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CS – 273

Homework #2

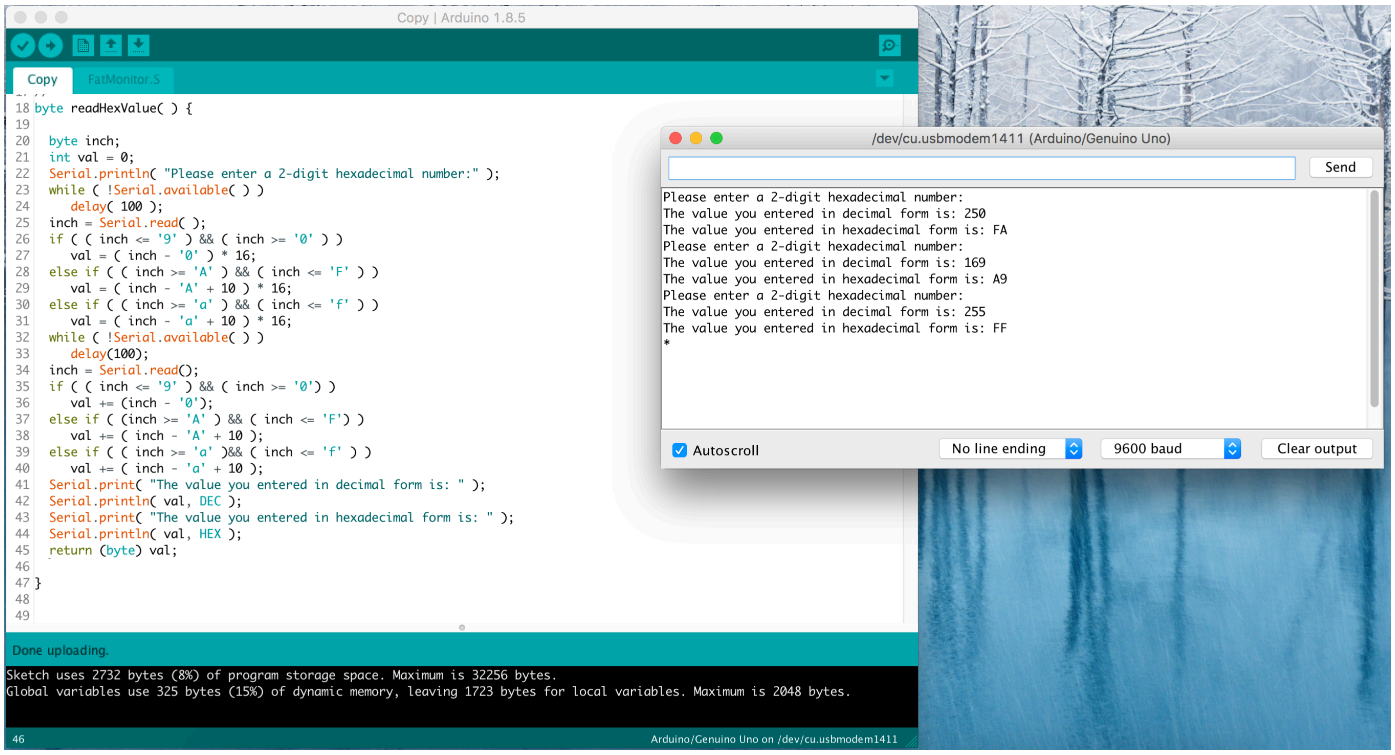
1. **Explain the range of numbers that can be represented by a 12-bit signed binary number. How many are negative and how many are positive numbers?**

To answer this question, we must use the equation provided to us: $-(2^{N-1})$ to $2^{N-1} - 1$. For this problem, $N = 12$. Therefore, by plugin it in into the equation, we get a range from $-(2^{11})$ to $2^{11} - 1$, which is the equivalent to -2048 to 2047. In other words, the range of numbers that can be represented by a 12-bit signed binary number is between (and including) -2048 to 2047. In addition, there are 2048 negative numbers and 2047 positive numbers (i.e. zero is not a negative nor a positive number).

2. **Modify the C function readDigitValue( ) in Lab 2 to read in a hexadecimal number of two digits. Call the new function readHexValue(). Make sure your code recognize all hexadecimal digits from 0 to 9, A to F, and a to f (lower case). This function should print out the number in both hexadecimal and decimal to verify your program is correct.**

```
byte readHexValue( ) {
   byte inch;
   int val = 0;
   Serial.println( "Please enter a 2-digit hexadecimal number:" );
   while ( !Serial.available( ) )
   delay( 100 );
   inch = Serial.read( );
   if ( ( inch <= '9' ) && ( inch >= '0' ) )
      val = ( inch - '0' ) * 16;
   else if ( ( inch >= 'A' ) && ( inch <= 'F' ) )
      val = ( inch - 'A' + 10 ) * 16;
   else if ( ( inch >= 'a' ) && ( inch <= 'f' ) )
      val = ( inch - 'a' + 10 ) * 16;
   while ( !Serial.available( ) )
       delay(100);
   inch = Serial.read();
   if ( ( inch <= '9' ) && ( inch >= '0') )
      val += (inch - '0');
   else if ( (inch >= 'A' ) && ( inch <= 'F') )
      val += ( inch - 'A' + 10 );
   else if ( ( inch >= 'a' )&& ( inch <= 'f' ) )
      val += ( inch - 'a' + 10 );
   Serial.print( "The value you entered in decimal form is: " );
   Serial.println( val, DEC );
   Serial.print( "The value you entered in hexadecimal form is: " );
   Serial.println( val, HEX );
   return (byte) val;
}
```

Here is a screenshot of my code and the output for three trivial hexadecimals.



