CS 351 Exam 1

Wed. 2/25/2015

Name: ______________________________________

Rules and Hints

- You may use one handwritten 8.5 × 11” cheat sheet (front and back). This is the only additional resource you may consult during this exam. *No calculators.*
- You may write your answers in the form *[mathematical expression][units]*. There is no need to actually do the arithmetic.
- Include step-by-step explanations and comments in your answers, and show as much of your work as possible, in order to maximize your partial credit.
- You may use extra scratch paper if you need more space, but make it clear where to find your answer to each question.

Grade

	Your Score	**Max Score**
Problem 1: Short answer		10
Problem 2: Processor performance and power		35
Problem 3: MIPS functions		30
Problem 4: MIPS arrays		25
Total		**100**

Problem 1: Short answer (10 points)

Part A (2 points)

+1 extra credit point if entire class gets it right.

How many bits are in a byte?

Part B (4 points)

What is the size (in *bits*) of each of the following in the MIPS ISA?

- A machine-code instruction
- A memory address
- The contents of a register
- The ID of a register

Part C (4 points)

Our favorite radiology researcher buys two of the systems you recommended in Project 1. The only difference between them is the CPU. Each machine has a single CPU with multiple cores, but each CPU is made by a different manufacturer:

	# cores	Peak frequency	Average power
Processor A	8	2.7 GHz	80 W
Processor B	12	2.5 GHz	60 W

The radiologist wants to know which system (A or B) will use less energy for his specific workload. In order to answer his question, why isn't this data sufficient? What else would you need to know?

Problem 2: Processor performance and power (35 points)

You have a workload with the following characteristics: 1 billion dynamic instructions

- 40% Class A instructions
- 20% Class B instructions
- 40% Class C instructions

You have a processor with the following characteristics:

- 4 cores
- Average CPI of 2 for Class A instructions; 3 for Class B; 5 for Class C
- Clock speed of 2.5 GHz
- Operating voltage of 1.5 V
- Static power of 20 W
- Dynamic power of 60 W

Part A: Execution time (10 points)

What is the execution time of your workload if it runs single-threaded on a single core of this processor?

Part B: Optimization (10 points)

If the Class C instructions can be run in parallel across all cores, what is the speedup of the parallel version over the serial version?

Part C: Frequency scaling (8 points)

For the serial version from Part A, draw a plot showing (roughly) how you expect the performance and power consumption to change if the clock frequency is varied from 1.5 GHz to 3 GHz, and ***explain your plot***. More specifically:

- The horizontal axis should be clock frequency, and you should plot two lines: one for *speedup*, and one for *normalized* power. In other words, the lowest power consumption should be plotted as 1, and other power values should be divided by the lowest power consumption.
- You're responsible for deciding how the change in frequency would be likely to affect the voltage, dynamic power, and static power. Your explanation should cover this.

Part D: Core scaling (7 points)

Repeat Part C, but this time, you should vary the number of cores from 1 to 12, and keep the frequency at 2.5 GHz. Again, explain your plot.

Problem 3: MIPS functions (30 points)

Translate the following C functions to MIPS. Obey all MIPS conventions about functions, registers, and stack usage.

```
int f(int x) {
    return (x >= 90 && x <= 100);
}

int g(int* x) {
    return *x + f(*x);
}
```

Problem 4: MIPS arrays (25 points)

Assume that *as* is a null-terminated string, with a pointer to the string stored in `$s0`. Write MIPS code to set `$s1` equal to the number of 'A' characters in the string *s*. You can use 'A' directly as an immediate operand without getting its ASCII numeric equivalent. Except for the count in `$s1`, obey all MIPS conventions about functions, registers, and stack usage.