Name:

Roll number:

End Semester Exam, CS101, Introduction to Computing, Spring' 12

Date: April 23, 2012 Marks: 100 Time: 180 minutes

Instructions:

1. Write unambiguous, concise and to-the-point answers.
2. You have to write answers only in the space provided.
3. You can use supplements for rough work. Answers written on the supplements will not be evaluated.
4. You will get zero marks in the exam for any academic dishonesty.

Question	1	2	3	4	5				Total
Maximum	10	5	3	12	20				50
Marks Obtained									
Question	6	7	8	9	10	11	12	13	Total
Maximum	8	4	4	3	6	5	10	10	50
Marks Obtained									

Question 1 [10 marks] **There will be no partial marking for this question.**

Three missionaries and three cannibals must cross a river using a boat which can carry at most two people, under the constraint that, for both banks, if there are missionaries present on the bank, they cannot be outnumbered by cannibals (if they were, the cannibals would eat the missionaries.) The boat cannot cross the river by itself with no people on board. How can all six get across the river safely?

You have to present your solution by filling the following table.

Initially all three missionaries and three cannibals are on the left bank of the river. This is indicated by entry "3M 3C" in the column corresponding to the left bank in row zero. The boat is also on the left bank of the river. This is indicated by "L" in the column corresponding to the boat position in row zero. During the first trip, one missionary and one cannibal travel in the boat to the right bank of the river. This is indicated by entry "1M 1C" in the column corresponding to the right bank in row number 1. Now, the boat is on the right bank and indicated by entry "R" in the boat position column of row number 1. There are two missionaries and two cannibals remaining on the left bank of the river. It is indicated by entry "2M 2C" in the column for left bank in row number 1. You have to develop your solution from this point.

At the end, we want all three missionaries and three cannibals on the right bank of the river with the boat. We have provided 17 rows in the table. However, your solution might not require all of them. You are not allowed to use more than 17 rows.

Solution 1

Row number	Left Bank	Right Bank	Boat Position
0	3M 3C	0M 0C	L
1	2M 2C	1M 1C	R
2	3M 2C	0M 1C	L
3	3M 0C	0M 3C	R
4	3M 1C	0M 2C	L
5	1M 1C	2M 2C	R
6	2M 2C	1M 1C	L
7	0M 2C	3M 1C	R
8	0M 3C	3M 0C	L
9	0M 1C	3M 2C	R
10	0M 2C	3M 1C	L
11	0M 0C	3M 3C	R

Solution 2

Row number	Left Bank	Right Bank	Boat Position
0	3M 3C	0M 0C	L
1	2M 2C	1M 1C	R
2	3M 2C	0M 1C	L
3	3M 0C	0M 3C	R
4	3M 1C	0M 2C	L
5	1M 1C	2M 2C	R
6	2M 2C	1M 1C	L
7	0M 2C	3M 1C	R
8	0M 3C	3M 0C	L
9	0M 1C	3M 2C	R
10	1M 1C	2M 2C	L
11	0M 0C	3M 3C	R

Question 2 [1+4 marks] Out of the following four statements, only one statement is true. Identify and prove it.

A. Every recursive function can be implemented as a non-recursive function.

Proof:
Recursive functions are implemented using stack to store values of local variables, arguments and return values. Same logic can be implemented using a loop and stack.

Giving just an example is not sufficient.

Question 3 [3 mark] Give example of at least one real world system that can be modeled as a DFA. Clearly the state different states in your DFA and the state transition table.

This question has many possible answers.

You have to mention four things

1. Purpose of your DFA
2. Description of what each state means
3. Input to your DFA
4. Transition table or diagram

Question 4 [12 marks] Multiple choice questions. Only one option is correct for each question. Identify the correct option. 1 mark for each correct answer and -1 mark for each wrong answer.

What happens when loop condition is no longer satisfied?
`The program execution will continue with the program statement immediately following the loop.`

Which of the following statements will be used when it is desirable to have the test made at the end of the loop, rather than at the beginning?
`do-while loop`

Which of the following is a false statement for C programming language?
Due to printing mistake this question had two correct options. We have awarded marks for choosing anyone of the following.
`++= is a compound assignment operator.`
`– is also an operator that decrements the value of its operand by one.`

In C programming language, what is a union?
`User defined data type`

What is a function in C programming language?
Collection statements that perform a particular task.

