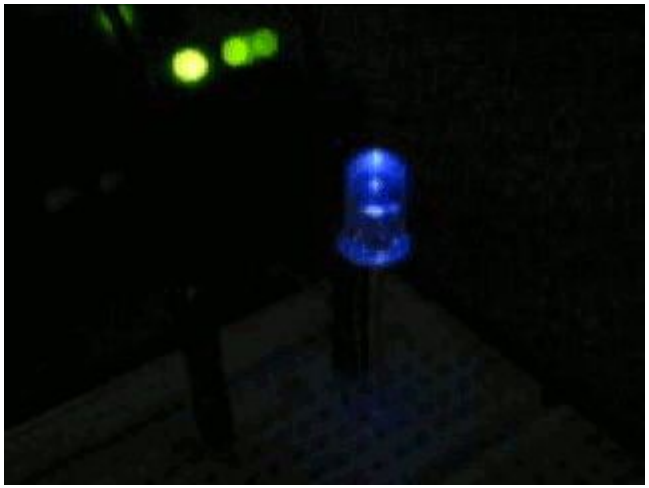
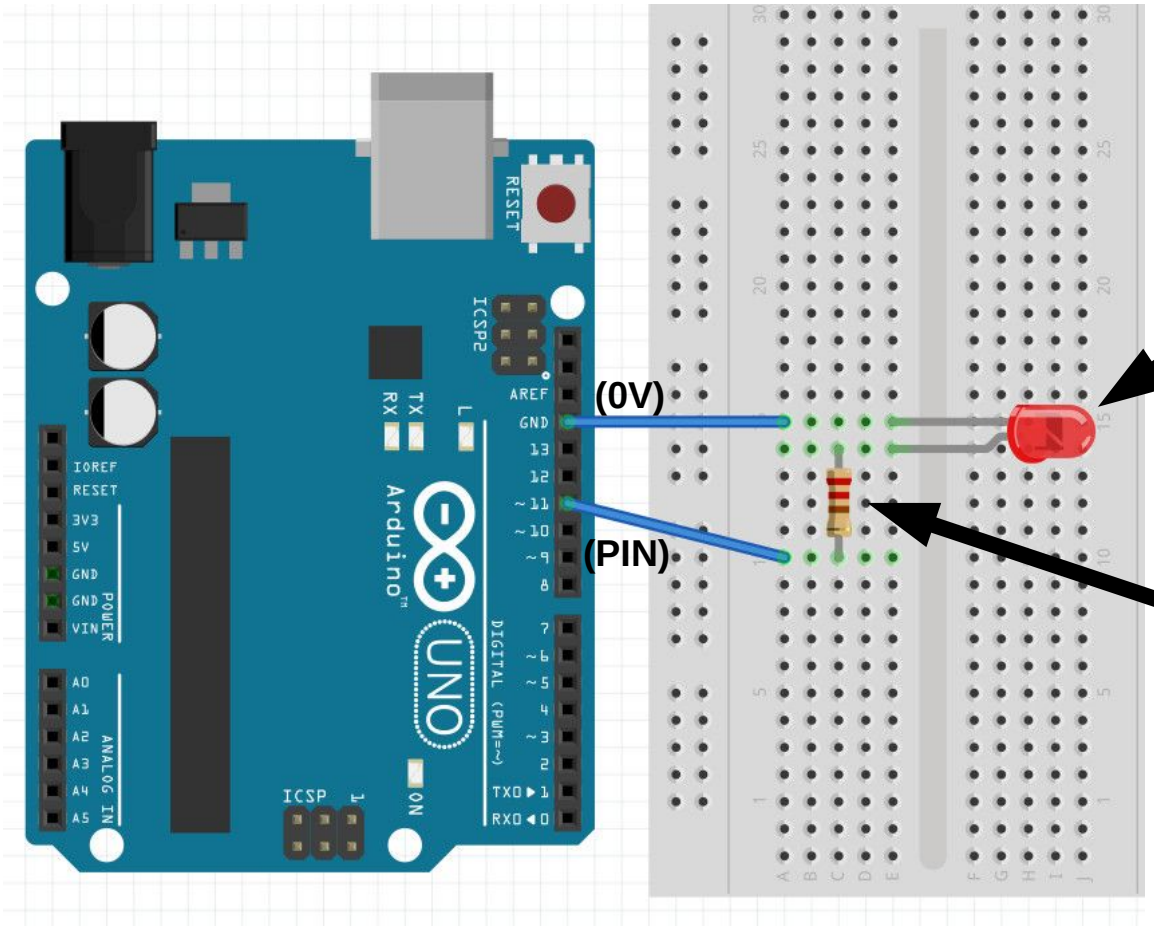
Light Control

- Today we will improve the Basic LED project by introducing dimmer effect



Review LED Circuit



When PIN is set to LOW (0V), there's no voltage differential across circuit, so no current.

When PIN is set to HIGH (5V), voltage differential causes current to flow and light LED.

Controlling Brightness

So, how can we control Brightness?

- Change Resistor
  (not really programmable, but let's **revisit in the next lesson!**)

- Change Power
  But, all of our Output pins are **Digital (On/Off)**

We need PWM!!!

What is PWM?

Pulse Width Modulation (PWM)

- An efficient method to vary and control power
- Used in various electrical systems
  - Lights
  - Motors
  - Comms & others

