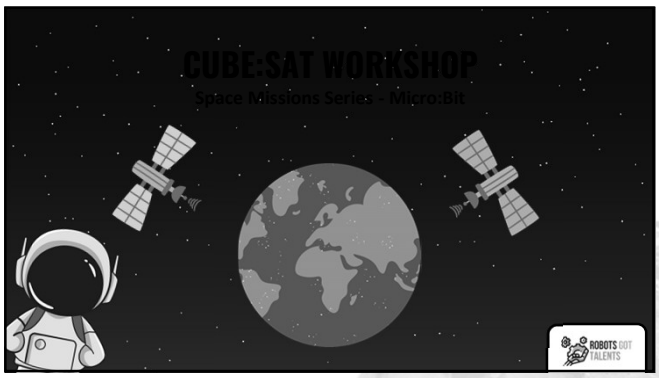
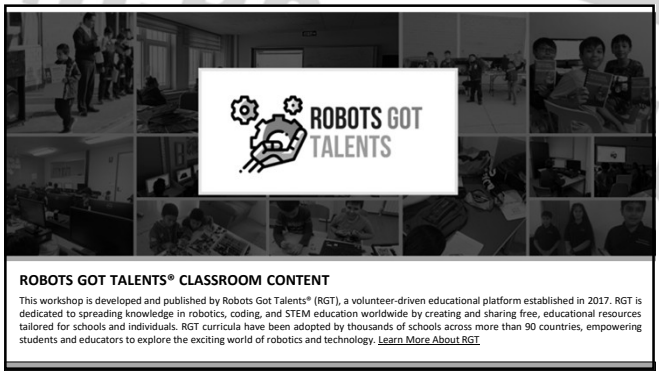

CUBE:SAT WORKSHOP
Space Missions Series - Micro:Bit

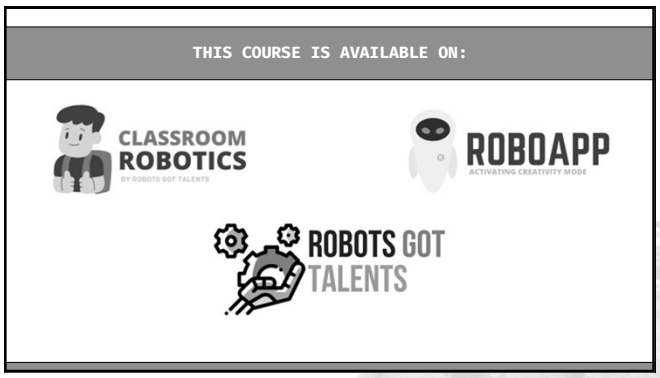
1


CUBE:SAT WORKSHOP
Space Missions Series - Micro:Bit
LESSON 1
LESSON 2
LESSON 3
TOPIC SELECTOR

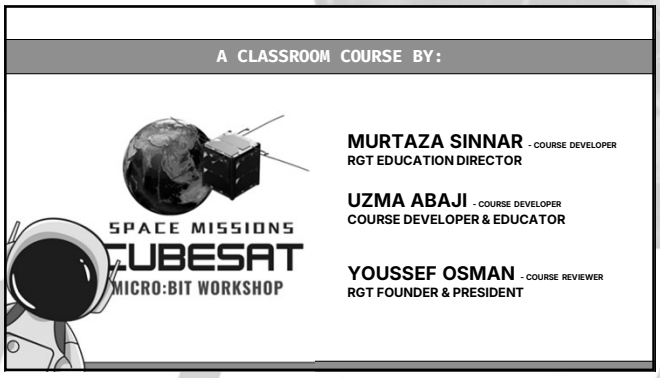
2


ROBOTS GOT TALENTS
ROBOTS GOT TALENTS® CLASSROOM CONTENT
This workshop is developed and published by Robots Got Talents® (RGT), a volunteer-driven educational platform established in 2017. RGT is dedicated to spreading knowledge in robotics, coding, and STEM education worldwide by creating and sharing free, educational resources tailored for schools and individuals. RGT curricula have been adopted by thousands of schools across more than 90 countries, empowering students and educators to explore the exciting world of robotics and technology. Learn More About RGT

3


THIS COURSE IS AVAILABLE ON:
CLASSROOM ROBOTICS
BY ROBOTS GOT TALENTS
ROBOAPP
ACTIVATING CREATIVITY MODE
ROBOTS GOT TALENTS

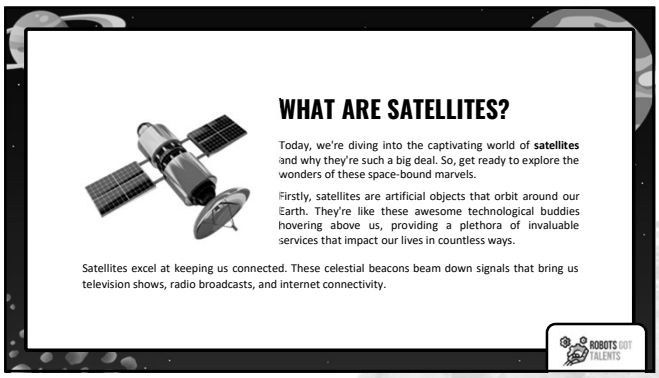
4


A CLASSROOM COURSE BY:
SPACE MISSIONS
CUBESAT
MICRO:BIT WORKSHOP
MURTAZA SINNAR - COURSE DEVELOPER
RGT EDUCATION DIRECTOR
UZMA ABAJI - COURSE DEVELOPER
COURSE DEVELOPER & EDUCATOR
YOUSSEF OSMAN - COURSE REVIEWER
RGT FOUNDER & PRESIDENT

