

Roll No: 16 JT134

Department of Mathematical and Computational Sciences
 National Institute of Technology Karnataka, Surathkal

End Semester Examination Part A

Course Name: Mathematical Foundations of Information Technology

Odd Semester (2017-18)

Date: 17/11/2017

Course Code: MA 200

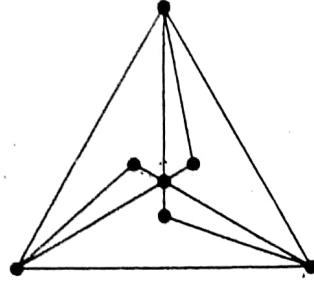
Time: 2 p.m to 5 p.m

Maximum Marks: 60

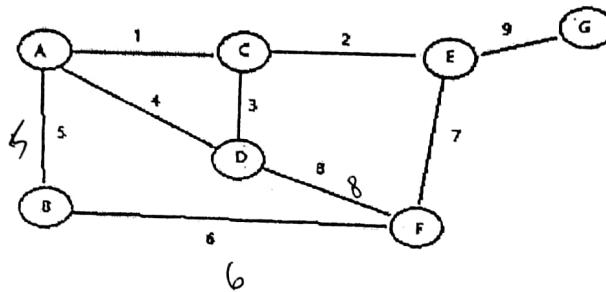
1. Answer ALL the 12 questions.
2. Rough work should NOT be done anywhere on the Question Paper.
3. Do the indexing properly.
4. There are questions on the other side of this paper also.

- i. Suppose that l lines are drawn through a circle and these lines form p points of intersection (involving exactly two lines at each intersection). How many regions r are formed inside the circle by these lines? Assume that the lines end at the edge of the circle at 2! distinct points. (6)
- ✓ 2. G is a simple graph with p vertices and each vertex has degree at least $(p - 1)/2$. Is it necessary that G is connected? Explain. (5)
- ✓ 3. Let G be a bipartite graph. Prove that G contains a perfect matching if and only if $|S| \leq |N(S)|$ for all $S \subset V(G)$. (5)
- ✓ 4. Let G be a connected bipartite graph with bipartition (X, Y) . Also, $\deg(x) \leq 6$ for each x in X . What is the best upper bound for $|Y|$ in terms of $|X|$? (5)
- ✓ 5. Suppose we know that an agency gets telephone calls at an average rate of 1.8 calls per hour. Find the probability that we observe at least 5 calls in a given 3 hour interval. (3)
- ✓ 6. P and Q are considering to apply for job. The probability that P applies for job is $1/4$. The probability that P applies for job given that Q applies for the job $1/2$ and The probability that Q applies for job given that P applies for the job $1/3$. Find the probability that P does not apply for job given that Q does not apply for the job. (5)
- ✓ 7. Joan and Jim agree to meet at the library after school between 3 p.m. and 4 p.m. Each agrees to wait no longer than 15 min for the other. What is the probability that they will meet? (6)
- ✓ 8. Consider the experiment of choosing a point at random from the disk of radius R in the plane centered at the origin. Let X be the random variable denoting the distance of the point chosen from the origin. Find the distribution function and the probability density function of the random variable X . (5)
- ✓ 9. Suppose 2% of the items made by a factory are defective. Find the probability p that there are 3 defective items in a sample of 100 items, assuming binomial distribution. Also find an approximation of p by using Poisson distribution. (6)

