

University of Virginia, Department of Computer Science
CS/ECE 3330: Computer Architecture, Fall 2011

Exam 1

September 26, 2011

Name:

Chugiao Wang

Problem

Possible Points

1 **20**

2 **20**

3 **8**

4 **20**

5 **20**

6 **12**

Bonus **5**

Total **105**

COMP

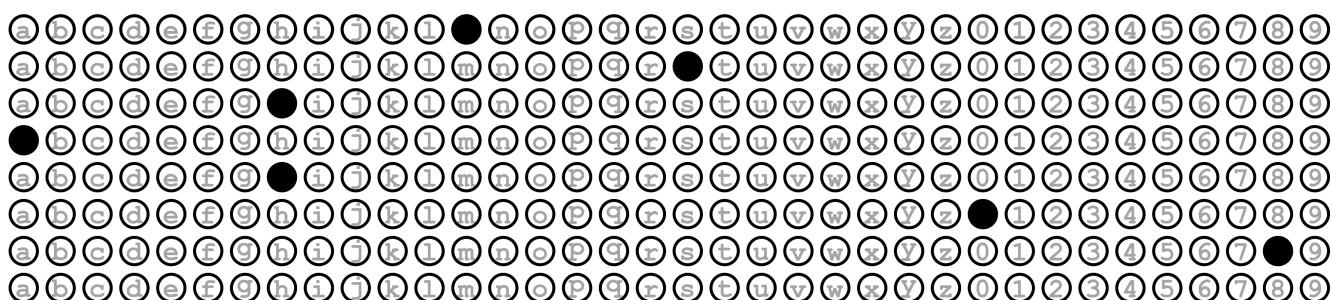
015

005

Student Name:



Student Username: mshah08



1. True or False (20 points)

- a. T F The “multicore revolution” happened because silicon became too expensive in the early 2000s.
- b. T F Energy is defined as the amount of power per unit time.
- c. T F MIPS is one of the oldest ISAs.
- d. T F In MIPS, single-precision arithmetic always produces a single-precision result.
- e. T F The MIPS `jal` instruction stores the next instruction into the `$ra` register.
- f. T F MIPS instructions can range from 4-bits to 32-bits long.
- g. T F The opcode for the MIPS `sb` instruction is 28(hex).
- h. T F The MIPS `$sp` (stack pointer) register is modified automatically by the MIPS hardware.
- i. T F By convention, the argument registers `$a0-$a3` are preserved after function calls.
- j. T F To multiply the contents of a register by two, `sll` is used with `shamt` set to 2.
- k. T F The binary number `1001.101` equals 9.625 in decimal.
- l. T F In IEEE 754 floating point notation, there are two values for zero.
- m. T F “Denormal numbers” represent numbers that slowly overflow in floating point arithmetic.
- n. T F Floating point numbers have an exponent bias in order to make number comparisons easier.
- o. T F The *decimal* number 0.1 can be represented exactly in IEEE floating point notation.
- p. T F The *binary* number 0.1 can be represented exactly in IEEE floating point notation.
- q. T F Intel lost millions of dollars in 1994 because of a multiplication bug in the Pentium processor.
- r. T F Java programs are compiled to “byte code” which runs natively on all computers.
- s. T F The “linker” produces an executable file that can be run on a computer.
- t. T F A 16-bit division produces a 32-bit quotient.

2. Performance Analysis (20 pts)

- a. (5 points) Using the table below, calculate the average CPI for the machine described.

Instruction Class	Cycles/Instruction Class	Frequency
A	2	60%
B	3	30%
C	4	10%

$$2 \times 60\% + 3 \times 30\% + 4 \times 10\% = 2.5 \text{ cycles/instruction}$$

Average CPI is 2.5 cycles per instruction

- b. (8 points) Computer A has an overall CPI of 1.2 and can be run at a clock rate of 550MHz. Computer B has a CPI of 2.1 and can be run at a clock rate of 680 MHz. We have a particular program we wish to run. When compiled for computer A, this program has exactly 120,000 instructions. How many instructions would the program need to have when compiled for Computer B, in order for the two computers to have exactly the same execution time for this program?

$$\text{Execution time}_A = 120,000 \text{ instructions} * 1.2 \text{ cycles/instruction} \div 550 \text{ MHz} \approx 2.6182 \times 10^{-4} \text{ s.}$$

$$\text{Execution time}_B = \text{Execution time}_A = \text{Instructions} * \text{CPI} / \text{clock rate}$$

$$2.6182 \times 10^{-4} = I * 2.1 \text{ cycles/instruction} / 680 \text{ MHz}$$

$$I \approx 84779 \text{ instructions}$$

- c. (7 points) Suppose that we can improve the floating point instruction performance of a machine by a factor of 9 (the same floating point instructions run 9 times faster on this new machine). What percent of the instructions must be floating point to achieve a Speedup of at least 5?