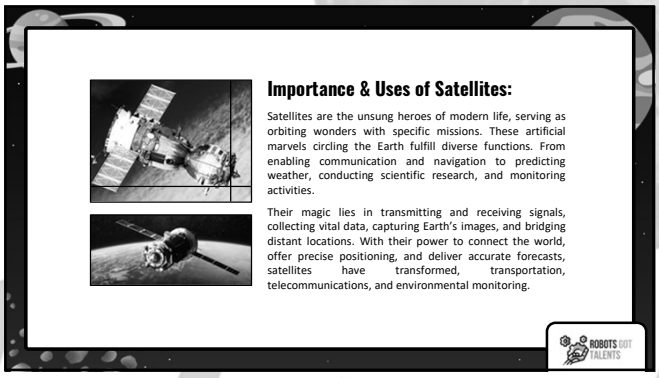
5


LESSON ONE
ROBOTS GOT TALENTS

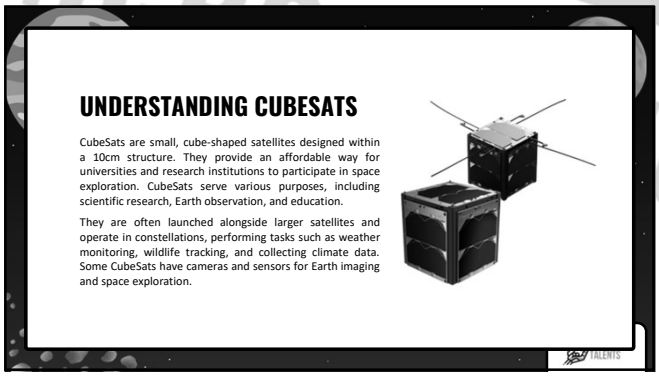
6


WHAT ARE SATELLITES?
Today, we're diving into the captivating world of satellites and why they're such a big deal. So, get ready to explore the wonders of these space-bound marvels.
Firstly, satellites are artificial objects that orbit around our Earth. They're like these awesome technological buddies hovering above us, providing a plethora of invaluable services that impact our lives in countless ways.
Satellites excel at keeping us connected. These celestial beacons beam down signals that bring us television shows, radio broadcasts, and internet connectivity.

7


Importance & Uses of Satellites:
Satellites are the unsung heroes of modern life, serving as orbiting wonders with specific missions. These artificial marvels circling the Earth fulfill diverse functions. From enabling communication and navigation to predicting weather, conducting scientific research, and monitoring activities.
Their magic lies in transmitting and receiving signals, collecting vital data, capturing Earth's images, and bridging distant locations. With their power to connect the world, offer precise positioning, and deliver accurate forecasts, satellites have transformed, transportation, telecommunications, and environmental monitoring.

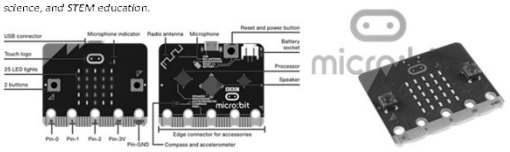
8


UNDERSTANDING CUBESATS
CubeSats are small, cube-shaped satellites designed within a 10cm structure. They provide an affordable way for universities and research institutions to participate in space exploration. CubeSats serve various purposes, including scientific research, Earth observation, and education.
They are often launched alongside larger satellites and operate in constellations, performing tasks such as weather monitoring, wildlife tracking, and collecting climate data. Some CubeSats have cameras and sensors for Earth imaging and space exploration.

9

INTRODUCTION TO MICRO:BIT

Micro:Bit is a small-sized microcontroller board developed by BBC. It is used for robotics, computer science, and STEM education.

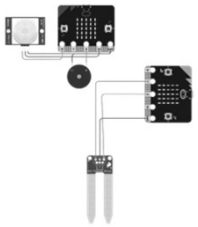


The back of the board contains the microcontroller chip, USB port, reset button, compass and accelerometer sensors, radio/Bluetooth antenna, microphone, speaker, and battery socket. The front side has 2 built-in push buttons, touch sensor and a 5x5 matrix LED.

10

MICRO:BIT PINS:

At the bottom of the board, there are a total of 5 pins, including 3 GPIO pins, a 3V pin, and a ground pin.



- **GPIO pins (P0, P1, P2):** These are used to connect external components such as LEDs, sensors, and motors, supporting both digital and analogue signals.
- **3V pin:** Provides a constant 3.3-volt output to the connected components.
- **GND pin:** Provides a common reference point (0V) for the electrical circuits connected to the board.

11

MICRO:BIT V2 BUILT-IN SENSORS:

The micro:bit V2 features a variety of built-in sensors that enable a wide range of interactive and educational projects. These include:

- **Accelerometer:** Detects movement, tilt, and orientation in three dimensions, allowing the board to respond to shakes, gestures, and changes in position.
- **Compass:** A magnetometer that measures the magnetic field to detect the board's orientation relative to magnetic north, enabling navigation applications.
- **Temperature Sensor:** Measures the ambient temperature, integrated into the board's microcontroller, suitable for environmental monitoring or basic experiments.

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MICRO:BIT V2 BUILT-IN SENSORS:

The micro:bit V2 features a variety of built-in sensors that enable a wide range of interactive and educational projects. These include:

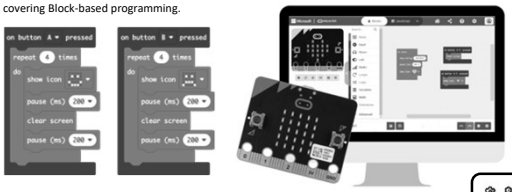
- **Microphone:** Captures sound levels, enabling sound-reactive projects. An LED indicator shows when the microphone is active.
- **Touch Sensor:** Built into the logo on the board, this touch-sensitive surface acts as an additional input for interactive designs.

These sensors, combined with the micro:bit's GPIO pins, allow for innovative projects that blend hardware and software seamlessly.

13

MAKECODE PROGRAMMING

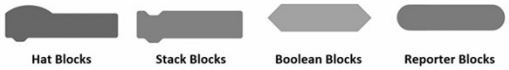
MakeCode is one of the programming options for Micro:bit. It features a drag-and-drop interface, and text-based editor with JavaScript and Python supported, in addition to a built-in Micro:bit simulator for testing code. This course will cover block-based programming. In this lesson, we will be covering Block-based programming.



14

MakeCode - Micro:bit Blocks

MakeCode Blocks are puzzle-shaped pieces based on the famous SCRATCH programming language. The blocks are connected vertically, so the program runs from the top to the bottom a series of connected blocks is called a stack. There are different types of blocks in the MakeCode platform which represent different types of data, each block type has its shape, which prevents syntax errors.



Hat Blocks | Stack Blocks | Boolean Blocks | Reporter Blocks

Hat Block: A block that starts a program when a specific event occurs.

Stack Block: A block that is shaped to fit above and below other blocks.

Reporter Block: A block that reports a variable reading/values to the program.

Boolean Block: A block that reports Boolean values.

