Sensors and Actuators

# IoT Standards and Protocols

# INTERACT WITH THE PHYSICAL WORLD

- **SENSORS**
  TO GATHER DATA
- **ACTUATORS**
  TO SEND FEEDBACK
- **PROJECT**
  BUILD A NIGHTLIGHT

# INTRODUCTION

## 2 IMPORTANT CONCEPTS

### SENSORS

- WHAT ARE SENSORS?
- USE A SENSOR
- SENSOR TYPES

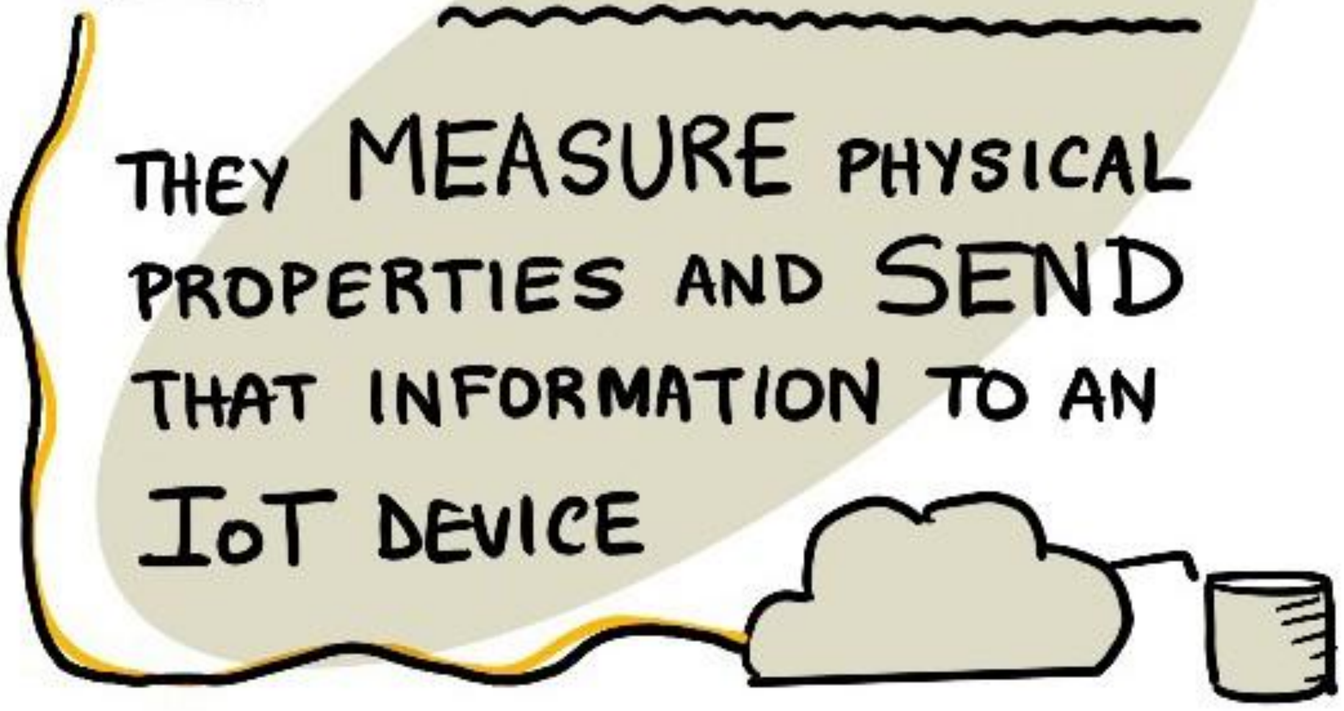
### ACTUATORS

- WHAT ARE ACTUATORS?
- USE AN ACTUATOR
- ACTUATOR TYPES

# WHAT ARE SENSORS?

HARDWARE DEVICES THAT SENSE THE PHYSICAL WORLD

THEY MEASURE PHYSICAL PROPERTIES AND SEND THAT INFORMATION TO AN IoT DEVICE



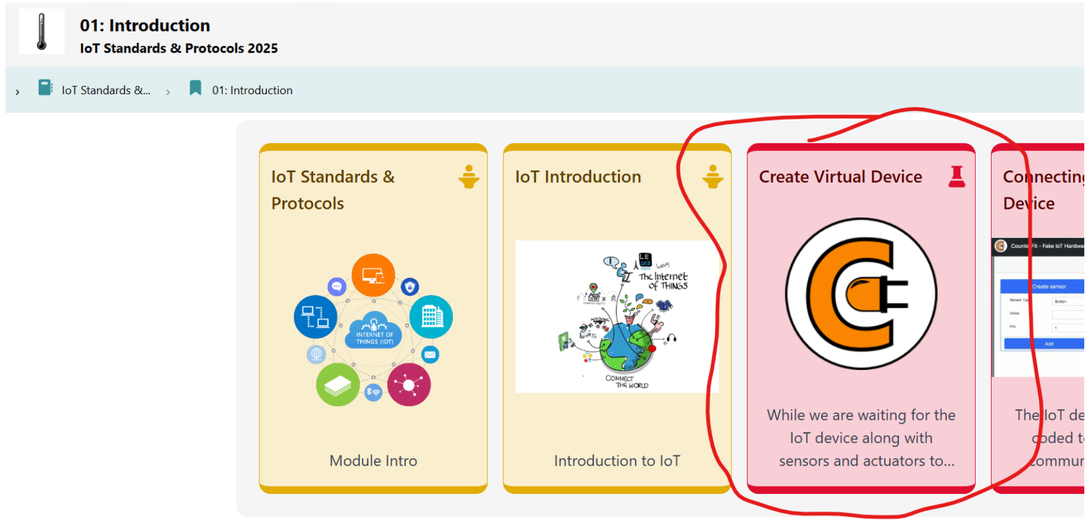
## COMMON SENSORS

- TEMPERATURE
  HUMIDITY
- BUTTONS (INTERACTION)
- LIGHT SENSOR (LEVELS, COLORS...)
- CAMERAS
- ACCELERATORS
- MICROPHONES

# QI


ALL SENSORS CONVERT THE SENSED INPUT INTO ELECTRICAL SIGNALS THAT IoT DEVICES CAN INTEPRET MEANINGFULLY

# USE A SENSOR






## Build a nightlight - Sensor

In this step, you will add a light sensor to your virtual IoT device.

### Virtual Hardware

The nightlight needs one sensor, created in the CounterFit app.

The sensor is a **light sensor**. In a physical IoT device, it would be a **photodiode** that converts light to an electrical signal. Light sensors are analog sensors that sends an integer value indicating a relative amount of light, that doesn't map to any standard unit of measurement such as **lux**.

