CST 370 – Spring A 2020
Homework 2

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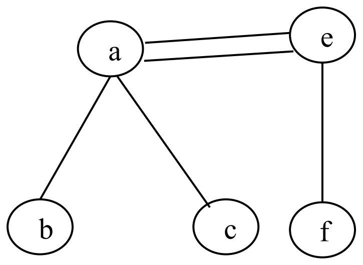
How to turn in?

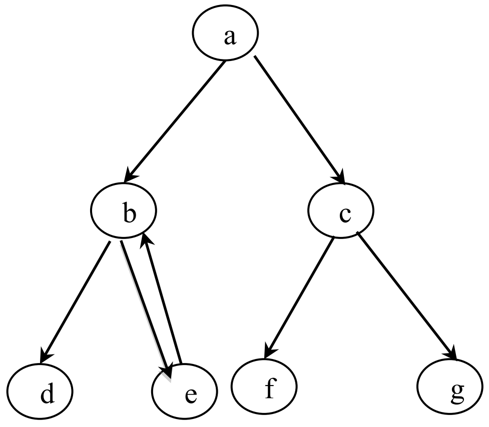
- Write your answer to the questions 1 to 7, and submit it on the iLearn. You can submit the file in PDF format. Don't forget to write your name and class ID number at the beginning of the file.
- For Questions 8 and 9, you should submit your C++ source files on the iLearn.
- Thus, you have to submit three files (one PDF file and two C++ source file) on the iLearn.
- Note that the due date is 11:55(PM). This is the iLearn's timestamp, not your submission time. Since there could be a long delay between your computer and iLearn, you should **submit early**.

1. (5 points) (a) Based on our textbook's definition, is this a graph? (True/False) Explain to support your answer.



False, because there are two duplicate undirected edges.

(b) Based on our textbook's definition, is this a graph? (True/False) Explain to support your answer

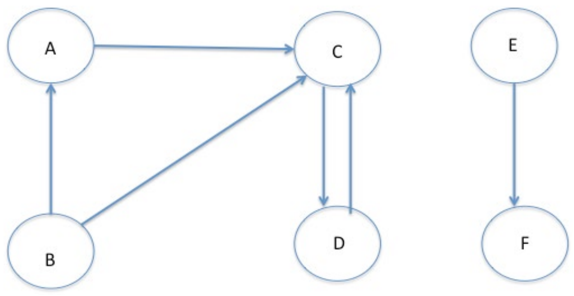


True, because this is a directed graph, edges **be** and **eb** are allowed because they point in different directions.

2. (10 points) Assume that you should search a number in a list of *n* numbers. How can you take advantage of the fact that **the list is known to be sorted**? Give separate answers for the following two cases.

(a) A list represented in an array.
A normal inefficient way to search for a value **n** would be to check each value of the array. Given that a list is sorted, one can cut down the number of operations needed significantly by implementing the binary search algorithm. For instance, because any random element of an array can be accessed any time, one can start in the middle of the array. If the value here is less than or greater than, it provides direction in which half of the array to proceed with, instantly eliminating one half of the list. The process is then repeated with the cursor starting at the middle of the array, until the value is or isn't found.
(b) A list represented in a linked list.
If a list is sorted in a doubly linked list with a pointer to the middle of the linked list, one can take advantage of the fact it is sorted. Once the value of the middle node is accessed, it provides the search algorithm a direction to proceed in—similar to the binary search algorithm. The difference here is that from here on out, each node of the linked list would have to be traversed as there is no way to "jump" to the middle of the remaining nodes.

3. (5 points) Represent the following graph in the adjacency list as you learned in the class. Note that there are **six vertices** (= A, B, C, D, E, and F) in the graph.