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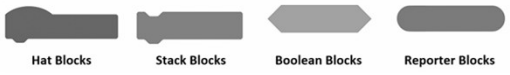
MakeCode - Micro:bit Blocks

MakeCode Blocks are puzzle-shaped pieces based on the famous SCRATCH programming language. The blocks are connected vertically, so the program runs from the top to the bottom a series of connected blocks is called a stack. There are different types of blocks in the MakeCode platform which represent different types of data, each block type has its shape, which prevents syntax errors.

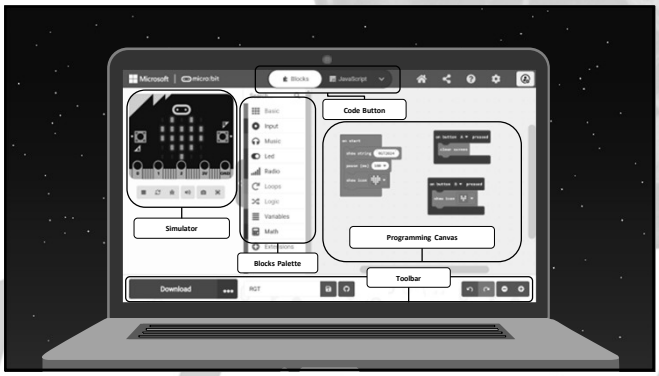


Hat Blocks | Stack Blocks | Boolean Blocks | Reporter Blocks

C Block: A block that is shaped like the letter "C", so other blocks can fit inside it.

Cap Block: A block that is designed to stop the project which it is plugged into.

16



17

Program Download Instructions:

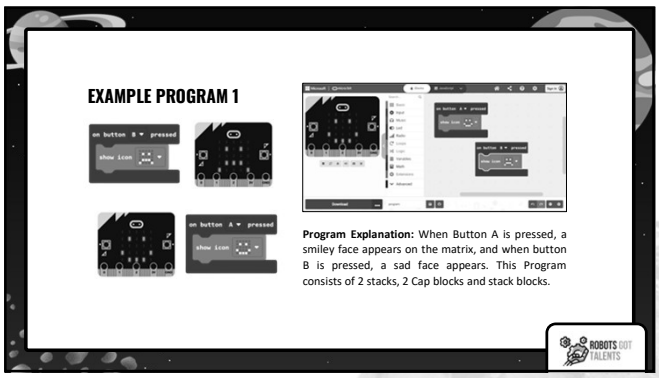
Downloading your program as file/ transferring program:

1. Connect your micro:bit to your computer with a USB cable.
2. Click Download to download the . hex file.
3. Move the . hex file from your computer onto the MICROBIT drive. The next section has instructions for the browser that you're using.

Downloading your program from MakeCode:

1. Connect your micro:bit to your computer with a USB cable.
2. Pair the device using the popup window in the browser
3. Click Download from MakeCode UI

18


EXAMPLE PROGRAM 1
on button B pressed
show icon
on button A pressed
show icon
Program Explanation: When Button A is pressed, a smiley face appears on the matrix, and when button B is pressed, a sad face appears. This Program consists of 2 stacks, 2 Cap blocks and stack blocks.

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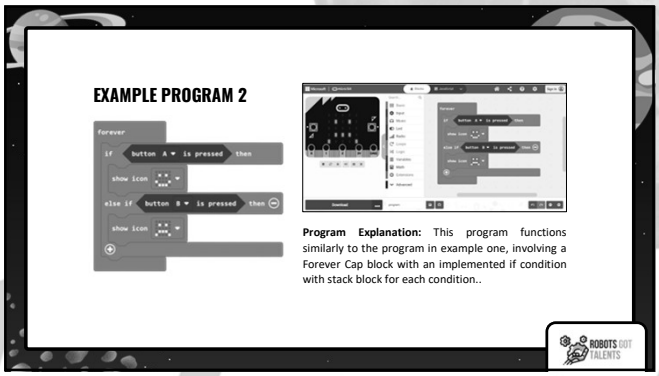
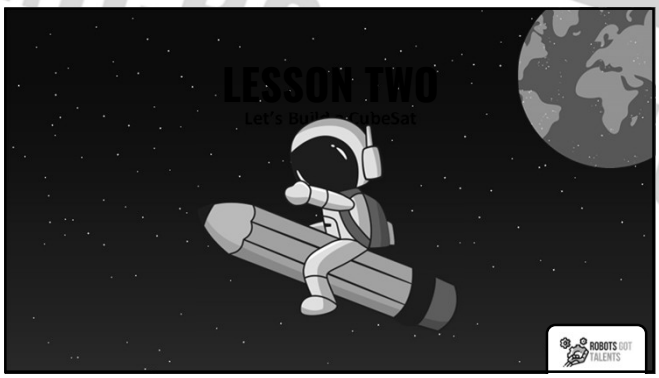

EXAMPLE PROGRAM 2
forever
if button A is pressed then
show icon
else if button B is pressed then
show icon
Program Explanation: This program functions similarly to the program in example one, involving a Forever Cap block with an implemented if condition with stack block for each condition..

20


LESSON TWO

21

Why CubeSats are used?

- **Cost-Effectiveness**
- **Constellation Capabilities**
- **Technology demonstration**
- **Available to a wide range of users**
- **Rapid development cycles**

CubeSats offer numerous benefits, including cost-effectiveness, rapid development, and standardized sizes that simplify design and integration. CubeSats are ideal for technology demonstrations, enable collaborative satellite constellations, and offer flexibility through modular designs, enhancing global access to space for countries and organizations with limited resources.

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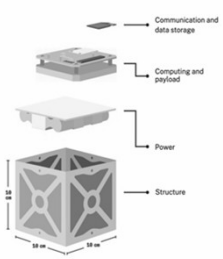
CUBESATS COMPONENTS:

Structure

- **Frame:** The frame provides structural integrity and protects the internal components. It is usually made of lightweight and strong materials.
- **Deployable Mechanisms:** Includes elements such as deployable solar panels, antennae, or booms that are stowed during launch and deployed once in orbit.
- **Thermal Control:** Passive or active thermal control systems to manage the heat generated by the electronics and maintain operational temperatures.

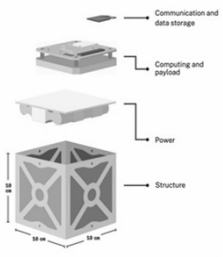


23

CUBESATS COMPONENTS:

Power

- **Solar Panels:** The primary power source for most CubeSats, these panels convert sunlight into electrical energy.
- **Batteries:** Rechargeable batteries store energy generated by the solar panels to power the satellite during periods when it is not in direct sunlight.
- **Power Management System:** This system regulates the distribution of power to various components.



