CS270
Midterm
Fall 2014

I, the undersigned, do hereby affirm that the work contained in this exam is solely my own, and that none of the results were achieved by cheating. This includes using automated tools to generate answers, stealing the answers off the web, etc. Please do the work yourself.

Name _____
(printed legibly)

Signature_____

9-digit Student ID _____
(printed legibly)

Grading

Section	Possible Points	Actual Points
Number Representation	30	
Floating Point Numbers	15	
Combinational Logic	20	
Sequential Logic	10	
LC-3 Architecture	15	
C Programming	10	
Total	100	

Problems 1-10 are about number representation and number conversion, no calculators allowed!

1) How many bits in a byte and bytes in a 64-bit word? (2 points)

8, 8

2) How many bits are required to represent 1015 unique patterns? How many are left over? (2 points)

10, 9

3) What is the binary equivalent of the hexadecimal number 0xABCD0123? (2 points)

0b **1010 1011 1100 1101 0000 0001 0010 0011**

4) What is the hexadecimal equivalent of the binary number 0b1100 0101 1001 1111? (2 points)

0x **C59F**

5) What is the decimal equivalent of the binary number 0b01110101? (2 points)

117

6) What is the binary equivalent of the decimal number 256 + 64 + 32 + 16 + 2 + 1 = 371? (2 points)

0b **101110011**

7) What is the (fixed-point) binary equivalent of the decimal number 5.625? (2 points)

101.101

8) What is the (fixed point) decimal equivalent of the binary number 1110.011? (2 points)

14.375

9) Translate the string "CS270" into decimal ASCII values (Hint: ASCII 'A' = 65, ASCII '0' = 48). (3 points)

67 83 50 55 48

10) What is the decimal value of the 8-bit 2's complement binary number 0b11110110? (2 points)

-10

11) Translate the decimal values below into 8-bit 2's complement binary values and do the arithmetic. (6 points)

```
   17   0b00010001          32   0b00100000
 +  9   0b00001001        + -8   0b11111000
 =  26  0b00011010        = 24   0b00011000
```

12) Show the result of the following logical operations in hexadecimal. Space is provided for binary values that may help you solve the problem but will not be graded (3 points)

```
  0x76                0x76                0xFF
& 0xBD              | 0xBD              ^ 0x0F
= 0x34              = 0xFF              = 0xF0
```

Problems 13-15 should be answered based on the IEEE 754 single-precision format.

HINT: 1 sign bit, 8 exponent bits, biased by 127, and 23 fractional bits, with an implicit 1.

13) What are the **binary** values of the fields of the IEEE 754 single-precision format of 12.25? (3 points)

Sign = **0 (positive)**

Exponent: **10000010 (130)**

Mantissa: 1.**10001**…

14) What is the **decimal** number represented by 0b 0 10000011 11000000000000000000000? (4 points)

Show your work for partial credit:

sign = 0, exponent = 131-127=4, mantissa = 1.11b = 1.75, * 2^4 = 28.0

15) Fill in the values below for each step to add the floating point numbers x = 2.25 and y = 4.125. (8 points)

x = 2.25 = 0x40100000, y = 4.125 = 0x40840000, sum = x + y

What is the (unbiased) exponent of x, in decimal? **1 (128 biased)**

What is the (unbiased) exponent of y, in decimal? **2 (129 biased)**

What is the mantissa of x in binary, with the implicit 1 shown? **1.001 (1.125 decimal)**

What is the mantissa of y in binary, with the implicit 1 shown? **1.00001 (1.03125 decimal)**

