M.Sc. Semester II Examination, 2025

Computer Science

Department of Computer and System Sciences, Visva-Bharati

MCSC 21: Advanced Algorithms

Full Marks: 40 Time: 3 hours

Answer Question No. 1 and any four questions from the rest.

1. Answer any four questions. $2 \times 4 = 8$

   (a) Sort the following functions in increasing order of asymptotic (big-O) growth. In case of ties, assign the same rank.

   - n^{n+1}
   - $n^{7\sqrt{n}}$
   - $4^{3n \log n}$

   (b) Let $f(n)$ and $g(n)$ be two asymptotically non-negative functions. Use the basic definition of Θ to prove that $\max(f(n), g(n)) = \Theta(f(n) + g(n))$.

   (c) Describe Optimal Substructure Property with an example.

   (d) Give asymptotic bound for the reccurrence $T(n) = 4T(\frac{n}{5}) + \lg^5 n\sqrt{n}$.

   (e) How can the divide-and-conquer technique be applied to matrix multiplication?

2. (a) Let $a \geq 1$ and $b > 1$ be constants, and let $f(n)$ be a non-negative function defined on exact powers of b. $T(n)$ is defined on exact powers of b by the recurrence:

$$T(n) = \begin{cases} \Theta(1) & \text{if } n = 1, \\ a \cdot T(n/b) + f(n) & \text{if } n = b^i, \text{ where } i \text{ is a positive integer.} \end{cases}$$

   Then prove that

$$T(n) = \Theta(n^{\log_b a}) + \sum_{j=0}^{\log_b n - 1} a^j f\left(\frac{n}{b^j}\right)$$

   (b) Show that if $f(n) = \Theta(N^{\log_b a} \lg^k n)$ where $k \geq 0$ in the above question, then the master recurrence has solution $T(n) = \Theta(N^{\log_b a} \lg^{k+1} n)$. For simplicity, confine your analysis to exact powers of b. 5+3=8

3. (a) Develop an efficient algorithm to compute the second maximum of a set of n numbers. You are required to provide your time complexity analysis.

   (b) You are given k sorted lists of numbers, where each list has length $\frac{n}{k}$. Thus, we have n numbers in all. Develop a fast algorithm to construct a sorted list of n numbers. You are required to provide your time complexity analysis. 4+4=8

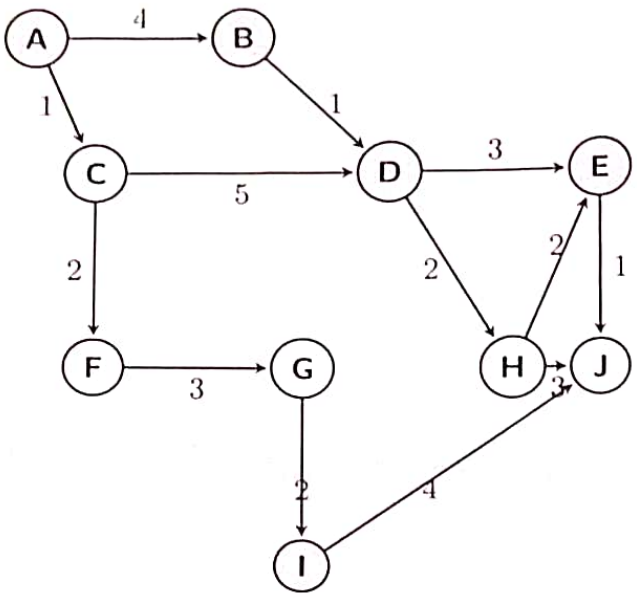
4. State the Matrix Chain Multiplication problem. Use Dynamic programming to develop a solution for this problem. Show that your solution is efficient. 1+6+1=8

5. In a robotic navigation scenario, LIDAR sensors detect points on the surface of obstacles. Because the shapes of the obstacles may be irregular, the detected points do not form perfect shapes. To simplify real-time decision-making and improve performance, the system approximates each obstacle by enclosing all its detected points within a simple geometric boundary.

   (a) Suggest a geometric method for representing the boundary of an obstacle given its surface points. Justify its suitability for autonomous navigation.

   (b) Develop an algorithm to compute the boundary efficiently. Use an example to explain how it works. Analyse its time complexity. 1+(4+2+1)=8

6. (a) The following directed graph represents a communication network with 10 routers, labeled A through J. The edge weights represent the time cost (in milliseconds) of sending data between routers. Starting from node A, apply Dijkstra's algorithm step by step. After each iteration, update the shortest distance estimates and the visited set. Show the distance table clearly. Write the final shortest path and total cost from node A to each other node in the graph.