Change Power

- We can On/Off or HIGH/LOW or 5V/0V

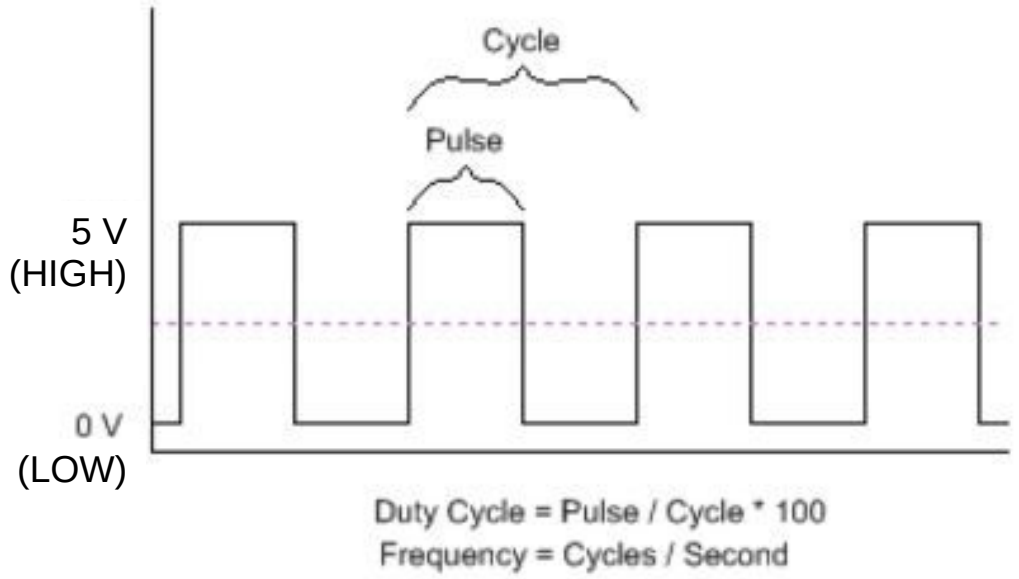
  But, what if we wanted **%50 power**?

- Can’t set digital output to 2.5V….

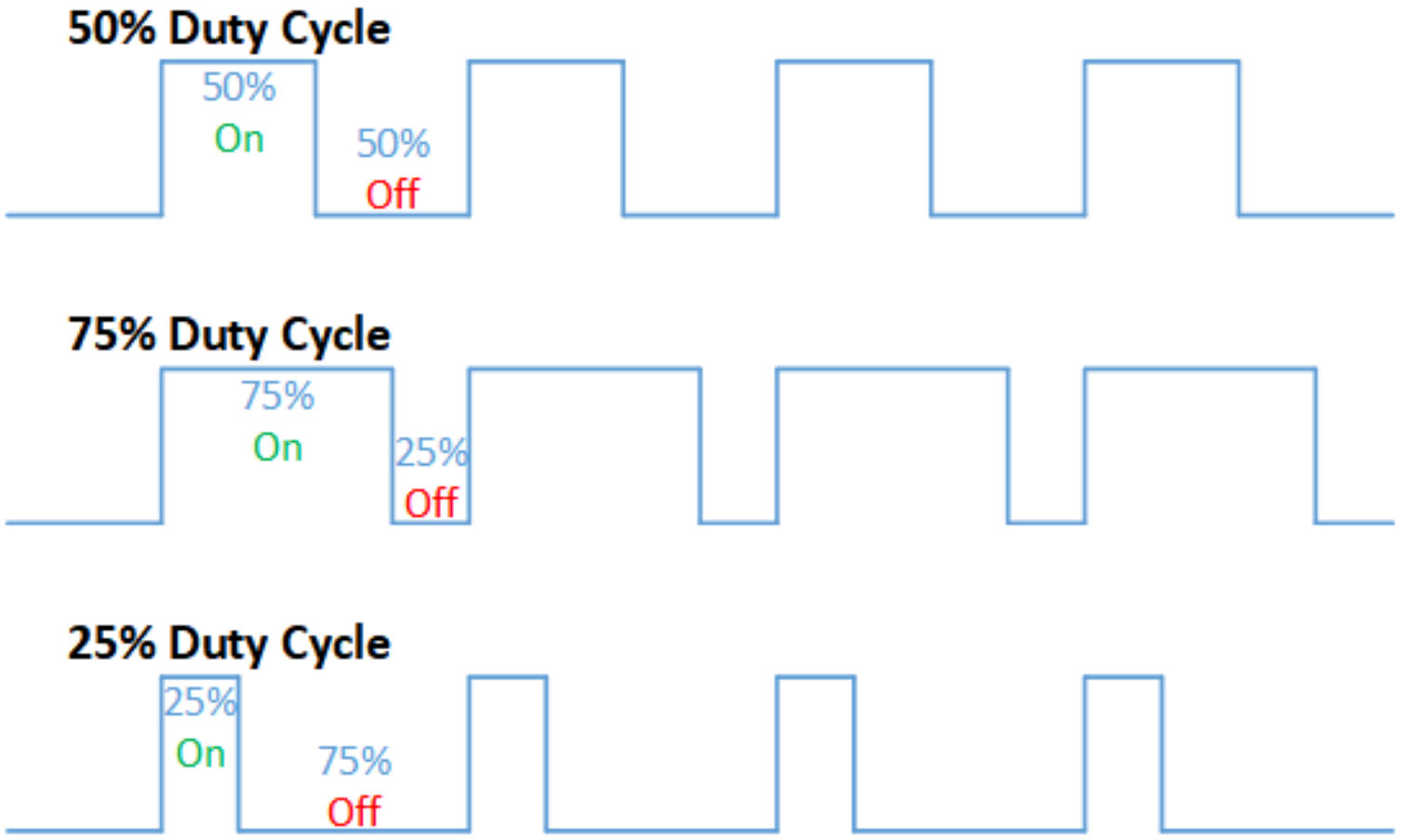
    - So, add ***Time*** to the equation!

