BLG351E-Microcomputer Lab.
Fall 2020-2021

Res. Assist. Kadir OZLEM

General Information

- Presentation days and hours:
  - Monday: 13:30-15:30 , CRN11641,
  - Thursday: 13:30-15:30 , CRN11639,
  - Friday: 15:30-17:30 , CRN11637.
- Course Web Page: Ninova path: BLG351/CRN: <<Your CRN Number>>
- Instructor: İlkay Öksüz
- Teaching Assistants:
  - Abdullah Ekrem Okur (okurabd@itu.edu.tr)
  - Kadir Özlem (kadir.ozlem@itu.edu.tr)
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Evaluation Criteria

- Laboratory performance: 50% (8 Experiments x 6.25 points),
  - %25 Code & Design
  - %25 Presentation
- Reports: 50% (8 experiments x 6.25 points)

- Note:
  - You will make experiments as groups that consist of 3 students.
  - If a student didn't join a group and not on any list, they will be inserted into other groups randomly.
  - If your group has less than 3 students, other students will join your group randomly.
  - Only one student in the group should send the list through the Ninova.

Schedule

Week*	Activity	Homework
19.10.2020	No Class	
26.10.2020	No Class	
02.11.2020	Introduction to the Laboratory	
09.11.2020		Experiment 1
16.11.2020	Experiment 1	Experiment 2
23.11.2020	Experiment 2	Experiment 3
30.11.2020	Experiment 3	Experiment 4
07.12.2020	Experiment 4	Experiment 5
14.12.2020	Experiment 5	Experiment 6
21.12.2020	Experiment 6	
28.12.2020	No Class (Happy New Year)	Experiment 7
04.01.2021	Experiment 7	Experiment 8
11.01.2021	Experiment 8	
18.01.2021	No Class	

* Week that starts on the shown date

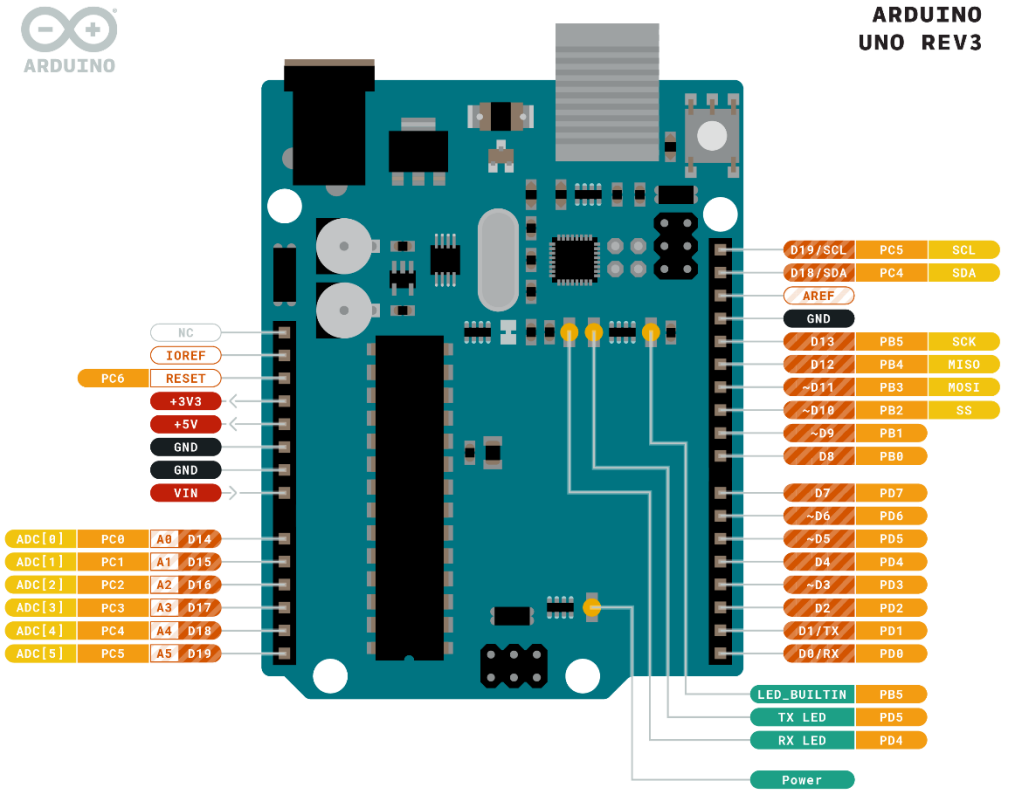
- Presentation
- Homework

Arduino Board

TINKERCAD AUTODESK® TINKERCAD®

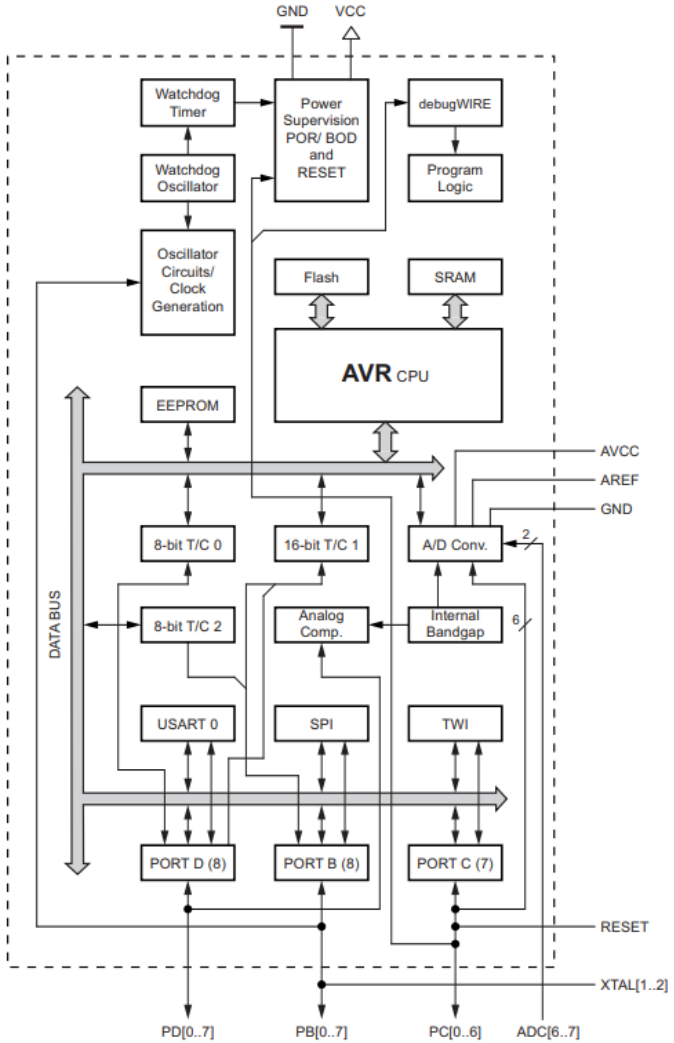
- Arduino is an open-source electronics platform based on easy-to-use hardware and software.
- Arduino boards are able to **read inputs** - light on a sensor, a finger on a button, or a Twitter message - and **turn it into an output** - activating a motor, turning on an LED, publishing something online
- Arduino Uno Board (REV 3) will be used.
- **Tinkercad** is a free, easy-to-use app for 3D design, electronics, and coding.
- Experiments will be in Arduino programming language.
- (Experiments contains assembly code blocks)
- Architecture of the Arduino UNO is important.

