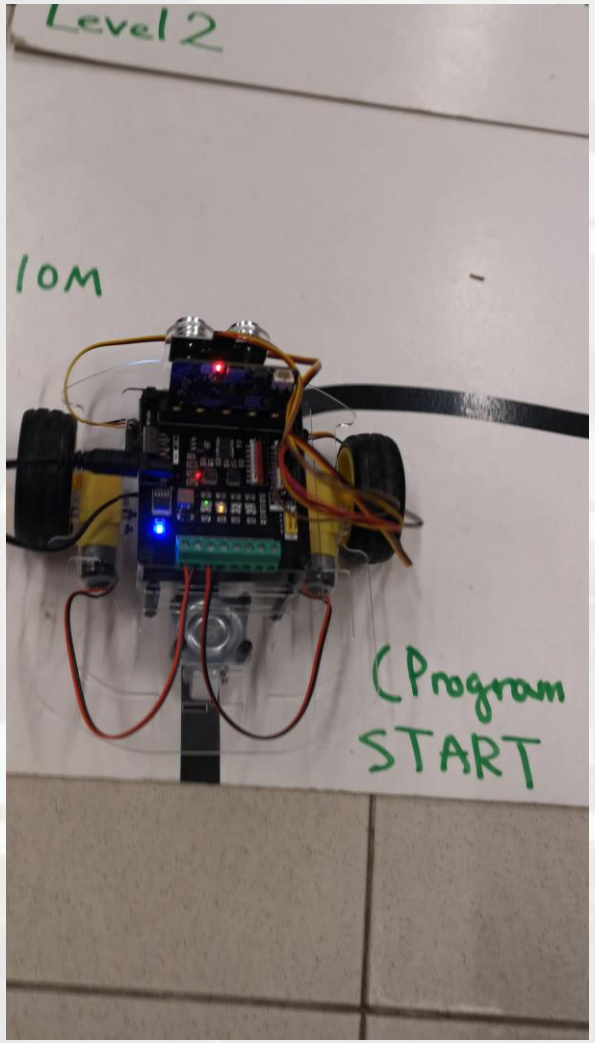
Level 6

- Recognise obstacle, leave the track, turn round and return to the track.



