KOLEJ UNIVERSITI TUNKU ABDUL RAHMAN

FACULTY OF COMPUTING AND INFORMATION TECHNOLOGY

ACADEMIC YEAR 2020/2021

SEPTEMBER/OCTOBER EXAMINATION

COMPUTER SCIENCE BACS2063
DATA STRUCTURES AND ALGORITHMS

THURSDAY, 1 OCTOBER 2020   TIME: 9.00 AM - 12.00 NOON (3 HOURS)

BACHELOR OF COMPUTER SCIENCE (HONOURS) IN DATA SCIENCE
BACHELOR OF COMPUTER SCIENCE (HONOURS) IN INTERACTIVE SOFTWARE
TECHNOLOGY
BACHELOR OF COMPUTER SCIENCE (HONOURS) IN SOFTWARE ENGINEERING

BACHELOR OF INFORMATION SYSTEMS (HONOURS) IN ENTERPRISE INFORMATION
SYSTEMS

BACHELOR OF INFORMATION TECHNOLOGY (HONOURS) IN INFORMATION SECURITY
BACHELOR OF INFORMATION TECHNOLOGY (HONOURS) IN INTERNET TECHNOLOGY
BACHELOR OF INFORMATION TECHNOLOGY (HONOURS) IN SOFTWARE SYSTEMS
DEVELOPMENT

BACHELOR OF SCIENCE (HONOURS) IN MANAGEMENT MATHEMATICS WITH
COMPUTING

Instructions to Candidates:

Answer **ALL** questions in the requested format or template provided.

- This is an open book final online assessment. You MUST answer the assessment questions on your own without any assistance from other persons.
- You must submit your answers within the following time frame allowed for this online assessment:
  - The deadline for the submission of your answers is **half an hour** from the end time of this online assessment.
- Penalty as below **WILL BE IMPOSED** on students who submit their answers late as follows:
  - The final marks of this online assessment will be reduced by 10 marks for answer scripts that are submitted within 30 minutes after the deadline for the submission of answers for this online assessment.
  - The final marks of this online assessment will be downgraded to zero (0) mark for any answer scripts that are submitted after one hour from the end time of this online assessment.
- Extenuation Mitigating Circumstance (EMC) encountered, if any, must be submitted to the Faculty/Branch/Centre within 48 hours after the date of this online assessment. All EMC applications must be supported with valid reasons and evidence. The UC EMC Guidelines apply.

This question paper consists of 2 questions on 6 printed pages.

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FOCS Additional Instructions to Candidates:
- Include your **FULL NAME**, **STUDENT ID** and **PROGRAMME OF STUDY** in your submission of answer.
- Read all the questions carefully and understand what you are being asked to answer.
- Marks are awarded for your own (original) analysis. Therefore, use the time and information to build well-constructed answers.

STUDENT'S DECLARATION OF ORIGINALITY

By submitting this online assessment, I declare that this submitted work is free from all forms of plagiarism and for all intents and purposes is my own properly derived work. I understand that I have to bear the consequences if I fail to do so.

Final Online Assessment Submission
Course Code:
Course Title:
Signature:
Name of Student:
Student ID:
Date:

BACS2063 DATA STRUCTURES AND ALGORITHMS

Question 1

a) Algorithm analysis focuses on the growth rate of the running time as a function of the input size n. The *Big-O* Notation is widely used to represent an algorithm's time efficiency.

    (i)   Explain the shortcomings of measuring an algorithm's time complexity by finding out the time elapsed between the start and end time of running the algorithm.   (6 marks)

    (ii)   How does the *Big-O* Notation resolve these limitations from Question 1 a) (i)? Justify your answer with an example of code segment (in your code example, indicate how do you derive the *Big-O*).   (5 + 5 marks)

    (iii)   Consider two programs – A and B – that have the following *Big-O* time efficiency:
        A: $O(n)$

        B: $O(n^2)$
        If each program requires 10 seconds to solve a problem of size 1000, estimate the time required by each program to solve a problem of size 2000.   (4 marks)

b) When is it suitable to use a Queue ADT? Explain your answer by giving an example of a system or an application that would use a Queue ADT. Your answer should include what is the object in the queue and how this ADT is used.   (10 marks)

c) Analyze **TWO (2)** benefits of using abstraction in the data structures. Justify your answer with relevant examples.   (8 marks)

d) Consider the program output in Figure 1(a). The output shows a triangle shape where the line number matches with the number of '*' symbol.

