

Your Name: _____ Answer Key _____

CS 216 Exam 1 – Part I – Closed Book

This initial portion of the Exam 1 is to be completed without consulting notes, text, or neighbors. You are to complete part one and hand it in, and you will be given the open book portion of the exam, Part II. Note that the closed book portion of the exam is worth 64 points and the open book portion is worth 36 points. Good luck!

1. (8 points) Define the terms

(a) $O(n^2)$, as in “this program executes in time $O(n^2)$ ”

The worst-case running time grows at the rate that kn^2 grows, where k is a constant and n is the size of the input.

(b) height of a tree

The greatest number of edges on any path from the root to any leaf.

(c) radix

The base of a numeric representation of a number or numbers.

(d) excess B representation

Representing a number K as $K+B$.

2. (6 points) What is the representation of each of the following in the indicated radix?

(a) $4F6A_{16}$ in octal 47552_8

(b) $1HC_{18}$ in decimal 642_{10}

(c) 137_{10} in radix 9 162_9

3. (4 points) Give one advantage and one disadvantage of using doubly-linked lists as compared to using singly-linked lists.

Advantages: insertion/deletion are $O(1)$ instead of $O(N)$; and, you can iterate in either direction.

Disadvantages: Uses more space for pointers, and you have to perform more pointer operations to maintain the list.

4. (6 points) With respect to “big-O” notation, e.g. $O(f(n))$:

(a) Order the following from fastest (least running time) to slowest:

$O(n^2)$, $O(n)$, $O(\log n)$, $O(n^3)$, $O(n \log n)$, $O(n^2 \log n)$.

$O(\log n)$, $O(n)$, $O(n \log n)$, $O(n^2)$, $O(n^2 \log n)$, $O(n^3)$

(b) How would you compute the big-O equation to describe the running time of the following pseudocode:

```
for (int i = 0; i < n; ++i) {
    if (condition) {
        call function A();
    }
    else {
        call function B();
    }
}
```

Find maximum big-O equation for A() and B(), multiply that by N.

5. (6 points) Consider the positive binary integer 0110101101111001_2 . Express

a. this binary number in octal 65571_8

b. this binary number in hexadecimal $6B79_{16}$

c. the negative of the number, assuming a two's complement representation (same number of bits) 1001010010000111_2

6. (3 points) Assume that you have an 8 bit, two's complement binary computer.

(a) What is the largest positive integer value that can be represented in a machine word?

$+127_{10}$

(b) What is the largest (i.e. in absolute value) negative integer value that can be represented in a machine word?

-128_{10}

(c) What is the representation of decimal -33 , i.e. -33_{10} ?

110111111_2

7. (4 points) How is integer subtraction performed on a binary, two's complement computer?

Negate number to be subtracted (by inverting all bits and then adding 1).
Add it to the first number.
Disregard the carry-out bit.

8. (4 points) The running time for most operations on a binary search tree can be $O(\log N)$. [Note that N is the number of tree nodes.] Why?

The height of the binary search tree is $O(\log N)$ on the average. Thus, all operations whose running time is dominated by the time taken to find an element will be $O(\log N)$, as the `find()` operation will be $O(\log N)$.

9. (9 points) Consider a binary tree that is built by inserting the sequence 4, 9, 2, 10, 3, 5, 8, 1 into an initially empty binary tree.

(a) Draw the tree constructed by this insertion sequence.

Root: 4

Next level: 2, 9

Next level: 1, 3, 5, 10

Right child of 5 is 8

(b) Given all rearrangements of the insertion pattern, what is the maximum height tree that could be built?

7.

(c) Given all rearrangements of the insertion pattern, what is the minimum height tree that could be built?

3.

10. (5 points) How could we implement two stacks so that overflow would not have to be declared unless every cell allocated to be used by the two stacks was occupied?

One grows upward in the allocated memory (e.g. in an array), and the other grows downward. No overflow occurs until the stack tops collide.

11. (4 points) Give one reason in favor of implementing a queue using an array, and one reason in favor of implementing a queue using dynamic memory allocation via a linked list.

Array: fast operations; no pointer following; no slowdown from new/delete operations; takes less space because there are no pointers to next or previous elements.