Arduino UNO Specifications



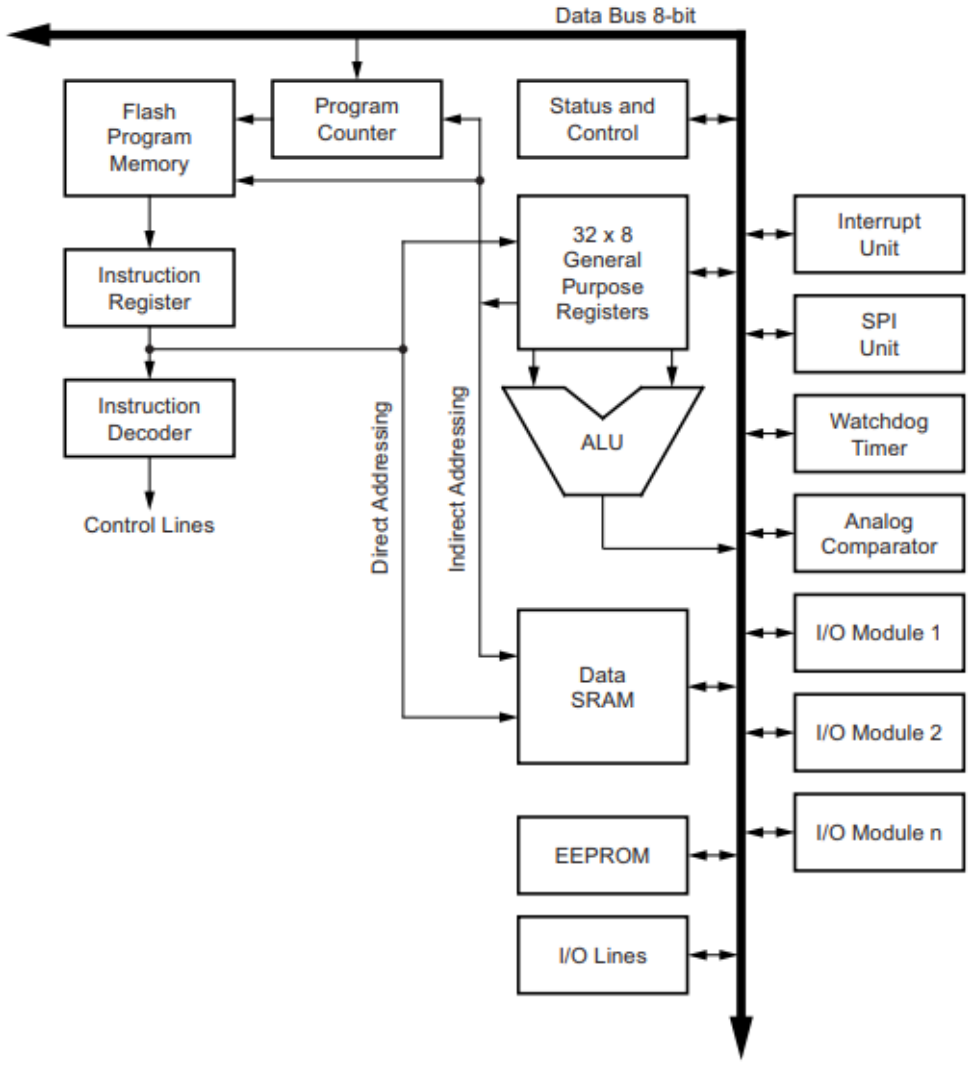
Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
LED_BUILTIN	13
Length	68.6 mm
Width	53.4 mm
Weight	25 g

Atmel® ATmega328P



- A low-power CMOS 8-bit microcontroller based on the AVR® enhanced RISC architecture
- High endurance non-volatile memory segments
  - 32K bytes of in-system self-programmable flash program memory
  - 1Kbytes EEPROM
  - 2Kbytes internal SRAM
- Peripheral features
  - 23 programmable I/O lines
  - Two 8-bit Timer/Counters and One 16-bit Timer/Counter
  - Real time counter with separate oscillator
  - Six PWM channels
  - 8-channel 10-bit ADC
  - Programmable serial USART
  - Master/slave SPI serial interface
  - Byte-oriented 2-wire serial interface (Phillips I2 C compatible)
  - On-chip analog comparator
  - Interrupt and wake-up on pin change

