EP1000

Embedded Systems 1

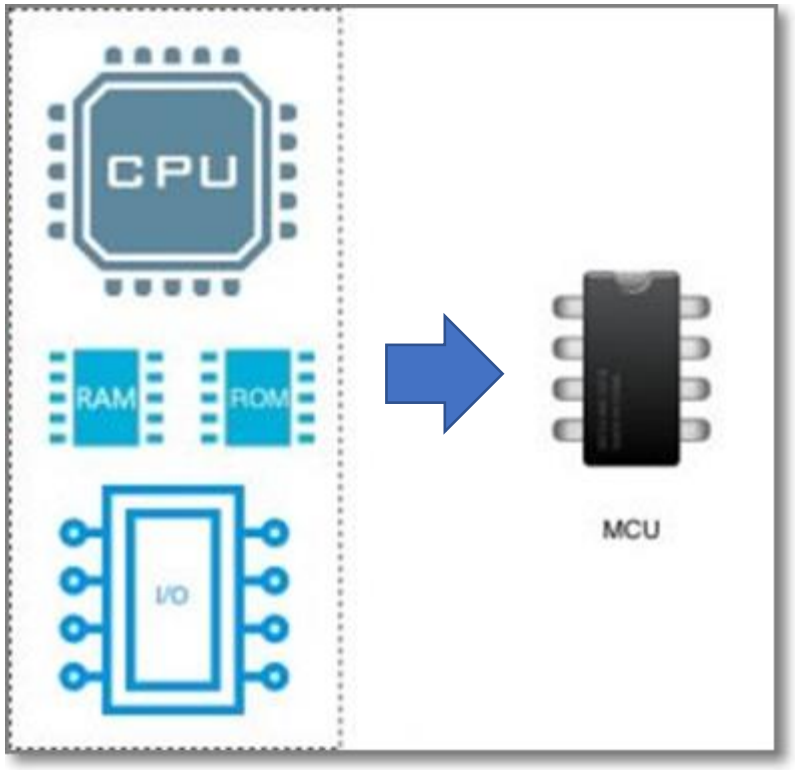
Embedded Systems

- A dedicated computer system with a dedicated function within a larger system to perform a specific task. E.g. smart TVs, ovens
- After development with a microcontroller, the circuit could be reduced to a single IC with support devices.

AudioQuest Dragonfly audio Digital-Analog Converter

Microcontroller Systems

- Combines
  - Microprocessor
  - Memory (RAM, ROM)
  - Input Output
    - Digital
    - Analog
    - Interface protocols
  - Timing
  - Other peripherals
- Into a Single chip



Common Microcontrollers

- Atmel
  - ATTiny 45, 44, 412, 1614
  - ATMega 328, 3u24
- ARM
  - D11C, D21E
- Xtensa
  - ESP8266, ESP32
  - Integrated RF, Bluetooth, networking

The Arduino Embedded System

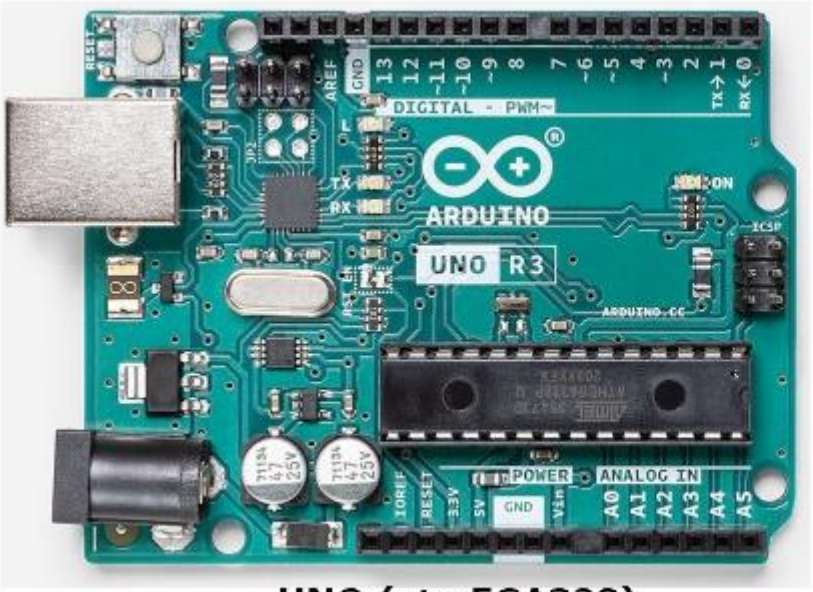
- An Arduino Embedded System comprises of
  - Software & Software Tools
    - Integrated Development system (IDE)
    - Arduino programming language (based on Processing)
    - Development & Debugging Tools
    - Software libraries
  - Hardware
    - ATmel processor boards (and others)
    - Shields (add-on modules)
    - Sensors, actuators, peripherals
  - Open Source Platform