A pointer variable is used to hold _____ of the variable.
Address

What is a NULL pointer?
None of the above options

When a program is running, values of variables are stored in
Either main memory or CPU registers

What actually gets passed when you pass an array as an argument to a function?
Base address of array

Character string is always terminated by
'\0'

Structure _____ reserves space in memory.
Variable definition

To add data at the end, the file should be opened in _____ mode.
Append

Questions for 101

1. [2] Convert the given 32 bit binary number to hexadecimal number
   1011, 1001, 0110, 1011, 0001, 1001, 0110, 0011
   B 9 6 B 1 9 6 3

2. [1] Multiple ported memory is used in
   (a) Cache (b) **Register File** (d) RAM (e) Program Counter

3. [2] What are the sizes (in bits) of single precision and double precision floating point number in a typical computer system ?
   (a) 16 bits and 32bits (b) 64 bits and 32 bits (c) 16 bits and 64 bits (d) **32 bits and 64 bits**

4. [1] The principle of locality of reference justifies the use of
   (a) Job scheduling, (b) Interrupts, (c) Main memory (d) **Cache memory**

5. [2 marks, No partial marks] From the statements identify all four conditions under which a deadlock happens:
   a. **Mutual exclusion**, b. A device crash, c. **Hold and wait**, d. Preemption
   e. **No preemption**, f. Round-robin scheduling, g. Cyclic procedure calls
   h. **Circular wait**

6. [1] Magnetic disks are the most popular medium for **(either b or c)**
   a. Direct access b. **Sequential access c. Both of above** d. None of these

7. [1] A superscalar processor has
   (a) **multiple functional units** (b) a high clock speed (c) a large amount of RAM (d) many I/O ports

8. [1] Pipelining improves CPU performance due to
   (a) reduced memory access time (b) increased clock speed (c) **the introduction of parallellism** (d) additional functional units

9. [1] Cache memory
   (a) has greater capacity than RAM (b) is faster to access than CPU registers (c) is permanent storage (d) **faster to access than DRAM**

10. [1] The memory data register is used to store
    (a) **data to be transferred to or from memory** (b) data to be transferred to the stack (c) the address of a memory location (d) an instruction that has been transferred from memory

11. [1] An assembly language program is translated to machine code by
    (a) **an assembler** (b) a compiler (c) an interpreter (d) a linker

12. [1] SRAM

    (a) is cheaper than DRAM (b) is used at boot up time only (c) **is used for cache memory** (d) is slower to access than DRAM

13. [1] Which of the following registers is used to keep track of address of the memory location where the next instruction is located?

    a. Memory Address Register b. Memory Data Register c. Instruction Register d. **Program Register**

14. [1] A time sharing system imply

    a. more than one processor in the system **b. more than one program in memory** c. more than one memory in the system d. None of above

15. [1] How many address lines would be required for an 1KB memory with 4B word at each location?

    (a) 10 (b) 12 (c) **8** (d) 40 (e) non of these

16. [1] A process is

    (a) **program in execution** (b) a concurrent program (c) any sequential program (d) something which prevents deadlock

17. [1] FCFS scheduler of OS uses which data structure to stores the processes

    (a) Stack, (b) List (c) Array (d) **Queue**

18. [1] RAM memory access is like array access [**T** / F]

19. [1] DISK access is like Linked list access [**T** / F]

Part B

6. Consider the array

10	9	8	7	6	5	4	3	2	1
0	1	2	3	4	5	6	7	8	9

Let us say we want to sort the array in ascending order. Write the state of the array after the 4^{th} round of

(a) Selection Sort – [2 marks]

1	2	3	4	6	5	7	8	9	10
0	1	2	3	4	5	6	7	8	9

(b) Bubble Sort – [2 marks]

6	5	4	3	2	1	7	8	9	10
0	1	2	3	4	5	6	7	8	9

(c) Insertion Sort – [2 marks]

As regards to this problem, we are ready to make the following concession. Both of the solutions provided below are acceptable based on whether you started from the first index or the second.

7	8	9	10	6	5	4	3	2	1
0	1	2	3	4	5	6	7	8	9

6	7	8	9	10	5	4	3	2	1
0	1	2	3	4	5	6	7	8	9

(d) Radix Sort – [2 marks]

1	2	3	4	5	6	7	8	9	10
0	1	2	3	4	5	6	7	8	9

7. Evaluate the following postfix expressions. You can assume all the operands are single digit numbers. Further, all arithmetic operations can be assumed to be integer arithmetic.

   Here you guys made a common mistake. If the operator is "–" and you are popping two elements from the stack, first A and then B, the operation should be $B - A$ and not $A - B$. Remember that this is a postfix expression.

   (a) 1 2 − 3 / 4 5 + 6 − ∗ = [0] [2 marks]

   (b) 1 2 + 3 ∗ 4 5 − 6 7 + $ − = [10] [2 marks]

8. Convert the following infix expressions to postfix forms. Similar to the convention followed in class, the "$" symbol is used to represent exponentiation.

