Electrical and Computer Engineering Department
University of Maryland
College Park, MD 20742-3285
Glenn L. Martin Institute of Technology ♦ A. James Clark School of Engineering
Dr. Charles B. Silio, Jr.
Telephone 301-405-3668
Fax 301-314-9281
silio@umd.edu

**ENEE 350 Homework Set No. 9** and **Programming Project 4**
(Due: Class 21, Mon., Jul. 7, 2014) (Due: Class 25, Mon., Jul. 14, 2014)

1. Read Appendix B of text by A. Tanenbaum, *Structured Computer Organization,* $5^{th}$ ed., Prentice-Hall, 2006, and work the following problems from Appendix B:

   a. Problem B–1. b. Problem B–2. c. Problem B–3.

2. What sign-magnitude decimal values are represented by the following IEEE 754 single precision floating-point words whose contents are shown using hexadecimal shorthand? (Hint: use C-compiler and formatted output to save yourself from doing considerable work.)

   a. `B9EBEDFA` c. `40490FDB`
   b. `7F800000` d. `FF83FD03`

3. Print out and read the handout on floating point representations by C. Silio in course website file **www.ece.umd.edu/class/enee350.Sum2014.Silio/Notes/fltngpt.pdf**.

4. The designers of a particular computer have decided that the computer must be capable of representing single-precision (single-word) floating-point numbers in the range $\pm(10^{-17}$ to $10^{17})$ with a precision of one part in $10^5$. Determine the minimal binary word length which must be chosen for this machine, and indicate the floating-point format you would choose for doing this in order to facilitate the sorting of floating-point numbers. (Assume that $2^{10} = 10^3$ to facilitate decimal to binary conversions.)

5. Recall from your reading of Silio's notes on floating-point representations that the UNIVAC 1100 series computers have 36-bit words and perform 1's complement arithmetic. Suppose UNIVAC 1100 registers $A1$ and $A2$ contain the following bit patterns in octal shorthand.

$$(A1) = 572053777777 \qquad (A2) = 206556400000$$

   Viewing the contents of A1 and A2 as single-precision floating-point numbers:

   a. What sign-magnitude decimal number is contained in A1?

   b. What sign-magnitude decimal number is contained in A2?

6. In a DEC PDP-11 the contents of two consecutive memory words are (in binary):

   1011111111010000 0000000000000000

   Recall that the single-precision floating-point format for this machine is of the form: 1+8+23(24) bits with a binary normalized mantissa 0.1xxx as in

| 1 | 8 | 23 |
|---|---|---|
| $S_M$ | BIASED EXPONENT | BINARY NORMALIZED MANTISSA |

   If this 32-bit pattern is interpreted as a single-precision floating-point number, what sign-magnitude decimal number does it represent?

7. The IBM 360/370 series computers use a sign-magnitude hexadecimally normalized, biased-exponent, 32-bit representation for single precision floating-point numbers in the following format:

| 1 | 7 | 24 |
|---|---|---|
| $S_M$ | BIASED EXPONENT | HEXADECIMALLY NORMALIZED MANTISSA |

   Write the 8-digit hexadecimal representation of the bit pattern in the 32-bits known to contain the single-precision representation of the floating-point number shown here in both its decimal and octal forms:

$$-(27\frac{2}{13})_{10} = -(33.1166116611661166...)_8$$

-continued-

8. Consider the following biased exponent (bias = $2^5$), sign-magnitude floating point format for representing binary normalized numbers in single-precision words in a machine with 2's complement fixed-point arithmetic; the mantissa (significand) is a binary normalized fraction, and there are no hidden bits:

| 1 | 6 | 7 |
|---|---|---|
| $S_M$ | BIASED EXPONENT | BINARY NORMALIZED MANTISSA |

Suppose we are given the following two operands represented in this format:

X = 1 000010 1010001    Y = 0 000101 1100110

Show the bit pattern in the single-precision word S that results from the floating add of the contents in X and Y, assuming that the result is truncated to a 7-bit precision fraction.

9. **Programming Project 4 (Due: Class 25, Mon., Jul. 14, 2014)**: Consider the following biased exponent (bias = $2^6$), sign-magnitude floating point format for representing binary normalized numbers in 16-bit single-precision words in a machine with 2's complement fixed-point arithmetic; the mantissa (significand) is a binary normalized mixed number with hidden bit similar to IEEE754.

| 1 | 7 | 8 |
|---|---|---|
| $S_M$ | BIASED EXPONENT | BINARY NORMALIZED SIGNIFICAND |

For example, the following two operands represented in this format:

A = 1 0000010 10100011    B = 0 0000101 11001100

where A = 0x82A3 = - $1.10100011 \times 2^{-62}$ and B = 0x05CC = $+1.11001100 \times 2^{-59}$.

a. Making use of the MAC-2 instruction repertoire and the inv(x) function you wrote and tested in programming assignment 3, write and test a procedure (i.e., a function subprogram) **or(x,y)** that computes the bit-wise logical OR of the n-tuples x and y. The arguments are passed by reference, with address y pushed on the stack first followed by address x pushed on the stack followed by a call to function **or**, which returns the value computed in the ac register (return by value).

b. Making use of the MAC-2 instruction repetoire, write a (void function) procedure **ashr2(x)** that performs a 1-bit position 2's-complement arithmetic (algebraic) right shift of the contents of memory location x and leaves the result in memory location x, where the address x is passed by reference on the stack.

c. Again, making use of the MAC-2 instruction repetoire and whatever other functions (such as the OR function and procedure ashr2(x) from parts a.) and b.) write and test a procedure (i.e., a function subprogram) **fadd(x,y)** that performs a floating add of single-precision floating point numbers in memory locations x and y and returns the single-precision floating-point format result in the ac register, where all single-precision floating point numbers are represented in the format specified above in Problem 9. Again, the arguments are passed by reference, with address y pushed on the stack first followed by address x pushed on the stack followed by a call to function **fadd**, which returns the value computed in the ac register (return by value).

d. Test your **fadd** function using the following main program (**prg4main**):

Repair the following main program, if necessary, to accomplish the desired results as stated in the comments.

```
         /prg4main
          EXTRN   inv
          EXTRN   or
          EXTRN   fadd
x1        0x7D5C
x2        0x7A33
x3        0x0b98
x4        0x02A3
ans1      RES      1
ans2      RES      1
ans3      RES      1
ans4      RES      1
ans5      RES      1
ans6      RES      1
start     loco    4020
          swap
          loco    x1
          push
          call    inv
          stod    x1      /create data x1=0x82A3
          stod    ans1
          loco    ans1
          push
          call    ashr2    /make sure ashr2 is working
          insp    1
          loco    x2
          push
          call    inv
          stod    x2      /create data x2=0x85CC
          call    or
          stod    ans2    /make sure OR is working
          call    fadd
          stod    ans3    /ans3=fadd(x1,x2)
          loco    x3
          stol    0
          call    ashr2    /ashr2 shifts x3 right arthimetically
          call    fadd
          stod    ans4    /ans4=fadd(x1,x3)
          loco    x4
          stol    1
          call    fadd
          stod    ans5    /ans5=fadd(x3,x4)
          loco    x2
          stol    0
          call    fadd
          stod    ans6    /ans6=fadd(x2,x4)
          insp    2
          halt
          END     start
```