Arduino Systems

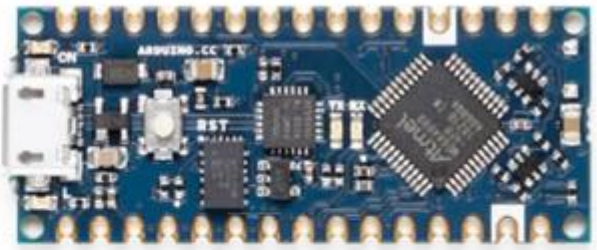
- A hardware and software company based in Italy
- Initial development – software (based on Processing) and later hardware boards (Atmel based)
- Produces and markets “official” boards: Uno, Due, Leonardo, Diecimila, Mega, Nano
- Software and hardware is open source.

Why use Arduino Systems

- Open source libraries & support
- Inexpensive, lots of clones, 3rd party manufacturers
- Simple, clear programming environment using GUI
- Cross-platform (Windows, MacOSx, Linux)



UNO (atmEGA328)



Nano (atmEGA328)

Digispark (ATTiny85)

Arduino Uno

- Most common microcontroller board to begin Arduino projects.
- Uses a ATmel Atmega328P processor with a separate programmable interface using another Atmel processor and USB.
- Has sockets for interfacing and power.
- So popular that it is called Arduino. (Please don't make this mistake!)

"Arduino" or "Uno"