A -> C
B - > A -> C
C -> D
D -> A
E -> F

4. (5 points) Assume a binary tree with six vertices such as v1, v2, v3, v4, v5, and v6. Determine the maximum number of edges possible in the tree.
Maximum number of edges = 6 vertices – 1 = 5

5. (5 points) (a) If your program takes *n*log n* time and your classmate's program takes n^2 time, whose program is faster? Pick one between "You" and "Your Classmate".
My program of n*log n time would be faster than my classmates n^2 program.

(b) If your program takes *log n* time and your classmate's program takes *constant* time, whose program is faster? Pick one between "You" and "Your Classmate".
Classmate's program that takes constant time would be faster than log n time.

6. (10 points) Consider the following algorithm.

```
Algorithm Compute (A[0.. n – 1])
1.  num1 ← A[0];
2.  num2 ← A[0]
3.  i ← 1
4.  while i < n do
5.      if A[i] < num1
6.          num1 ← A[i];
7.      if A[i] > num2
8.          num2 ← A[i];
9.      i ← i + 1
10. return (num2 – num1);
```

(a) Present the basic operation of the algorithm. When you present the basic operation, you should indicate the line number of the basic operation clearly.

Operation	Line #	Array size n = 1	Array size n = 2	Array size = *n*
<	4	2	3	n+1
<	5	1	2	n
>	7	1	2	n
+	9	1	2	n
return	10	1	1	1

The comparison used to check the while loop is has more operations than the others and is the basic operation in this pseudocode. For very large **n**, we can say line 5 or 7 is the basic operation because the difference between line 4 and the rest is only 1 operation.

(b) Present the time complexity category of the algorithm among the eight most popular time complexity categories we covered in the lecture.
Time complexity is of the order of **O(n)** time.

7. (10 points) Consider the following algorithm

```
1. Algorithm Mystery(n)
2. // Input: A nonnegative integer n
3. S ← 0
4. for i ← 1 to n do
5.     k ← i * i
6.     S ← S + k
7. return S
```

(a) What does this algorithm compute?
Algorithm computes the sum of squares

(b) What is its basic operation?
Basic operation can be either the for loop on line 4, the multiplication on line 5, or the addition on line 6.

(c) Present the time complexity category of the algorithm among the eight most popular time complexity categories we covered in the lecture.
Time complexity is of the order of **O(n)** time.

8. (25 points) Write a C++ program called **sieve.cpp** that implements the **sieve of Eratosthenes** algorithm in our textbook (page 6 ~ 7). The following video will help your understanding of the algorithm:
https://youtu.be/klcIklsWzrY

For the assignment, you can assume that the user always enters a positive integer which is bigger than 1. For the program, you have to use a **dynamic memory** to create array(s) to store data. For details on the dynamic memory, read http://www.cplusplus.com/doc/tutorial/dynamic/

For the assignment, you **have to write your program based on the pseudocode in our textbook**. If you use other algorithm or library, you will get penalized.

Grading guide and test cases for the sieve.cpp:

- Missing head comment elements (= Title, Abstract, ID, Name, and Date).
- Compilation failed → It will be very serious.
- Your program should use the dynamic memory for array(s).
- Test case 1: Input number 2 → 2
- Test case 2: Input number 10 → 2, 3, 5, 7
- Test case 3: Input number 25 → 2, 3, 5, 7, 11, 13, 17, 19, 23
- Test case 4: Input number 101 → 2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47, 53, 59, 61, 67, 71, 73, 79, 83, 89, 97, 101

9. (25 points) Write a C++ program "palindrome.cpp" that reads a string of characters from user and determines if the string is a palindrome or not. For the program, you should store each

character of the string in an array (use **dynamic memory** to create array(s)) and follow the algorithm described in the lecture.

Palindrome is a string that reads the same from both the beginning and the end. Here are sample test cases:

(1) Input string 1: racecar
    Output: Yes, it's a palindrome
(2) Input string 2: abcdefghijihgfedcba
    Output: Yes, it's a palindrome
(3) Input string 3: CSUMB
    Output: No, it's not a palindrome