24

CUBESATS COMPONENTS:

Computing & Payload

- **Computing Components:** Central Processing Unit, Microcontrollers
- **Scientific Instruments:** Depending on the mission, these could include cameras, spectrometers, magnetometers, or other sensors to collect data.
- **Experiment Modules:** For educational or experimental missions, the payload might include components to test new technologies or conduct scientific experiments.

Communication & Data Storage

- **Radio Transmitters and Receivers:** These are used for transmitting data to and receiving commands from ground stations. In addition to antennas, modems, and transceivers, they all manage the communication system.
- **Communication:** Communication is managed by onboard computers & nonvolatile memory.

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DATA LOGGING IN CUBESAT

DATA WORKFLOW - MODEL 1

Data will start journey from the temperature sensor on Microbit 1 in CubeSat Then it will be transmitted to Micro:bit 2 using Radio communication and then from Micro:bit 2 to Data Streamer and finally to Computer

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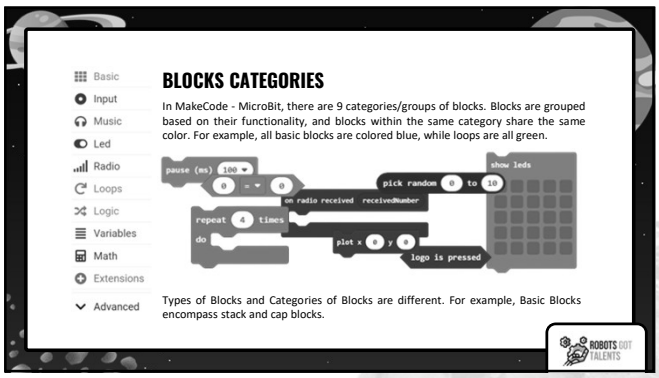
DATA LOGGING - KEY CONCEPT

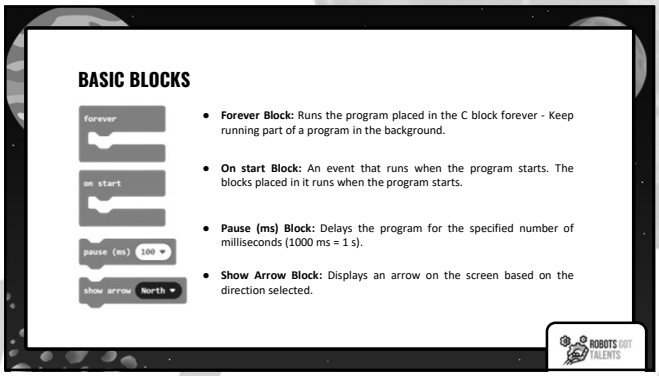
Data Logging is the process of collecting and storing data over a period of time in different systems by tracking a variety of events. While data logging generally is associated with devices, even looking at a thermometer daily at a set time and writing down the temperature on a piece of paper with a pen is a simple way to "log data".

Putting it simply, it is collecting data about a specific, measurable topic or topics, regardless of the method used.

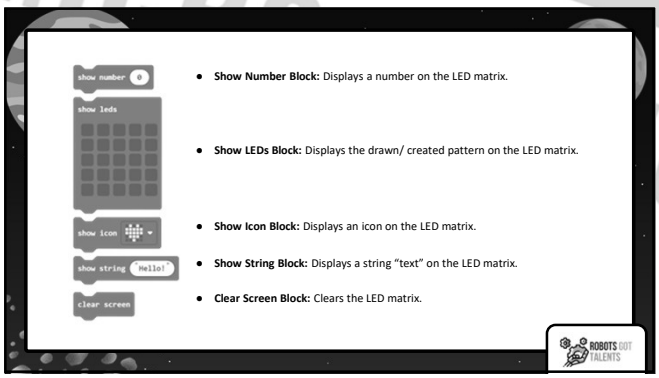
27


Basic
Input
Music
Led
Radio
Loops
Logic
Variables
Math
Extensions
Advanced
BLOCKS CATEGORIES
In MakeCode - MicroBit, there are 9 categories/groups of blocks. Blocks are grouped based on their functionality, and blocks within the same category share the same color. For example, all basic blocks are colored blue, while loops are all green.
pause (ms) 100
pick random 0 to 10
show leds
on radio received receivedNumber
repeat 4 times
do
plot x 0 y 0
logo is pressed
Types of Blocks and Categories of Blocks are different. For example, Basic Blocks encompass stack and cap blocks.
ROBOTS GOT TALENTS

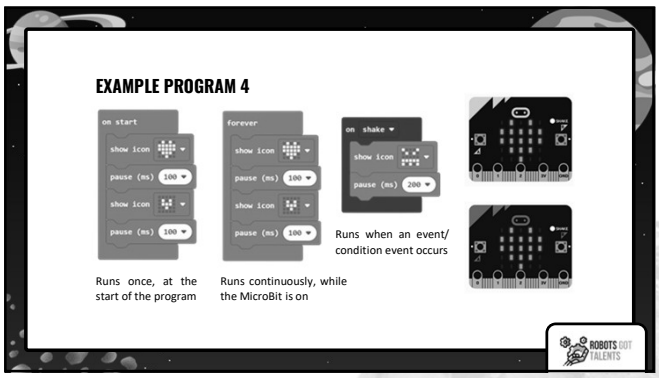
28


BASIC BLOCKS
forever
on start
pause (ms) 100
show arrow North
Forever Block: Runs the program placed in the C block forever - Keep running part of a program in the background.
On start Block: An event that runs when the program starts. The blocks placed in it runs when the program starts.
Pause (ms) Block: Delays the program for the specified number of milliseconds (1000 ms = 1 s).
Show Arrow Block: Displays an arrow on the screen based on the direction selected.
ROBOTS GOT TALENTS