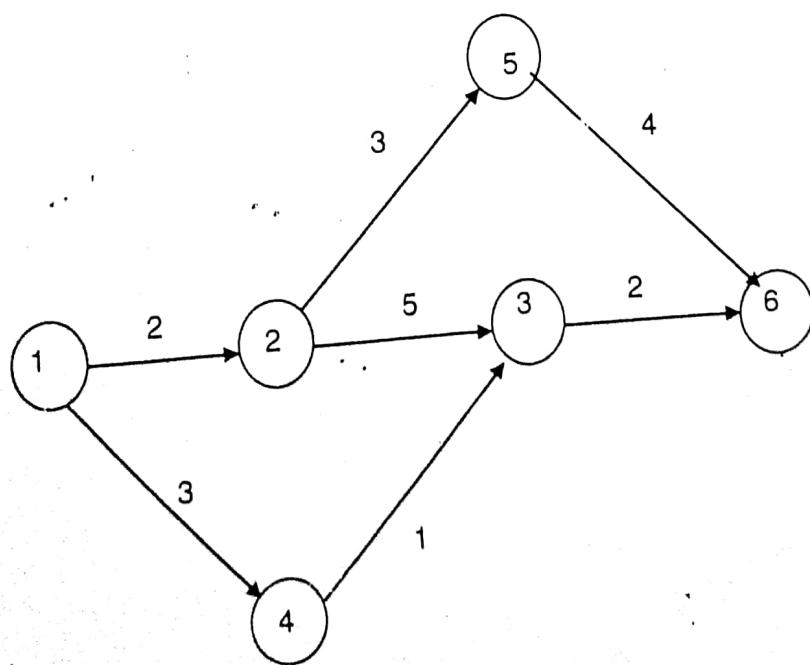
10. Is the following graph Hamiltonian? Justify your answer. (4)



11. Find a minimum spanning tree using (i) Kruskal's Algorithm, (ii) Prim's Algorithm. In both cases clearly indicate the order in which you are choosing the edges. (5)



12. Find a maximum flow from vertex 1 to vertex 6 in the graph network given below. Also find a corresponding minimum cut. (5)



DEPARTMENT OF INFORMATION TECHNOLOGY, NITK SURATHKAL

END SEMESTER EXAMINATION, NOVEMBER 2017

IT206: PARADIGMS OF PROGRAMMING-I

Class: III SEM B.TECH (IT)

Time: 3 Hrs.

Date: 24.11.2017

Marks: 80

Register No.

1	6	1	T	1	3	4
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1. Demonstrate the usage of three differnt keywords (final, finally and finalize) in Java with appropriate Java programming example. **5M**
2. a) What will be the output for the following code? **4M**

1. **try**

```
{  
    System.out.Println("Welcome to  
try");  
}  
System.out.Println("hi");  
catch(Exception E)  
{  
    System.out.Println("Exception  
handled properly");  
}
```

2. **try**

```
{  
    System.out.Println("A new  
try block");  
}  
catch (Exception E)  
{  
}  
finally  
{  
    try  
{  
    }  
catch( Exception E)  
{System.out.Println("Exception  
handled properly");  
}  
}
```

- b) Compute the output of the following code? Construct a runtime stack mechanism for the give program and also show how destruction of runtime stack is carried out. **5M**

```
public class ExceptionHandling  
{  
    public static void main(String[] args)  
    {  
        secondmethod();  
    }
```

P.T.O

```
public static void secondmethod()
{
    firstmethod();
    System.out.println("Method second");
}
public static void firstmethod()
{
    System.out.println(10 / 0);
    System.out.println("Method first");
}
```

3. a) What is a native method in Java? Provide few examples of native method.

3M

~~b) Compute the output of the following program. Re-write the following program with synchronization of methods and blocks and compute its output. State the difference between synchronizing methods and blocks.~~

8M

```
class First
{
    public void display(String msg)
    {
        System.out.print ("["+msg);
        try
        {
            Thread.sleep(1000);
        }
        catch(InterruptedException e)
        {
            e.printStackTrace();
        }
        System.out.println ("]");
    }
}
class Second extends Thread
{
    String msg;
    First fobj;
    Second (First fp, String str)
    {
        fobj = fp;
        msg = str;
        start();
    }
    public void run()
    {
```

P.T.O

```

fobj.display(msg);
}
}

public class Syncro
{
    public static void main (String[] args)
    {
        First fnew = new First();
        Second ss = new Second(fnew, "welcome");
        Second ss1= new Second (fnew,"new");
        Second ss2 = new Second(fnew, "programmer");
    }
}

```

4. a) List out the properties and restrictions of static variables and methods with example. 3M

b) Can we invoke private methods or variables with the help of reflection? Explain with a programming example how refelction is acheived and what are the different methods employed in it and also state its advantages and disadvantages. 8M

