ICS 232 Computer Organization & Architecture
Homework 2 - Chapter 2 - 10 points
Due Date: 5/31/2023

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Note: Please post your homework to ICS232 D2L on or before the due date.

Chapter 2 – Data Representation

Essential Terms and Concepts

7. What does overflow mean in the context of unsigned numbers?

- the result of the arithmetic operation is outside the range of allowable precision for the given number of bits

18. What are the three components of a floating-point number?

- sign : 1 = negative number 0 = positive number
- exponent : represents positive/negative exponents
- mantissa : precision bit of the number

25. Explain the difference between ASCII and Unicode.

ASCII : 7/8 - bits, less memory, encodes symbols, digits, letters, ...

Unicode : 4 character schemas, encodes special texts from different languages, letters, symbols

26. How many bits does a EBCDIC, ASCII and Unicode character require?

EBCDIC : 8 - bit

ASCII : 8 - bit

Unicode : 8/16 bit

Exercises

2. Perform the following base conversions using subtraction or division-remainder:

a) 588_{10} = 210210 $_3$

b) 2254_{10} = 33004 $_5$

c) 652_{10} = 1621 $_7$

d) 3104_{10} = 4228 $_9$

A)
3 | 588 0
3 | 196 1
3 | 65 2
3 | 21 0
3 | 7 1
3 | 2 2
0
210210_3

B)
5 | 2254 4
5 | 450 0
5 | 90 0
5 | 18 3
5 | 3 3
0
33004_5

C)
7 | 652 1
7 | 93 2
7 | 13 6
7 | 1 1
0
1621_7

D)
9 | 3104 8
9 | 344 2
9 | 38 2
9 | 4 4
0
4228_9

5. Perform the following base conversions.

A) $20012_3 = X_{10}$

$2\times3^4 + 0\times3^3 + 0\times3^2 + 1\times3^1 + 2\times3^0$

$= 2\times81 + 0\times27 + 0\times9 + 1\times3 + 2\times1$

$= 162 + 0 + 0 + 3 + 2$

$= 167_{10}$

C) $3236_7 = X_{10}$

$3\times7^3 + 2\times7^2 + 3\times7^1 + 6\times7^0$

$= 3\times343 + 2\times49 + 3\times7 + 6\times1$

$= 1029 + 98 + 21 + 6$

$= 1154_{10}$

$49 \times 7 = 343$, $343 \times 3 = 1029$

$1029 + 98 = 1127$, $1127 + 27 = 1154$

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B) $4103_5 = X_{10}$

$125 \times 4 = 500$

$4\times5^3 + 1\times5^2 + 0\times5^1 + 3\times5^0$

$= 4\times125 + 1\times25 + 0\times5 + 3\times1$

$= 500 + 25 + 0 + 3$

$= 528_{10}$

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a) $20012_3 =$ 167 $_{10}$
b) $4103_5 =$ 528 $_{10}$
c) $3236_7 =$ 1154 $_{10}$
d) $1378_9 =$ 1043 $_{10}$

D) $1378_9 = X_{10}$

$1\times9^3 + 3\times9^2 + 7\times9^1 + 8\times9^0$

$= 1\times729 + 3\times81 + 7\times9 + 8\times1$

$= 729 + 243 + 63 + 8$

$= 1043_{10}$

$729 + 243 = 972$, $972 + 71 = 1043$

8. Convert the following decimal fractions to binary with a maximum of six places to the right of the binary point:

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a) 25.84375 11001.110110
b) 57.55 111001.100011
c) 80.90625 1010000.111010
d) 84.874023 1010100.110111

10. Convert the following binary fractions to decimal:

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a) 10111.1101 23.8125
b) 100011.10011 35.59375
c) 1010011.10001 83.53125
d) 11000010.111 194.875

15. Convert the hexadecimal number DEAD BEEF $_{16}$ to binary.

Utilizing the chart

D = 1101, E = 1110, A = 1010, D = 1101
B = 1011, E = 1110, E = 1110, F = 1111

$(DEADBEEF)_{16} = (1101\ 1110\ 1010\ 1101\ 1011\ 1110\ 1110\ 1111)_2$

17. Represent the following decimal numbers in binary using 8-bit signed magnitude, one's complement, and two's complement representations:

a) 60
b) -60
c) 20
d) -20

	signed-magnitude	one's complement	two's complement
60	00111100	00111100	00111100
-60	10111100	11000011	11000100
20	00010100	00010100	00010100