Atmel® ATmega328P

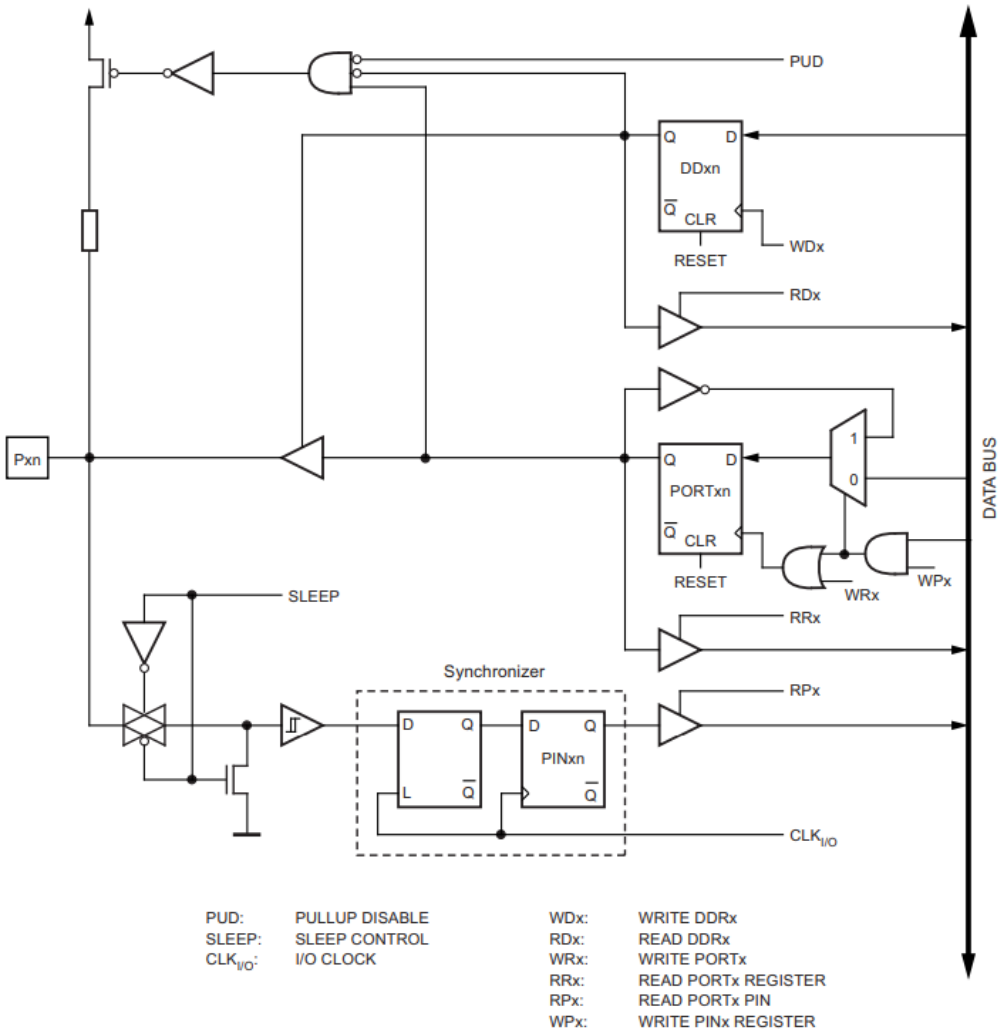


The AVR status register – SREG – is defined as:

Bit	7	6	5	4	3	2	1	0	
0x3F (0x5F)	I	T	H	S	V	N	Z	C	SREG
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

	7 … 0	Addr.	
General Purpose Working Registers	R0	0x00	
	R1	0x01	
	R2	0x02	
	…		
	R13	0x0D	
	R14	0x0E	
	R15	0x0F	
	R16	0x10	
	R17	0x11	
	…		
	R26	0x1A	X-register Low Byte
	R27	0x1B	X-register High Byte
	R28	0x1C	Y-register Low Byte
	R29	0x1D	Y-register High Byte
	R30	0x1E	Z-register Low Byte
	R31	0x1F	Z-register High Byte

Atmel® ATmega328P – General Digital I/O



MCUCR – MCU Control Register

Bit	7	6	5	4	3	2	1	0	
0x35 (0x55)	–	BODS	BODSE	PUD	–	–	IVSEL	IVCE	MCUCR
Read/Write	R	R	R	R/W	R	R	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

- **Bit 4 – PUD: Pull-up Disable**

When this bit is written to one, the pull-ups in the I/O ports are disabled even if the DDxn and PORTxn registers are configured to enable the pull-ups ({DDxn, PORTxn} = 0b01).

PORTB – The Port B Data Register

Bit	7	6	5	4	3	2	1	0	
0x05 (0x25)	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0	PORTB
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

DDRB – The Port B Data Direction Register

Bit	7	6	5	4	3	2	1	0	
0x04 (0x24)	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0	DDRB
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

PINB – The Port B Input Pins Address

Bit	7	6	5	4	3	2	1	0	
0x03 (0x23)	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0	PINB
Read/Write	R	R	R	R	R	R	R	R	
Initial Value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

Arduino Programming Language

- Includes.
- Global variable declaration.

- Initialize variables, pin modes, start using libraries.
- Only run once, after each powerup or reset.

- Loops consecutively
- Allow your program to change and respond
- Use it to actively control the Arduino board.

```
1  volatile uint8_t* port;
2
3  void setup()
4  {
5    DDRB|=B00000001;
6    port=&PORTB;
7    Serial.begin(115200);
8  }
9
10 void loop()
11 {
12   PORTB|=B00000001;
13   Serial.println(*port);
14   delay(1000); // Wait for 1000 millisecond(s)
15   PORTB&=B11111110;
16   Serial.println(*port);
17   delay(1000); // Wait for 1000 millisecond(s)
18 }
```

Arduino Programming Language

FUNCTIONS

For controlling the Arduino board and performing computations.

Digital I/O
- digitalRead()
- digitalWrite()
- pinMode()

Analog I/O
- analogRead()
- analogReference()
- analogWrite()

Zero, Due & MKR Family
- analogReadResolution()
- analogWriteResolution()

Advanced I/O
- noTone()
- pulseIn()
- pulseInLong()
- shiftIn()
- shiftOut()
- tone()

Time
- delay()
- delayMicroseconds()
- micros()
- millis()

Math
- abs()
- constrain()
- map()
- max()
- min()
- pow()
- sq()
- sqrt()

Trigonometry
- cos()
- sin()
- tan()

Characters
- isAlpha()
- isAlphaNumeric()
- isAscii()
- isControl()
- isDigit()
- isGraph()
- isHexadecimalDigit()
- isLowerCase()
- isPrintable()
- isPunct()
- isSpace()
- isUpperCase()
- isWhitespace()

Random Numbers
- random()
- randomSeed()

Bits and Bytes
- bit()
- bitClear()
- bitRead()
- bitSet()
- bitWrite()
- highByte()
- lowByte()

External Interrupts
- attachInterrupt()
- detachInterrupt()

Interrupts
- interrupts()
- noInterrupts()

Communication
- Serial
- Stream

USB
- Keyboard
- Mouse

VARIABLES

Arduino data types and constants.

Constants
- HIGH | LOW
- INPUT | OUTPUT | INPUT_PULLUP
- LED_BUILTIN
- true | false
- Floating Point Constants
- Integer Constants

Conversion
- (unsigned int)
- (unsigned long)
- byte()
- char()
- float()
- int()
- long()
- word()

Data Types
- array
- bool
- boolean
- byte
- char
- double
- float
- int
- long
- short
- size_t
- string
- String()
- unsigned char
- unsigned int
- unsigned long
- void
- word

Variable Scope & Qualifiers
- const
- scope
- static
- volatile

Utilities
- PROGMEM
- sizeof()

Arduino Programming Language

STRUCTURE

The elements of Arduino (C++) code.

Sketch
loop()
setup()

Control Structure
break
continue
do...while
else
for
goto
if
return
switch...case
while

Further Syntax
#define (define)
#include (include)
/* */ (block comment)
// (single line comment)
; (semicolon)
{} (curly braces)

Arithmetic Operators
% (remainder)
* (multiplication)
+ (addition)
- (subtraction)
/ (division)
= (assignment operator)

Comparison Operators
!= (not equal to)
< (less than)
<= (less than or equal to)
== (equal to)
> (greater than)
>= (greater than or equal to)

Boolean Operators
! (logical not)
&& (logical and)
|| (logical or)

Pointer Access Operators
& (reference operator)
* (dereference operator)

Bitwise Operators
& (bitwise and)
<< (bitshift left)
>> (bitshift right)
^ (bitwise xor)
| (bitwise or)
~ (bitwise not)

Compound Operators
%= (compound remainder)
&= (compound bitwise and)
*= (compound multiplication)
++ (increment)
+= (compound addition)
-- (decrement)
-= (compound subtraction)
/= (compound division)
^= (compound bitwise xor)
|= (compound bitwise or)

Libraries

The Arduino environment can be extended through the use of libraries, just like most programming platforms. Libraries provide extra functionality for use in sketches, e.g. working with hardware or manipulating data. To use a library in a sketch, select it from **Sketch > Import Library**.
A number of libraries come installed with the IDE, but you can also download or create your own. See these instructions for details on installing libraries. There's also a tutorial on writing your own libraries. See the API Style Guide for information on making a good Arduino-style API for your library.