%50 Duty Cycle

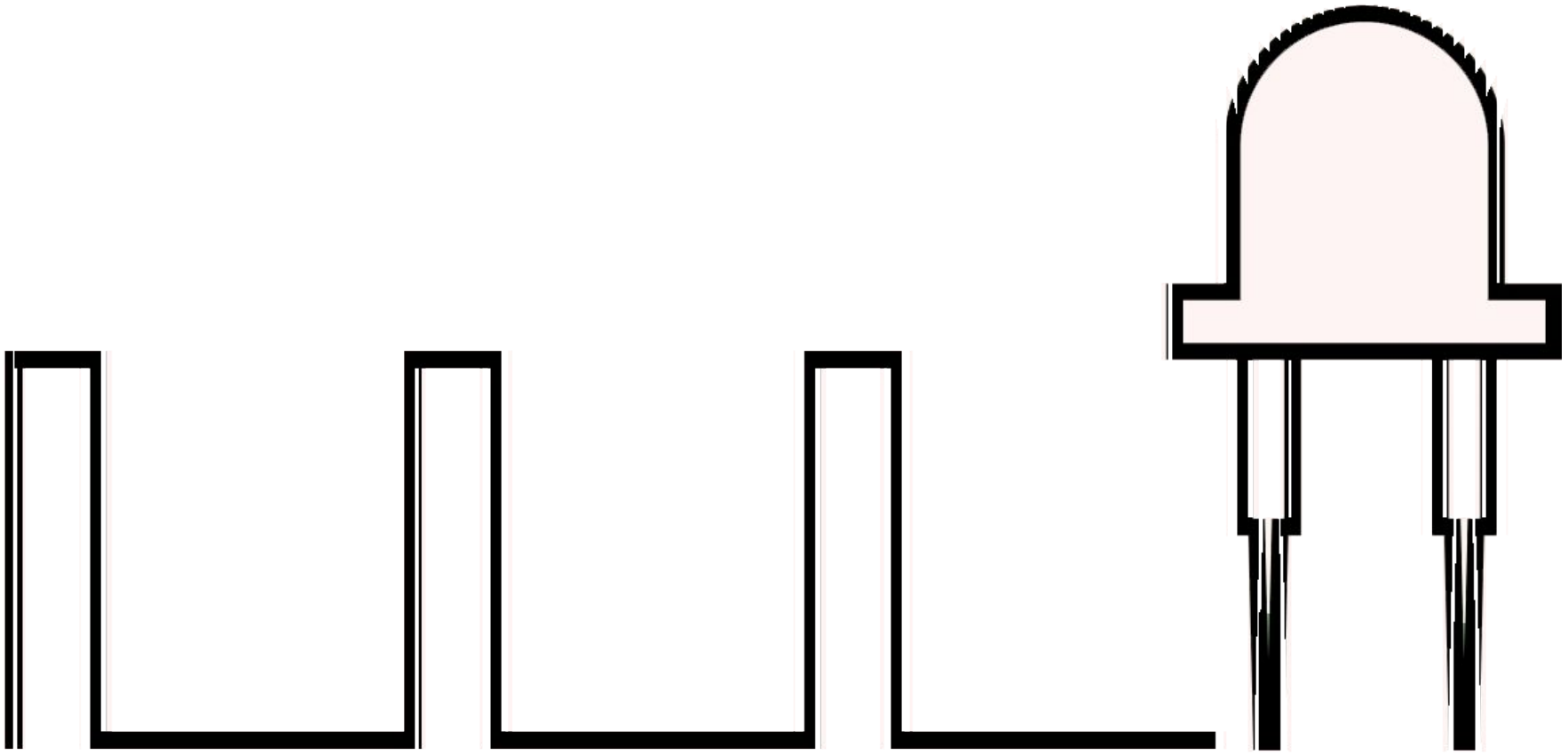
- Pick some Interval or Period (1 ms, or 1000 Hz)
- Set signal to HIGH ½ of the period (0.5 ms)
- Set signal to LOW rest of the period (0.5 ms)
- Run signal over and over...



Duty Cycle

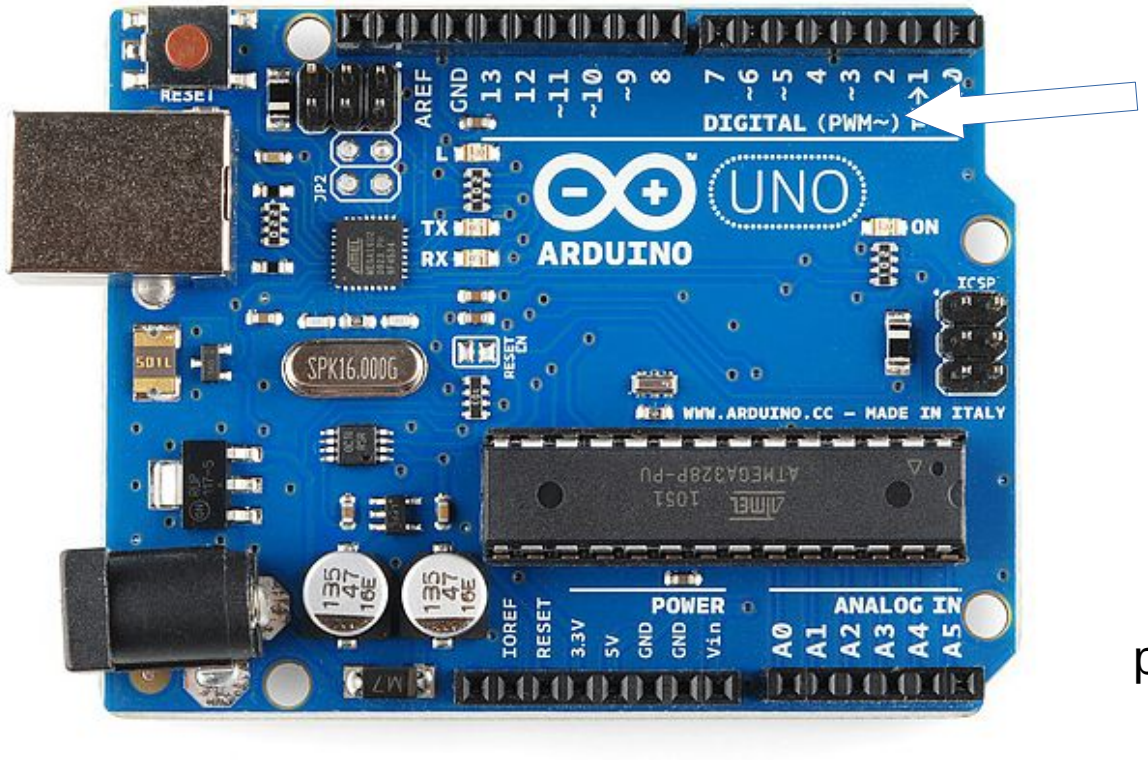

50% Duty Cycle
50%
On
50%
Off
75% Duty Cycle
75%
On
25%
Off
25% Duty Cycle
25%
On
75%
Off

Duty Cycle



PWM Pins

- Today we'll work with Pulse Width Modulation (PWM)
- Take note which pins support PWM



