Physical Computer Science

with the Raspberry Pi

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Computer Science

"…as much about computers as astronomy is about telescopes."

- Growing in demand across country. (K12CS, CS for All, etc)
- Need for Computer Science and computational thinking across all grade levels
- Computer science in every classroom, applicable to every classroom
- Nothing too hard, only new

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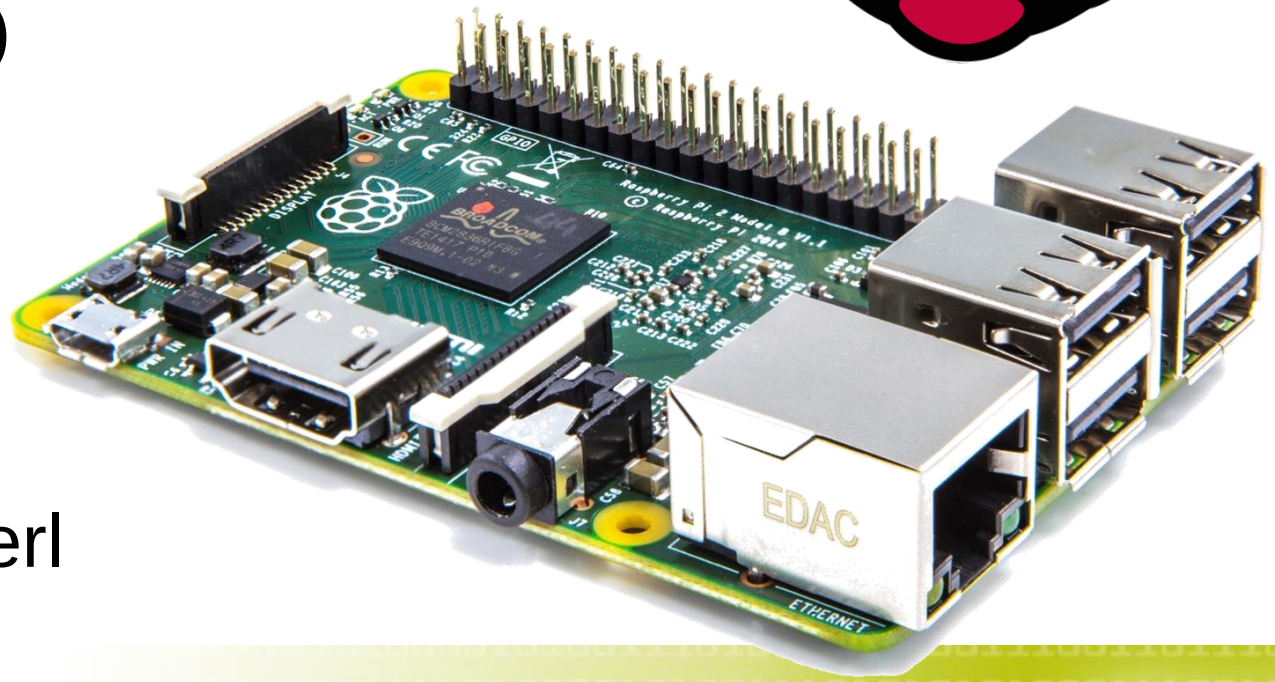
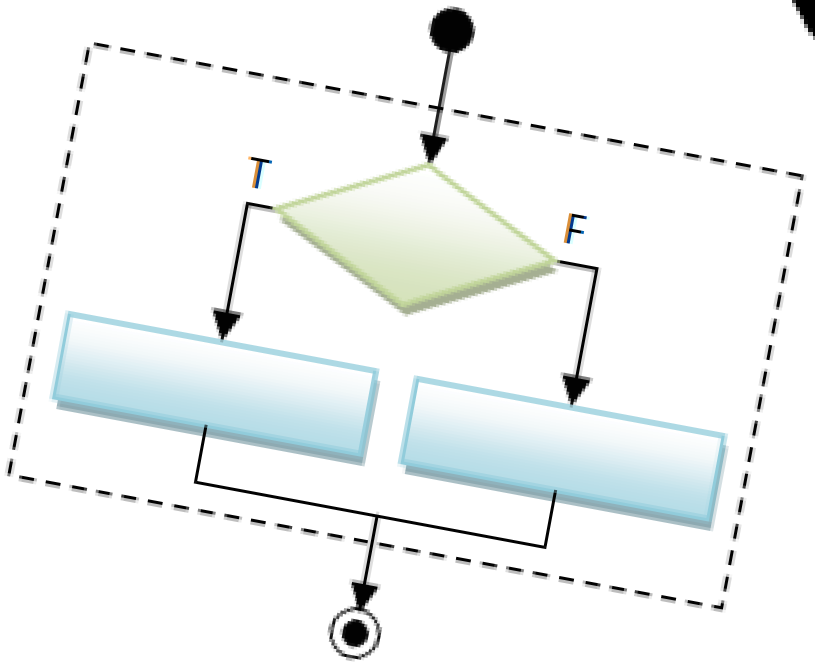
Raspberry Pi

