Roll No.: | 1 | 7 | I | T | 2 | 4 | 8 | |

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

Even Semester (2018 - 2019) Examination: End Semester
Course Code & Title: MA204 - Linear Algebra and Matrices
Date:13/04/2019 Time:08:00 a.m. to 11:00 a.m. Maximum Marks: 100

INSTRUCTIONS:

1. Answer ALL the questions (Part - A consists of 15 questions and Part - B is of 06 questions).
2. Answers for Part - A should be given in question paper and will be collected back at 09.30 a.m. Encircle your option(s) neatly.
3. Questions in Part - A can have more than one correct answer. If an MCQ is of M marks and it has N correct choices, each correct answer carries M/N marks and each wrong answer carries $-M/N$ marks. If netmark gained for a question is negative, zero mark is awarded.
4. Mobile phones are strictly prohibited.

PART - B (Maximum Mark: 60)

1. State and prove the Rank-Nullity Theorem. [10]

2. Let $T : \mathbb{R}^5 \to \mathbb{R}^3$ be a linear transformation given by $T((x, y, z, s, t)) = (x+2y+2z+s+t, x+2y+3z+2s-t, 3x+6y+8z+5s-t)$ with respect the standard basis. Find the matrix of the linear transformation with respect to the following bases: [10]
$B = \{(-1,1,1,1,1), (1,-1,1,1,1), (1,1,-1,1,1), (1,1,1,-1,1), (1,1,1,1,-1)\}$ of $\mathbb{R}^5$ and $B' = \{(1,2,2), (2,1,2), (2,2,1)\}$ of $\mathbb{R}^3$.

3. Let V be a vector space over a field $\mathbb{R}$. If $S = \{v_1, v_2 \dots v_n\}$ spans V and $S' = \{w_1, w_2 \dots w_m\}$ is linearly independent in V, then state the condition on m and n. Justify your statement with detailed arguments. [10]

4. (a) Use Gram-Schmidt Orthogonalization process to construct an orthonormal basis for $\mathbb{R}^3$ with respect to the standard inner product on $\mathbb{R}^3$, for the basis $\{(1,0,1), (1,3,1), (3,2,1)\}$. [7]

   (b) Let T be a linear transformation from a finite dimensional vector space to itself. Then show that T is injective if and only if it is surjective. [3]

5. Reduce the Quadratic form $2x_1x_2 + 2x_1x_3 - 2x_2x_3$ to Canonical form. Also discuss its nature. [10]

6. (a) Verify whether the following map is a linear transformation. If so, find the dimension of its Kernel: $T : \mathbb{R}^3 \to \mathbb{R}^4$, defined by $T((x_1, x_2, x_3)) = (x_1 - 3x_3, x_1 + x_2 - 6x_3, x_2 - 3x_3, x_1 - 3x_3)$. [7]

   (b) Find the eigenvalues of the following system: $8x - 4y = \lambda x; 2x + 2y = \lambda y$. [3]

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DEPARTMENT OF INFORMATION TECHNOLOGY, NITK SURATHKAL

END SEMESTER EXAMINATION, APRIL 2019

IT252: DESIGN AND ANALYSIS OF ALGORITHMS

Class: IV SEM B.TECH (IT)
Date: 15/04/2019

Time: 3 Hrs.
Marks: 100

Register No. | 1 | 7 | I | T | 2 | 4 | 8 |

NOTE:
1. There are six questions in this paper.
2. Each question has multiple parts. Read the entire question carefully.
3. Use Pseudo-code to describe algorithms, unless asked otherwise.

