



MR BIT 'MAKER' PROJECTS AND 2D MODELS

Kitronik Version

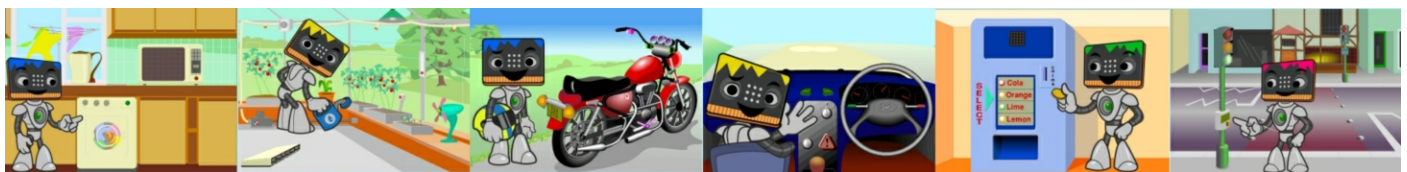
Mr Bit 'Maker' projects are designed to work with the **BBC micro:bit** in a practical way: you control real models containing sensors and devices which are connected to the micro:bit. Each project involves building a simple 2-dimensional model and creating a control system.

Connections to the micro:bit may be made in several different ways:

1. Directly to the micro:bit (allowing a maximum of three inputs or outputs).
2. Via the *Kitronik* 'Edge Connector Breakout Board' (providing access to all pins using jumper wires).
3. Via the *Kitronik* 'Terminal Block Breakout Board' (wire screw connections to all pins).
4. Via the *Kitronik* 'Simple Servo Control Board' (battery powered outlets for 3 servos and 4 devices).

The sensors (push buttons, switches, temperature sensors etc.) and devices (LEDs, buzzers, motors etc.) may be mounted on an A4 size board displaying the Mr Bit scenario from the *Scene* view, thus creating a 2-dimensional working model. These notes describe ten such models which can be made from inexpensive materials and components. The models are:

- | | | | | |
|--------------------|------------------|-------------------|---------------------|-------------------|
| 1. Dream bedroom | 3. Motorbike | 5. Drinks machine | 7. Greenhouse | 9. Petrol Station |
| 2. Kitchen gadgets | 4. Car dashboard | 6. Heating system | 8. Pelican crossing | 10. Car park |



The software resources in the 'Projects' section of the *Mr Bit* app offer two sets of tasks for each scenario:

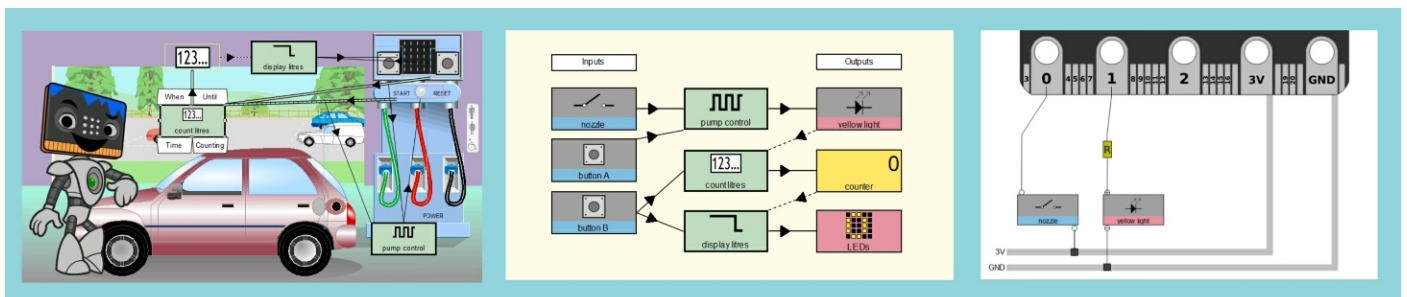
'controls' tasks are designed for the virtual world of the *Scene* view. They give practice at analysing problems and designing control solutions and are useful preparation for the 'maker' tasks.

'maker' tasks are designed for controlling Mr Bit models connected to the micro:bit. They give explicit directions about the physical connection of the components to the micro:bit.

Programming Methodology

Although the *Scene* views are designed to be motivating and semi-realistic, it is usually much easier to design systems and program the modules in the *System* view. The block presentation of the components makes it easier to follow the dependencies and flow of information. Also, the larger and uniform size of the blocks makes all the adjustments easier, especially on a touch screen. Selecting the 'Fit' setting on the toolbar ensures the optimum zoom scaling which automatically adjusts as blocks are moved or the number of them is increased. Thus it is recommended:

1. Build and program the control systems in the *System* view.
2. Then return to the *Scene* view and adjust the positions of the modules to create a tidy arrangement with the minimum of crossing links.



Scene view

System view

Connections view

Constructing Mr Bit models

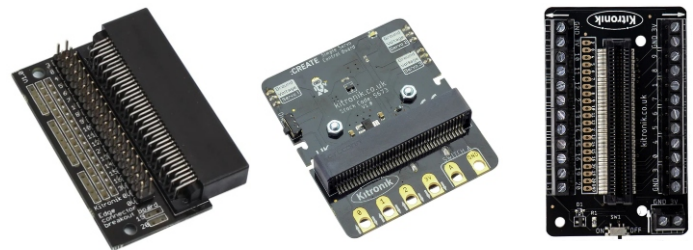
The building of 2-dimensional models offers several advantages over 3D models:

1. They may be constructed using cheap readily available materials including stiff cardboard.
2. Being simple, they may be constructed quite quickly and demand only minimal skill.
3. They occupy minimal space, so are easily stored.

Accompanying these notes is an appendix containing templates for Mr Bit background pictures for models constructed on A4 card. These emulate the *Scene* view pictures for the projects supplied in the app.

Connections

The most interesting models demand more inputs and outputs than the three available on the native micro:bit. It is possible to partially implement most of the Mr Bit control systems, but full implementation is guaranteed with the use of the *Kitronik Breakout* and *Control Boards*. In each case the micro:bit is inserted into an edge connector mounted on the board.



Components

A typical components kit required for implementing Mr Bit maker projects consists of:

- *Digital sensors*: push button, toggle switch, micro switch, reed switch with magnet, touch sensor
- *Analogue sensors*: thermistor (for temperature), LDR for light level, potentiometer, moisture
- *Digital and analogue devices*: LEDs, lamps, buzzers, motors, piezo sounder, speaker.

See the Appendix to these notes for a detailed list of recommended components.

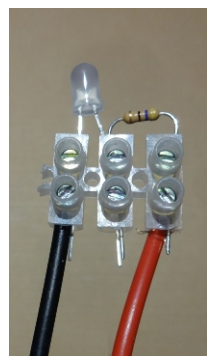
Light-emitting-diodes (LEDs)

Liberal use of LEDs are made in the Projects. Their low current consumption makes them well suited as outputs to the micro:bit, offering an advantage over torch bulbs which demand sources of higher current. Traditionally interfaces and buffer boxes are used for this purpose. The projects frequently use LEDs as symbolic substitutes for a number of more sophisticated or expensive devices, such as relays, heaters, solenoids and so on. For example, an electric convection heater may be represented by a row of red LEDs, avoiding real elements and motorised fans.

There are two precautions which should be observed when using LEDs:

1. Each LED requires a resistor in series to limit the forward current to a safe value. (Working at 3 volts, a 47 ohm resistor is suitable for most LEDs.)
2. The polarity of the connections should be observed. (Reverse connection will not damage the LED, but it will not light up, giving the impression that it is not working; it is simply doing the job of a diode to conduct in one direction only.)

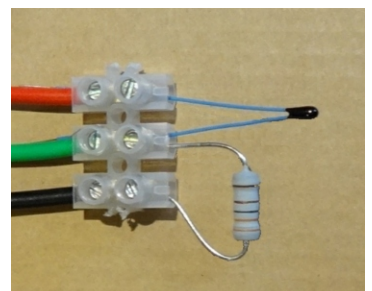
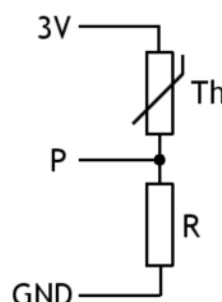
A convenient method of mounting an LED in series with the resistor, avoiding circuit boards and soldering, is to use a small terminal block containing screw fixings.



Temperature and light sensors:

Normally these sensors are combined with a resistor in series to create a *potential divider* circuit. When the full 3 volts is connected across the combination, the voltage across the resistor varies as the temperature or light level changes, and this may be used as an input signal.

For temperature, a suitable sensor is the *thermistor* whose resistance reduces as its temperature increases. For light, a *light dependent resistor* (LDR) is suitable. In both cases the circuit is the same:





DREAM BEDROOM

Maker projects:

1. Control main room light by opening and closing a door and with a push button by the bed.
2. Control an electric heater with a temperature sensor.
(The heater is implemented with red LEDs in parallel.)
3. Control an electric fan with a temperature sensor.
(The fan is implemented with a small electric motor.)