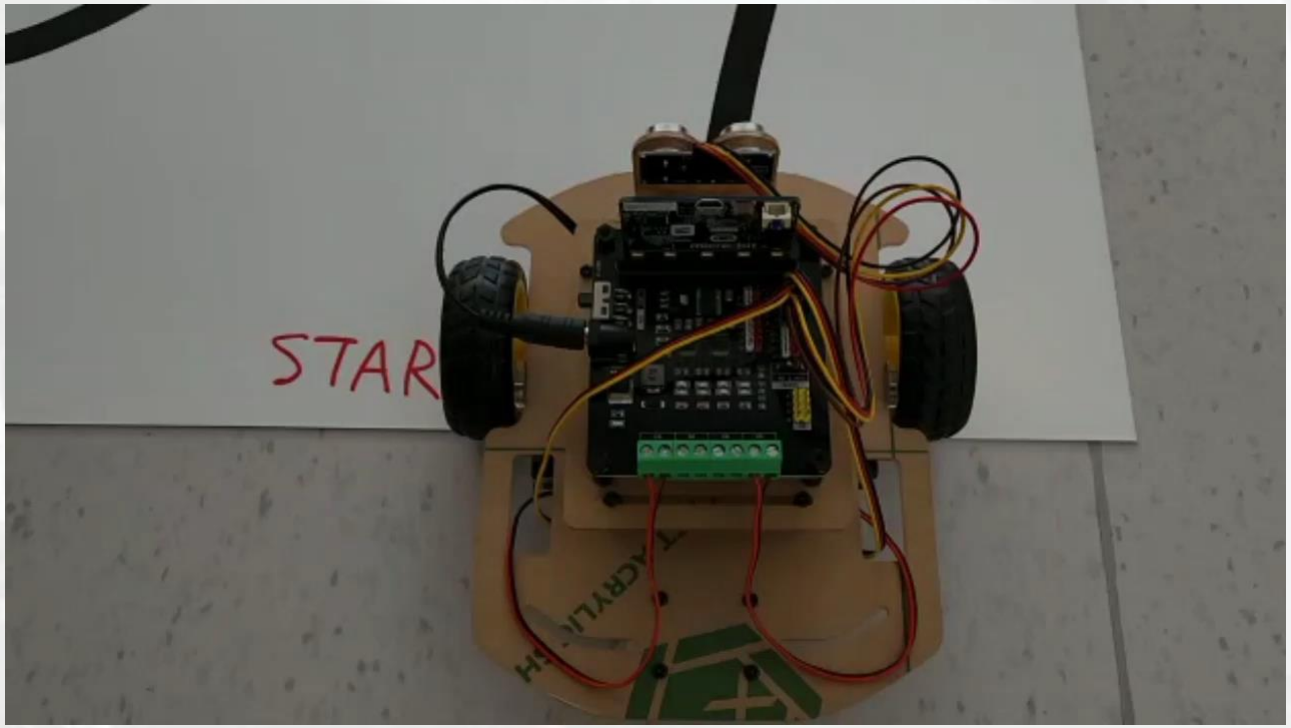


Project 1 Videos



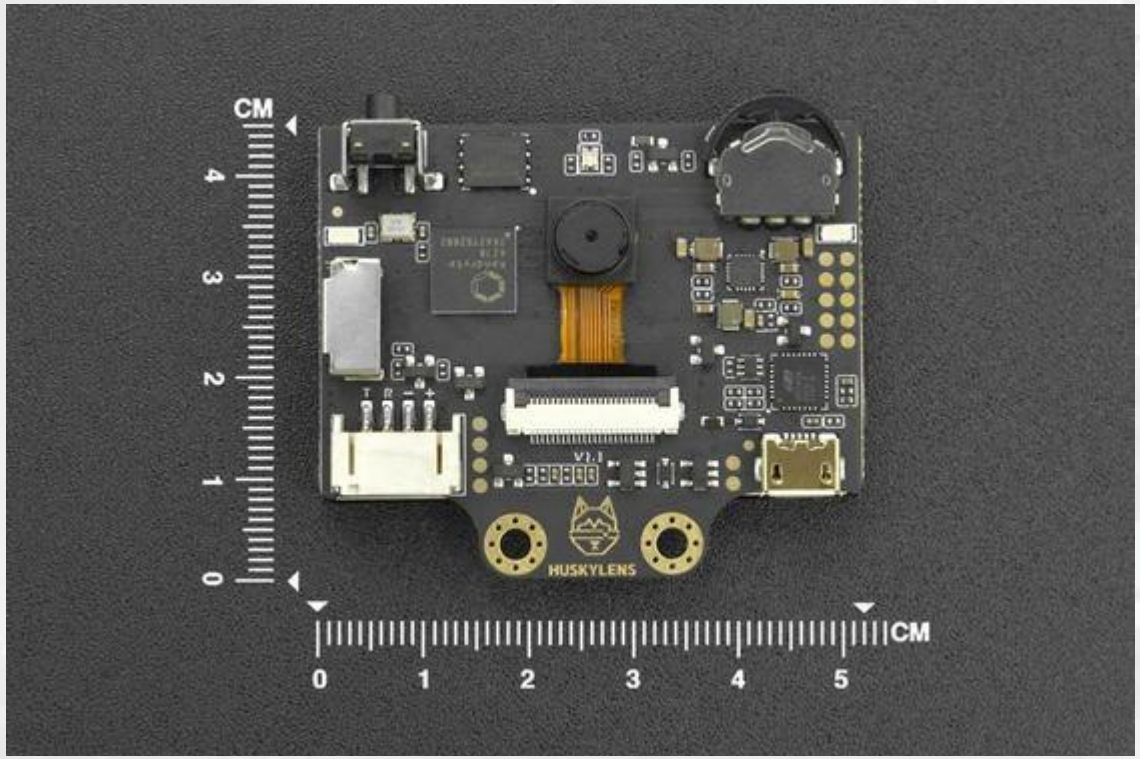
Simple Version

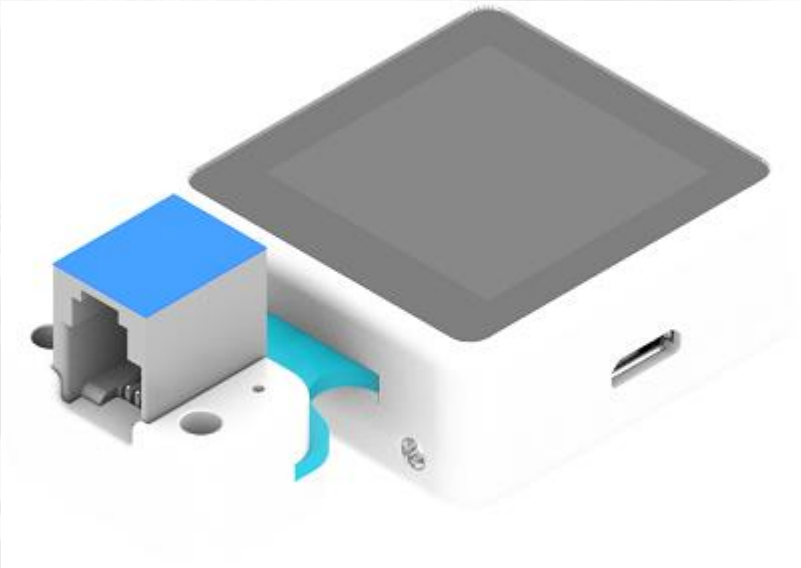
Difficult Version



Project 1: Future Plans

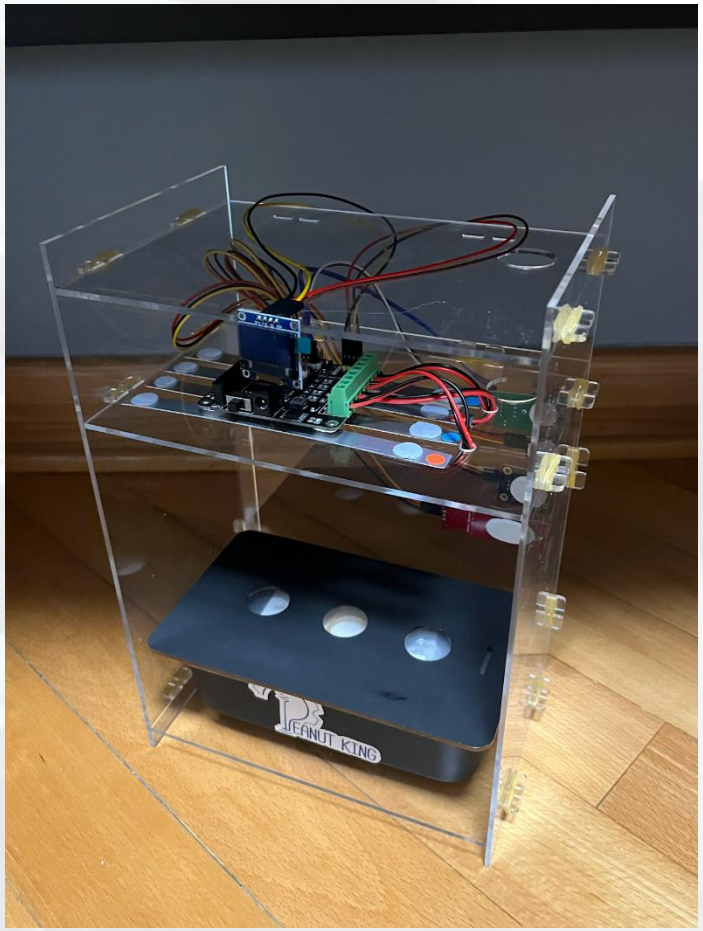
- Application of AI Camera





Project 2:
F2 Hydroponics

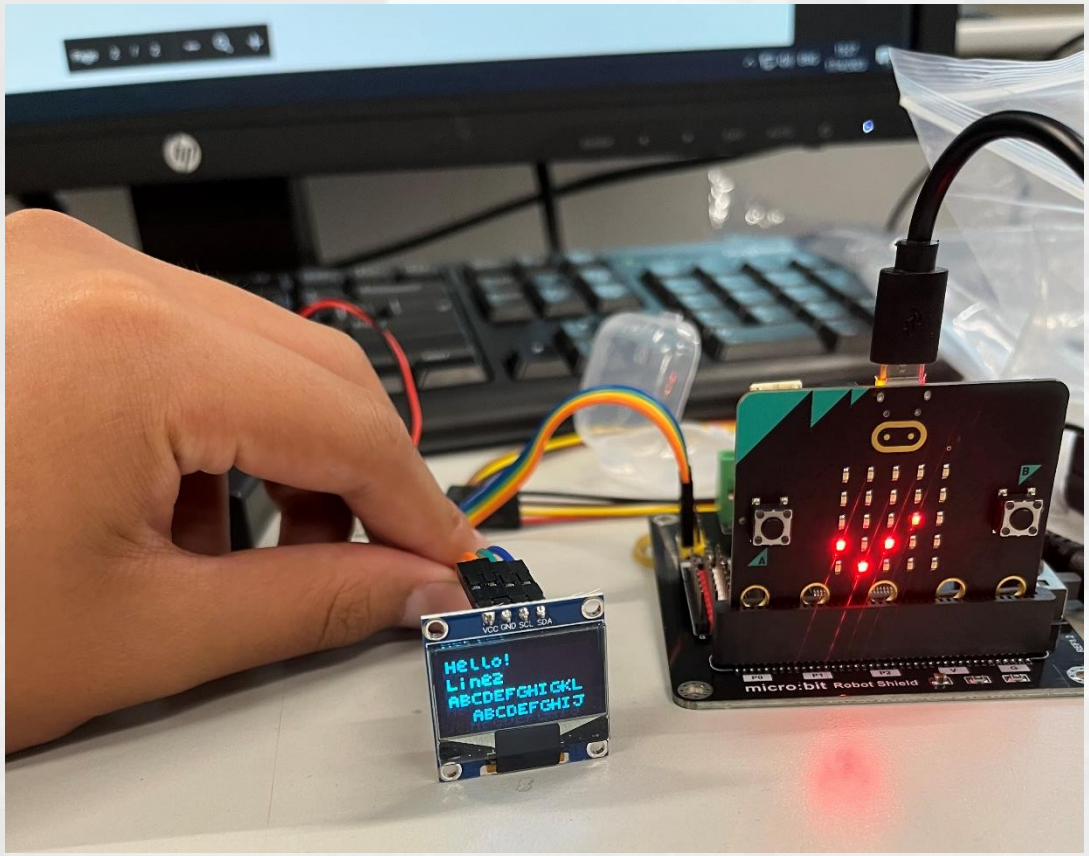
Innovative 24 Hour Real-time Automated Control and Scientific Investigation