-20 | 10010100 | 11101011 | 11101100

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22. What decimal value does the 8-bit binary number 10110100 have if:
    a) it is interpreted as an unsigned number? 180
    b) it is on a computer using signed-magnitude representation? -52
    c) it is on a computer using one's complement representation? -75
    d) it is on a computer using two's complement representation? -76
    e) it is on a computer using excess-127 representation? 53

33. Add the following unsigned binary numbers as shown.

```
a)   01000100   b)   01011011   c)  10101100
   + 10111011      + 00011111     + 00100100
   0 11111111        01111010     0 11010000
```

Note: each shift to the left multiplies the number by 2
each shift to the right divides the number by 2

44. Using arithmetic shifting, perform the following:
    a) double the value 00010101_2 A) shift 1 bit to the left and add 1 zero to the farthest-right: 00010101 → 00101010_2
    b) quadruple the value 01110111_2 B) shift 2 bits to the left and add 2 zero to the farthest-right: 01110111 → 11011100
    c) divide the value 11001010_2 in half C) shift 1 bit to the right and preserve the sign: 11100101

52. Show how each of the following floating-point values would be stored using IEEE-754 double precision (be sure to indicate the sign bit, the exponent, and the significand fields):

	sign	exponent	mantissa
a) 12.5	0	10000010	10010000 ----- 0
b) −1.5	1	01111111	10000 ····· 0
c) 0.75	0	01111110	10000 ····· 0
d) 26.625	0	10000011	1010000 ----- 0

55. Given that the ASCII code for A is 1000001, what is the ASCII code for J?

100 1010

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58. Decode the following ASCII message, assuming 7-bit ASCII characters and no parity:

    1001010 1001111 1001000 1001110 0100000 1000100 1001111 1000101

    John Doe

X1. Encode the following four characters in Unicode:

    0 ∑ @ π (zero, summation, at-sign, pi)

    0: U+0030
    π: U+03C0
    Σ: U+03A3
    @: U+0040

X2. Perform the following unsigned hexadecimal arithmetic:

```
a)   1AF4    b)   3DE7      c)   F938
   + 3304       + D496         - 395D
     ====       ======           ====
     4DF8        1127D           BFDB
```

(DB2)16

X3. Decode the following hexadecimal ASCII message, assuming 8-bit ASCII characters:

    54 68 65 20 45 6E 64   The End

On a Windows PC: Install WSL 2

1. Install WSL 2 by following these instructions:
   https://docs.microsoft.com/en-us/windows/wsl/install-win10
   You can install any Linux distribution you like. I used Ubunto.

   The following video may also help:
   WSL2 Ubuntu GUI - Bing video
   (https://www.bing.com/videos/search?q=wsl+ubuntu&&view=detail&mid=E14207E987583178E63EE14207E987583178E63E&&FORM=VRDGAR)

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2. Install GCC compiler by
   a. Use sudo apt update to update the package database.
   b. Use sudo apt upgrade to make sure all of your packages are current.
   c. Use sudo apt install gcc to install the GNU C x86 and x86-x64 compiler.
   d. Use sudo apt install gcc-multilib to install the GNU C cross-compilation feature.
   e. Use sudo apt install gdb to install the GNU debugger.