- Communication (754)
- Data Processing (164)
- Data Storage (94)
- Device Control (551)
- Display (319)
- Other (287)
- Sensors (664)
- Signal Input/Output (262)
- Timing (146)
- Uncategorized (128)

Standard Libraries

- EEPROM - reading and writing to "permanent" storage
- Ethernet - for connecting to the internet using the Arduino Ethernet Shield, Arduino Ethernet Shield 2 and Arduino Leonardo ETH
- Firmata - for communicating with applications on the computer using a standard serial protocol.
- GSM - for connecting to a GSM/GRPS network with the GSM shield.
- LiquidCrystal - for controlling liquid crystal displays (LCDs)
- SD - for reading and writing SD cards
- Servo - for controlling servo motors
- SPI - for communicating with devices using the Serial Peripheral Interface (SPI) Bus
- SoftwareSerial - for serial communication on any digital pins. Version 1.0 and later of Arduino incorporate Mikal Hart's NewSoftSerial library as SoftwareSerial.
- Stepper - for controlling stepper motors
- TFT - for drawing text , images, and shapes on the Arduino TFT screen
- WiFi - for connecting to the internet using the Arduino WiFi shield
- Wire - Two Wire Interface (TWI/I2C) for sending and receiving data over a net of devices or sensors.

Port Registers

Port registers allow for lower-level and faster manipulation of the i/o pins of the microcontroller on an Arduino board. The chips used on the Arduino board (the ATmega8 and ATmega168) have three ports:

- B (digital pin 8 to 13)
- C (analog input pins)
- D (digital pins 0 to 7)

Each port is controlled by three registers, which are also defined variables in the arduino language. The DDR register, determines whether the pin is an INPUT or OUTPUT. The PORT register controls whether the pin is HIGH or LOW, and the PIN register reads the state of INPUT pins set to input with pinMode(). The maps of the ATmega8 and ATmega168 chips show the ports. The newer Atmega328p chip follows the pinout of the Atmega168 exactly.

DDR and PORT registers may be both written to, and read. PIN registers correspond to the state of inputs and may only be read.

PORTD maps to Arduino digital pins 0 to 7

DDRD - The Port D Data Direction Register - read/write
PORTD - The Port D Data Register - read/write
PIND - The Port D Input Pins Register - read only

PORTB maps to Arduino digital pins 8 to 13 The two high bits (6 & 7) map to the crystal pins and are not usable

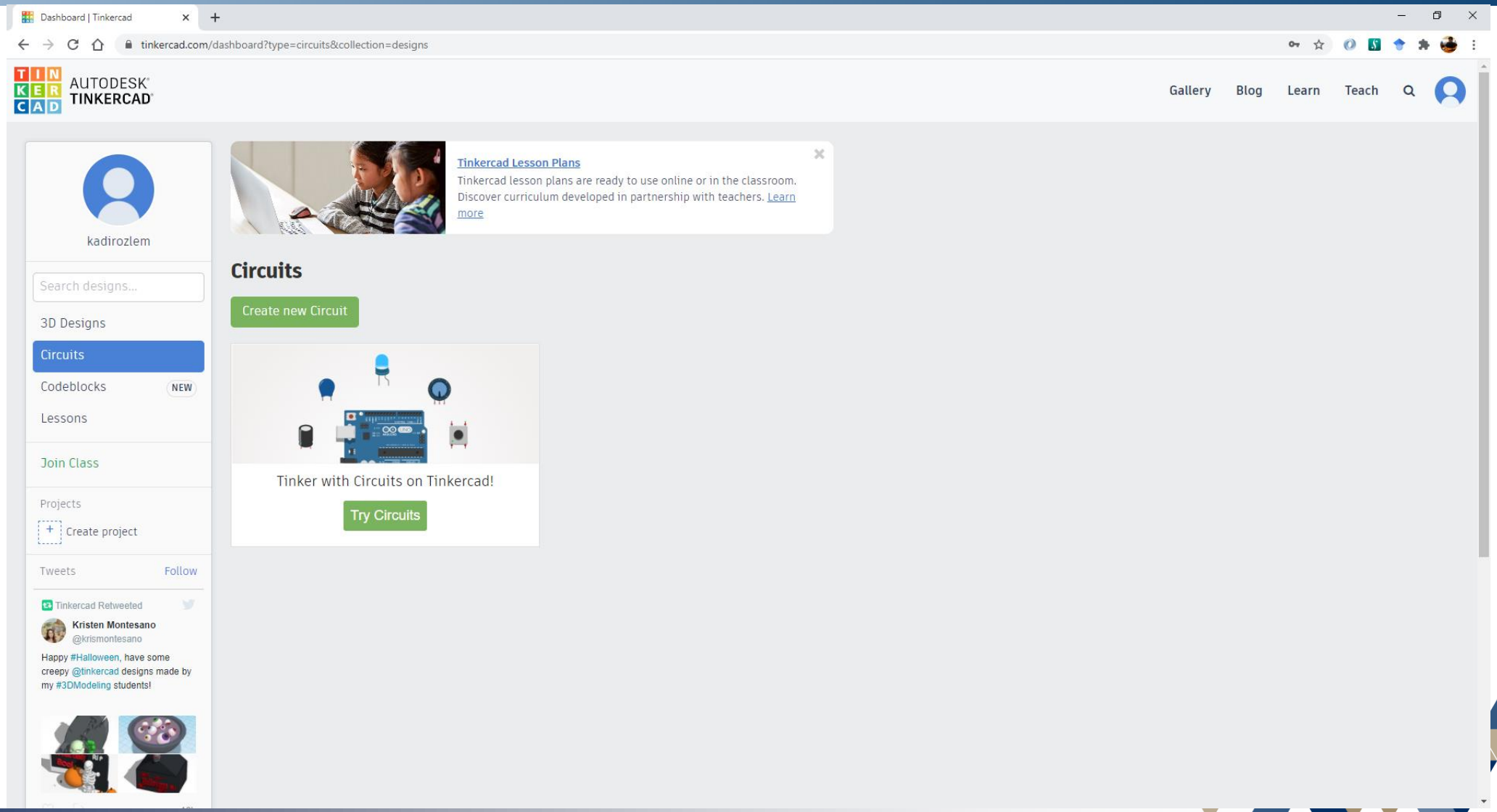
DDRB - The Port B Data Direction Register - read/write
PORTB - The Port B Data Register - read/write
PINB - The Port B Input Pins Register - read only

PORTC maps to Arduino analog pins 0 to 5. Pins 6 & 7 are only accessible on the Arduino Mini

