Lab 1: Number Systems and Introduction to Arduino IDE

Submit lab1.txt at the end of your lab.

I. Lab Environment

- Need a card to access the lab. If you have a card, email engrcard@engr.uvic.ca (include the 5-digit card number and your student number) to set up the card access. If you don't have a card, you can purchase it from the bookstore for a non-refundable $10 fee. For card related problems, email. engrcard@engr.uvic.ca, include the 5-digit card number, student number, the room, the time and day, and for what course, so that the problem can be solved more quickly.
- Tip: if you purchase the card only, you can go to the computer store (inside the bookstore) and purchase one there to avoid the long line up.
- Use your netlink ID and password to log in. Email itsupport@csc.uvic.ca if you have any difficulties to log on to the machines or to print documents in the labs.
- ECS 249 is the only lab with hardware/software provided for this course. The software is also installed in two drop-in labs ECS 266 and ECS 348 (Window's machines only) and two other teaching labs ECS250/258 (when no labs are in session). Suggest you start your assignments early.
- **"H"** drive is your network space on the CSC server. Store all your work in H drive and keep a back up copy using other portable devices (such as a flash memory or a floppy disk). Files stored in the C drive might be erased overnight.
- For printing, once you send your printing job, use the printers outside. There are two printers: one on the 2nd floor, and the other is on the 3rd floor, in the study areas. Log in using your netlink ID and password. If you have credit on your student card, you can release your work. Otherwsie, you need to add credit to your card.
- ECS Outside doors open from 7:30-10:30pm Mon-Fri except holidays. ECS drop-in lab doors are open business hours starting at 7:30am - 7pm, Mon-Fri except holidays. Outside these hours, card access only.
- It is a busy lab. We share the lab with csc 355 students. Suggest you check the csc 355 course outline at https://heat.csc.uvic.ca/coview/course/2019091/CSC355. In the weeks when there are no csc 355 labs, you may use the computers during their lab hours.

