Visva-Bharati University
M.Sc. Examinations, 2024-
Semester – III
Computer & System Sciences
Paper: MCSO 03
(Approximation Algorithms)

Time Three hours

Full Marks-40

Questions are of marks as indicated in the margin
Answer any four questions

1 a) Define the TSP problem with triangle inequality.

b) Consider a TSP instance with six cities {0,1,2,3,4,5}. The cost of the edge (i,j) is |i-j|. Justify the fact that the problem instance satifies the triangle inequality.

c) Execute Christofide's algorithm to obtain an 1.5 approximate TSP solution of the problem (show all steps). 2+5+3=10

2. a) Define the Bottleneck Disjoint Path ~~Mathing~~ Problem.

b) Execute a 2-approximation algorithm for the Bottleneck Disjoint Path Matching problem on the weighted graph in Problem 1 (show all steps).

c) What is the ratio error in this problem instance? 2+6+2 =10

3. a) Define the multiway K-cut problem.

b) Present an approximation algorithm for the problem with a ratio error 2(1-1/K).

c) Present an instance on which the algorithm provides the best performance. 2+6+2=10

4. Consider the following set cover problem instance.

$S = \{1,2,3,4\}$

$S_1 = \{1,2\}$, $S_2 = \{2,3,4\}$, $S_3 = \{1,4\}$

The weight of S_i is $w(S_i) = 1$.

a) Formulate the set cover problem as an interger linear program.

b) Obtain its LP relaxation.

c) Use the LP relaxation to obtain an approximate solution of the problem.

d) Obtain the ratio error of the approximation algorithm used.

3+1+4+2=10

5. a) Define the knapsack problem.

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b) Design an exponential time exact algorithm to solve the problem.

c) Use it to design a FPTAS for the problem.

d) Prove correctness of the approximation algorithm. 2+3+2+3=10

6. Write Short notes on:

a) PTAS reductions

b) Class Apx Hard

c) Approximation preserving reductions

d) Gap preserving reduction $4 \times 2\frac{1}{2} = 10$

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M.Sc. in Computer Science Examination, 2025
Semester-III
Paper- MCSC-23
[Distributed Systems]

Time : Three hours **Full marks : 40**

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

1. a) What is an object adapter.
   b) Write a Java client program which will send a message "Happy new year" to the server.
   c) Briefly describe vertical distribution in client-server architectures.

   2+3+3

2. a) What are the necessary conditions for process synchronization?
   b) Write a centralized algorithm to ensure mutual exclusion.

   3+5

3. a) What is the utility of middleware in distributed system design?
   b) How reference parameters are handled in RPC ?
   c) What are different scalabilities in distributed system ?

   2+2+4

4. a) Write an algorithm for client-server binding.
   b) Would it make sense to limit the number of threads in a server process ?
   d) Is a server that maintains TCP/IP connection is state-full or stateless ?

   4+2+2

5. a) Write a Java program for echo server.
   b) Write a JavaScript to create two buttons to color a given text in two different colors according to the button click. Is it an example of code migration, justify?

   3+(3+2)

6. a) Explain Lamport's timestamping in case of partial ordering of events.
   b) What is vector timestamping in case of partial ordering of events.
   c) A distributed system contains 30 processes spanning over 9 sites. Calculate the minimum number of messages required to detect a deadlock in the system.

   3+2+3

7. a) Briefly describe the NFS architecture and its utility.
   b) What is a Stub ? What is parameter marshaling ?

   4+2+2

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M. Sc in Computer Science, Semester – III Examination 2024
Machine Learning (MCSC -31)

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

Questions are of equal marks.

Answer any four questions.

1. What is the purpose of a Perceptron? What is backpropagation? Explain, with suitable diagram, the difference between a Single Layer Perceptron and a Multi Layer Perceptron. Illustrate how a Perceptron may be used for XOR gate realization.

$2 + 2 + 3 + 3 = 10$

2. Explain – (i) Feedback, (ii) Feed-forward flow in an Artificial Neural Network (ANN). Discuss – (i) Single Trainer/Single Learner, (ii) Single Trainer/Multiple Learner, (iii) Multiple Trainer/Single Learner and Multiple Trainer/Multiple Learner models with suitable diagrams. Discuss the role of collaboration and/or cooperation in such contexts.