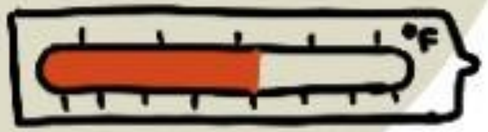
#### Add the sensors to CounterFit

# SENSOR TYPES

## ANALOG SENSORS

PRODUCES A CONTINUOUS ANALOG SIGNAL PROPORTIONAL TO THE SENSED INPUT

- EXAMPLE:
  TEMP SENSOR




## 2 PRIMARY TYPES

- ANALOG
- DIGITAL

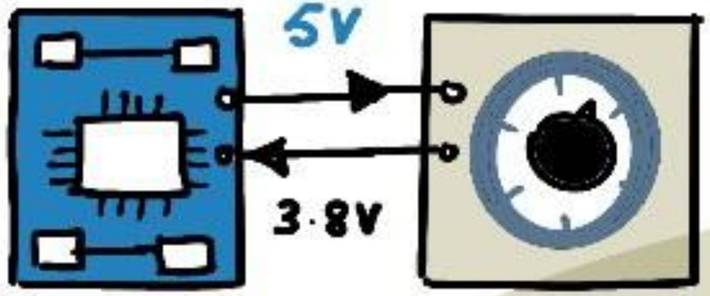
## DIGITAL SENSORS

PRODUCES DISCRETE VALUES (0,1 – BINARY STATES)

EXAMPLE:
LIGHT SWITCH

# ANALOG SENSORS

## HOW IT WORKS




SENSOR RECEIVES VOLTAGE FROM IOT DEVICE, ADJUSTS AND RETURNS IT TO REFLECT DATA

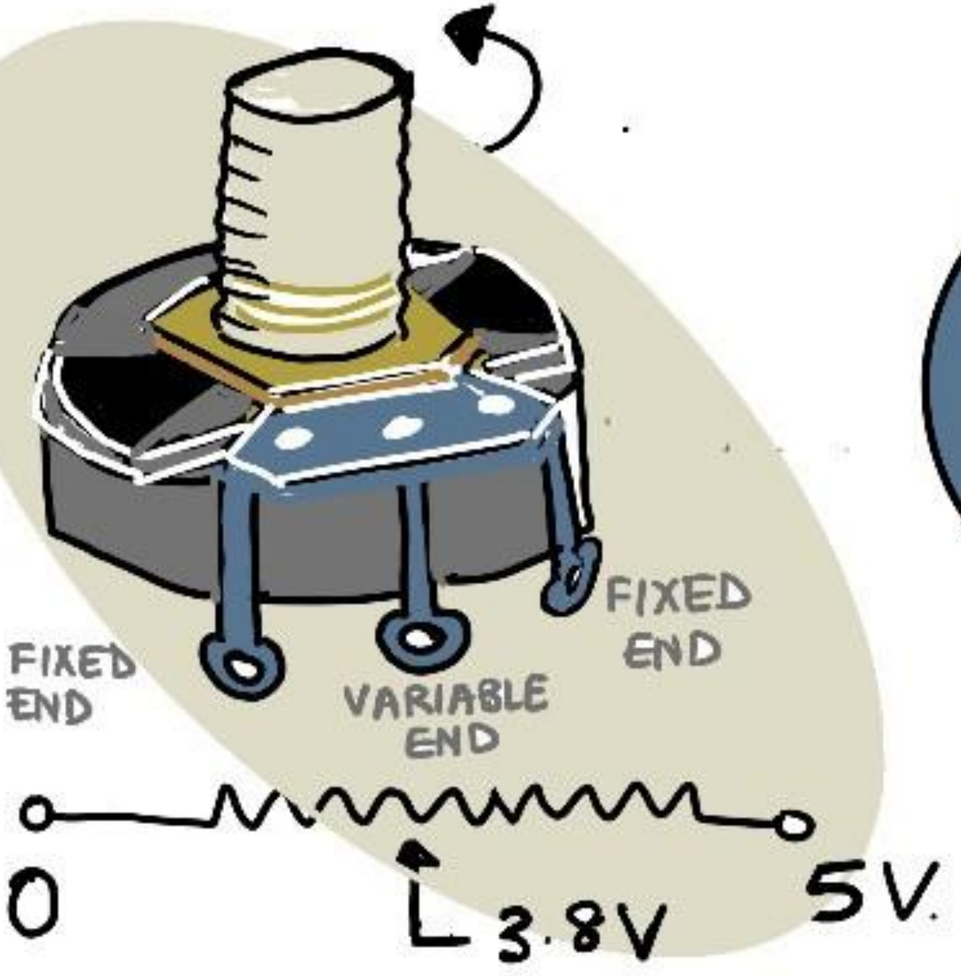
## WHAT IS VOLTAGE?

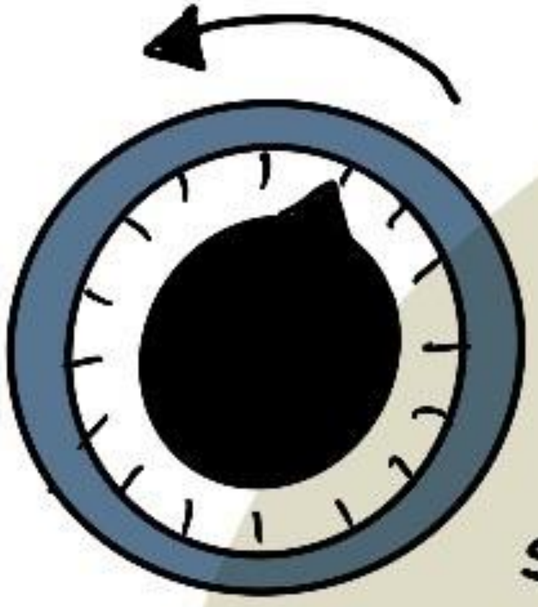
IT'S A MEASURE OF EFFORT NEEDED TO PUSH ELECTRICITY FROM ONE POINT TO ANOTHER

THE IOT DEVICE CAN 'READ' THE VOLTAGE COMING OUT OF THE SENSOR AND REACT TO ITS VALUE OR CHANGE

# POTENTIOMETER

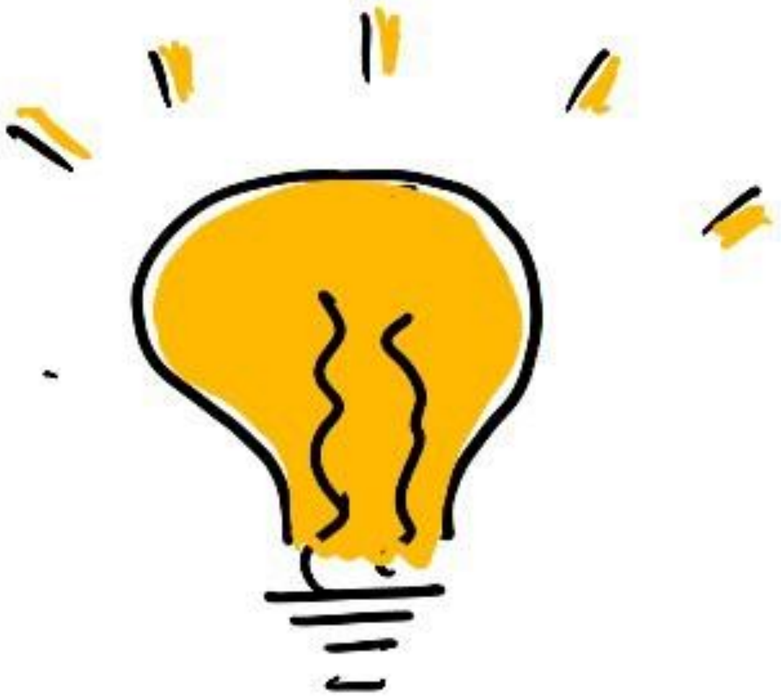
IS ONE EXAMPLE OF AN ANALOG SENSOR DEVICE