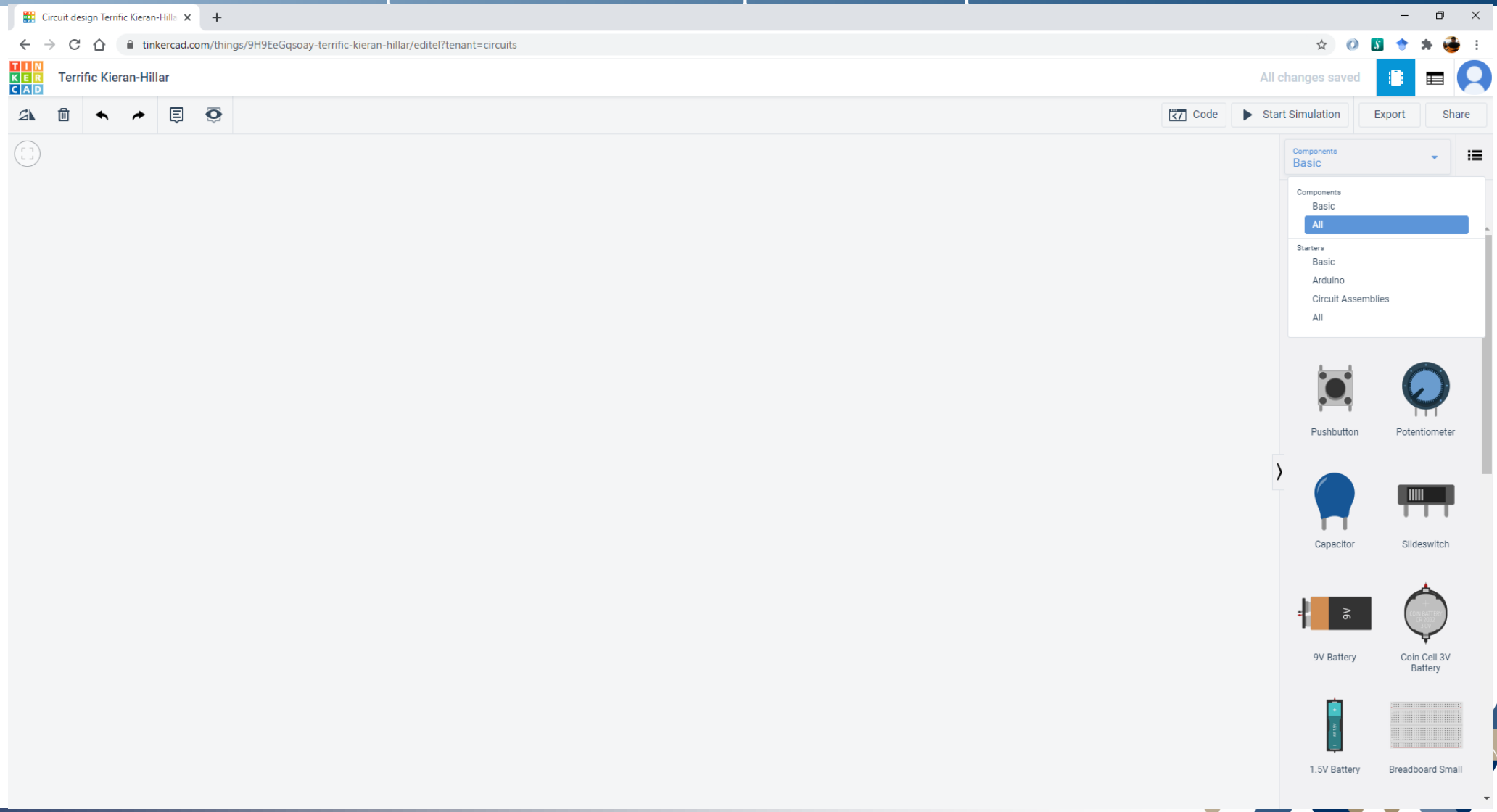
DDRC - The Port C Data Direction Register - read/write
PORTC - The Port C Data Register - read/write
PINC - The Port C Input Pins Register - read only

Demonstration

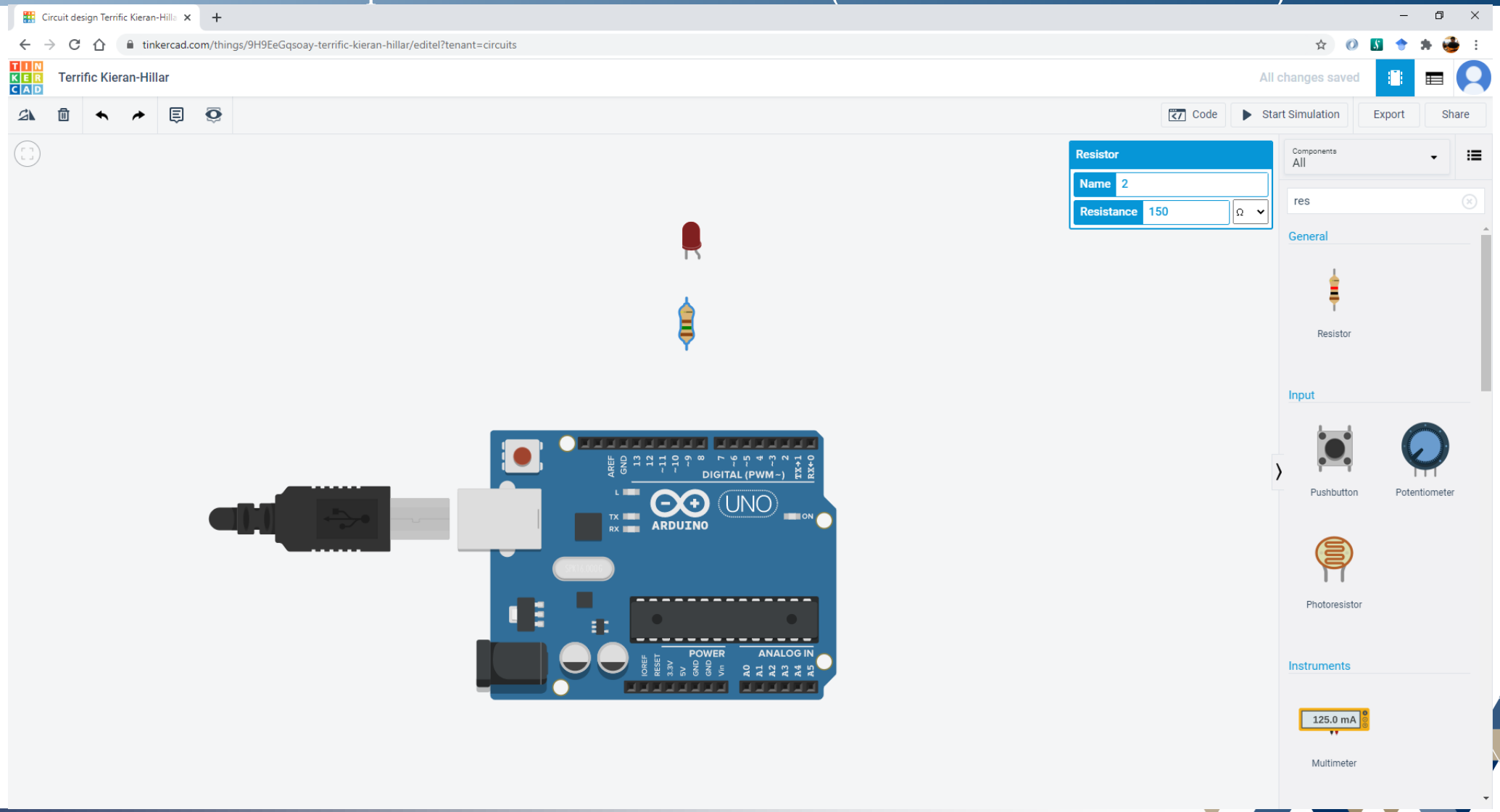
Tinkercad – Click the «Create new Circuits» button



