**George Mason University** **Mid-term Exam**
**CS 367 Computer Systems & Programming** **March 22, 2005**

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**Important Notes:**

1. You have 75 minutes for answering the following questions. There are 6 questions in all. The points for each question are indicated in parentheses at the end of the question.
2. Be concise and accurate in your answers. If you don't know the answer to a question the best strategy is to move on, and return to the question later.
3. Please answer the questions in the space provided below the question. If you need additional space use the blank page at the end. You can use your own paper for rough work if necessary.

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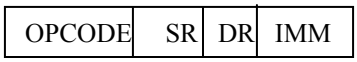
**Q1.** Suppose a 32-bit instruction takes the following format:




where SR and DR refer to the source and destination registers respectively and IMM refers to an immediate field that is a 2's complement value. If there are 60 opcodes and 32 registers, what is the range of values that can be represented in the IMM field? If there are 70 opcodes and 64 registers, what is the range of values that can be represented in IMM? Explain your answer. ***(20)***

**A1**.

**Q2.** Answer the following questions:

a. How might one use a single LC-3 instruction to move the value in R2 into R3?

b. The LC3 has no subtract instruction. How could one perform the following operations using only three LC-3 instructions

R1 ← R2 – R3

c. Using only one LC3 instruction and without changing the contents of any register, how might one set the condition codes based on the value that resides in R1?

d. Write an LC-3 instruction that clears the contents of R2.

**For full credit, you need to explain your answers.** ***(20)***

**A2.**

**Q3.** Which LC-3 addressing mode makes the most sense to use under the following conditions: (There may be more than one correct answer; therefore justify your answer with some explanation.)

- **a.** You want to load one value from an address which is less than $\pm 2^8$ locations away
- **b.** You want to load one value from an address which is more than $\pm 2^8$ locations away
- ***c.*** You want to load an array of sequential addresses. ***(15)***

**A3.**

**Q4.** Consider the following program:

```
        .ORIG       x3000
        STI         R0, LABEL
        OUT
        HALT
LABEL   .STRINGZ "%"
        .END
```

a. Show the symbol table created by the assembler at the end of its first pass through the program above.
b. Show the machine code generated by the assembler for the program above.

***(15)***

**A4.**

**Q5.**

**a.** How many trap service routines can be implemented in the LC-3? Why?

**b.** Why must a RET instruction be used to return from a TRAP routine? Why won't a BR (unconditional branch) instruction work instead?

***c.*** How many accesses to memory are made during the processing of a TRAP instruction? Assume that the TRAP instruction is already loaded into the IR (instruction register). ***(15)***

**A5.**

**Q6.** The following program is supposed to print the number 5 on the screen. It does not work. Why? Answer in no more than 10 words.

```
        .ORIG   x3000
        JSR     A
        OUT
        BRnzp   DONE
A       AND     R0, R0, #0
        ADD     R0, R0, #5
        JSR     B
        RET
DONE    HALT
ASCII   .FILL   x0030
B       LD      R1, ASCII
        ADD     R0, R0, R1
        RET
        .END
```

***(15)***

**A6.**