$(1 + 1) + (1 \times 4) + 4 = 10$

3. Discuss, with suitable examples – (i) Supervised learning, (ii) Unsupervised learning. Discuss K – Nearest Neighbour classification with an example. Indicate the implication of large and small values of K.

$2 \times 2 + 4 + 2 = 10$

4. What is the difference between Classification and Clustering? Provide appropriate examples of each. Explain, in details, the functioning of a Decision Tree on a suitable dataset of your choice. Indicate a strong point and a weak point in favour of a Decision Tree classifier.

$2 + 2 + 4 + 2 = 10$

5. Explain statistical classification of a data point between two normal distributions (univariate) having distinct mean parameters but same variance parameter where
   (i) Mean parameters are known and variance parameter is also known,
   (ii) Mean parameters are unknown but variance parameter is known,
   (iii) Mean parameters are known but variance parameter is unknown,
   (iv) All the parameters are unknown.

$2 + 2 + 3 + 3 = 10$

6. Write short notes on any two:
   (a) Random Forest classifier.
   (b) K-Means Clustering.
   (c) Regression in machine learning.

$5 \times 2 = 10$

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M.Sc.(CS) Examination, 2024
Semester-III
Subject: Computer Science
Course: MCSC32
(Algorithmic Graph Theory)

Time: 3 Hours

Full Marks: 40

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

1. (a) Prove that in a nonseparable graph the set of edges incident on each vertex of G is a cutset.
   (b) Prove or disprove that all simple graphs having fewer than five vertices are perfect.
   (c) Explain $\chi(G), \alpha(G), \kappa(G)$, and $\omega(G)$ of a graph G. [2+2+4=8]

2. (a) What is the transitive orientation property of a graph? Describe with a suitable example.
   (b) Prove that a permutation graph $G = (V, E)$ is transitively orientable.
   (c) Prove that the complement of a bipartite graph is a perfect graph.
   (d) Define maximum matching and perfect matching. [$2 \times 4 = 8$]

3. (a) Let G be a graph with e edges. Prove that deleting or contracting an edge leads to the recursive relation for the chromatic polynomial:
   $P(G, \lambda) = P(G - e, \lambda) - P(G/e, \lambda)$.
   (b) Show that the chromatic polynomial of a graph consisting of a single circuit of length n is $P_n(\lambda) = (\lambda - 1)^n + (\lambda - 1)(-1)^n$. [3+5=8]

4. (a) Define a simplicial vertex and a triangulated graph.
   (b) Prove or disprove that a triangulated graph has at least two simplicial vertices.
   (c) Write an algorithm to find the chromatic number of a triangulated graph. Analyse its time complexity. [2+2+4=8]

5. (a) Write an algorithm to check whether two graphs are 1-isomorphic or not. Describe with an example.
   (b) Let G be a planar graph having n vertices, e edges, r regions, and k components. Establish the relation among n, e, r, and k.
   (c) Describe a procedure for recognizing a comparability graph. Illustrate with an example. [2+2+4=8]

6. (a) What are the properties of a flow in a flow network?
   (b) What is the difference between a residual network and an original network?
   (c) State and explain the Ford-Fulkerson algorithm. [2+2+4=8]

7. (a) Write an algorithm to find a maximum matching in a bipartite graph.
   (b) Prove that there are n^{n-2} labeled trees with n vertices ($n \geq 2$). [4+4=8]

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M.Sc. Semester III Examination, 2024
Computer Science
Department of Computer and System Sciences, Visva-Bharati
MCSE 34: Evolutionary Computing

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) Design a problem scenario where A* performs poorly in terms of memory usage. How can this be mitigated?

   (b) Design a heuristic function for the 8-puzzle problem and analyze its computational complexity.

   (c) Discuss why hill-climbing can get stuck in a local maximum and suggest modifications to overcome this limitation.

   (d) How does the choice of selection strategy (e.g., roulette wheel, tournament selection) influence GA's performance?

   (e) Analyze how the balance between exploration and exploitation is achieved in Firefly Algorithm.

   (f) Analyze the performance of Simulated Annealing Algorithm when applied to a high-dimensional search space.