[2 x 10 = 20 marks]

Problem 1

State if the following statements are True or False. Give clear justifications for your answer.

a) The runtime of a divide and conquer algorithm with a recurrence relation $T(n) = 8T(n/2) + n^3$ is $O(n^3)$.

b) If G has a cycle with a unique lightest edge e, then e must be part of every MST.

c) Finding if a directed acyclic graph has a Hamiltonian path is not an NP-Complete problem.

d) $f(n) = O(g(n))$ implies that $2^{f(n)} = O(2^{g(n)})$.

e) For a connected graph $G=(V,E)$ and some source vertex s, the shortest-path tree computed by Dijkstra's algorithm is necessarily an MST of graph G.

f) Given n numbers $a_1, \ldots, a_n$ (where $n > 20$), the median of the smallest ten numbers and the largest ten numbers among them can be computed in $O(n)$ time.

g) Let G be a graph with a negative weight cycle. Then the shortest path between all pairs of vertices is undefined.

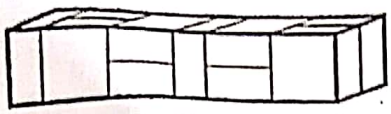
h) The operations of a Disjoint-Set data structure that does not implement *Union-by-rank* and *Path-compression* will be correct but inefficient.

i) For any instance of the Stable Matching Problem, if there exists a perfect matching that is not stable due to m and w wanting to be together, then (m, w) will be in every stable matching of that instance. In other words, if (m, w_0) and (m_0, w) are both in a perfect matching and m prefers w over w_0, and w prefers m over m_0, then (m, w) will be in every stable matching.

j) If $P=NP$, then any NP-Hard problem can be solved in polynomial time.

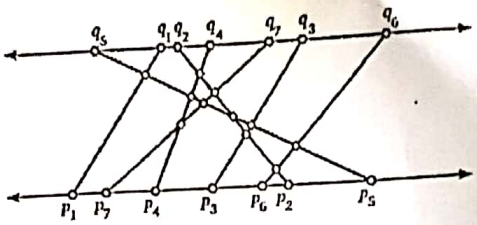
Problem 2 [4+10=14 marks]

a) A slab is a three-dimensional box with dimensions $1 \times 2 \times 2$, $2 \times 1 \times 2$, *or* $2 \times 2 \times 1$. We want to compute the number of different ways to fill a $2 \times 2 \times n$ box with n slabs. Set up a recurrence relation for the solution and write a $O(n)$ time program to compute this solution.



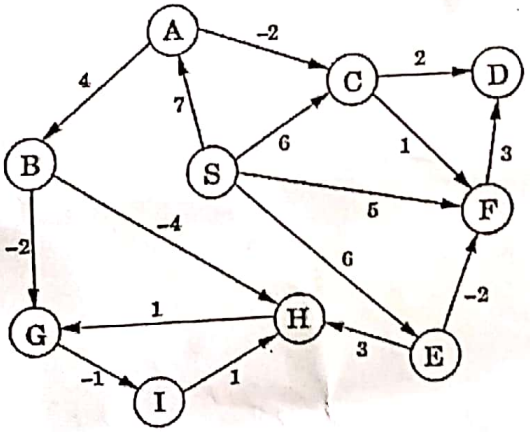
a $2 \times 2 \times 10$ box filled with ten slabs.

b) Given two sets of n points $\{p_1,p_2,...p_n\}$ and $\{q_1,q_2,..q_n\}$, the first set of points on the line $y=0$ and the second one on the line $y=1$, create a set of n line segments by joining point p_i to the corresponding point q_i. So p_1 is joined with q_1, p_2 with q_2 and so on. Describe and analyse a $O(nlogn)$ time Divide-and-Conquer algorithm to find out how many pairs of these n line segments intersect. For example in the figure below, the seven line segments intersect at eleven points, i.e. eleven pairs of these line segments intersect.



