**Lab 10:**

**Fixed-Point Arithmetic**

**Name (Print):** \_\_\_\_\_\_REZA SHISHEIE\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ID\_\_\_\_\_2708062\_\_  
  
**Give brief answers to the following questions. You can edit this document and insert your answers after each question.**

**Due dates:**

**MW – Wed, Apr 25, beginning of class  
TTH – Tue, Apr 24, beginning of class**

**Circle one: MW or TTH**

1. (1 pt) What is the 5-bit two’s complement representation of 10 decimal? What is the 5-bit two’s complement representation of −10 decimal?  
     
   **Ans.**

10 decimal = 01010 🡪 Two’s complement = 10101 + 0001 = 10110 = -10 decimal

-10 decimal = 10110 🡪 Two’s complement = 01001 + 0001 = 01010 = 10 decimal

1. (1 pt) What is the range (in decimal) of a 32-bit two’s complement integer?  
     
   **Ans.**

2^(32) = 4294967296 🡪two’s complement range = [2^16-1 , -2^16]

=[4294967296/2-1 , 4294967296/2] = [2147483647 , 2147483648]

1. (1 pt) How many bits do you need to represent integers in the range [**−**10,000, +10,000]?  
     
   **Ans.**2\*10000+1 = 20001

2^14 = 16384 < 20001 < 2^15=32768

There should be 15 bits

1. (2 pts) Give the recursive Newton’s Method formula for computing the cube root of the number *a*. Suppose your formula is used to find the cube root of 8027. Write down the results of the iteration until you see convergence, starting with the initial guess *x*0= 1. Assume that integer math is used and that the fractional part of divide operations is truncated. (Hint: it takes 14 iterations to converge.)

**Ans.**

y(x) = x^3 🡪 yprime = 3x^2 🡪

x(n+1)=x(n)-y/yprime

x(n+1) = x(n)- (x(n)^3-a)/3x(n)^2

x(1) = 1 🡪 x(2)= 2676  
x(2) = 2676 🡪 x(3)= 1785

x(3) = 1785 🡪 x(4)= 1190

x(4) =1190 🡪 x(5)= 793

x(5) =793 🡪 x(6)= 528

x(6) =528 🡪 x(7)= 352

x(7) =352 🡪 x(8)= 234

x(8) =234 🡪 x(9)= 156

x(9) =156 🡪 x(10)= 104

x(10) =104 🡪 x(11)=69

x(11) = 69 🡪 x(12)=46

x(12) =46 🡪 x(13)=31

x(13) = 31 🡪 x(14)=23

x(14) =23 🡪 **x(15)=20**

x(15) =20 🡪 **x(16)=20**

1. (1 pt) Suppose W = 0xFF. What are the contents of W (in hex) and STATUS<C> after the instruction sublw .128 ? Indicate whether a borrow occurred.  
     
   **Ans.**  
   W = 0xFF = 255 🡪

sublw .128 = 128 – 255

1000 0000 1000 0000

- 1111 1111 + 0000 0001

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1000 0001 🡪 since the carry bit is zero (C=0) and we are doing a subtraction this result is not valid and the result would be the complement

1000 0001 🡪 0111 1110 + 1 = 0111 1111 = -127

W=0x81 and C=0

1. (1 pt) Suppose W = 0x64. What are the contents of W (in hex) and STATUS<C> after the instruction sublw .128 ? Indicate whether a borrow occurred.  
     
   **Ans.**  
   W = 0x64 = .100 = 0110 0100 🡪

sublw .128 = 128 – 100 = 28

1000 0000 1000 0000

- 0110 0100 + 1001 1011 + 1 = 1001 1100

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(1) 0001 1100 🡪 since the carry bit is 1 (C=1) and we are doing an addition this result is valid and the result would be

0001 1100 s= 28

W = 0x1C

C = 1

1. (1 pt) Give a single PIC assembly code instruction that computes the two’s complement of the contents of the W register.  
     
   **Ans.**SUBLW 0 🡪 and W is the number you’d like to get twos complement. So if I want to get the twos complement of 11 I would do 0-11 = -11
2. (2 pts) Complete the following table.

|  |  |  |  |
| --- | --- | --- | --- |
| **Decimal Digit** | **BCD** | **ASCII (dec)** | **ASCII (hex)** |
| 0 | 0000 | 48 | 0x30 |
| 1 | 0001 | 49 | 0x31 |
| 2 | 0010 | 50 | 0x32 |
| 3 | 0011 | 51 | 0x33 |
| 4 | 1000 | 52 | 0x34 |
| 5 | 0101 | 53 | 0x35 |
| 6 | 0110 | 54 | 0x36 |
| 7 | 0111 | 55 | 0x37 |
| 8 | 1000 | 56 | 0x38 |
| 9 | 1001 | 57 | 0x39 |

Now suppose that the W register contains the BCD code for a decimal digit. Write **one instruction** that converts the BCD code in W to the ASCII code for that decimal digit and returns the result in the W register.

addlw 0.48

1. (4 pts) Write a routine called Abs that computes the absolute value of the 8-bit two’s complement number in the W register, and returns the result in W. Comment your code.   
     
   If the MSB of W is 0, then W is positive so the routine should simply return. If the MSB of W is 1, then W is negative so the routine needs to return the two’s complement of the number.   
     
   Use the simulation mode and test your routine on the numbers 123 and – 109. Show the result in decimal in a Watch window. Demonstrate and explain the code to the Ins/TA.  
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   **Instructor/TA signature** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date \_\_\_\_\_\_\_\_\_
2. (8 pts) Write a routine called TwosComp16 that computes the two’s complement of a 16-bit number that is contained in registers MultCH (high byte) and MultCL (low byte) and returns the result to the same registers. Comment your code.   
     
   Use the simulation mode and test your routine on the numbers 0x7B50 and 0xB2FD. Show the result in hex in a Watch window. Demonstrate and explain the code to the Ins/TA.  
     
   **Instructor/TA signature** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date \_\_\_\_\_\_\_\_\_