ROTATE THE DIAL BETWEEN TWO FIXED ENDS (mapped to 0V, 5V)

SENSOR MEASURES ROTATION BY SENDING REDUCED VOLTAGE (OR NUMERIC MAPPING) CORRESPONDING TO SHIFT



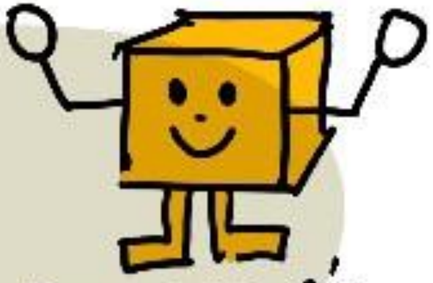
DO YOUR RESEARCH

- WHAT IS A THERMISTOR? WHAT TYPE OF SENSOR IS IT — AND HOW DOES IT WORK?

- WHAT DO YOU THINK HAPPENS IF SENSOR SENDS OUT HIGHER VOLTAGE THAN IT RECEIVES?

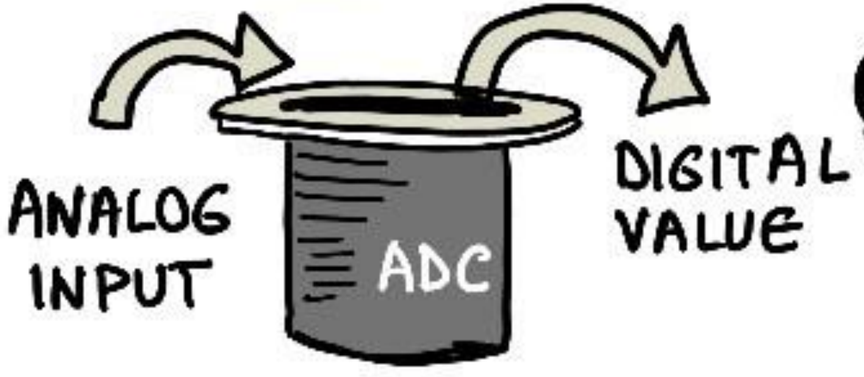
# ANALOG-TO-DIGITAL

## IOT DEVICES ARE DIGITAL!



GIVE ME 0's AND 1's !!

ANALOG SENSORS NEED TO 'DIGITIZE' THEIR VALUES BEFORE IOT DEVICE CAN USE THEM



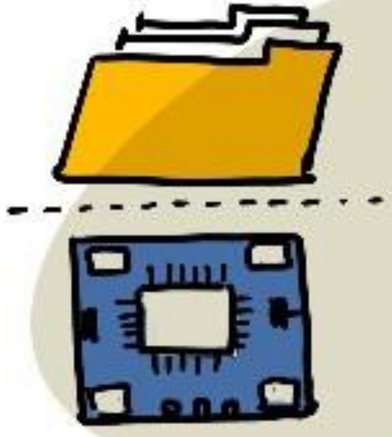

ADC = ANALOG-TO-DIGITAL CONVERTER

WE HAVE OPTIONS

MANY IOT DEVICES HAVE BUILT-IN ADC

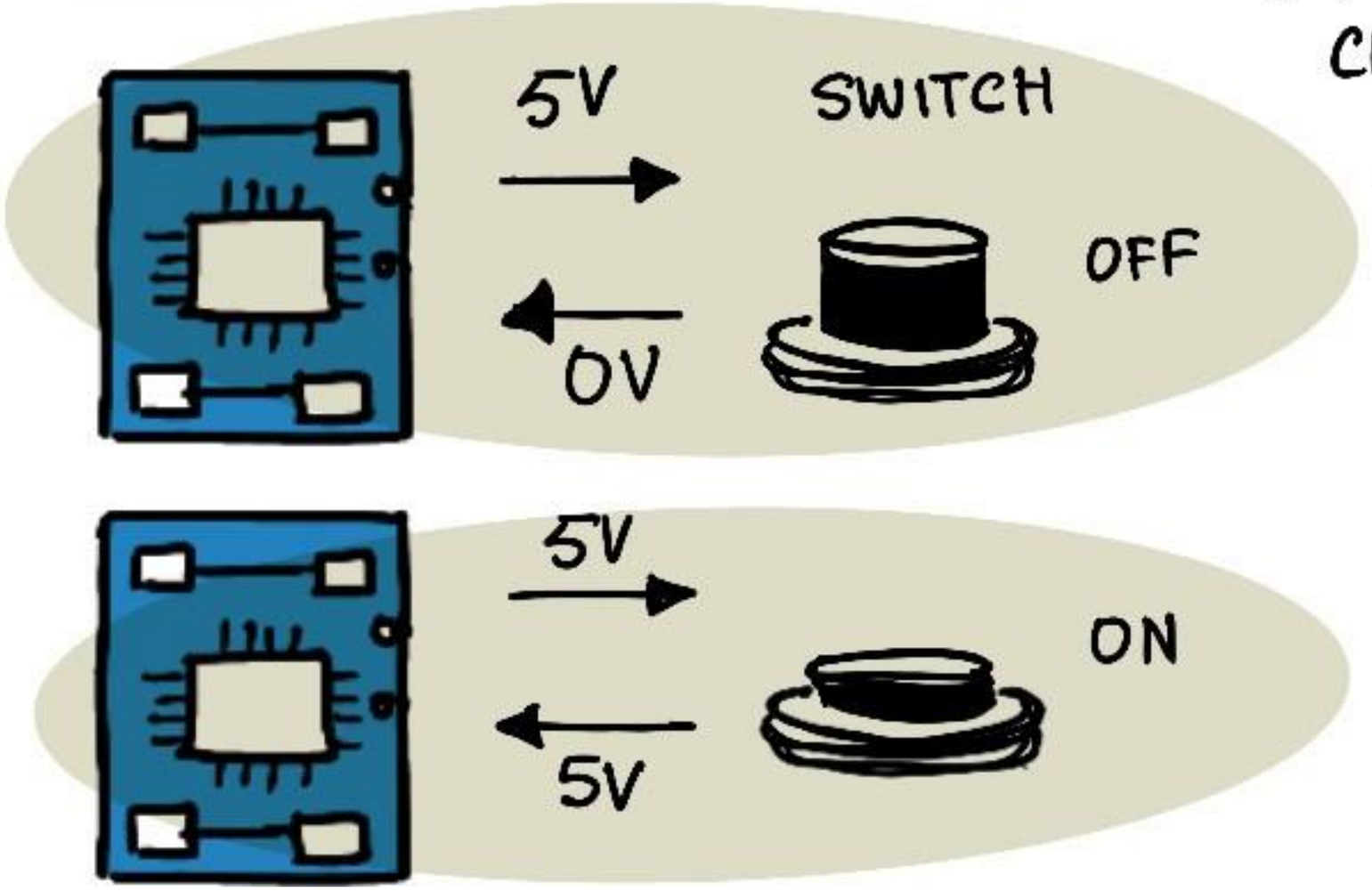
AND

MANY SENSORS CAN WORK WITH ADCs VIA A CONNECTOR BOARD!