Problem 3 [10 + 12 = 22 marks]

a) Run Bellman-Ford's shortest path algorithm on the graph shown below, with source node *S*. Clearly show the intermediate distance values of all the nodes after each iteration of the algorithm. Also draw the final shortest-path tree.



b) Consider the following job scheduling problem: There are n jobs all of which need to be scheduled on a single resource (processor). The i^{th} job has weight w_i and length (duration) l_i. The goal is to come up with a scheduling that minimizes the *weighted completion time* of the jobs. Design a greedy algorithm for this problem and give a proof that your algorithm is indeed correct.
[Some explanation: Consider 3 jobs with lengths 1,2,3 and weights 9,8,7 respectively. The scheduling (job1,job2,job3) – i.e. first job1, then job2, then job3 -- has completion times 1, 3 and 6, since Job1 finishes at time 1, job2 at time 1+2 and job3 at time 3+3. Thus the weighted completion time for this schedule is 1.9 + 3.8 + 6.7 = 75. For the schedule (job3, job2, job1) the weighted completion time is 3.7 + 5.8 + 6.9 = 115.]

Problem 4 **[8 + 6 = 14 marks]**

a) You are given a list of n ranges represented by min and max (e.g. [1,3], [4,5], [4,9], [6,8], [7,10]). Give an $O(n \log n)$-time algorithm that decides whether or not a set of ranges contains a pair that overlaps. You need not report all intersections. If a range completely covers another, they are overlapping, even if the boundaries do not intersect.

b) A long string consists of the four characters A, C, G, T ; they appear with frequency 31%, 20%, 9%, and 40%, respectively. Construct the Huffman tree for encoding this string. What is the Huffman encoding of these four characters?

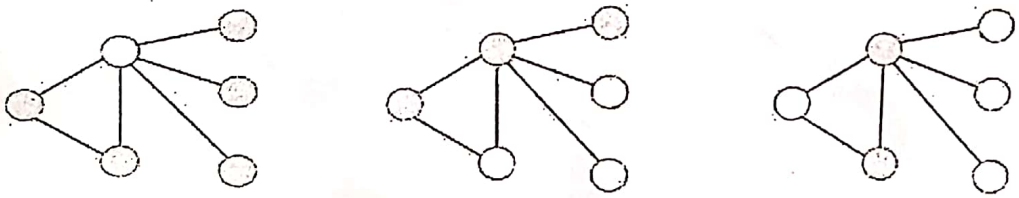
Problem 5 **[16 marks]**

A certain string-processing language offers a primitive operation which splits a string into two pieces. Since this operation has to copy the original string, it takes n units of time for a string of length n, no matter where the cut is made. Suppose, now, that you want to break a string into many pieces. The order in which the breaks are made can affect the total running time. For example, if you want to cut a 20-character string at positions 3 and 10, then making the first cut at position 3 gives a total cost of 20 + 17 = 37, while cutting at position 10 first and then at position 3 has a better cost of 20 + 10 = 30.

Derive a $O(n^2)$ time dynamic programming algorithm that, given the locations of m cuts in a string of length n, finds the minimum cost of breaking the string into $m + 1$ pieces. Give a recursive and an iterative version of this algorithm. Clearly define the appropriate sub-problems and give a brief justification why your algorithm is correct. For the iterative version show the dependencies between the sub-problems which justifies the order of evaluating the sub-problems.

Problem 6 **[2 + 12 = 14 marks]**

A vertex cover of a graph $G=(V,E)$ is a subset S of V such that every edge in E has at least one of its end-points in S. That is the set of vertices S *covers* all the edges in E. For example, for the same graph, the figures below show three possible vertex covers, given by the shaded vertices.



The search version of this problem is: given a graph G, find a vertex cover of G of ***minimal*** size. For the above example this is the vertex cover of size two, given in the right-most graph.

a) Write the decision version of the Vertex-Cover problem.

b) Prove that the decision Vertex-Cover problem is NP-Complete, by giving a suitable reduction from the decision version of the Clique or Independent-Set problem.

DEPARTMENT OF INFORMATION TECHNOLOGY, NITK SURATHKAL

END SEMESTER EXAMINATION, APRIL 2019

IT251: Computer Communication and Networking

Class: IV Semester.
Date: 16/04/2019

Time: 3 Hrs.
Marks: 80

Register No. | 1 | 7 | I | T | 2 | 4 | 8 |

Answer all the questions.

1.

