**Name:** . . . . . .

**ID Number**: . . . . . .

# COMP203: Mid-Term Test

13 April, 2005

### Instructions

- Maximum time: **90 minutes**.
- Answer **all** the questions.
- There are 90 marks in total.
- Write your answers in the boxes in this test paper and hand in all sheets.
- Paper translation dictionaries are allowed.
- Non-programmable calculators are allowed.
- Every box with a heavy outline requires an answer.
- Page 11 shows some commonly used MIPS instructions and registers.

| **Questions** | **Marks** |
|---|---|
| 1. Basic Concepts | [10] |
| 2. Registers, Memory, and Big Constants | [10] |
| 3. Decision Making | [10] |
| 4. Addressing Modes and Instruction Formats | [10] |
| 5. Number Conversion | [10] |
| 6. Boolean Expression and Logic Gates | [10] |
| 7. Multiplication | [10] |
| 8. Overflow Detection and Manipulation | [10] |
| 9. Procedures/Functions | [10] |
| **Total Marks** | [90] |

**Question 1. Basic Concepts** [10 marks]

**(a)** [3 marks] Briefly define the term *ALU* in the context of computer organisation.

**(b)** [2 marks] Briefly define the term *control* in the context of computer organisation.

**(c)** [2 marks] Briefly define the term *instruction* in the context of computer organisation.

**(d)** [3 marks] Briefly describe the major differences between combinational logic blocks and sequential logic blocks:

**Question 2. Registers, Memory and Big Constants** [10 marks]

**(a)** [6 marks] Consider the following C statement:

```
A[15] = A[20] + j;
```

Assume that register `$s1` holds integer variable `j` and that register `$s0` holds the base address of the integer array `A`. Write a sequence of MIPS instructions that directly corresponds to this statement. Use temporary registers if necessary.

**(b)** [4 marks] Consider the following sequence of MIPS instructions:

```
lui $t1, 0x1234
ori $t2, $t1, 0x8201
addi $t3, $t1, 0x8201
```

What values will be stored in registers `$t1, $t2, $t3` after the above instructions are executed?

**Question 3. Decision Making** [10 marks]

Consider the following C code segment:

```
if (x >= 5)
   x = x - m;
else
   x = x + m;
x = x + 10;
```

Assume that the registers `$s0` and `$s1` hold the integer variables `x` and `m`, respectively.

Write a sequence of MIPS instructions that directly corresponds to this C code segment. Use temporary registers if necessary.

**Question 4. Addressing Modes and Instruction Formats** [10 marks]

Use the following sequence of MIPS instructions labelled as 1 to 8 to answer questions (a) and (b).

```
1          slt $t0, $s1, $s0
2          bne $t0, $zero, Else
3          sub $s1, $s1, $s0
4          addi $s1, $s1, 10
5          j Exit
6    Else: lw $t0, 4($s4)
7          add $s1, $s1, $t0
8    Exit: or $s1, $s1, $t0
```

**(a)** [8 marks] For each of the above 8 labelled instructions, state its addressing mode and instruction format.

**(b)** [2 marks]

Calculate the value of the branch relative address (*the offset in machine code*) of `Else` in Instruction 2 "`bne $t0, $zero, Else`". **Present the final result only** in the box below.

## Question 5. Number Conversion [10 marks]

This question concerns different formats of numbers. **Write only the final answer into the boxes.**

**(a)** [2 marks] Convert the decimal number `-2049` into a 16-bit two's complement binary number.

**(b)** [2 marks] Convert the 16-bit two's complement binary number `1111 1111 0000 0000` into a decimal number.

**(c)** [2 marks] Convert the IEEE 754 single precision binary number
`0000 0000 0000 0000 0000 0000 0000 0000` into a decimal number.

**(d)** [4 marks] Show the IEEE 754 binary representation of the the decimal floating point number `-5.125` in single precision format.

**Question 6. Boolean Expression and Logic Gates** [10 marks]

Given the following truth table for a PLA (Programmable Logic Array), answer questions (a) and (b):

| Input | | | Output | | |
|---|---|---|---|---|---|
| A | B | C | D | E | F |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 0 | 0 |
| 0 | 1 | 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 | 1 | 0 |
| 1 | 0 | 0 | 1 | 0 | 0 |
| 1 | 0 | 1 | 1 | 1 | 0 |
| 1 | 1 | 0 | 1 | 1 | 0 |
| 1 | 1 | 1 | 1 | 0 | 1 |

**(a)** [4 marks] Give a boolean expression for each of D, E and F based on the truth table.

**(b)** [6 marks] Design a PLA (Programmable Logic Array) to implement the truth table based on the boolean expressions you gave in part (a).

