M.Sc. Examination, 2024
Semester-I
Computer Science
Paper: MCSC-11
(Theory of Computation)

Time: 3 Hours Full Marks: 40

Questions are of value as indicated in the margin.
Answer **Question No. 1** and **any four** from the rest.

1. Answer **any four**: 4 × 2 = 8

a) Is $L = \{a^n b^{2n} c^{3n} : n \geq 1\}$ regular? Justify your answer.
b) Can all programming language constructs be expressed as context-free grammars? Justify.
c) Write subset and superset relationships of the following family of languages: LL-grammar, LR-grammar, s-grammar, deterministic CFG, and non-deterministic CFG.
d) What is the Chomsky hierarchy?
e) Define a language which is not recursively enumerable.
f) Define a function that is not computable.

2. a) Show that the family of regular languages is closed under reversal.
b) Can we design a deterministic pushdown automaton that accepts the language $L=\{ww^R : w \in \{a, b\}^+\}$? Justify.
c) Using the CYK algorithm, determine if the string *baba* is in the language generated by the following grammar: $S \rightarrow AB \mid BC, A \rightarrow BA \mid a, B \rightarrow CC \mid b, C \rightarrow AB \mid a$

3+2+3=8

3.a) State Turing's thesis.
b) Design a Turing Machine that accepts the language $L= \{ww^R: w \in \{a, b\}^+\}$.
c) Design a Turing machine that computes the following function where x and y are positive integers:

$$f(x) = x + y$$

2+3+3=8

4. a) Define nondeterministic Turing machine. Show that the class of deterministic Turing machines and the class of nondeterministic Turing machines are equivalent.
b) Prove that the set of all Turing machines, although infinite, is countable.

4+4=8

5. a) Show that a language is recursively enumerable if and only if there is an enumeration procedure for it.
b) Let S be an infinite countable set. Show that its powerset 2^S is not countable.

4+4=8

6. a) Define the membership problem for Turing machines. Show that the membership problem for Turing machines is undecidable.
b) Show that the following function is not computable:
$f(n)$ = the maximum number of moves that can be made by any Turing machine with n states that halts when started with a blank tape.

(1+3)+4=8

7. Write short notes on **any two** of the following: 2 × 4 = 8

a) Ambiguity in context-free grammars
b) Linear bounded automata
c) Universal Turing machine
d) Primitive recursive functions

M.Sc. Examination, 2024
Semester–I
Computer Science
Course: MCSC-12 (Advanced Data Structures)

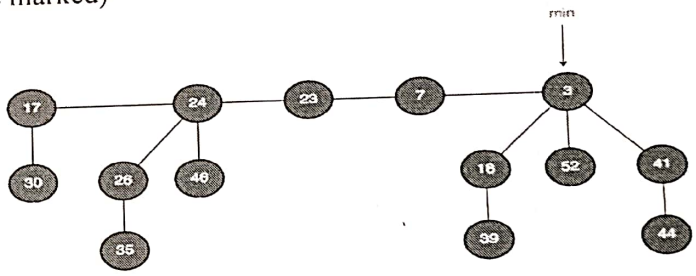
Time: 3 hours **Full Marks: 40**

Questions are of values indicated in the margin
Answer question 1 and any four from the rest

1 a) Calculate the hash value for 1234321 using folding method. Consider the size of the hash table to be 100.
b) Justify that the properties of a red-black tree guarantee that its total height is $O(\log_2 n)$.
c) Find the orders of the trees present in a binomial heap obtained with 33 nodes.
d) Distinguish between a binary search tree and a digital search tree.
[2×4]

2 a) Use the following elements to construct a max-heap: 80, 26, 35, 71, 62, 58, 72, 88, 47, 49, 59. Obtain the complexity.
b) Discuss how you can implement priority queues using arrays.
[(3+1)+4]

3 a) Perform the following operations, one after the other, on the following Fibonacci heap. (note that nodes 26 and 52 are marked)
(i) insert 6
(ii) insert 8
(iii) delete_min
(iv) decrease 35 to 5
(v) delete 17.



b) How is the delete_min operation different in cases of Binomial and Fibonacci heaps.
[(0.5+0.5+3+2+1)+1]