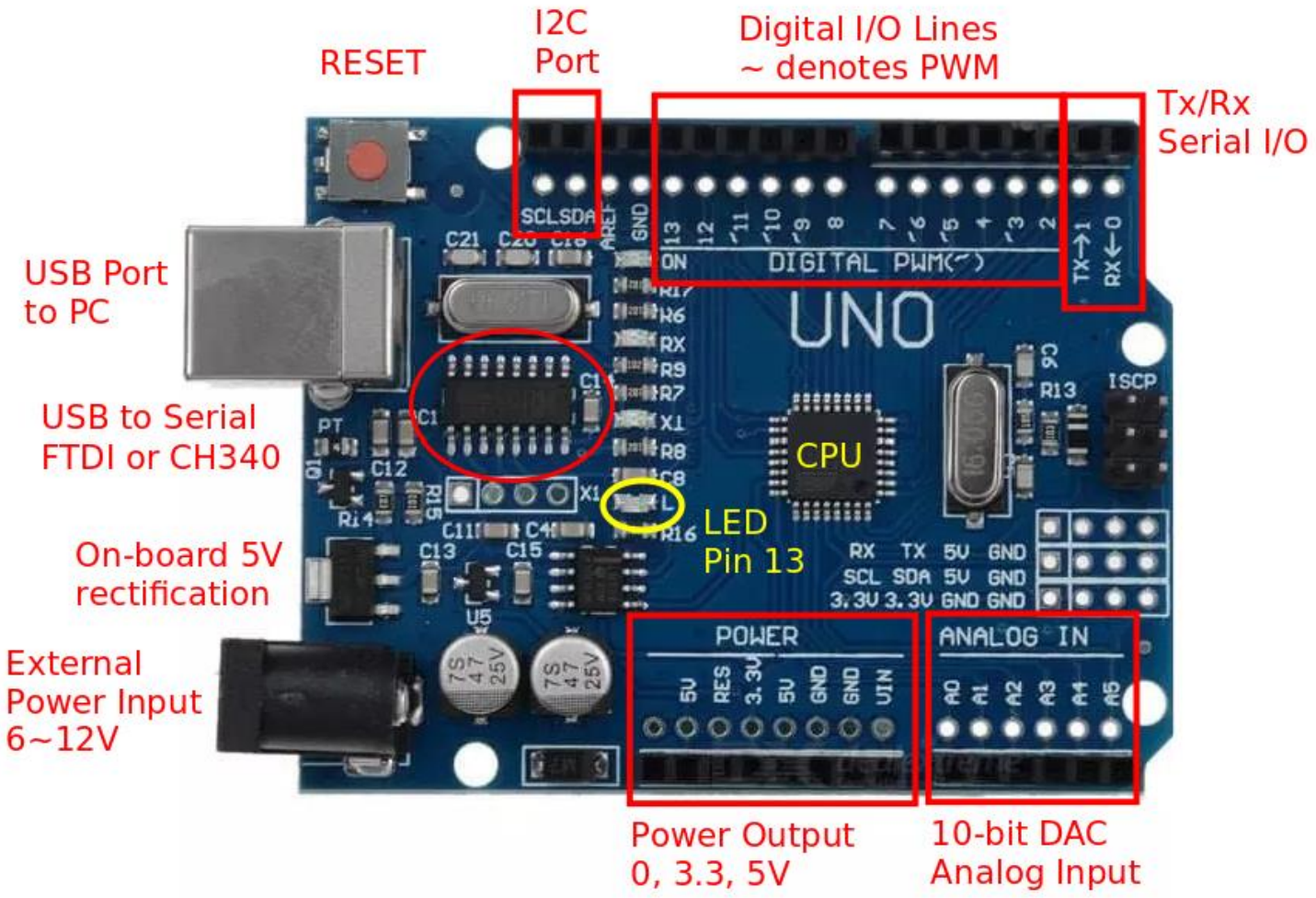
Variations of the Uno

- Being open-source, there are many variations.
- Programming and usage are basically the same with some minor variations.
- All boards use the ATMega328P processor (may be in different formats)
- All boards have the same I/O pins
- Difference is in $$cost$$

Main Uno board difference

- Expensive boards use the FTDI chip for USB
  China clones use the CH340 chip
- Need to install the CH340 drivers.
- Lots of tutorials from Google

