ENEE 350
TEST 1-Spring 2005
CLOSED BOOK AND NOTES
EXAM PERIOD 75 MINUTES

Instructions:

- Points for each problem are indicated right after the problem. The total score is 100 points.
- Use the space provided below each problem. if you need more space, please ask a proctor.
- Write your name and student id on the cover sheet.
- Promptly hand in your test to a proctor when the test is over.

NAME:

STUDENT ID:

Problem 1 (20 points): Consider the following vesp program. Specify the values in memory locations 0, 1, and 10 after the execution of the program is completed, and explain why.

```
100      LDA    0, 50;
102      LDA    1,-15;
104      ADD;
105      MOV    10,0;
107      JPS    104;
108      HLT;
```

Note: All addresses and operand values are expressed in decimal.

   Answer:
     Location 0:   50
     Location 1:   -15
     Location 10: -10

Problem 2 (20 points):

The computation engine of a given processor executes four logic instructions on a pair of 4-bit operands,

   $A = [a_0, a_1, a_2, a_3]$

   $B = [b_0, b_1, b_2, b_3]$

whose instruction format is given below:

Instruction	Op-code	Operation
Copy B	00	A = B
Complement A	01	A = ~A
Left shift A	10	A = A << 1
Right shift A	11	A = A >> 1

Design a combinational circuit that can carry out these four instructions in the computation engine of this processor. (*Note: You are only required to describe a combinational circuit that performs these logic instructions, not the entire computation engine of the processor.*)
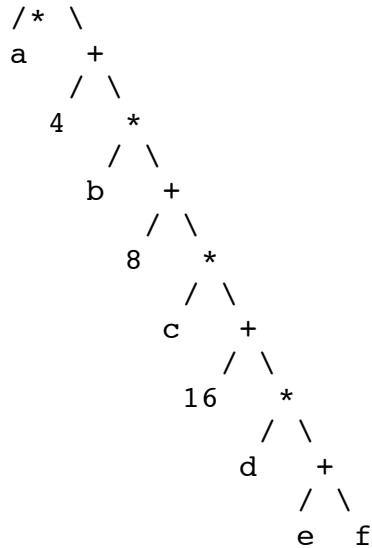
Answer: Use four 4x1 multiplexers with select inputs Op-code[0],Opcode[1] to select B, ~A, A << 1, A>> 1 into A[0],A[1],A[2],A[3].

Problem 3 (20 points): Consider the following expression

$$a *(4+ b *(8+ c *(16 + d*(e + f))))$$

(a) Draw a binary tree that represents this expression

Solution:

```
  /* \
 a    +
     / \
    4    *
        / \
       b    +
           / \
          8    *
              / \
             c    +
                 / \
                16    *
                     / \
                    d    +
                        / \
                       e   f
```

(b) Show a post-order expression that is equivalent to this expression

Solution: Post-order traversal: visit left subtree, visit right subtree, visit root.

a 4 b 8 c 16 d e f + * + * + * + *

(c) Show a pre-order expression that is equivalent to this expression

Solution: Pre-order traversal: visit root, visit left subtree, visit right subtree.

*a+4*b+8*c+16*d+ef

(d) Write a CodeMill stack program for the pre-order expression you obtained in part (c)

```
PUS e; PUS f; ADS; PUS d; MPS;
PUS 16; ADS; PUS c; MPS;  PUS 8;
ADS; PUS b; MPS; PUS 4; ADS;
PUS a; MPS;
```

(e) Clearly show the first 5 frames of CodeMill's stack during the execution of your program assuming that the stack pointer is initially set to the floor of the stack.

```
Frame 1: e

Frame 2: f
         e

Frame 3: f+e

Frame 4: d
         f+e

Frame 5: d*(f+e)
```

Problem 4 (20 points): The following code describes the instruction sequencer of a central processor unit. Give a control circuit that implements this instruction sequencer, clearly indicating the events that occur in each state.

```
while(reset == 0)
{
Step 1: X = Y; Y =   Y +4;
Step 2: U = MEMORY[X];
Step 3: switch(U[0:2])
{
case 0: A = A +1;  break; case 1: A = A - 1; break;
case 2: A = A + B; break; case 3: A = A - B; break;
case 4: A = 2A;    break; case 5: A = A/2;   break;
case 6: A = 0;     break; case 7: A = 1;     break;
}
}
```

Answer: You would need three D Flip-flops and a 3x8 decoder. Cascade the three flip-flops together, and logically AND the outputs of the 3x8 decoder with the Q output of the third flip-flop. The inputs of the decoder should be connected to the three bits in U.

Problem 5 (20 points): Write a vesp program to sort the numbers in memory locations 120,121,122 in ascending order. For example, if the numbers in locations 120, 121, and 122 are 4, -2 17, after sorting, they will be -2, 4, 17.

Answer: This one requires using 2's complement addition, and conditional branch instructions to compare the numbers in locations 120,121, and 122. Since there are only three numbers, the easiest approach is to find the smallest number and put in location 120, and then find the smaller of the remaining two numbers, and, store it in location 121. Since the numbers are declared to be all positive, one must careful about the subtraction operation.