CSE351 Autumn 2013 – Midterm Exam (30 Oct 2013)

Please read through the entire examination first! We designed this exam so that it can be completed in 50 minutes and, hopefully, this estimate will prove to be reasonable.

There are 6 problems for a total of 100 points. The point value of each problem is indicated in the table below. Write your answer neatly in the spaces provided. If you need more space (you shouldn't), you can write on the back of the sheet where the question is posed, but please make sure that you indicate clearly the problem to which the comments apply. Do NOT use any other paper to hand in your answers. If you have difficulty with part of a problem, move on to the next one. They are independent of each other.

The exam is CLOSED book and CLOSED notes. Please do not ask or provide anything to anyone else in the class during the exam. Make sure to ask clarification questions early so that both you and the others may benefit as much as possible from the answers.

Name: _____

ID#: _____

Problem	Max Score	Score
1	10	
2	10	
3	25	
4	20	
5	25	
6	10	
TOTAL	**100**	

1. Number Representation – Integers (10 points)

A. Explain why we have a Carry-Flag and an Overflow-Flag in x86 condition codes. What is the difference between the two? (Explain in at most two sentences.)

B. Add 11011001 and 01100011 as two's complement 8-bit integers & convert the result to decimal notation.

```
  11011001
+ 01100011
----------
```

C. Convert your answer from the previous problem to a 2-digit hex value.

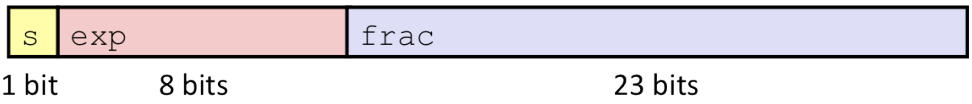
2. Number Representation – Floats (10 points)

For this question, assume we are working with a 64-bit architecture.

A. For each of the casts below, circle T if a loss of precision is possible and F, otherwise.

int → float	**T**	**F**
float → int	**T**	**F**
double → int	**T**	**F**
int → double	**T**	**F**

B. This is how single-precision floating point numbers are stored in memory.



Fill in the corresponding fields for the two numbers below. Please be sure to show the bits by writing "0", "1", "all 0s", "all 1s", or a pattern of 0s and 1s in the spaces provided.

0 (zero):

s = _____

exp = _____

frac = _____

- ∞ (negative infinity):

s = _____

exp = _____

frac = _____

C. Consider the following code snippet where the variables a and b are both floats.

```
if (a + (b – b)  == a) { printf("Equals a\n"); }
if ((a + b) – b) == 0) { printf("Equals 0\n"); }
```

Suppose the user runs this program and sees the following output:

```
Equals a
Equals 0
```

How is this possible given that addition and subtraction are associative, for example, (a + b) + c is equal to a + (b + c)? (Two sentences max.)

Give an example value for both a and b in <u>decimal</u> that would generate this output (do **<u>not</u>** consider the case where a or b are equal to 0)?

a = _____ b = _____

3. C to Assembly Code (25 points)

Write x86-64 assembly instructions (see appendix for the list of instructions that you can use) that might be generated by the C code for the function `foo` (note: you are not being asked to write any code for the function `bar` which you can simply assume is at label `bar`). It may be a good idea to consult the register chart provided at the back of this exam.

```
int bar(int c) { … }

int foo(int a, int b) {
  int x;
  x = bar(a >> 4);
  if (x != 0)
    return x;
  else
    return b;
}
```

Place the assembly code for function `foo` here (you should only need between 5 and 10 instructions) and add a comment to each line:

4. Assembly Code to C (20 points)

Given the following assembly instruction for the function 'mystery', on a IA32 32-bit architecture derive the C code for the function (you can assume all values are signed integers).

```
mystery:
  pushl   %ebp
  movl    %esp,%ebp
  movl    8(%ebp),%eax
  addl    %eax,%eax
  addl    8(%ebp),%eax
  addl    $2,%eax
  subl    12(%ebp),%eax
  popl    %ebp
  ret
```

Please write the code for the function below (make sure to include return and parameter types; the body of the function should only need to be a few C statements at most) and add a comment to each statement you write.