Uno Board Features



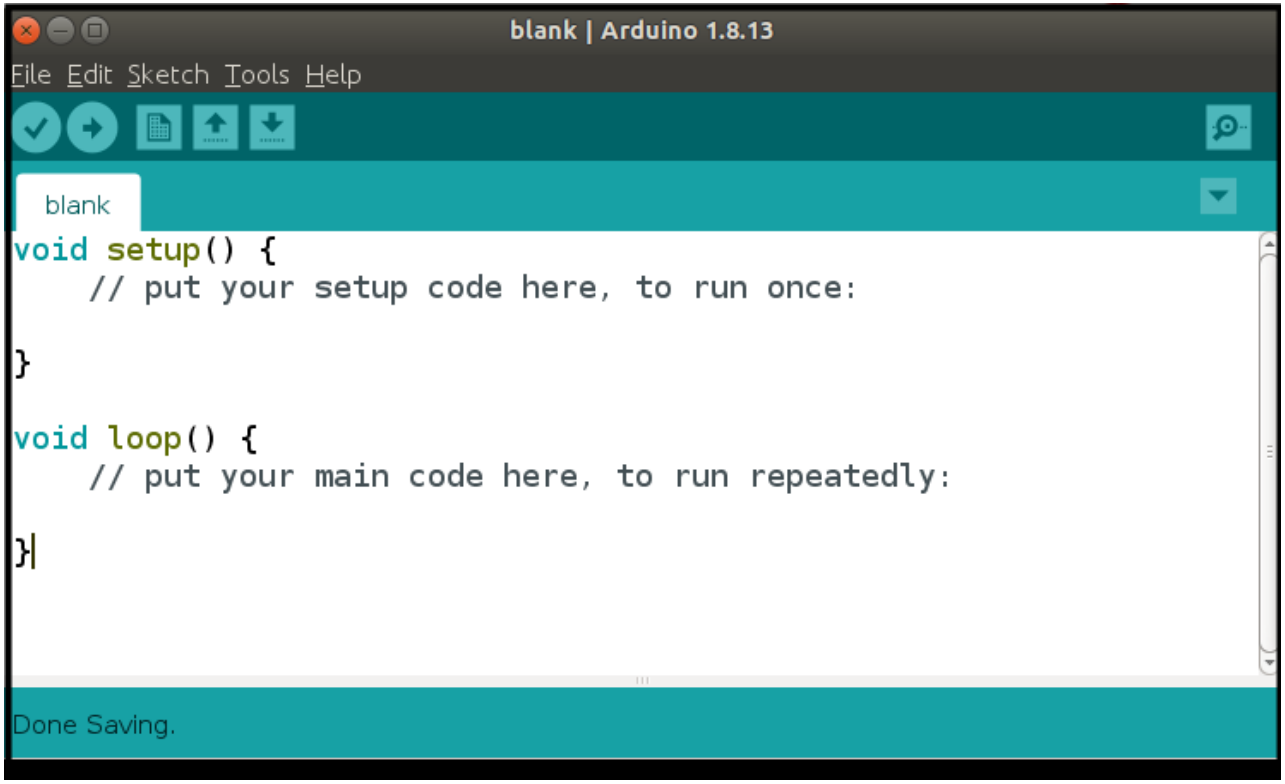
Uno Board Features

- Power
  - Can be powered from USB port (<0.5A)
  - External power from DC jack 6V ~ 12V
  - Power outputs: 0 (GND), 3.3V, 5.0V (up to 0.3A), Vref (5V)
- Digital Input/Output pins
  - Can be configured as Input, Output or Pull-Up Inputs
  - Has Pulse-Width-Modulation on ~ indicated Pins
  - Built-in LED on Pin13
- Analog Inputs
  - 10-bit Analog inputs
- Others
  - Serial I/O interface
  - I2C interface
  - SPI interface

Programming the Uno

- Requires an Integrated Development Environment
  - Download from Arduino.CC
  - Suggest using v2.0 BETA because of features
    - Syntax highlighting
    - Auto Assist in typing keywords (CTRL-SPACEBAR)
- Arduino programs are called sketches.
  - In text
  - Have extension .ino

Programming: Getting Started



- Saved as sketches (extension .ino)
- Follows most characteristics of a C++ syntax/structure
- Always has 2 functions:
  - setup() – code is only executed once
  - loop() – code is continuously looped

setup()

- Executed only ONCE after each powerup or reset of the UNO.
- UNO is automatically reset after each successful sketch upload
- Contains
  - initialization code
  - initialization of variables
  - setup and configuration of I/O ports
  - setup of other interfaces
- Tip: Use identifiers to name your I/O pins, it makes programming and code recognitions much easier

loop()

- The loop() function is executed after the setup() code completes.
- Loops infinitely executing code within the loop() function.
- Place your code/program within this function, there is NO stopping this code

Coding Tips

- Arduino code is loosely based on C++ (actually Processing)
- Follow good C++ programming habits:
  - use comments
  - indent your code
  - use UPPERCASE to denote constants or defines
  - name your variables intelligently

Digital Input/Output

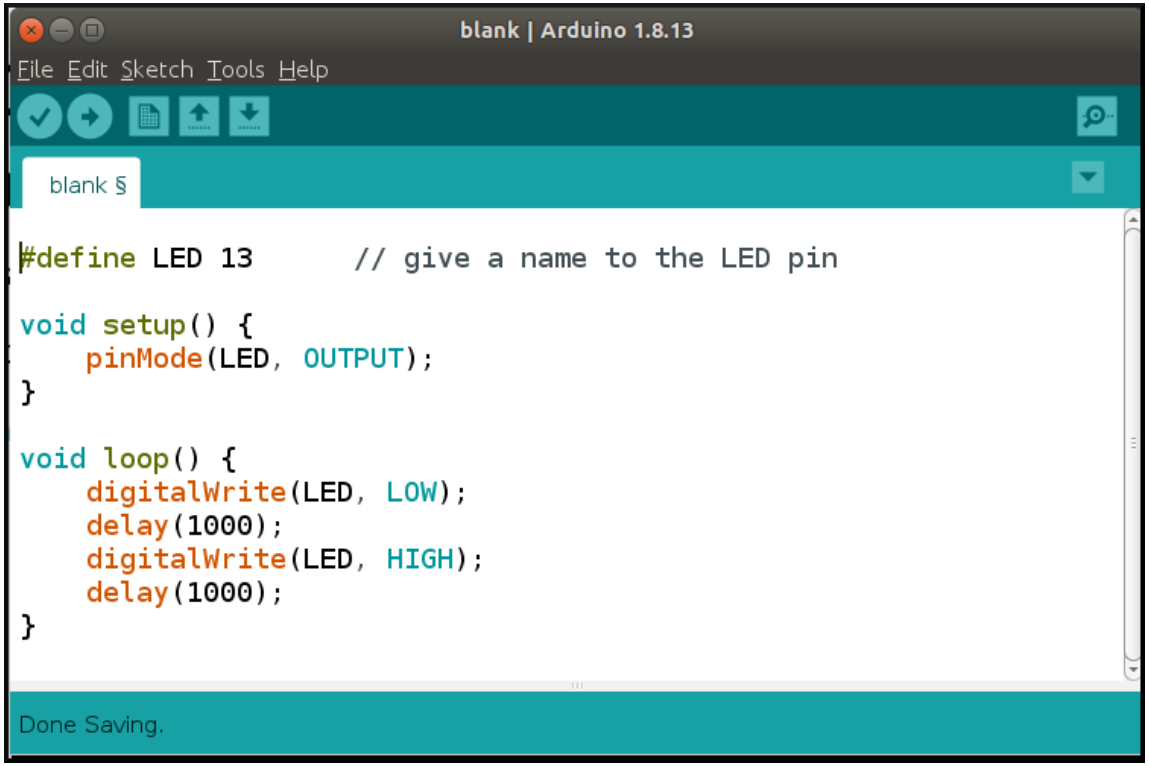
- ATMega328 has 14 digital I/O Pins
  - labelled pin0 to pin13
  - Pin0(Tx), Pin1(Rx) are assigned as Serial I/O
  - Pin3, Pin5, Pin6, Pin9, Pin10 and Pin11 have PWM functionality
- Digital values
  - 0 (0 V, GND, ON, LOW)
  - 1 (5 V, Vcc, OFF, HIGH - typically > 3.3 V)
- Some pins are multifunctional, i.e. have different functions depending on how they are initialized.
  - inputs (default)
  - inputs with pull-up resistors
  - outputs
  - Pulse Width Modulation outputs