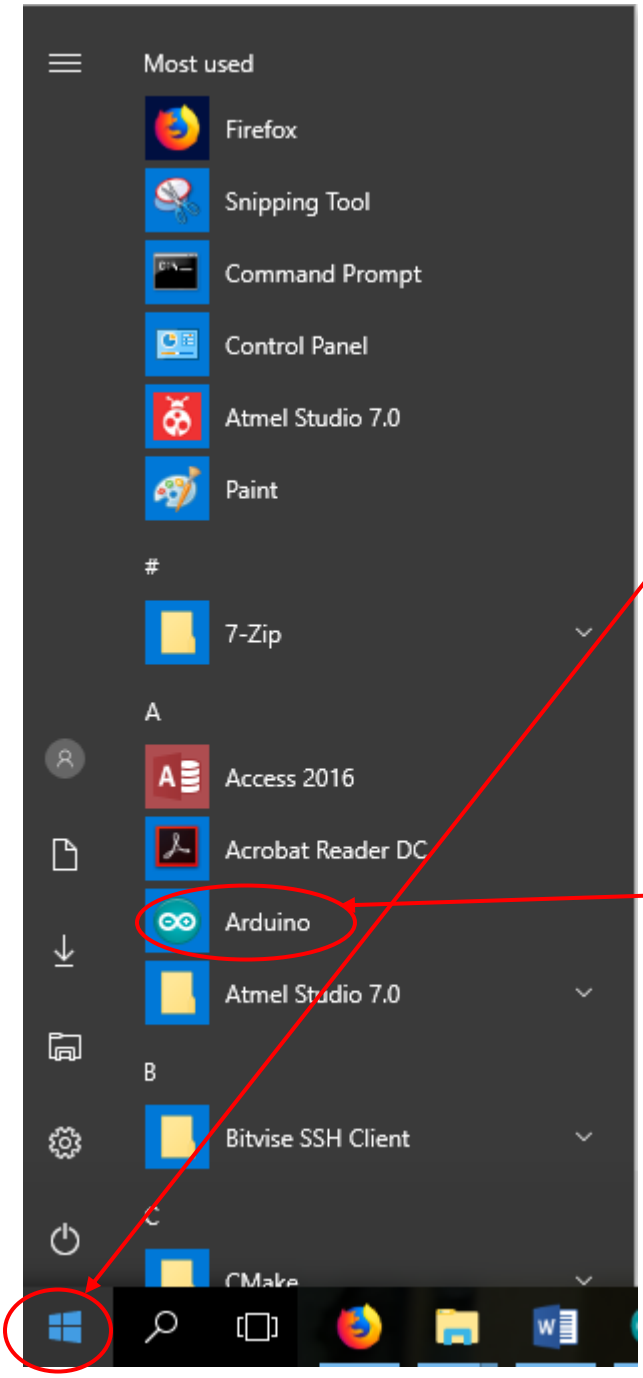
II. Number Systems

In the computer system, we need to know how many bits (storage space) are used. For example, let's count the number of students in the lab. In decimal number system, we just need two digits. In binary number system, how many bits do we need? Let's do counting up in decimal, binary and hexadecimal. Here is the conversion table (try to be very familiar with or memorize the purple part):

Decimal (2 digits)	Binary (5 bits)	Hexadecimal (2 digits)
0	0b0**0000**	0x0**0**
1	0b0**0001**	0x0**1**
2	0b0**0010**	0x0**2**
3	0b0**0011**	0x0**3**
4	0b0**0100**	0x0**4**
5	0b0**0101**	0x0**5**
6	0b0**0110**	0x0**6**
7	0b0**0111**	0x0**7**
8	0b0**1000**	0x0**8**
9	0b0**1001**	0x0**9**
10	0b0**1010**	0x0**A**
11	0b0**1011**	0x0**B**
12	0b0**1100**	0x0**C**
13	0b0**1101**	0x0**D**
14	0b0**1110**	0x0**E**
15	0b0**1111**	0x0**F**
16	0b10000	0x10
17	0b10001	0x11
18	0b10010	0x12
19	0b10011	0x13
20	0b10100	0x14
21	0b10101	0x15
22	0b10110	0x16
23	0b10111	0x17
24	0b11000	0x18

III. Test the Arduino Board - Introduction to Arduino IDE [1]

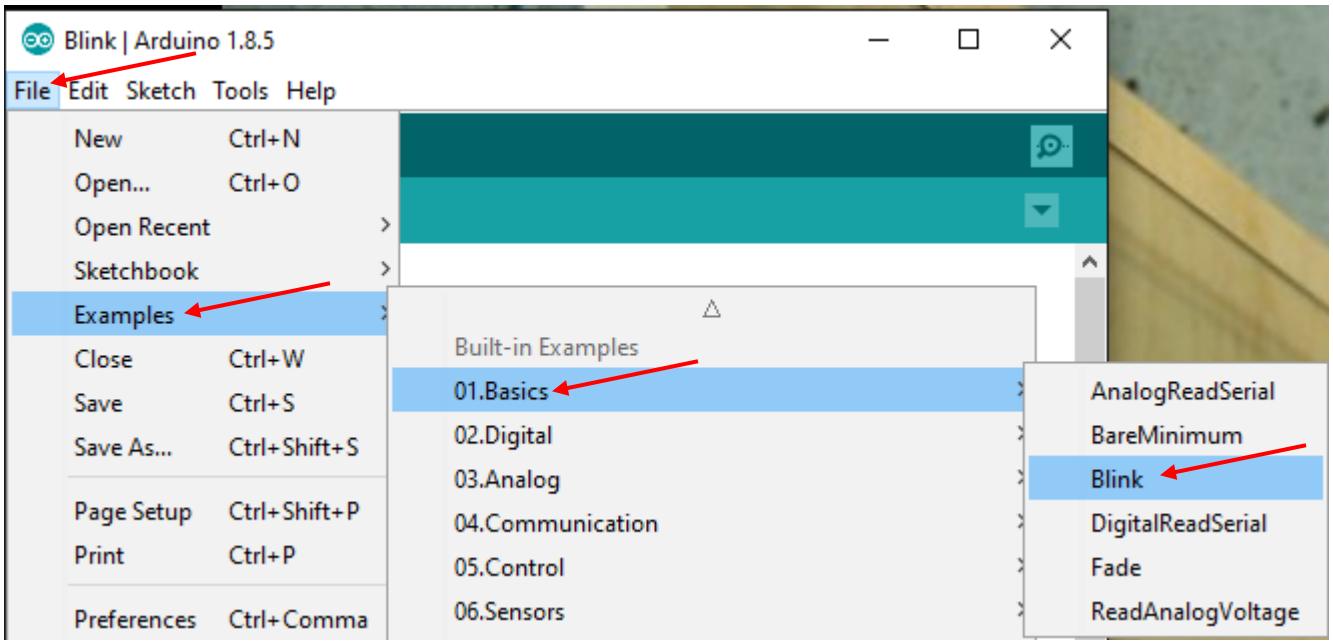
- Launch Arduino IDE: click on the *Start* button, then click on the *Arduino* program.