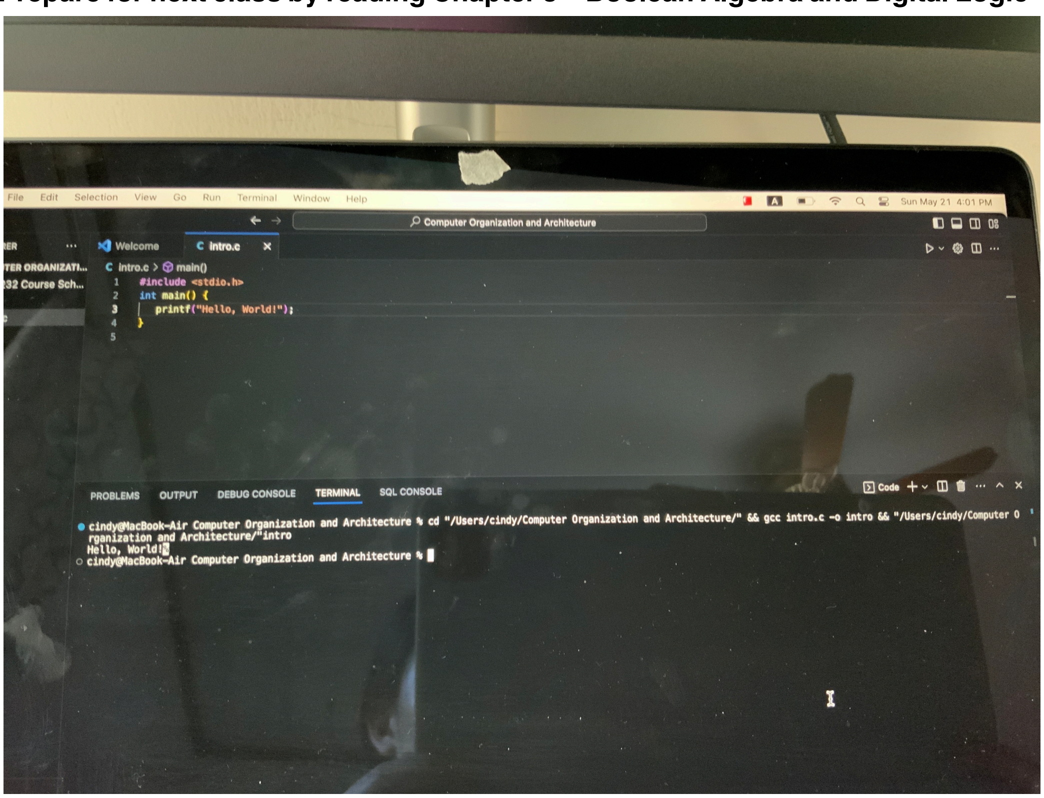
On a Mac: You may need to install Xcode. Then use a terminal window which will act just like the WSL window.

3. Refer to https://stackoverflow.com/questions/2603489/how-do-i-compile-a-c-file-on-my-mac for more help.

Then either using WSL or the Mac terminal window:

4. Write or copy from the Internet any simple C program and run it. Include the program and the output here. Compile with gcc <filename.c> and run with ./a.out.

Prepare for next class by reading Chapter 3 – Boolean Algebra and Digital Logic



8. Convert the following decimal fractions to binary with a maximum of six places to the right of the binary point:

a) 25.84375

b) 57.55

c) 80.90625

d) 84.874023

8a) 25.84375

· the decimal part

2 | 25	1
2 | 12	0
2 | 6	0
2 | 3	1
2 | 1	1
0	

bottom to top 11001

· the fraction part

$0.84375 \times 2 = 1.68750$ integer is 1

$0.68750 \times 2 = 1.37500$ integer is 1

$0.37500 \times 2 = 0.75000$ integer is 0

$0.75000 \times 2 = 1.50000$ integer is 1

$0.50000 \times 2 = 1.00000$ integer is 1

$0.00000 \times 2 = 0.00000$ integer is 0

top to bottom 110110

$\boxed{11001.110110}$

8b) 57.55

· the decimal part

$$\begin{array}{r|l l} 2 & 57 & 1 \\ 2 & 28 & 0 \\ 2 & 14 & 0 \\ 2 & 7 & 1 \\ 2 & 3 & 1 \\ 2 & 1 & 1 \\ & 0 & \end{array}$$

from buttom to top 111001

· the fraction part

$$\begin{array}{r} 0.55 \\ \times \quad 2 \\ \hline 1.10 \end{array}$$ integer is 1

$$\begin{array}{r} 0.10 \\ \times \quad 2 \\ \hline 0.20 \end{array}$$ integer is 0

$$\begin{array}{r} 0.20 \\ \times \quad 2 \\ \hline 0.40 \end{array}$$ integer is 0

$$\begin{array}{r} 0.40 \\ \times \quad 2 \\ \hline 0.80 \end{array}$$ integer is 0

$$\begin{array}{r} 0.80 \\ \times \quad 2 \\ \hline 1.60 \end{array}$$ integer is 1

$$\begin{array}{r} 0.60 \\ \times \quad 2 \\ \hline 1.20 \end{array}$$ integer is 1

top to buttom 100011

$\boxed{111001.100011}$

8c) 80.90625

· the decimal part

$$\begin{array}{r|l l} 2 & 80 & 0 \\ 2 & 40 & 0 \\ 2 & 20 & 0 \\ 2 & 10 & 0 \\ 2 & 5 & 1 \\ 2 & 2 & 0 \\ 2 & 1 & 1 \\ & 0 & \end{array}$$