Digital Input/Output

- Arduino provides useful functions and libraries simplifying these operations
  - pinMode() - initialises the pin
  - digitalRead() - reads/inputs a digital value
  - digitalWrite() - outputs a digital value
  - analogWrite() - outputs a PWM

Digital Output

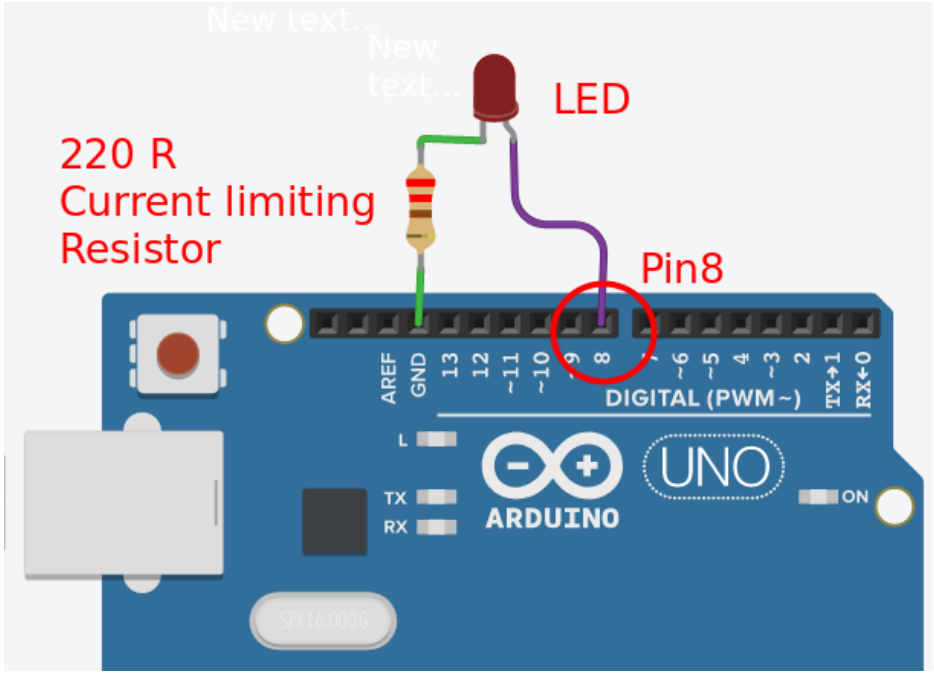
- Let's blink (turn ON/OFF) the on-board LED
  - pinMode() initialises pin13 to be an OUTPUT pin
  - digitalWrite() outputs a 0 or a 1 alternately
  - delay of 1 second to allow us to view the result



pinMode(pin, MODE)

- Configures specified pin to behave either as input or output.
- Modes available
  - INPUT
    digital input mode (high-impedance states)
  - INPUT_PULLUP
    digital input mode with internal 20K-50K ohm pull-up resistor
  - OUTPUT
    digital output mode
    able to source up to 40mA per pin, total of 200mA per chip