5. Correct if there are any errors & Explain what the following code is supposed to do. Rewrite the code with interfaces and abstract classes. 8M

```

class Instrument {
    void play(Note n) { print("Instrument.play() " + n); }
    String what() { return "Instrument"; }
    void adjust() { print("Adjusting Instrument"); }
}

class Wind extends Instrument {
    void play(Note n) { print("Wind.play() " + n); }
    String what() { return "Wind"; }
    void adjust() { print("Adjusting Wind"); }
}

class Percussion extends Instrument {
    void play(Note n) { print("Percussion.play() " + n); }
    String what() { return "Percussion"; }
    void adjust() { print("Adjusting Percussion"); }
}

class Stringed extends Instrument {
    void play(Note n) { print("Stringed.play() " + n); }
    String what() { return "Stringed"; }
    void adjust() { print("Adjusting Stringed"); }
}

class Brass extends Wind {
    void play(Note n) { print("Brass.play() " + n); }
}

```

P.T.O

```

void adjust() { print("Adjusting Brass"); } }
class Woodwind extends Wind {
void play(Note n) { print("Woodwind.play() " + n); }
String what() { return "Woodwind"; }
}
public class Music3 {

public static void tune(Instrument i) {

i.play(Note.MIDDLE_C);
}

public static void tuneAll(Instrument[] e) {
for(Instrument i : e)
tune(i);
}

public static void main(String[] args) {

Instrument[] orchestra = {
new Wind(),
new Percussion(),
new Stringed(),
new Brass(),
new Woodwind()
};
tuneAll(orchestra);
}
}

```

6. a) Does it matter in what order catch statements for FileNotFoundException and IOException are written? Explain with a java programming example. **4M**

b) If suppose there arises a situation where thread execution is to be stopped temporarily what are the different methods that can be employed to achieve it? Give a suitable programming example and also state thread life cycle in it. **8M**

7. In What order will the constructor be called for the given program? Explain. **5M**

```

class One {
One() { print("One()"); }
}
class Two {
Two() { print("Two()"); }
}
class Three { Three() { print("Three()"); } }

```

P.T.O

```

class Four {
Four() { print("Four( )"); }
}
class Five extends One {
Five() { print("Five( )"); }
}
class Six extends Five {
Six() { print("Six( )"); }
}
public class Seven extends Six {
private One b = new One();
private Two c = new Two();
private Three l = new Three();
public four() { print("Four( )"); }
public static void main(String[] args) {
new Seven();
}
}

```

8. a) What are different paradigms of programming? Explain each with an example. 5M
- b) Correct if there are any errors & Explain what the following code is supposed to do. What is the output after running the below code? 8M

```

interface Selector {
boolean end();
Object current();
void next();
}
public class Sequence {
private Object[] items;
private int next = 0;
public Sequence(int size) { items = new Object[size]; }
public void add(Object x) {
if(next < items.length)
items[next++] = x;
}
private class SequenceSelector implements Selector {
private int i = 0;
public boolean end() { return i == items.length; }
public Object current() { return items[i]; }
public void next() { if(i < items.length) i++; }
public Selector selector() {
return new SequenceSelector(); }
}

```

P.T.O

```

public static void main(String[] args)
{
    Sequence sequence = new Sequence(10);
    for(int i = 0; i < 10; i++)
        sequence.add(Integer.toString(i));
    Selector selector = sequence.selector();
    while(!selector.end())
    {
        System.out.print(selector.current() + " ");
        selector.next();
    }
}

```

9. a) Compute the output of following program and explain. 3M

```

#include <stdio.h>
int main()
{
    int *ptr;
    int x;
    ptr = &x;
    *ptr = 0; printf(" x = %d\n", x);
    printf(" *ptr = %d\n", *ptr);
    *ptr += 5;
    printf(" x = %d\n", x);
    printf(" *ptr = %d\n", *ptr);
    (*ptr)++;
    printf(" x = %d\n", x);
    printf(" *ptr = %d\n", *ptr);
    return 0;
}

```

b) Compute the output of following program and explain. 3M

```

#include <stdio.h>
int main()
{
    struct bitfields
    {
        int bits_1: 2;
        int bits_2: 4;
        int bits_3: 4;
        int bits_4: 3; }bit = {2, 3, 8, 7};
    printf("%d %d %d %d", bit.bits_1, bits.bit_2, bit.bits_3, bits.bit_4);
}

```

i. Runtime error

ii. Compilation error

iii. 2 3 8 7

iv. -2 3 -8 -1

ALL THE BEST-----

DEPARTMENT OF INFORMATION TECHNOLOGY, NITK SURATKAL

END SEMESTER EXAMINATION, NOVEMBER 2015

IT202 UNIX PROGRAMMING AND PRACTISE

Class : III Semester IT

Time: 3 Hours

Date : 27-11-2015

Maximum Marks: 40

Register No

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Answer all the questions and answer to the point.

