Beijing-Dublin International College

SEMESTER I FINAL EXAMINATION - 2019/2020

School of Computer Science

COMP2002J Data Structures and Algorithms 1

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Time Allowed: 120 minutes

Instructions for Candidates

All questions carry equal marks. The distribution of marks in the right margin shown as a percentage gives an approximate indication of the relative importance of each part of the question.

BJUT Student ID: _____ **UCD Student ID:** _____

I have read and clearly understand the Examination Rules of both Beijing University of Technology and University College Dublin. I am aware of the Punishment for Violating the Rules of Beijing University of Technology and/or University College Dublin. I hereby promise to abide by the relevant rules and regulations by not giving or receiving any help during the exam. If caught violating the rules, I accept the punishment thereof.

Honesty Pledge： _____ **(Signature)**

Instructions for Invigilators

Non-programmable calculators are permitted.
No rough-work paper is to be provided for candidates.

Question 1: Stack

(a) For an Array-based implemented of the Stack Abstract Data Type (size=10), what should the array contain after executing the following operations?

push(15); push(41); push(8); push(24); pop(); top(); push(1); push(7);

[5 marks]

(b) Write an implementation for the normal pop() operation on stacks.

[5 marks]

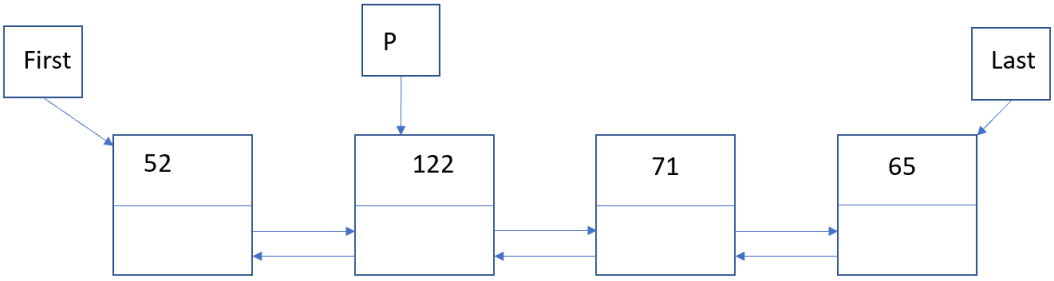
[Total 10 marks]

Question 2: List

Imagine you have a double linked list implementation of the List Abstract Data Type.

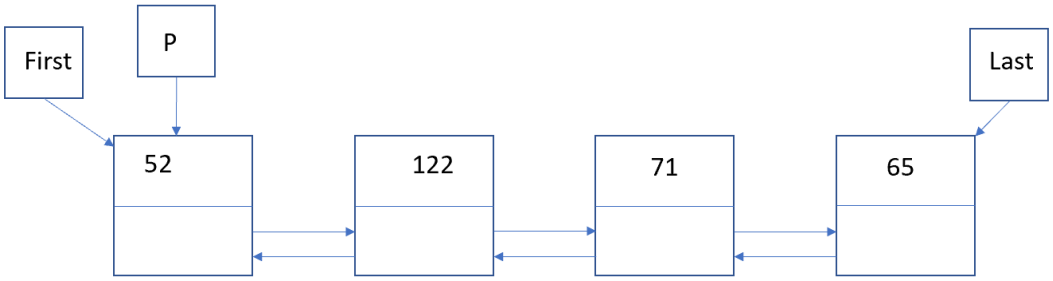
Answer the following questions:

(a) `insertAfter(p,d)`: Adding a new Node `N` with value `d` after position `p`. According to the following image and `p` position, write the lines of code that are needed to assign correct values to the pointers of the nodes involved.



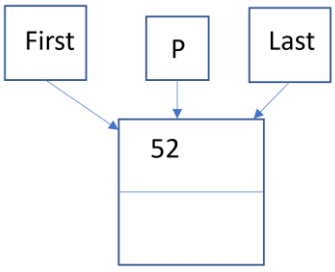
[5 marks]

(b) `insertBefore(p, d)`: Adding a new Node `N` with value `d` before position `p`. According to the following image and `p` position, write the lines of code that are needed to assign correct values to the pointers of the nodes involved.