Suppose there're total I instructions, $x\%$ FP instructions

$$\frac{I}{5} = \frac{I - x\%}{9} + (1 - x\%) I$$

$$\frac{1}{5} = \frac{x}{900} + 1 - \frac{x}{100}$$

$$x = 90$$

Therefore, 90% of the instructions must be FP.

3. ISA: MIPS to/from C (8 pts)

a. (4 points) The following C code has been partially translated into MIPS assembly. Fill in the blanks. Assume a, b, c are in \$s1, \$s2, \$s3.

if (a > b) c++

slt \$t0, \$s2, \$s1 a>b t0=1
beq \$t0, \$zero, L
addi \$s3, \$s3, 1

L:

b. (4 points) The following C code has been partially translated into MIPS assembly. Fill in the blanks. Assume h is in \$s2, and the base address of A is in \$s3.

A[15] = h + A[9]

lw \$t0, 36 (\$s3)
add \$t0, \$s2, \$t0
sw \$t0, 60 (\$s3)

4. ISA: MIPS to/from Binary (20 pts)**a. (9 points)** Consider the hex value 0x8d28fff4.

- (1) What binary number does it represent?

$$0x\ 8d\ 28\ fff4 = \underline{1000}\ \underline{1101}\ \underline{0001}\ \underline{0}\ \underline{1000}\ \underline{111}\ \underline{111}\ \underline{111}\ \underline{0100}_2$$

- (2) What MIPS instruction does it represent? (A copy of the tear-out card is shown on the last page of the exam.) Show the entire instruction, with all fields.

lw \$t0, 65524(\$t1)

- (3) What type (R-type, I-type, J-type) does it represent?

I-type

b. (5 points) Encode the following instruction. Show your answer as a word in hex.

and	\$t1,	\$s0,	\$t3			
<u>op</u>	<u>rs</u>	<u>rt</u>	<u>rd</u>	<u>shamt</u>	<u>funct</u>	
<u>000000</u>	<u>10000</u>	<u>01011</u>	<u>01001</u>	<u>000000</u>	<u>100100</u>	

0x020B4824

c. (6 points) Encode the branch/jump instructions below by filling in the TWO missing fields.(All values in table are in *hexadecimal*)

Loop:	sll	\$t1,	\$s3,	2	40000
	add	\$t1,	\$t1,	\$s6	40004
	bne	\$t0,	\$s5,	Exit	40008
	sw	\$t0,	2(\$t1)		4000c
	addi	\$s3,	\$s3,	1	40010
	j	Loop			40014
Exit:	...				40018

0	0	13	9	4	0
0	9	16	9	0	20
5	8	15		3	
2B	9	8		2	
8	13	13		1	
2		10000			
			...		

5. Integer Arithmetic (20 pts)

- a. (8 points) Perform the following operations by converting the operands to 2's complement binary numbers and then doing the addition or subtraction shown. Please show all work in binary, operating on 8-bit numbers.

(1) $7 + 19$

$$\begin{array}{r}
 0000\ 0111_2 \\
 + 0001\ 0011_2 \\
 \hline
 0001\ 1010_2 = 26
 \end{array}$$

Overflow?

Circle one: Y N

(2) $14 - 8$

$$\begin{array}{r}
 0000\ 1000_2 \\
 + 1111\ 1000_2 \\
 \hline
 *0000\ 0110_2 = 6
 \end{array}$$

Overflow?

Circle one: Y N

- b. (12 points) Perform the following operations using sign magnitude form. Please show all work in binary, operating on 8-bit numbers.

(1) $(-12) + (-5)$

$$\begin{array}{r}
 1000\ 1100_2 \\
 + 1000\ 0101_2 \\
 \hline
 1001\ 0001_2 = -17
 \end{array}$$

Overflow?

Circle one: Y N

(2) $1 - 24$

$$\begin{array}{r}
 1001\ 1000_2 \quad (-24) \\
 - 0000\ 0001_2 \quad (+1) \\
 \hline
 1001\ 0111_2 = -23_{10}
 \end{array}$$

Overflow?

Circle one: Y N

(3) $(-28) - (-9)$

$= -28 + 9$

$$\begin{array}{r}
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 \hline
 1001\ 0011_2 = -19_{10}
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Overflow?

Circle one: Y N

6. Floating-Point (12 pts)

- a. (6 points) Assuming single-precision IEEE 754 format, what decimal is represented by this word? (Hint: remember to use the biased form of the exponent)

1 10000111 11100000000000000000000000000000
Sign: $(-1)^1 = -1$

Exponent: $135 - 127 = 8$

Fraction: $\frac{1}{2^1} + \frac{1}{2^2} + \frac{1}{2^3} = 0.875$

$$(-1)^1 * (1 + 0.875) \times 2^8 = -1.875 \times 2^8$$

- b. (6 points) Perform rounding on the following fractional binary numbers, use the bit positions in italics to determine rounding (use the rightmost 3 bits). Your result should have six bits to the right of the decimal point.