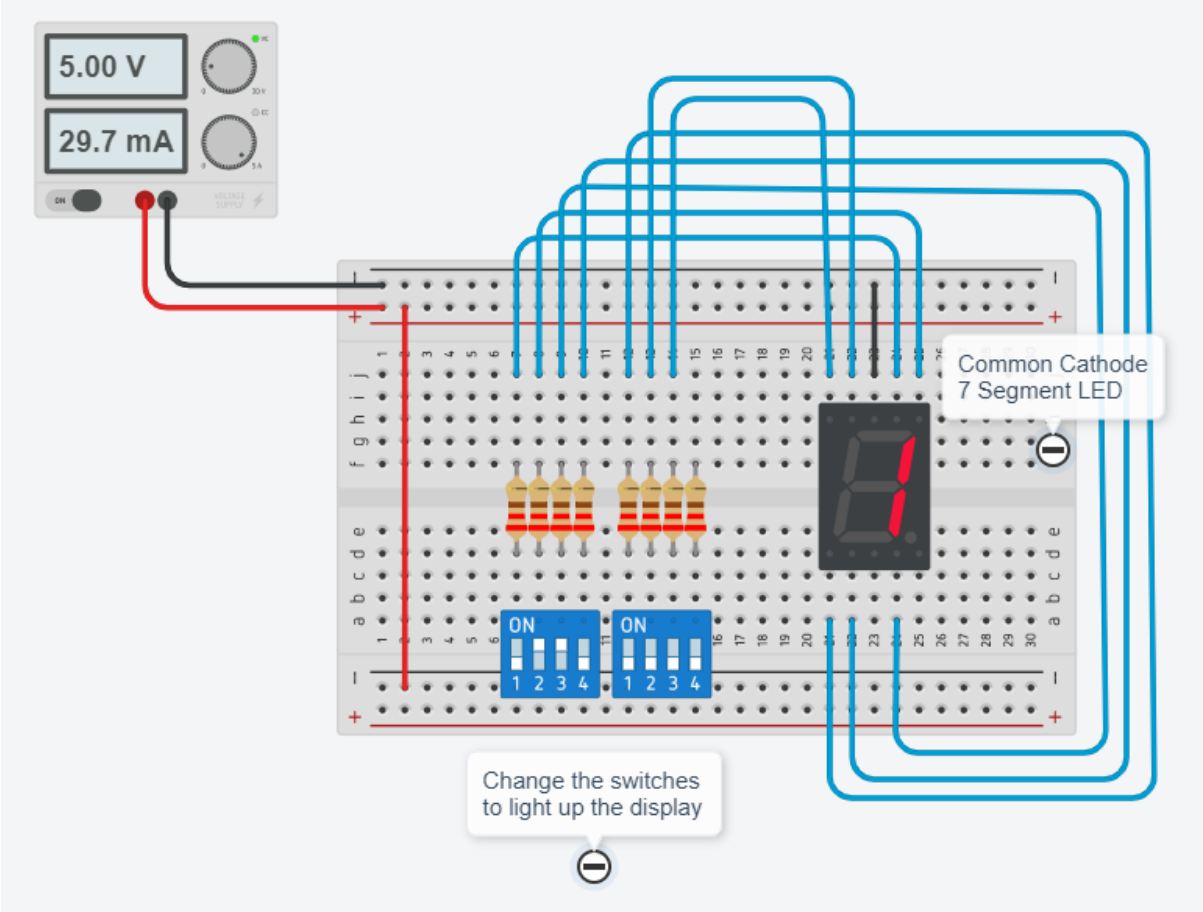
Using an External LED



- Let's blink an external LED
  - need to WIRE-up the circuit
  - requires a current-limiting resistor
  - change the pin to 8
  - Compile, Upload, Execute!

What is the purpose of the resistor?
Which pins can be used as output pins?
Can you add additional leds?

Assignment: A countdown timer



- Seven segment LED
  - Made up of 7 separate LEDs
  - Combined in segments, forms digits
- Change the switches to see the effect

TinkerCAD: CC 7 Seg LED

Assignment: A countdown timer

1. Experiment with the 7-segment circuit
2. Convert the circuit which uses an Uno to control the 7-segment CC display
3. Write a program that counts from 0 to 9 continuously

Why I should use Arduino IDE 2.0?
Why can't I use a single resistor at the CC pin?

Review: This lesson

- Review the notes (Introduction to Arduino Systems)
- Install Arduino IDE (ver 2)
- Use TinkerCAD, play with Uno + single LED
- Use TinkerCAD, open Uno CC 7 Seg display
  - Check out codes of digits 0..9
  - Replace switches with UNO
  - Program UNO to display 0..9 continuously, 1 second between digits

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End