

Name (please print): \_\_\_\_\_ Total points: \_\_\_/140

**Instructions**

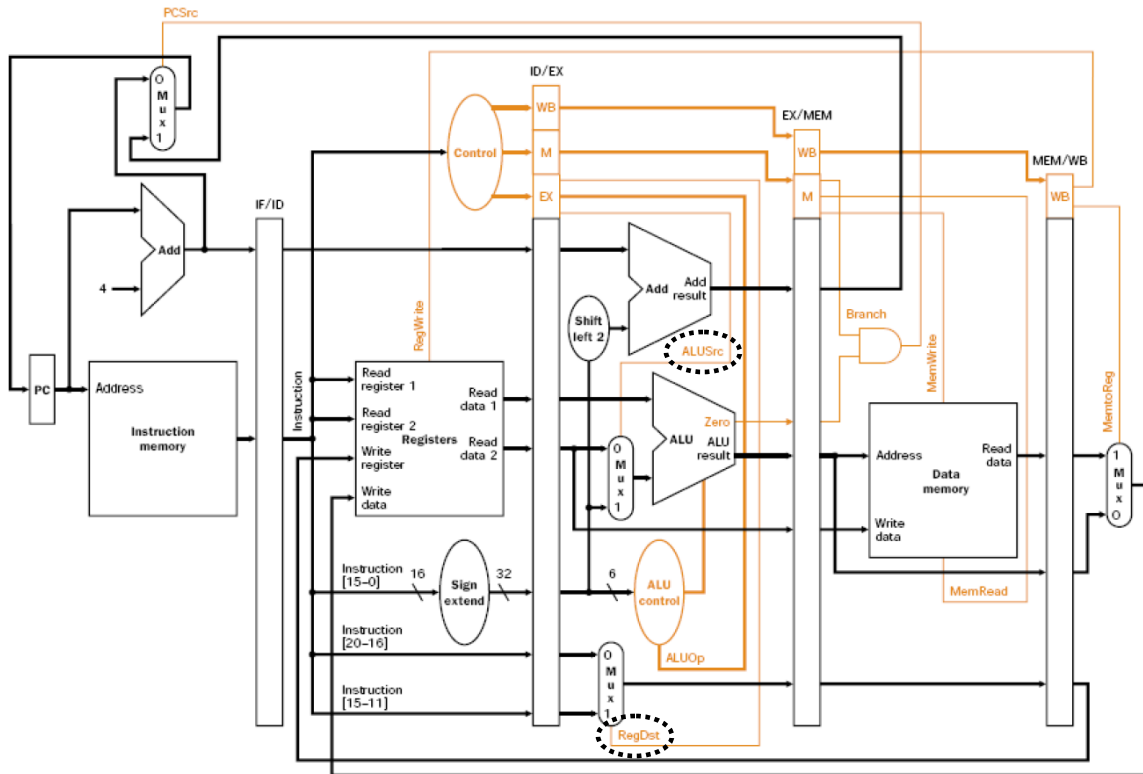
This is a **CLOSED BOOK** and **CLOSED NOTES** exam. However, you may use calculators, scratch paper, and the green MIPS reference card from your textbook. Ask the instructor if you have any questions. Good luck, and have a good summer break!

1. (10 points) Consider the following sequence of actual outcomes for a single branch instruction. T means the branch is taken. N means the branch is not taken. Assume we're using a 2-bit branch predictor. Fill in the table below:

| Current prediction | Actual branch outcome | Misprediction (Y/N)? |
|--------------------|-----------------------|----------------------|
| N                  | T                     |                      |
| N                  | T                     |                      |
|                    | T                     |                      |
|                    | N                     |                      |
|                    | T                     |                      |
|                    | N                     |                      |
|                    | N                     |                      |
|                    | T                     |                      |

2. (10 points) Assume a correctly predicted branch has a latency of 2 cycles (one trailing bubble) and an incorrectly predicted branch has a latency of 3 cycles (two trailing bubbles). What is the average CPI of the sequence of branches described in the above table?
3. (10 points) Suppose you have a machine which executes a program consisting of 50% floating point multiply, 20% floating point divide, and the remaining 30% are other instructions. You can make the divide run 3 times faster and the multiply run 8 times faster. If you make **both** improvements, what is the speed of the improved machine relative to the original machine?
4. (10 points) Suppose that we can improve the floating point instruction performance of a machine by a factor of 15. What percent of the instructions must be floating point to achieve a speedup of at least 4?