SOFTWARE LIBRARIES FOR SENSORS/DEVICES HANDLE MUCH OF THIS FOR YOU TRANSPARENTLY

# DIGITAL SENSORS



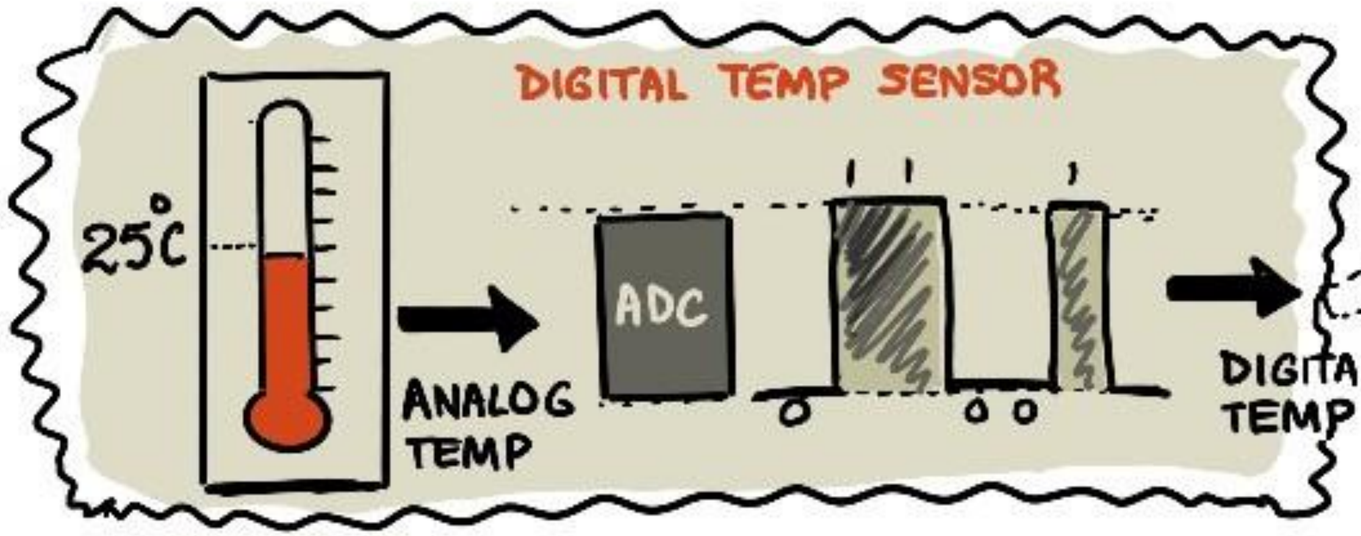

ALSO DETECT WORLD BY MEASURING ELECTRICAL CHANGES **BUT**

THEY OUTPUT DIGITAL SIGNALS (EITHER BY USING BINARY STATE OR BY USING AN ADC)

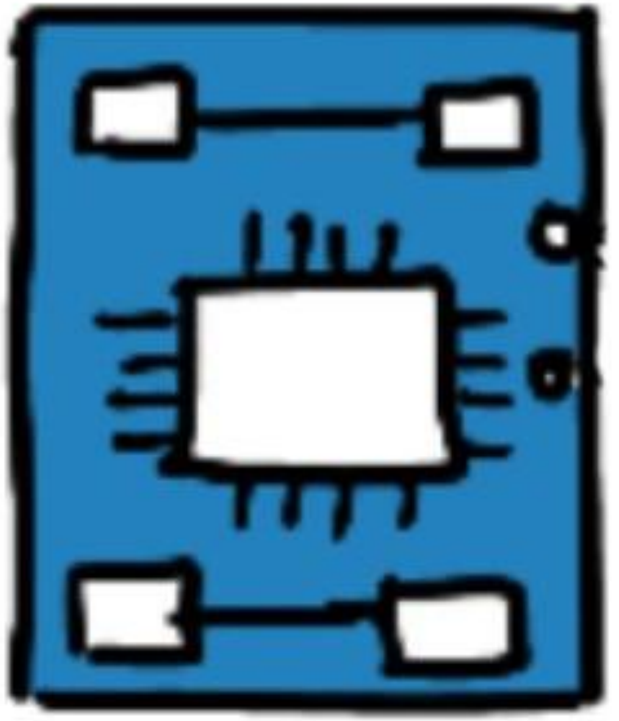
SIMPLEST EXAMPLE ON/OFF SWITCH

# ADVANCED DIGITAL SENSORS

- READ ANALOG SIGNALS
- CONVERT USING ON-BOARD ADC
- OUTPUT PURELY DIGITAL SIGNALS




DIGITAL INPUTS ARE MORE RELIABLE TO READ IN.

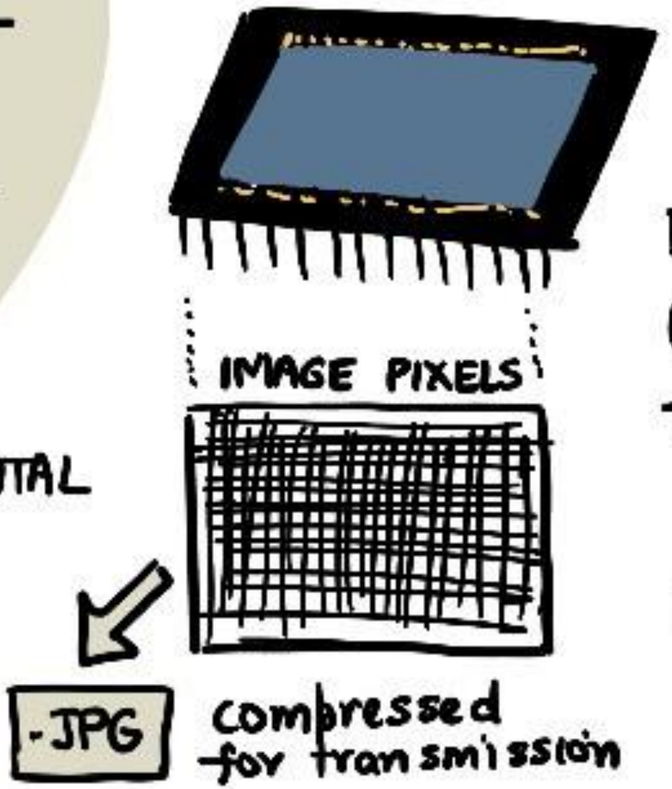


# ADVANCED DIGITAL SENSORS

## DIGITAL DATA HAS ADDED BENEFITS

- SENSORS CAN BE MORE COMPLEX, SEND DETAILED DATA
- EASIER TO ENCRYPT DATA FOR SECURE TRANSMISSION
- MORE IMMUNE TO ENVIRONMENTAL AND ELECTRONIC 'NOISE'
- MORE FLEXIBILITY IN SIGNAL PROCESSING SYSTEMS

