ECE 120 First Midterm Exam
Spring 2016

Tuesday, February 16, 2016

Name: _____ NetID: _____

Discussion Section:

9:00 AM	[ ] AB1	
10:00 AM	[ ] AB2	
11:00 AM	[ ] AB3	
12:00 PM	[ ] AB4	
1:00 PM	[ ] AB5	[ ] ABA
2:00 PM	[ ] AB6	
3:00 PM	[ ] AB7	[ ] ABB
4:00 PM	[ ] AB8	[ ] ABC
5:00 PM	[ ] AB9	[ ] ABD

- **Be sure that your exam booklet has 9 pages.**
- **Write your name, netid and check discussion section on the title page.**
- **Do not tear the exam booklet apart.**
- **Use backs of pages for scratch work if needed.**
- **This is a closed book exam. You may not use a calculator.**
- **You are allowed one handwritten 8.5 x 11" sheet of notes (both sides).**
- **Absolutely no interaction between students is allowed.**
- **Clearly indicate any assumptions that you make.**
- **The questions are not weighted equally. Budget your time accordingly.**
- **Show your work.**

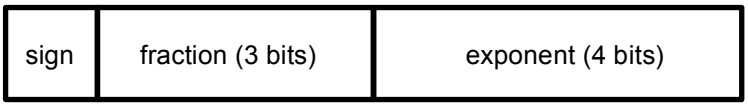
Problem 1	20 points	_____
Problem 2	10 points	_____
Problem 3	22 points	_____
Problem 4	20 points	_____
Problem 5	17 points	_____
Problem 6	11 points	_____
Total	100 points	_____

Problem 1 (20 points): Floating-point representation

In class, you studied the standard IEEE 754 that allows to represent floating-point numbers with a 32-bit representation. The ECE 120 startup *Short Answer, Inc*. makes machines with the following 8-bit floating point representation:

$$(-1)^{sign} \times 1.fraction \times 2^{exponent}$$

using 1 sign bit, 3 bits of fraction, and 4 bits of **exponent encoded in 2's complement**:



Using *Short Answer, Inc.*'s format, answer the following questions. You do NOT need to simplify your answers.

1. (4 points) What is the **decimal value** encoded by 1000 1011?

Answer: _____

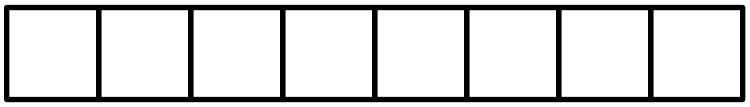
2. (4 points) What is the **decimal value** encoded by 0x60?

Answer: _____

3. (4 points) What is the **smallest positive** number that can be expressed with this 8-bit floating point data type? Write your answer as a **decimal value**.

Answer: _____

4. (8 points) Represent the decimal number $\mathbf{-0.875_{10}}$ in the boxes below using *Short Answer, Inc.*'s format. (Write one bit per box.) Show your work.



Problem 2 (10 points): 2's complement

Let **X = 11011100** and **Y = 10110011** be two 8-bit 2's complement numbers.

1. (4 points) What is the **decimal value of X**? (Express your answer as a simple number, not an expression: e.g. write 24 rather than 21 + 3.) Show your work.

Answer: **X =** _____

2. (6 points) Compute **X - Y using 2's complement addition**. *Show your arithmetic*, **including all carry bits** (**0's and 1's**). (Leave your answer in 2's complement form.) Does overflow occur?

Answer: **X-Y=**_____
(in 2's complement representation)

Overflow? Yes ( ) No ( )

Problem 3 (22 points):

1. (6 points) Consider the following 16-bit binary number: **0 1 1 1 1 1 1 0 0 0 1 1 1 1 0 1**

a. Give the **hexadecimal** representation.

Answer: _____

b. This binary number can be interpreted as a string of **8-bit ASCII characters**. **Specify these ASCII characters**. Use the ASCII table on the last page of the exam.

Answer: _____

2. (4 points) **How many 8-bit ASCII characters** can be represented by a binary string of length $\mathbf{2^K}$ **bits** (K≥3)?

Answer: _____

3. (12 points) Consider the unsigned binary number **1 0 0 0 1 1 0 1 . 1 1**

a. Express this number in **decimal** (base-10) form.

Answer: 10001101.11_2 **=** _____$_{10}$

b. In class we have represented numbers in base-2 (binary), base-10 (decimal), and base-16 (hexadecimal) number systems. In this problem we introduce base-4, which uses the four digits 0, 1, 2, 3.
Example: 123.2_4 has decimal value $1x4^2 + 2x4^1 + 3x4^0 + 2x4^{-1} = 16 + 8 + 3 + 0.5 = 27.5$

Express **1 0 0 0 1 1 0 1 . 1 1 in base-4** form.

Answer: 10001101.11_2 **=** _____$_4$

c. Examine the binary and base-4 numbers in part (b). **State a <u>simple</u> rule** for converting **from binary to base-4**. *Hint:* Recall the binary to base-16 conversion.
Illustrate your rule with the binary number **1 1 0 1 1 0 0 0 1 0 0 0 1 0**.