   (a) $((A - B)/C) * ((D + E) - F)$

   $\Longrightarrow$ A B – C / D E + F – *

   [2 marks]

   (b) $((A + B) * C - (D - E) \$ (F + G))$

   $\Longrightarrow$ A B + C * D E – F G + $ –

   [2 marks]

9. Convert the following postfix expression to infix form. Here too, the "$" symbol is used to represent the exponentiation operator.

A B + C D E − ∗ + F G / $

$\Longrightarrow$ (A + B + C * (D – E)) $ (F / G)

[3 marks]

10. Consider the following algorithm that works on strings consisting of the symbols $\{a, b, c\}$. The algorithm uses a stack for managing the data.

Input symbol is a **:** `Push 2 a's in the stack.`

Input symbol is b **:** `Pop a symbol from the stack.`

Input symbol is c **:** `Pop a symbol from the stack.`

If at any point the `pop` operation fails because the stack is empty, the algorithm outputs "`No`". The algorithm also outputs "`No`" if the stack is non-empty after input has been exhausted. Otherwise, the algorithm outputs "`Yes`".

For the following two questions, either encircle "`Yes`" or give a counter example in the space provided.

(a) The algorithm outputs "`Yes`" if and only if the input string is of the form $a^n b^n c^n$ (n a's followed by n b's followed by n c's, where n is an arbitrary integer). For strings of any other type, the algorithm outputs "`No`".

Yes a c b [3 marks]

Firstly, the algorithm does not only accept strings of the form $a^n b^n c^n$. There could be million counterexamples. I just provided one.

(b) The algorithm outputs "`Yes`" if and only if the number of b's and c's in the input string is twice the number of a's. For strings of any other type, the algorithm outputs "`No`".

Yes b a c [3 marks]

In this case, the algorithm does not accept all strings of the form stated in the above question. There could be million counterexamples. I just provided one.

11. Let us modify the *Binary Search* algorithm to come up with a new algorithm called *Ternary Search*.

The routine is named ternarySearch and it takes 3 arguments – a sorted integer array A, an integer n denoting the size of the array, and the element, x, to search in the sorted array A.

Algorithm 1: ternarySearch(A, n, x)

```
1 if size of array A is 1 then
2     Check if the element in the array is x and report appropriately.
3 else
4     if x ≤ A[n/3] then
5         Call ternarySearch() with the first one-third of the array A
6     if x ≥ A[2n/3] then
7         Call ternarySearch() with the last one-third of the array A
8     if A[n/3] < x < A[2n/3] then
9         Call ternarySearch() with the middle one-third of the array A
```

The worst-case time complexity of ternarySearch() is

$\implies$ O(log n) [5 marks]

The analysis goes along the lines of binary search. One just needs to observe that after each step, only one-third of the elements are left to be searched. So, at the beginnning of the iteration, if the array contains n elements, after the iteration the number of elements left to be searched is atmost $\frac{n}{3}$. Again, similar to the binary search analysis, we deduce that the time taken would be $O(\log_3 n)$. But in the order notation, $O(\log n)$ is perfectly acceptable.

12. In the space provided below, you are to present an algorithm to check whether a given string is a palindrome. The only data structures you are allowed to use are *stacks* and *queues*.

    Please note that –

    - You are not allowed to use pointers, arrays, linked lists, or any other data structure you know or can conjure.
    - Your answer must be in terms of the number of stacks or queues used, and their corresponding `push` and `pop` operations.
    - You are not expected to write C code. An explanation of your algorithm would suffice.

    [10 marks]

    Note: Reading the input more than once is illegal. The data structure in which the input is stored is not provided and hence is not necessarily a stack or a queue. It could be graphs, trees, array, or some array complicated data structure. You can read the input once, and only once.

    Using a stack and a queue . As you read the input, keep pushing the symbols in the stack and the queue. Pop the elements of the stack and the queue and compare.

    Using 3 stacks. As you read the input, keep pushing the symbols in the first two stacks. After exhausting the input, pop all elements from stack 1 and push it in stack 3. Now, pop elements from stack 2 and 3 and compare.

    Any other correct innovative solution.

13. In the space provided below, write a piece of code that prints the second last node of a linked list. The input to your code will be a pointer to the beginning of a linked list.

[10 marks]

This question many of you have attempted more or less correctly. But again, most of you have forgotten to check for boundary conditions – is the list empty? or does the list contain just one element? For each of these conditions, two marks were alloted. So, correct code will fetch you 6 marks and each boundary condition will fetch you 2 marks.