4 a) Draw the suffix tree for the word "COMMUNICATION".
b) What do you mean by a prefix tree? Give an example.
c) Give an application of prefix trees.
[3+3+2]

5 a) Discuss the algorithm of inserting a node into a red-black tree.
b) How can you find a minimal spanning tree using Kruskal's algorithm and disjoint sets?
[4+4]

6 a) Insert 0010, 0100, 1100, 1000, 1001, 0111, 0101, 0011 0001 into a digital search tree and a binary trie.
b) Obtain compressed binary trie and patricia from the binary trie obtained above.
[4+4]

7 Write short notes on the following:
(i) Hash function
(ii) Deletion from a B+ tree.
[4+4]

M.Sc (Semester-I) Examinations, 2024
Subject – Computer Science
Paper – MCSC13 (Computational Statistics)

Time : 3 hours Full Marks – 40

Questions are of value as indicated in the margin.

Answer Question number 1 and any THREE from the rest.

1. Indicate if the statements below are TRUE or FALSE.

a) For two mutually independent events A and B, Prob(A+B) = Prob(A) + Prob(B). (1)

b) If two events A and B are mutually exclusive, Prob(A/B) = Prob(A)/prob(B). (1)

c) Value of Probability Mass Function of a discrete random variable X with argument x, denoted by $P_X(x)$, indicates probability of (X=x). (1)

d) Value of $F_X(x)$, the Cumulative Distribution Function of a continuous random variable X at x, is equal to the probability(X>x). (1)

e) The CDF of a random variable is a monotonically increasing function with maximum value = 1. (1)

f) For two events A and B, Prob(A) = 0.7, Prob(A,B) = 0.4. Hence Prob(A/B) = 4/7. (2)

g) If arrival of vehicles at a traffic signal is assumed to be Poisson distributed, the inter-arrival time between two vehicles is exponentially distributed. (1)

h) Skewness of a random variable X is defined as average[$(X\text{-mean})^3/(\text{sigma})^3$] which indicates asymmetry of PDF around mean value. (1)

i) Variance of a random variable X can be obtained by computing avg(X^2) and avg(X), where avg stands for average. (1)

2. Two teams A and B are playing a cricket test match series of 5 matches. Probability(Team A winning a match) = 0.4, Probability(Team B winning) = 0.3, Probability(Draw) = 0.3.
a) Find the probability of the series getting drawn. (6)
b) Given that the series gets drawn, find the probability that Team B has won at least 1 match. (4)

3. $f_X(x)$, the PDF of a continuous random variable X is as below :
$f_X(x)$ = 0 for x< 1,
= 0.25 for 1<=x<2
= 0.5 for 2<=x<3
= 0.25 for 3<=x<4
= 0 for x>4
a) Find the CDF of X ($F_X(x)$) for X=3.25. (4)
b) Find the probability of 1.75 <=X < 3.25. (3)
c) Find the average value of X. (3)

4. Vehicles arrive at a traffic signal following a Poisson distribution with mean arrival rate = 6 vehicles/minute.

a) Find the probability of 5-10 vehicles arriving within 30 seconds. (5)

b) Find the probability that, inter-arrival time of two vehicles is more than 20 seconds. (5)

5. Mean arrival rate in a queue with Poisson arrival = 5/sec, and the mean service time with exponential service time = 100 msec. (2X5 = 10)

a) Find the probability that the system has no entity.

b) Find the probability that the system has 10 entities at one point of time.

c) Find the average number of entities in the system.

d) Find the average waiting time of entities in the queue.

e) Find the average queue size.

6. The maximum relative humidity in percentage and the amount of rainfall for 10 days in a month is given below. Find the Pearson's linear correlation coefficient for the two sets of data. (10)

Maximum relative humidity	Rainfall in mm
89.5	1.5
91.3	10.7
85.5	6.5
94.5	21.3
98.5	31.3
96.3	9.5
92.8	15.4
93.4	8.2
84.3	0.5
88.6	4.3

7. The Chi-Square table is given below :

df	$\chi^2_{.995}$	$\chi^2_{.990}$	$\chi^2_{.975}$	$\chi^2_{.950}$	$\chi^2_{.900}$	$\chi^2_{.100}$	$\chi^2_{.050}$	$\chi^2_{.025}$	$\chi^2_{.010}$	$\chi^2_{.005}$
1	0.000	0.000	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860
5	0.412	0.554	0.831	1.145	1.610	9.236	11.070	12.833	15.086	16.750

Here is some data regarding the public transport modes preferred used by male and female in a city within some time.