- Developed by Raspberry Pi Foundation from Cambridge University
- $35 computer (base cost)
- Shrunken full-size PC
- ~Pentium 3 (circa 2001)
- Runs Linux (Raspbian)
- Programming via Scratch, Python, Java, Perl



Computer Science Concepts

- Sorting
- Searching
- Logic (AND / OR / NOT)



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Scratch

- Free visual programming language
- Runs in Browser or as stand-alone
- Developed by MIT
- Teaches logic, flow control, graphic manipulation
- Runs on Raspberry Pi
- Special version allows access to GPIO
  - General Purpose Input/Output pins

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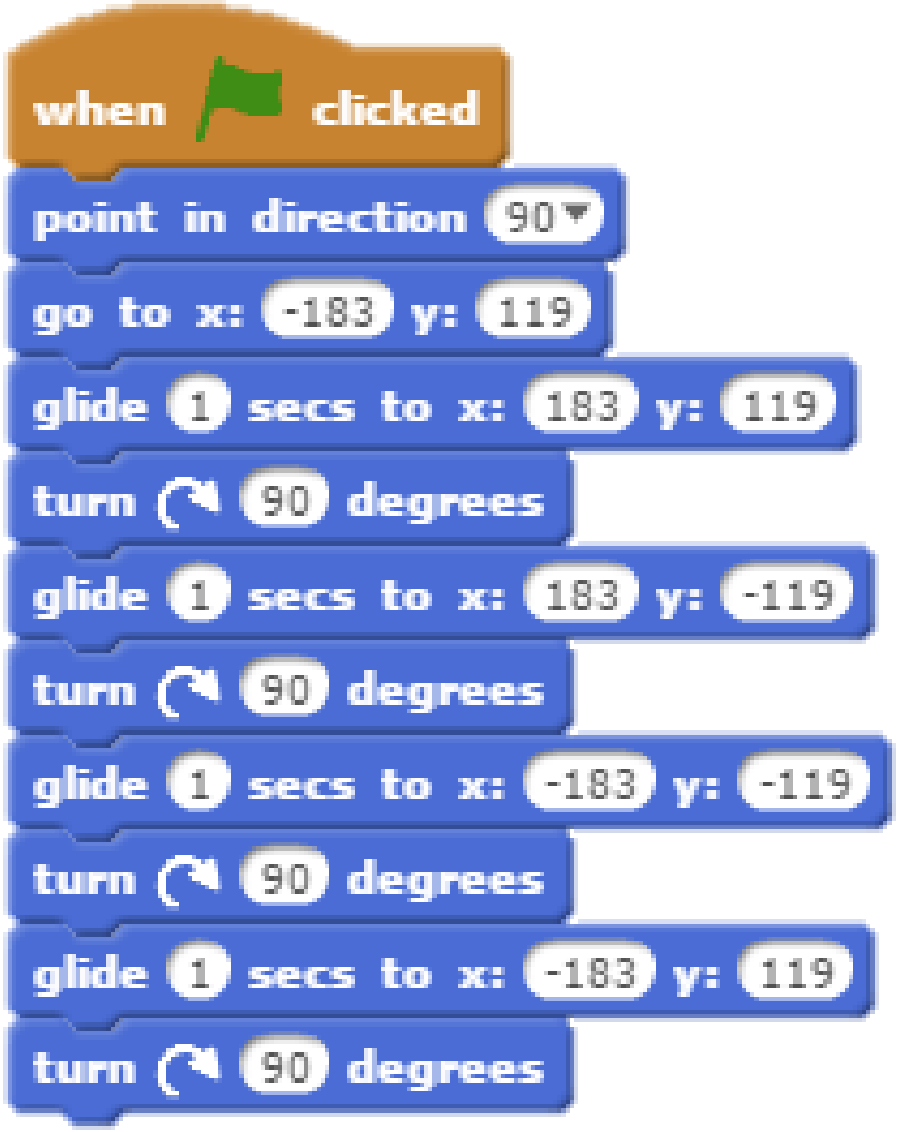
Scratch Movement