Programming elements

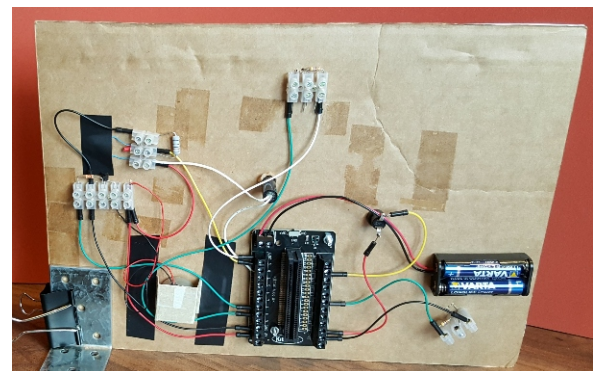
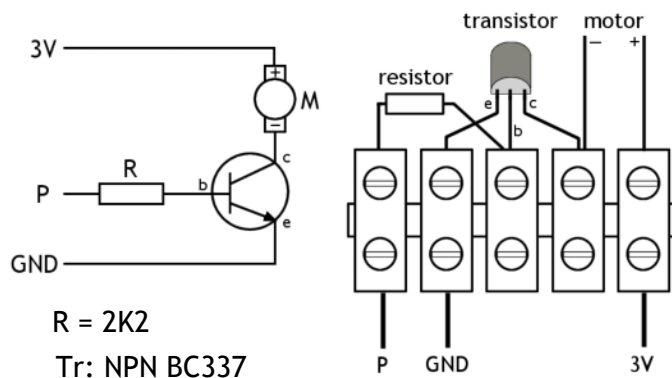
- Simple on/off control systems using both sensor *states* and change *events* as conditions for program instructions.
- The difference between *state* and *event* conditions is employed.
- Condition settings involve the evaluation of values returned by analogue sensors; greater than, less than, etc.

Components

- Door: Magnet and reed switch
- Wall button: Push button
- Temperature sensor: Thermistor + resistor (3K3 ohm)
- Ceiling light: White LED
- Heater: 3 Red LEDs with resistor (47R ohm)
- Fan: Motor with resistor and transistor

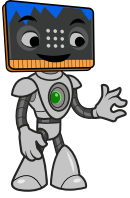
Construction

- The door is a cardboard flap with a magnet as the handle. The reed switch sensor is inserted in the board behind the door.
- The thermistor (10K NTC) needs a resistor (3K3 1%). Using the recommended components, the reading is of optimal accuracy at 25°C.
- The motor requires a small circuit containing a resistor and transistor as shown:



Connections are made to the *Kitronik Terminal Breakout Board*.

See the *Connections* view for full details of the allocation of components to the available pins/sockets.



KITCHEN GADGETS

Maker projects

1. Simple washing machine: Control the rotation of clothes in a washing machine, dependent on closing the machine door and pressing the start button. The rotation is accompanied by a lit LED.
2. Advanced washing machine: Simulate a washing cycle and spin dry by programming forward and reverse rotations. A buzzer sounds when the cycle is complete.
3. Microwave cooker: The oven is simulated by a white LED which illuminates the interior. The time for cooking is specified by the number of presses of a button.

Programming elements

Washing machine:

- Simple on/off control systems involving AND/OR conditions from two sensor *states* and *events*.
- Using the state of an output device (buzzer) as an input condition.
- Building a sequence of motor actions (forward and reverse) to simulate a wash/spin cycle for a washing machine.
- Use of *Repeat* module.

Microwave cooker:

- Use *Counter* module to count button presses.
- Using *Timer* to measure time and compare this with a counter value.
- Use *Pulse* control to bleep a buzzer.

Components

- button (start/stop)
- magnet & reed switch (door)
- button (microwave)
- green LED
- servo motor (washing)
- white LED (microwave cooker)

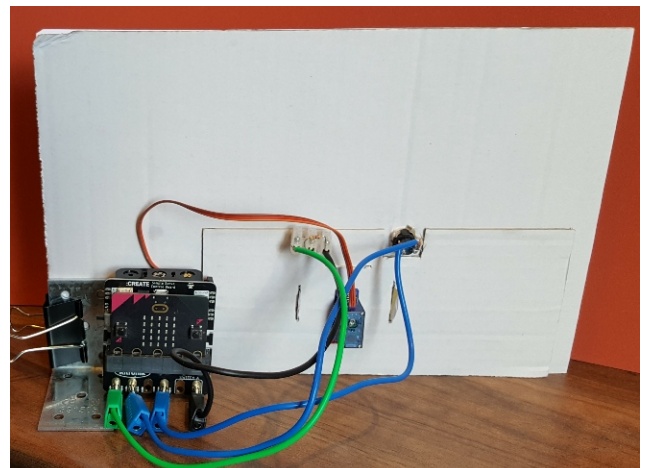
Need *Kitronik Simple Servo Control Board* for motor.



Construction - Washing machine

- The push button and LED are mounted in the washing machine.
- The 'washing' consists of a rotating cardboard disc attached to a rotational servo motor behind the scene board. Connections are made to the *Kitronik Simple Servo Control Board*.
- The washing machine door is a shallow cardboard box with a circular hole in the front and attached with masking tape at the side. A small magnet is attached to the door and closure is detected by a reed switch mounted behind the scene.

The microwave oven is illuminated from behind by a white LED. A rectangular hole in the cardboard can provide translucency.





MOTORBIKE

Maker projects

1. Control the brake light using a microswitch behaving as the brake pedal.
2. Control the horn (a buzzer) by pressing a button.
3. Flash the left and right turn indicator lights with buttons on the handlebars.

Programming elements

- Simple on/off control systems using sensor *states* as conditions.
- Use of a *Pulse* control module for flashing lights.

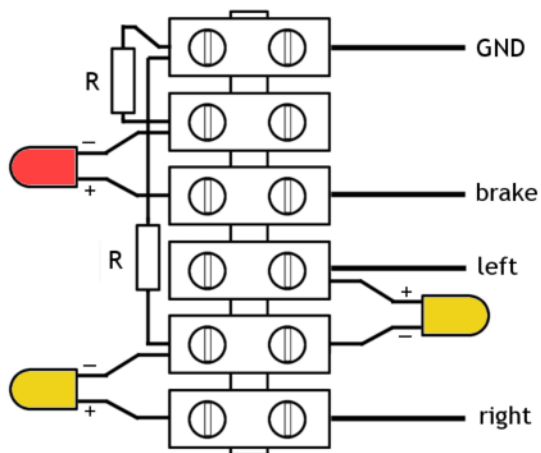
Components

- Brake pedal: micro switch
- Horn button: push button
- Left button: push button
- Right button: push button
- Brake light: red LED
- Indicator lights: 2 yellow LEDs
- Horn: buzzer
- Resistors for LEDs

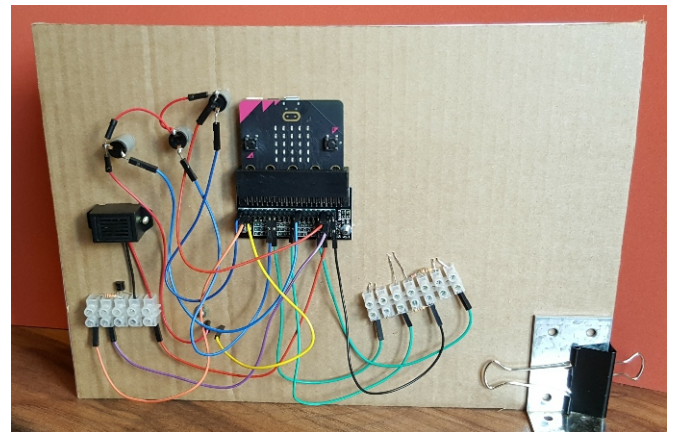
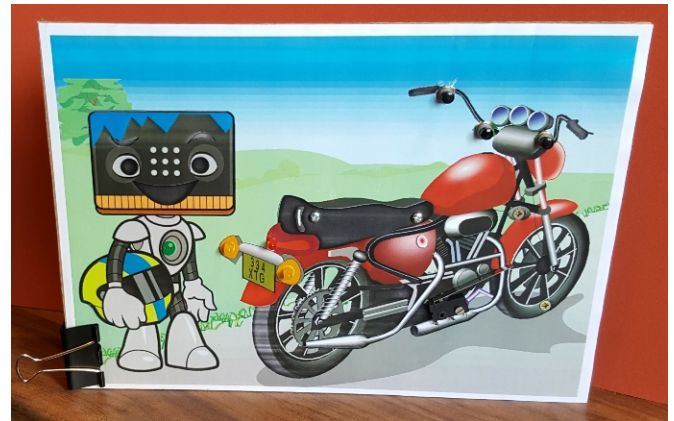
Connections are made with jumper leads to the *Kitronik Edge Connector Breakout Board*.

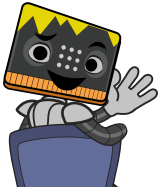
Construction

- The LEDs are mounted on the front with their wires poked through pinholes in the scene board. They are secured behind by a 6-stage terminal block which also contains the current limiting resistors, as shown:



- The microswitch is mounted in the brake pedal position with connecting leads fed through holes in the scene board.





CAR DASHBOARD

Maker projects

1. Flash the left and right turn indicator lights using buttons on the steering column.
2. Control both indicator lights with a 'hazard' switch. Control the horn (a buzzer) by pressing a button.
3. Control the headlights with a switch. Add an alarm system which flashes the headlights and pulses the horn intermittently.