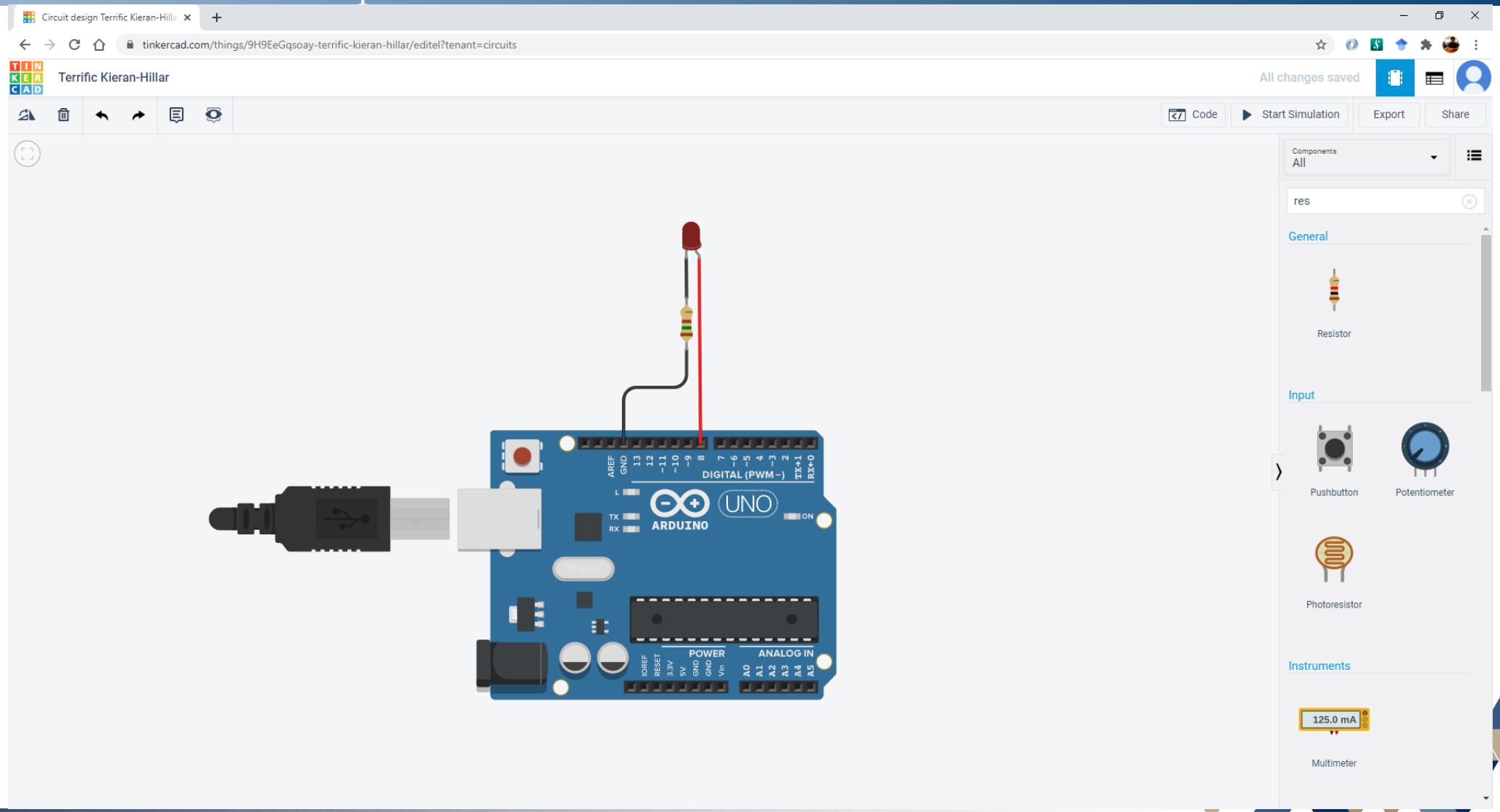
Tinkercad – Select the All Components under Components Drop-Down Menu



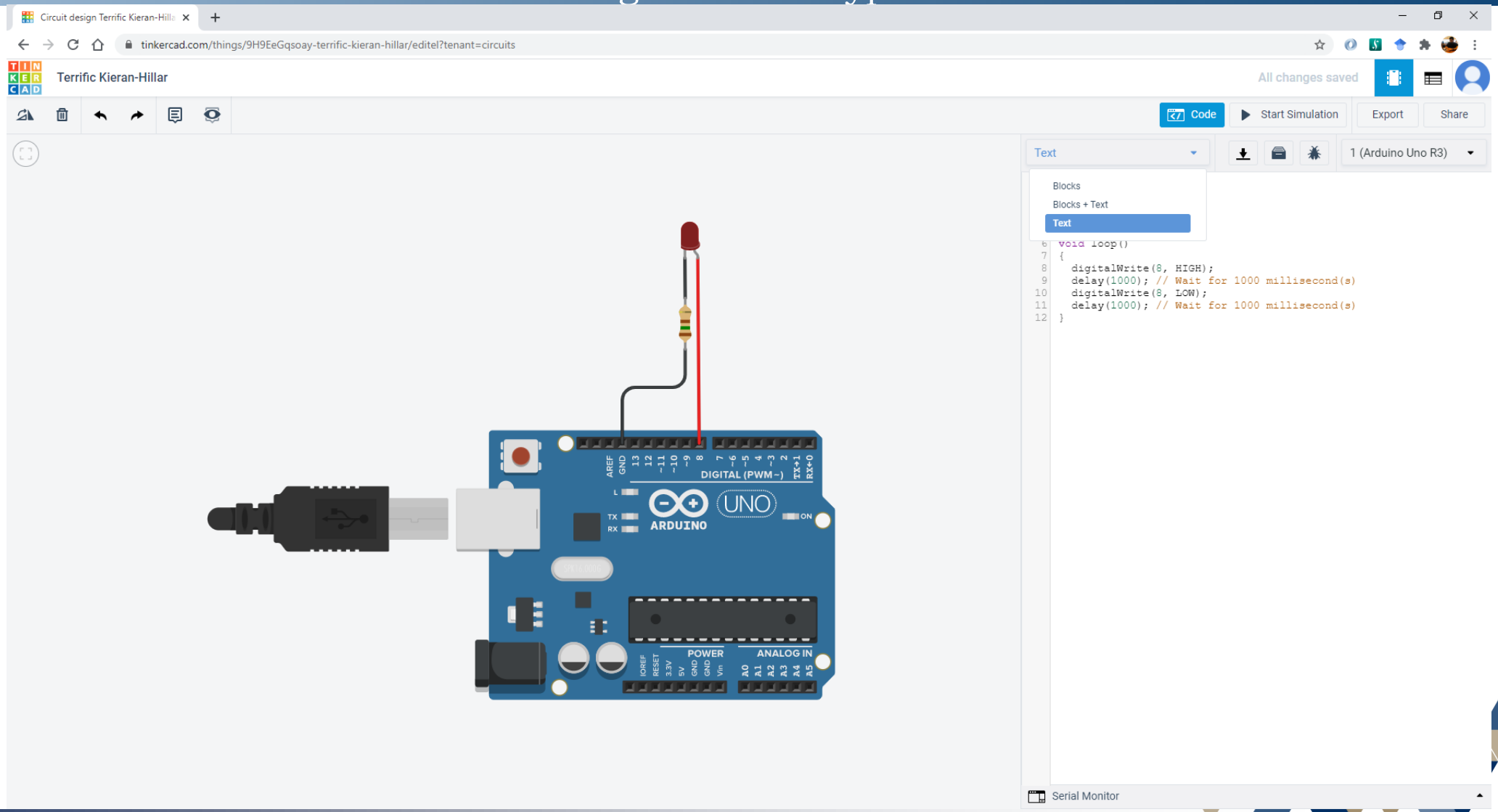
Tinkercad – Add suitable components and set its value (Ex:150 ohm for resistor)