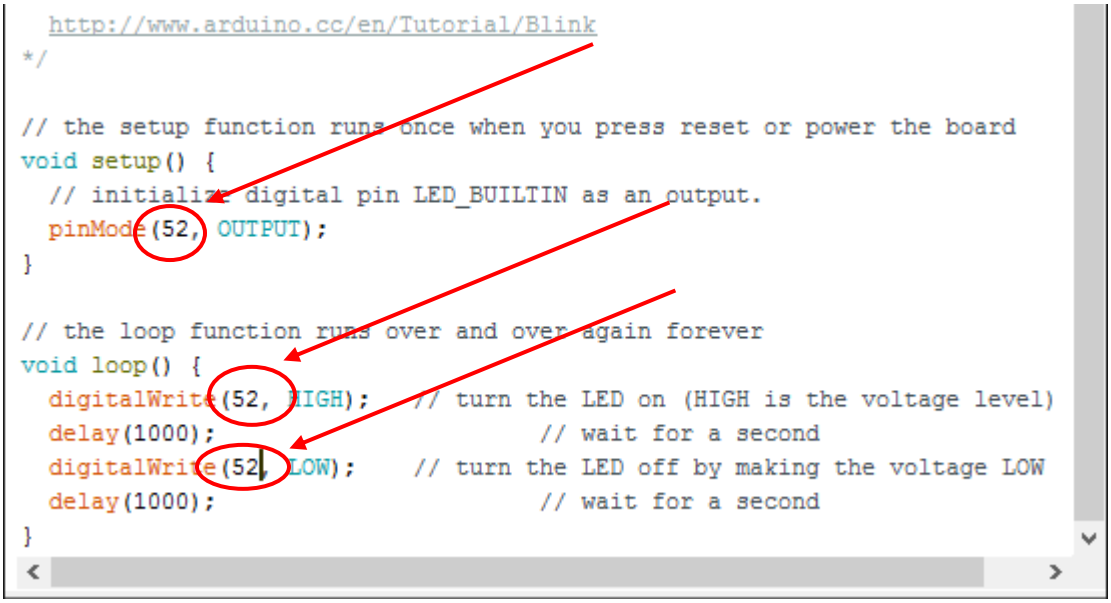
Click on the *Start* button.

Click on the *Arduino* program.

