PRACTICE MIDTERM EXAM FOR COMPSCI/ECE 250

Summer 2016, Prof. Tyler Bletsch

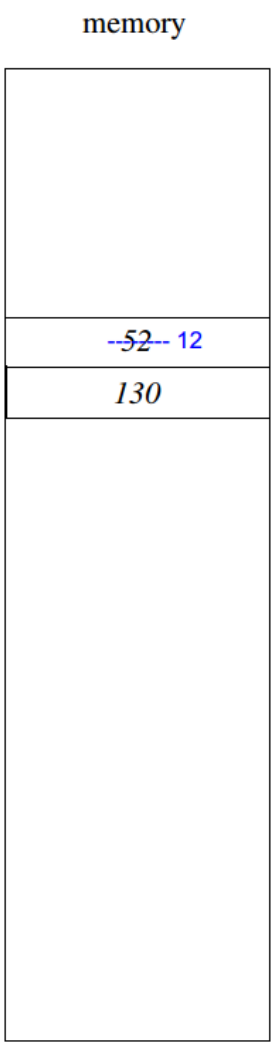
These questions are pasted in from various sources; ignore the question numbers and point values. Answers to SOME questions are provided in blue. For those without answers, you're encouraged to post your proposed answers, and the teaching staff will confirm/correct them for the benefit of the whole class.

1) [10 points]

(a) Add the following base-10 numbers using **6-bit** 2s complement math: -3, -4. **Show your work!**

```
To get -3 in binary, start with 3 and negate (flip all bits and add one):

    000011
    111100  < bits flipped
    111101  < added one
    ^ this is -3

Same to get -4 in binary:

    000100
    111011  < bits flipped
    111100  < added one
    ^ this is -4 in binary

Now we add:

   1111     < carries
    111101
  + 111100
  --------
    111001  < sum


Check our work -- let's convert the sum to decimal. first we negate it to
make it positive:

    111001
    000110  < bits flipped
    000111  < added one
    ^ this is the negation of our sum

    111 in binary is 7 in decimal

    this makes sense, as -3 + -4 = -7
```

2) Assume that $2 = 2000 and $3=12. Assume that memory holds the values at the addresses shown on the left. "lw" = load word, and "sw" = store word.



(a) If the computer executes sw $3, 4($2), then what is the value of $3 after this instruction?

12

(the store doesnt change the register, it changes the memory)

(b) If, after the instruction in part (a), the computer executes lw $3, 0($2), what is the value of $3 after this instruction?

130

(c) What single instruction could you use to write the value in $5 into address 2008?

sw $5, 8($2)

or as a joke answer: sw $5, 1878($3)

(d) What single instruction could you use to read the word of memory at address 1996 and put the result in $8?

lw $8, -4($2)

3) [10] The IEEE 754 floating point standard specifies that 32-bit floating point numbers have one sign bit, an 8-bit exponent (with a bias of 127), and a 23-bit significand (with an implicit "1"). Represent the number -11.75 in this format.

Sign bit: 1 (negative)
Fractional representation: -11 3/4
Binary representation: -1011.11
Binary representation, normalized: -1.01111 * 2^3
Mantissa with the first one removed: 01111
Exponent with bias added: 3+127 = 130
Biased exponent in binary: 10000010

1 10000010 01111000000000000000000

4) [10] The following questions are based on the following code snippet.

(a) What is *(array+7) ? Please give its datatype and its value.

Same as array[7]
Type: int
Value: 49

(b) On a MIPS machine, how big (how many bytes) is the variable array?

The variable array, like all pointers on a system with 32-bit words, is 32-bits long, which is 4 bytes long.

(c) On a MIPS machine, how big (how many bytes) is array[2]?

It's the size of an integer, which on MIPS, is 32-bits, or 4 bytes.