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     val = ( inch - 'A' + 10 ) * 16;
  else if ( ( inch >= 'a' ) && ( inch <= 'f' ) )
     val = ( inch - 'a' + 10 ) * 16;
  while ( !Serial.available( ) )
     delay(100);
  inch = Serial.read();
  if ( ( inch <= '9' ) && ( inch >= '0') )
     val += (inch - '0');
  else if ( (inch >= 'A' ) && ( inch <= 'F') )
     val += ( inch - 'A' + 10 );
  else if ( ( inch >= 'a' )&& ( inch <= 'f' ) )
     val += ( inch - 'a' + 10 );
  Serial.print( "The value you entered in decimal form is: " );
  Serial.println( val, DEC );
  Serial.print( "The value you entered in hexadecimal form is: " );
  Serial.println( val, HEX );
  return (byte) val;

}
```

```
Done uploading.
Sketch uses 2732 bytes (8%) of program storage space. Maximum is 32256 bytes.
Global variables use 325 bytes (15%) of dynamic memory, leaving 1723 bytes for local variables. Maximum is 2048 bytes.
```

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```
Please enter a 2-digit hexadecimal number:
The value you entered in decimal form is: 250
The value you entered in hexadecimal form is: FA
Please enter a 2-digit hexadecimal number:
The value you entered in decimal form is: 169
The value you entered in hexadecimal form is: A9
Please enter a 2-digit hexadecimal number:
The value you entered in decimal form is: 255
The value you entered in hexadecimal form is: FF
*
```

3. Explain the main innovation of the modern computer, as compared to the calculator.

The main innovation of the modern computer, as compared to the calculator, is that it is capable of multiprogramming and multiprocessing and can be multiuser and multifunctional. The implications of this is that the modern computer can execute multiple complex instructions and/or calculations in one run while calculators can only carry out one instruction or calculation at a time. Therefore, modern computers can, theoretically, execute everything that calculators do, but calculators ***cannot*** execute everything that computers do. For example, the modern computer can take many numbers, organize them, and find their mean, range, max, min, and median. In addition, modern computers have RAM and hard drive space, meaning that they can store, retain, and recall much more information (e.g. functions that they might need to complete a complex operation, etc.) than calculators. Lastly, the modern computer can run computer programs, which are a series of instructions that are given to computers. This means that, unlike calculators, users do not need to be constantly telling a computer the steps it needs to do for it to solve a complex calculation.

4. If the address bus has 32 bits, how many locations can the memory have?

If the address bus has 32 bits, then there can be a total of 2^{32} memory locations. In other words, the actual number of locations is 4, 294,967,296.

5. If a memory chip must have address from 0x800 to 0xFFF, please design a logical circuit using logical gates to select the chip when the address is within the range and deselect the chip otherwise.

First, we need to convert the memory addresses 0x800 and 0xFFF into binary numbers. We do this by dividing each character.

- 0x800

  8 | 0 | 0

  1000 0000 0000

  Therefore, 0x800 = 0b100000000000

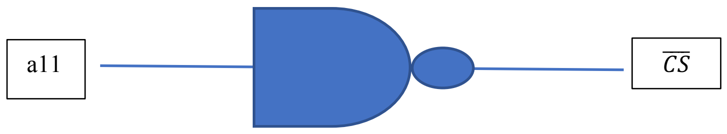
- 0xFFF

  F | F | F

  1111 1111 1111

  Therefore, 0xFFF = 0b111111111111

We note that the first bit is the only common digit, therefore, we only need to use a **NAND** logical gate to accomplish the task. (**NOTE:** We could have also used the **NOT** logical gate).



6. <u>Read page 5 to 6 of 8-bit AVR Microcontroller with 4/8/16/32K Bytes In-System Programmable Flash and answer the following questions:</u>

a. What is the name of the program memory on AVR?

- Flash Memory.
  (Note: The full name is "In-System Reprogrammable Flash Program Memory").

b. What is the capacity of the program memory of ATmega328P, the microcontroller used on Arduino boards?

- It has 32K Bytes of program memory.

c. What is the name of the data memory on AVR?

- The name of the data memory on AVR is SRAM.

d. What is the capacity of the data memory of ATmega328P?

- The capacity of the data memory of ATmega328P is 2K Bytes of memory space