What is the mantissa of the sum after normalization? **1.10011**

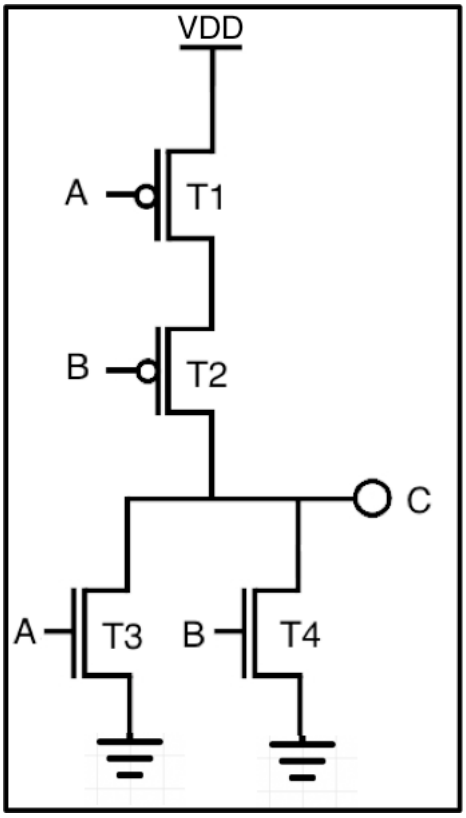
What is the (unbiased) exponent of the sum, after normalization? **2 (129 biased)**

What is the hexadecimal value of the sum? **0x40CC0000**

What is the decimal value of the sum? **6.375**

Problems 16-20 cover transistors, gates, and basic circuits.

16) Analyze the transistor circuits shown below and complete the truth table. Hint: A p-type transistor is closed with 0 input and open with 1 input, an n-type transistor the opposite. (4 points)



A	B	T1 (p-type)	T2 (p-type)	T3 (n-type)	T4 (n-type)	C
0	0	Closed	Closed	Open	Open	1
0	1	Closed	Open	Open	Closed	0
1	0	Open	Closed	Closed	Open	0
1	1	Open	Open	Closed	Closed	0

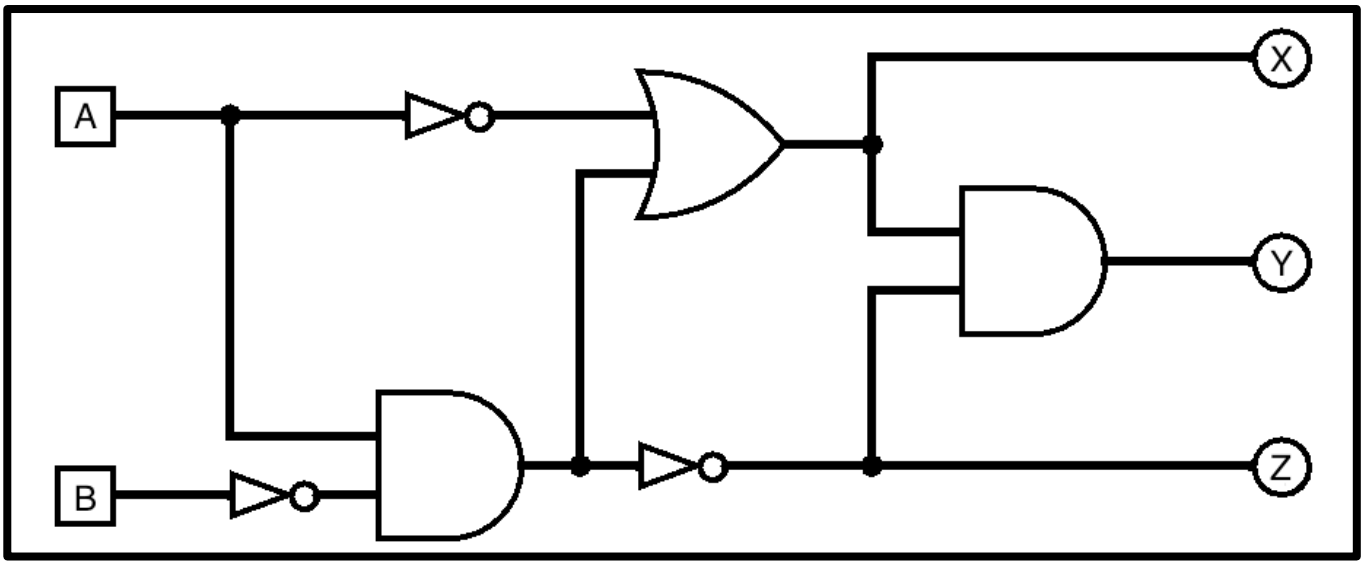
17) How many select lines are needed for a 16 to 1 multiplexer? (2 points)

