Student ID:

Family name:

Given name(s):

COMP203 (1999) Mid-trimester Test

6:30 to 8:00 p.m. Friday 10 September 1999

Instructions

- No textbooks, notes or calculators allowed.
- Attempt all questions.
- There are 39 marks in this 90-minute test.

- Write your answers in the boxes provided.
- Cross out any rough working that you do not want marked.
- Write legibly and be clear in your explanations.

- Do not leave until the end of the test because it disturbs the other students.
- Hand in this booklet as you leave the room.

Logic Design Basics

1. What is the essential difference between *sequential* and *combinational* logic blocks? **[2 marks]**

Performance

2. What is the *main advantage* of using benchmarks to measure performance instead of MIPS or MFLOPS? **[2 marks]**

3. Calculate the *weighted arithmetic mean response time* for a computer that executes program A 175 times, program B 250 times, and program C 100 times. Each execution of A, B and C takes 2s, 3s, and 4s respectively. Show the formula for the weighed arithmetic mean response time and give your answer as a decimal number. **[3 marks]**

4. You are designing the next generation of Macintosh computers and there are two possible improvements: either make multiplication instructions run 4 times faster then before or make memory accesses 2 times faster than before. You repeatedly run a program that takes 100s to execute. Of this time, 20% is used for multiplication, 50% for memory access instructions and 30% for other tasks. Which improvement increases the performance most, and exactly how much is the improvement? Give your final answer to 3 significant figures. **[4 marks]**

5. A user sees the following at her Unix command prompt:

```
% time grep "COMP203" *.html
  real  0m0.250s
  user  0m0.008s
  sys   0m0.017s
```

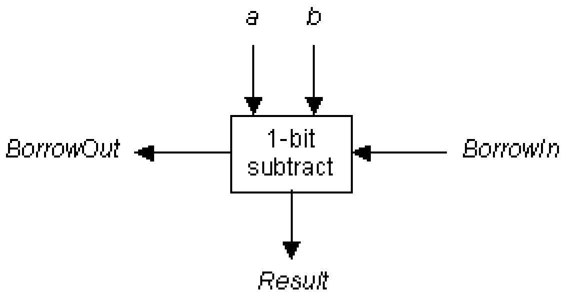
Explain what the three numbers represent. **[3 marks]**

Computer Arithmetic

6. A single precision IEEE number is stored in memory at address X. Write a sequence of MIPS instructions to multiply the number at X by 2 and store the result back at X. Accomplish this without using any floating point instructions (and don't worry about overflow). **[4 marks]**

7. With respect to IEEE 754 floating point numbers, what is the difference in meaning between *range* and *accuracy*? **[2 marks]**

8. The logic block shown below calculates *a* - *b* where *a* and *b* are both single bit values. The logic block has inputs for the two bits (*a* and *b*) and an input *BorrowIn* which performs a role analogous to that of *CarryIn* for a 1-bit adder. There is an output bit *Result* and an output bit *BorrowOut*.



Construct the truth table for the subtract function. **[3 marks]**

9. Write an expression in Boolean algebra for *BorrowOut*. You should be able to spot a simplification. **[3 marks]**

10. Using AND, OR, and NOT gates draw the logic needed to compute *BorrowOut* from *a, b,* and *BorrowIn*. Be sure to label the inputs and outputs. **[3 marks]**

Machine Language

11. The MIPS `add` instruction uses the I format which contains the three register fields *rs*, *rt*, and *rd*.

What is the size of the *rs* field (in bits) and why did the MIPS designers choose that particular size? **[2 marks]**

12. The capacity (measured in bits) of a typical DRAM chip increases every three years by a factor of... how much? **[2 marks]**

13. Consider a hypothetical machine called SIC: Single Instruction Computer. As its name implies, SIC has only one instruction: subtract and branch if negative (`sbn` for short). The `sbn` instruction has three operands, each being an address of a word in memory. For example:

```
sbn a, b, c
```

subtracts the number at address b from the number at address a and puts the result back into address a. If the result of the subtraction is less than zero then the computer will branch to address c, otherwise the control will 'fall through' to the next instruction. SIC has no registers and no other instructions!

Although the SIC is so simple, some interesting operations can be emulated. Here, for instance, is some code to copy the number from address a to address b (note "`.+1`" means "the address of the following instruction"):

```
sbn temp, temp, .+1
sbn temp, a, .+1
sbn b, b, .+1
sbn b, temp, .+1
```

Write the shortest SIC program that you can to multiply a and b, leaving the result in c. You may assume that the memory location 'one' contains the value 1 and that a and b are greater than zero initially. **[4 marks]**

14. Briefly summarise the argument made by proponents of the RISC. **[2 marks]**

End of exam questions.

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