SCC 120 Fundamentals of Computer Science 2022-2023

Term 1 Coursework

Deadline for submission: Friday 18 November, 2022, at 20:00

Submission is electronic as **PDF** file on Moodle.

This coursework is worth 20% for both BJTU and LU credits.

Please answer all questions. You must do this coursework completely by yourself. In this instance, it means **you are not even allowed to discuss the coursework questions with other students**. Your submitted files will automatically be checked for plagiarism.

You are allowed to ask the instructor about these questions. But I can only clarify the questions or give you suggestions if you get stuck, and I will try not to tell you whether you have the correct answer (to be fair to all students).

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Coursework Term 1 SCC 120

For the following 3 questions, let A = {1, 2, 3, 4, 5, 6, 7, 8} and B = {1, 4, 5, 9, 10}.

Q1. What is $(A \cup B) \cap B$? [1 mark]

Q2. What is B – A? [1 mark]

Q3. What is $(A \cap B) - B$? [1 mark]

For the following 5 questions, let f(x) = 2x - 2 and g(x) = 3x + 3.

Q4. What is the function f + g? [1 mark]

Q5. What is the function f * g? [2 marks]

Q6. What is the function $f \circ g$? [2 marks]

Q7. Find the inverse function of f(x). [2 marks]

Q8. Define f(x) recursively. [3 marks]

Q9. Convert the following English statement into a proposition.

"I am going shopping only if it is sunny", where A = "I am going shopping." and B = "it is sunny". [1 mark]

For the following 2 questions, here are some equivalences.

- Implication: $(P \rightarrow Q) \Leftrightarrow (\sim P \vee Q)$
- Associativity: $(P \vee Q) \vee R \Leftrightarrow P \vee (Q \vee R)$
- Commutivity: $(P \vee Q) \Leftrightarrow (Q \vee P)$
- Domination: $(P \vee True) \Leftrightarrow True$

Q10. To convert $(D \vee E) \vee \sim G$ into $\sim G \vee (D \vee E)$, which equivalence do you apply? [1 mark]

Q11. To convert $(D \vee E) \rightarrow G$ into $\sim(D \vee E) \vee G$, which equivalence do you apply? [1 marks]

Q12. What is the decimal equivalent of the two's complement 8-bit binary 11111011? [2 marks]

Q13. Convert the following binary number to hexadecimal. [2 marks]
1101 1110 0111 1000

Consider the following C code, used in Qs 14-16.

```
char play[] = "football";
strcpy(play, "basketball");
```

Q14. What is the size of the array `play`? [2 marks]

Q15. If the runtime allocates the character '`f`' in `play` at address 128 (decimal), what is the address of the character '`b`', assuming each byte has its own address? [2 marks]

Q16. What is the result after executing statement `strcpy(play, "basketball")`? [2 marks]

Consider the following C code, used for Qs 17-18

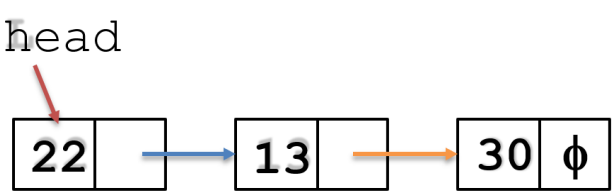
```
int sum = 0;
for (i=1; i<10; i++) {
     printf ("Counting…\n");
     for (j=0; j<i; j++){
          if(j%3 == 0)
               sum = sum + 1;
     }
}
```

Q17. How many "`Counting…`" messages will be printed? [2 marks]

Q18. What is the value of `sum` after executing this code? [2 marks]

Q19. Which of the following statements are NOT true for structures? Tick all that apply. [2 marks]
A. Fields of a structure cannot be randomly accessed using an integer index like arrays.
B. Fields of a structure must be the different data type.
C. Structures are compound data structures/types.
D. In C, programmers must provide methods as part of the structure definition to access fields of the structure.

Q20. Consider a linked list that is made up of three nodes. You are given a pointer "head" of type node, which points to the first node of the list; and that the next field of the last node is NULL. The list is described in the following diagram: [2 marks]



What code should we write to remove the second node from the list?

Consider the following C code, used for Qs 21-22

```
int y = 0;
int *p;
int main(){
            int x;
            p=malloc(sizeof(x));
            return 0;
}
```

Q21. Which memory region do we use to store `y`? Which memory region do we use to store `x`? [2 marks]

Q22. Which region is variable `p` stored? Which region does p point to? [2 marks]

Q23. The following functions represent the number of statements executed by some algorithms for input data sets of size n. What is the asymptotic (Big O) complexity class (and name) of each function? Rank the functions in terms of order of increasing complexity. [4 marks]

(a) $f_1(n) = n + 15$
(b) $f_2(n) = 5/4 + 2n^2 + 3n$
(c) $f_3(n) = 10n + n^3 + 234$
(d) $f_4(n) = 432$

Q24. What is the worst complexity of this code? Assume n is the size of the input array. [3 marks]

```
for (int i=0; i<n; i++) {
    for (int j=n-5; j<n; j++) {
        for (int k=j; k<n; k++) {
            ... some O(1) code ...
        }
    }
}
```

Q25. Consider the code fragment below. Assume the inputs are two arrays of size N and M respectively.

```
for (i = 0; i < N; i++) {
    sequence of statements
}
for (j = 0; j < M; j++) {
    sequence of statements
}
```

Determine worst-case complexity for each of the following cases. Also explain why. [4 marks]
(a) Each sequence of statements in each loop is O(1)
(b) Each sequence of statements has O(N) complexity

Q26. (a) Give one example of an input (i.e. an array of integers and an integer to search for) where sentinel search is faster than linear search. Please explain the reasons. [3 marks]

(b) Give one example of an input (i.e. an array of integers and an integer to search for) where sentinel search with sorted array (the algorithm in slide titled Sentinel on Sorted) is faster than sentinel search. Please explain the reasons. [3 marks]

(c) Give one example of an input (i.e. an array of integers and an integer to search for) where binary search is faster than sentinel search with sorted array. Please explain the reasons. [3 marks]

Q27.This question is about insertion sort. Let's say you have an array with these integers:

3,15,5,30,10,20,6,2,3.

(a) Write out manually what insertion sort would do with this set of integers. [4 marks]

(b) The best-case runtime for insertion sort is O(n). Using the sequence of integers above, what would the input be to achieve the best-case runtime? [2 marks]

(c) The worst-case runtime for insertion sort is $O(n^2)$. Using the sequence of integers above, what would the input be to achieve the worst-case runtime? [2 marks]

(d) What's the average case of the insertion sort? Please provide details of time complexity function T(N) and the Big O notation. [4 marks]