

CS 2130 Midterm 1

Name _____ Computing ID _____

You **MUST** clearly write your computing ID and name on the top of this page. Do this **before** you begin. Please write legibly.

If you are still writing when “pens down” is called, your exam will not be graded – even if you are still signing the honor pledge. So please do that first. Sorry to have to be strict on this!

There are 6 pages to this exam. Once the exam starts, please make sure you have all the pages. Questions are worth different amounts of points, so be sure to look over all the questions and plan your time accordingly.

This exam is **CLOSED** text book, closed notes, closed cell phone, closed smart watch, closed computer, closed neighbor, closed generative AI, closed smart glasses, etc. You may **not** discuss this exam with anyone until after the grades have been released. Please sign the honor pledge below.

On my honor as a student, I have neither given nor received aid on this exam.
I will not discuss the content of this exam, even in vague terms, with *anyone*
other than current course staff, until *after* grades have been released.

Computers themselves, and software yet to be developed, will revolutionize the way we learn.
–Steve Jobs

Page 2: Scratch Paper

Our Example Toy ISA. This is the ISA described in class and used in Labs 4-5 and Homework 3. Each instruction is one (or two) bytes, defined as:



If the reserved bit (bit 7) in our instruction is 0, the following table defines our instruction encoding.

icode	b	behavior
0		$rA = rB$
1		$rA \&= rB$
2		$rA += rB$
3	0	$rA = \sim rA$
	1	$rA = !rA$
	2	$rA = -rA$
	3	$rA = pc$
4		$rA = \text{read from memory at address } rB$
5		$\text{write } rA \text{ to memory at address } rB$
6	0	$rA = \text{read from memory at } pc + 1$
	1	$rA \&= \text{read from memory at } pc + 1$
	2	$rA += \text{read from memory at } pc + 1$
	3	$rA = \text{read from memory at the address stored at } pc + 1$
		For icode 6, increase pc by 2 at end of instruction
7		Compare rA as 8-bit two's-complement to 0 if $rA \leq 0$ set $pc = rB$ else increment pc as normal

Nothing on this page will be graded.

Page 3: Programming our Computer

Suppose we extended the ISA simulator you wrote in Lab 4 with the following code:

```
if (reserved == 1 && icode == 7) {
    R[a] = R[b] >> M[oldPC + 1];
    return oldPC + ____;
}
```

- [4 points] What is the value that we will need to increment the `oldPC`? (Fill in the blank below.)

```
return oldPC + _____;
```

- [10 points] Using the new instruction above **at least once**, write a program that determines if both of the hexadecimal digits representing the byte in register 1 are odd, storing a 1 in register 0 if both are odd and a 0 if either are even. For example, if `r1` is `0x73`, store a `0x01` in `r0`; if `r1` is `0xE9`, store a `0x00` in `r0`. Do not change the values stored in `r1`, `r2`, or `r3`. Answer in hexadecimal bytes, separated by spaces. *Hint: You may need to write additional instructions.*

Answer: _____

- [12 points] Complete the table below listing all the register values as hex digits after the following code executes. Assume that all registers start with value `0x00` and that the first instruction is at address `0x00`.

64 05 09 26 4E 62 F8 14 80

Register	Value
0	
1	
2	
3	

Page 4: Binary

4. [6 points] Convert 172 into hexadecimal.

Answer

5. [15 points] Answer the following questions assuming 8-bit two's-complement numbers.

A. Compute the following sum, showing your work (such as carry bits, etc).

$$\begin{array}{r} 0\ 0\ 1\ 1\ 1\ 0\ 1\ 1 \\ +\ 0\ 1\ 1\ 0\ 0\ 1\ 1\ 1 \\ \hline \end{array}$$

B. Is your result a positive or negative number? (circle one)

Positive

Negative

C. Convert your solution to decimal.

Answer

6. [4 points] Which of the following will result in integer overflow, assuming 8-bit two's complement signed integers? *Fill in the circle completely for all that apply.*

-19 + -109

-25 + 127

110 + 15

-128 + 1

Page 5: Floating Point and Bitwise Operations

7. [8 points] The following number is encoded as an 8-bit floating point number assuming a 4-bit exponent value.

01001111

A. Write the value in binary scientific notation.

Answer

B. Write the value in decimal.

Answer

8. [12 points] Assume x is an 8-bit two's complement integer. For each of the following pairs of expressions, if the two expressions are equivalent for all x , write "same"; otherwise, write an example x in binary for which the two are different.

A. $x \wedge 0xFF$ and $\sim x$

Answer

B. $!(x \& -x)$ and $(\sim x \& !x) \& 0x01$

Answer

9. [5 points] Which of the following will swap the upper- and lower-4-bit values of x ? Assume x is a 1-byte value. For example, for $x = 0x2C$, $y = 0xC2$. *Fill in the circle completely.*

$y = ((x \& 0x0F) \ll 4) \& ((x \& 0xF0) \gg 4)$

$y = ((x \& 0x0F) \ll 4) | ((x \& 0xF0) \gg 4)$

$y = ((x \& 0x0F) \ll 4) | ((x \gg 4) \& 0x0F)$

$y = (x \ll 4) \& (x \gg 4)$

None of the above

Page 6: Circuits and General Questions

10. [14 points] Using only 2-input `and`, `or`, `xor` gates, 1-input `not` gates, and constants 0 and/or 1, draw a circuit that has 3-bit input a with bits labeled a_2 , a_1 , and a_0 ; 3-bit output with bits labeled b_2 , b_1 , b_0 ; which computes $b = -a$ in 3-bit two's complement. *Clearly label your inputs and output bits individually.*

11. [10 points] True/False questions. For each of the statements below, fill in the **T** circle *completely* if you think the statement is True. If you think it's False, fill in the **F** circle *completely*.

T **F** The program counter (PC) stores the bits of the current instruction being executed.

T **F** The 1-bit register discussed in class (the positive-edge-triggered D flip-flop) has inputs `D` and `clock` and output `Q`. When `clock` transitions to 1, `Q` transitions to the value of `D`.

T **F** A 32-bit ripple carry adder will have approximately twice as many gates as a 16-bit ripple carry adder.

T **F** When using two's complement to encode integers, we can encode one more positive number than negative numbers.

T **F** If the input to an 4-bit increment circuit changes from 0101 to 0110, then the output of the circuit will immediately change to 0111 without delay.