- (1) Round toward positive infinity: +0.101101101_{binary}

+ 0.101110₂

- (2) Round toward negative infinity: -0.001011001_{binary}

- 0.0011000₂

- (3) Round toward zero: +0.110101000_{binary}

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7. Bonus Points for Coming to Class and Reading the Book (5 pts)

a. (1 points) What branch of the service is Chris Gregg in?

Navy

b. (2 points) What was the brand and make of computer that ran Guy Steele's "ugliest program"? (partial credit will be given)

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c. (1 point) Name one university that either of the authors of your textbook work at.

UMass

d. (1 point) What power of 10 does the size prefix "zepto-" stand for? (as in, 1.2 zeptometers)

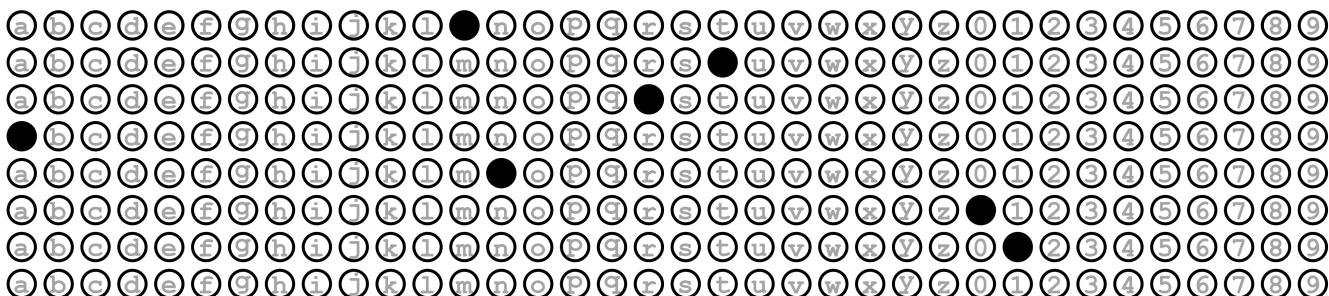
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Do you believe your performance on this exam will fairly and adequately reflect your understanding of the course material? If not, explain why.

instructor's name, student's name, and student's identification number.

Exam 1**September 26, 2011****Name:****Chugiao Wang****Problem****Possible Points****1** **20****2** **20****3** **8****4** **20****5** **20****6** **12****Bonus** **5****Total** **105****COMP****015****005****Student Name:**

Student Username: mtran01

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- b. T F Energy is defined as the amount of power per unit time.
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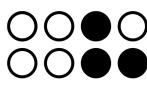
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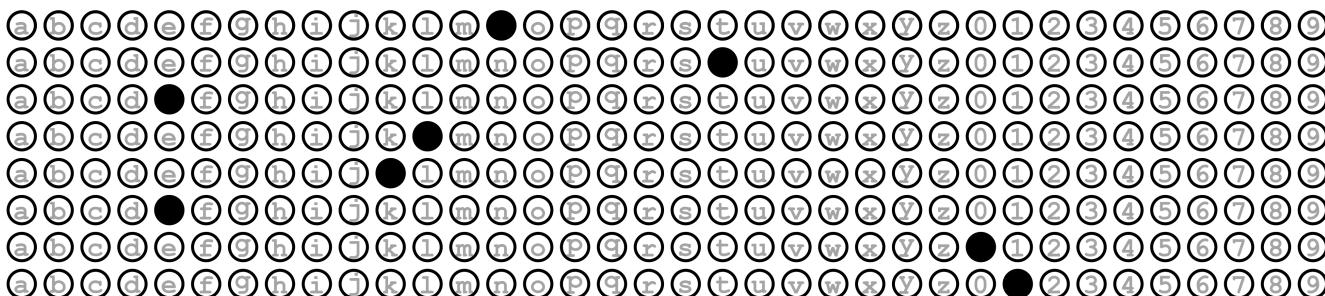
-21

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Instructions: You have 1 hour and 15 minutes to complete this exam. You may use one page of notes.

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Student Username: ntelke01

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slt \$t0, \$s2, \$s1 a>b t0=1
beq \$t0, \$zero, L
addi \$s3, \$s3, 1

L:

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<u>000000</u>	<u>10000</u>	<u>01011</u>	<u>01001</u>	<u>000000</u>	<u>100100</u>	

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c. (6 points) Encode the branch/jump instructions below by filling in the TWO missing fields.(All values in table are in *hexadecimal*)

Loop:	sll	\$t1,	\$s3,	2	40000
	add	\$t1,	\$t1,	\$s6	40004
	bne	\$t0,	\$s5,	Exit	40008
	sw	\$t0,	2(\$t1)		4000c
	addi	\$s3,	\$s3,	1	40010
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0	0	13	9	4	0
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5	8	15		3	
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Overflow?