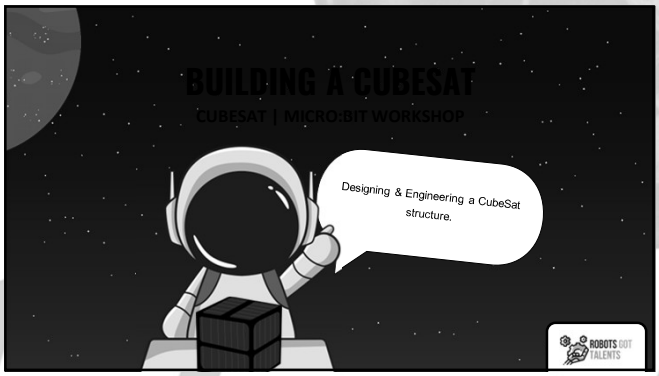
29


show number 0
show leds
show icon
show string Hello!
clear screen
Show Number Block: Displays a number on the LED matrix.
Show LEDs Block: Displays the drawn/ created pattern on the LED matrix.
Show Icon Block: Displays an icon on the LED matrix.
Show String Block: Displays a string "text" on the LED matrix.
Clear Screen Block: Clears the LED matrix.
ROBOTS GOT TALENTS

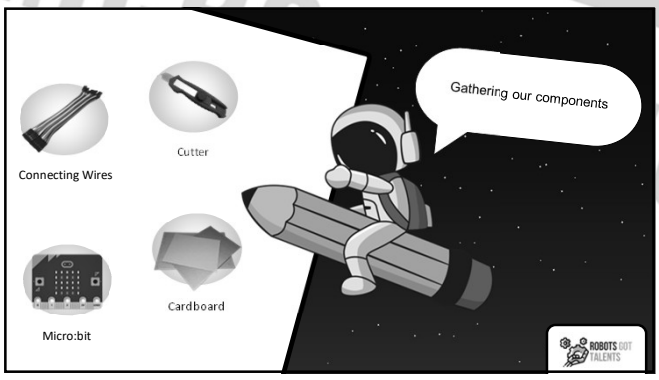
30


EXAMPLE PROGRAM 4
on start
show icon
pause (ms) 100
show icon
pause (ms) 100
forever
show icon
pause (ms) 100
show icon
pause (ms) 100
on shake
show icon
pause (ms) 200
Runs once, at the start of the program
Runs continuously, while the MicroBit is on
Runs when an event/ condition event occurs
ROBOTS GOT TALENTS

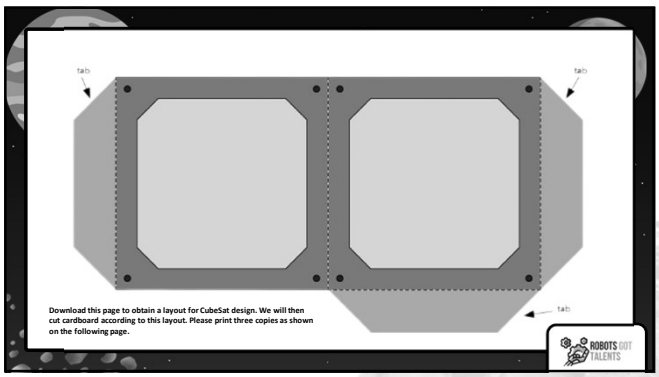
31


BUILDING A CUBESAT
CUBESAT | MICRO:BIT WORKSHOP
Designing & Engineering a CubeSat structure.
ROBOTS GOT TALENTS

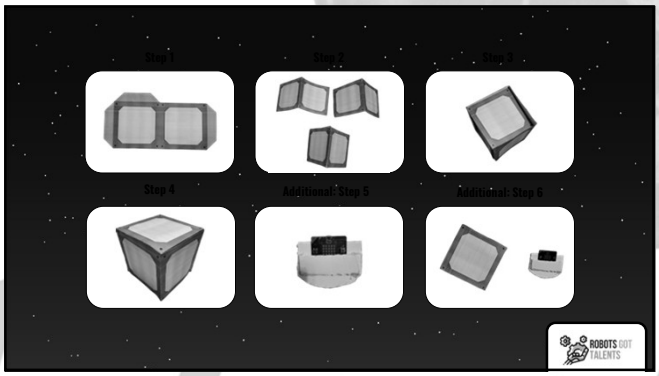
32


Connecting Wires
Cutter
Micro:bit
Cardboard
Gathering our components
ROBOTS GOT TALENTS

33


tab
tab
tab
Download this page to obtain a layout for CubeSat design. We will then cut cardboard according to this layout. Please print three copies as shown on the following page.

34


Step 1
Step 2
Step 3
Step 4
Additional: Step 5
Additional: Step 6

35


LESSON THREE

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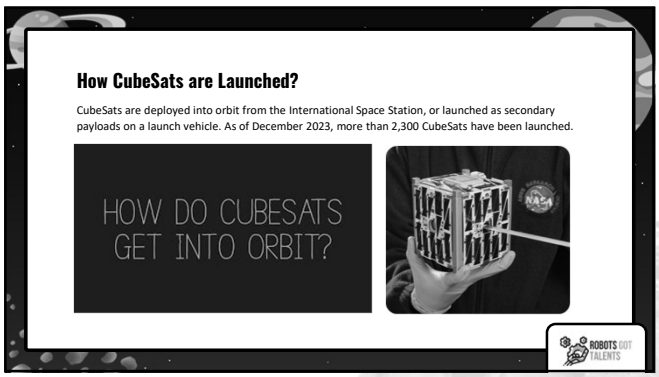
How CubeSats are Launched?
CubeSats are deployed into orbit from the International Space Station, or launched as secondary payloads on a launch vehicle. As of December 2023, more than 2,300 CubeSats have been launched.
HOW DO CUBESATS GET INTO ORBIT?
ROBOTS GOT TALENTS