(a) Mention and explain the roles of different network hardware devices at each layer of OSI protocol stack. (4)

(b) Why we need two different addresses (MAC and IP) for identifying a host in the network ? Also explain in details how MAC address to IP address and vice versa mapping is done and also mention at which layer such mapping is done? (2 + 2)

(c) If IETF asks you to give a proposal for next version of IPv, what extra features you would like to add in the new version ? and What would be its name ? (2)

2. Write a note on virtual circuit subnet and data gram subnet. Write the routing table contents for the following datagram and virtual circuit subnets shown in Fig. 1. (5 + 2 + 3)

Datagram subnet:

a. Routing table contents when optimal path is chosen .
b. Routing table contents when optimal path gets congested and a new optimal path has been chosen.

Virtual Circuit Subnet:

(a) Process 1 in Host 1 starts a session to process 1 in host 2.
(b) Process 1 in host 3 starts a session to process 1 in host 2 while session (a) still going on.
(c) Process 1 in host 4 starts a session to process 1 in host2 while sessions (a) and (b) still going on.

3.

(a) Explain IPv4 header format in brief. Instead of number of hops, can we give time as a value in TTL ? such that when time expires the packet will be discarded. (6 + 2)

(b) Like there is a phase shift in IPv (from IPV4 to IPV6) , why there is no phase shift for MAC address ? will MAC address will ever get exhausted ? (2)

4.

(a) Explain three way hand shake connection establishment process in detail. (6)

(b) "Congestion Control in turn achieves Flow Control" give your comments. Do you really think flow control and congestion control should be at different layers ? (4)

5. Calculate the CRC codes for the following data bits and the polynomial. Also show how the receiver checks whether the transmitted bit series are error free. (6 + 4)

Data Bits: 1 1 0 1 0 1 1 1 1 1

Polynomial : $X^4 + X + 1$

6.

(a) Think that you have been asked to set up a LAN (of about 100 systems) for the new lab in the IT dept. The LAN in turn is connected to the internet. Give a brief idea of the LAN setup. (4)

(b) Explain how framing is done at data link layer using FLG bytes with byte stuffing. Also for the following inputs design a frame using FLG and byte stuffing. Use your own code for byte stuffing.

Data Bits: 1 0 1 1 0 1 0 0 1 0 FLG Byte : 10 (3 + 3)

7.

(a) Explain the different factors affecting the congestion in the subnet. (3)

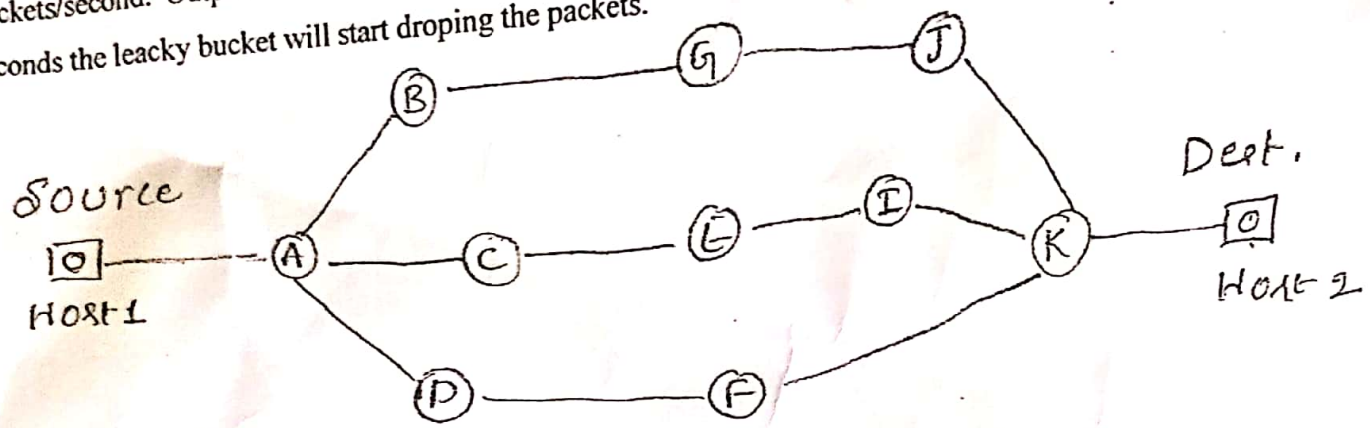
(b) Explain the roles of each layer when two Hosts, Host1 (source) and Host 2 (destination) in two different networks, communicate with each other. Desscribe the journey of a message sent by Host 1 from Application Layer to Physical layer in the OSI protocol stack. And journey of the same message from Physical Layer to Application layer in the Host 2. (3 + 4)