Programming elements

- Simple on/off control systems using sensor *states* and change *events* as conditions.
- AND/OR conditions involving signals from two sensors.
- Use of a *Pulse* control module for flashing lights.

Components

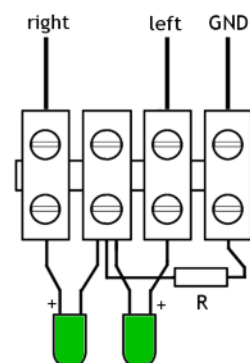
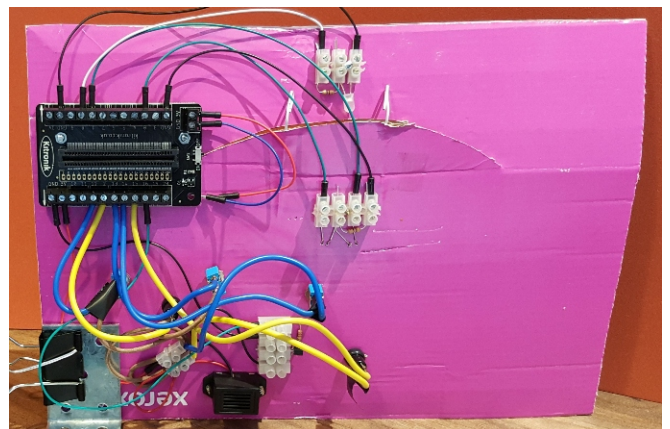
- Left indicator: push button
- Right indicator: push button
- Headlights switch: toggle switch
- Hazard switch: toggle switch
- Alarm: micro:bit button A
- Horn button: push button
- Horn: buzzer
- Indicator lights: 2 green LEDs
- Headlight: white LED
- Resistors for LEDs

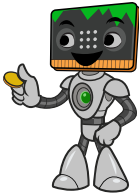


To connect all the components at once, the *Kitronik Terminal Breakout Board* is needed. Alternatively, up to three components at a time may be connected directly to the micro:bit. The micro:bit buttons A and B may also be used.

Construction

- The headlight white LED is mounted behind the board. When a suitable slot is made in the cardboard in the windscreen area, the LED can illuminate the road through the open space.
- The buzzer may be mounted anywhere on the rear of the scene board.
- The indicator LEDs are mounted on the front with their wires poked through pinholes in the scene board. They are secured behind by a 4-stage terminal block which also contains a current limiting resistor for both.





DRINKS MACHINE

Maker projects

1. Control the drinks LEDs so that the light up in turn, each time the select button is pressed.
2. Show a message on the LEDs: "Select your drink". Change the message to "Insert 3 coins" when the select button is pressed.
3. Build a system to count the number of coins inserted. Switch on the delivery LED after the third coin is inserted.

Programming elements

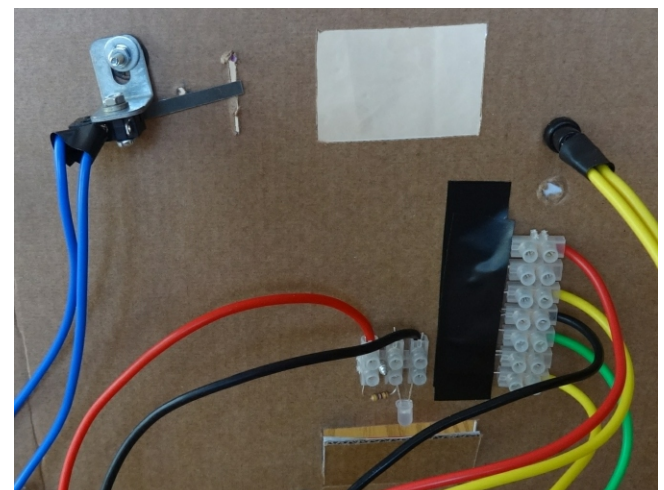
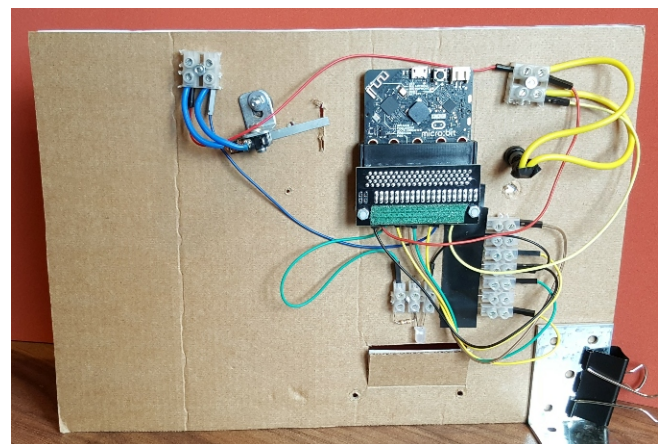
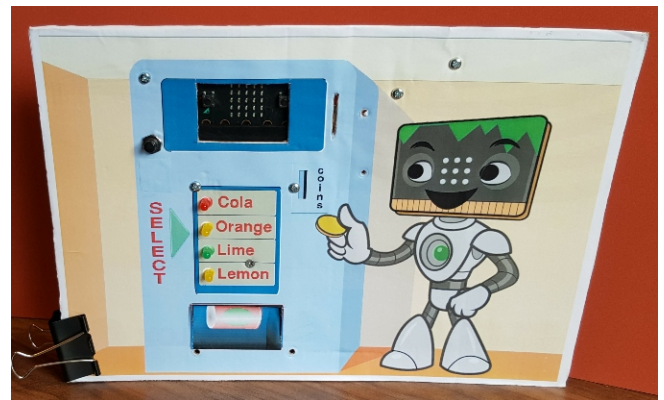
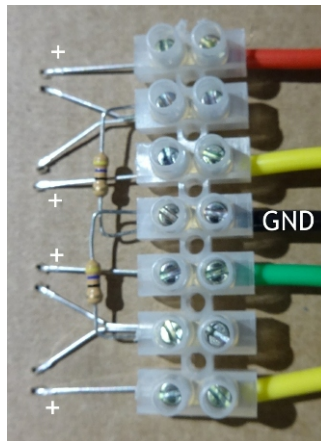
- Simple on/off control systems using sensor *states* and change *events* as conditions.
- Switch on a series of lights in a sequence.
- Create a sequence of messages for the LEDs.
- Use of a *Counter* module for counting number of coins inserted.

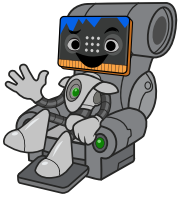
Components

- 'Select' button: push button
- Coin slot: microswitch
- Drinks indicators: 4 coloured LEDs
- Delivery slot: white LED
- Messages: micro:bit LEDs
- Resistors (47R) for LEDs

Construction

- The drinks LEDs are mounted on the front with their wires poked through pinholes in the scene board. They are secured behind by a terminal block which also contains the current limiting resistors.
- The white LED for the delivery slot is mounted behind the board. A suitable opening in the cardboard above the delivery slot allows the LED to illuminate the can delivery.
- The microswitch is mounted behind the coin slot so that it is activated each time a coin is pushed through the slot.
- The *Kitronik Edge Connector Breakout Board* is needed to provide sufficient inputs and outputs for the LEDs and sensors. A rectangular hole in the upper part of of the drinks machine is needed to provide a view of the micro:bit LEDs.





HEATING SYSTEM

Maker projects

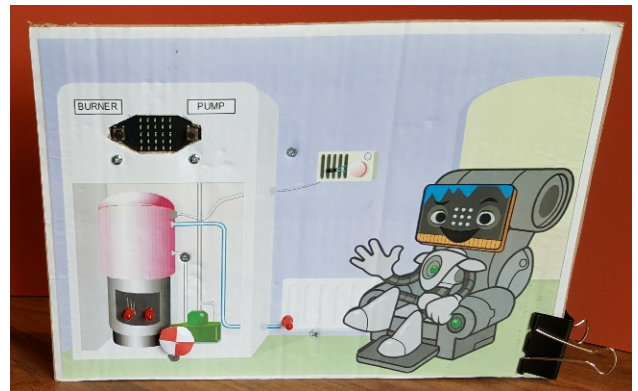
1. Control the boiler burner (simulated with two red LEDs) with button A on the micro:bit.
Switch the burner off when the temperature exceeds 20.
2. Control the pump motor so that it only switches on when the burner is on and pump button is pressed. Show a message on the LEDs "Heating ON".
3. Switch on the radiator (shown by an LED monitor light) when the pump is on.
4. Display room temperature when pumps is off.

Programming elements

- Simple on/off control systems using sensor *states* and change *events* as conditions.
- Use an analogue sensor for a condition setting.
- Display number and string messages on the LEDs display.
- Use AND/OR logic for a condition setting.