**Question 7. Multiplication** [10 marks]

Calculate the following multiplication using the Booth's algorithm:

`0110` $\times$ `1111`

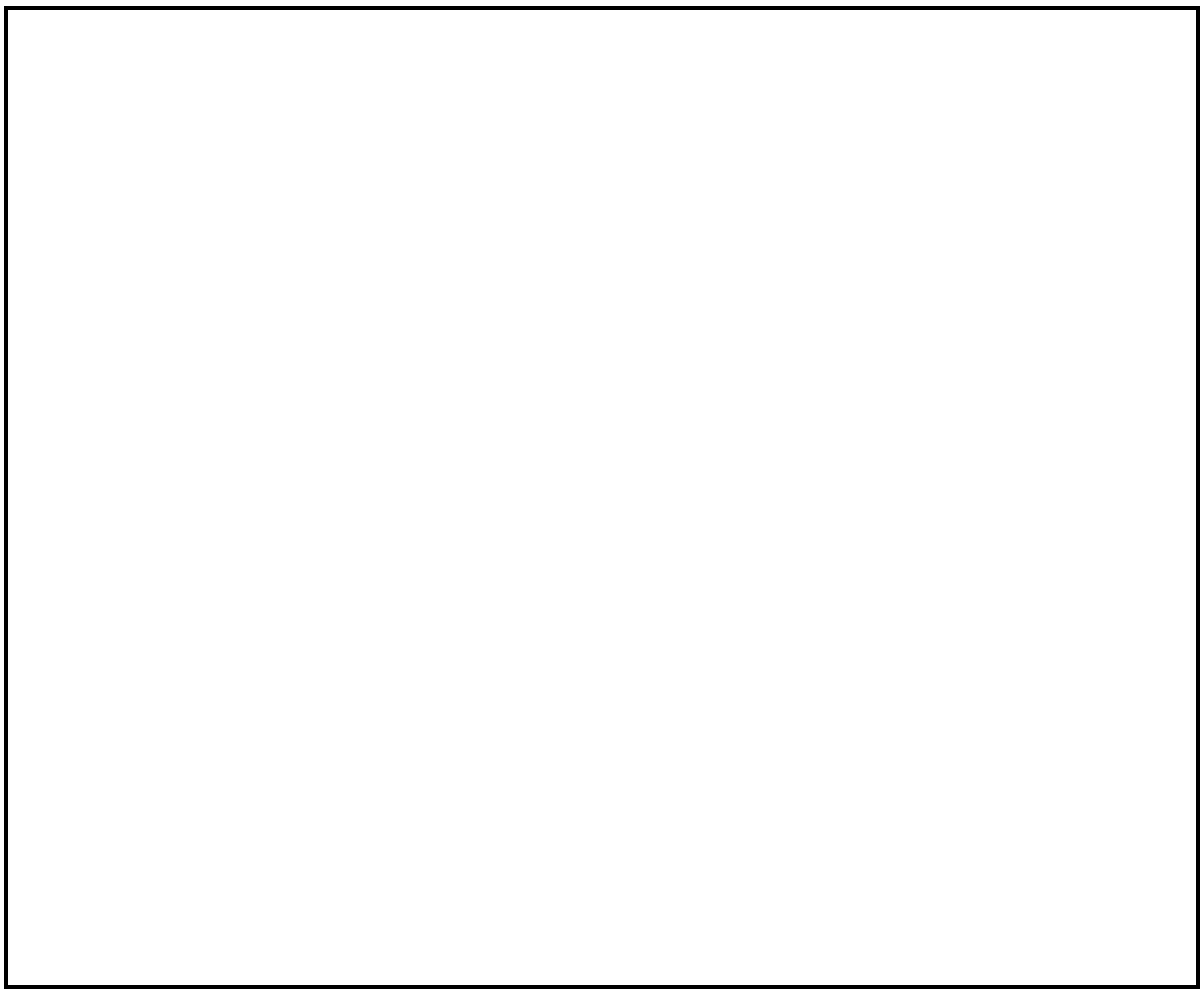
Assume that the multiplicand and the multiplier are 4-bit 2's complement integers (consider the sign). Show your work in a table and identify your final result.

**Question 8. Overflow Detection and Manipulation** [10 marks]

Assume that A and B are negative integers and that variables A, B, and C are placed in registers `$s1`, `$s2` and `$s3`, respectively. Write **at most 10** MIPS instructions in total to perform the following tasks:

- $C = A + B$;
- If there is no overflow, then add decimal constant 500 to C (`$s3`) and place the result in register `$s4`;
- Otherwise, set the least significant bit of C (`$s3`) to 0.

Use temporary registers if necessary.



**Question 9. Procedures/Functions** [10 marks]

Given the following C procedure/function:

```
int test(int m, int n)
{
   int k;

   k = m + n - 3;

   return k;
}
```

Assume that register `$s0` holds the variable `k`. Write a sequence of MIPS instructions that directly corresponds to this function. Use temporary registers if necessary.

# A Commonly Used MIPS Instructions

| | |
|---|---|
| add | sub |
| lw | sw |
| addi | lui |
| and | or |
| andi | ori |
| sll | srl |
| jal | jr |
| j | |
| beq | bne |
| slt | slti |
| mult | div |
| mul | |
| lb | sb |

# B MIPS Registers — Numbers and Names

| Name | Number | Usage |
|---|---|---|
| $zero | 0 | constant value 0 |
| $at | 1 | reserved for assembler |
| $v0–$v1 | 2–3 | values for results and expression evaluation |
| $a0–$a3 | 4-7 | arguments, for functions/procedures |
| $t0–$t7 | 8-15 | temporaries |
| $s0–$s7 | 16-23 | saved. Fast locations for data |
| $t8–$t9 | 24-25 | more temporaries |
| $k0–$k1 | 26-27 | reserved for the OS |
| $gp | 28 | global pointer |
| $sp | 29 | stack pointer |
| $fp | 30 | frame pointer |
| $ra | 31 | return address, for functions/procedures |

**********