Write steps, programs or diagrams wherever necessary.

1 a) Explain the following commands

4M

umask 022

grep -n '[dD]on\t' tasks

pr -t emp.txt

touch -m 0303 10 30 vtu.txt

b) Explain the list of insert commands in VI editor? Explain the commands to move the cursor along a line in VI editor

3M

c) Write a program in awk to store the totals of the basic pay, DA, HRA, and gross pay of the sales and marketing people.

3M

2 a) What is shell script? Explain the following statements with syntax and examples?

4M

1. if

2. case

3. while

b) Explain what these wild card patterns match

4M

i). [A-Z]????*

ii). *[0-9]*

iii). *![0-9]

iv). *.[!s][!h].

c) How would you write a shell script that prints all the arguments passed to it in reverse order?

2M

3 a) What are special characters that can be used in shell script

4M

b) Write a command that will do the following:

Look for all files in the current and subsequent directories with an extension c,v

Strip the,v from the result (you can use sed command)

Use the result and use a grep command to search for all occurrences of the word ORANGE in
the files. 3M

c) How would you count every occurrence of the term "potato" in all the files appearing under
the current directory, and its subdirectories, recursively? 3M

✓ 4 a) What is a process? Explain the mechanism of process creation? 3M

✓ b) What is the output of the below code? 3M

```
void exit_handler1();
void exit_handler2();
int main() {
    int pid;
    atexit(exit_handler1);
    atexit(exit_handler2);
    pid = fork();
    if(pid == 0) {
        exit(0);
    } else {
        sleep(2);
        exit(0);
    }
    return 0;
}
```

✓ c) Explain different file tests, character string test and arithmetic test that can be performed in
shell scripting 4M

DEPARTMENT OF INFORMATION TECHNOLOGY, NITK SURATHKAL

END SEMESTER EXAMINATION, NOVEMBER 2017

IT200: DATA STRUCTURES AND ALGORITHMS

Class: III SEM B.TECH (IT)

Date: 20/11/2017

Time: 3 Hrs.

Marks: 100

Register No.

1	6	1	T	1	3	4
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NOTE:

1. There are 10 questions in this paper.
2. Each question has multiple parts. Read the entire question carefully.
3. Use pseudo-code to describe algorithms, not C or Python code.

Problem 1 :

[4+4+2 = 10 marks]

a) Give the tightest Big-O representation of the following expressions:

- i) $n^2 + n \log n$ ii) $\sqrt{n} + (\log n)^4$ iii) $n^3 + 2^n$ iv) $n + \sqrt{n} \log n$

b) A double-ended queue (Deque) supports adding & removing items on both ends of a queue. These are implemented by four operations `addFront`, `addRear`, `removeFront` and `removeRear`. For e.g. the figures below shows how these operations modify the Deque: figure (a) shows a Deque; figure (b) shows the Deque after `addRear(3)`; figure (c) shows the Deque after `addFront(6)`; and figure(d) shows the Deque after a `removeRear()` operation.

10	8	
(a)		

10	8	3	
(b)			

6	10	8	3	
(c)				

6	10	8
(d)		

Suppose you have to implement the Deque ADT operations using only Stacks (which implement the usual `push`, `pop`, `isEmpty` operations). What is the minimum number of Stacks you will need to do this? Clearly show (using a suitable example) how the Stack(s) can be used to implement each of the Deque operations. You can only use the `push`, `pop` and `isEmpty` operations of the Stack - you can not access/change the Stack's underlying implementation.

b) What is the worst-case runtime of each of the Deque operations in your implementation? Give reasons for your answer.