from buttom to top 1010000

· the fraction part

$$\begin{array}{r} 0.90625 \\ \times \quad 2 \\ \hline 1.81250 \end{array}$$ integer is 1

$$\begin{array}{r} 0.81250 \\ \times \quad 2 \\ \hline 1.62500 \end{array}$$ integer is 1

$$\begin{array}{r} 0.62500 \\ \times \quad 2 \\ \hline 1.25000 \end{array}$$ integer is 1

$$\begin{array}{r} 0.25000 \\ \times \quad 2 \\ \hline 0.50000 \end{array}$$ integer is 0

$$\begin{array}{r} 0.50000 \\ \times \quad 2 \\ \hline 1.00000 \end{array}$$ integer is 1

$$\begin{array}{r} 0.00000 \\ \times \quad 2 \\ \hline 0.00000 \end{array}$$ integer is 0

from top to bottom 111010

$\boxed{1010000.111010}$

8d) 84.874023

· the decimal part

2	84	0
2	42	0
2	21	1
2	10	0
2	5	1
2	2	0
2	1	1
	0	

from bottom to top 1010100

· - on part

$$\begin{array}{r} 0.874023 \\ \times \quad 2 \\ \hline 1.748046 \end{array}$$ integer is 1

$$\begin{array}{r} 0.748046 \\ \times \quad 2 \\ \hline 1.496092 \end{array}$$ integer is 1

$$\begin{array}{r} 0.496092 \\ \times \quad 2 \\ \hline 0.992184 \end{array}$$ integer is 0

$$\begin{array}{r} 0.992184 \\ \times \quad 2 \\ \hline 1.984368 \end{array}$$ integer is 1

$$\begin{array}{r} 0.984368 \\ \times \quad 2 \\ \hline 1.968736 \end{array}$$ integer is 1

$$\begin{array}{r} 0.968736 \\ \times \quad 2 \\ \hline 1.937472 \end{array}$$ integer is 1

from top to bottom 110111

$\boxed{1010100.110111}$

10. Convert the following binary fractions to decimal:

a) 10111.1101

b) 100011.10011

c) 1010011.10001

d) 11000010.111

10a) 10111.1101

1) write the numbers spaced out
2) write 2^x exponents on top of number
3) multiply top with bottom for each column, add the results of all columns
4) add all numbers

$$\begin{array}{ccccccccc} 2^4 & 2^3 & 2^2 & 2^1 & 2^0 & 2^{-1} & 2^{-2} & 2^{-3} & 2^{-4} \\ 1 & 0 & 1 & 1 & 1. & 1 & 1 & 0 & 1 \end{array}$$

$$2^4 + 0 + 2^2 + 2^1 + 1 + \frac{1}{2} + \frac{1}{2^2} + 0 + \frac{1}{2^4}$$

$$= 16 + 0 + 4 + 2 + 1 + 0.5 + 0.25 + 0.0625$$

$$= 23.8125$$

10b) 100011.10011

$$\begin{array}{ccccccccccc} 2^5 & 2^4 & 2^3 & 2^2 & 2^1 & 2^0 & 2^{-1} & 2^{-2} & 2^{-3} & 2^{-4} & 2^{-5} \\ 1 & 0 & 0 & 0 & 1 & 1. & 1 & 0 & 0 & 1 & 1 \end{array}$$

$$2^5 + 0 + 0 + 0 + 2 + 1 + \frac{1}{2} + 0 + 0 + \frac{1}{2^4} + \frac{1}{2^5}$$

$$= 35.59375$$

10c) 1010011.10001

$$\begin{array}{cccccccccccc} 2^6 & 2^5 & 2^4 & 2^3 & 2^2 & 2^1 & 2^0 & 2^{-1} & 2^{-2} & 2^{-3} & 2^{-4} & 2^{-5} \\ 1 & 0 & 1 & 0 & 0 & 1 & 1. & 1 & 0 & 0 & 0 & 1 \end{array}$$

$$2^6 + 0 + 2^4 + 0 + 0 + 2 + 1 + \frac{1}{2} + 0 + 0 + 0 + \frac{1}{2^5}$$

$$= 83.53125$$

10d) 11000010.111

$$\begin{array}{ccccccccccc} 2^7 & 2^6 & 2^5 & 2^4 & 2^3 & 2^2 & 2^1 & 2^0 & 2^{-1} & 2^{-2} & 2^{-3} \\ 1 & 1 & 0 & 0 & 0 & 0 & 1 & 0. & 1 & 1 & 1 \end{array}$$

$$2^7 + 2^6 + 0 + 0 + 0 + 0 + 2 + 0 + \frac{1}{2} + \frac{1}{2^2} + \frac{1}{2^3}$$

$$= 194.875$$

17. Represent the following decimal numbers in binary using 8-bit signed magnitude, one's complement, and two's complement representations:

a) 60
b) -60
c) 20
d) -20

17a) 60

positive number

2	60	0
2	30	0
2	15	1
2	7	1
2	3	1
2	1	1
	0	

bottom to top 111100

so, 60 in binary is 111100

so, 60 in normal binary is 00111100 ← flip backwards???