EXAMPLE : CAMERA AS DIGITAL SENSOR

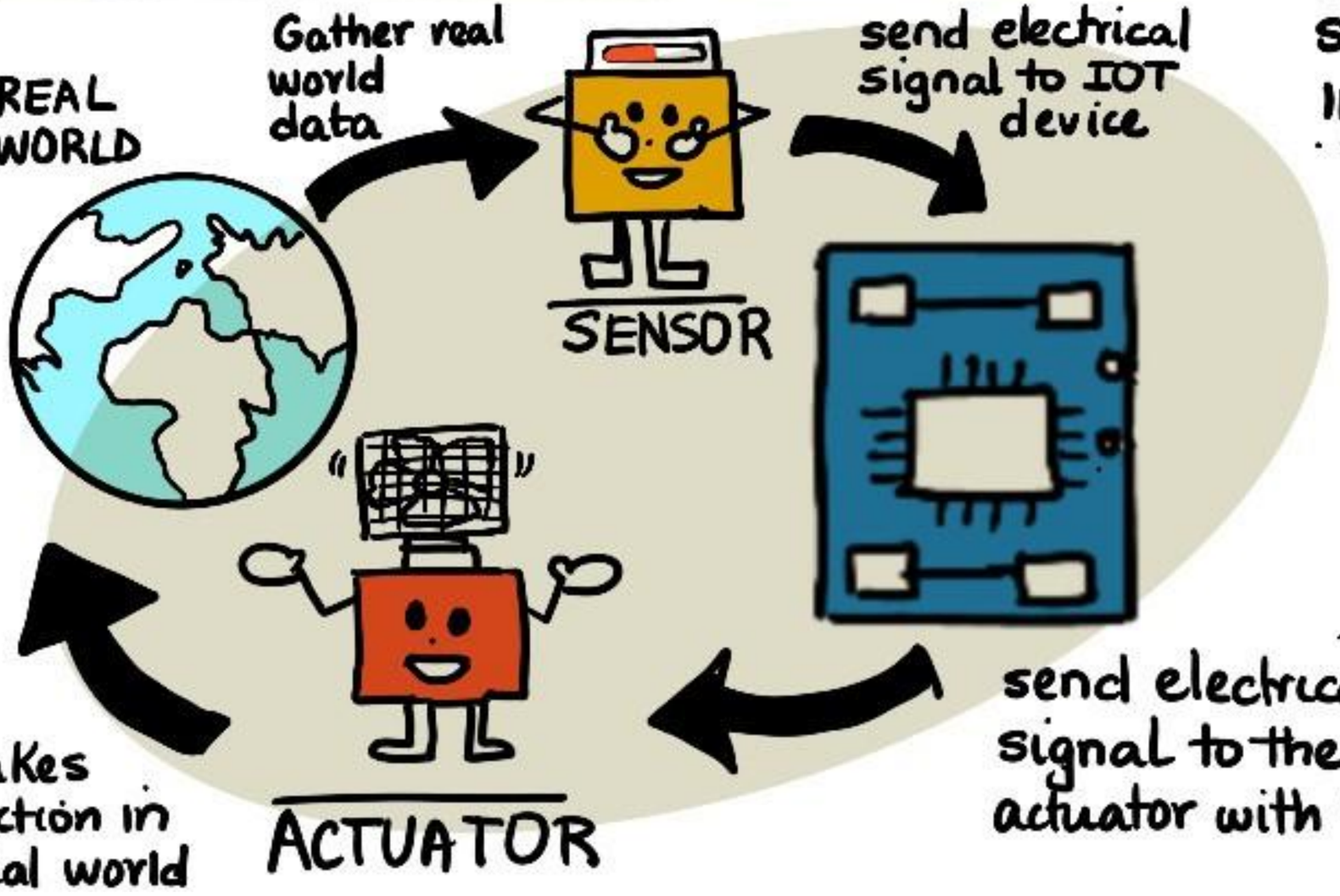



DIGITAL CAMERAS USE SENSORS LIKE THIS TO CAPTURE LIGHT FROM THE LENS AS PIXELS IN A FRAME/IMAGE

# WHAT ARE ACTUATORS?

OPPOSITE OF SENSORS

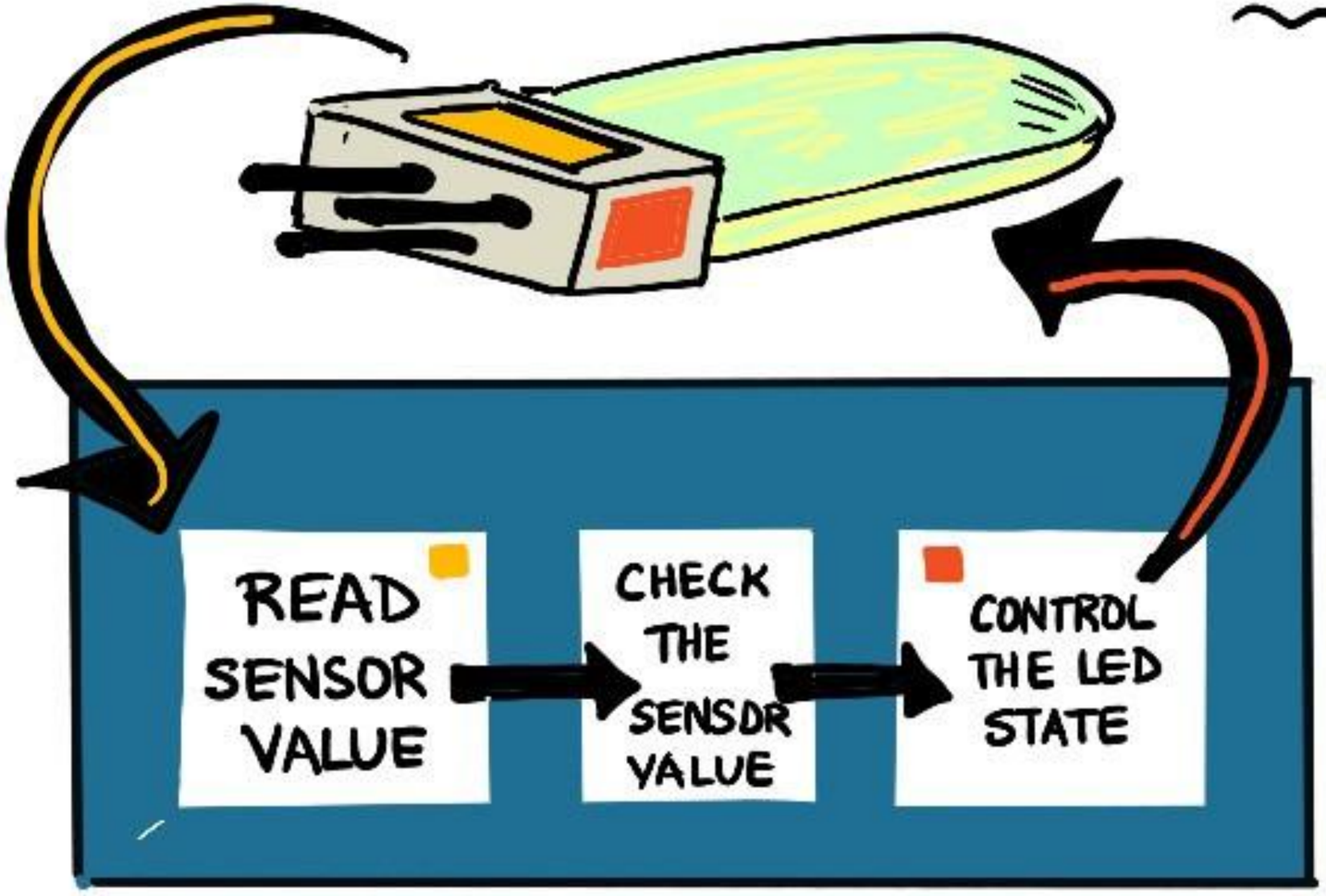