Mode of transport	Male	Female	Total
Bus	1450	1350	2800
Metro	2030	2420	4420
Taxi	890	680	1570
Autorickshaw	1000	850	1850

Test the NULL hypothesis that, mode of transport used by males and females are independent. (10)

M.Sc. Semester I Examination 2025
Computer Science
Paper MCSC-14 (Advanced Software Engineering)
F.M. : 40 **Time: Three hours**

Answer the question no. 1 and any 4 from the rest.

1. Answer the following questions(any eight) : 1x8=8

i. Describe the role of Stub and Driver modules in Unit Testing.
ii. What do you understand by generic software?
iii. For a project development requirements are easily understandable and defined- which software development model is best suited?
iv. For a project development time and budget is fixed-- which model is best suited?
v. Condition coverage criteria is stronger than statement coverage criteria- Explain with example.
vi. What do you mean by feasibility study of a Project?
vii. Do you think SRS document is required for Agile development methodology?
viii. Does Agile software development need any SRS document?

2. What is cyclomatic complexity of a Control Flow Graph(CFG)? What are the characteristics of cyclomatic complexity?
How does it is related to Software Testing?
1+2+1+1+2+1=8
Consider the following software code: Draw the control flow graph and calculate the cyclomatic complexity. Establish how the cyclomatic complexity is related to the number of predicate nodes of the CFG.

```
int compute_gcd(int x, int y)
{
 while (x!=y)
{
 if (x>y) then
 x=x-y;
 else y=y-x;
  }
 return x;
}
```

3. Describe various stages of Software Testing. What is the objective of Integration testing? What is the important factor that guides the Integration Plan? Discuss the Bottom-up, Top-down and Sandwich approaches for the integration Testing. Give comparative study of all approaches.

1+2+1+2+2=8

4.

(a) What is software life cycle? Discuss prototype model? What are the advantages of developing a prototype of a system?

(b) Sketch a neat diagram of spiral model of software life cycle. Discuss how the project risk is considered in spiral model. Why it is called a meta model?

5. Define various Halstead Software metrics. 2+1+5=8

Consider the following programming code :

```
main ( ) {
int a,b,c,avg;

scanf ( "%d,%d,%d"; &a, &b, &c);
avg a+b+c)/3;
printf ( " avg=%d", avg);
}
```

i. Calculate the number of unique operators and operands of the above program segment.

ii. Calculate the following Halstead Software matrices for the above programming code:
Program length, Vocabulary size, Program Volume, Difficulty Level, Effort.

6. What are the various types of Software according Bohm's classification. Explain each of them in brief. According to basic COCOMO model how the Development Time and Efforts are estimated with single variable. What are the objectives of Intermediate and Complete COCOMOs? (3+2)+3=8

   Assume that the size of an organic type software product is estimated to be 32000 lines of source code. Consider that the average salary of a software developer is Rs.15000 per month. Determine the effort required to develop the software product. Compute the same parameters for the embedded software.

7. What is Mutation testing? What is mutant? What are the dead and alive mutants? How mutation testing is carried over? For the following Program segment consider Mutant 1 : GE in case of LE; Mutant 2 EQ in case of LE. Find out the dead and alive mutants in each cases (A,B): (1,2),(0,3), (3,1),(2,2) and (1,1). Analyze the resul

   1+1 +1+5=8

```
10      READ A,B

        IF (A.EQ.-1) GO TO 11
        IF( (A+B).LE.3) GO TO 12
        C=(A+B)**2
        GO TO 14
12      C=(A+B)**3
14      PRINT A,B,C
11      STOP
        END
```

M.Sc. Semester I Examination, 2024
Computer Science
Department of Computer and System Sciences, Visva-Bharati
MCSC 15: Operations Research

Full Marks: 40 Time: 3 hours

Answer Question no. 1 and any three questions from the rest

1. Answer any five questions. 2X5=10

   (a) When can you say a LP problem is unbounded?