The board usually indicates which pins have PWM built-in support

In this case Pins 3,5,6,9,10,11 (see '~')

All output pins are **digital** (LOW/HIGH), so we can only vary power using something like the PWM method

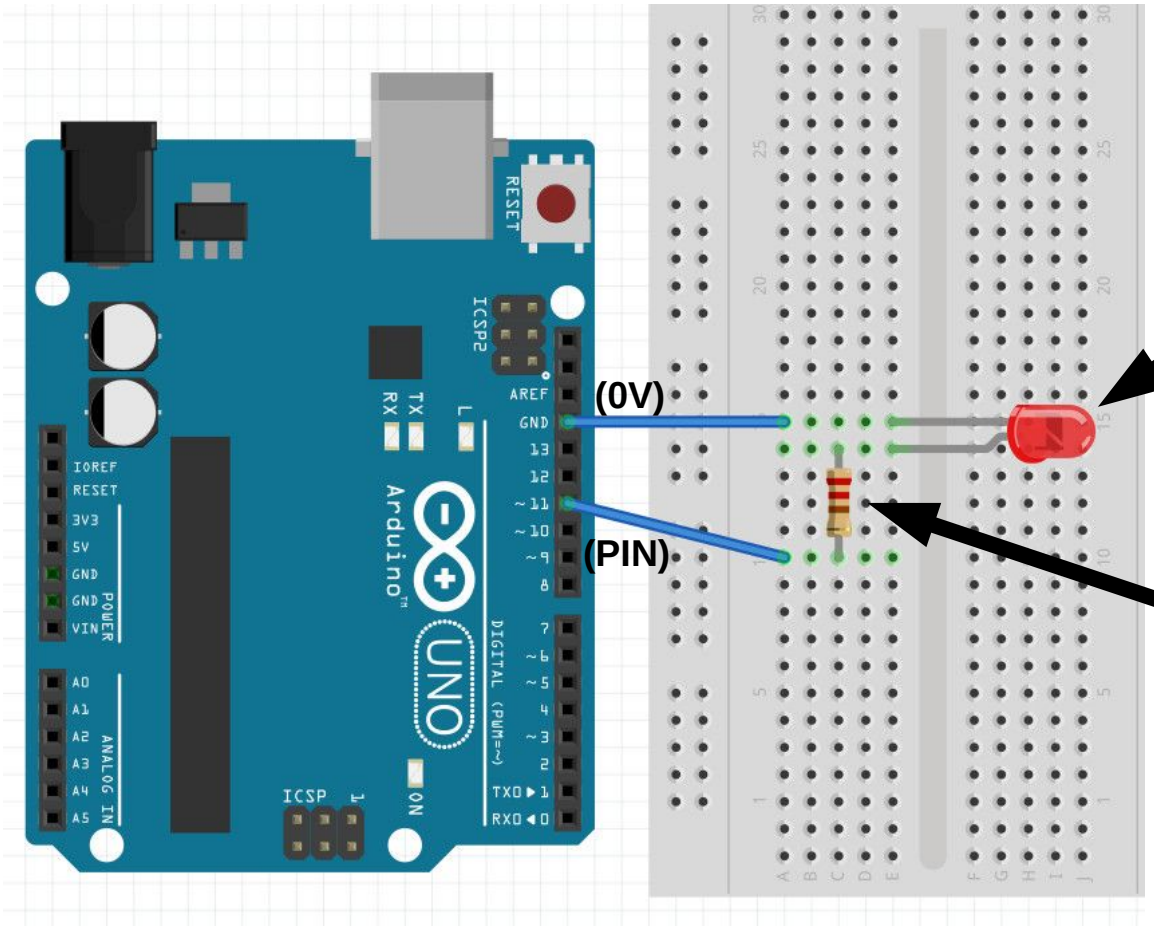
Exercise 2a

Control LED Brightness

A POSTERIORI

Play · Experience · Learn

Review LED Circuit

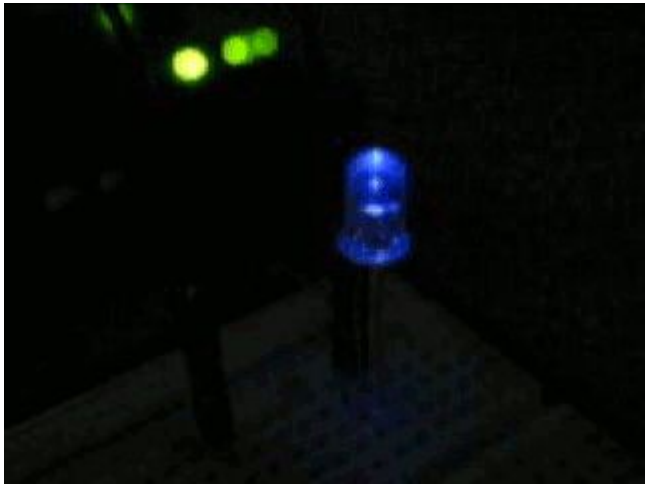


When PIN is set to LOW (0V), there's no voltage differential across circuit, so no current.

When PIN is set to HIGH (5V), voltage differential causes current to flow and light LED.

Light Control

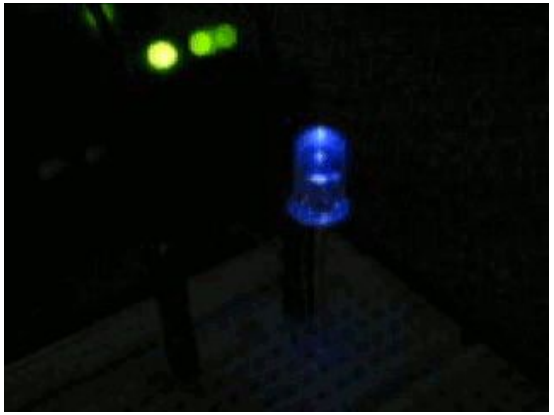
- Back to our dimmer effect...