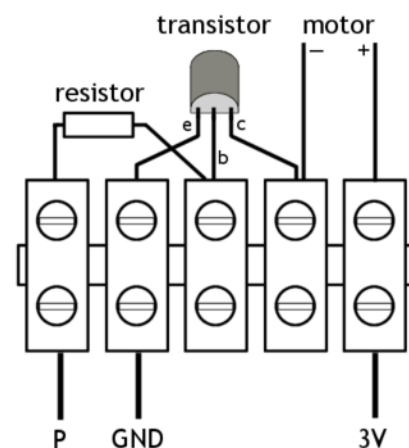
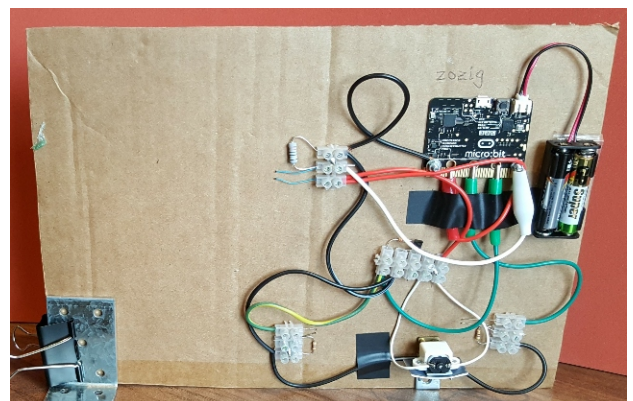
Components

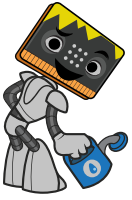
- micro:bit buttons
- temperature sensor: thermistor + resistor
- micro:bit LEDs
- Radiator: red LED
- Burner: 2 red LEDs
- Pump: motor
- Resistors for LEDs (47R ohm)
- Transistor BC337



Construction

- The red LEDs for the burner and radiator are mounted on the front with their wires poked through pinholes in the scene board. They are secured behind by a terminal block which also contains the current limiting resistors. The thermistor for the thermostat is mounted in a similar manner.
- The motor for the pump is mounted behind the scene with the disc fixed to the spindle in front. The motor needs a transistor driver mounted behind the scene.
- An opening in the upper part of the boiler is needed to provide a view of the micro:bit LEDs and access to buttons A and B.
- The micro:bit may be secured on the card with nuts and bolts (size M3) through the P0 and GND socket holes.





GREENHOUSE

Maker projects

1. Control the light using a light level sensor so that the light goes on in the dark.
2. Use a moisture sensor to switch on a water pump when it gets too dry.
3. Control an electric fan using a temperature sensor.

Programming elements

The systems here illustrate two methods of using an analogue sensor signal to control an output device:

1. The *light control* and *moisture control* make a simple high/low decision using the threshold value; when the light or moisture value falls below the threshold, the sensor signal is defined as 'low'; for values above the threshold the signal is 'high'.
2. The *temperature control* defines the start condition by comparing the sensor value with a chosen temperature (30) but the fan is not switched off until the temperature drops below 25. Using this method allows you to specify a range of temperatures within which variation is allowed in the greenhouse.

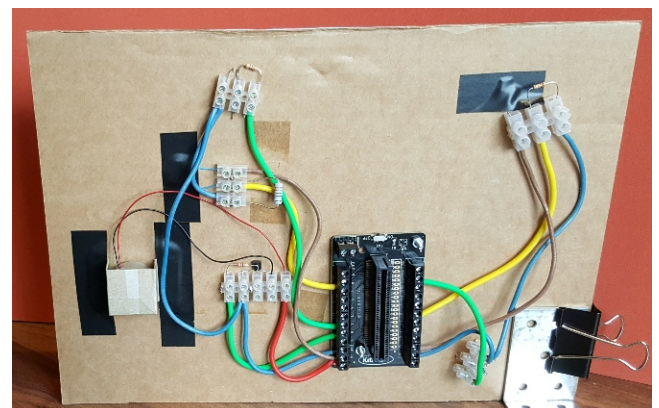
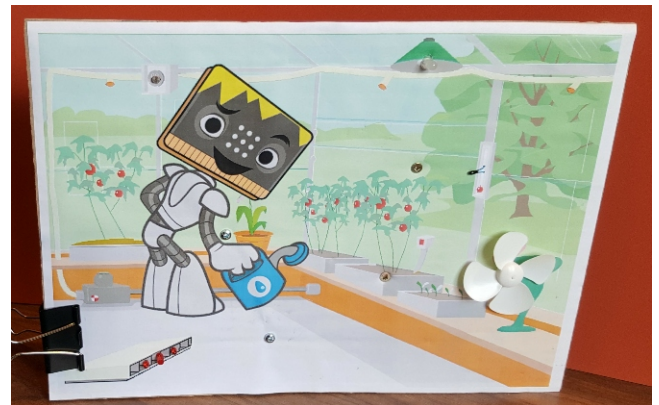
Additional activities

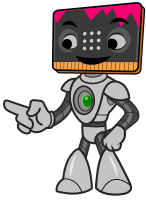
We may wish to prevent the water pump from switching on when the fan is running. This may be achieved by modifying the WHEN and UNTIL settings to work with two signals:
“When the temperature is warmer than 30 and the fan is off, switch on the pump until it is cooler than 25 or the fan is on.”

Construction

- The white LED for the overhead light and red LEDs for the heater are mounted on the front with their wires poked through pinholes in the scene board. They are secured behind by a terminal block which also contains the current limiting resistors. The LDR for light measurement and the thermistor for temperature measurement are mounted in a similar manner.
- The motor for the fan is mounted behind the scene with the blades fixed to the spindle in front. The motor needs a transistor driver mounted behind the scene.
- The water pump and moisture sensor are supplied in the *Kitronik Smart Greenhouse Kit* and may be employed to monitor and water a real plant in a suitable pot.
- The heater is represented by three red LEDs arranged in parallel and clamped from behind the scene board in a 3-stage terminal block.

Connections are made to the *Kitronik Terminal Block Breakout Board*.





PELICAN CROSSING

Maker projects

1. Create the traffic lights sequence for a Pelican crossing. The sequence for crossing begins when the button is pressed.
2. Add pedestrian lights to indicate 'wait' (red LED) or 'cross' (green LED).
3. Add a pulsing buzzer when the 'cross now' light is on.

Extension activities: embellish with flashing crossing lights and floodlights in dark. etc.

Programming elements

- Create a sequence of timed instructions to switch LEDs on and off.
- Use event condition with push button
- Use ON/OFF state of one LED as a condition to control other LEDs.

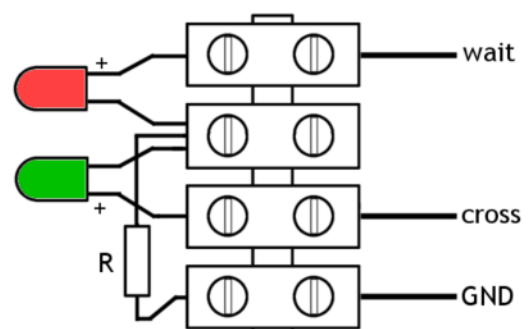
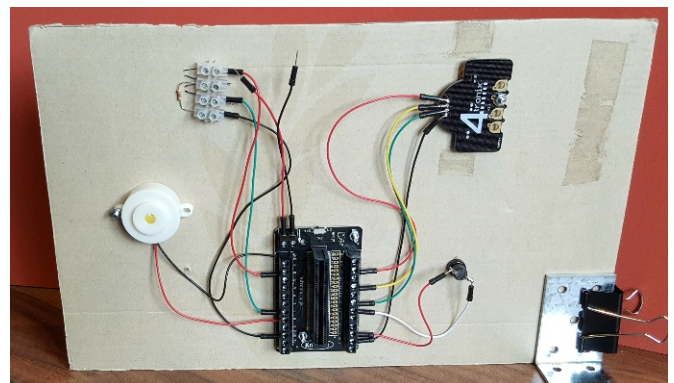
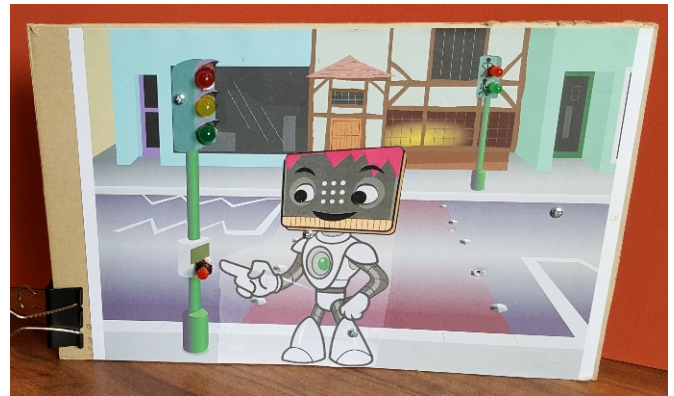
Components

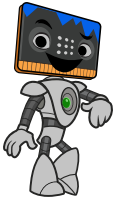
- push button
- large red LED
- large yellow LED
- large green LED
- Pedestrian light: red LED
- Pedestrian light: green LED
- Beeper: Buzzer (with drive)
- Resistors for LEDs (47R ohm).

Construction

- The push button is mounted as shown and the buzzer may be mounted on the opposite lightpost.
- The buzzer may be placed anywhere on the back of the scene board.
- The LEDs for the traffic and crossing lights are mounted on the front with their wires poked through pinholes in the scene board. They are secured behind by a terminal block which also contains the current limiting resistors. The arrangement for the crossing lights is shown here. A convenient traffic light LED array mounted on a purpose designed board is available. (See the list of recommended components in the appendix for details.)