Circle one: Y N

(2) $14 - 8$

$$\begin{array}{r}
 0000\ 1000_2 \\
 + 1111\ 1000_2 \\
 \hline
 *0000\ 0110_2 = 6
 \end{array}$$

Overflow?

Circle one: Y N

- b. (12 points) Perform the following operations using sign magnitude form. Please show all work in binary, operating on 8-bit numbers.

(1) $(-12) + (-5)$

$$\begin{array}{r}
 1000\ 1100_2 \\
 + 1000\ 0101_2 \\
 \hline
 1001\ 0001_2 = -17
 \end{array}$$

Overflow?

Circle one: Y N

(2) $1 - 24$

$$\begin{array}{r}
 1001\ 1000_2 \quad (-24) \\
 - 0000\ 0001_2 \quad (+1) \\
 \hline
 1001\ 0111_2 = -23_{10}
 \end{array}$$

Overflow?

Circle one: Y N

(3) $(-28) - (-9)$

$= -28 + 9$

$$\begin{array}{r}
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 \end{array}$$

Overflow?

Circle one: Y N

6. Floating-Point (12 pts)

- a. (6 points) Assuming single-precision IEEE 754 format, what decimal is represented by this word? (Hint: remember to use the biased form of the exponent)

1 10000111 11100000000000000000000000000000
Sign: $(-1)^1 = -1$

Exponent: $135 - 127 = 8$

Fraction: $\frac{1}{2^1} + \frac{1}{2^2} + \frac{1}{2^3} = 0.875$

$$(-1)^1 * (1 + 0.875) \times 2^8 = -1.875 \times 2^8$$

- b. (6 points) Perform rounding on the following fractional binary numbers, use the bit positions in italics to determine rounding (use the rightmost 3 bits). Your result should have six bits to the right of the decimal point.

- (1) Round toward positive infinity: +0.101101101_{binary}

+ 0.101110₂

- (2) Round toward negative infinity: -0.001011001_{binary}

- 0.0011000₂

- (3) Round toward zero: +0.110101000_{binary}

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7. Bonus Points for Coming to Class and Reading the Book (5 pts)

a. (1 points) What branch of the service is Chris Gregg in?

Navy

b. (2 points) What was the brand and make of computer that ran Guy Steele's "ugliest program"? (partial credit will be given)

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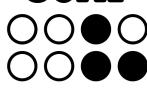
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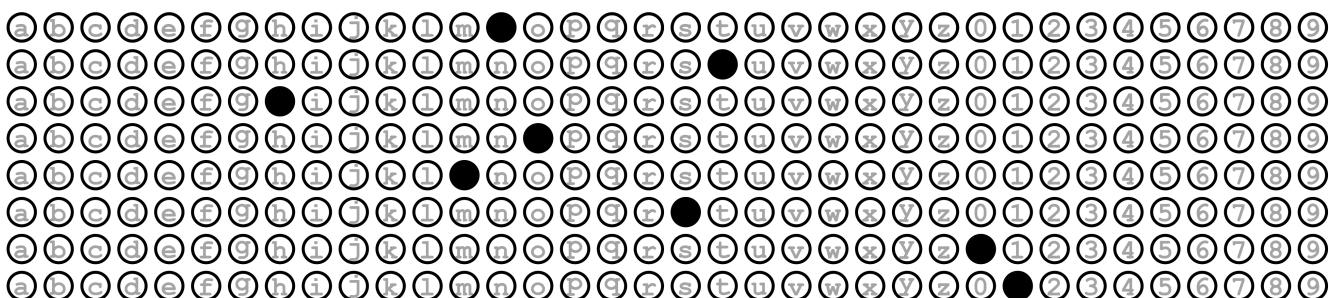
-21

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Instructions: You have 1 hour and 15 minutes to complete this exam. You may use a calculator.