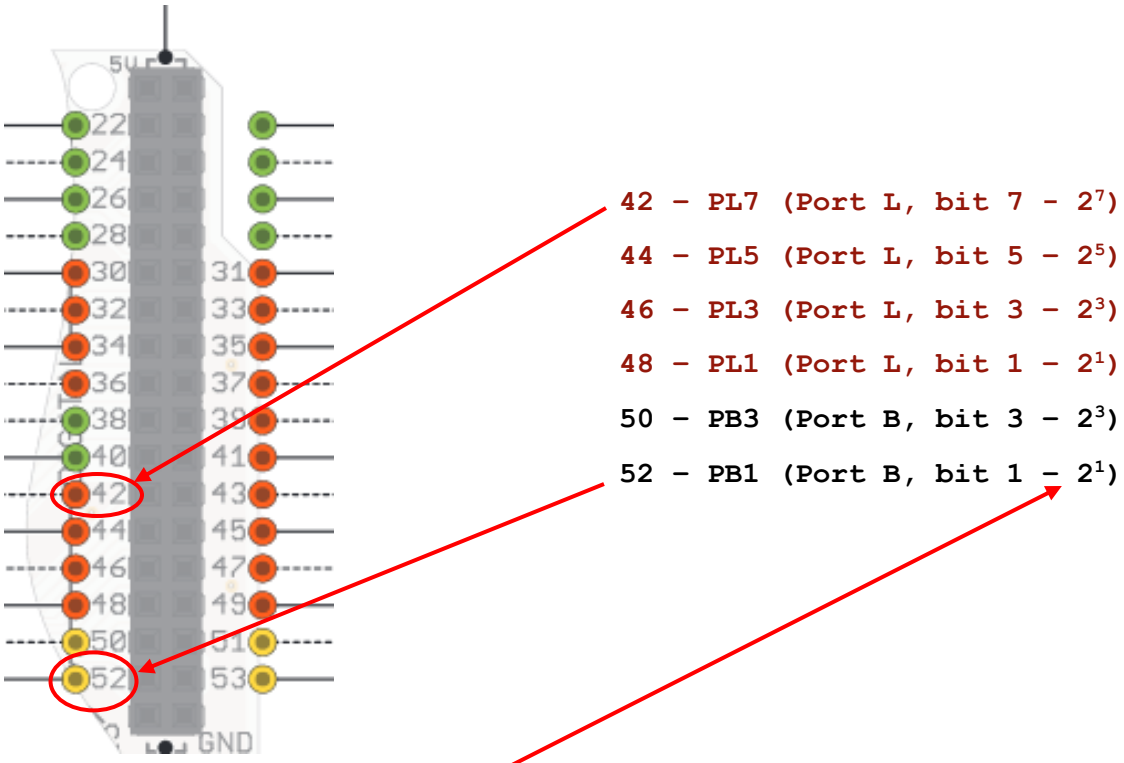
- The Arduino IDE is launched, go to the menu, click on *File -> Examples -> 01.Basics -> Blink.*



- Scroll down the source code and change *LED_BUILTIN* to 52:



- Why change it to 52? It is the pin number on the Arduino board. You will learn more later in the course. To give you a brief explanation now, see the portion of a diagram of the Arduino board below. It shows the pins connected to the LED lights. Pin 52 controls the LED light at the bottom.