4 lines

18) For a 4-bit adder, what are the outputs for the inputs 0x8 and 0x9, if the CarryIn bit is 1. (4 Points)

Sum = **2** Carryout = **1**

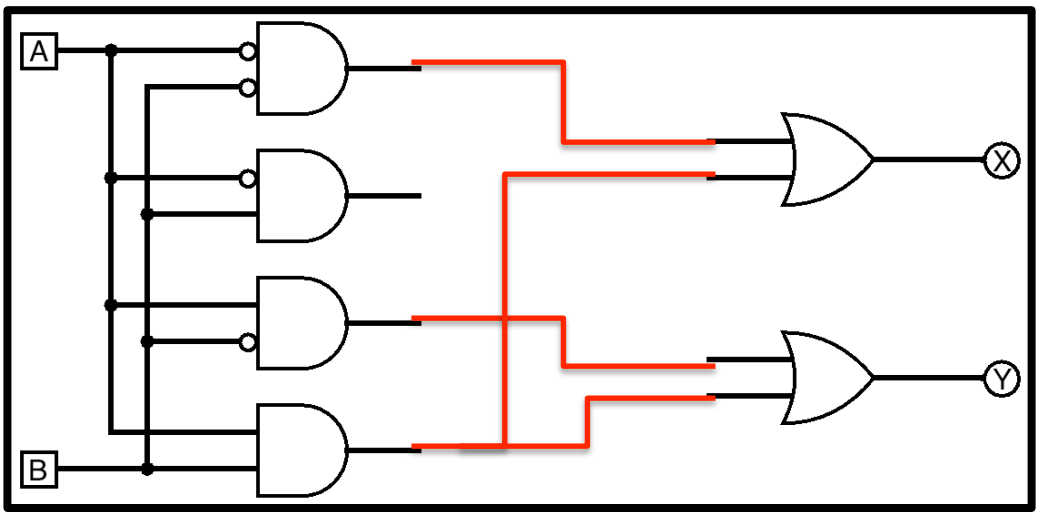
19) Analyze the combination logic shown below and complete the truth table. (6 Points)



A	B	X	Y	Z
0	0	1	1	1
0	1	1	1	1
1	0	1	0	0
1	1	0	0	1

20) Connect the output of the appropriate AND gates to the OR gates to fulfill the truth table below. (4 points)