Exam 1**September 26, 2011****Name:***Chugiao Wang***Problem****Possible Points****1** **20****2** **20****3** **8****4** **20****5** **20****6** **12****Bonus** **5****Total** **105****COMP****015****005****Student Name:**

Student Username: *nthoms01*

1. True or False (20 points)

- a. T F The “multicore revolution” happened because silicon became too expensive in the early 2000s.
- b. T F Energy is defined as the amount of power per unit time.
- c. T F MIPS is one of the oldest ISAs.
- d. T F In MIPS, single-precision arithmetic always produces a single-precision result.
- e. T F The MIPS `jal` instruction stores the next instruction into the `$ra` register.
- f. T F MIPS instructions can range from 4-bits to 32-bits long.
- g. T F The opcode for the MIPS `sb` instruction is 28(hex).
- h. T F The MIPS `$sp` (stack pointer) register is modified automatically by the MIPS hardware.
- i. T F By convention, the argument registers `$a0-$a3` are preserved after function calls.
- j. T F To multiply the contents of a register by two, `sll` is used with `shamt` set to 2.
- k. T F The binary number `1001.101` equals 9.625 in decimal.
- l. T F In IEEE 754 floating point notation, there are two values for zero.
- m. T F “Denormal numbers” represent numbers that slowly overflow in floating point arithmetic.
- n. T F Floating point numbers have an exponent bias in order to make number comparisons easier.
- o. T F The *decimal* number 0.1 can be represented exactly in IEEE floating point notation.
- p. T F The *binary* number 0.1 can be represented exactly in IEEE floating point notation.
- q. T F Intel lost millions of dollars in 1994 because of a multiplication bug in the Pentium processor.
- r. T F Java programs are compiled to “byte code” which runs natively on all computers.
- s. T F The “linker” produces an executable file that can be run on a computer.
- t. T F A 16-bit division produces a 32-bit quotient.

2. Performance Analysis (20 pts)

- a. (5 points) Using the table below, calculate the average CPI for the machine described.

Instruction Class	Cycles/Instruction Class	Frequency
A	2	60%
B	3	30%
C	4	10%

$$2 \times 60\% + 3 \times 30\% + 4 \times 10\% = 2.5 \text{ cycles/instruction}$$

Average CPI is 2.5 cycles per instruction

- b. (8 points) Computer A has an overall CPI of 1.2 and can be run at a clock rate of 550MHz. Computer B has a CPI of 2.1 and can be run at a clock rate of 680 MHz. We have a particular program we wish to run. When compiled for computer A, this program has exactly 120,000 instructions. How many instructions would the program need to have when compiled for Computer B, in order for the two computers to have exactly the same execution time for this program?

$$\text{Execution time}_A = 120,000 \text{ instructions} * 1.2 \text{ cycles/instruction} \div 550 \text{ MHz} \approx 2.6182 \times 10^{-4} \text{ s}$$

$$\text{Execution time}_B = \text{Execution time}_A = \text{Instructions} * \text{CPI} / \text{clock rate}$$

$$2.6182 \times 10^{-4} = I * 2.1 \text{ cycles/instruction} / 680 \text{ MHz}$$

$$I \approx 84779 \text{ instructions}$$

- c. (7 points) Suppose that we can improve the floating point instruction performance of a machine by a factor of 9 (the same floating point instructions run 9 times faster on this new machine). What percent of the instructions must be floating point to achieve a Speedup of at least 5?

Suppose there're total I instructions, $x\%$ FP instructions

$$\frac{I}{5} = \frac{I - x\%}{9} + (1 - x\%) I$$

$$\frac{1}{5} = \frac{x}{900} + 1 - \frac{x}{100}$$

$$x = 90$$

Therefore, 90% of the instructions must be FP.

3. ISA: MIPS to/from C (8 pts)

a. (4 points) The following C code has been partially translated into MIPS assembly. Fill in the blanks. Assume a, b, c are in \$s1, \$s2, \$s3.

if (a > b) c++

slt \$t0, \$s2, \$s1 a>b t0=1
beq \$t0, \$zero, L
addi \$s3, \$s3, 1

L:

b. (4 points) The following C code has been partially translated into MIPS assembly. Fill in the blanks. Assume h is in \$s2, and the base address of A is in \$s3.

A[15] = h + A[9]

lw \$t0, 36 (\$s3)
add \$t0, \$s2, \$t0
sw \$t0, 60 (\$s3)

4. ISA: MIPS to/from Binary (20 pts)**a. (9 points)** Consider the hex value 0x8d28fff4.

- (1) What binary number does it represent?

$$0x\ 8d\ 28\ fff4 = \underline{1000}\ \underline{1101}\ \underline{0001}\ \underline{0}\ \underline{1000}\ \underline{111}\ \underline{111}\ \underline{111}\ \underline{0100}_2$$

- (2) What MIPS instruction does it represent? (A copy of the tear-out card is shown on the last page of the exam.) Show the entire instruction, with all fields.

lw \$t0, 65524(\$t1)

- (3) What type (R-type, I-type, J-type) does it represent?