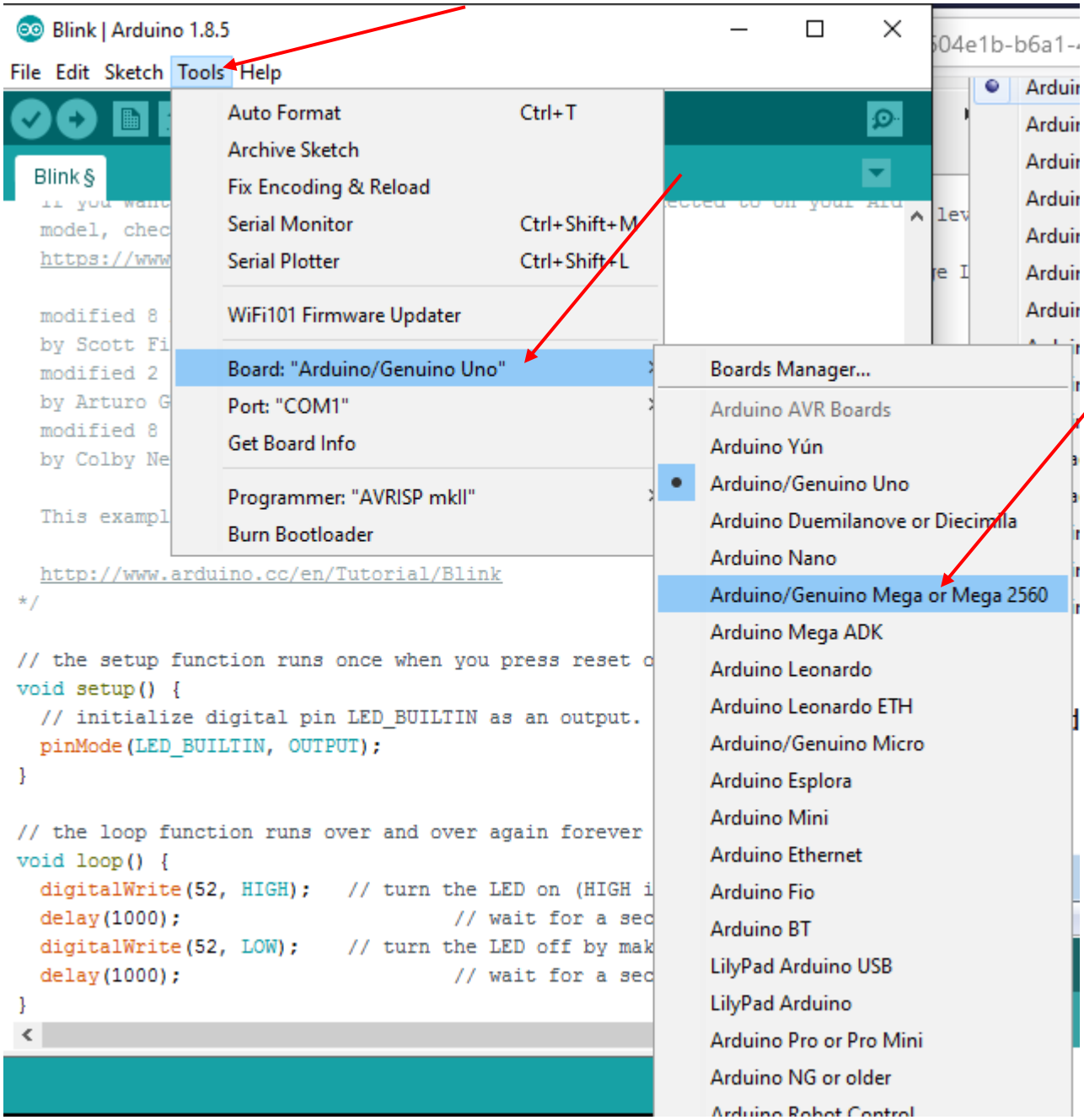


What does *bit 1* mean?