(b) Discuss how the algorithm would behave differently if negative edge weights were present. Why is Dijkstra's algorithm unsuitable in such cases? 6+(1+1)=8

7. Write short notes on any two. 2×4=8

(a) NP Completeness

(b) Bellman-Ford algorithm

(c) Deterministic selection

M.Sc. Examination, 2025
Semester–II
Computer Science
Course: MCSC-22 (Compiler Construction)

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) Draw the block diagram of a lexical analyzer.
b) What do you mean by important states of a NFA?
c) How are semantic errors different from syntax errors?
d) What are synthesized and inherent attributes? [2×4]

2 a) Write an algorithm to construct a DFA from a regular expression.
b) For the grammar: $expr \rightarrow expr + trm \mid expr - trm$
$term \rightarrow 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9$
(i) Write the semantic rules to convert an expression into its postfix form.
(ii) Draw the annotated parse tree for $9 + 6 - 3$. [4+4]

3 a) Define and write the rules for evaluating the following: *firstpos, lastpos, followpos* and *nullable*.
b) Evaluate *firstpos, lastpos, followpos* and *nullable* for the augmented regular expression
$ab(a + b)^* ab\#$ [4+4]

4 a) What are the different types of three-address codes?
b) For the following expression $(a - c) * (b - c) + (a - b - c)$
(i) Draw the syntax tree.
(ii) Write three-address codes.
(iii) Write the quadruples. [3+(2+2+1)]

5 a) Draw the parsing table for the following grammar:
E→TE' E'→+TE'|ϵ T→FT' T'→*FT'|ϵ F→(E)|id
b) Write the LR parsing algorithm. [5+3]

6 a) What are the expressions for *gen[S]* and *kill[S]* where *S* is
(i) a definition, $a=b+c$ (ii) a set of two statements (iii) an if-statement (iv) a self loop.
b) What do you mean by dominators? What are back-edges and self loops? [4+4]

7 Write short notes on
(i) Phases of a compiler
(ii) Subset construction method. [4+4]

M.Sc. Examination, 2025
Semester–II
Computer Science
Course: MCSC-23 (Fuzzy System)

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

The question paper contains six questions. You may answer any four out of them.
All questions are of equal marks.

1. Explain the importance of membership in the context of a fuzzy set. Discuss using suitable figures, how the following membership functions are represented parametrically – (i) Trapezoidal membership function, (ii) Sigmoid membership function, (iii) Gaussian membership function, (iv) Bell membership function.
$2 + (2 + 2 + 2 + 2) = 10$

2. Explain, how are the following set theoretic operations defined with respect to a fuzzy set – (i) cardinality, (ii) subset, (iii) complement, (iv) union, (v) intersection. Prove the following properties in the context of a fuzzy set – (i) involution, (ii) De' Morgan's law.
$(1 \times 5) + (1 + (2 + 2)) = 10$

3. Define a fuzzy relation mathematically. Explain, how a fuzzy similarity relation may be defined. Discuss, with a suitable example on two fuzzy relation matrices R and S, how are (i) max-min and (ii) max-dot compositions defined (assuming R and S are of size 3×4 and 4×2 respectively). Define the following – (i) Cartesian product relation on two fuzzy sets, (ii) domain of a fuzzy relation, (iii) range of a fuzzy relation, (iv) height of a fuzzy relation. $2 + 2 + 2 + 4 = 10$

4. Explain with suitable figure, in the context of a fuzzy set, the following – (i) core, (ii) support, (iii) boundary, (iv) persistence. Discuss, one fuzzification and one de-fuzzification technique with examples. In this context, explain the significance of λ-cut.
$4 + (2 + 2) + 2 = 10$

5. Let $A=\{0, 1\} \subset X=\{-2, -1, 0, 1, 2\}$. Find set $B \subset Y = \{0, 1, 2, 3, ..., 10\}$ with the mapping $y=|4x|+2$. Let A be a fuzzy set defined on the universe $U=\{1, 2, 3\}$ as A = {(1, 0.6), (2, 1.0), (3, 0.8)}. Map the elements of this fuzzy set to another universe, V, under the function $v=f(u)=2u-1$. Define two fuzzy numbers "approx. 2" and "approx. 3". Hence, derive "approx. 6". 3+3+4=10

6. Explain with suitable figures (i) dilation and (ii) intensification. Define two fuzzy linguistic expressions – "small" and "large" in respect of the number of rooms available in a house. Hence, deduce how to describe "not very smalland not very, very large". Define – (i) tautology, (ii) modus ponens, (iii) modus tollens. $(2 + 2) + 3 + 3 = 10$

M.Sc. Semester II Examination 2025
Advance Computer Architecture
Paper MCSC-24

F.M. : 40 **Time: 3 hours**

Answer any five questions from the following 5x8=40

1. i)Define speedup ratio in a pipelining system.