Problem 4 (20 points): Logical operations

1. (8 points) Perform the following bitwise logical operations. Express your answers in **hexadecimal** notation.

a. **xAC OR x89 =** _____

b. **NOT (x3B XOR xE9) =** _____

2. (8 points) Let WXYZ be the hex representation of a 16-bit number.

a. Show how to **mask** the rightmost 8 bits of WXYZ. Specifically, determine the binary operation ♥ and a 4-digit hexadecimal mask PQRS such that

WXYZ ♥ PQRS = WX00

WXYZ _____ _____ **= WX00**
operation ♥ 4-digit hex mask

b. Assuming WXYZ is a **signed-magnitude number**, compute the **absolute value of WXYZ**, denoted | WXYZ |. More specifically, determine the binary operation ♦ and the 4-digit hexadecimal mask PQRS such that

WXYZ ♦ PQRS = | WXYZ |

WXYZ _____ _____ **= | WXYZ |**
operation ♦ 4-digit hex mask

3. (4 points) Let X and Y be **hexadecimal digits**. Describe in words what it says about X and Y when we have **X XOR Y = 0**

Problem 5 (17 points): C Program Analysis

Consider the following "mystery" C program. Assume that the numbers entered by the user are 0.7 and 4. Trace the execution of this program (make notes on this page or on the scratch pages if needed) to find the results of the computation performed. Answer the questions on the next page.

```
#include <stdio.h>
#define PREFIX 0

int main()
{
     float number, value;
     int k;

     scanf("%f", &number);
     scanf("%d", &k);

     printf("The answer is %d.", PREFIX);

     while(k > 0)
     {
          k = k-1;

          if(number * 2 < 1)
          {
               value = 0;
               printf("0");
          }
          else
          {
               value = 1;
               printf("1");
          }

          number = (number * 2) - value;

          /* CHECKPOINT FOR PART 1 */
     }

     return 0;
}
```

Problem 5 (17 points), continued:

(Inputs replicated from previous page for your convenience.) Assume that the numbers entered by the user are 0.7 and 4.

1. (13 points) At the location in the program marked "CHECKPOINT FOR PART 1," determine and list the current values of the variables for each time that the program reaches that checkpoint. Fill in **only as many rows as needed** below.

k =		value =		number =	
k =		value =		number =	
k =		value =		number =	
k =		value =		number =	
k =		value =		number =	
k =		value =		number =	
k =		value =		number =	

2. (4 points) Write down EXACTLY the formatted text that will be printed on the terminal screen by the program AFTER the user input has been provided.

Problem 6 (11 points): Programming in C

Complete the program below that prints one of the truth tables shown below, depending on whether the user enters the character '&' or '|', respectively:

```
A B Z
0 0 0
0 1 0
1 0 0
1 1 1
```

```
A B Z
0 0 0
0 1 1
1 0 1
1 1 1
```

Line #	Program
01	`#include <stdio.h>`
02	
03	`int main()`
04	`{`
05	`    int a, b, z;`
06	`    ________ operator;   /* character that stores user's choice */`
07	
08	`    printf("Enter '&' or '|':");`
09	`    scanf("%c", _______________);   /* user chooses AND or OR */`
10	`    printf("A B Z\n");              /* print truth table heading */`
11	
12	`    for(____________; _____________; _____________)`
13	`    {`
14	`        for(____________; _____________; _____________)`
15	`        {`
16	`            if(operator ______ '&')       /* if user chose AND */`
17	`                z = a & b;`
18	`            else                          /* else user chose OR */`
19	`                z = a | b;`
20	`            /* print a truth table row and a newline character  */`
21	`            printf("_____________________________", a, b, _________);`
22	`        }`
23	`    }`
24	
25	`    return 0;`
26	`}`

Table of ASCII Characters

Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex
(nul)	0	00	(sp)	32	20	@	64	40	`	96	60
(soh)	1	01	!	33	21	A	65	41	a	97	61
(stx)	2	02	"	34	22	B	66	42	b	98	62
(etx)	3	03	#	35	23	C	67	43	c	99	63
(eot)	4	04	$	36	24	D	68	44	d	100	64
(enq)	5	05	%	37	25	E	69	45	e	101	65
(ack)	6	06	&	38	26	F	70	46	f	102	66
(bel)	7	07	'	39	27	G	71	47	g	103	67
(bs)	8	08	(	40	28	H	72	48	h	104	68
(ht)	9	09	)	41	29	I	73	49	i	105	69
(lf)	10	0a	*	42	2a	J	74	4a	j	106	6a
(vt)	11	0b	+	43	2b	K	75	4b	k	107	6b
(ff)	12	0c	,	44	2c	L	76	4c	l	108	6c
(cr)	13	0d	-	45	2d	M	77	4d	m	109	6d
(so)	14	0e	.	46	2e	N	78	4e	n	110	6e
(si)	15	0f	/	47	2f	O	79	4f	o	111	6f
(dle)	16	10	0	48	30	P	80	50	p	112	70
(dc1)	17	11	1	49	31	Q	81	51	q	113	71
(dc2)	18	12	2	50	32	R	82	52	r	114	72
(dc3)	19	13	3	51	33	S	83	53	s	115	73
(dc4)	20	14	4	52	34	T	84	54	t	116	74
(nak)	21	15	5	53	35	U	85	55	u	117	75
(syn)	22	16	6	54	36	V	86	56	v	118	76
(etb)	23	17	7	55	37	W	87	57	w	119	77
(can)	24	18	8	56	38	X	88	58	x	120	78
(em)	25	19	9	57	39	Y	89	59	y	121	79
(sub)	26	1a	:	58	3a	Z	90	5a	z	122	7a
(esc)	27	1b	;	59	3b	[	91	5b	{	123	7b
(fs)	28	1c	<	60	3c	\	92	5c	|	124	7c
(gs)	29	1d	=	61	3d	]	93	5d	}	125	7d
(rs)	30	1e	>	62	3e	^	94	5e	~	126	7e
(us)	31	1f	?	63	3f	_	95	5f	(del)	127	7f