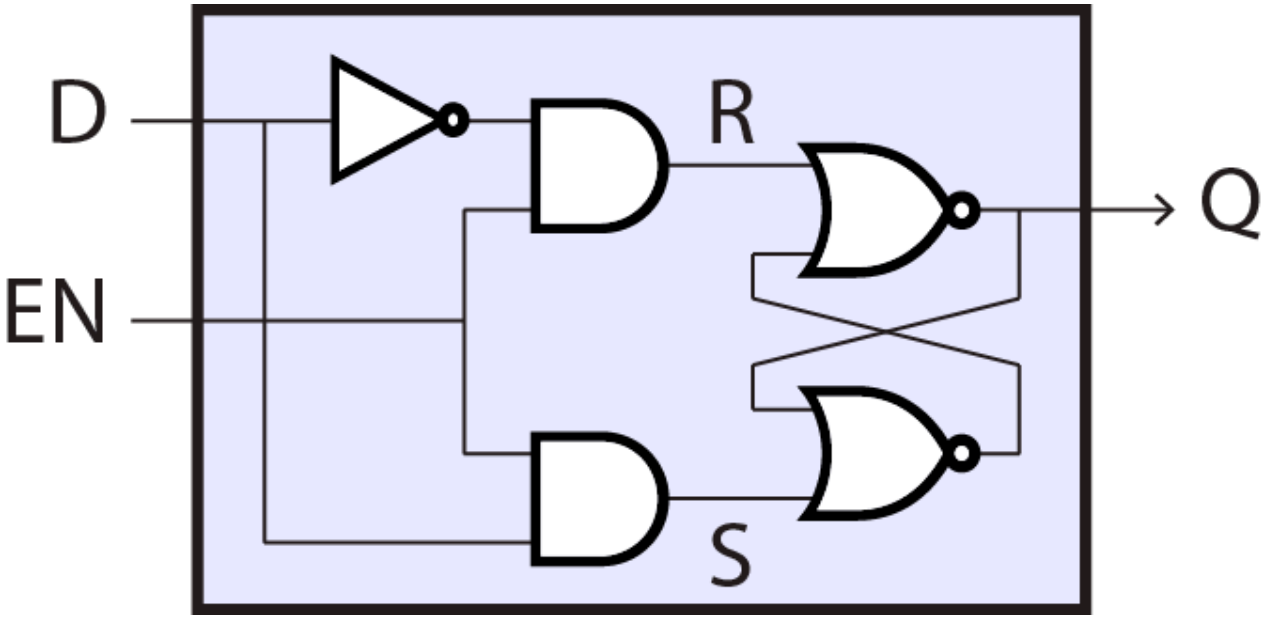
A	B	X	Y
0	0	1	0
0	1	0	0
1	0	0	1
1	1	1	1



Problems 21 and 22 cover sequential logic and state machines.

21) Fill in the truth table for the D latch circuit show below. (5 points)

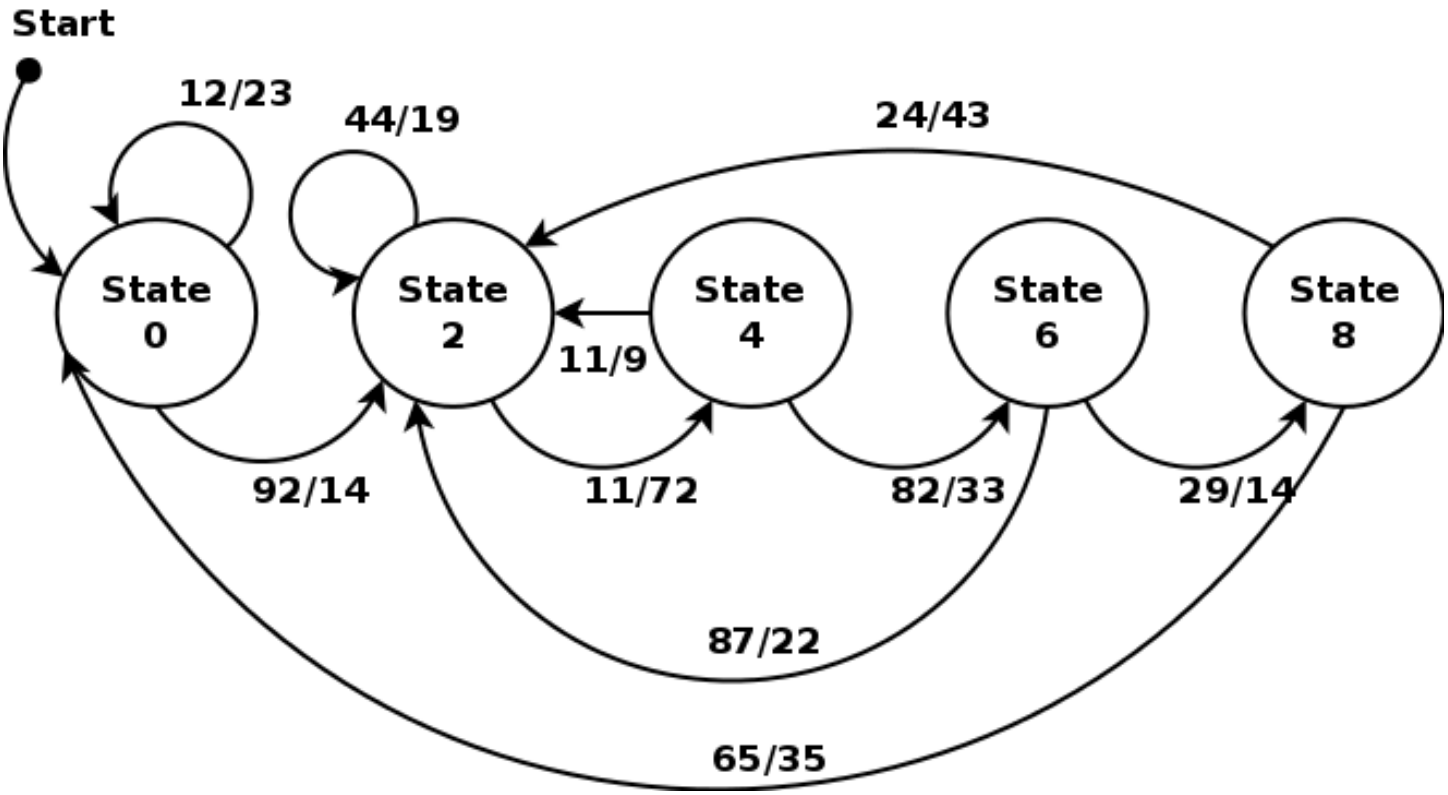
Data (D)	Enable (EN)	Previous State	Output (Q)
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1