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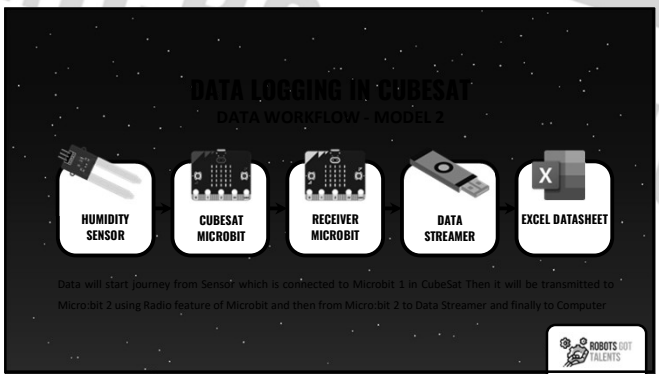
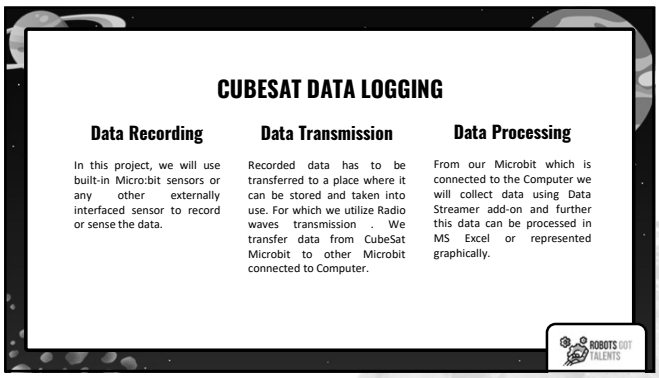
DATA LOGGING IN CUBESAT
DATA WORKFLOW - MODEL 1
TEMPERATURE SENSOR
CUBESAT MICROBIT
RECEIVER MICROBIT
DATA LOGGER
EXCEL DATASHEET
Data will start journey from the temperature sensor on Microbit 1 in CubeSat Then it will be transmitted to Micro:bit 2 using Radio communication and then from Micro:bit 2 to Data Streamer and finally to Computer
ROBOTS GOT TALENTS

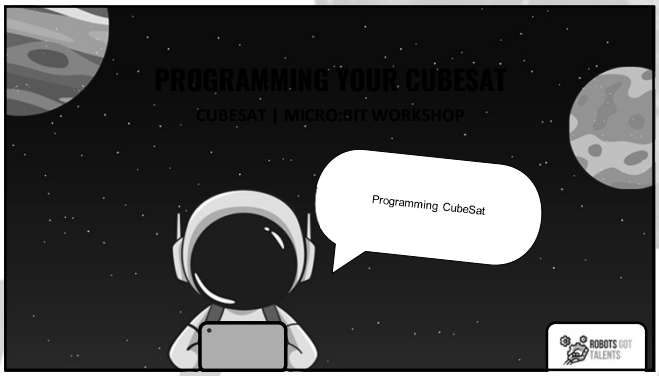
38


DATA LOGGING IN CUBESAT
DATA WORKFLOW - MODEL 2
HUMIDITY SENSOR
CUBESAT MICROBIT
RECEIVER MICROBIT
DATA STREAMER
EXCEL DATASHEET
Data will start journey from Sensor which is connected to Microbit 1 in CubeSat Then it will be transmitted to Micro:bit 2 using Radio feature of Microbit and then from Micro:bit 2 to Data Streamer and finally to Computer
ROBOTS GOT TALENTS

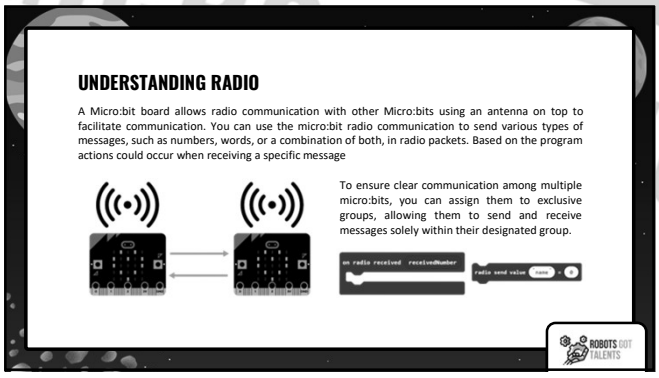
39


CUBESAT DATA LOGGING
Data Recording
In this project, we will use built-in Micro:bit sensors or any other externally interfaced sensor to record or sense the data.
Data Transmission
Recorded data has to be transferred to a place where it can be stored and taken into use. For which we utilize Radio waves transmission . We transfer data from CubeSat Microbit to other Microbit connected to Computer.
Data Processing
From our Microbit which is connected to the Computer we will collect data using Data Streamer add-on and further this data can be processed in MS Excel or represented graphically.

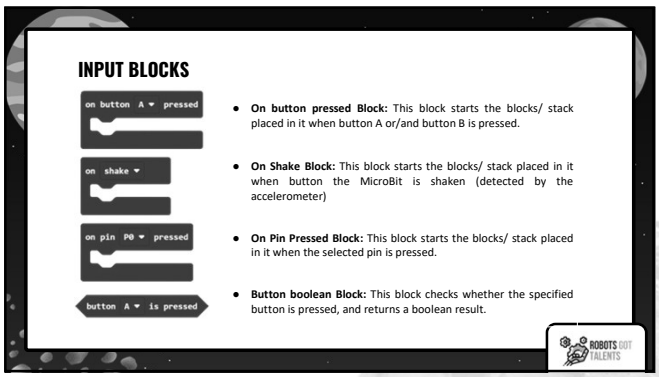
40


PROGRAMMING YOUR CUBESAT
CUBESAT | MICRO:BIT WORKSHOP
Programming CubeSat

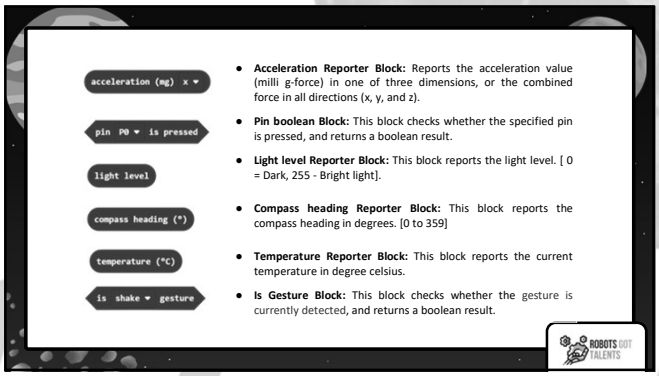
41


UNDERSTANDING RADIO
A Micro:bit board allows radio communication with other Micro:bits using an antenna on top to facilitate communication. You can use the micro:bit radio communication to send various types of messages, such as numbers, words, or a combination of both, in radio packets. Based on the program actions could occur when receiving a specific message
To ensure clear communication among multiple micro:bits, you can assign them to exclusive groups, allowing them to send and receive messages solely within their designated group.