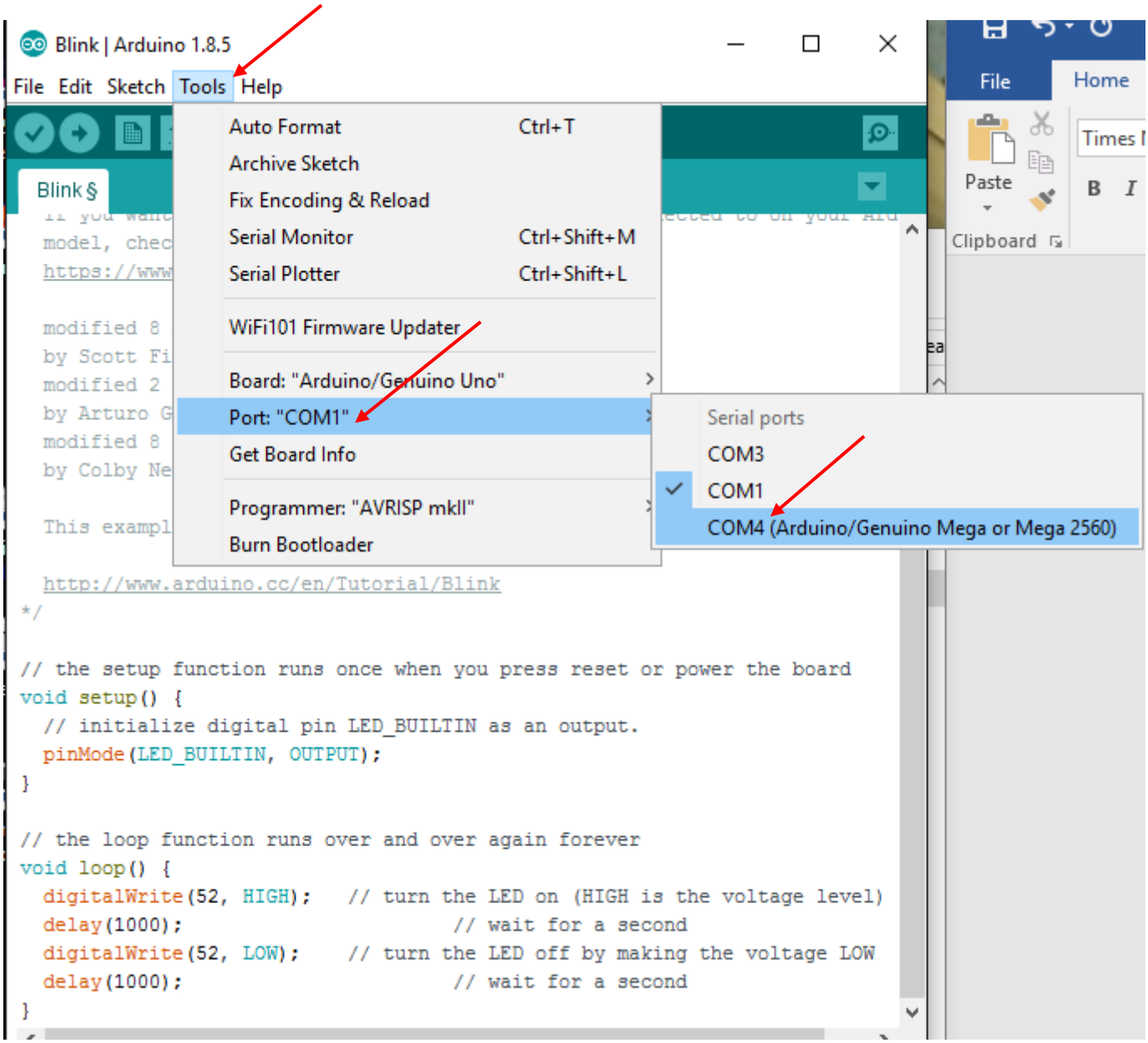
It means at 2^1 position in a binary system. In order to turn on the LED light at the bottom, the binary number assigned to PORTB should set the *bit 1* to 1. For example, the position of an 8-bit binary number (1 byte) 0b0000010 is listed below:

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
0	**0**	**0**	**0**	**0**	**0**	**1**	**0**

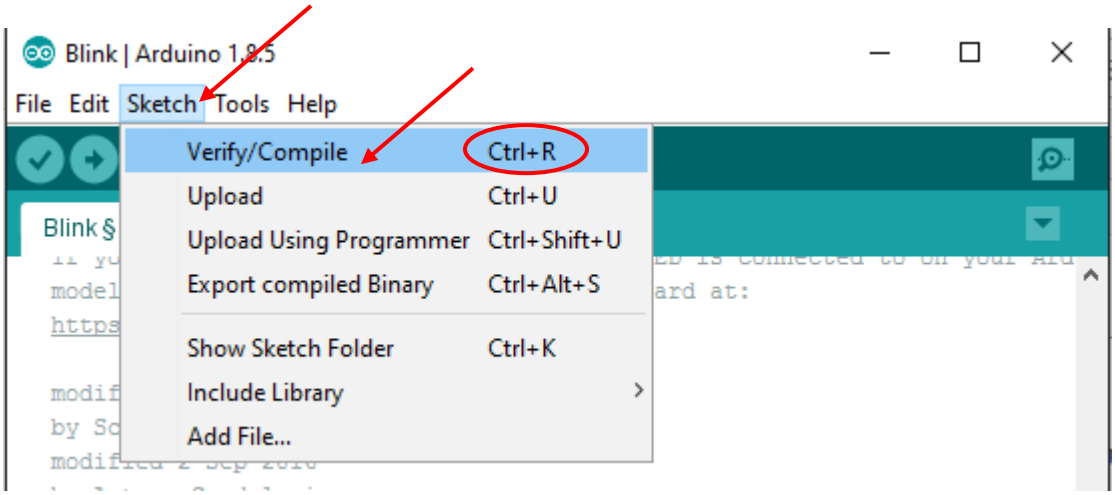
- In the Arduino IDE program, select the right board: go to the menu, click on *Tools →Board: "Arduino/Genuino Uno" → Arduino/Genuino Mega Or Mega 2560*.