CONVERT ELECTRICAL SIGNAL FROM IOT DEVICE INTO ACTION IN REAL WORLD




EXAMPLES

- LED
- SPEAKER
- RELAY
- SCREENS
- STEPPER MOTORS

# USE AN ACTUATOR




PICK YOUR HARDWARE PATH

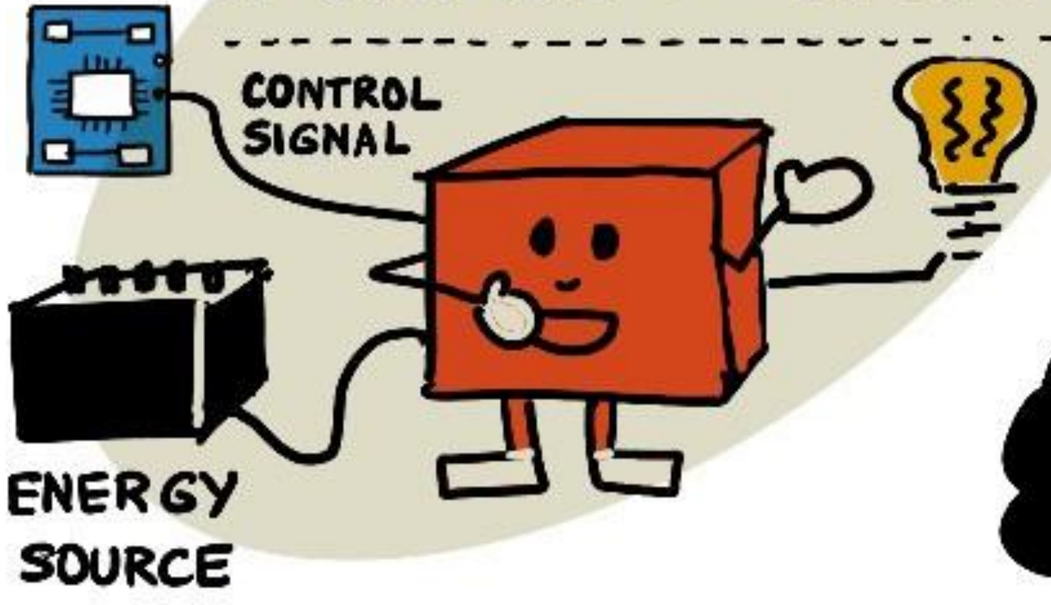
ADD AN ACTUATOR (USE GUIDE)