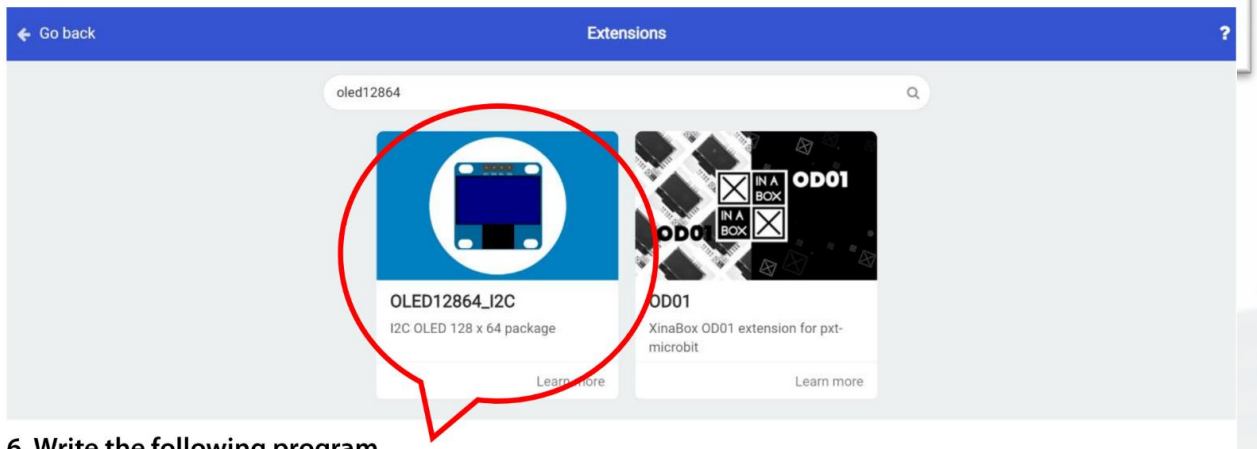


Original: F2 Integrated Science Scientific Investigation

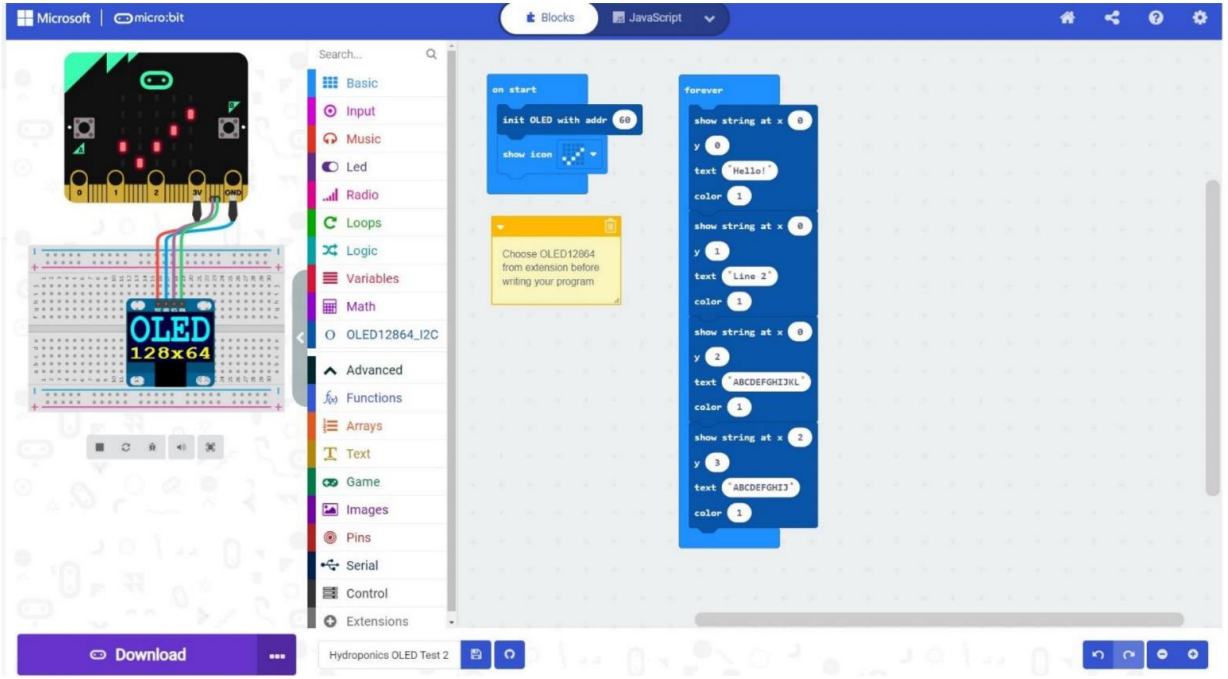
Task 1: OLED Display

- Basic display





6. Write the following program



Task 1: OLED Display

- More complicated display

```
on start
  set another screen to 0
  init OLED with addr 60
  show icon

on button A pressed
  set another screen to 1
  clear
  show string at x 0
  y 0
  text "The current  temperature:"
  color 1
  pause (ms) 500
  show string at x 0
  y 2
  text join temperature (°C) "°C"
  color 1
  pause (ms) 1000
  clear
  set another screen to 0

on button B pressed
  set another screen to 1
  clear
  show string at x 0
  y 0
  text "The current  brightness:"
  color 1
  pause (ms) 500
  show a Number at x 0
  y 2
  number light level
  color 1
  pause (ms) 1000
  clear
  set another screen to 0

forever
  if another screen = 0 then
    repeat 4 times
    do
      show string at x 0
      y 0
      text "C&T is AWSOME!!!!!!!!!!!!"
      color 1
      pause (ms) 200
      clear
    draw a horizontal line at x 0
    y 15
    number 9
    color 1
    pause (ms) 200
    draw a horizontal line at x 0
    y 17
    number 9
    color 1
    pause (ms) 200
    draw a horizontal line at x 0
    y 19
    number 9
    color 1
```

Task 2: Real Time Clock

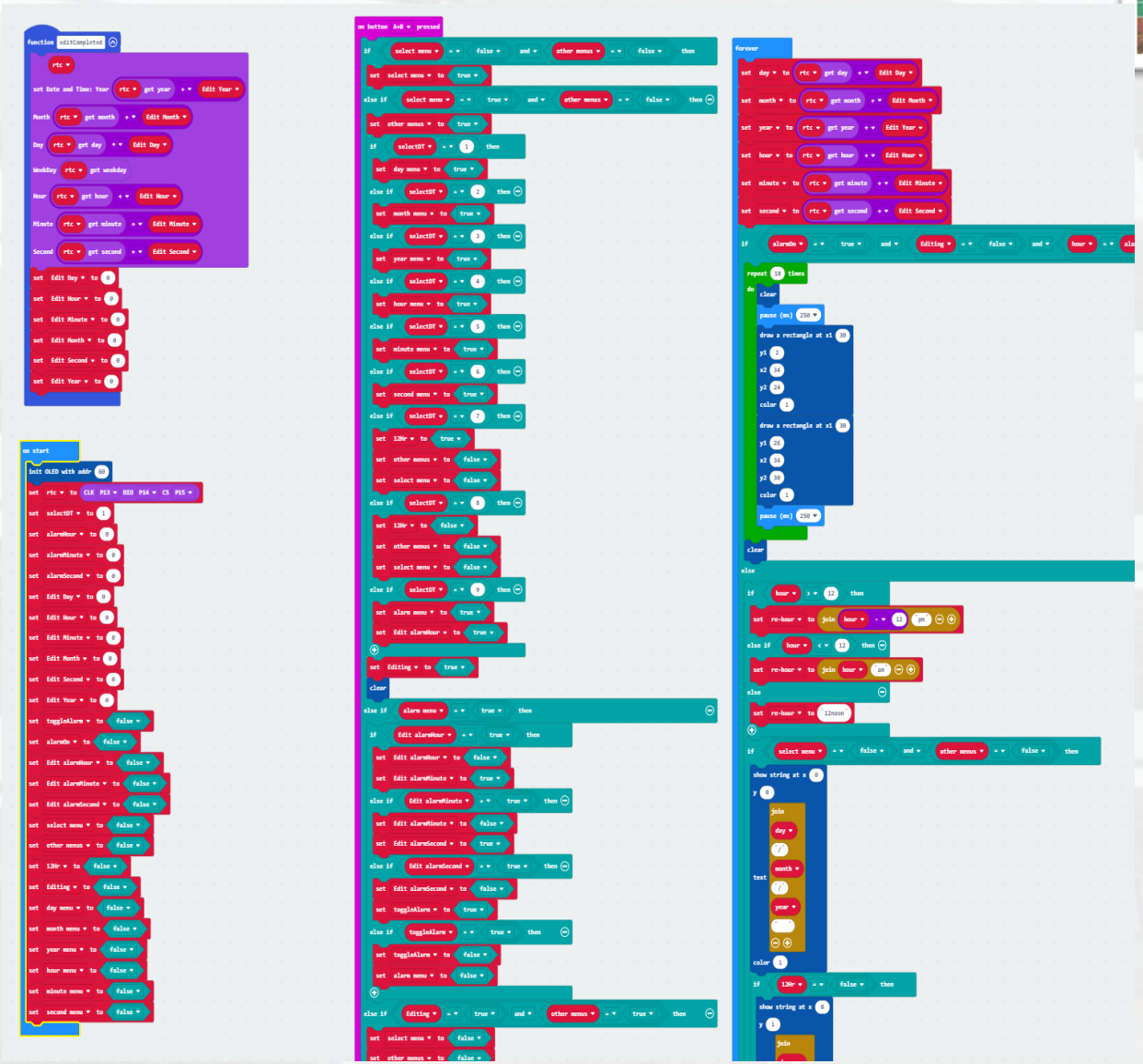
- Basic Clock

```
on start
  set rtc to CLK P13 DIO P14 CS P15
    rtc
    set Date and Time: Year 2023
    Month 4
    Day 25
    WeekDay 2
    Hour 15
    Minute 7
    Second 32
```