- Basic movement in Scratch
- Simple syntax



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Scratch Movement

- Basic movement in Scratch
- Simple syntax

Scratch Variable

- Track value, refer to data by name

```
when [green flag] clicked
point in direction 90
go to x: -183 y: 119
set counter to 0
repeat 2
    glide 1 secs to x: 183 y: 119
    turn ↻ 90 degrees
    change counter by 1
    glide 1 secs to x: 183 y: -119
    turn ↻ 90 degrees
    change counter by 1
    glide 1 secs to x: -183 y: -119
    turn ↻ 90 degrees
    change counter by 1
    glide 1 secs to x: -183 y: 119
    turn ↻ 90 degrees
    change counter by 1
```

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Scratch (GPIO)

- To enable GPIO we must enable Scratch's GPIO interfaces
- Click **Edit**, then click **Start GPIO server**
- Next, select **Show Motor Blocks**
  - These are all the special blocks that give us access to the GPIO pins

Circuits

- Many ways to learn about circuits
- Vocabulary:
  - Polarity (+ and -)
  - 5V
  - 3V3
  - GND

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Resistors

- Used to consume electricity in a controlled, predictable way

- Two types in kit:
  - Red, Red, Brown
  - Brown, Black, Orange

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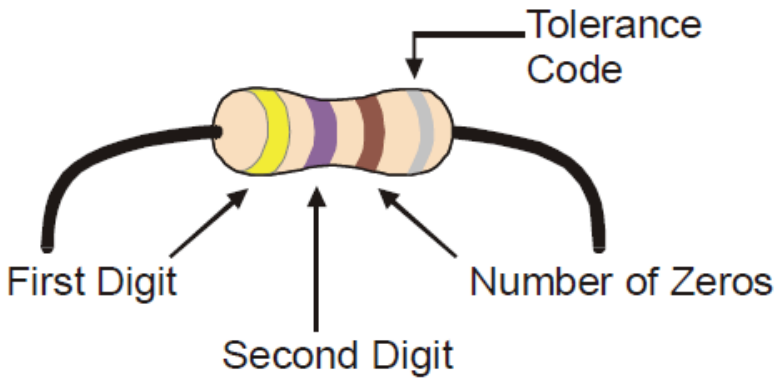
RESISTORs

Digit	Color
0	Black
1	Brown
2	Red
3	Orange
4	Yellow
5	Green
6	Blue
7	Violet
8	Gray
9	White



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RESISTORS

Digit	Color
0	Black
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9	White

Identifying Resistors – Use Scientific Notation!

Consider a Brown, Black, Orange:

1, 0, three 0's: 10,000 Ω (10k Ω)

Consider a Brown, Black, Red:

1, 0, two 0's: 1,000 Ω

Consider a Yellow, Violet, Red:

4, 7, two 0's: 4,700 Ω (4.7k Ω)

Consider a Yellow, Violet, Brown:

4, 7, one 0: 470 Ω

The third stripe is the place value!

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LED

- Light Emitting Diode
- LEDs must be connected to 3V or 5V through a resistor

- Polarity does matter!

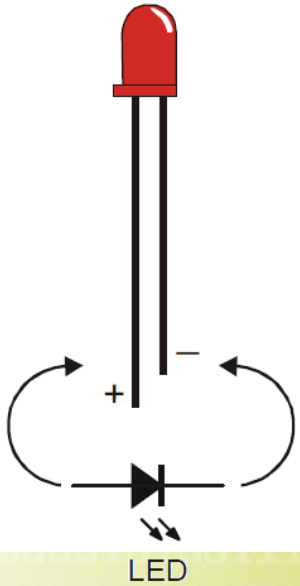

Figure 2-3
LED Part Drawing and Schematic Symbol

Part drawing (above) and schematic symbol (below)

The LED part drawings in later pictures will have a + next to the anode leg.