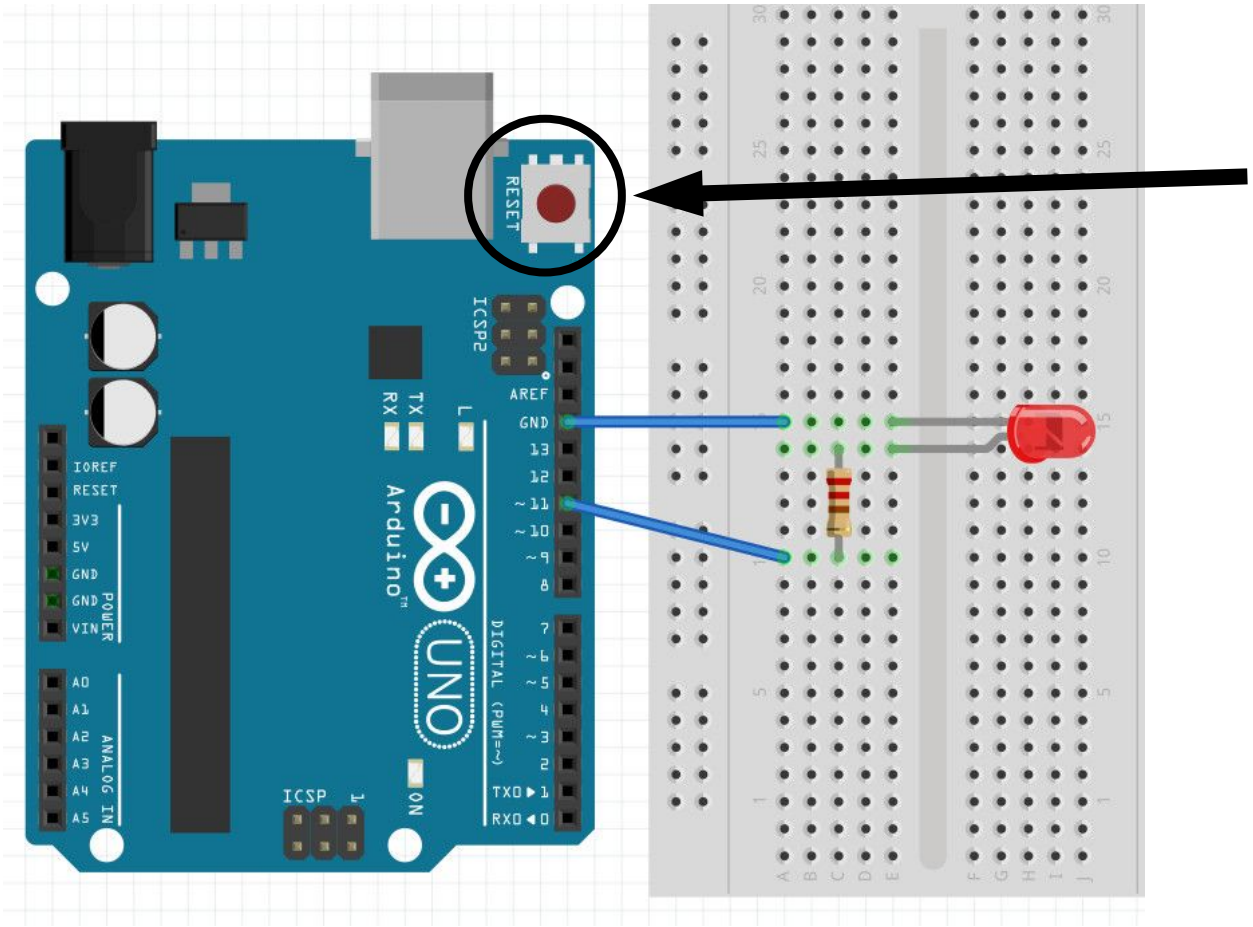
- Can you use your program to create this effect?

Light Control

- Sort of...
  If we want a smooth dimmer effect we need to run LED through all/many PWM levels 0-255



RESET to Restart



Press **RESET** button to restart Arduino, and rerun the uploaded program

Current Limits

- Arduino UNO max current
  - 40 mA per I/O pin
  - 200 mA total
  - 5V pin can supply 500mA (cannot control in program)

20mA

150mA

300mA

1.8A (each motor)

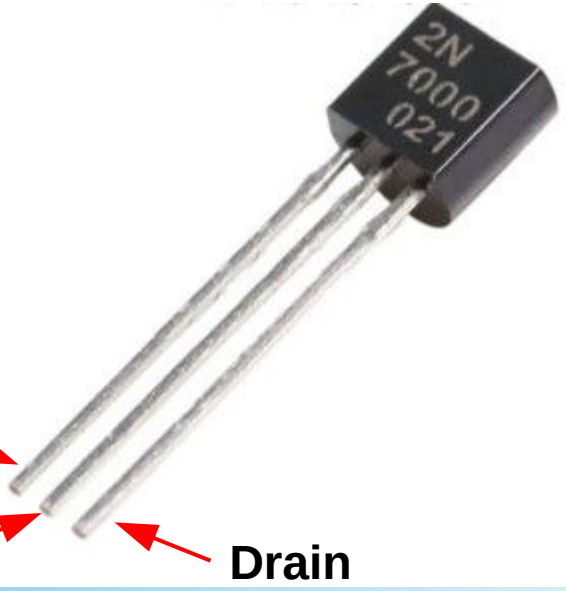
Current Limits

- 40mA is only enough for…
  - Small LEDs
  - Small speakers
  - Sensors (...most requires very little current)

Transistor

- Works like a switch
  - Can control much higher current than an Arduino
  - Receives electrical signal from the Arduino to turn on or off