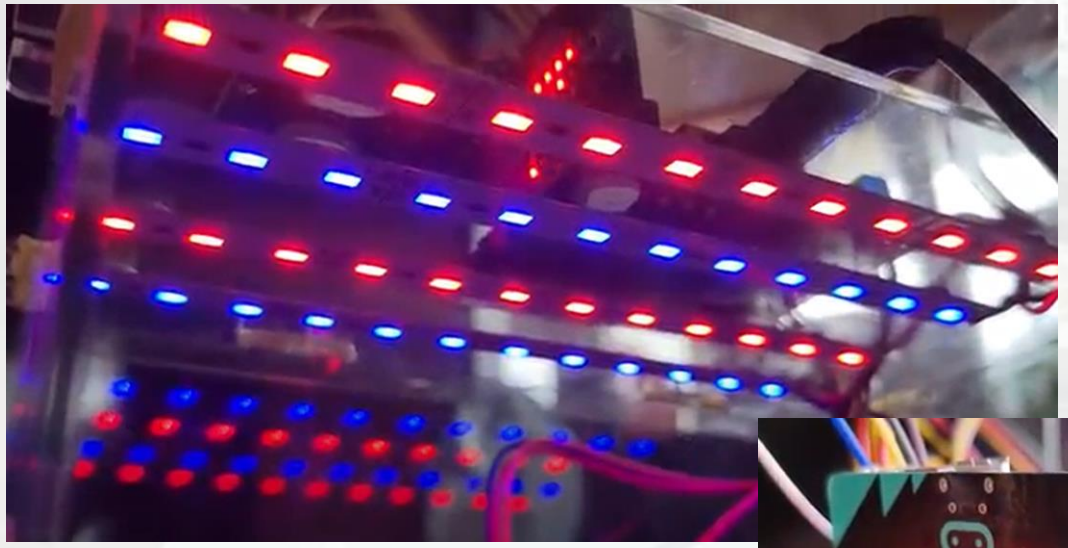
```
forever
  set day to rtc get day
  set month to rtc get month
  set year to rtc get year
  set hour to rtc get hour
  set minute to rtc get minute
  set second to rtc get second
  show number day
  show string "/"
  show number month
  show string "/"
  show number year
  clear screen
  show number hour
  show string ":"
  show number minute
  show string ":"
  show number second
```

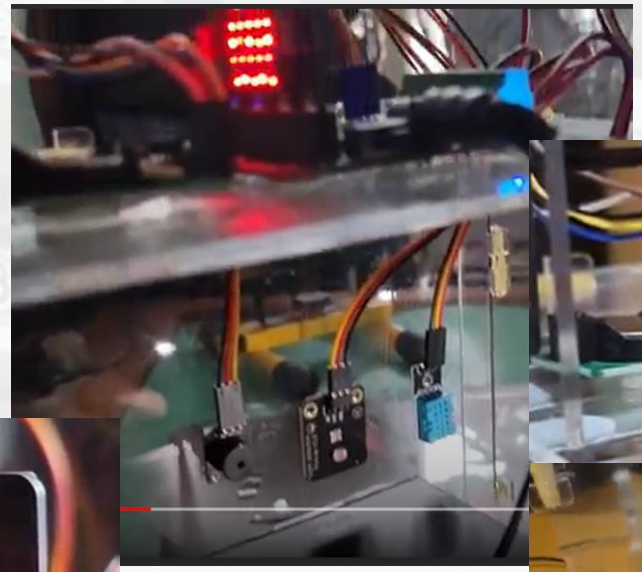
Task 2: Real Time Clock

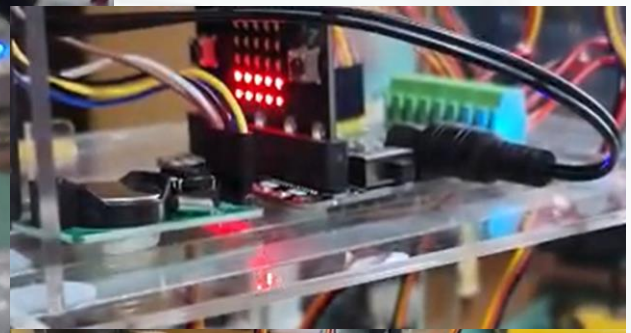
- Full Function Clock

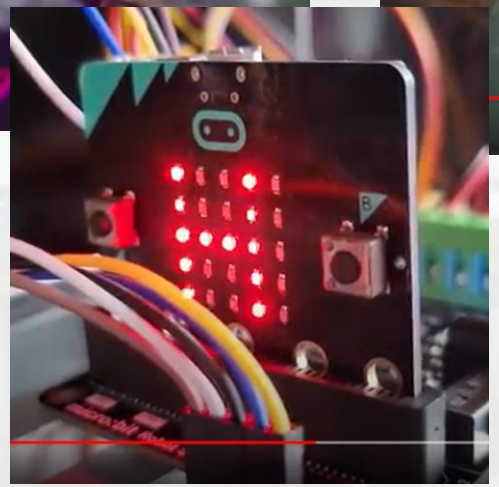


Task 3: LED brightness test
Task 4: Temperature and humidity test
Task 5: Light detection and water level test







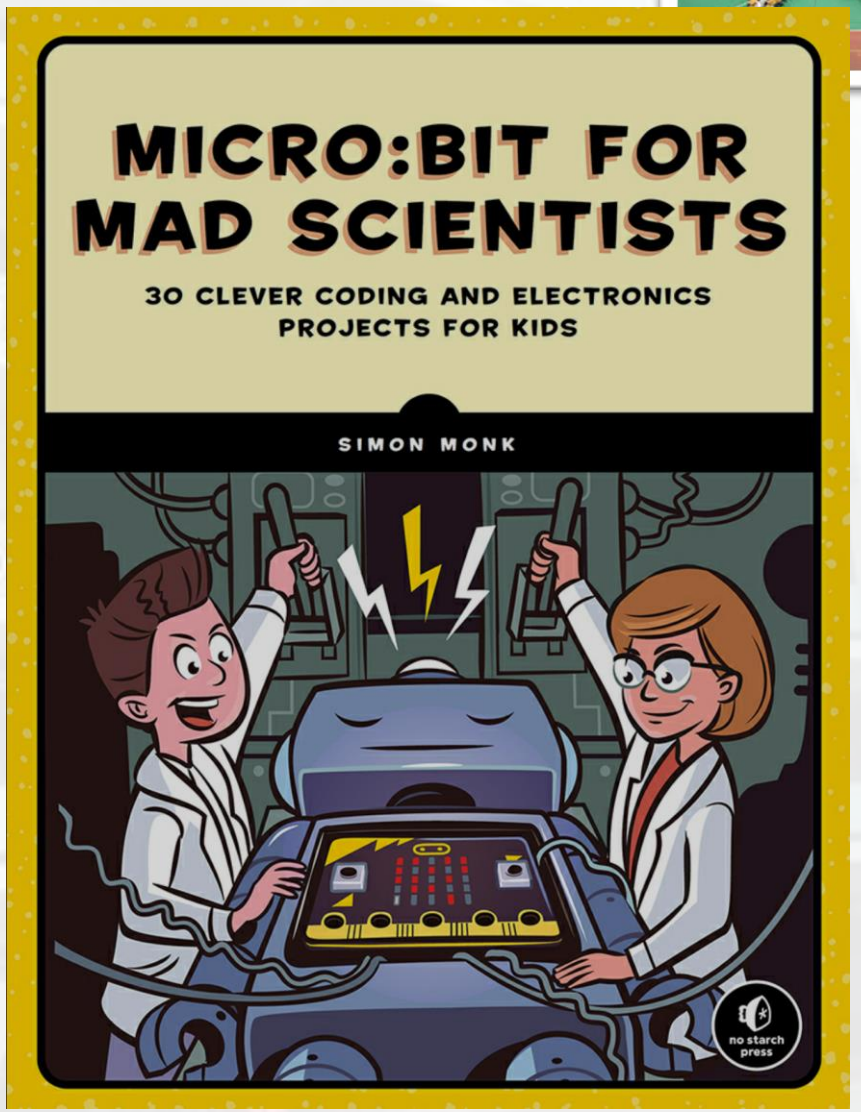


Final Product

Project 3: Mini Project F3 Magical Magnetism

Original Idea (Amazon ebook)

- Micro:bit for Mad Scientists
- By Simon Monk



Task 1: Compass

- Basic Scientific Knowledge

How it Works: The Earth's Magnetic field

The magnetic field is generated by electric currents due to the motion of convection currents of a mixture of molten iron and nickel in the Earth's outer core, as shown in Figure 4-5.