[5+5 = 10 marks]

Problem 2 :

a) Give an algorithm to return the middle element in a singly linked list. What is the runtime of your algorithm?

b) Write Python code to define a class `Student` with four attributes `rollno`, `name`, `email` and `phonenum`. Write a constructor with appropriate parameters that initialises the class attributes to the parameter values. Define a function `hashcode` within this class that computes a hashvalue for a given `Student` object by concatenating its four attributes and returning the component sum (sum of the ASCII values of the characters) of the resulting string.

Problem 3 :

[2+2+2 = 6 marks]

- a) You are building an application that displays the details of the 101 students in your batch. Your application repeatedly needs to answer queries of the following form: given a student's roll number, return the other details of the student. (Assume that a *Student* object has been created for each student and that the roll numbers are positive integers from 1 to 101.) What Data Structure would you use for your application so as to minimize the runtime and space requirements? Give reasons for your choice.

- b) Consider the $\text{delete}(x, T)$ operation that deletes an element x from a Hash-table T (x is a pointer to the element in the Hash-table, not simply its key). The Hashtable resolves collisions with chaining. What is the worst-case runtime of the delete operation for these two cases: when the chain is implemented using a singly linked list, and when the chain is a doubly linked list? Give reasons for your answer.
- c) In Universal Hashing, whenever a new hashtable is *created*, its hash function h is randomly chosen from a set of pre-defined hash functions H . What is the advantage of universal hashing over hashing using a single pre-defined hash function?

Problem 4 :

[6+3+4 = 13 marks]

- a) You are given a (initially empty) *balanced binary search tree* T that only supports the *insert*, *delete* & *minimum* operations on it. Give an algorithm that takes an array A of n numbers and prints them in sorted (increasing) order, using only the tree T . Assuming that the *insert*, *delete* & *minimum* operations each take $O(\log n)$ time, what is the runtime of your sorting algorithm? Give clear reasons/show the steps in your derivation.
- b) You are given a sequence of n values x_1, x_2, \dots, x_n . You need to repeatedly answer queries of the following form: given i and j (where $i \leq j$), find the smallest value in the sub-sequence x_i, \dots, x_j . Design a data structure that uses $O(n^2)$ space and answers these queries in $O(1)$ time.
- c) For the previous problem, design a data structure that uses $O(n)$ space and answers these queries in $O(\log n)$ time. (A design of $O(n \log n)$ space and $O(\log n)$ query time will get partial credit).

Problem 5 :

[3+6+2 = 11 marks]

- a) A post-order traversal of a binary expression tree prints the following:

6 5 2 - / 9 7 * 8 4 / 3 + - +

Draw the expression tree corresponding. Can there be more than one expression tree that gives the above post-order traversal? Why?

- b) The following operations are performed sequentially on an (initially empty) AVL tree:
 $\text{insert}(15)$, $\text{insert}(10)$, $\text{insert}(12)$, $\text{insert}(4)$, $\text{insert}(3)$, $\text{insert}(1)$, $\text{delete}(4)$, $\text{delete}(3)$. Show the resulting AVL tree after each operation. Also show intermediate rotation(s) (if any).

- c) Is the *delete* operation in AVL trees commutative? That is, if two nodes n_1 and n_2 are deleted from an AVL tree is the resulting tree the same irrespective of the order in which nodes n_1 and n_2 are deleted? Is the *insert* operation in AVL trees commutative? Give reasons for your answer.

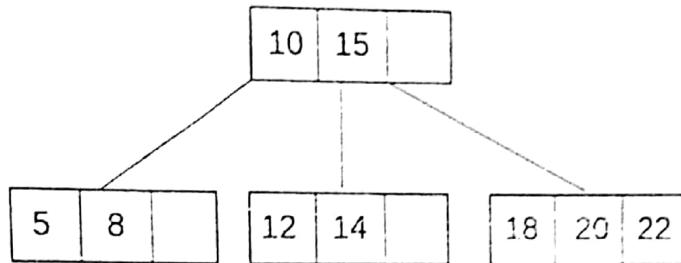
Ans.

Problem 6 :

- a) In a multiway (a,b)-Tree each internal node has at least a and at most b children. Derive a relation (show the steps) between the values a and b such that they can form a valid (a,b)-Tree. Does $a=24$, $b=45$ satisfy your condition? i.e. is a (24,45)-Tree well defined?