(c) What is the datatype of fun?

int**

(A pointer to a pointer to an int. Size is still 4 bytes, since it's a pointer)

```
int* array = (int*) malloc(42*sizeof(int));
int** fun = &array;
for (int i=0; i<42; i++){
    array[i] = i*i;
}
free (array);
```

5) [25] Convert the following C code for the function foo() into MIPS code. **Use appropriate MIPS conventions for procedure calls**, including the passing of arguments and return values, as well as the saving/restoring of registers. Assume that there are 2 argument registers ($a0-$a1), 2 return value registers ($v0-$v1), 3 general-purpose callee-saved registers ($s0-$s2), and 3 general-purpose caller-saved registers ($t0-$t2). Assume $ra is callee-saved. The C code is obviously somewhat silly and unoptimized, but YOU MAY NOT OPTIMIZE IT -- you must simply translate it as is.

```
1: int foo (int num){
2:   int temp = 0; //temp MUST be held in $t0
3:   if (num <0) {
4:       temp = num + 2;
5:   }else{
6:       temp = num - 2;
7:   }
8:   int sumA = bar(temp); // sumA MUST be held in $s0
9:   int sumB = sumA + temp + num;// sumB MUST be held in $s1
10: return (sumB + 2);
11:}

12: int bar (int arg){
```

line(s) of C	instruction(s)	what code MUST do (if not obvious from C code)

1	# need 20 bytes for s0,s1,t0,t1,ra
	# why t1 even though its not needed in the problem?
	# because i need to backup a0 before the call
	addiu $sp,$sp,-20
	sw $s0,0($sp)
	sw $s1,4($sp)
	sw $ra, 8($sp)
		create stack frame large enough for callee-saved and caller-saved registers; save callee-saved registers (ONLY necessary ones)

2	li $t0, $t0, 0 # alternately, i could do "move $t0,$0"	

3-7	bgez $a0, else # invert the compare to get to the else
	#then
	addi $t0, $a0, 2
	j end_if # bypass the else
	else:
	addi $t0, $a0, -2
	end_if:	

8	move $t1,$a0 # backup num
	move $a0, $t0
	sw $t0, 12($sp)
	sw $t1, 16($sp)
	jal bar
		save caller-saved registers (ONLY necessary ones); call bar() with appropriate arguments

after line 8	lw $t0, 12($sp)
	lw $t1, 16($sp)
	mov $s0, $v0
		restore caller-saved registers; get value returned from bar() and put it in appropriate place

9	add $s1, $s0, $t0 # sumA+temp add $s1, $s1, $t1 # += num	

10	addi $v0, $s1, 2
	lw $s0,0($sp)
	lw $s1,4($sp)
	lw $ra, 8($sp)
	addiu $sp, $sp, 20
	jr $ra
		pass return value back to whoever called foo(); restore callee-saved registers; destroy stack frame; return to caller

1) [10 points] Write the truth table for the output of the following boolean expression that has three inputs (a, b, c): output = $abc + \bar{a}c + b\bar{c}$

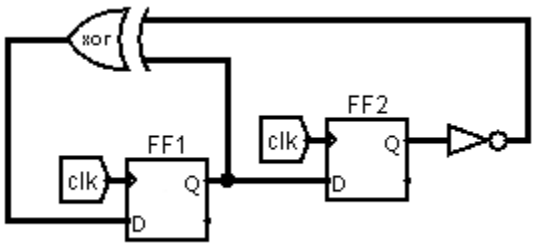
a	b	c	output
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

2) [10 points] Convert the following truth table into a boolean expression in ~~product-of-sums~~ sum-of-products format. Note that there are three inputs (a,b,c) and one output. Do NOT simplify or optimize in any way.

a	b	c	output
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

(!a & !b & !c) | (!a & b & c) | (a & !b & c) | (a & b & !c) | (a & b & c)

Question 1 [20 points]: Consider the circuit below. Assuming the two flip flop start with a value of zero, what will the state of the flip flips be for the clock cycles shown? The initial state is done for you.



Clock cycle	FF1	FF2
0	0	0
1	1	0
2	0	1
3	0	0

Same exercise, but with a different starting condition:

Clock cycle	FF1	FF2
0	1	1
1	1	1
2	1	1

Question 2 [17 points]: Draw a finite state machine that will output a 1 if and only if a sequence of characters of the following form is received: exactly one 'D', *zero* or more 'O's, and exactly one 'G'. (If you happen to know regular expression notation, this is the expression /DO*G/.) Examples of matching inputs include: "DG", "DOG", "DOOOOG". Your machine can be of the Mealy or Moore variety. It doesn't matter what your machine does after it outputs 1.