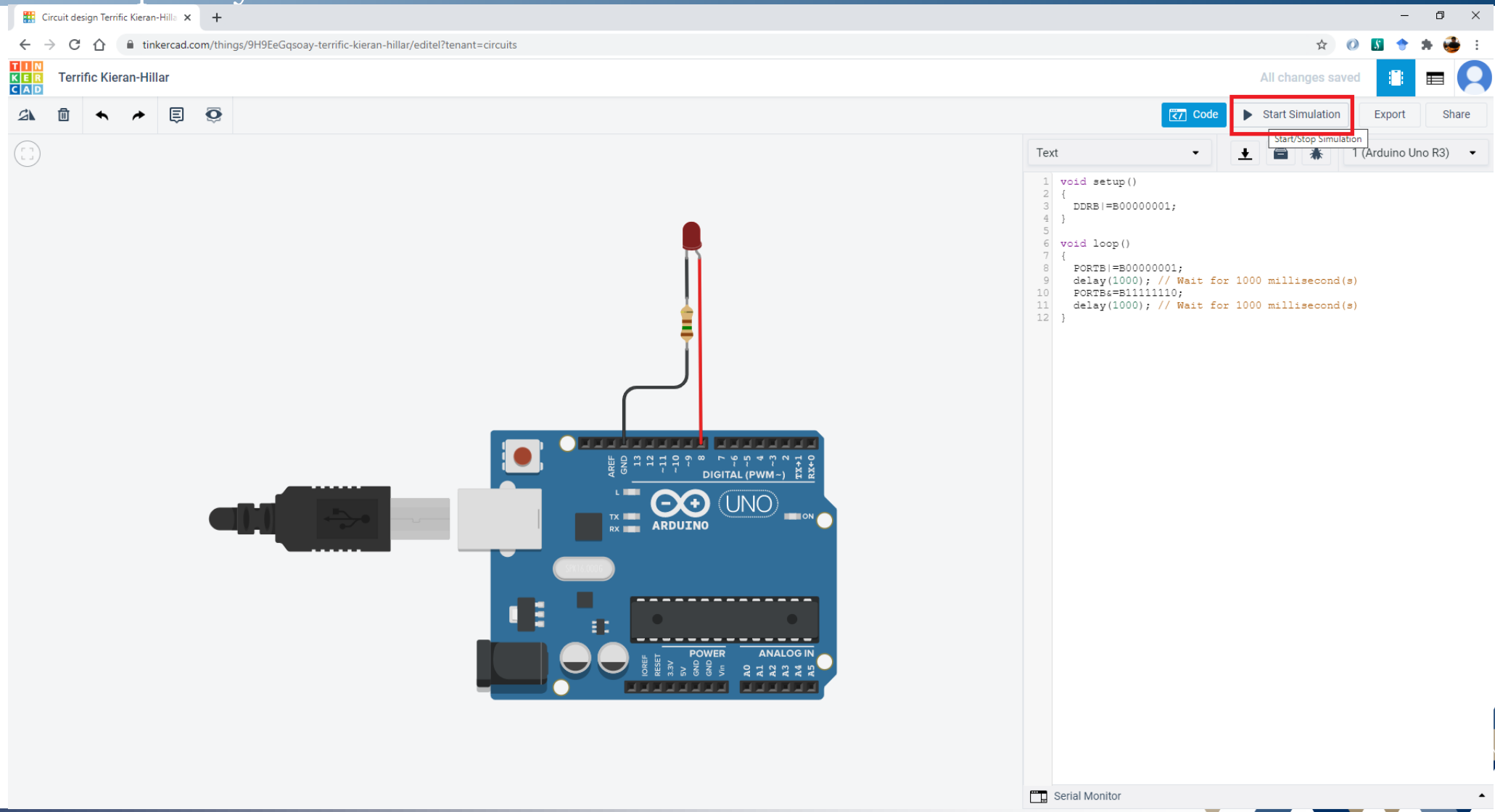
Tinkercad – Connect the components via cable