[3+4+3 = 10 marks]

- b) State all the conditions for a binary tree to be a Red-Black tree. Show that the height of a Red-Black tree is $O(\log n)$, where n is the number of nodes in the Red-Black tree.
- c) Sequentially insert the following keys into the 2-4 tree shown below: 2, 13, 19, 16, 11, 3.

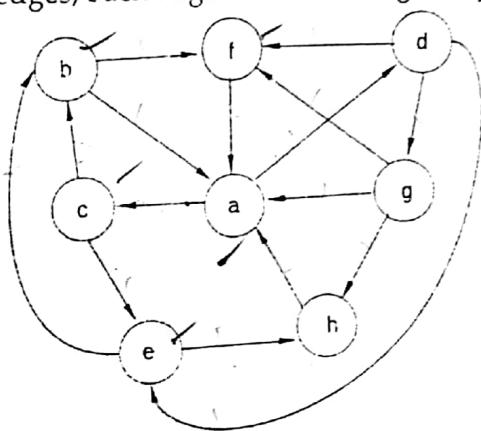


Draw the Red-Black tree corresponding to the final 2-4 tree thus obtained.

Problem 7 :

[5+1+2+2 = 10 marks]

- a) Perform a depth-first search on the graph below starting from vertex a. Whenever there is a choice of vertices to explore, pick the one that is alphabetically first. What is the sequence of vertices explored? Draw the final DFS tree, showing the time stamps of each vertex. Explicitly label the tree edges, forward edges, back edges and cross edges in your DFS tree.



- b) "If a directed graph G contains a path from node u to v, and if u is discovered before v in a DFS of G, then v is a descendant of u in the DFS Tree". Is this statement True or False? Give reasons for your answer.

- c) Give one advantage and disadvantage of the adjacency matrix and adjacency list representation of a graph.

- d) Define a connected component in an undirected graph. Prove that a undirected graph with n vertices has to have at least $n-1$ edges to be connected.

Problem 8:

[3+3+4 = 10 marks]

a) Define the compressed Trie data structure. If S represents the set of all strings to be inserted in a compressed Trie, m is the length of the longest word in S and d is the size of the alphabet, what is the space required by a compressed Trie? Give clear reasons for your answer.

b) What are the main operations of the Priority Queue ADT? List any three Data Structures that can be used to implement the Priority Queue ADT. Give the worst-case runtime of each of the ADT operations for each implementation.

c) Explain the functioning of the heapify function in a binary max-heap with a suitable example. Show how heapify functions when the max-heap is represented by an array A . What is the runtime of the heapify operation?

Problem 9 :

[5+1+4 = 10 marks]

a) If you are only allowed to use two colors (i.e. a single bit) to store a node's color, rewrite the Breadth-first search algorithm so that it produces the same final result (the same BFS Tree, node distances, predecessor nodes, etc) as when using three colors. What is the runtime of the BFS if the input graph G is represented by an adjacency matrix instead of an adjacency list? Give reasons for your answer.

b) "If the BFS Tree of an undirected graph G has two vertices u, v such that (u, v) is an edge in G and the distance labels of u and v are the same, then graph G has a cycle". Is this statement True or False? Why?

c) Sometimes there is no *unique* shortest path between two vertices: there can be two or more different paths between them with the same minimum length. Given an undirected graph $G=(V,E)$ with positive edge weights and a source vertex s , give a $O((V+E) \log V)$ algorithm that computes a boolean array `uniquesp` of size V with the following property: for a vertex $u \in V$ `uniquesp[u]=true` if and only if there is a unique shortest path from source vertex s to vertex u .

Problem 10 :

[4+6= 10 marks]

a) Describe with a suitable example the Divide, Conquer and Combine phases of Mergesort. Write the recurrence relation for the runtime of the algorithm in the worst case. Solve this recurrence relation, showing the intermediate steps, to derive the worst case runtime of Mergesort.

b) One way to do the partition step of Quicksort is to simultaneously scan the input array from the left and the right, repeatedly swapping elements that are out of order (i.e. elements in the left that are greater than the pivot are swapped with elements in the right that are less than the pivot). Write a pseudocode for this partition procedure.