I-type

b. (5 points) Encode the following instruction. Show your answer as a word in hex.

and	\$t1,	\$s0,	\$t3			
<u>op</u>	<u>rs</u>	<u>rt</u>	<u>rd</u>	<u>shamt</u>	<u>funct</u>	
<u>000000</u>	<u>10000</u>	<u>01011</u>	<u>01001</u>	<u>000000</u>	<u>100100</u>	

0x020B4824

c. (6 points) Encode the branch/jump instructions below by filling in the TWO missing fields.(All values in table are in *hexadecimal*)

Loop:	sll	\$t1,	\$s3,	2	40000
	add	\$t1,	\$t1,	\$s6	40004
	bne	\$t0,	\$s5,	Exit	40008
	sw	\$t0,	2(\$t1)		4000c
	addi	\$s3,	\$s3,	1	40010
	j	Loop			40014
Exit:	...				40018

0	0	13	9	4	0
0	9	16	9	0	20
5	8	15		3	
2B	9	8		2	
8	13	13		1	
2		10000			
			...		

5. Integer Arithmetic (20 pts)

- a. (8 points) Perform the following operations by converting the operands to 2's complement binary numbers and then doing the addition or subtraction shown. Please show all work in binary, operating on 8-bit numbers.

(1) $7 + 19$

$$\begin{array}{r}
 0000\ 0111_2 \\
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Overflow?

Circle one: Y N

(2) $14 - 8$

$$\begin{array}{r}
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-21

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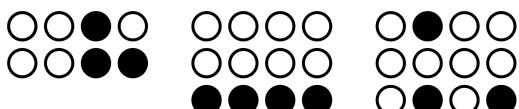
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Exam 1
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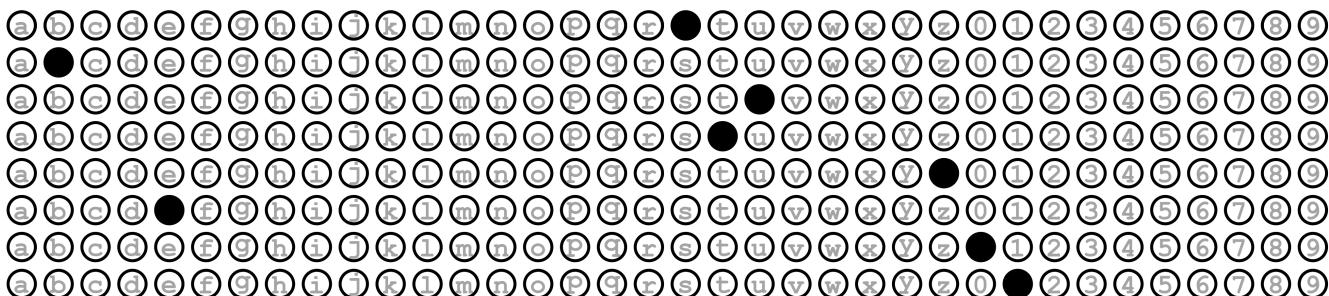
Name: Chuqiao Wang

Problem	Possible Points
1	20
2	20
3	8
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Bonus	5
Total	105

COMP 015 005 **Student Name:**



Student Username: sbutze01



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slt \$t0, \$s2, \$s1 a>b t0=1
beq \$t0, \$zero, L
addi \$s3, \$s3, 1

L:

b. (4 points) The following C code has been partially translated into MIPS assembly. Fill in the blanks. Assume h is in \$s2, and the base address of A is in \$s3.

A[15] = h + A[9]

lw \$t0, 36 (\$s3)
add \$t0, \$s2, \$t0
sw \$t0, 60 (\$s3)

4. ISA: MIPS to/from Binary (20 pts)**a. (9 points)** Consider the hex value 0x8d28fff4.

- (1) What binary number does it represent?

$$0x\ 8d\ 28\ fff4 = \underline{1000}\ \underline{1101}\ \underline{0001}\ \underline{0}\ \underline{1000}\ \underline{111}\ \underline{111}\ \underline{111}\ \underline{0100}_2$$

- (2) What MIPS instruction does it represent? (A copy of the tear-out card is shown on the last page of the exam.) Show the entire instruction, with all fields.

lw \$t0, 65524(\$t1)

- (3) What type (R-type, I-type, J-type) does it represent?

I-type

b. (5 points) Encode the following instruction. Show your answer as a word in hex.

and	\$t1,	\$s0,	\$t3			
<u>op</u>	<u>rs</u>	<u>rt</u>	<u>rd</u>	<u>shamt</u>	<u>funct</u>	
<u>000000</u>	<u>10000</u>	<u>01011</u>	<u>01001</u>	<u>000000</u>	<u>100100</u>	

0x020B4824

c. (6 points) Encode the branch/jump instructions below by filling in the TWO missing fields.(All values in table are in *hexadecimal*)

Loop:	sll	\$t1,	\$s3,	2	40000
	add	\$t1,	\$t1,	\$s6	40004
	bne	\$t0,	\$s5,	Exit	40008
	sw	\$t0,	2(\$t1)		4000c
	addi	\$s3,	\$s3,	1	40010
	j	Loop			40014
Exit:	...				40018

0	0	13	9	4	0
0	9	16	9	0	20
5	8	15		3	
2B	9	8		2	
8	13	13		1	
2		10000			
			...		