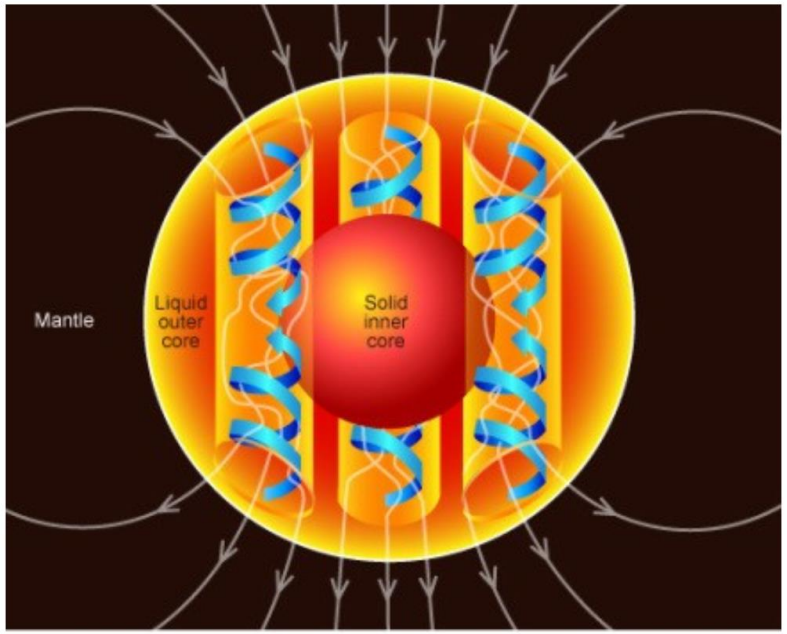
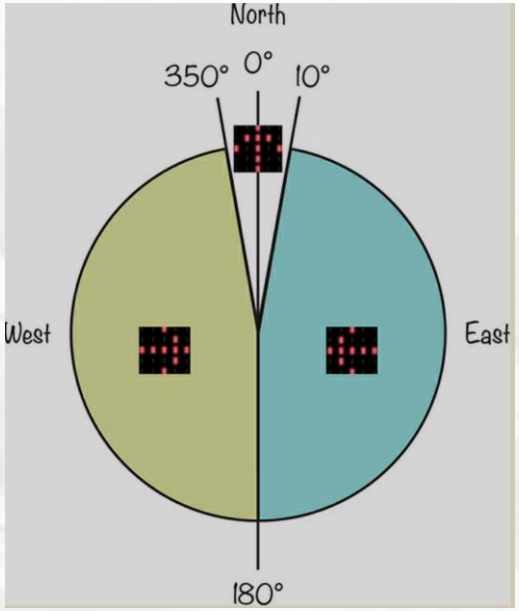


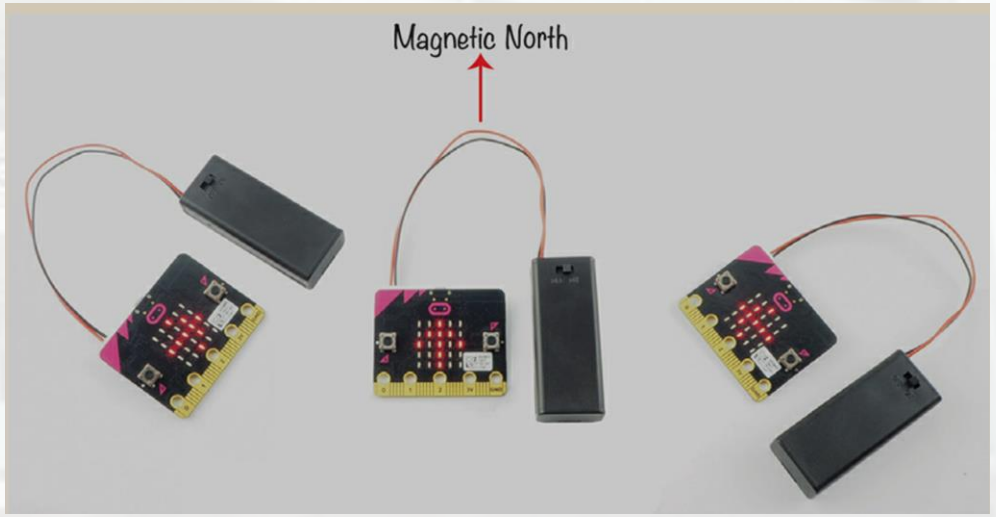
Figure 4-5: Convection current of molten iron and nickel

The micro:bit's magnetometer measures the strength of Earth's magnetic field to deduce the direction the micro:bit is facing.

Task 1: Compass

- Build your micro:bit compass





- Modification: The micro:bit compass can always points towards the north

Task 2: Measuring Magnetic Fields

3. Align your ruler so the 0cm mark is pointing north and the 20cm mark is point south, as shown in figure 1-10. The ruler allows you to make sure the magnet continues to face north so that the effect of Earth's magnetic field remains constant.

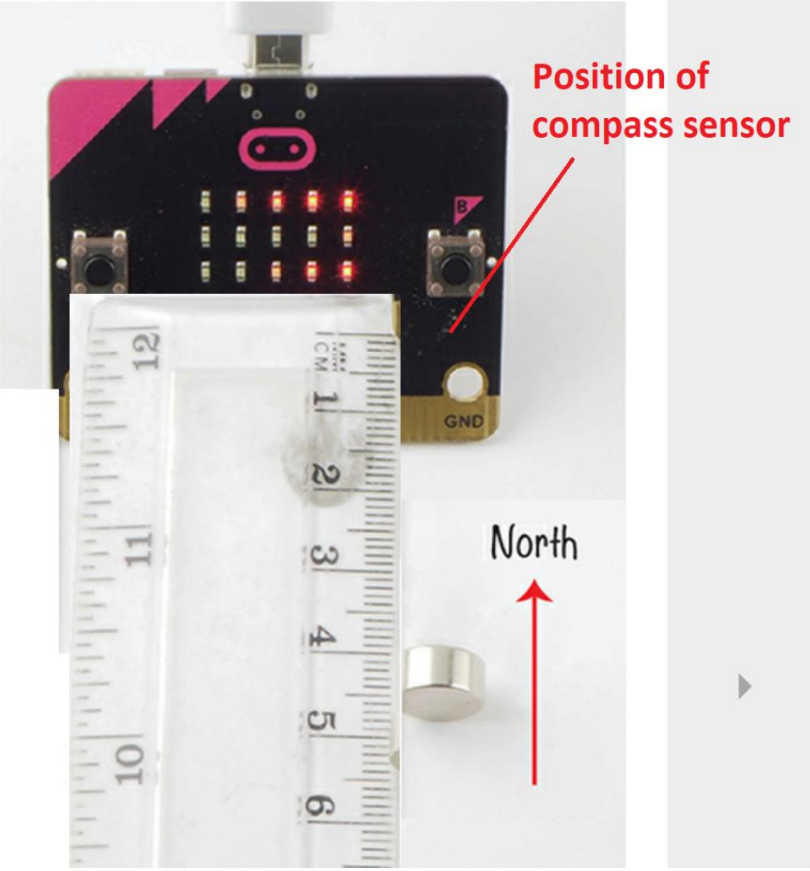
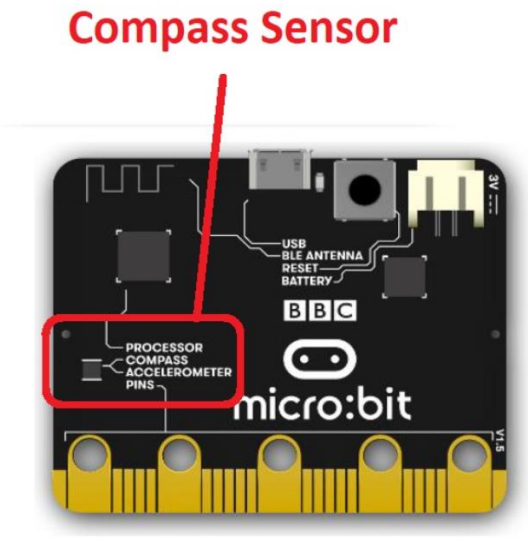


Figure 1-10: Place the ruler in the north-south direction



Back of Micro:bit

Task 2: Students' Result

4. Remove the magnet and then measure the background magnetic field strength. The unit of magnetic field strength is a tesla (which is a very strong magnetic field), so the readings from the micro:bit are in microtesla or (1/1,000,000) Tesla, represented by μT.