8.

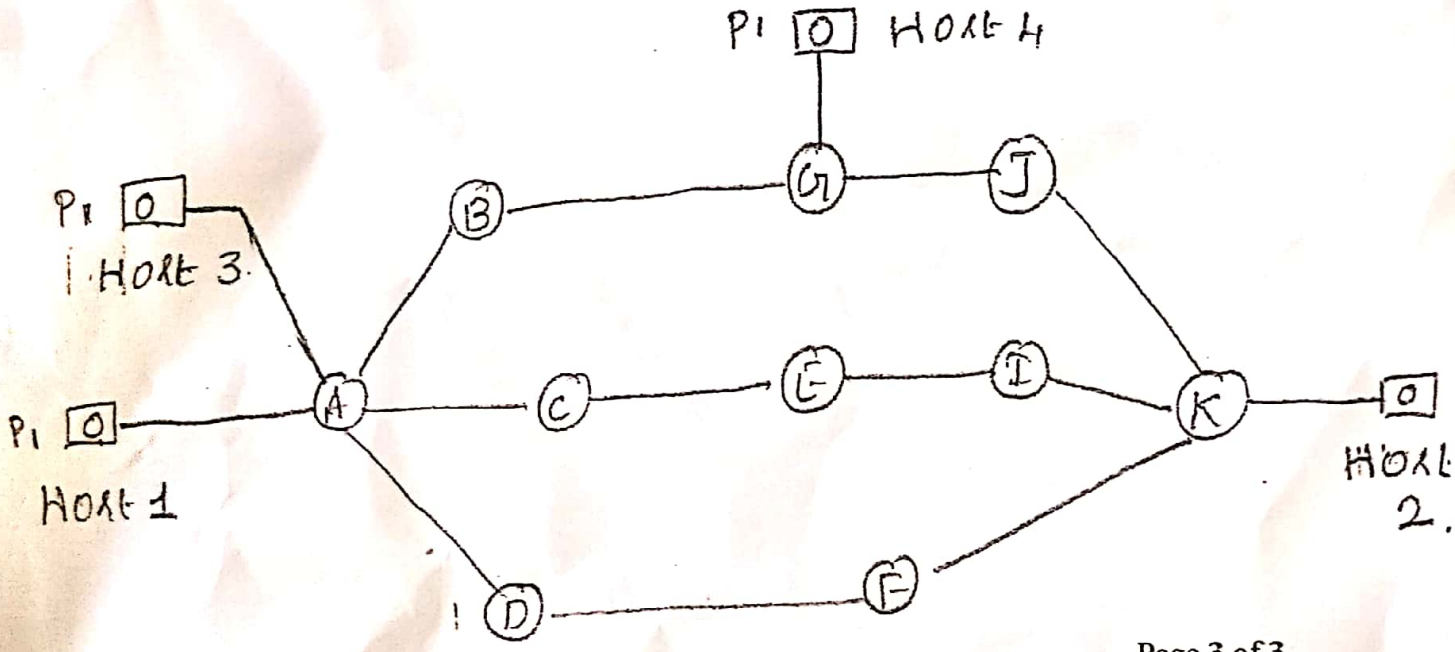
(a) Explain Token Bucket Algorithm in detail and give one application of token bucket and leaky bucket algorithm. (4 + 2)

(b) Consider a Token bucket with capacity of 30 packets and the bucket can generate tokens at 2 tokens/second. Inflow to the token bucket is 3 packets/second. Calculate after how many seconds the packets will start overflowing from the token bucket. (2)

(c) Consider a Leaky bucket with capacity of 30 packets and has got an inflow of 3 packets/second. Output rate of the leaky bucket is 1 packet/second. Calculate after how many seconds the leacky bucket will start droping the packets. (2)



Datagram Subnet.