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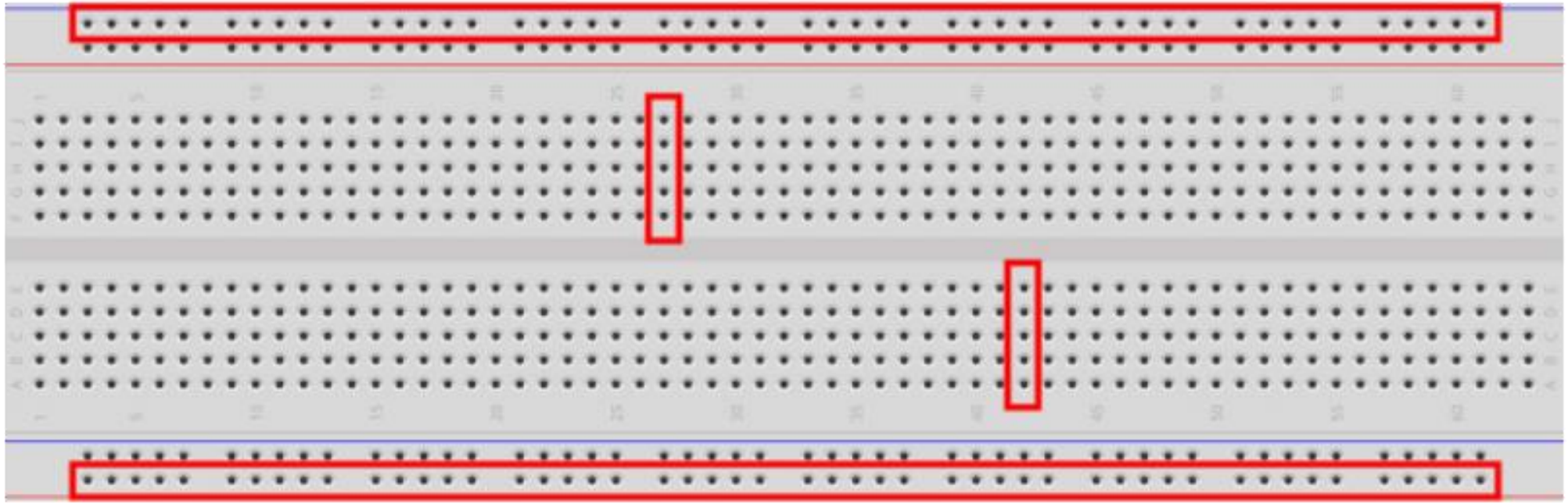
Breadboard



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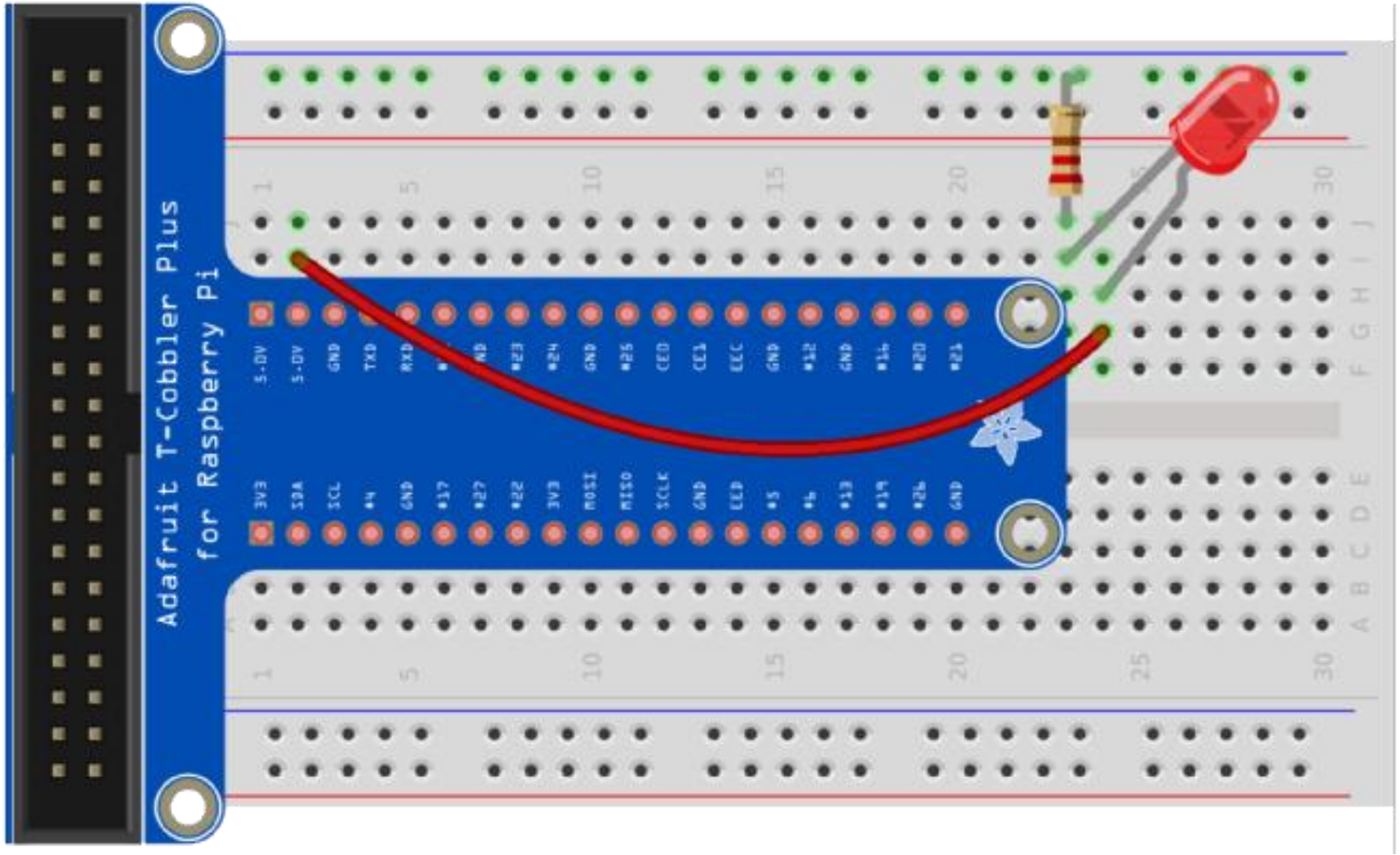
LED



