ENEE 350 Homework Set No. 9
(Due: Class 21, Tues., Nov. 10, 2015)
and
Programming Project 4
(Due: Class 24, Thurs., Nov. 19, 2015)

1. Read Appendix B of text by A. Tanenbaum, *Structured Computer Organization*, 5th or 6th ed., 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
   b. 7F800000
   c. 40490FDB
   d. FF83FD03


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.
   \[(A1) = 572053777777 \quad (A2) = 206556400000\]
   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):
   \[1011111111010000 \quad 0000000000000000\]
   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
   \[
   \begin{array}{c|c|c}
   S_M & BIASED & BINARY NORMALIZED \\
   \hline
   1 & 8 & 23 \\
   \end{array}
   \]
   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:

<table>
<thead>
<tr>
<th>1</th>
<th>7</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>BIASED</td>
<td>HEXADECIMALY NORMALIZED MANTISSA</td>
</tr>
</tbody>
</table>

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

\[-(27 \frac{2}{13})_{10} = -(33.116611661166166...)_8\]

-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:

<table>
<thead>
<tr>
<th>1</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>BIASED</td>
<td>BINARY NORMALIZED MANTISSA</td>
</tr>
</tbody>
</table>

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

\[X = 1 000010 1010001 \quad Y = 0 000101 1100110\]

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 24, Thurs., Nov. 19, 2015):** 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.

<table>
<thead>
<tr>
<th>1</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>BIASED</td>
<td>BINARY NORMALIZED SIGNIFICAND</td>
</tr>
</tbody>
</table>

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

\[A = 1 0000010 10100011 \quad B = 0 0000101 11001100\]

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 repertoire, 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 repertoire 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.

```assembly
/prg4main
EXTRN inv
EXTRN ashr2
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 arithimetically
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
```