BUILD A NIGHTLIGHT

- ARDUINO - WIO TERMINAL
- SINGLE BOARD COMPUTER - RASPBERRY PI
- SINGLE BOARD COMPUTER - VIRTUAL DEVICE

# ACTUATOR TYPES

ACTUATORS HAVE A CONTROL SIGNAL AND A SOURCE OF ENERGY




JUST LIKE SENSORS, THERE ARE **2** TYPES OF ACTUATORS

ANALOG ✂ DIGITAL

BASED ON SIGNAL, THEY CONVERT ENERGY INTO SOME MOTION OR INTERACTION

EXAMPLE : CONTROL SIGNAL TRIGGERS ROTARY SWITCH TO MOVE, TURNS LIGHT ON IN ROOM

DO YOUR RESEARCH

ACTUATORS CAN BE CATEGORIZED BY THE FUNCTION THEY SERVE AND HOW THEY CONVERT ENERGY

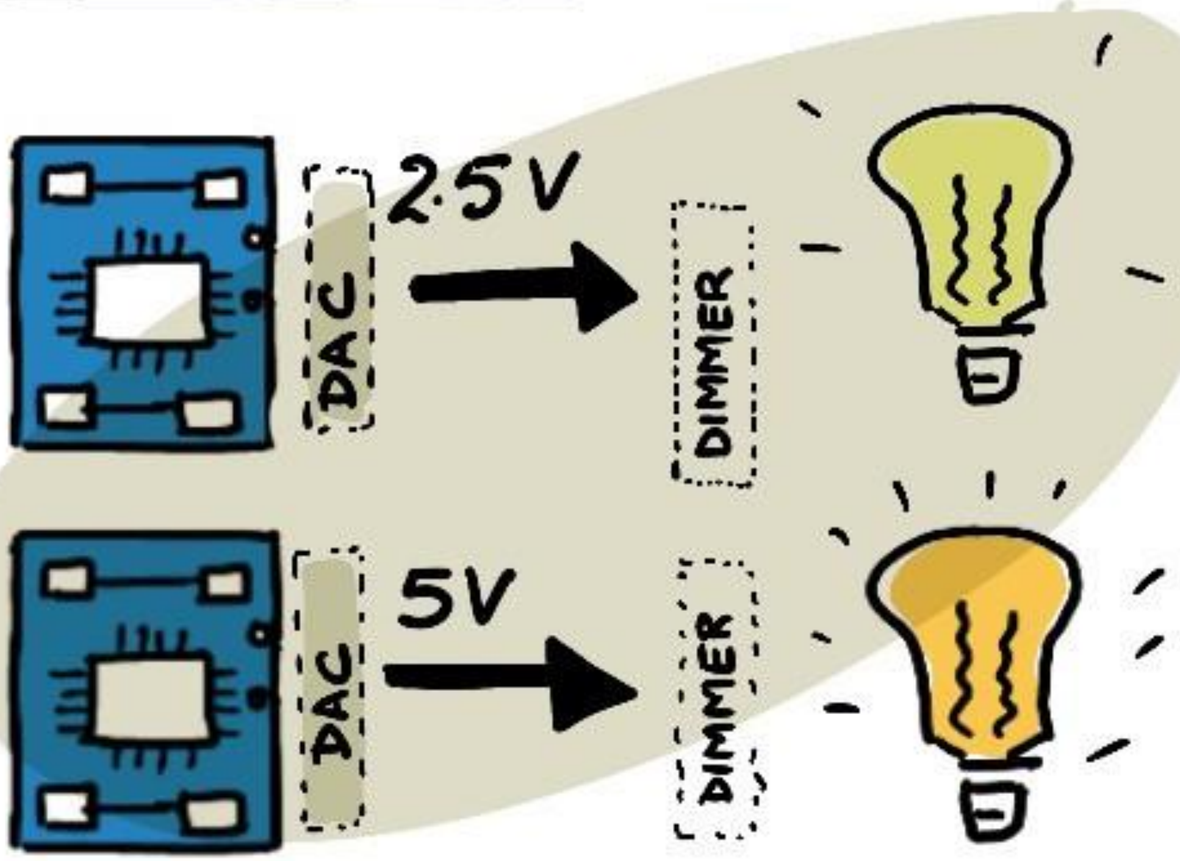
Learn About

- PNEUMATIC
- HYDRAULIC
- ELECTRIC
- THERMAL
- MAGNETIC

How do these actuators effect change?

# ANALOG ACTUATORS

Ex: DIMMABLE LIGHTS



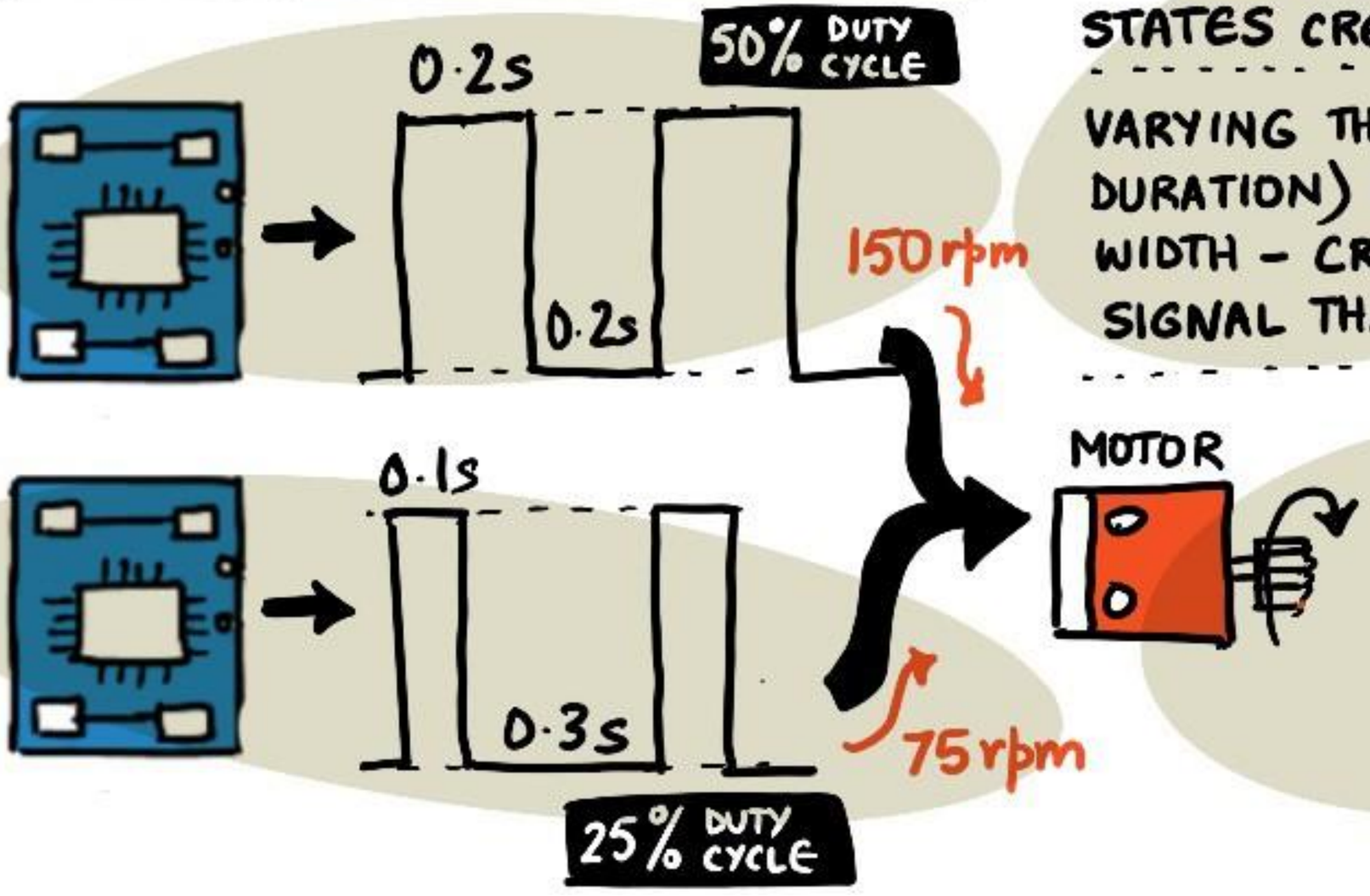

ANALOG ACTUATOR CONVERTS ANALOG SIGNAL INTO SOME INTERACTION THAT IS PROPORTIONATE TO VOLTAGE SUPPLIED

DAC = DIGITAL TO ANALOG CONVERTER

REQUIRED TO CONVERT IOT DEVICE DIGITAL OUTPUT (0,1) TO ANALOG VOLTAGE (RANGE)

# PULSE WIDTH MODULATION

= SWITCH DIGITAL SIGNAL FROM IOT DEVICE BETWEEN TWO STATES CREATING PULSES.