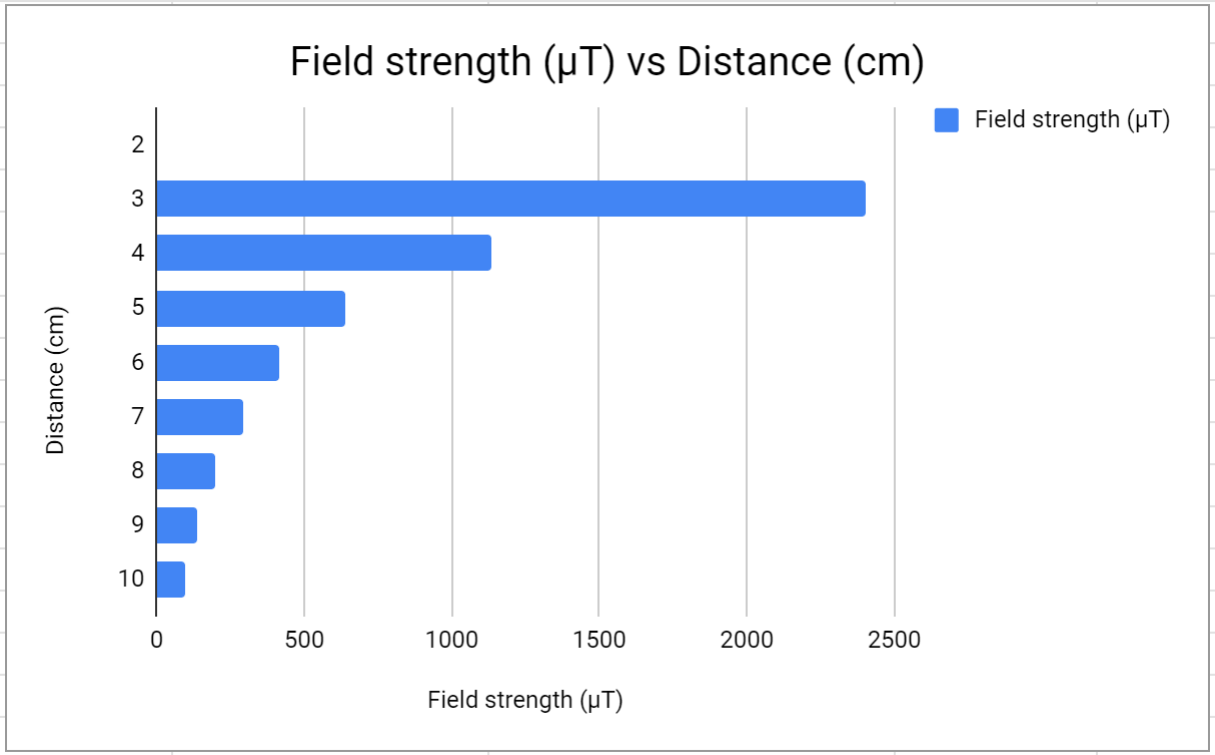
   Background magnetic field strength: _____35.32_____ μT (Sci: 5 marks)

5. Set the magnet on its curved edge next to the 1cm mark on the ruler. Make sure the north side is facing the micro:bit. Pointing the micro:bit south and align its edge with the 0cm mark. Record the reading displayed on the micro:bit in the following table, in the 1cm row.

Distance from micro:bit to magnet (cm)	Magnetic field strength (μT)	Corrected Magnetic field = Magnetic field strength - Background (μT)
1	-------	-------
2	rejected	rejected
3	2405.58	2370.26
4	1133.36	1098.04
5	639.31	603.99
6	412.93	377.61
7	291.29	255.97
8	195.45	160.13
9	139.86	104.54
10	97.71	62.39

(Sci: 20 marks)

Maximum magnetic field strength can be measured by a micro:bit ~2700 micro T



Task 2:
Different approach for the explanation

2. Scientist found that the relations between magnetic field strength and distance as

Magnetic field strength (μT) = k / (distance (cm))2

Estimate k from your graph or chart obtained. Briefly explain how you come out your answer or show your work of finding the answer. (You may write your answer on a piece of paper, take a photo and insert it in the area below. (Maths: 25 marks)

$1098.04 = k/4^2$

$k = 17568.64 \mu Tcm^2$

$603.99 = k/5^2$

$k = 15099.75 \mu Tcm^2$

$377.61 = k/6^2$

$k = 13593.96 \mu Tcm^2$

$255.97 = k/7^2$

$k = 12642.53 \mu Tcm^2$

$160.13 = k/8^2$

$k = 10248.32 \mu Tcm^2$

The average of k=(17568.64+15099.75+13593.96+12642.53+10248.32)/5

$= 13830.64 \mu Tcm^2$

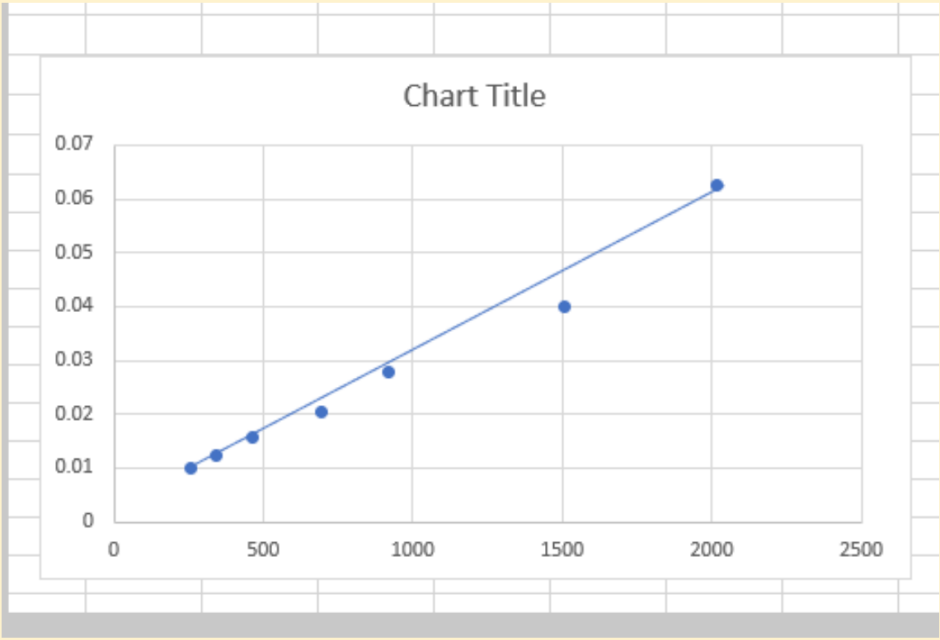
The error is about=[((13830.64-17568.64)/17568.64)(100%)] ~ [((13830.64-10248.32)/10248.32)(100%)]= -21.3% ~ 35.0%

Therefore the error of k is about 35.0%.

2. Scientist found that the relations between magnetic field strength and distance as

Magnetic field strength (μT) = k / (distance (cm))^2

Estimate k from your graph or chart obtained. Briefly explain how you come out your answer or show your work of finding the answer. (You may write your answer on a piece of paper, take a photo and insert it in the area below. (Maths: 25 marks)



When a graph of magnetic field against (1/distance^) is plotted, it is found that a straight line graph passing through the origin, within experimental error, is plotted. Therefore the relation is verified.

Project 4: Cross Curricular Project F3 Water Rocket

Roles of different subjects:

1. Integrated Science
   A. Introduce the Chinese Space Program
   B. Basic understand of the uniform accelerated motion
   C. Presentation
2. Mathematics
   A. Basic Graphical method. Find the slope from a segment of a graph
3. Computer and Technology
   A. Make a Remote control Data logger
   B. Launch the rockets
   C. Collect data and plot acceleration, velocity and displacement time graphs
   D. Evaluate the data collected and the graphs plotted

Original Idea

- A micro:bit water rocket
- By Fablab Bratislava at SlovakCentre of Scientific and Technical Information (SCSTI)
- https://wikifactory.com/+fablabbratislava/a-microbit-water-rocket

- Modification was made after micro:bit V2 was sold in the market
- Clumsy wireless transfer of data to computer was replaced by standalone micro:bit built-in data logger