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LED

- Connect **positive wire** to GPIO21
- ***ALWAYS*** *use a resistor with LEDs!*
- Create Scratch **broadcast** blocks to do the following:
  - **gpio21on**
  - **gpio21off**
- Anytime you turn a gpio pin **on**, remember to turn it **off**

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led

Challenge

- Make light come on for 1 second then turn off
- Loop 10 times

- Add second LED

- Simultaneous lights
- Alternating lights

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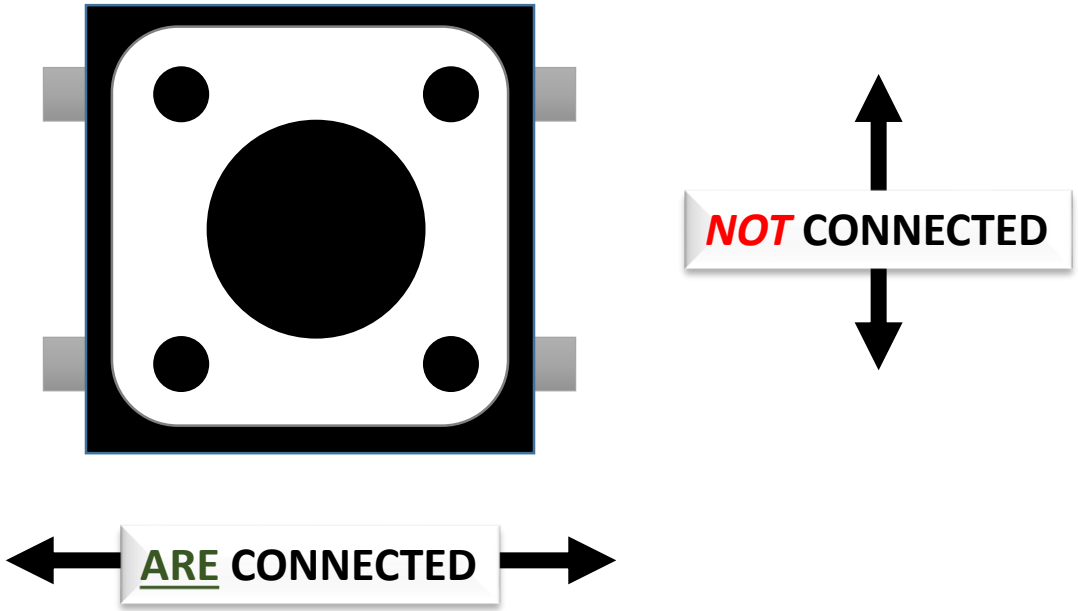
PUSH BUTTON



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Push ButtoN

- Create Scratch **broadcast** block to do the following:
  - **config19in**

- Go to Sensing and grab a *sensor value* block
  - Change dropdown value to **gpio19**
  - Value will be either 1 or 0
  - *That's* something we can work with!