    (i)   This problem can be solved iteratively, as shown in Figure 1(b). For the output in Figure 1(a), the shape is produced by passing n=10 to the method *drawPattern*. Write a recursive solution to the code segment in Figure 1(b). Your answer should be written in one or more methods. You do not need to write the code for the driver program.   (8 marks)

    (ii)   Compare the iterative solution in Figure 1(b) with your recursive solution in Question 1   d) (i). Which is a better solution? Briefly explain your reason.   (4 marks)

```
Output - ProjectX (run)  ×
run:
*
**
***
****
*****
******
*******
********
*********
**********

BUILD SUCCESSFUL (total time: 0 seconds)
```

Figure 1(a): Program Output

```
public static void drawPattern(int n){

    for(int i=0; i<n; i++){
        for(int j=0; j<=i; j++){
            System.out.print("*");
        }
        System.out.println();
    }

}
```

Figure 1(b): Iterative solution

[Total: 50 marks]

This question paper consists of 2 questions on 6 printed pages.

Question 2

a) The *Penang State Public Library* would like to implement a search function to their existing library system.

Books are being represented as objects in the library system.
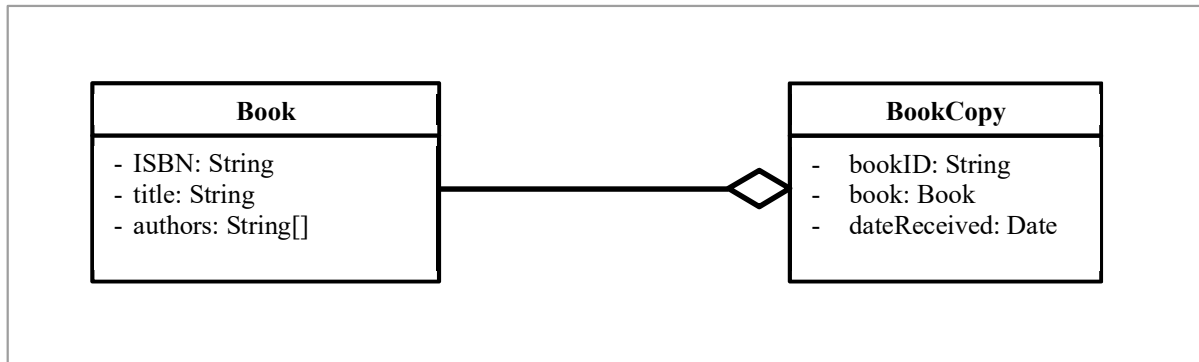Figure 2 below shows the relationship between the *Book* class and the *BookCopy* class.

Figure 2: Part of the Analysis Class Diagram for the Penang State Public Library System

The code snippet of the classes is shown in Figure 3.

```
public class Book{                      public class BookCopy{
    private String ISBN;                    private String BookID;
    private String title;                   private Book book;
    private String[] authors;               private Date dateReceived;
    …….                                      …….
    …….                                      …….
}
                                        }
```

Figure 3: Code Snippet of the Book Class and BookCopy Class

The Search function allows the user to enter a **word** (which should be part of the book **title**) to search for a book from a database. The returned records (books which have the title containing the searched word) would be stored in a suitable variable (*X*) of a particular Collection Abstract Data Type (ADT). The variable *X* should be able to be sorted by the title in ascending order (A-Z). If the user clicks on a particular book title from the search results, the system must be able to access that particular book from variable *X* and display the details of the book.

You are being assigned to develop this search function for the above requirements.

Select a suitable Abstract Data Type (ADT) to store the search object of book. Justify why your ADT is suitable for this purpose.
(10 marks)

Question 2 (Continued)

b) The code segment given in Figure 4 is the implementation of a sorting algorithm that sorts an array of String in ascending order.

```java
public static void XXSort(String[] arr) {

  int n= arr.length;

  for (int x = 1; x < n; x++) {
    String firstUnsorted = arr[x];
    doSomething(firstUnsorted, arr, x - 1);
  }
}

  private static void doSomething(String element, String[] arr, int end) {
  int index = end;

  while ((index >= 0) && (element.compareTo(arr[index]) < 0)) {
    arr[index + 1] = arr[index];
    index--;
  }
  arr[index + 1] = element;
}
```

Figure 4: Code segment for a sorting algorithm

Based on the code segment given in Figure 4, answer the following questions:

(i)   What is the type of sorting algorithm shown in Figure 4?