VC Subnet.

Fig. 1.

DEPARTMENT OF INFORMATION TECHNOLOGY, NITK SURATHKAL

END SEMESTER EXAMINATION, APRIL 2019

IT250: OPERATING SYSTEMS

Class: IV SEM B.TECH (IT) Time: 3 Hours

Date: 20/04/2019 Marks: 80

Register No. | 1 | 7 | I | T | 2 | 4 | 8 |

NOTE: 1. Answer All Questions to the Point only.

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1) Logical address is the address generated by the CPU and physical address is the address in the physical memory. Design a technique for mapping these addresses with a neat sketch. For the given addresses below, find the total number of pages and total number of frames (represented in bits) required in the secondary and primary memory respectively.

Logical Address = 9 bits

Physical Address = 6 bits

Page Size = 8 words

(10)

2) Design a Resource allocation graph with the following criteria

$P = \{ P_1, P_2, P_3 \}$ is the total number of Processes

$R = \{ R_1, R_2, R_3, R_4 \}$ is the total number of Resources where,

R_1 and R_3 consists of one instance each

R_2 consists of two instances

R_4 consists of three instances

Sketch the graph with the occurrence of deadlock and differentiate the same without any deadlock in it. (10)

3) Using Deterministic modeling approach, analyze the three main process scheduling algorithms namely, First-Come First-Served (FCFS), Shortest-Job-First (SJF), Round-Robin (RR) (say Time Quantum is 3) for the following predetermined workload. Calculate

the average waiting time, Turnaround time for each algorithm (say the arrival time is same for all the processes) and determine which algorithm best suits for the workload as shown in the Table below. (10)

Table. 1

PROCESS	BURST TIME
P_1	10
P_2	29
P_3	3
P_4	7
P_5	12

4) Consider a system with the processes **P_1, P_2, P_3, P_4, P_5** of three resource types **A, B and C** respectively. At a given time **t_0**, the following Table represents their respective **Allocation, Maximum and Available** criteria. Find the **Safe Sequence** of all these processes in the system so that deadlock could be gracefully avoided. (10)

Table. 2 Resource Criteria of various Processes

PROCESSES	ALLOCATION			MAX			AVAILABLE		
	A	*B*	*C*	*A*	*B*	*C*	*A*	*B*	*C*
P_1	2	1	0	6	4	3	5	1	6
P_2	5	1	2	7	8	9			
P_3	4	5	0	5	6	2			
P_4	0	5	8	4	6	9			
P_5	7	5	0	8	9	1			

5) There are various pages waiting to be placed in the frames of the Main Memory (RAM). Consider the following reference string and the number of Frames as 3, calculate the Hit Ratio and Miss Ratio of the pages using the following algorithms.

1. First-Come First-Serve (FIFO)
2. Optimal Page Replacement
3. Least Recently Used (LRU)

State which algorithm performs better for the reference string given below.