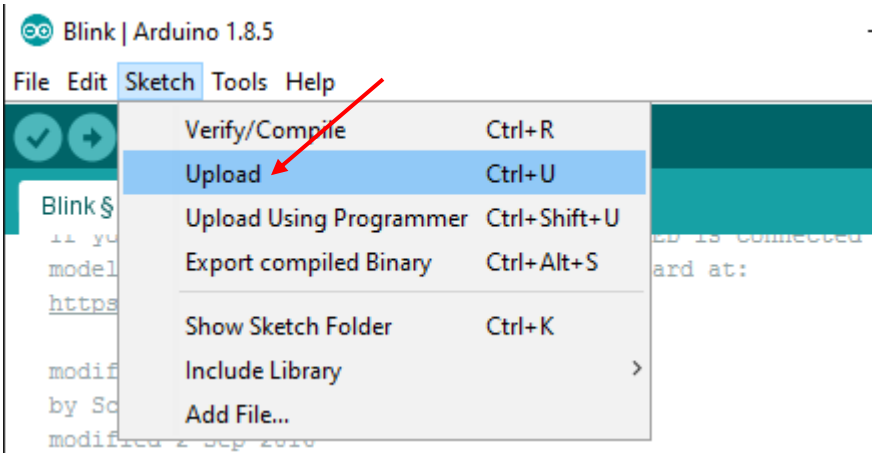
- Select the right port: go to the menu, click on *Tools →Port: "COM1" → COM4 (Arduino/Genuino Mega or Mega 2560)*. The port number veries among chips. Yours may be COM3, or COM5 etc.



- Compile your code: go to the menu, click on *Sketch →Verify/Compile Ctrl+R*. You may use shortcut keys: press *Ctrl* key and *r* (lower case r) key at the same time.



- If no errors, upload your program to the board: go to the menu, click on *Sketch →Upload.* The LED light at the bottom blinks. Change 52 to other numbers (42, 44, 46, 48 or 50) and observe the LED lights.



IV. Exercises

1. Why do we use 5 bits in the table in part II (the number of students attending the lab)? Can we use only 4-bits instead?
2. How many different values can be represented by 6 bits?
3. There are 194 students registered in CSc 230, what is the minimum number of bits needed to represent this number in binary (assume it is an unsigned number)?
4. Convert the following numbers:
    a. 0b1001101 (unsigned) to decimal
    b. 63 to unsigned binary and unsigned hexadecimal
5. Convert the following numbers:
    a. -63 to binary (using 2's complement notation) and then to Hex
    b. 0b101011 (2's complement) to decimal
    c. 0b001110 (2's complement) to decimal

6. What are the minimum and maximum values (in decimal) represented by a 4-bit binary number: a) as an unsigned number? b) as a signed number (2's complement)? How about 8 bits, 16 bits, k bits? For example, if it is a 2-bit number:

Number of bits	Unsigned	Signed
2	[0, 3]	[-2,1]

7. What is the result of bit-wise AND operation of: 0b10110010 with 0b11110000?
8. What is the result when bit-wise XOR and mask of 0b11111111 are applied on byte 0b10110100?
9. Recall the position of each bit in an 8-bit number (one byte) is $2^7 2^6 2^5 2^4 2^3 2^2 2^1 2^0$. What is the 8-bit binary number x (also called mask) to be used if we want to clear bits at positions 2^2, 2^3, 2^5 and 2^7 of an 8-bit (1 byte) binary number n? For example, if n is 0b10100110, after "and" with x, the result is: 0b00000010. Notice that bits at positions 2^2, 2^3, 2^5 and 2^7 are set to 0, and the bits at other positions are not changed. The questions is: what is the value of x in binary?

Download lab1.txt. Write your answers and submit lab1.txt via conneX. You must click the "Submit" button. Write your name, student number at the top. Due at the end of your lab.

1. Adapted from the lab notes written by Dr. Bill Bird for csc 230 in the summer of 2018.