(2 marks)

(ii)   The usual number of results returned from the search in *Question 2 a)* is between 1 to 20 books. **Based on the algorithm you had given in *Question 2 b) (i)*,** is this sorting algorithm suitable to be used to sort the book search results in *Question 2 a)*? Why?

(6 marks)

(iii)   Suppose the sorting **algorithm shown in Figure 4** is used to sort the book titles returned in the search results in *Question 2 a)*. Some sample data of book records is shown in Table 1.

ISBN	Title	Authors
9781623171322	The Abundance of Less	Andy Couturier
9780593187741	Clutter-Less	James Carter
9781401954871	The Year of Less	Cait Flanders
9781601427994	The Simplicity of Less	Joshua Green

*Table 1: Sample data of **Book** records*

Illustrate how the algorithm in Figure 4 sorts the book objects based on the **title**. Show your answers in Figure 5 and **explain the changes after each pass** is performed.

(12 marks)

	0	1	2	3
Original	"The Abundance of Less"	"Clutter-Less"	"The Year of Less"	"The Simplicity of Less"
After Pass 1				
...				
...				

Figure 5

Question 2 (Continued)

c) Based on the binary search tree from Figure 6, answer the following questions:
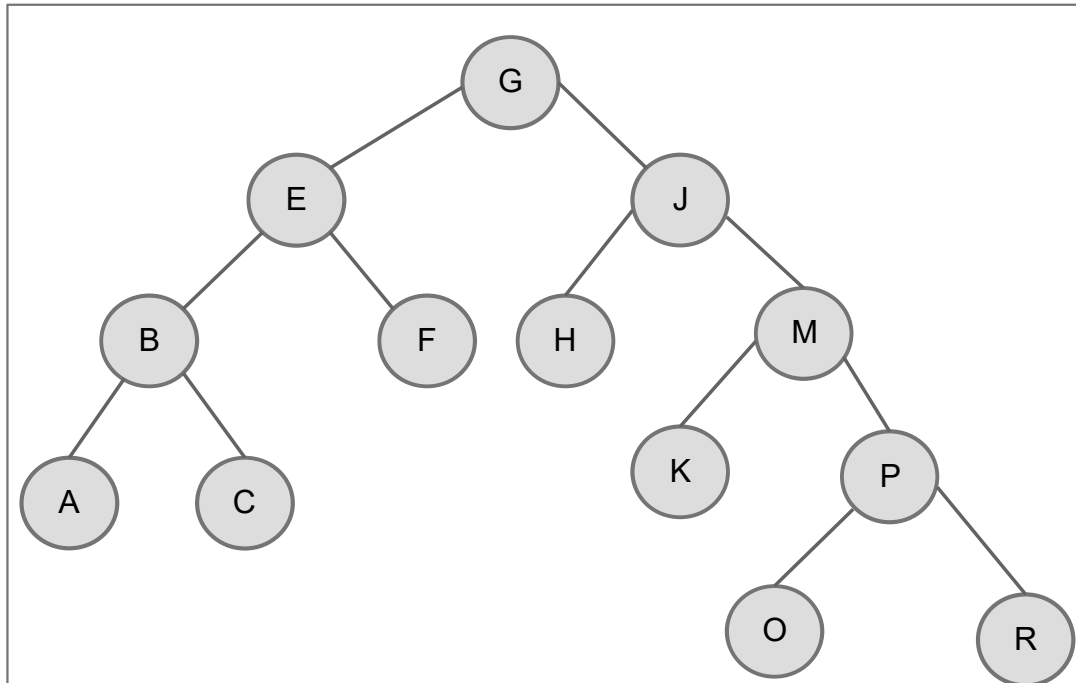

Figure 6: Binary Search Tree

    (i) Show the results of the **inorder** and **postorder** traversals on the binary search tree in Figure 6.

        (6 marks)

    (ii) Draw the resulting tree after 'M' is removed from the tree. Briefly explain your answer.

        (6 marks)

d) You are intending to store the details of 75 students of the Vegan Society into a hash table with table size as 83. Design an appropriate hash function using the Student ID (sample data given below) as input. Express your answer in coding or algorithm.   (8 marks)

20PMD1250	20PMD1251	20PMD1252	….	….	….	20PMD1325

[Total: 50 marks]