5. Integer Arithmetic (20 pts)

- a. (8 points) Perform the following operations by converting the operands to 2's complement binary numbers and then doing the addition or subtraction shown. Please show all work in binary, operating on 8-bit numbers.

(1) $7 + 19$

$$\begin{array}{r}
 0000\ 0111_2 \\
 + 0001\ 0011_2 \\
 \hline
 0001\ 1010_2 = 26
 \end{array}$$

Overflow?

Circle one: Y N

(2) $14 - 8$

$$\begin{array}{r}
 0000\ 1000_2 \\
 + 1111\ 1000_2 \\
 \hline
 *0000\ 0110_2 = 6
 \end{array}$$

Overflow?

Circle one: Y N

- b. (12 points) Perform the following operations using sign magnitude form. Please show all work in binary, operating on 8-bit numbers.

(1) $(-12) + (-5)$

$$\begin{array}{r}
 1000\ 1100_2 \\
 + 1000\ 0101_2 \\
 \hline
 1001\ 0001_2 = -17
 \end{array}$$

Overflow?

Circle one: Y N

(2) $1 - 24$

$$\begin{array}{r}
 1001\ 1000_2 \quad (-24) \\
 - 0000\ 0001_2 \quad (+1) \\
 \hline
 1001\ 0111_2 = -23_{10}
 \end{array}$$

Overflow?

Circle one: Y N

(3) $(-28) - (-9)$

$= -28 + 9$

$$\begin{array}{r}
 1001\ 1100_2 \quad (-28) \\
 - 0000\ 1001_2 \quad (+9) \\
 \hline
 1001\ 0011_2 = -19_{10}
 \end{array}$$

Overflow?

Circle one: Y N

6. Floating-Point (12 pts)

- a. (6 points) Assuming single-precision IEEE 754 format, what decimal is represented by this word? (Hint: remember to use the biased form of the exponent)

1 10000111 11100000000000000000000000000000
Sign: $(-1)^1 = -1$

Exponent: $135 - 127 = 8$

Fraction: $\frac{1}{2^1} + \frac{1}{2^2} + \frac{1}{2^3} = 0.875$

$$(-1)^1 * (1 + 0.875) \times 2^8 = -1.875 \times 2^8$$

- b. (6 points) Perform rounding on the following fractional binary numbers, use the bit positions in italics to determine rounding (use the rightmost 3 bits). Your result should have six bits to the right of the decimal point.

- (1) Round toward positive infinity: +0.101101101_{binary}

+ 0.101110₂

- (2) Round toward negative infinity: -0.001011001_{binary}

- 0.0011000₂

- (3) Round toward zero: +0.110101000_{binary}

+ 0.110101₂

7. Bonus Points for Coming to Class and Reading the Book (5 pts)

a. (1 points) What branch of the service is Chris Gregg in?

Navy

b. (2 points) What was the brand and make of computer that ran Guy Steele's "ugliest program"? (partial credit will be given)

IBM

c. (1 point) Name one university that either of the authors of your textbook work at.

UMass

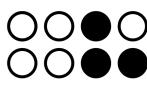
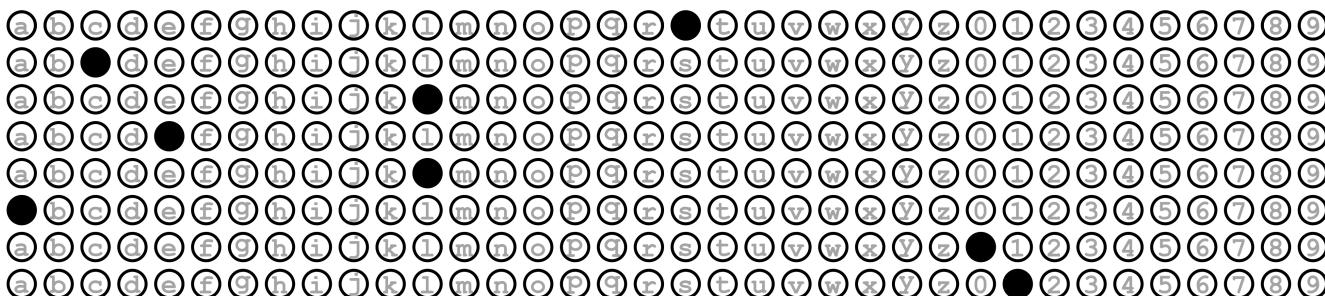
d. (1 point) What power of 10 does the size prefix "zepto-" stand for? (as in, 1.2 zeptometers)

-21

8. Optional Feedback (no credit)

Do you believe your performance on this exam will fairly and adequately reflect your understanding of the course material? If not, explain why.