Linked list: flexible; we don't have to decide in advance how big the queue can get.

12. (5 points) You are given a programming problem, and you are told you must use either a stack or a queue as the underlying ADT for your implementation of the key data structure of the program. How would you decide which one to use?

Stack is LIFO, queue is FIFO. If the application behavior requires me to access the last-in element next, I use a stack. If it requires me to use the first-in element next, I use a queue.

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CS 216 Exam 1 – Part II – Open book

While working on the remainder of Exam 1, you may consult your notes or text.

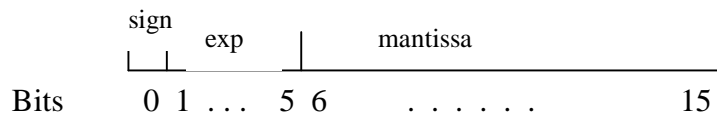
Several questions involve IBCM coding. In case it is useful to you, the following table provides the operation code definitions. It is the same as the table in class handouts.

OP	Mnem	Note	OP	Mnem	Note
0	halt	halt!	8	or	logical OR mem into accum
1	io	bit 4 I/O, bit 5 hex/ascii	9	xor	logical XOR mem into accum
2	shift	bit 4 shift/rotate, bit 5 left/right	A	not	logical complement of accum
3	load	load accum from mem	B	nop	no operation, do nothing
4	store	store accum to mem	C	jmp	unconditional jump
5	add	add mem to accum	D	jmpe	jump to addr if accum is 0
6	sub	subtract mem from accum	E	jmpl	jump to addr if accum < 0
7	and	logical AND mem into accum	F	brl	jump to addr; set accum to value of PC just before jump

11. (3 points) Assume that an IBCM word contains the hexadecimal value: $2C04_{16}$. What does it mean if it is interpreted as

- a) an instruction rotate right 4 bits
- b) an integer integer value $2C04_{16} == 11268_{10}$
- c) an address out of range/invalid; last IBCM address is $0FFF_{16}$.

12. (12 points) Given a 16 bit word machine with IEEE floating point format depicted as:



Assume that the mantissa is 10 bits (11 with hidden) and that the exponent is 5 bits with excess 8 format. What is the representation (in binary and in hex) of the **exponent** in the representation for

- a) 40.0_{10} $01101_2 == 0D_{16}$
- b) $1.875 * 2^{-5}$ $00011_2 == 03_{16}$

13. (12 points) This problem deals with function invocation and return. In the IBCM code fragment below is code to call and return from a function Zap. This is the call and return code that we discussed in class. Extend this code so that the Zap returns one value (call it X) to its caller. Make it evident how Zap's caller will be able to find the returned value. Remember, different calls will be made to Zap from different call sites. All such callers need to be able to find the value that Zap returns to them. Use the code format discussed in class and illustrated below.

Code/Data (in hex)	Location	Label	Instruction	Pseudocode
	...			
F1B4	C1 C2		BRL Zap	call Zap from here
C000 51B3	1B3 1B4 1B5	jmpCon Zap	DW C000 ADD jmpCon STORE ZapExit	Function Zap starts here

(see handouts from class for various solutions)

0000	1D0	ZapExit	DW 0	Zap is done; return to caller
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14. (9 points) Write an IBCM program for the following code fragment that sums only the negative numbers contained in the integer array A (containing 50 values). Use the format described in class and in your notes. Your code for this program should start in location 100_{16} . Note that variables i, sum and the array A are contiguous starting at location 4. Please be neat. Comment your code. If I can't read it, you can't get credit !!

```

i = 1; sum = 0;
while (i < 50) {
    if (A[i] < 0) sum = sum + A[i];
    i = i + 1;
}

```

Code/Data (in hex)	Location	Label	Instruction	Comments
	0			
	1			
	2			
	3			
	4	i	dw	count array elements
	5	sum	dw	accumulate the sum
	6	A	dw	array of 50 elements
...				
	100			

(see separate file q14-answer.txt for solution.)

Pledge for the open and closed book exam: On my honor, I have neither given, nor received, unauthorized aid on this exam.

Sign your name