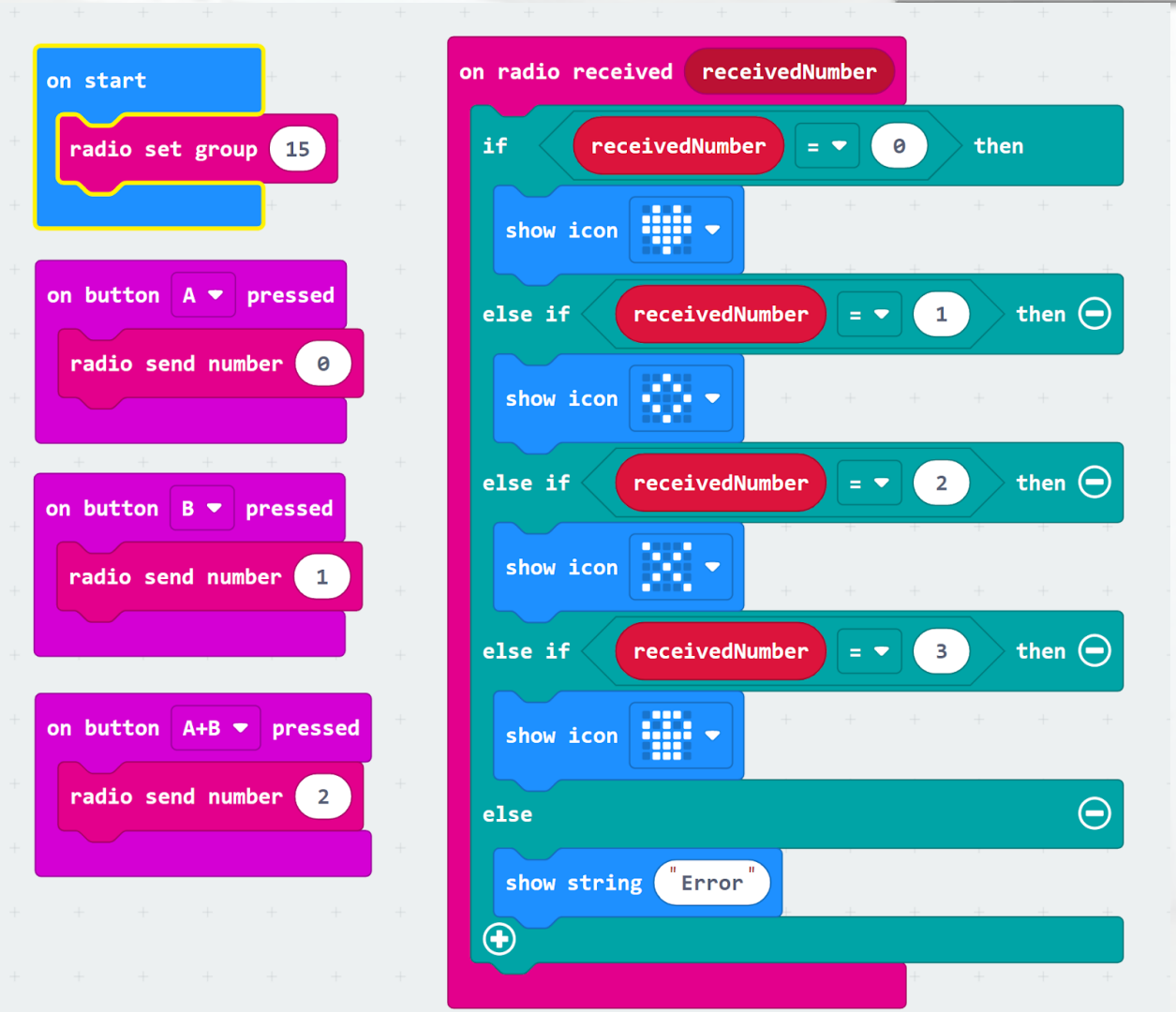
Data Logging Program

- Installed in the rocket to record the acceleration of the rocket against time

```
on start
  radio set group 15
  set Logging to false
  set columns "Acceleration"

on log full
  set Logging to false
  radio send number 3
  show icon

every 100 ms
  if Logging then
    log data column "Acceleration" value acceleration (mg) strength

on radio received receivedNumber
  if receivedNumber = 0 then
    show icon
    radio send number 0
    set Logging to true
  else if receivedNumber = 1 then
    show icon
    radio send number 1
    set Logging to false
  else if receivedNumber = 2 then
    delete log
    set Logging to false
    set columns "Acceleration"
    radio send number 2
    show icon
  else
    radio send number 4
    show string "Error"
```

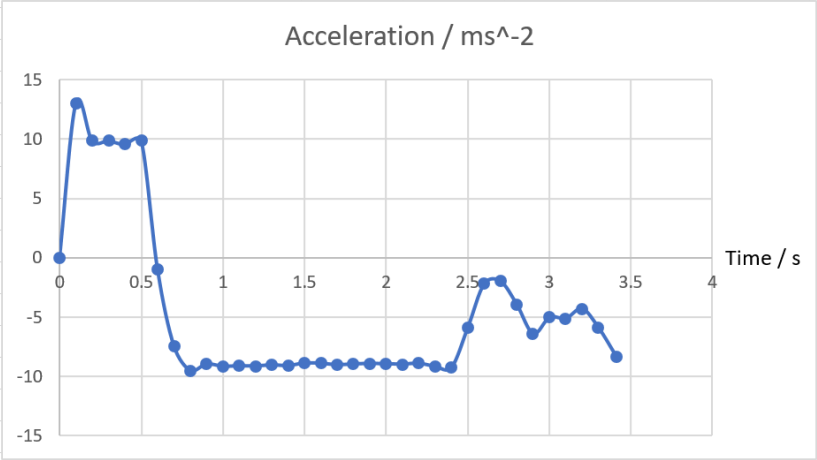
Remote control program

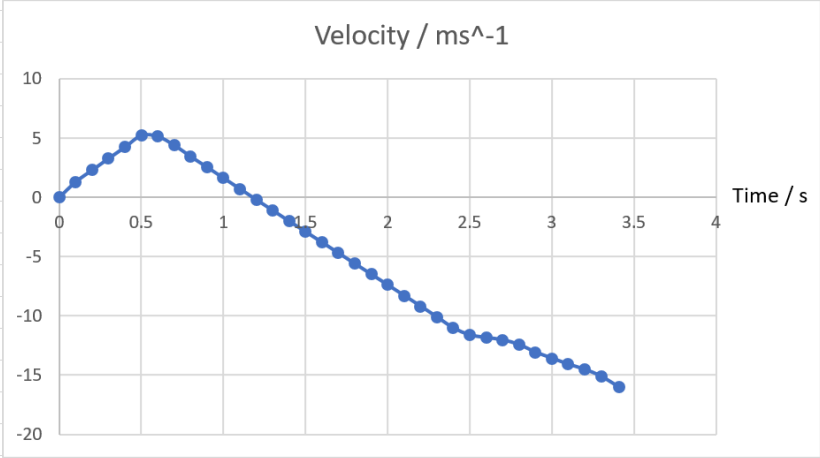
- To start and stop data logging, and clear data recorded in the micro:bit