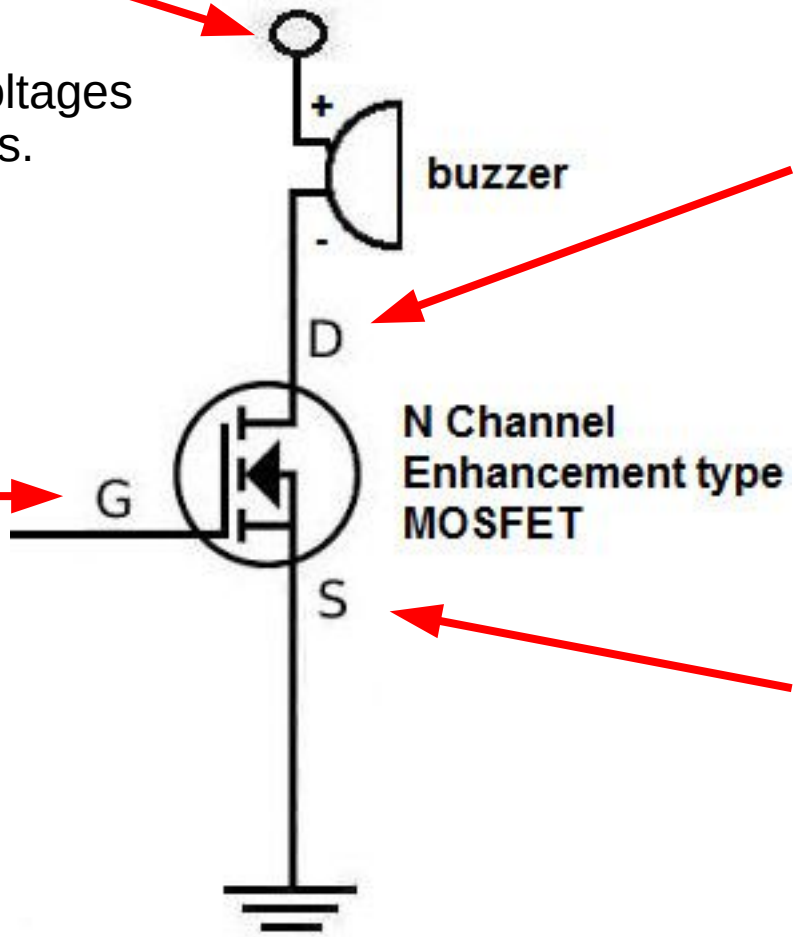
Works the same, but without the finger



Transistor

Positive Voltage
Connect to Arduino Vin pin.

Can also connect to higher voltages to drive more powerful devices.



Drain
Connect to the load.
Load can be a buzzer, LED, motor, etc...

Gate
Connect to Arduino I/O pin (eg. pin 11).

Transistor turns on when pin 11 is **High (5V)**.

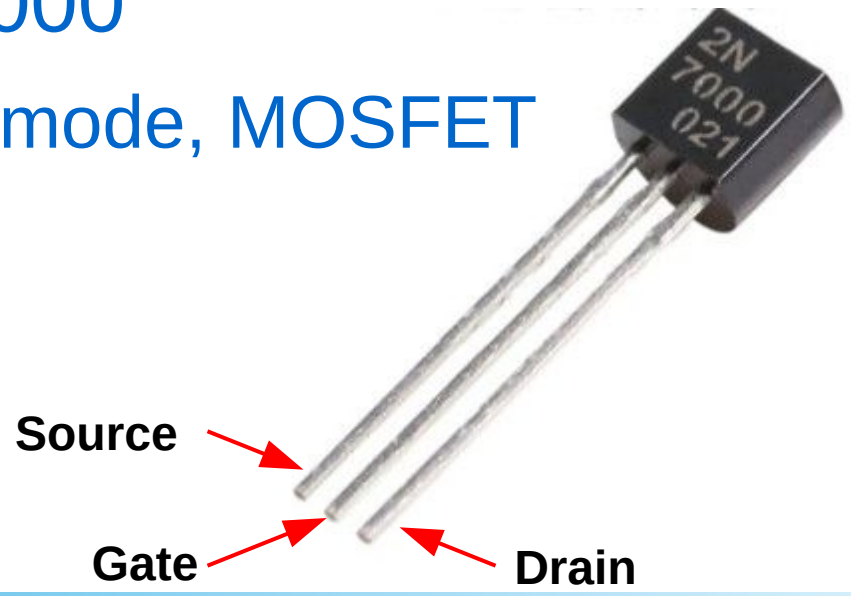
Transistor turns off when pin 11 is **Low (0V)**.

Source
Connect to Gnd

Transistor

- Many types of transistors…
  - BJT, Darlington, MOSFET, JFET, PNP, NPN, etc…

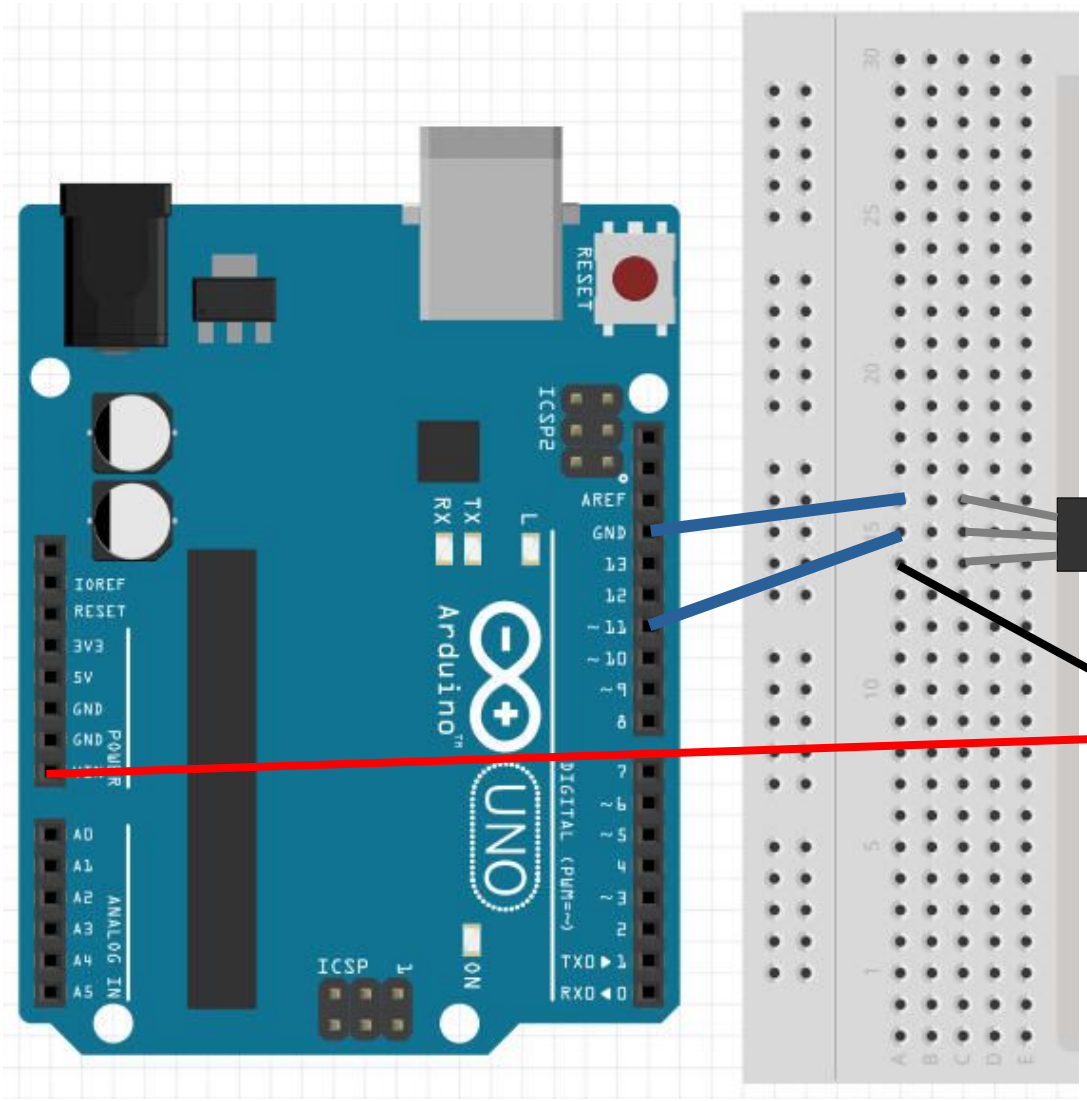
- Model we are using: 2N7000
  - N-channel, Enhancement-mode, MOSFET
  - Max voltage 60V
  - Max current 200mA