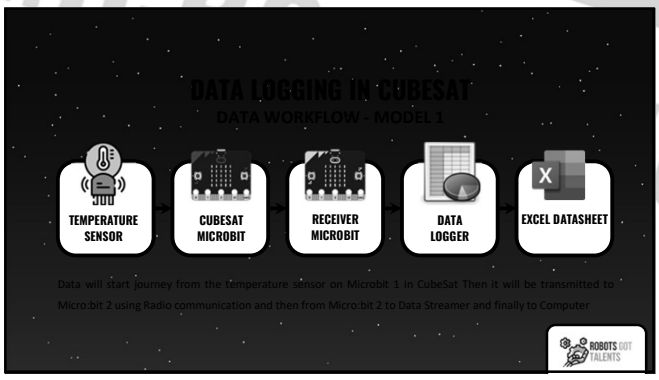
42


INPUT BLOCKS
on button A pressed
on shake
on pin P0 pressed
button A is pressed
On button pressed Block: This block starts the blocks/ stack placed in it when button A or/and button B is pressed.
On Shake Block: This block starts the blocks/ stack placed in it when button the MicroBit is shaken (detected by the accelerometer)
On Pin Pressed Block: This block starts the blocks/ stack placed in it when the selected pin is pressed.
Button boolean Block: This block checks whether the specified button is pressed, and returns a boolean result.

43


acceleration (mg) x
pin P0 is pressed
light level
compass heading (°)
temperature (°C)
is shake gesture
Acceleration Reporter Block: Reports the acceleration value (milli g-force) in one of three dimensions, or the combined force in all directions (x, y, and z).
Pin boolean Block: This block checks whether the specified pin is pressed, and returns a boolean result.
Light level Reporter Block: This block reports the light level. [0 = Dark, 255 - Bright light].
Compass heading Reporter Block: This block reports the compass heading in degrees. [0 to 359]
Temperature Reporter Block: This block reports the current temperature in degree celsius.
Is Gesture Block: This block checks whether the gesture is currently detected, and returns a boolean result.

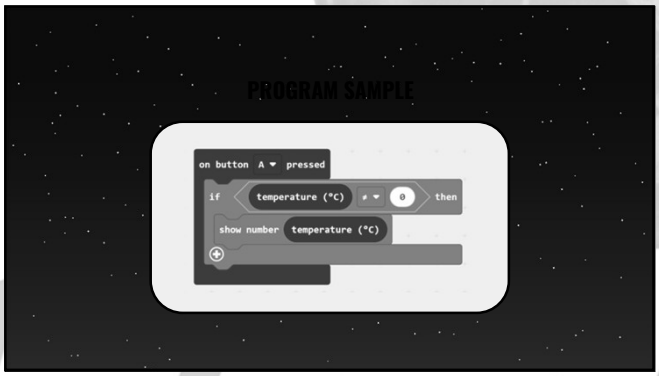
44


DATA LOGGING IN CUBESAT
DATA WORKFLOW - MODEL 1
TEMPERATURE SENSOR
CUBESAT MICROBIT
RECEIVER MICROBIT
DATA LOGGER
EXCEL DATASHEET
Data will start journey from the temperature sensor on Microbit 1 in CubeSat Then it will be transmitted to Micro:bit 2 using Radio communication and then from Micro:bit 2 to Data Streamer and finally to Computer

45


RECORDING & DISPLAYING DATA
Create a program that reads the ambient temperature. When button A is pressed, if the temperature is greater than 0°C, display the temperature in degrees Celsius on an LED matrix.

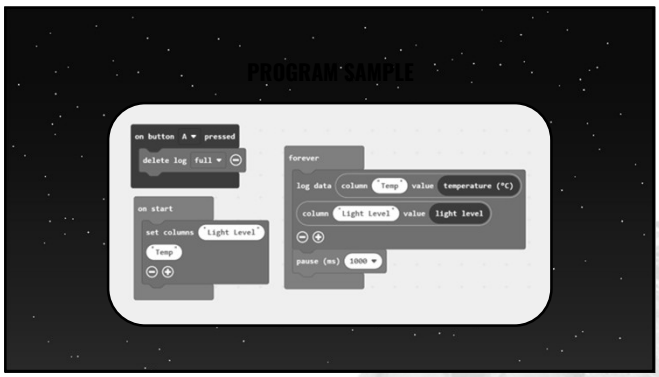
46


PROGRAM SAMPLE
on button A pressed
if temperature (°C) ≠ 0 then
show number temperature (°C)

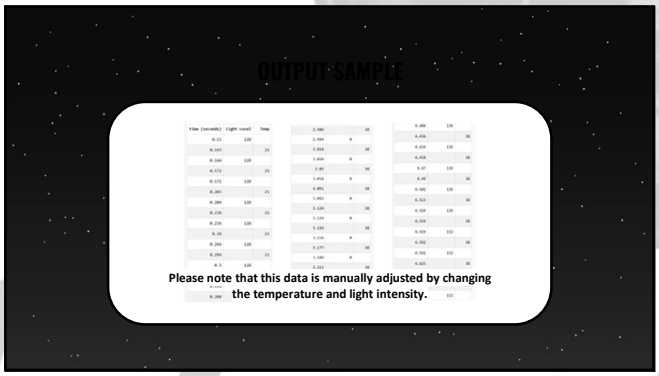
47


READING AND SAVING DATA
Use the data logger extension to create a table with columns for temperature and light level. Values should be updated using the built-in sensors on the micro:bit every second, and when button A is pressed, the data should be deleted.

48


PROGRAM SAMPLE
on button A pressed
delete log full
on start
set columns Light Level
Temp
forever
log data column Temp value temperature (°C)
column Light Level value light level
pause (ms) 1000

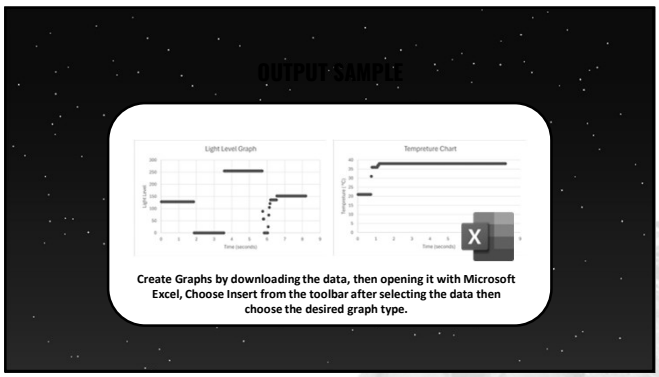
49


OUTPUT SAMPLE
Please note that this data is manually adjusted by changing the temperature and light intensity.

50


OUTPUT SAMPLE

51


OUTPUT SAMPLE
Light Level Graph
Tempreture Chart
Create Graphs by downloading the data, then opening it with Microsoft Excel, Choose Insert from the toolbar after selecting the data then choose the desired graph type.

