ENEE 350 Homework Set No. 9

and

Programming Assignment 4
(Due: Class 21, Thurs., Nov. 10, 2005)

1. Read Appendix B of text by A. Tannenbaum, *Structured Computer Organization*, 5th 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
   b. 7F800000
   c. 40490FD8
   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 \( \pm (10^{-17} \text{ to } 10^{17}) \) with a precision of one part in \( 10^{6} \). 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):

\[
10111111111110000 \quad 0000000000000000
\]

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

<table>
<thead>
<tr>
<th>1</th>
<th>8</th>
<th>23</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>BIASED</td>
<td>BINARY NORMALIZED</td>
</tr>
<tr>
<td></td>
<td>EXPONENT</td>
<td>MANTISSA</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?

-continued-
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>1</th>
<th>7</th>
<th>24</th>
</tr>
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<tbody>
<tr>
<td>SM</td>
<td>BIASED</td>
<td>HEXADECIMALLY NORMALIZED</td>
</tr>
<tr>
<td></td>
<td>EXPONENT</td>
<td>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:

\[-(27 \frac{2}{13})_{10} = -(33.116611661166...)_8\]

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</td>
</tr>
<tr>
<td></td>
<td>EXPONENT</td>
<td>MANTissa</td>
</tr>
</tbody>
</table>

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

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

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 Assignment 4: 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</td>
</tr>
<tr>
<td></td>
<td>EXPONENT</td>
<td>SIGNIFICAND</td>
</tr>
</tbody>
</table>

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

\[A = 1 0000010 \quad 10100011 \quad B = 0 0001011 \quad 11001100\]

where $A = 0x82A3 = -1.10100011 \times 2^{-52}$ and $B = 0x05CC = +1.11001100 \times 2^{-52}$.

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 ashr(x) that performs a 1-bit position 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 ashr(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).

c. 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.

```
/prg5main
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=0x2A3
stod ans1
loco ans1
push
call ashr /make sure ashr is working
insp 1
loco x2
push
call inv
stod x2 /create data x2=0x85C
call or
stod ans2 /make sure OR is working
call fadd
stod ans3 /ans3=fadd(x1,x2)
loco x3
stol 0
call ashr /ashr shifts x3 right arithmetically
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
```