Final Exam Information

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The exam will be on Thursday, 10 December at 7 p.m. It will cover material from the entire semester, but will focus particularly on the following topics:

- Performance considerations (the “performance equation” and related problems)
- MIPS basics: manipulating data in registers and in memory; arithmetic, shift, and logical operations
- MIPS control structures, particularly loops and function calls
- binary and hexadecimal; signed integers (twos-complement representation)
- C programming basics: general program structure, control structures (while, for, if, etc.), functions and function calls, character input/output (getchar, putchar), arrays (including character arrays)
- logic gates and circuit design with AND, OR, and NOT gates; Karnaugh maps, basic boolean expressions, DeMorgan’s Law
- simplified datapath structure

Question types will include:

- Short answer (“define …”, “what is the value of …”, etc.)
- Write portions of C code
- Explain portions of C code
- Write portions of MIPS code
- Explain portions of MIPS code
- Calculation problems (binary/decimal/hexadecimal computations, comparing processor performance, etc.)

You will be given the first page of the MIPS reference card, a short table of ASCII characters, and perhaps other aids (depending on the problems).

See review sheets for midterm exams 1 and 2 (on the course web site under “Handouts”).

HANDED OUT ON 1 DECEMBER 2015
Here are examples of the kinds of questions that might be asked. This is not intended to be a sample exam; the topics covered below are not intended to be an exhaustive review. In particular, knowing the answers to all the questions below will not guarantee a good grade on the exam!

For questions 1–6, assume that the MIPS data section looks like this (line numbers are for reference only):

```
1     .data
2     label:  .asciiz  "x=
3     .align  2
4     x:  .word  0x000FFE7B
5     y:  .word  0xFFFFF09A
6     z:  .space  4
```

1. In line 4, does location x contain an even integer (i.e., is it divisible by 2)?
2. In line 5, does location y contain a positive integer?
3. How many bytes of memory are occupied by the string declared in line 2?
4. Write the MIPS instructions (load, store, and any other instructions) to compute
   \[ z = 8 \times x \]
   Use a shift operator to do the multiplication.
5. Write the MIPS instructions (load, store, and any other instructions) to compute
   \[ z = y/2 \]
   Use a shift operator to do the division.
6. Write the MIPS instructions (load, store, and any other instructions) to compute
   \[ z = x + y \]

For questions 7–10, assume that processor A has a clock rate of 4 GHz and processor B has a clock rate of 2.5 GHz.

7. If an average instruction in machine A takes 5 cycles, how many seconds will it take to execute a program consisting of 1000 instructions?
8. If the average CPI in machine B is 2.5 cycles per instruction, how many seconds will it take to execute a program consisting of 1000 instructions?
9. Which machine executes the most instructions per second?
10. Suppose a “load” instruction takes 3 cycles, a “store” instruction takes 4 cycles, and any other instruction takes 2 cycles. A certain program consists of 1000 instructions, where 25% are load instructions, 25% are store instructions, and the rest are “other”. What is the average CPI for the program?
For questions 11–14, refer to the following C program. The line numbers are for reference:

```c
#include <stdio.h>

int main() {
    int i,c;
    char msg[81];
    i = 0;
    while ((c = getchar()) != '
') {
        msg[i++] = c;
    }
    msg[i] = '\0';
    /* see instructions below */
    c = msg[0] - 'a';
}
```

11. Suppose the user types the five characters `hello`, followed by a newline. What is the value of variable `i` in line 11?

12. Is the newline character stored in the `msg` array?

13. Write a loop (to be inserted at line 12) that prints out the string in “`msg`” from right to left (i.e., reversed). If you need any additional variables you may declare them.

14. In line 14, what is the final value of variable `c`, assuming that the user typed `hello` as the input?

15. Create a Karnaugh map for the following boolean function `f(A, B, C)`, then find a logical expression describing the output of function `f`:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>f(A, B, C)</th>
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<tbody>
<tr>
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16. Assuming 32-bit signed integers (i.e., using twos complement representation), write the hexadecimal value corresponding to -1.

17. Assuming 32-bit signed integers (i.e., using twos complement representation), write the hexadecimal value corresponding to the most negative integer (which is, if you are interested, is -2147483648, although you don’t need that information to answer the question).
18. Write the decimal value corresponding to the positive binary number 110010.

19. Write the binary value corresponding to the hexadecimal number 89A.

20. In the following simplified image of a datapath, indicate the data paths required for a “jump” instruction.

21. Write a complete C function (NOT a complete program, just a function) that takes two parameters: an integer array named \( a \) and a positive integer \( n \), where \( n \) is the size of the array. The function should return the largest value in \( a \).

22. Write a function prototype for the function you wrote in the preceding problem.

23. What are the final values in registers \( t1 \), \( t2 \), \( t3 \), and \( s0 \) after executing the following MIPS statements?

\[
\begin{align*}
    &\text{li} \quad t1,10 \\
    &\text{li} \quad t2,10 \\
    &\text{slt} \quad t3,t1,t2 \\
    &\text{beq} \quad t3,\text{zero},\text{skip} \\
    &\text{li} \quad s0,50 \\
    &j \quad \text{skip2} \\
    &\text{skip: li} \quad s0,60 \\
    &\text{skip2:} \quad ...
\end{align*}
\]

I will try to create more review problems for you, but this is a start.

The above is not a full review!