5. Consider the following pipelined processor design:



a. (10 points) Describe the functionality of the **RegDst** and the **ALUSrc** control wires. What is their purpose?

b. (10 points) Does this design support **data forwarding**? Why or why not?

6. (20 points) Convert the following Java code to MIPS assembly.

```

sum=0;
for (i=0;i<num;i++) {
    myval=vals[i];
    if (myval>10) sum=sum+vals[i];
}

```

7. (10 points) Assuming single precision IEEE 754 format, what decimal number is represent by the following value? Show your answer in base 10 and without any exponents.

1 1000011 0010000000000000000000

8. (10 points) Consider the following program (with line numbers added):

```

1   add   $t2, $s1, $sp
2   lw    $t1, 0($t1)
3   addi  $t2, $t1, 7
4   add   $t1, $s2, $sp
5   lw    $t1, 0($t1)
6   addi  $t1, $t1, 9
7   sub   $t1, $t1, $t2

```

Identify whether the value for each register operand originates from a forwarding path or from the register file. For clarity, write **REG** or **FORWARD** in each box.

| Instruction | Source operand 1 | Source operand 2 |
|-------------|------------------|------------------|
| 1           |                  |                  |
| 2           |                  | N/A              |
| 3           |                  | N/A              |
| 4           |                  |                  |
| 5           |                  | N/A              |
| 6           |                  | N/A              |
| 7           |                  |                  |

9. (10 points) Computer A has an overall CPI of 1.3 and can be run at a clock rate of 600MHz. Computer B has a CPI of 2.5 and can be run at a clock rate of 750 MHz. We have a particular program we wish to run. When compiled for computer A, this program causes the execution of exactly 100,000 instructions. How many instructions would the program need to execute when compiled for Computer B, in order for the two computers to have exactly the same execution time for this program?

10. (10 points) The design team for a processor is choosing between a pipelined or non-pipelined implementation. Here are some design parameters for the two possibilities:

| Parameter                           | Pipelined Version | Non-Pipelined Version |
|-------------------------------------|-------------------|-----------------------|
| <b>Clock rate</b>                   | 500 MHz           | 350 MHz               |
| <b>CPI for ALU instructions</b>     | 1                 | 1                     |
| <b>CPI for Control Instructions</b> | 2                 | 1                     |
| <b>CPI for Memory Instructions</b>  | 2.7               | 1                     |

For a program that executes 20% ALU instructions, 10% control instructions and 70% memory instructions, which design will be faster? Give a quantitative performance measure for each case (for each you can compute  $\text{CPI} \times \text{clock period} = \text{seconds per instruction}$ ).

11. (10 points) Write a short segment of MIPS assembly code that will multiply the value stored in register \$s0 by 5. You may not use the multiply instruction.

*Hint: Since the multiplier is fixed, this is significantly simpler than the multiplier you wrote for project 2 (no loop is required).*

12. (10 points) Describe, in words, how overflow is determined for signed addition and subtraction.

EXTRA CREDIT. (20 points) Write a MIPS subroutine named **CO\_12** that:

- (1) takes two integer arguments in registers \$a0 and \$a1,
- (2) determines if there is a carry out into bit 12 when these values are added, and
- (3) returns a 1 in register \$v0 if this the case and 0 otherwise.

The subroutine should use the stack to ensure that it doesn't modify any of the caller's register values (except \$v0).

*Hint: You may need to shift the input values and shift their sum.*