   Prove that for K-stage pipelining system maximum speedup will be K, assume necessary parameters.

   ii)Consider a 4 segment pipeline and t_p=20 ns is the processor time required to complete one task. There are 100 tasks in the pipeline then calculate speed up ratio.

   iii)Describe Amdahl's law.

   Suppose that a given application is run on a 4-processor machine and that 70% of the application is parallelizable how much speed up will be obtained?
   If the number processors is increased from 4 to 16, 32, 64 and 128 what would be the nature of speedup ratio. (1+2+2+3)=8

2. i)What is Memory Hierarchy? What are its characteristics? Explain where you will place the processor registers in the memory hierarchy pyramid.

   ii)What is property of locality of reference?
   Explain the role of cache memory in computer memory system. State how the performance of a cache is measured? (2+1+1+2+2)=8

3. i)Explain the write through and write back protocols for cache operations.
Discuss advantages and disadvantages of different types of cache mapping.

ii)Consider a system with a cache having 128 blocks 16 words each and main memory has 4K blocks 16 words each.
Write down tag ,block and word fields of for Direct mapping.
How the main memory will be addressed in case of associative mapping.

iii) Consider 4-way set associative mapping, write down the set block and word fields for such mapping.
Show that direct mapping and associative mapping is a limiting case of set associative mapping. (1+2) +3+2=8

4. i)Compare and contrast programmed I/O, interrupt driven I/O and Direct Memory Access(DMA).

ii)Why the peripherals are not directly connected with system buses? Write down the function of DMA controller. Explain cycle stealing DMA and brust mode DMA.

iii)When a device became bus master?
What is bus arbitration? And hence write down the function bus arbiter circuit?
3+(3+1)+1=8

5. i) What do you understand by page fault? When do page faults occur? What are the necessary actions taken by the OS during page fault situations?

ii). Consider a system with main memory 4K and auxiliary memory 8K, the how many address lines are required to address memory space and address space separately. Explain with a schematic diagram how the virtual address issued by the processor will be translated to physical address. (4+4)=8

6. What is Belady's anomaly? Explain. With which page replacement algorithm Belady's anomaly is related? Does it occur in any page reference string?
Establish Belady's Anomaly with the following page reference string considering the cases where number of Page Frames 3 and 4 (1+1+1+5)
0,1,2,3,0,1,4,0,1,2,3,4.

7. In a paging system main memory has the capacity of 3 pages. The execution of a program requires reference upto 5 pages. The page address stream formed by executing a program is
2 3 2 1 5 2 4 5 3 2 5 2
Considering initially the primary memory is empty. Calculate number of hit and misses using FIFO, LRU and OPT replacement algorithms. Which one is best in this case? Explain. 6+2=8

M.Sc(Semester-II) Examinations, 2025

Subject: Computer Science

Paper – MCSC25 (Internet systems and protocols)

Full Marks – 40 Time : 3 hours

Questions are of value as indicated in the margin.

Answer any FOUR questions.

1. a) Explain how the slot duration of a slotted Aloha system is determined. [4]
   b) Describe with a suitable diagram how collision can occur in a slotted Aloha system and can be resolved using p-persistency mechanism. Assume any value of p. [3+3]

2. a) Describe the CSMA-CD multiple access mechanism. [4]
   b) What is Binary Exponential Backoff? [2]
   c) Describe how BE Backoff is used in CSMA-CD. [4]

3. a) Why is CSMA-CD not used in 802.11 Wireless LAN systems? [3]
   b) Which multiple access scheme is used there instead of CSMA-CD? [1]
   c) Briefly explain the working principle of that scheme. Can it completely avoid collisions? [4+2]

4. a) What is the use of subnet mask in IPv4 addressing? Explain with an example. [4]
   b) Explain why and how localized IPv4 addresses are used in a network and traffic to and from external networks are handled. [4]
   c) What is the significance of TTL field in IPv4 header? [2]

5. a) Why is the fragmentation functionality needed in IPv4? [2]
   b) Explain IPv4 fragmentation mechanism with an example. [3]
   c) Write down possible routing tables for an enterprise network with four component physical networks A, B, C and D where A is neighbour of B and C, B is the neighbour of A, C and D, C a neighbour of A, B, D and D is a neighbour of B and C. Assume that external traffic is handled by a router in network A. Any choice of routes from any network to other non neighbouring networks is allowed. [5]

6. a) Explain the active open and passive open stages of a TCP connection. [4]
   b) Explain the 3-way handshake in TCP connection establishment. [4]
   c) What is half-close of a TCP connection? [2]