Hong Kong University of Science and Technology

COMP180: Computer Organization

Spring 2000

Midterm Examination

3 April 2000, 7:00-8:30pm

Student Name: _____

Student Number: _____

Lab Section: _____

Instructions

1. This is a closed-book, closed-notes examination.
2. Check that you have all 10 pages (including this cover page).
3. Write your name, student number and lab section on this page.
4. Answer all questions in the space provided using a ball pen.
5. Rough work should be done only on the back pages.

Question 1 (4%): _____

Question 2 (4%): _____

Question 3 (4%): _____

Question 4 (14%): _____

Question 5 (10%): _____

Question 6 (10%): _____

Question 7 (15%): _____

Question 8 (15%): _____

Question 9 (12%): _____

Question 10 (12%): _____

TOTAL (100%): _____

1. (4 points)

Which of the following statements is incorrect?

a) In the computer industry, annual increase in DRAM capacity is higher than annual increase in clock rate.
b) Different computers can have the same instruction set architecture.
c) The `bne` instruction in MIPS uses the program counter as a base register.
d) Increase in throughput must imply decrease in execution time.
e) The program counter is a special register.

Answer: _____

2. (4 points)

Which of the following statements is correct?

a) The use of instructions based on immediate addressing helps to avoid the need for the slower memory-reference instructions.
b) The `sub` instruction in MIPS is a pseudoinstruction rather than a real instruction because integer subtraction a - b can be implemented as a + (-b) using an adder.
c) Each pseudoinstruction in MIPS is implemented by several real instructions.
d) The existence of single-precision and double-precision representations is a violation of the principle of fixed-length instructions.
e) The `beq` and `jr` instructions use the same machine instruction format.

Answer: _____

3. (4 points)

Which of the following statements is correct?

a) Two's complement representation is used for representing both signed integers and floating-point numbers.
b) The ripple carry adder is simply a more efficient implementation of the carry lookahead adder.
c) Shifting all the bits of an unsigned integer by 3 bit positions to the left is equivalent to multiplying the integer by 4 ($= 2^{3-1}$), assuming that the operation does not lead to overflow.
d) Both the `and` and `andi` instructions use the R-type instruction format.
e) When two signed integers in two's complement representation are added together, it suffices to check only the sign bits of the two operands and the summation result to detect whether overflow occurs.

Answer: _____

4. (14 points)

Consider two different implementations, M1 and M2, of the same instruction set. There are three instruction classes, A, B, and C, in the instruction set. M1 has a clock rate of 400MHz and M2 has a clock rate of 200MHz. The average number of cycles per instruction (CPI) for each instruction class on M1 and M2 is given in the following table:

Instruction Class	**CPI on M1**	**CPI on M2**	**Instruction Mix for C1**	**Instruction Mix for C2**	**Instruction Mix for C3**
A	4	2	30%	30%	50%
B	6	4	50%	20%	30%
C	8	3	20%	50%	20%

The table also contains a summary of how three different compilers, C1, C2, and C3, use the instruction set. C1 is a compiler produced by the makers of M1, C2 is a compiler produced by the makers of M2, and C3 is a compiler produced by an independent compiler vendor. Assume that each compiler uses the same number of instructions for a given program but that the instruction mix is as described in the table.

a) Using C1 on both M1 and M2, how much faster can the makers of M1 claim that M1 is compared with M2?

b) Using C2 on both M1 and M2, how much faster can the makers of M2 claim that M2 is compared with M1?

c) If you purchase M1, which of the three compilers would you choose and why?

d) If you purchase M2, which of the three compilers would you choose and why?

5. (10 points)

Consider two different implementations, M1 and M2, of the same instruction set. M1 is a single-clock-cycle implementation with a 400MHz clock and M2 is a multiple-clock-cycle implementation with a 200MHz clock. For M2, the number of clock cycles for each instruction type is:

Instruction Type	**Number of Clock Cycles**
Load	5
Store	4
Arithmetic/logic	4
Branch	3
Jump	3

Given a program with a mix of 20% load, 10% store, 50% arithmetic/logic, 15% branch, and 5% jump instructions, calculate which machine is faster in executing the program and by how much.

6. (10 points)

Show how you can implement the MIPS `ble` pseudoinstruction using at most two real MIPS instructions.

7. (15 points)

Consider the following C code segment:

```
for (i=0; i<10; i++) {
  a[i] = i + 1;
}
```

Assume that `i` is an integer variable of 32 bits in size and each element of the integer array `a` is also of 32 bits in size. Suppose the base address of `a` is in `$t0` and `$t1` is associated with variable `i`. Write the MIPS assembly code for the `for` loop above. Include brief comments in the code.

8. (15 points)

Consider a 1-bit full adder with inputs a, b, and CarryIn.

a) Give the truth table for the adder with outputs Sum and CarryOut.

b) Write down the logic equation for Sum.

c) Using the logic equation in b), draw the hardware implementation of the Sum bit of the adder showing all the logic gates needed.

9. (12 points)

Using the IEEE 754 floating-point standard, determine the largest positive single-precision number that is less than 1.

a) Show the 32 bits of the number. (Hint: The significand and exponent fields have 23 and 8 bits, respectively.)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

b) Give the decimal value of the number. Express your answer in the form $1 - 2^x$ for the appropriate value of x.

c) What is the major advantage of the biased notation?

10. (12 points)

Given the following 32-bit pattern:

1	0	0	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

What decimal number does the bit pattern represent for each of the following forms? You only need to give the expressions for the values, but not to compute the values themselves as the numbers may be too large in magnitude.

a) Unsigned integer

b) Signed integer in two's complement representation

c) IEEE 754 single-precision floating-point number

THE END