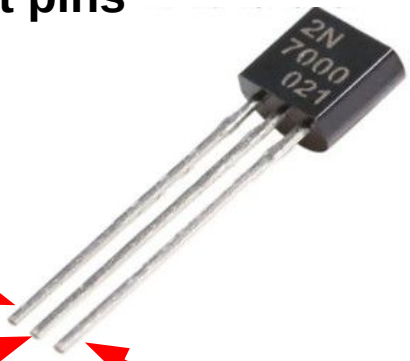
2N7000

- N-Channel
  - Connect transistor between Load and Ground
- Enhancement-mode
  - Supply voltage to turn on
- MOSFET
  - Gate draws very little current (...treated as zero)

Transistor + Pump



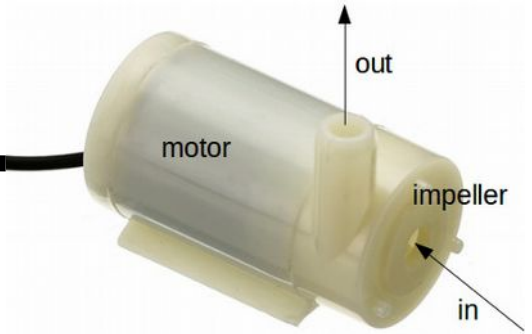
Here we connect gate to pin 11, but you can use any of the output pins