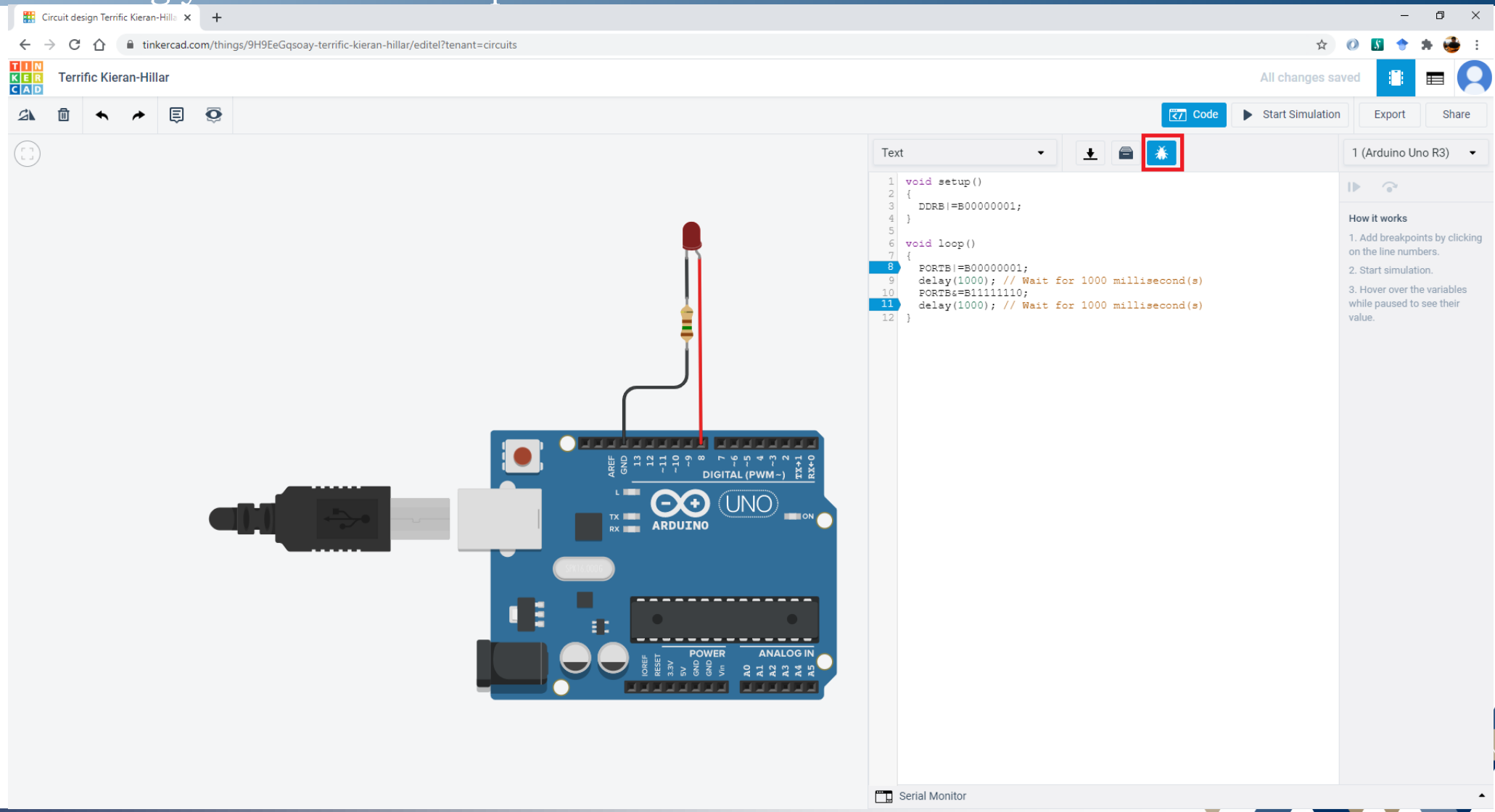
Tinkercad – Click the code button and change the code type Blocks to Text



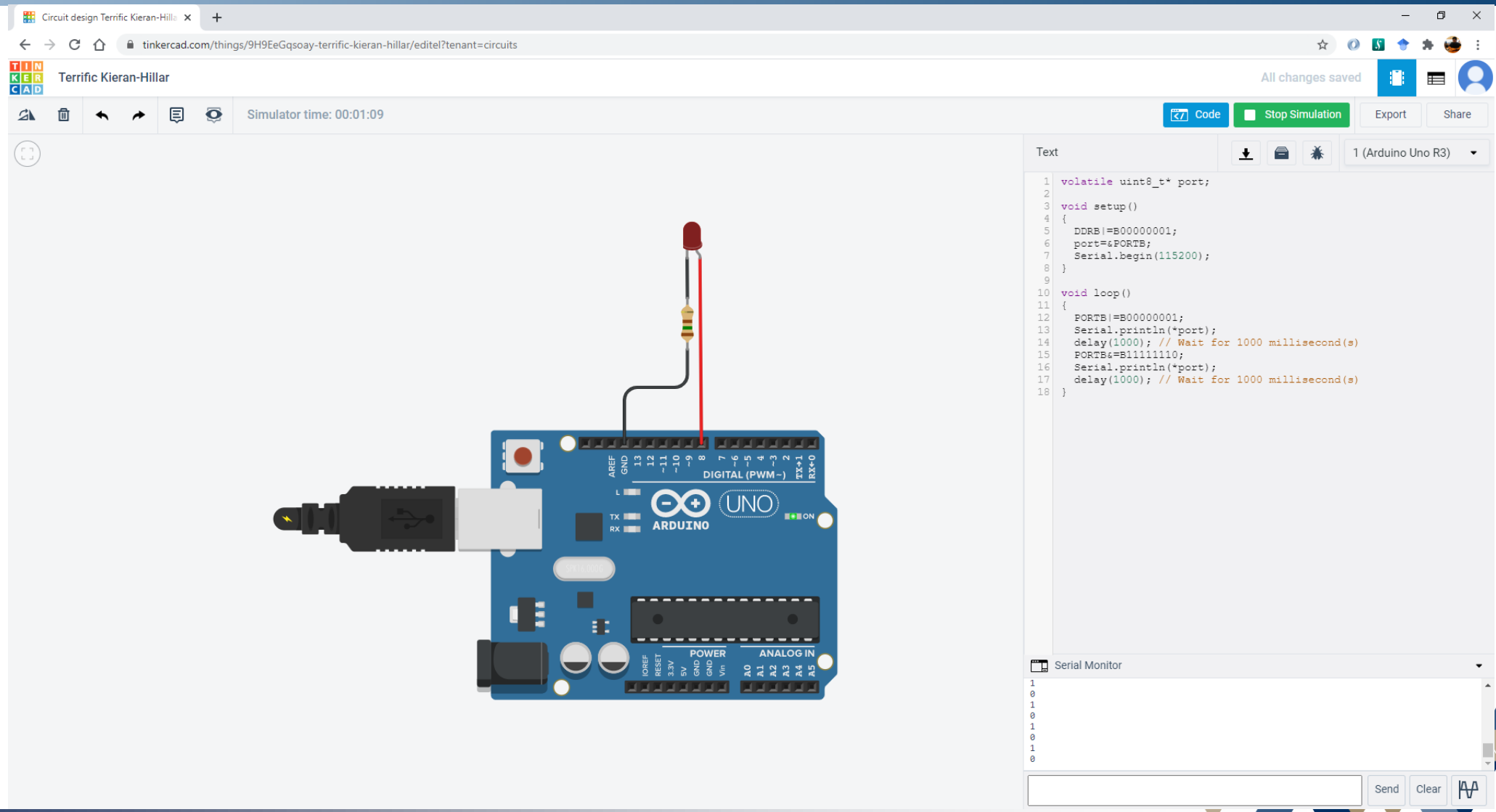
Tinkercad – Complete your code and start the simulation



Tinkercad – Debug your if there is a problem



Tinkercad – Use the serial monitor for communication between the microcontroller and the computer



Thanks for your attention…

Questions, Comments ???