Connections are made to the *Kitronik Terminal Block Breakout Board*.





PETROL STATION

Maker projects

1. Switch on the petrol pump when the nozzle is in the filler tube: a 4mm plug and socket simulate the nozzle and filler tube; a flashing LED and micro:bit animation simulate the working pump.
2. Count the number of LED flashes to simulate the number of litres delivered and display the number on the micro:bit LEDs.
3. Calculate and display the cost of the petrol delivered.

Programming elements

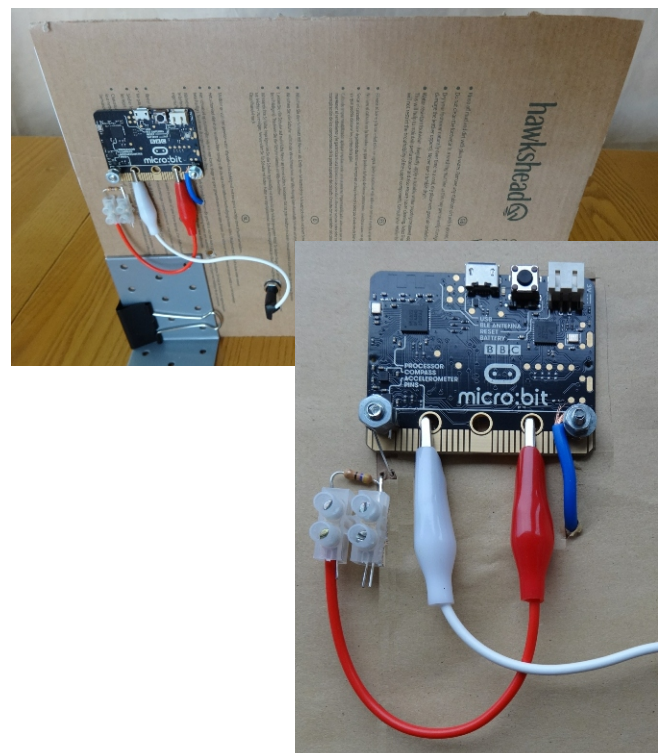
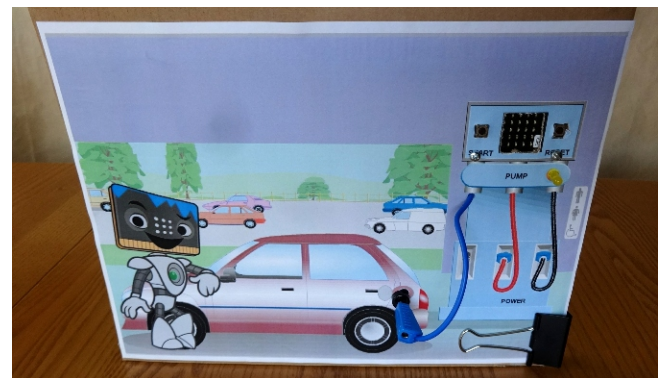
- Simple on/off control systems using sensor *states* and change *events* as conditions.
- Use a *Pulse* control module to flash a light.
- Use the LEDs display to show an animation and number variables.
- Use a *Counter* module to count light flashes.
- Use a *Calculation* module.

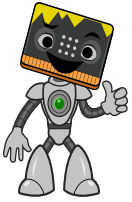
Components

- Nozzle and fill tube: Plug and socket
- micro:bit buttons and LEDs
- yellow LED + resistor (47R ohm)

Construction

- The yellow LED for the petrol flow monitor is mounted on the front with its wires poked through pinholes in the scene board. It is secured behind by a terminal block which also contains the current limiting resistor.
- The filler tube is A 4mm socket and a 4mm plug on lead provide the nozzle and petrol pipe.
- A rectangular hole in the petrol pump housing provides access to the micro:bit mounted behind the scene. Two smaller holes are needed to give access to buttons A and B. The micro:bit may be secured on the card with nuts and bolts (size M3) through the P0 and GND socket holes.





CAR PARK

Maker projects

1. Raise the entry barrier when the button is pressed: the barrier is a drinking straw attached to a position servo.
2. Raise the exit barrier when the exit sensor is touched: the exit sensor is a touch sensor consisting of two metal bolts fixed 1 cm apart.
3. Control the traffic lights as the entry barrier is raised and lowered: the lights are red and green LEDs.
4. Count the number of times the entry and exit barriers are raised: the entry count is given by the number of button presses and the exit count is obtained from the number of times the exit sensor is touched.
5. Calculate the number of parking spaces free from the entry and exit count values. Display the result on the micro:bit LEDs.

Programming elements

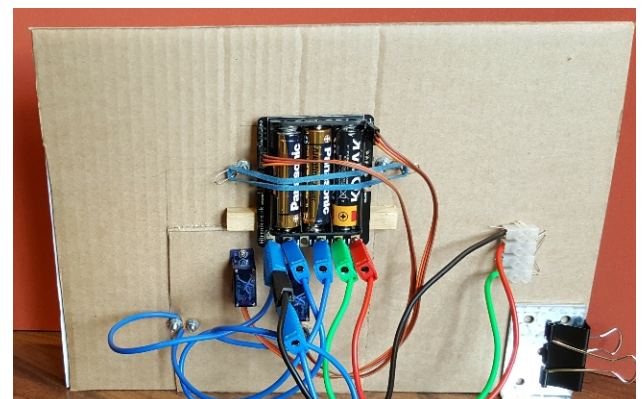
- Simple on/off control systems using sensor *states* and change *events* as conditions.
- Use the LEDs display to show messages and number variables.
- Use a *Counter* module to count entry and exit events.
- Use a *Calculation* module to obtain the number of free spaces.

Components

- 2 position servos
- push button, 2 nuts and bolts (touch sensor)
- Red and green LEDs + resistor (47R ohm)
- Terminal connector strip

Construction

- The barrier arms are attached to two position servos mounted on the back of the card.
- The traffic light LEDs are mounted by poking their wires through pinholes and secured by a 4-stage terminal block, together with a current-limiting resistor, as with the previous Pelican Crossing model.
- The exit sensor is made from two M2 size bolts, mount just below the exit barrier arm. Touching both bolts simultaneously with a moist finger is sufficient to register a 'touch' input signal on the micro:bit.
- Connections are made to the *Kitronik Simple Servo Control Board* with a micro:bit slotted in its edge connector. The unit is mounted behind the scene resting on a wooden strip and secured by an elastic band. A rectangular hole above the car park entrance provides a view of the micro:bit LEDs.