2. A company is planning to open facilities in a region to serve a set of customer locations. The goal is to minimize the total cost, which includes both the **fixed cost** of opening facilities and the **transportation cost** of serving customers from the facilities. There are 3 potential facility locations: F_1, F_2, F_3 and 4 customer locations: C_1, C_2, C_3, C_4. The Fixed Costs for Opening Facilities are $F_1 : 50$, $F_2 : 40$, $F_3 : 60$. The Transportation Costs are following:

Facility/Customer	C_1	C_2	C_3	C_4
F_1	10	15	20	25
F_2	20	10	25	15
F_3	30	20	15	10

   The objective of the problem is to minimize the **total cost**. The total cost is given by:

   $$\text{Total cost} = \text{Fixed cost of open facilities} + \text{Transportation cost}$$

   Following are the Constraints:

   - Each customer must be assigned to exactly one open facility.
   - Facilities cannot serve customers unless they are open.

   You can use following chromosome representation where facility selection and customer assignment are combined.
   Chromosome: $[1, 0, 1, F_1, F_3, F_3, F_1]$. It represents following:

   - Facilities F_1 and F_3 are open.
   - Customers C_1 and C_4 are served by F_1, while C_2 and C_3 are served by F_3.

   (a) Generate six chromosomes to be included in the initial population and evaluate their fitness.

   (b) Demonstrate how roulette wheel selection can be used to choose parents based on fitness.

   (c) Design a crossover and mutation strategy.

   (d) What can be the termination condition? (2+1)+2+(2+2)+1=10

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3. (a) In the context of a dynamic optimization problem, where the environment changes over time, how can PSO be adapted to maintain its performance despite changes in the objective function or constraints?

   (b) In a PSO algorithm, what happens if w is set to 0? Discuss the implications for the exploration and exploitation phases.

   (c) Calculate the new velocity and position of the following particle.

   i. Particle's current position: $\mathbf{x} = [2, 3]$
   ii. Particle's current velocity: $\mathbf{v} = [0.5, -0.3]$
   iii. Personal best position: $\mathbf{p}_{\text{best}} = [3, 1]$
   iv. Global best position: $\mathbf{g}_{\text{best}} = [1, 2]$
   v. Inertia weight: $w = 0.7$
   vi. Acceleration coefficients: $c_1 = 1.2$, $c_2 = 1.8$
   vii. Random numbers: $r_1 = 0.9$, $r_2 = 0.4$

3+(2+2)+3=10

4. A cloud service provider needs to allocate its servers to handle multiple incoming tasks. Each server has a limited capacity, and each task has specific computational demands. The objective is to allocate tasks to servers such that the total computational cost is minimized while ensuring no server exceeds its capacity. Number of Servers (S) is 3. Number of Tasks (T) is 5. Task Demands are $D = \{12, 7, 14, 10, 8\}$. Server Capacities are $C = \{20, 25, 15\}$. Computational Cost Matrix is:

Server/Task	Task 1	Task 2	Task 3	Task 4	Task 5
Server 1	4	3	7	6	5
Server 2	6	5	8	7	4
Server 3	3	4	5	8	6

We need to allocate tasks to servers using ACO algorithm such that:

- The total computational cost is minimized.
- No server exceeds its capacity

The cost function to be minimized:

$$\text{Cost} = \sum_{i=1}^{S} \sum_{j=1}^{T} c_{ij} \cdot x_{ij}$$

where $x_{ij} = 1$ if task j is assigned to server i, otherwise 0.

   (a) Use an appropriate heuristic function to calculate η_{ij} for each pair (i, j).

   (b) Assume the initial pheromone level is $\tau_0 = 1.0$. You can assume the value for all the other parameters. Now, compute the initial probability for one ant's task assignment.

   (c) How we can solve a multi-objective optimization problem with m number of objectives using ACO?

3+5+2=10

5. (a) What is the role of the waggle dance in the Bee Colony Optimization (BCO) algorithm?

   (b) Discuss the criteria used to abandon a food source and how new sources are generated in the scout bee phase.

   (c) Explain how BCO handles local optima and ensures global search.

   (d) In what scenarios would you choose BCO over other optimization techniques such as Genetic Algorithm or Ant Colony Optimization?

2+3+3+2=10

6. Write short notes on any two.

   (a) Niche Count

   (b) Multi-objective PSO

   (c) Meta-Heuristic algorithms

5X2=10

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