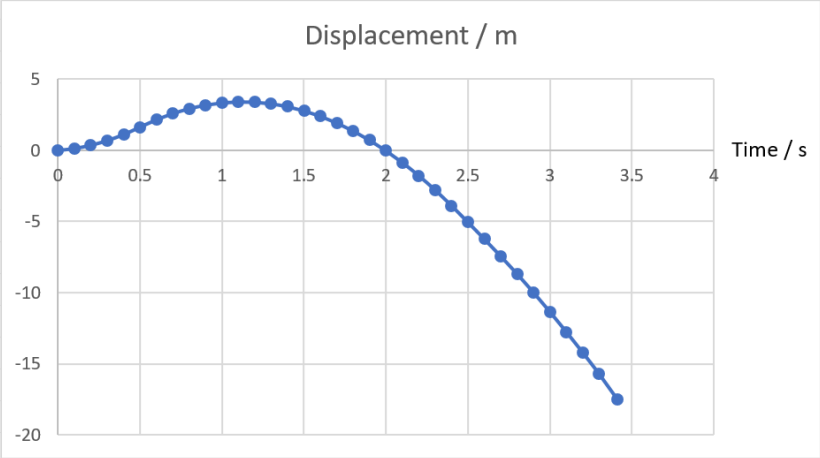


Excel Data Analysis

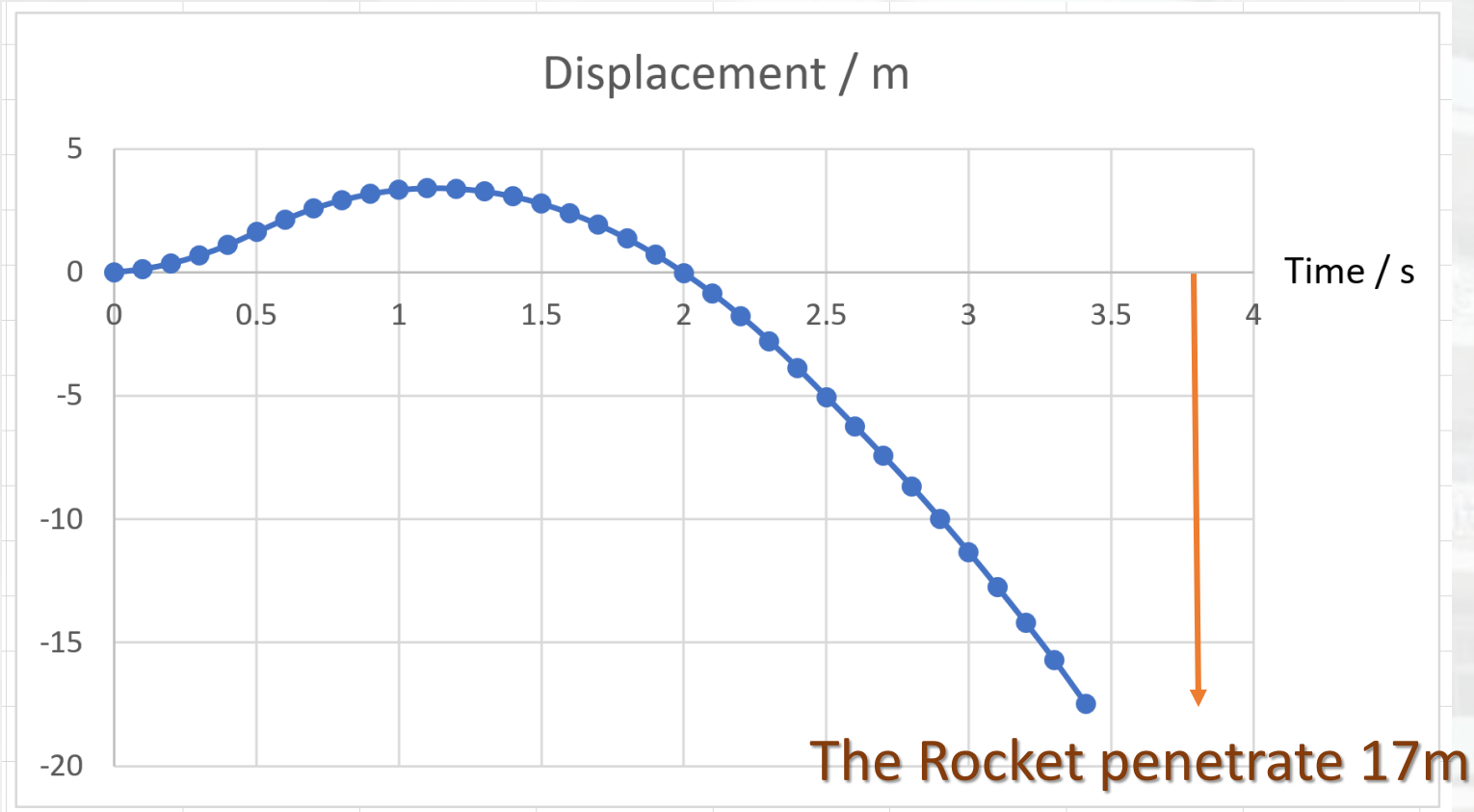
Average measured acceleration			Acceleration under gravity
1079.91			9.81
Time / s	Acceleration / ms^-2	Velocity / ms^-1	Displacement / m
0	0	0	0
0.1	13.04	1.30	0.13
0.2	9.85	2.29	0.36
0.3	9.87	3.28	0.69
0.4	9.55	4.23	1.11
0.5	9.89	5.22	1.63
0.6	-0.98	5.12	2.14
0.7	-7.44	4.38	2.58
0.8	-9.52	3.43	2.92
0.9	-8.97	2.53	3.18
1	-9.17	1.61	3.34
1.1	-9.12	0.70	3.41
1.2	-9.15	-0.22	3.39
1.3	-9.05	-1.12	3.27
1.4	-9.11	-2.03	3.07
1.5	-8.89	-2.92	2.78
1.6	-8.91	-3.81	2.40
1.7	-9.04	-4.72	1.93
1.8	-8.97	-5.61	1.37
1.9	-8.93	-6.50	0.72
2	-8.95	-7.40	-0.02
2.1	-8.99	-8.30	-0.85
2.2	-8.91	-9.19	-1.77
2.3	-9.18	-10.11	-2.78
2.4	-9.26	-11.03	-3.89
2.5	-5.89	-11.62	-5.05
2.6	-2.20	-11.84	-6.23
2.7	-1.98	-12.04	-7.44
2.8	-3.95	-12.44	-8.68
2.9	-6.42	-13.08	-9.99
3	-5.04	-13.58	-11.35
3.1	-5.12	-14.10	-12.76
3.2	-4.31	-14.53	-14.21
3.3	-5.90	-15.12	-15.72
3.41	-8.36	-16.04	-17.49





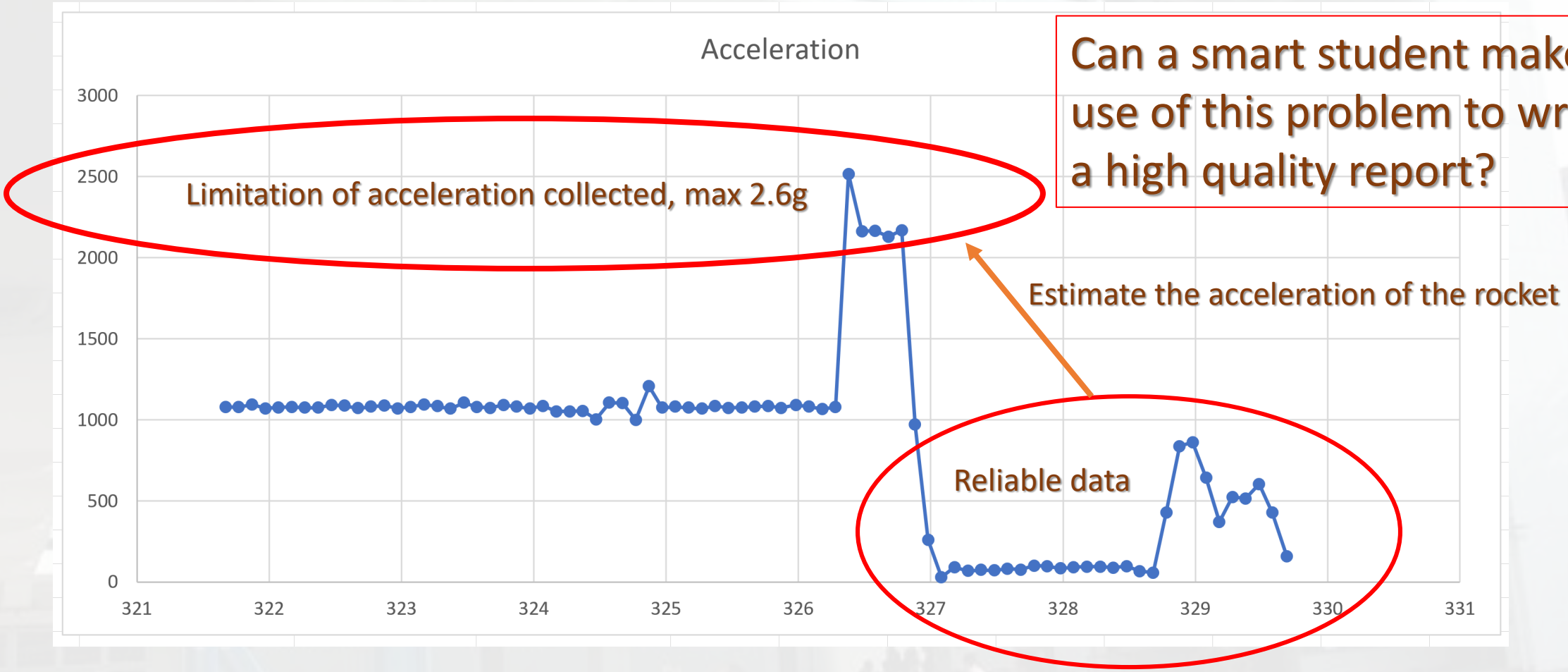


Why did this happen?



The Rocket penetrate 17m under the ground!

Why did this happen?



Can a smart student make use of this problem to write a high quality report?

Thank you