22) If the state machine below starts in State 0 and is sent the input pattern 92, 44, 44, 11, 82, 29, 65, 12, what is the output and final state? (5 points)

Output: **14, 19, 19, 72, 33, 14, 35, 23**

Final State: **0**



Problems 23-27 are related to LC-3 architecture and LC-3 assembly code.

23) What are the address space, word size, and number of registers on the LC-3 computer? (3 points)

65536 or 16-bits or 2^{16}, 16-bits, 8 registers

24) Translate the following instruction into a hexadecimal value: AND R3,R6,#5 (3 points)

0x57A5 or 0b 0101 0111 1010 0101

25) Translate the following hexadecimal value into an assembly instruction: 0x94FF (3 points)

NOT R2,R3

26) What is in the PC offset field of the following LC-3 branch instruction? (3 points)

```
        BRnp LABEL
        AND R2,R2,#0
        AND R3,R3,#0
LABEL   .FILL x1234
```

PC offset = 2

27) What are the values in R0, R1, and R2 after the following code executes? (3 points)

```
        BR MAIN
DATA0   .FILL xABCD
DATA1   .FILL x1234
DATA2   .FILL xFFF6
MAIN    LD R0, DATA0
        LD R1, DATA1
        LD R2, DATA2
        BRp NEXT1
        AND R0,R0,#0
NEXT1   NOT R0,R0
        BRp NEXT2
        AND R2,R2,#F
NEXT2   ADD R1,R2,R1
        HALT
```

R0 = 0xFFFF
R1 = 0x123A
R2 = 0x0006

Questions 28-32 are related to the C program shown below, fill in what is printed. Note that the questions are in order of execution. (4 points each)

```
#include <stdio.h>

void doubleArray(int array[], int length) {
        for (int i = 0; i < length-2; i++) {
                array[i] += array[i];
        }
        length += 5;
        printf("%d\n", length);              // Question 29
}

int main(int argc,char *argv[]) {

        int integers[6] = { 3, 4, 5, 6, 7, 8};
        int length = 6;

        printf("%d\n", integers[4]);                 // Question 28
        doubleArray(integers, length);
        printf("%d\n", *(integers + 3));    // Question 30
        printf("%d\n", *(integers + 4));    // Question 31
        printf("%d\n", length);              // Question 32
}
```