Reference String: 8, 6, 1, 6, 0, 5, 0, 4, 6, 3, 0, 3, 1, 6, 8, 0, 5, 3, 4, 0 (10)

6) A typical disk contains 300 tracks (0-299). The request queue for accessing various tracks on the disk is given below:

Request Queue: 78, 57, 88, 50, 20, 45, 180, 30, 150, 35

Considering the current Read/Write head position as 60, calculate the total number of track movements using Shortest Seek Time First (SSTF), SCAN and LOOK algorithm (direction of the Read/Write head is towards the larger track value) respectively. Also, calculate the total time taken (in nanoseconds) for the movement of Read/Write head and state which algorithm performs better. (10)

7) How will you protect the data stored on a disk from failure? Give an appropriate solution with fault tolerant capability that could clearly state various levels for storing the data on the disk with neat sketches wherever required. (10)

8) i) Unnecessary swap-in and swap-out of pages to and from the memory leads to performance degradation. Give an appropriate solution to swap the pages in only when it is required. Also, formulize an effective memory access time criterion to analyze the occurrence of page fault in the system. (5)

ii) How is the degree of multi-programming directly linked to Thrashing? Give a neat graph and state few solutions to illustrate the same. (5)

DEPARTMENT OF INFORMATION TECHNOLOGY, NITK SURATHKAL

END SEMESTER EXAMINATION, APRIL 2019

IT253: PARADIGMS OF PROGRAMMING II

Class: IV SEM B.TECH (IT)
Date: 22 / 04 / 2019

Time: 3 Hrs.
Marks: 100 (20x5)

Register No. | 1 | 7 | I | T | 2 | 4 | 8 |

NOTE: 1. Give suitable examples/syntax wherever necessary

2. All Questions carry equal marks

PART A

Q1. What is heterogeneous programming? Name two languages used for heterogeneous programming and explain how they help in programming heterogeneous devices.

Q2. In the context of programming languages, what constructs can be accepted by regular languages and what can be accepted by Context Free Grammars. Give an example construct (a) which can be accepted by CFG and not by regular languages (b) which cannot be accepted by CFG.

Q3. Explain what L, A, R and k stand for in LL(k), LALR(k) and LR(k) parsers. Compare their relative powers between them.

Q4. What is meant by Left Recursion in grammars and why are they problematic in parsing. Which parsers have problem in handling left recursions in grammars and how can they be worked around?

Q5. What is the parsing program say for predictive parser for the below case (X is the symbol on the top of the stack and 'a' is the current input symbol) and M is the parsing table:

– If X is a non-terminal then Check M[X, a] then……

Q6. For LR parsers, we have this line in the parsing table: If action[s_m, a_i] = Reduce A-> β, then a_i and s_m are replaced by A. What if the top | β| symbols is NOT exactly β? What does parser do in that case? Explain your answer.

Q7. What are ambiguous grammars? What are the techniques used for parsing ambiguous grammars in LR parsers? Give examples.

Q8. How is the code generated from the intermediate code like abstract syntax tree in a typical parser? Explain with a simple example expression.

Q9. What is meant by "binding"? Explain different ~~types~~ times of binding in the context of variables in a typical programming language. Give an example for at least two of these.

Q10. What are the different ways of parameter passing seen in programming languages? Include an example for each in your answer.

PART B

Q11. Explain procedure linkages spanning both caller and the callee. Indicate which ones are done usually by the architecture design (x86 hardware for example).

Q12. What are the typical supports available in programming languages for expressing and implementing concurrency? Give an example for each in a programming language.

Q13. What is the support needed in hardware design for implementing concurrency control in programming languages? What are the abstractions available over this feature, which are available for programmers for concurrency control in programs?

Q14. What is the main advantage of pure functional programming? What factors contribute for this unique advantage for pure functional languages?

Q15. Write a function in Scheme to apply a function "square" to a list of numbers. The output should be another list with each element in the list squared.

Q16. Why are logical programs like SQL or PROLOG called "declarative" style of programming? How are they different from imperative languages?

Q17. What is the fundamental difference between .NET and Java platforms from the perspective of programmers? Explain two similarities between these two popular frameworks.

Q18. What is hotspot compiler in Java? How does that improve performance of the Java application at runtime?

Q19. What is the difference between explicit and implicit concurrency? Give one advantage, one disadvantage and an example for each.

Q20. Name one language which you would use naturally in each of these domains: (a) Scientific/High Performance computing (b) Business Applications (c) Web Application (d) Heterogeneous Programming. Explain why.