VARYING THE DUTY CYCLE (ON/OFF DURATION) MODULATES PULSE WIDTH - CREATING AN OUTPUT SIGNAL THAT ACTS ANALOG

Control a motor's speed with a 5V digital supply

Pulse modulation varies avg rpm based on duty cycle

THE DUTY CYCLE OF MODULATED PULSE

CONTROL SIGNAL

INFLUENCES THE SPEED OF ROTATION OF MOTOR

ACTUATOR MOTION

DO YOUR RESEARCH

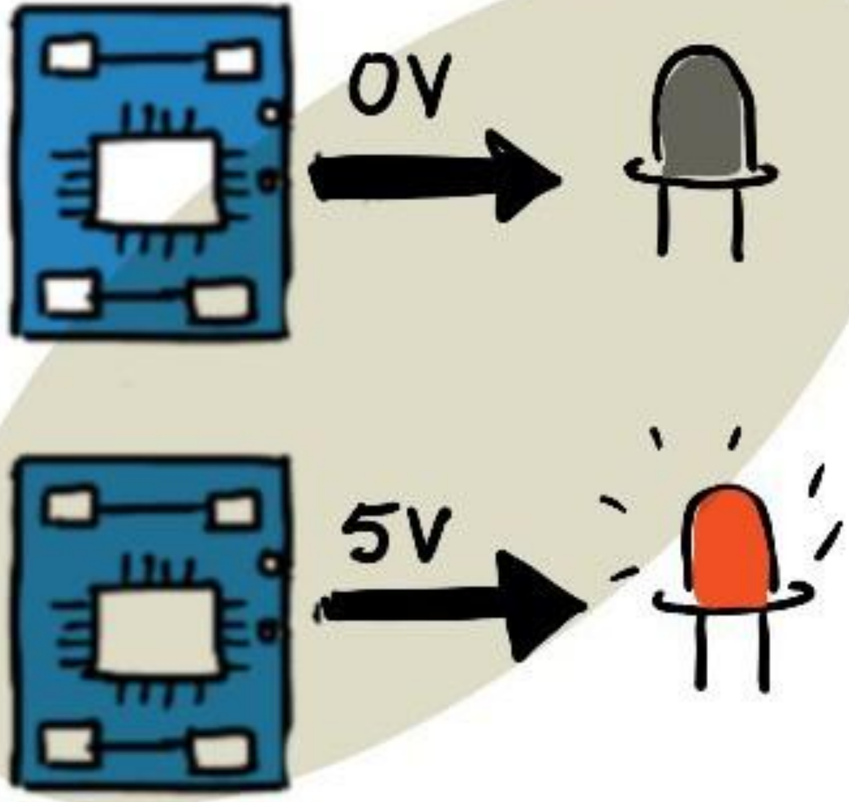
HOW WOULD YOU KEEP MOTOR ROTATION SMOOTH?

# DIGITAL ACTUATORS

1. HAVE 2 STATES (CONTROLLED BY HIGH AND LOW VOLTAGE) LIKE DIGITAL SENSORS

OR

2. HAVE BUILT-IN DAC THAT CONVERTS DIGITAL INPUT INTO ANALOG SIGNAL THEY CAN USE!




**EXAMPLE**

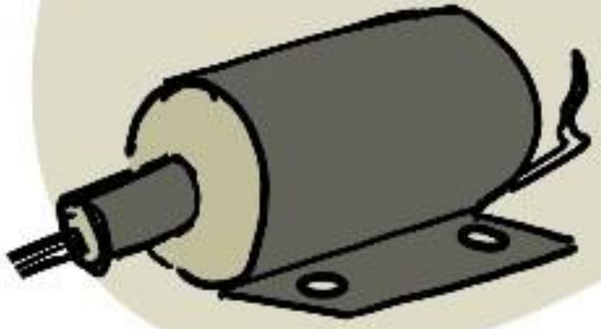
SIMPLE LED

2 STATES (ON/OFF)

HIGH VOLTAGE = ON
LOW VOLTAGE = OFF

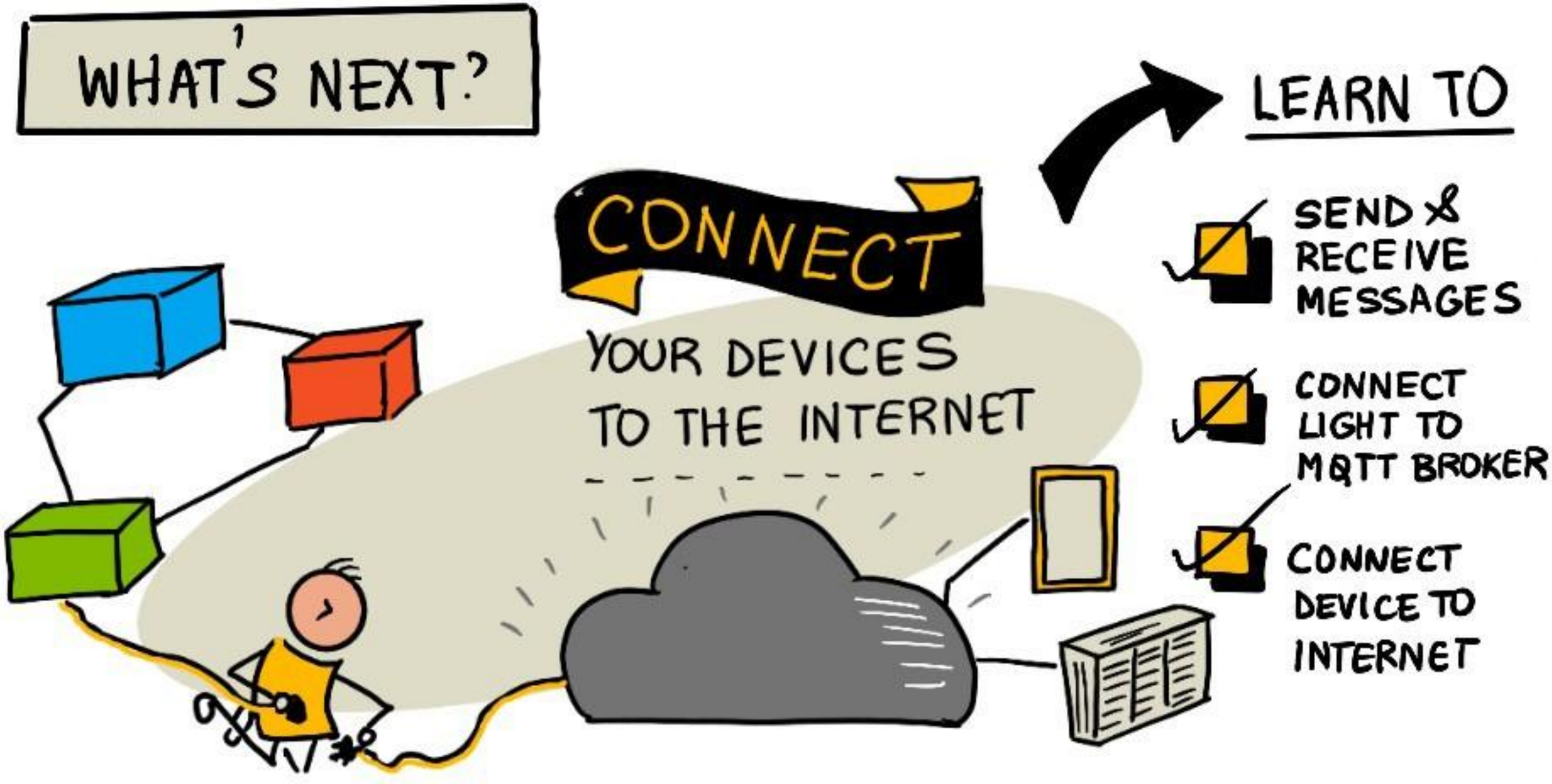
DO YOUR RESEARCH

WHAT ARE SOME OTHER EXAMPLES OF 2-STATE ACTUATORS ?



HOW ABOUT A SOLENOID?

WHERE IS IT USED?


WHAT'S NEXT?
CONNECT
YOUR DEVICES
TO THE INTERNET
LEARN TO
SEND & RECEIVE MESSAGES
CONNECT LIGHT TO MQTT BROKER
CONNECT DEVICE TO INTERNET