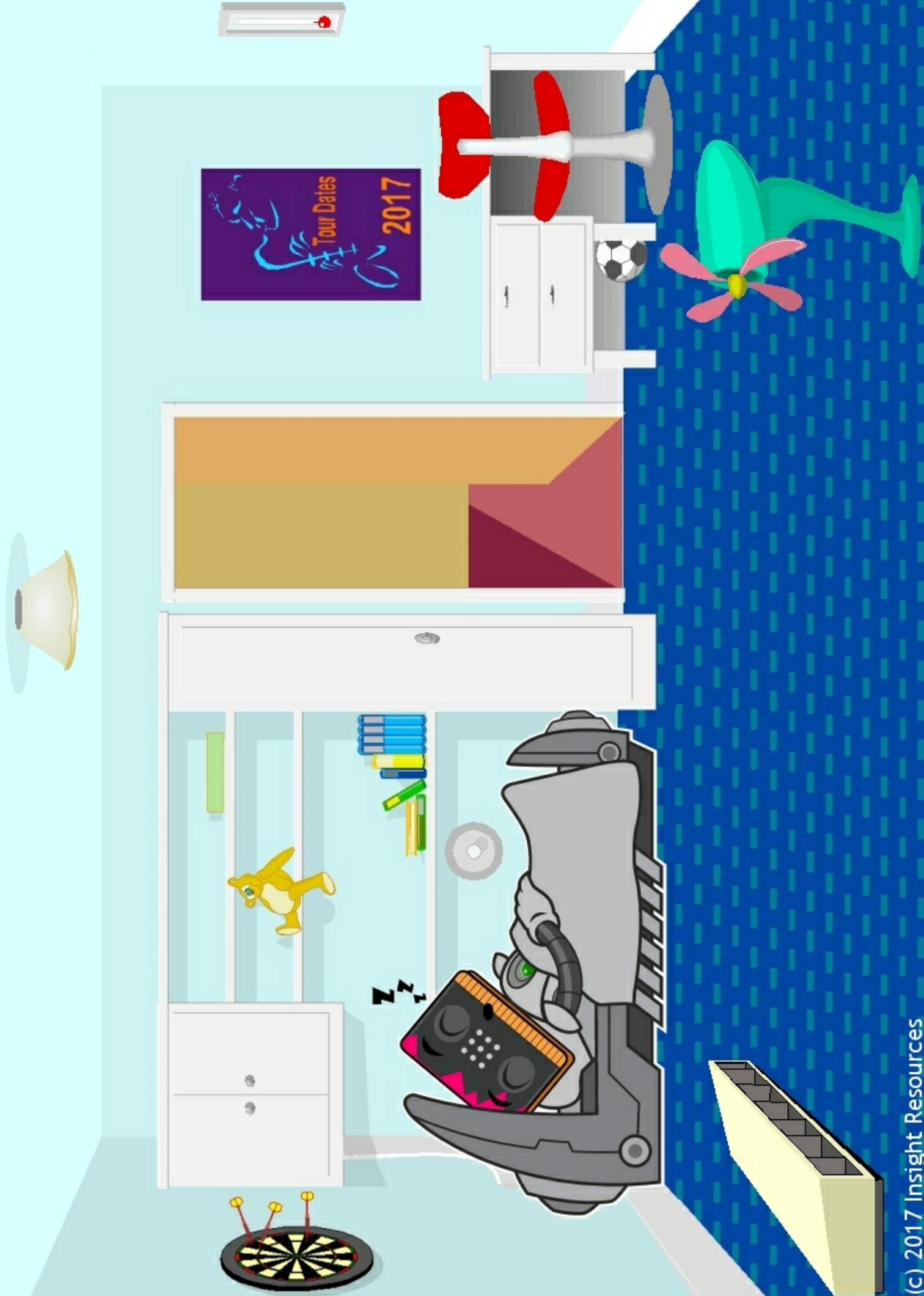




APPENDIX

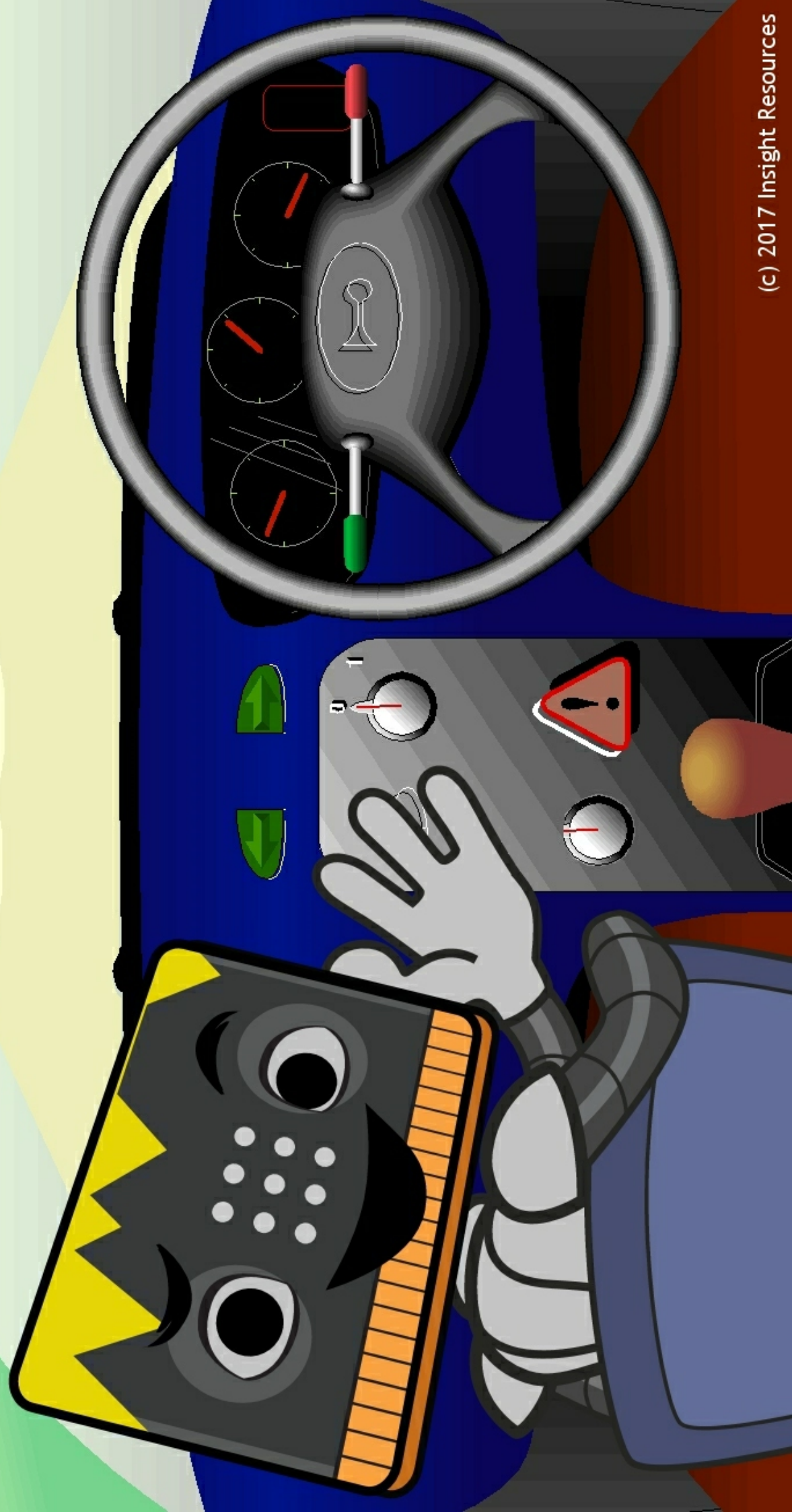
Recommended Components

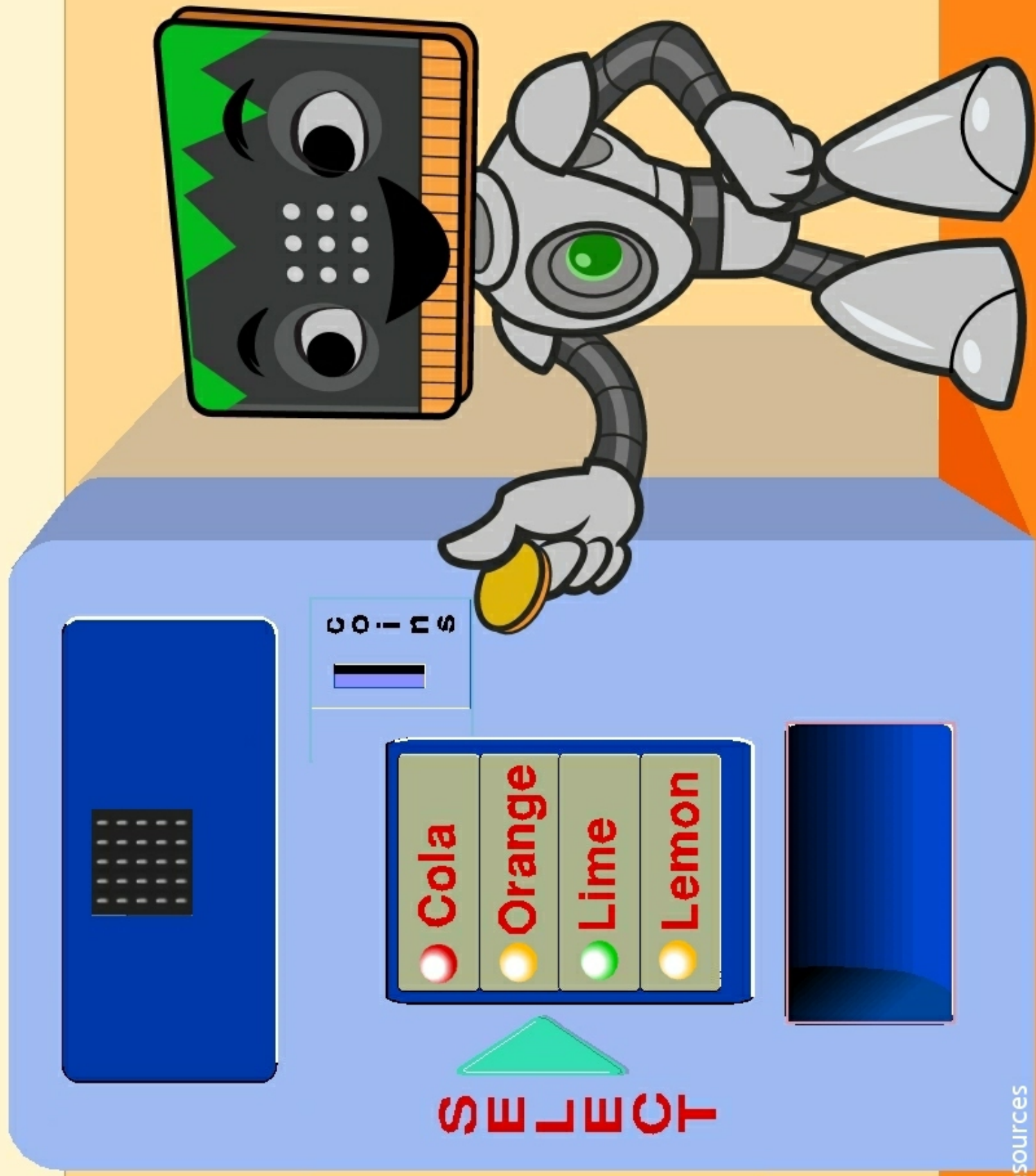
Component	Part number	Supplier
Red LED	3504	Kitronik
Yellow LED	3506	Kitronik
Green LED	3505	Kitronik
White LED	3542	Kitronik
Traffic lights LEDs	CRTRFC	4tronix
Buzzer	3301-01	Kitronik
Miniature motor geared 3V	N20-nnn	4tronix
Miniature motor 3V	2546	Kitronik
Fan blades	2544	Kitronik
Push button	Red 78-0030 Black 78-0035 White 78-0055	Rapid
Toggle switch	75-0152	Rapid
Microswitch	78-2408	Rapid
Magnet switch	78-1670	Rapid
Thermistor 10k NTC	Epcos B5786 50-9581	Rapid
LDR (Light dependent resistor)	NORPS12 914-6714 NSL19M51914-6710	RS Components
Resistor 47R	3003-47R	Kitronik
Resistor 2K2	3003-2K2	Kitronik
Resistor 3K3 1%	62-7928	Rapid
Resistor 10K	3003-10K	Kitronik
Transistor (for motor control) BC337 NPN	2938	Kitronik
Terminal connector strip (mini)		Wilkinson
4mm plug connecting leads	Black 17-2836 Blue 17-2837 Red 17-2839 Yellow 17-2840 Green 17-2838	Rapid
Edge Connector Breakout Board	5601B	Kitronik
Terminal Block Breakout Board	5651	Kitronik
Simple Servo Control Board	5673	Kitronik