[5 marks]

(c) `remove(p)`: Remove the node at position `p`. According to the following image and `p` position, write the lines of code that are needed to assign correct values to the pointers of the nodes involved.



[2 marks]

(d) Imagine you have an Array-based list of MaxSize = 20 in which you are keeping records of 18 students attending the Data Structures module. However, a couple of days after the start of the term you realize 10 more students should be also registered for this module. How do you change your list size to store all students' records? Write the relevant method for this purpose.

[8 marks]

[Total 20 marks]

Question 3: Queue

(a) Explain how a Circular array-based Queue should be implemented and what advantages it offers over a non-circular array-based queue.

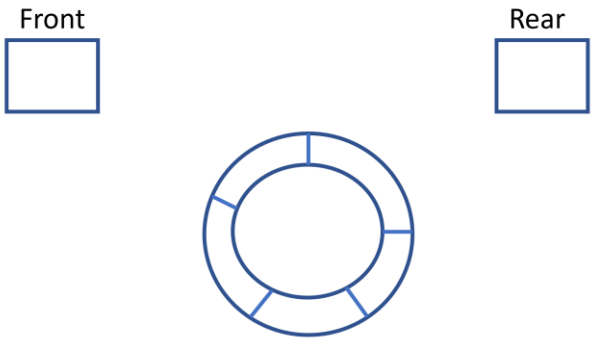
[4 marks]

(b) Imagine you have a Circular array-based Queue, shown in the image below (array size = 5), and you want to perform the following operations:

enqueue(5); enqueue(1); enqueue(7); enqueue(9); dequeue(); enqueue(3); enqueue(11); dequeue();

For each operation, what is the value of Front and Rear and what does the array contain?

Hint: at the beginning when the queue is empty Front= 0 and Rear = 0.



Your answer should be in the following format:

enqueue(5) Rear= … Front= … Array= …

enqueue(1) Rear= … Front= … Array= …

…

[8 marks]

(c) A Link-based Double-ended Queue is implemented based on Node class below, which maintains two references: `next` and `previous`. Implement the `addLast(int o)` method in Java.

```
public class Node implements Position {
  private Object element;
  Node next;
  Node previous;
  public Node(int e) { this.element = e;  }
  public Object element() { return element; }
}
```

[8 marks]

[Total 20 marks]

Question 4: Map

Imagine you have a Hash Map ADT. The Hash function for this Map is:

$$h(x) = x \bmod 11$$

Entries that must be put in the Map are as follows:

(22, green) (13, blue) (45, red) (71, orange) (66, purple) (21, yellow) (3, Pink)

(a) Put the entries into the Map based on separate chaining collision handling. What would the Map look like?

[10 marks]

(b) Put the entries into the Map based on open addressing collision handling. What would the Map look like?

[10 marks]

[Total 20 marks]

Question 5: Sorting

(a) If you have the following array of integer values, what are the steps when sorting it using a merge sort in increasing order? (*Hint: Code is not expected just show the steps of the algorithm by drawing the array at each step*).

35	13	12	45	67	6	1	10

[10 marks]

(b) Write code for an algorithm that sorts an array of integers with a complexity of $O(n^2)$.

[10 marks]

[Total 20 marks]

Question 6: Complexity

(a) Express the time complexity of the following running times using big O notation:

(i) $n^4 + 3n^3 + 40n + 1$

(ii) $nlog(n) + n^2 + 7$

[4 marks]

(b) What is the best and worst performance for the following code in big O notation?

```
boolean bSearch(int f[], int n, int x) {
  int j = 0;
  int k = n;
  while (j + 1 != k) {
    int i = (j + k)/2;
    if (x >= f[i]) {
      j = i;
    } else {
      k = i;
    }
  }
  return (f[j]==x);
}
```

[6 marks]

[Total 10 marks]