one's complement : 00111100

two's complement : 00111100

signed-magnitude : 00111100

17b) -60

negative number

2	60	0
2	30	0
2	15	1
2	7	1
2	3	1
2	1	1
	0	

bottom to top 111100

so, 60 in binary is 111100

so, 60 in normal binary is 00111100 ← flip backwards???

signed-magnitude : set 1 as the farthest-left bit, since its a negative number

00111100 becomes 10111100

one's complement : flip 1's to 0's and 0's to 1's

00111100 flips to 11000011

two's complement : add 1 to the above results

11000011 + 1 = 11000100

$$\begin{array}{r} 11000011 \\ + \quad 1 \\ \hline 11000100 \end{array}$$

17c) 20

positive number

2	20	0
2	10	0
2	5	1
2	2	0
2	1	1
	0	

bottom to top 10100

so, 20 in binary is 10100

so, 20 in normal binary is 00101 ← flip backwards ???

one's complement : 00010100

two's complement : 00010100

signed-magnitude : 00010100

17D) -20

negative number

2	20	0
2	10	0
2	5	1
2	2	0
2	1	1
	0	

bottom to top 10100

so, 20 in binary is 10100

so, 20 in normal binary is 00010100 ← flip backwards ???

signed-magnitude : set 1 as the farthest-left bit, since its a negative number

00010100 becomes 10010100

one's complement : flip 1's to 0's and 0's to 1's

00010100 becomes 11101011

two's complement : add 1 to the above results

11101011 + 1 = 11101100

$$\begin{array}{r} 11101011 \\ + \quad 1 \\ \hline 11101100 \end{array}$$

22. What decimal value does the 8-bit binary number 10110100 have if:

a) it is interpreted as an unsigned number?

b) it is on a computer using signed-magnitude representation?

c) it is on a computer using one's complement representation?

d) it is on a computer using two's complement representation?

e) it is on a computer using excess-127 representation?

22a) 10110100

$= 1\times2^7 + 0\times2^6 + 1\times2^5 + 1\times2^4 + 0\times2^3 + 1\times2^2 + 0\times2^1 + 0\times2^0$

$= 2^7 + 0 + 2^5 + 2^4 + 0 + 2^2 + 0 + 0$

$= 180$

22b) 10110100

farthest-left bit is 1, so the number is negative

convert the rest of the number to decimal:

0110100

$= 0\times2^6 + 1\times2^5 + 1\times2^4 + 0\times2^3 + 1\times2^2 + 0\times2^1 + 0\times2^0$

$= 0 + 2^5 + 2^4 + 0 + 2^2 + 0 + 0$

$= 52$

So, 10110100 from signed-magnitude to decimal is -52

22c) 10110100

farthest-left bit is 1, so the number is negative

① flip all bits, 1's to 0's, 0's to 1's, 10110100 becomes 01001011

② convert result to decimal 1001011

$= 1\times2^6 + 0\times2^5 + 0\times2^4 + 1\times2^3 + 0\times2^2 + 1\times2^1 + 1\times2^0$

$= 2^6 + 0 + 0 + 2^3 + 0 + 2^1 + 1$

$= 75$

Answer: -75

22d) 10110100

farthest-left bit is 1, so the number is negative

① flip all bits, 1's to 0's, 0's to 1's, 10110100 becomes 01001011

② Add 1 to the above result: 01001011 + 1 = 1001100

```
  0 1 0 0 1 0 1 1
+             1 1 1
-----------------
    1 0 0 1 1 0 0
```

③ convert result to decimal 1001100

$= 1\times2^6 + 0\times2^5 + 0\times2^4 + 1\times2^3 + 1\times2^2 + 0\times2^1 + 0\times2^0$

$= 2^6 + 0 + 0 + 2^3 + 2^2 + 0 + 0$

$= 76$

Answer = -76