28) 7

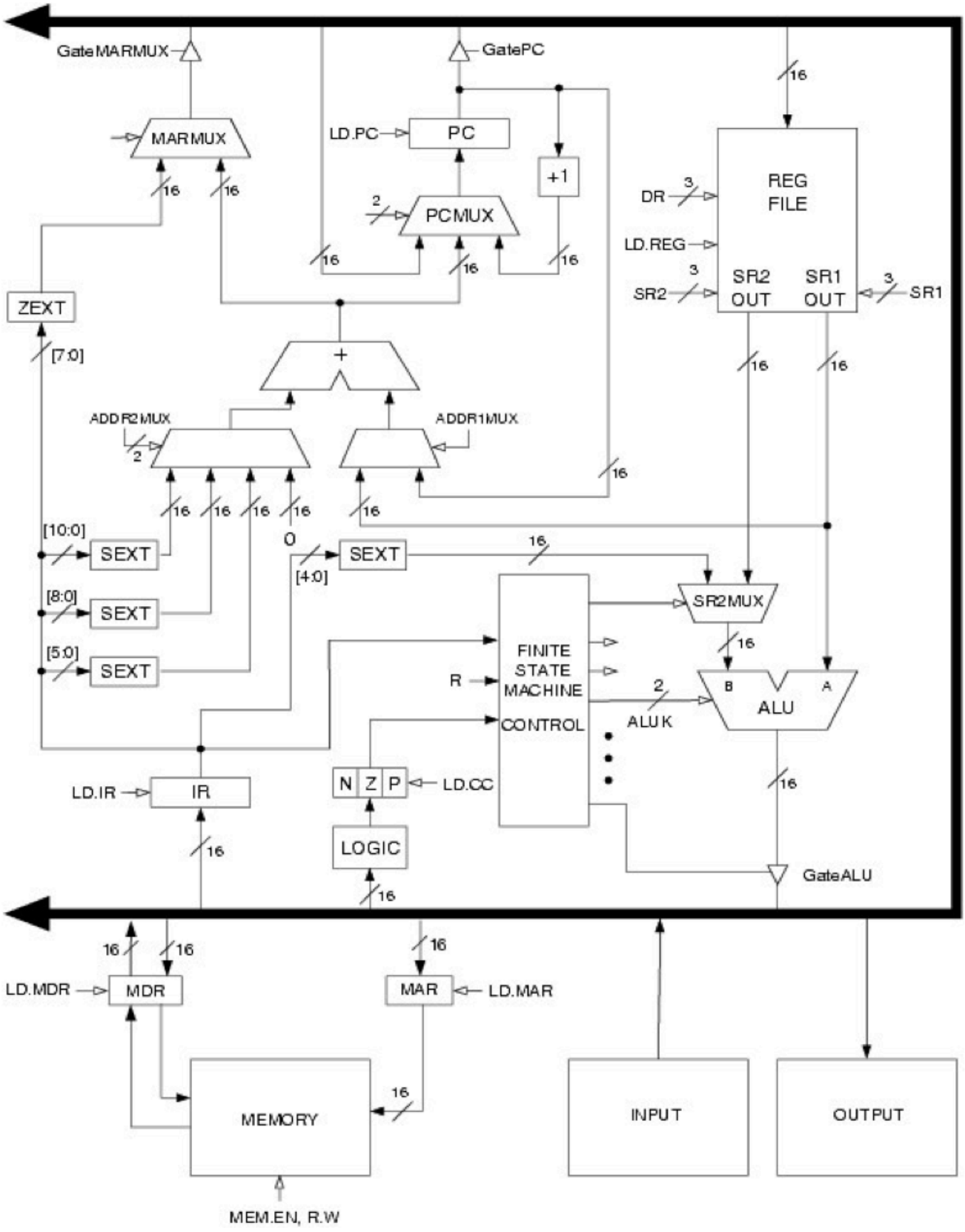
29) 11

30) 12

31) 7

32) 6

Appendix A) LC-3 Computer Schematic



Appendix B) LC-3 Instruction Set

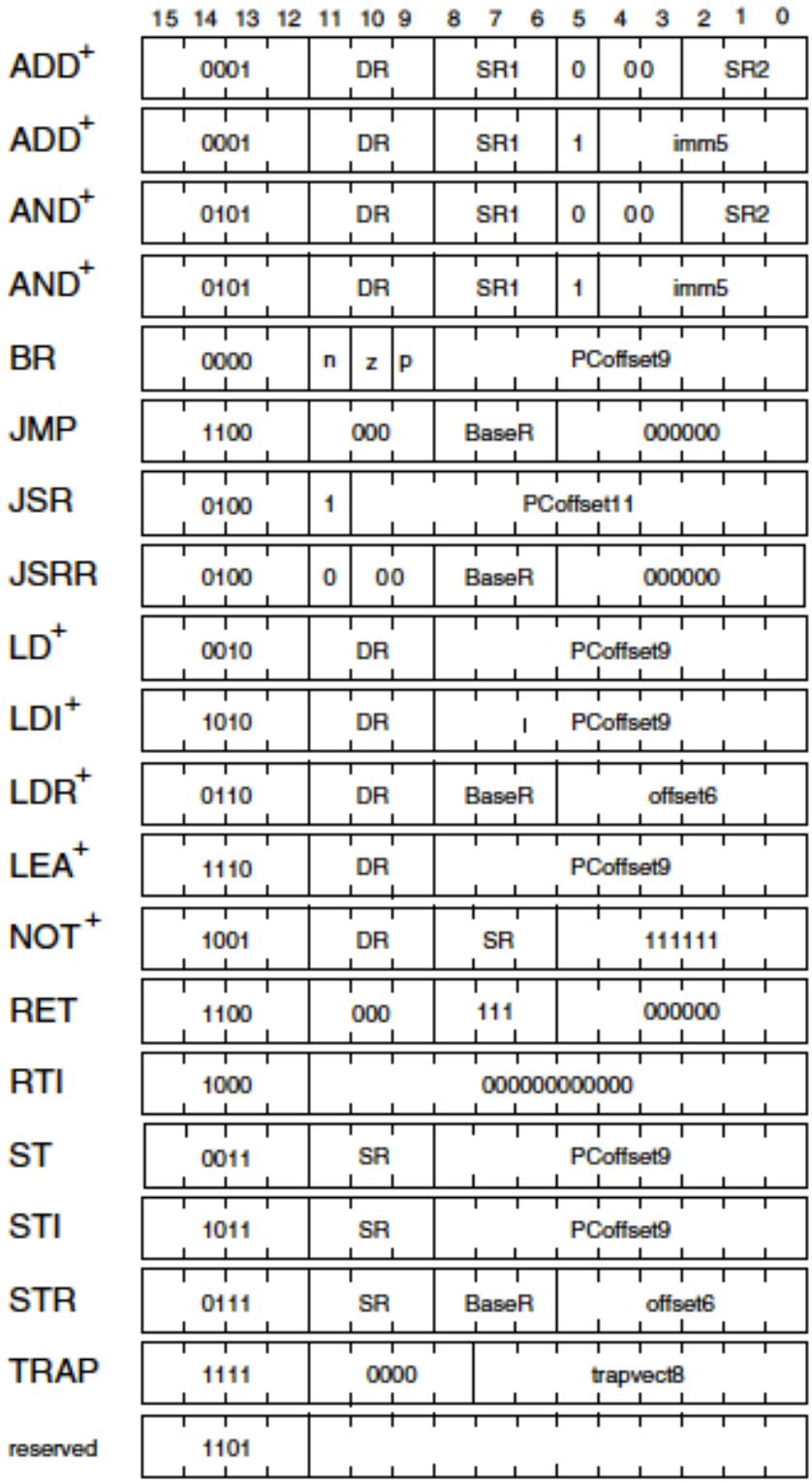


Figure A.2 Format of the entire LC-3 instruction set. **Note:** + indicates instructions that modify condition codes

Scratch paper, please do not put any answers here unless you reference this page in an answer!