ENEE 350 Homework Set No. 9  
(Due: Class 21, Mon., Apr. 15, 2019)  
and  
Programming Project 4  
(Due: Class 26, Wed., May 1, 2019)

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; e.g., hex2float.c in Notes directory on class website.)
   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.
   \((A1) = 572053777777\)  
   \((A2) = 20656400000\)

   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

<table>
<thead>
<tr>
<th>S_M</th>
<th>BIASED</th>
<th>BINARY NORMALIZED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>23</td>
</tr>
<tr>
<td>8-bits</td>
<td>EXPONENT</td>
<td>23-bits</td>
</tr>
</tbody>
</table>

   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 hexadecimal normalized, biased-exponent, 32-bit representation for single precision floating-point numbers in the following format:

<table>
<thead>
<tr>
<th>S</th>
<th>M</th>
<th>BIASED EXPONENT</th>
<th>HEXADECIMALLY NORMALIZED MANTISSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
<td>24</td>
<td></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:

\[-(27\frac{2}{13})_{10} = -(33.1166116611661166...)_{8}\]

-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:

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

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 26, Wed., May 1, 2019): 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>S</th>
<th>M</th>
<th>BIASED EXPONENT</th>
<th>SIGNIFICAND</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

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

A = 1 0000010 10100011
B = 0 000101 11001100

where A = 0x82A3 = -1.10100011×2⁻⁶² and B = 0x05CC = +1.11001100×2⁻⁵⁹.

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) \( \text{or}(x,y) \) that computes the bit-wise (parallel) 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 \( \text{ashr2}(x) \) 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) \( \text{fadd}(x,y) \) 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 \texttt{fadd} function using the following main program (\texttt{prg4main}):

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

```
/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
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
```