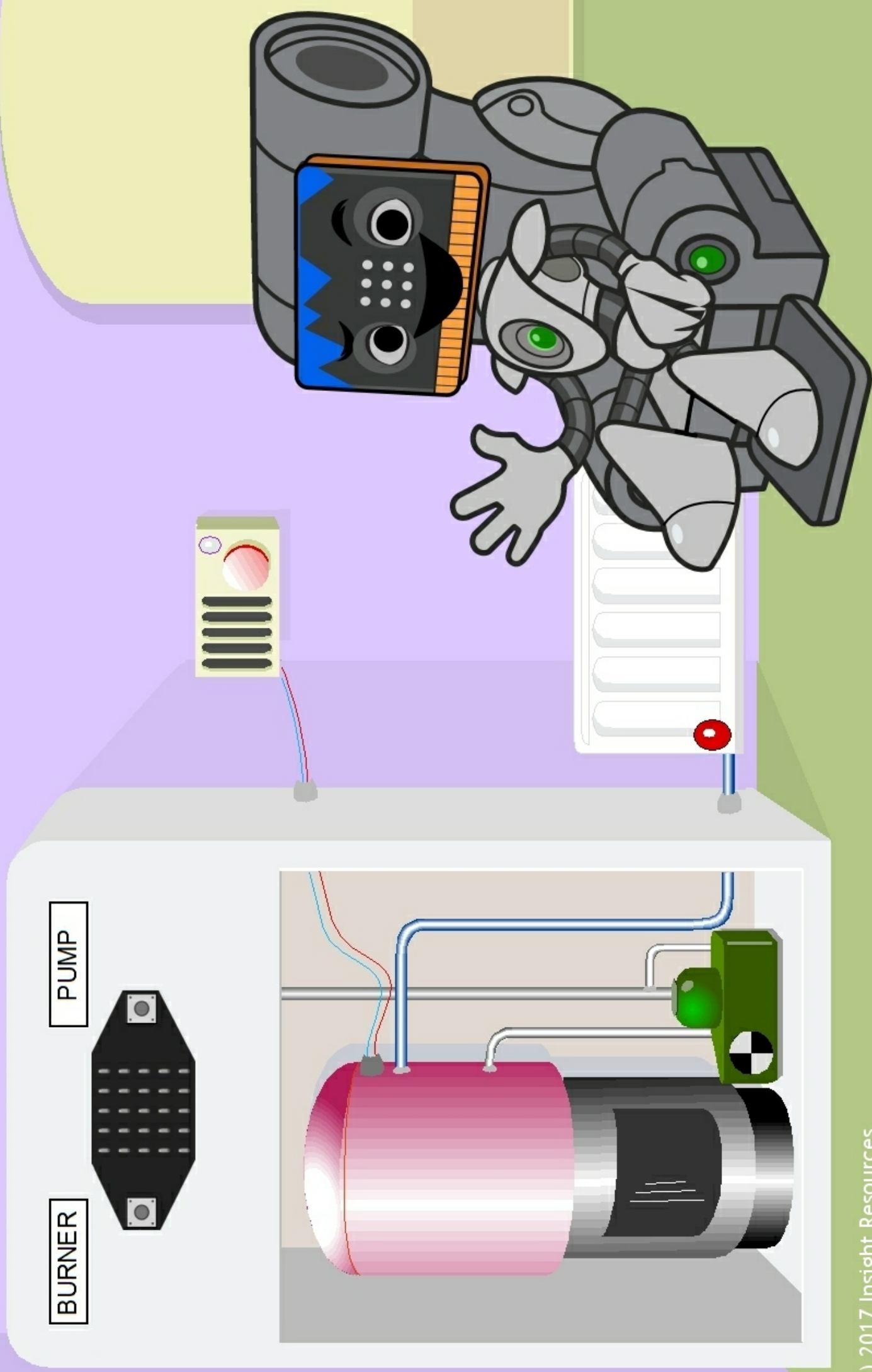


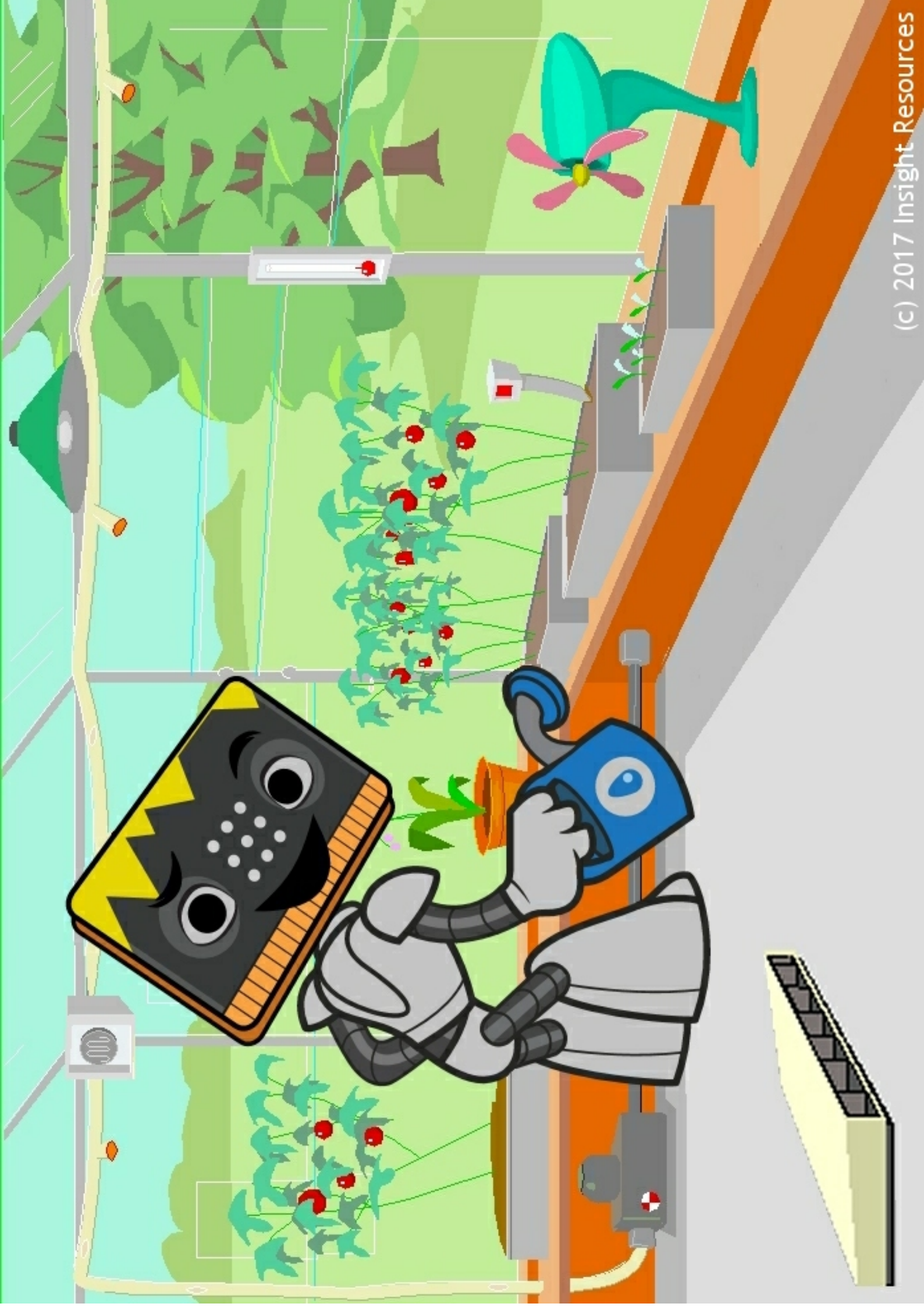


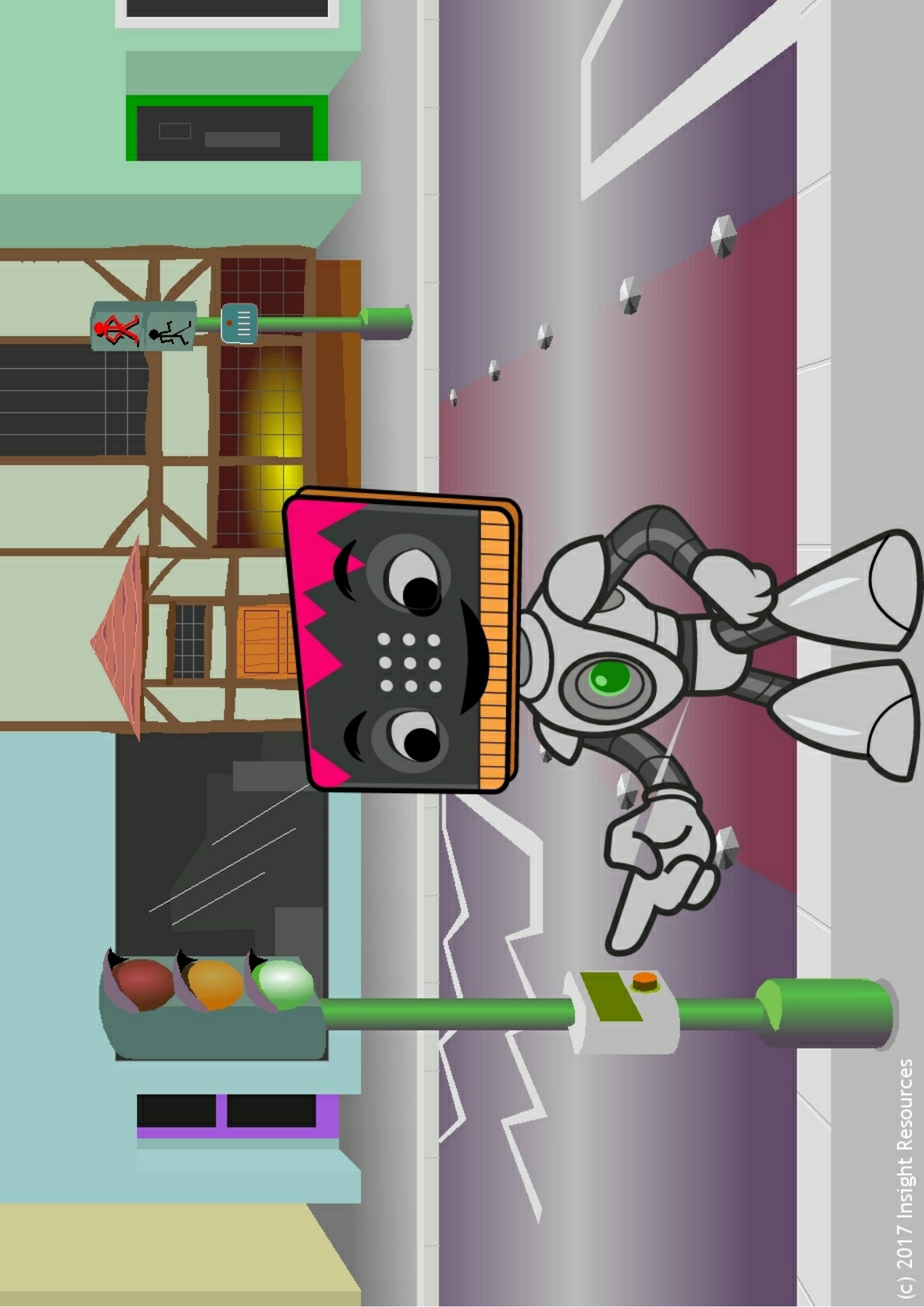