Instructions: You have 1 hour and 15 minutes to complete this exam. You may use a calculator.

Exam 1**September 26, 2011****Name:***Chugiao Wang***Problem****Possible Points****1** **20****2** **20****3** **8****4** **20****5** **20****6** **12****Bonus** **5****Total** **105****COMP****015****005****Student Name:****Student Username:** sclela01

1. True or False (20 points)

- a. T F The “multicore revolution” happened because silicon became too expensive in the early 2000s.
- b. T F Energy is defined as the amount of power per unit time.
- c. T F MIPS is one of the oldest ISAs.
- d. T F In MIPS, single-precision arithmetic always produces a single-precision result.
- e. T F The MIPS `jal` instruction stores the next instruction into the `$ra` register.
- f. T F MIPS instructions can range from 4-bits to 32-bits long.
- g. T F The opcode for the MIPS `sb` instruction is 28(hex).
- h. T F The MIPS `$sp` (stack pointer) register is modified automatically by the MIPS hardware.
- i. T F By convention, the argument registers `$a0-$a3` are preserved after function calls.
- j. T F To multiply the contents of a register by two, `sll` is used with `shamt` set to 2.
- k. T F The binary number `1001.101` equals 9.625 in decimal.
- l. T F In IEEE 754 floating point notation, there are two values for zero.
- m. T F “Denormal numbers” represent numbers that slowly overflow in floating point arithmetic.
- n. T F Floating point numbers have an exponent bias in order to make number comparisons easier.
- o. T F The *decimal* number 0.1 can be represented exactly in IEEE floating point notation.
- p. T F The *binary* number 0.1 can be represented exactly in IEEE floating point notation.
- q. T F Intel lost millions of dollars in 1994 because of a multiplication bug in the Pentium processor.
- r. T F Java programs are compiled to “byte code” which runs natively on all computers.
- s. T F The “linker” produces an executable file that can be run on a computer.
- t. T F A 16-bit division produces a 32-bit quotient.

2. Performance Analysis (20 pts)

- a. (5 points) Using the table below, calculate the average CPI for the machine described.

Instruction Class	Cycles/Instruction Class	Frequency
A	2	60%
B	3	30%
C	4	10%

$$2 \times 60\% + 3 \times 30\% + 4 \times 10\% = 2.5 \text{ cycles/instruction}$$

Average CPI is 2.5 cycles per instruction

- b. (8 points) Computer A has an overall CPI of 1.2 and can be run at a clock rate of 550MHz. Computer B has a CPI of 2.1 and can be run at a clock rate of 680 MHz. We have a particular program we wish to run. When compiled for computer A, this program has exactly 120,000 instructions. How many instructions would the program need to have when compiled for Computer B, in order for the two computers to have exactly the same execution time for this program?

$$\text{Execution time}_A = 120,000 \text{ instructions} * 1.2 \text{ cycles/instruction} \div 550 \text{ MHz} \approx 2.6182 \times 10^{-4} \text{ s}$$

$$\text{Execution time}_B = \text{Execution time}_A = \text{Instructions} * \text{CPI} / \text{clock rate}$$

$$2.6182 \times 10^{-4} = I * 2.1 \text{ cycles/instruction} / 680 \text{ MHz}$$

$$I \approx 84779 \text{ instructions}$$

- c. (7 points) Suppose that we can improve the floating point instruction performance of a machine by a factor of 9 (the same floating point instructions run 9 times faster on this new machine). What percent of the instructions must be floating point to achieve a Speedup of at least 5?

Suppose there're total I instructions, $x\%$ FP instructions

$$\frac{I}{5} = \frac{I - x\%}{9} + (1 - x\%) I$$

$$\frac{1}{5} = \frac{x}{900} + 1 - \frac{x}{100}$$

$$x = 90$$

Therefore, 90% of the instructions must be FP.

3. ISA: MIPS to/from C (8 pts)

a. (4 points) The following C code has been partially translated into MIPS assembly. Fill in the blanks. Assume a, b, c are in \$s1, \$s2, \$s3.

if (a > b) c++

slt \$t0, \$s2, \$s1 a>b t0=1
beq \$t0, \$zero, L
addi \$s3, \$s3, 1

L:

b. (4 points) The following C code has been partially translated into MIPS assembly. Fill in the blanks. Assume h is in \$s2, and the base address of A is in \$s3.

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<u>000000</u>	<u>10000</u>	<u>01011</u>	<u>01001</u>	<u>000000</u>	<u>100100</u>	

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