Source

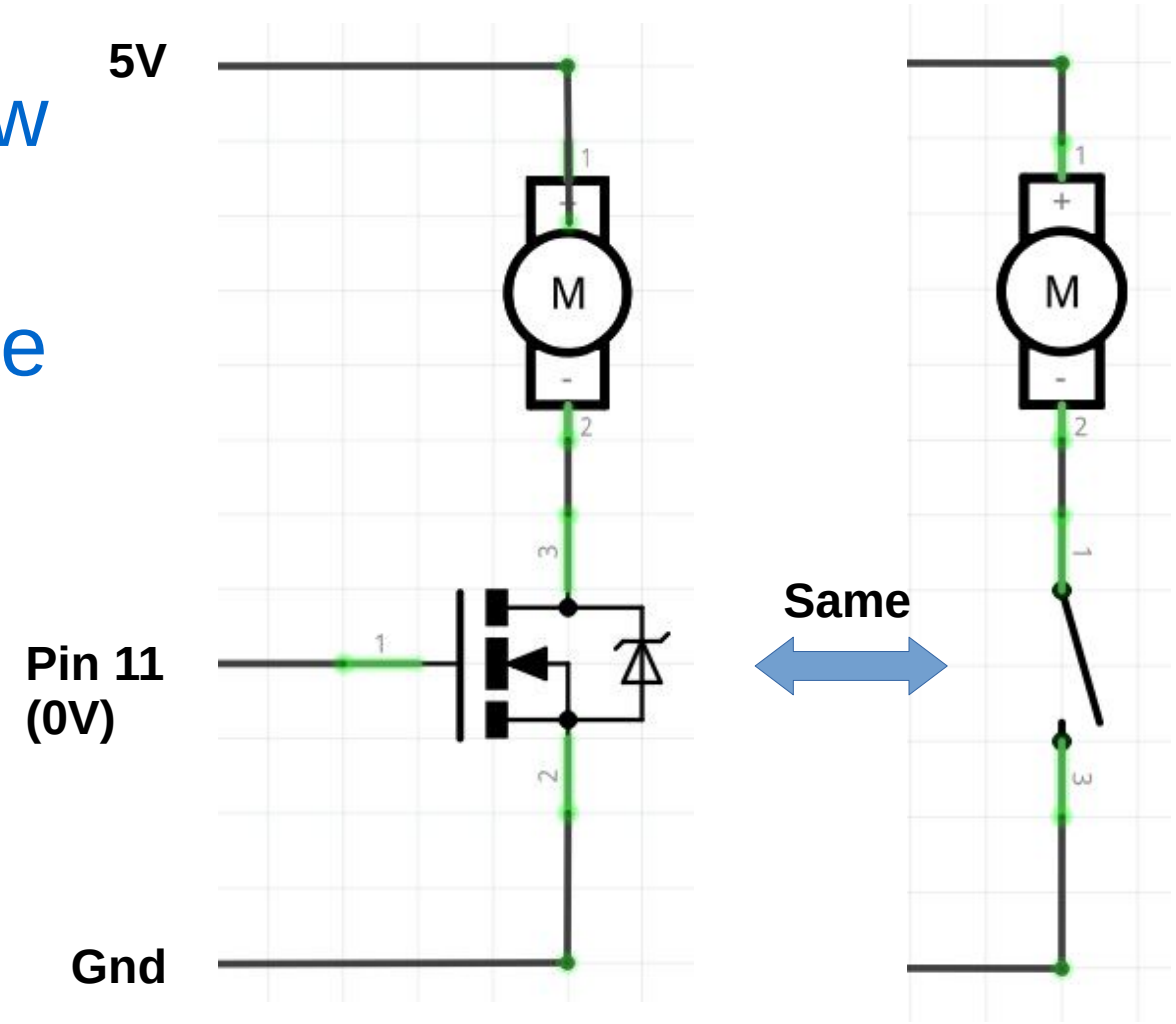
Gate

Drain



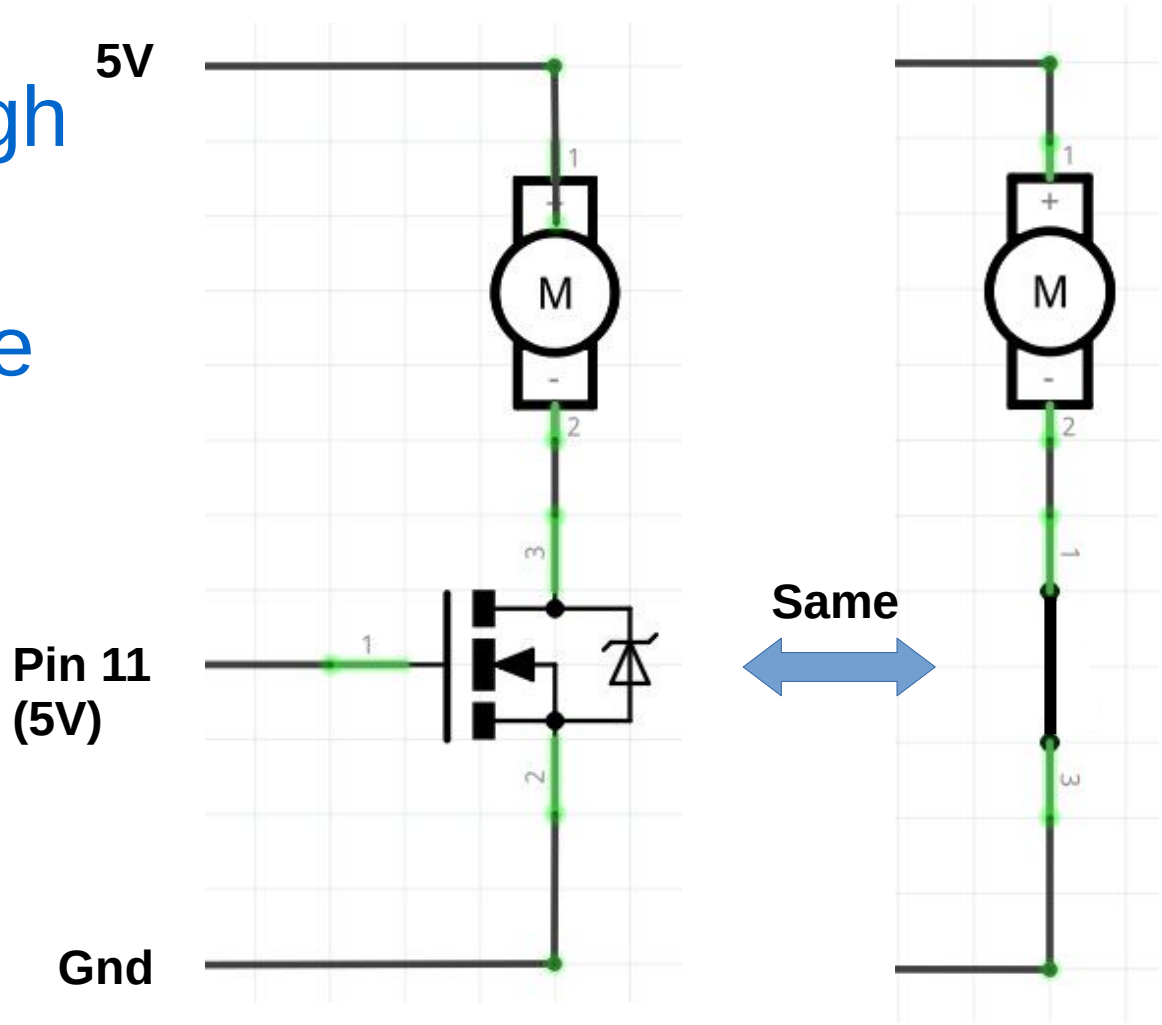
Transistor + Pump

- When pin 11 is low (0 V)
- Transistor acts like an opened switch



Transistor + Pump

- When pin 11 is high (5 V)
- Transistor acts like an closed switch



Try Out

- Like an LED, we can adjust the power of the pump using PWM.
- Unlike an LED, the pump may not turn at all if the PWM power is too low

What’s the lowest power you can set and still have the pump turn?

Minimum Power

- Unlike an LED, a pump motor has inductance. This means that it takes a while for the current to flow.
- The pump will also need to overcome friction to start turning.
- If the PWM power is too low, it’s not enough to overcome friction.

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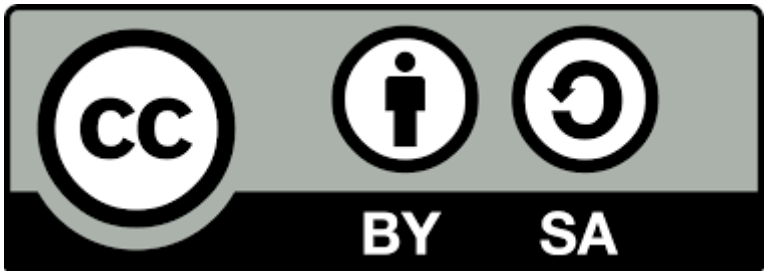
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