   (b) Write the dual of the following primal problem:
   Maximize $Z = 5a + 20b$ s.t.
   $5a + 2b \leq 20$
   $a + 2b \leq 8$
   $a + 6b \leq 12$ and both a and b are ≥ 0.

   (c) Differentiate between Perfect and Imperfect Information Games.

   (d) Explain the role of Nash Equilibrium in Game Theory.

   (e) How would you deal with an assignment problem where the objective function is to be maximized?

   (f) What is the use of slack and surplus variables in simplex method?

2. A company manufactures two products, X and Y by using three machines A, B, and C. Machine A has 4 hours of capacity available during the coming week. Similarly, the available capacity of machines B and C during the coming week is 24 hours and 35 hours respectively. One unit of product X requires one hour of Machine A, 3 hours of machine B and 10 hours of machine C. Similarly one unit of product Y requires 1 hour, 8 hour and 7 hours of machine A, B and C respectively. When one unit of X is sold in the market, it yields a profit of Rs. 5/- per product and that of Y is Rs. 7/- per unit. Formulate the LPP. Hence solve the problem by using graphical method to find the optimal product mix. 3+7=10

3. (a) By using two phase method find whether the following problem has a feasible solution or not?
   Maximize $Z = 4a + 5b$ s.t.
   $2a + 4b \leq 8$
   $a + 3b \geq 9$ and both a and b are ≥ 0

   (b) Solve the given LPP using Big-M method.
   Minimize $Z = 4a + 2b$ s.t.
   $3a + b \geq 27$
   $-a - b \leq -21$
   $a + 2b \geq 30$ and both a and b are ≥ 0. 4+6=10

4. A new search engine founder plans to generate revenue through advertisements on the platform and has secured ads from three local retailers—A, B, and C. These advertisers require their ads to appear whenever users search for specific keywords: market, shopping, retail, and discount. The site owner estimates that "market" will receive 35,000 searches, "shopping" will get 25,000, "retail" will have 15,000, and "discount" will generate 5,000 searches. Additionally, it is predicted that 20% of users who see an ad will click on it. A, B, and C will pay a specified amount per click, as detailed in the Table 1 below. The websites of A, B and C have different capacities. A can get maximum 6000 visitors, B can get maximum 2000 visitors and C can get maximum 9000 visitors. For each word searched, only one advertisement for one firm can be shown on the search engine. The site owner wants to maximize his revenue by deciding on which word and how many of that word should result in showing advertisement of each firm.

	Market	Shopping	Retail	Discount
A	2	3	11	7
B	1	2	6	1
C	5	8	15	9

Table 1: Payment plan

(a) Model this problem as a transportation problem by constructing a balanced transportation table.

(b) First, apply any suitable method to obtain the initial basic feasible solution and then apply MODI method to optimize the solution. 3+(4+3)=10

5. An airline company has introduced five new flight routes and needs to assign five pilots to these routes. Each pilot has ranked their preference for the routes on a scale of 1 to 10, with higher numbers indicating stronger preferences. However, some routes are unsuitable for certain pilots due to domestic regulations, and these are marked with an"X". Determine the optimal allocation of pilots to flight routes that maximizes the total preference scores.

	Flight Number				
Pilot	1	2	3	4	5
A	8	2	X	5	4
B	10	9	2	8	4
C	5	4	9	6	X
D	3	6	2	8	7
E	5	6	10	4	3

Table 2: Flight plan

10

6. (a) Determine the optimal strategies for each player in the following game (Figure 1). Mention the saddle point as well as game value.

$$\begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} \begin{array}{cccc} B_1 & B_2 & B_3 & B_4 \end{array} \\ \begin{pmatrix} -5 & 2 & 0 & 7 \\ 5 & 6 & 4 & 8 \\ 4 & 0 & 2 & -3 \end{pmatrix} \end{array}$$

Figure 1: Pay-off matrix

(b) How do you solve a two-person zero-sum game when saddle point is absent? 6+4=10