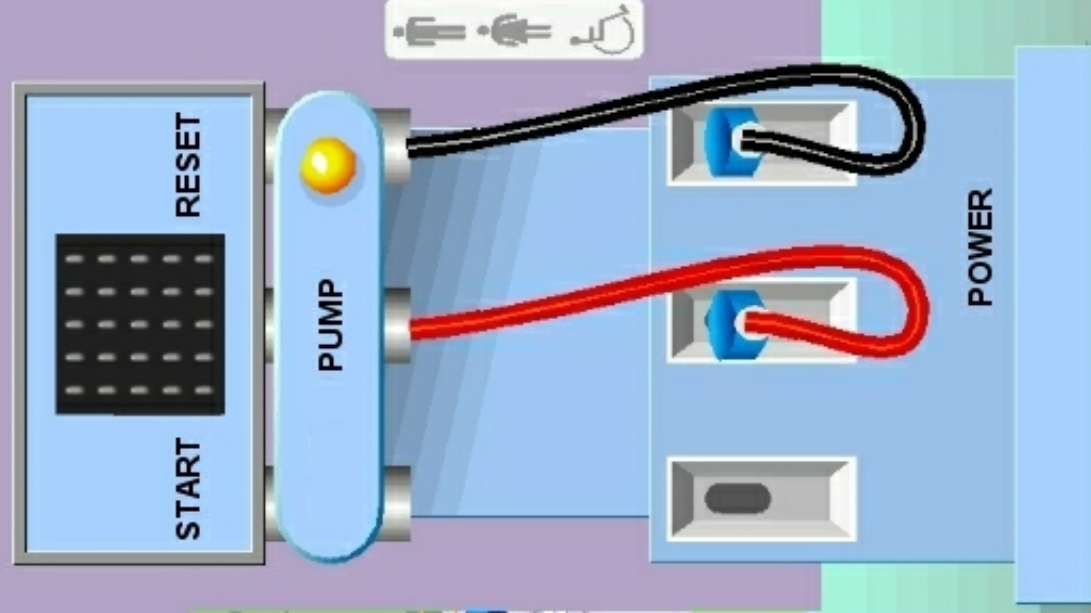
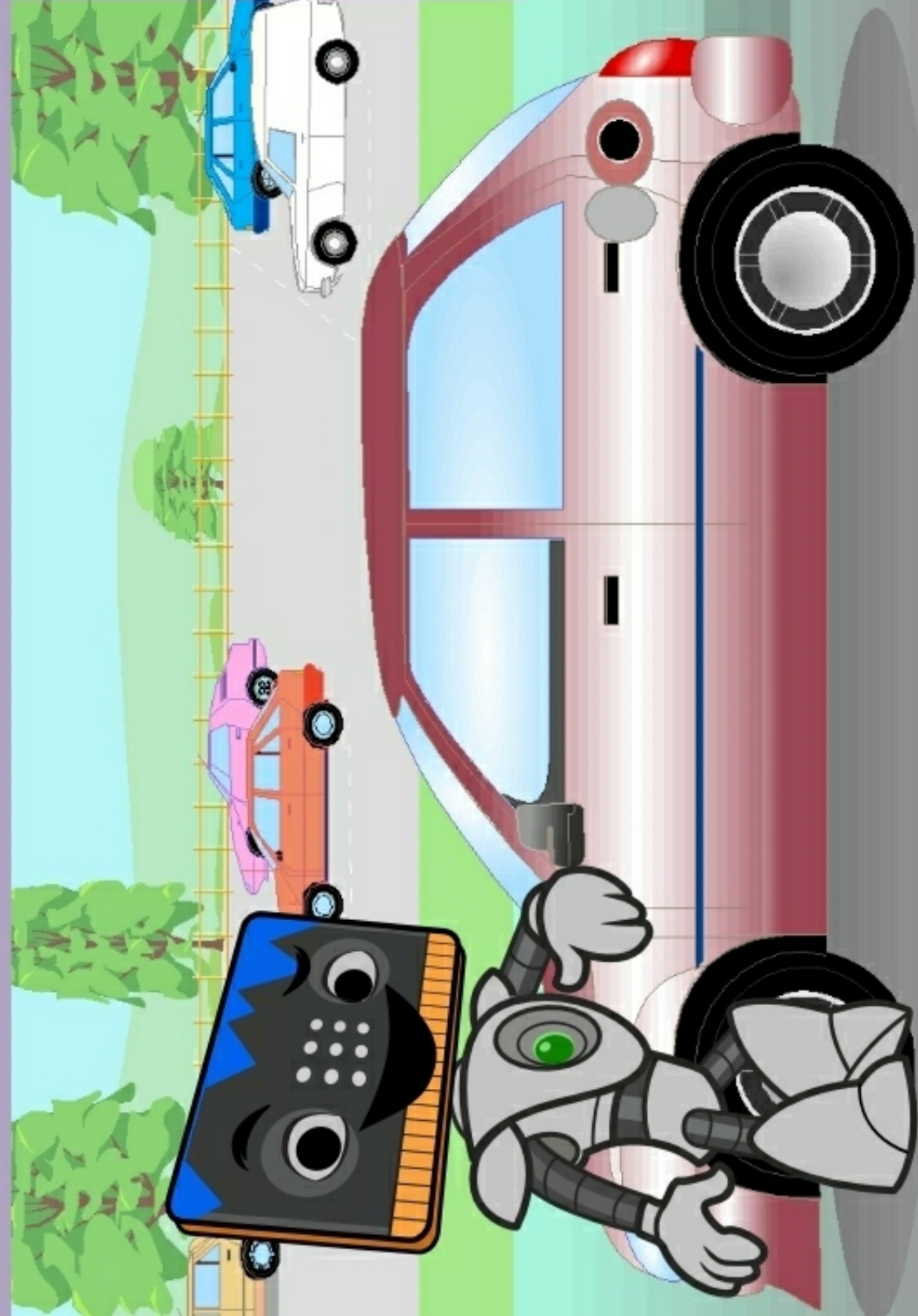














SPACES FREE