5. Stack Discipline (25 points)

The following table shows the contents of a part of stack memory just after calling a function in an x86-64 architecture.

Memory address	Value
0x7fffffffffffad8	0xf00
0x7fffffffffffad0	0x7fffffffffffb00
0x7fffffffffffac8	0xcab1e
0x7fffffffffffac0	0xface
0x7fffffffffffab8	0xdeadbeef
0x7fffffffffffab0	0x12
0x7fffffffffffaa8	0x3

```
%rbp = 0x7fffffffffffad0
%rsp = 0x7fffffffffffaa8
```

A. Assuming a 32-bit stack discipline is being followed by the compiler, what is the size of the stack frame for the function shown in the diagram?

B. What is the value of the program counter (%rip) after the function returns?

C. Suppose that no parameters were passed into the function on the stack. What are the values of rsp and rbp when this function returns?

D. The first 4 lines of assembly for this particular function are below. What is the value in register rbx after executing the fourth line of the assembly below?

```
push %rbp
mov %rsp, %rbp
push %rbx
mov $20, %rax
```

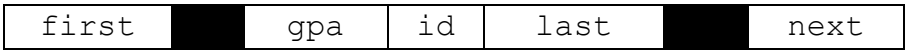
_____

6. Structs (10 points)

Suppose you are given the following struct definition for an x86-64 architecture that is used to implement a linked list of student records.

```
typdef struct node{
    char first [15];
    double gpa;
    int id;
    char last [15];
    node* next;
} student;
```

A. Given the following diagram for the bytes of this struct, specify the **byte offsets** of each of the **five** fields in the space provided below each and the **size** of the **two** shaded areas of internal fragmentation (wasted space) below them.



Offset _ _ _ _ _ _ _ _ _ _

Space _ _

B. What is the size of the struct?

C. How much internal fragmentation does this struct have?

D. How much external fragmentation does this struct have?

REFERENCES

Powers of 2:

$2^0 = 1$	
$2^1 = 2$	$2^{-1} = .5$
$2^2 = 4$	$2^{-2} = .25$
$2^3 = 8$	$2^{-3} = .125$
$2^4 = 16$	$2^{-4} = .0625$
$2^5 = 32$	$2^{-5} = .03125$
$2^6 = 64$	$2^{-6} = .015625$
$2^7 = 128$	$2^{-7} = .0078125$
$2^8 = 256$	$2^{-8} = .00390625$
$2^9 = 512$	$2^{-9} = .001953125$
$2^{10} = 1024$	$2^{-10} = .0009765625$

Assembly Code Instructions:

`push`	push a value onto the stack and decrement the stack pointer
`pop`	pop a value from the stack and increment the stack pointer
`call`	jump to a procedure after first pushing a return address onto the stack
`ret`	pop return address from stack and jump there
`mov`	move a value between registers and memory
`lea`	compute effective address and store in a register
`add`	add src (1^{st} operand) to dst (2^{nd}) with result stored in dst (2^{nd})
`sub`	subtract src (1^{st} operand) from dst (2^{nd}) with result stored in dst (2^{nd})
`and`	bit-wise AND of src and dst with result stored in dst
`or`	bit-wise OR of src and dst with result stored in dst
`sar`	shift data in the dst to the right (arithmetic shift) by the number of bits specified in 1^{st} operand
`jmp`	jump to address
`jne`	conditional jump to address if zero flag is not set
`cmp`	subtract src (1^{st} operand) from dst (2^{nd}) and set flags
`test`	bit-wise AND src and dst and set flags

Register map for x86-64:

Note: all registers are caller-saved except those explicitly marked as callee-saved, namely, `rbx`, `rbp`, `r12`, `r13`, `r14`, and `r15`. `rsp` is a special register.

`%rax`	Return value
`%rbx`	Callee saved
`%rcx`	Argument #4
`%rdx`	Argument #3
`%rsi`	Argument #2
`%rdi`	Argument #1
`%rsp`	Stack pointer
`%rbp`	Callee saved

`%r8`	Argument #5
`%r9`	Argument #6
`%r10`	Caller saved
`%r11`	Caller Saved
`%r12`	Callee saved
`%r13`	Callee saved
`%r14`	Callee saved
`%r15`	Callee saved