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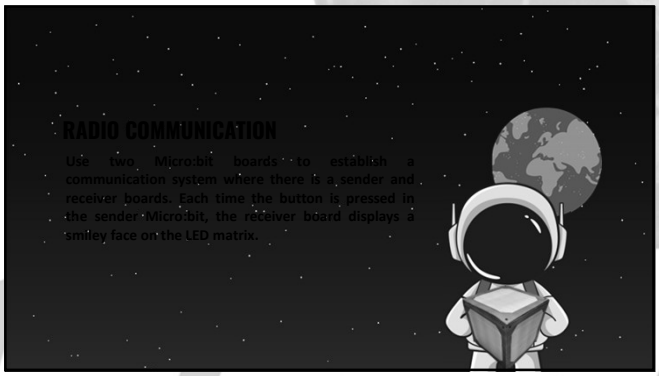
RADIO COMMUNICATION
Use two Micro:bit boards to establish a communication system where there is a sender and receiver boards. Each time the button is pressed in the sender Micro:bit, the receiver board displays a smiley face on the LED matrix.

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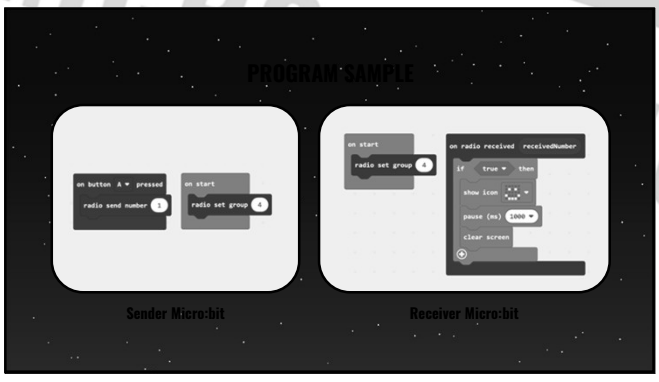
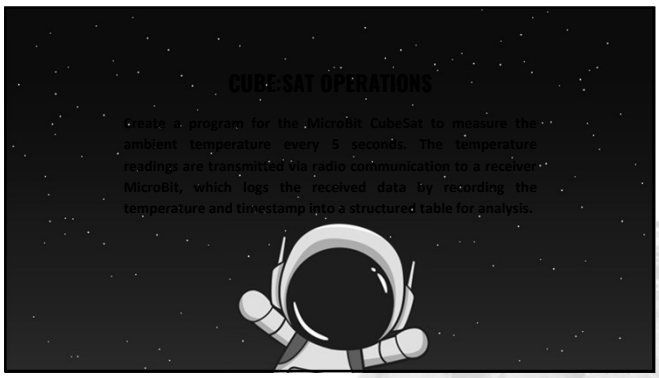

PROGRAM SAMPLE
on button A pressed
radio send number 1
on start
radio set group 4
Sender Micro:bit
on start
radio set group 4
on radio received receivedNumber
if true then
show icon
pause (ms) 1000
clear screen
Receiver Micro:bit

54


CUBE:SAT OPERATIONS
Create a program for the MicroBit CubeSat to measure the ambient temperature every 5 seconds. The temperature readings are transmitted via radio communication to a receiver MicroBit, which logs the received data by recording the temperature and timestamp into a structured table for analysis.

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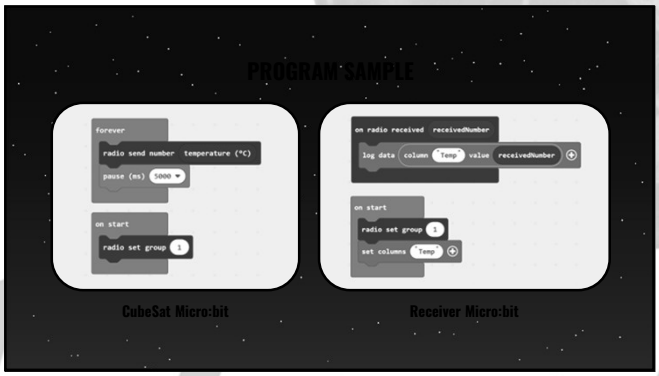
PROGRAM SAMPLE
forever
radio send number temperature (°C)
pause (ms) 5000
on start
radio set group 1
CubeSat Micro:bit
on radio received receivedNumber
log data column "Temp" value receivedNumber
on start
radio set group 1
set columns "Temp"
Receiver Micro:bit

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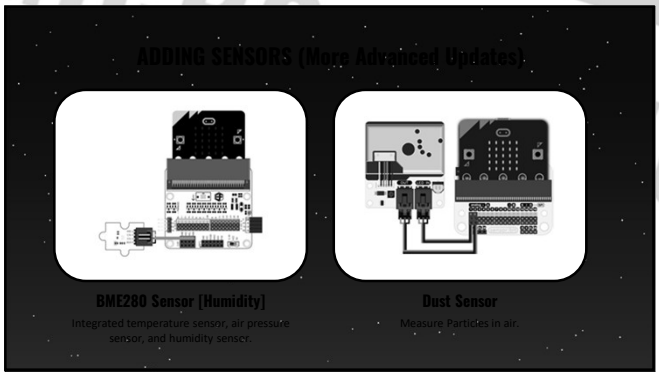
ADDING SENSORS (More Advanced Updates)
BME280 Sensor [Humidity]
Integrated temperature sensor, air pressure sensor, and humidity senscr.
Dust Sensor
Measure Particles in air.

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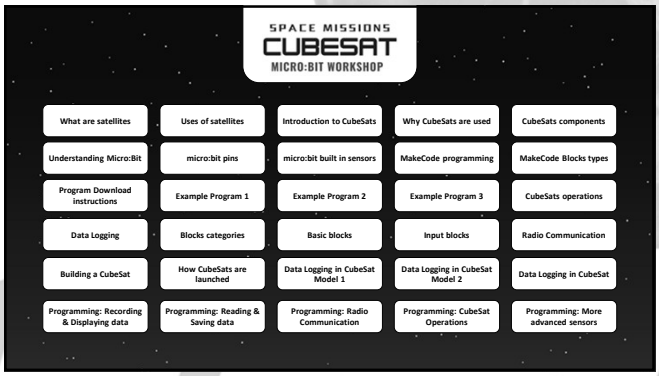

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