PUSH BUTTON

Challenge

- Make LED come on *when* push button is pressed
- …on until button is pressed again?

- Move character when button is pressed

- Add second push button
- Move Sprite UP with one button, DOWN with another

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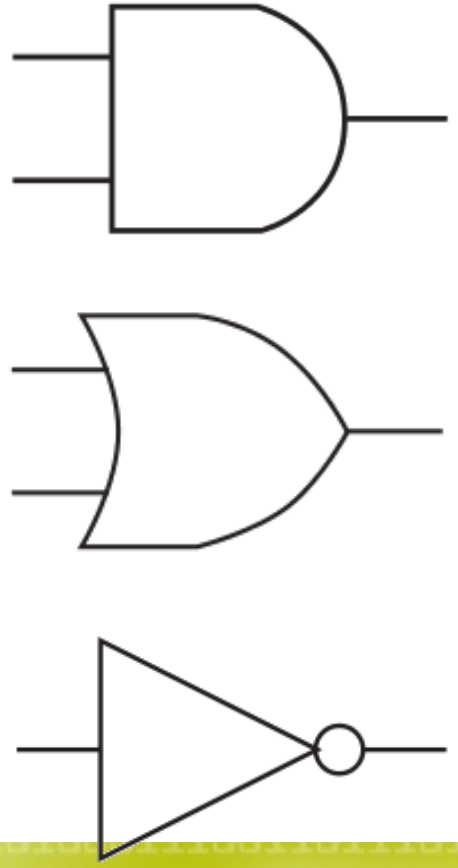
Logic

- Computers are built upon simple *logic*
  - AND
  - OR
  - NOT
- Logic allows for decisions making
- Decision making allows for algorithm development



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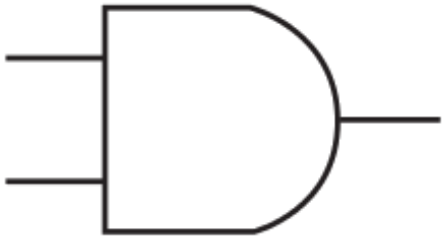
The AND gate

- 2 inputs (A and B), 1 output (Z)
- Outputs a 1 when **both** inputs are 1 (a 0 otherwise)



A	B	Z
0	0	0
0	1	0
1	0	0
1	1	**1**

Switch A	Switch B	Light
Open	Open	Off
Open	Closed	Off
Closed	Open	Off
Closed	Closed	**On**

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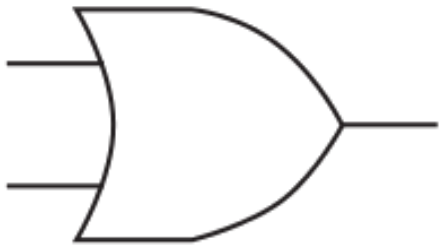
The OR gate

- 2 inputs (A and B), 1 output (Z)
- Outputs a 0 when **both** inputs are 0 (a 1 otherwise)



A	B	Z
0	0	0
0	1	**1**
1	0	**1**
1	1	**1**

Switch A	Switch B	Light
Open	Open	Off
Open	Closed	**On**
Closed	Open	**On**
Closed	Closed	**On**

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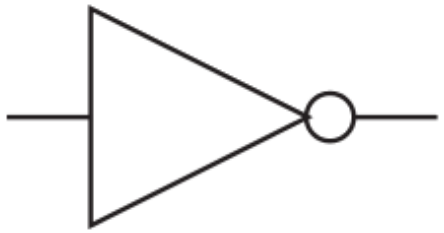
The NOT gate

- 1 input (A), 1 output (Z)
- Inverts the input



A	Z
0	1
1	0

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logic

Challenge

- LED is on when button 1 OR button 2 is pressed
- LED is on when button 1 AND button 2 are pressed

- LED is NOT on when button 1 is pressed
  - Inverted thinking!

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Search

- Max/Min – Lesson 4, Activity 1
- Max/Min – Lesson 4, Activity 2

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Sorting

- Bubble Sort - Lesson 4, Activity 3

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