

# Lab 1: Computation & Data Representations

**Due Date: Friday 2/2/2018 11:59PM**

This lab covers the first three lectures. Feel free to refer to my lecture notes (posted on the course page) and the recommended textbook (Patt & Patel) Chapters 1 and 2. Be sure to go to your labs on Friday to get assistance from the TAs. When you encounter a number written  $x_y$  you should read it as “ $x$  in base  $y$ .” For example,  $2_{10}$  means “2 base 10” (decimal 2) and  $10_2$  means “10 base 2” (binary 10, same thing as decimal 2). Numbers without a subscript are assumed to be in decimal.

**If you’re unsure about a result, be sure to explain your thinking. In general, you should show your work.** A well-reasoned but wrong answer (for example with a minor error) will receive more points than a wrong answer with no context at all.

## Problems (100 points total)

1. For the following, use no more than 3 sentences in your answer.
  - a) What advantage do transistors have over other mechanical or electrical switching devices such as vacuum tubes or electromechanical relays?
  - b) Why do we use binary for computers and not, say, ternary or quaternary?
2. Invent an efficient data encoding for DNA sequences. Recall that a DNA sequence is entirely comprised of four nucleotides—adenine (A), thymine (T), guanine (G), and cytosine (C).
3. How would one write  $7_{10}$  in *unary* (base one)?
4. Write out the following numbers in terms of powers of 2. Omit the powers of 2 that are not present. For example,  $43_{10}$  would be written as :

$$(1 \times 2^5) + (1 \times 2^3) + (1 \times 2^1) + (1 \times 2^0)$$

- a) 16
  - b) 31
  - c) 33
  - d) 12
5. Convert  $10110_2$  to decimal. Assume it is unsigned.

6. Solve for  $x$  in

$$2^x = 01000000_2$$

7. Convert  $10011001_2$  to decimal. Assume unsigned again.

8. a) Given a 5-bit string of binary digits, how many unique binary strings are there?  
 b) What's the largest *unsigned* integer we can represent with this many bits?  
 c) How many unique binary strings for an  $n$ -bit string?  
 d) And the largest unsigned integer with  $n$  bits?

9. Add 37 and 18 *in binary* (give the answer in binary). Assume 8-bit unsigned integers. Show your work.

10. Subtract 19 from 87 *in binary*. Again, 8-bit unsigned.

11. Take the *one's complement* of  $01011101_2$ . Give the result in binary and in decimal.

12. a) We have a 8-bit signed, *two's complement* integer. What are the maximum (most positive) and minimum (most negative) values we can represent with it?  
 b) For an  $n$ -bit signed, 2's complement int, what are the most positive and negative numbers we can represent?

13. Fill in the rows in the following table. The first row is an example for your reference. Put an X when the number cannot be represented. Assume 6 bits.

Number	Signed Magnitude	One's Comp.	Two's Comp	Unsigned
-12	101100	110011	110100	X
-3				
8				
-1				
10				
-32				
31				

14. Subtract  $12_{10}$  from  $9_{10}$  ( $9 - 12$ ) *in binary* using 6-bit, signed, 2's complement integers.  
**Hint:**  $x - y = x + (-y)$ .

## Hand-in Instructions

**Make sure to put your name on your submission. Submissions without names will be given zero points!**

**Physical** : If you're submitting a written copy, hand it to one of the TAs or to the instructor. You can also leave it in the instructor's mailbox in the CS department office, but make sure to get it time stamped when you do (see the "Submitting Work" section of the syllabus).

**Digital** : If you would like to submit an electronic copy, note that **I will only accept PDF files (no Word docs)**. Again, see the “Submitting Work” section of the syllabus. Please do not take a poorly lit picture of your assignment. Your grade will suffer commensurately with our inability to read your work. Once you have a PDF, you should submit it on *fourier*. You should name your file `yourid-lab1.pdf` where `yourid` is the thing in front of the `@hawk.iit.edu` in your e-mail address. **Make sure your full name is on the first page of your PDF.**

You can first get your PDF (for example, for me it might be called `kh123-lab1.pdf`) onto *fourier* like so:

```
[me@mylocalmachine]$ scp kh123-lab1.pdf kh123@fourier.cs.iit.edu:
```

Then you can login to *fourier* via `ssh` and submit it:

```
[kh123@fourier]$ cp kh123-lab1.pdf /home/khale/HANDIN/lab1
```