



CPT-281 - Introduction to Data Structures with C++

Sample Exam 1 (75 Minutes, 40 Points)

Part I - Multiple-Choice Questions (16 Points)

- There are 8 multiple-choice questions (Questions 1 to 8) in this part. Each question's value is 2 points.
- In each question, there exists only one correct/best answer.
- Your score in each question will be either 0 (you did **not** select the correct answer) or 2 (you selected the correct answer). **No** partial credits will be given in this part.

1. The time complexity of inserting an item into a doubly-linked list is _____.
 - A. $O(1)$
 - B. $O(\log n)$
 - C. $O(n)$
 - D. $O(n^2)$
2. Theoretically, which of the following data structures supports iterators?
 - A. Queue
 - B. Deque
 - C. Stack
 - D. Vector
3. Which of the following statements is **incorrect** about vector and linked list?
 - A. Data stored in a vector are physically connected in the memory; data stored in a linked list are logically connected in the memory.
 - B. Inserting an element to the rear end requires $O(1)$ of time for both vector and linked list.
 - C. Inserting an element to the front end requires $O(n)$ of time for both vector and linked list.
 - D. User can use iterators in both vectors and linked lists.

4. When defining a class in C++, if some of the private class data fields are pointers, then which of the following class-member functions are required?

- ① Stream insertion operator ② Stream extraction operator ③ Copy constructor
④ Dereferencing operator ⑤ Destructor ⑥ Assignment operator

A. ①②③

B. ③④⑤

C. ①⑤⑥

D. ③⑤⑥

5. The evaluation result of postfix arithmetic expression "7 9 3 - 2 * +" is _____.

A. 16

B. 19

C. -4

D. 64

6. Which of the following is **not** an application of stacks?

A. Print job

B. Undo/redo system

C. Depth-first search

D. Recursive algorithms

7. C++ function my_function() is defined as below:

```
1  int my_function(int x, int y) {  
2      if (y == 0) { return 1; }  
3      return x * my_function(x, y - 1);  
4  }
```

If input values $x, y > 0$, what does the function actually return?

A. $1 + x + x^2 + x^3 + \dots + x^y$

B. x^y

C. y^x

D. $x^{1+2+3+\dots+y}$

8. Which of the following statements is **incorrect**?

- A. Vector can be used to implement stack.
- B. Linked list can be used to implement deque.
- C. Deque can be used to implement queue.
- D. Linked list can be used to implement vector.

Part II - Mechanism Question (6 Points)

- There is 1 question (Questions 9) in this part. The question's value is 6 points.
- The question is **not** a programming question; do **not** write any code to answer the question.
- If your answer is lack of accuracy, based on the quality of your answer, partial credits may be awarded.

9. Please convert the infix expression below to equivalent postfix expression.

$(3 + 2) * 5 - (16 - 7)$

You **must** show your stepwise conversion procedure.

Part III - Programming Question (8 Points)

- There is 1 question (Questions 10) in this part. The question's value is 8 points.
- The question requires you to write some C++ code to complete a function.
- Code comments are **not** required, but your code **must** be readable and understandable.
- If your code is lack of accuracy, based on the quality of your code, partial credits may be awarded.

10. Given a vector of positive integers, please write a function to find the next greater element for each element in the vector. If an element does **not** have a next greater element, then write 0 in the output.

- The return value of the function should be a vector of non-negative integers containing the next greater element for all elements in the input vector.
- Your algorithm should have time complexity of $O(n)$, where n is the size of the input vector. Failing to design an algorithm with required time complexity will result in losing at least 50% of points. You are required to design an efficient algorithm, **not** just designing a correct algorithm.
- Please see the example below to better understand the expected function behavior.

Example	
Function argument	[4, 5, 2, 2, 25, 5]
Expected return value	[5, 25, 25, 25, 0, 0]
Explanation	<div> <p>Next greater element</p> </div> <div> <p>Next greater element</p> </div> <div> <p>Next greater element</p> </div> <div> <p>Next greater element</p> </div> <div> <p>No next greater element</p> </div> <div> <p>No next greater element</p> </div>

- Please only complete the required function. Do **not** write a main() program.

```

1  class Solution {
2  public:
3      /** Finds the next greater element for all the elements in a vector.
4       * @param vec: a vector of positive integers
5       */
6      static vector<unsigned int> next_greater(const vector<unsigned int>& vec) {
7          // Please add your code here to solve the problem.
8      }
9  };

```

Part IV - Algorithm Question (10 Points)

- There is 1 question (Question 11) in this part. However, the question has multiple parts.
- You **must** present your algorithms using structured language (pseudocode). Writing paragraphs or drawing flowcharts to present your algorithms will result in zero credits for the question.
- If your answer is lack of accuracy, based on the quality of your answer, partial credits may be awarded.

11. A company allows customers to call to report problems or ask for clarifications. There are some employees who work to respond to calls from customers. When a customer calls, he/she has to wait until the next employee is available to talk to him/her. There are two types of customers, a **regular customer** who uses basic services, and a **premium customer** who uses advanced services. The call center prioritizes the premium customers over the regular customers. For every two premium customers that are served, one regular customer is served.

- 1) (2 points) What data structure will you use to model the waiting of customers? Why?
- 2) (4 points) Please write the algorithm of **a customer joining a line**.
- 3) (4 points) Please write the algorithm of **serving a customer**.