Computer Science
Paper-I

Time Allowed: Three Hours **Maximum Marks: 300**

Note: 1. *The figures in the margin indicate full marks for the questions.*

2. *Candidate should answer questions No. **1** and **5** which are compulsory and any **three** of the remaining questions, selecting at least **one** from each section.*

SECTION – A

1. (a) Construct a regular expression for the following languages over the alphabet {0,1} 20

(i) Set of all strings that starts 00 and end with 11.

(ii) Set of all strings that has a substring 1001.

(iii) Set of all strings that has a substring 001 and 100.

(b) Construct a Turing machine for the language $L=\{a^nb^nc^n \mid n>=1\}$? 20

(c) An operating system supports a paged virtual memory, using a central processor with a cycle time of 1 microsecond. It costs an additional 1 microsecond to access a page other than the current one. Pages have 1000 words, and the paging device is a drum that rotates at 3000 revolutions per minute, and transfers 1 million words per second. The following statistical measurements were obtained from the system: 20

- 1 per cent of all instructions executed accessed a page other than the current page.
- Of the instructions that accessed another page, 80 per cent accessed a page already in memory.
- When a new page was required, the replaced page was modified 50 per cent of the time.

Calculate the effective instruction time on this system, assuming that the system is running one process only, and that the processor is idle during drum transfers.

2. (a) Construct context free grammar for the following languages over the alphabet {a, b} 20

(i) equal number of a's and b's

(ii) $\{a^n b^n \mid n>=1\}$

(b) Prove that the following language is context-free: 20

$L = \{ww^R : w \neq abba, \text{ and } w \in \{a, b\}^*\}$

(c) Describe in detail the different kinds of addressing modes with an example. 20

3. (a) Illustrate Booth Algorithm with an example. 20

(b) A cache may be organized such that: 20

- In one case, there are more data elements per block and fewer blocks.
- In another case, there are fewer elements per block but more blocks. However, in both cases – larger blocks but fewer of them OR shorter blocks, but more of them – the cache's total capacity (amount of data storage) remains the same.

What are the pros and cons of each organization? Support your answer with a short example assuming that the cache is direct mapped.

(c) (i) What are the differences between user-level threads and kernel-supported threads? Under what circumstances is one type "better" than the other? 10

(ii) What two advantages do threads have over multiple processes? What major advantages do they have? Suggest one application that would benefit from the use of threads, and one that would not. 10

4. Consider the following set of processes, with the length of the CPU -burst time given in milliseconds:

Processes	Burst Time	Priority
P1	10	3
P2	1	1
P3	2	3
P4	1	4
P5	5	2

The processes are assumed to have arrived in the order P1, P2, P3, P4, P5, all at time 0.

(a) Draw four Gantt charts illustrating the execution of these processes using FCFS, SJF, a non pre-emptive priority (a smaller priority number implies a higher priority), and RR (quantum = 1) scheduling. 20

(b) What is the turnaround time of each process for each of the scheduling algorithms? 20

(c) What is the waiting time of each process for each of the scheduling algorithms? 20

SECTION – B

5. Consider the following pre-emptive priority-scheduling algorithm based on dynamically changing priorities. Larger priority numbers imply higher priority. When a process is waiting for the CPU (in the ready queue, but not running), its priority changes at a rate α; when it is running, its priority changes at a rate β. All processes are given a priority of 0 when they enter the ready queue. The parameters α and β can be set to give many different scheduling algorithms.

(a) What is the algorithm that results from $\beta > \alpha > 0$ and explain the algorithm in detail? 20

(b) What is the algorithm that results from $\alpha < \beta < 0$ and explain the algorithm in detail? 20

(c) (i) What is a test - and - set instruction? How can it be used to implement mutual exclusion? 10

(ii) What are the major tasks of Software Configuration Management (SCM) during development and maintenance? 10

6. (a) Assume that you have 4 Gbytes of main memory at your disposal. 20

– 1 Gbyte of the 4 Gbytes has been reserved for process page table storage

– Each page table entry consists of:

- A physical frame number
- 1 valid bit
- 1 dirty bit
- 1 LRU status bit

– Virtual addresses are 32 bits

– Physical addresses are 26 bits

– The page size is 8 Kbytes

How many process page tables can fit in the 1 Gbyte space?

(b) Consider a system with three smoker processes and one agent process. Each smoker continuously rolls a cigarette and then smokes it. But to roll and smoke a cigarette, the smoker needs three ingredients: tobacco, paper, and matches. One of the smoker processes has paper, another has tobacco, and the third has matches. The agent has an infinite supply of all three materials. The agent places two of the ingredients on the table. The smoker who has the remaining ingredient then makes and smokes a cigarette, signaling the agent on completion. The agent then puts out another two of the three ingredients, and the cycle repeats. Write a program to synchronize the agent and the smokers. 20

(c) Give pushdown automata that recognize the following languages. 20

$A = \{ w \varepsilon \{ 0, 1 \}^* \mid w \text{ contains at least three 1 s} \}$

7. (a) Explain the purpose of the checkpoint mechanism. How often should checkpoints be performed? 20

How does the frequency of checkpoints affect:

- System performance when no failure occurs?
- The time it takes to recover from a system crash?
- The time it takes to recover from a disk crash?

(b) Given memory partitions of 100K, 500K, 200K, 300K, and 600K (in order), how would each of the First-fit, Best-fit, and Worst-fit algorithms place processes of 212K, 417K, 112K, and 426K (in order)? Which algorithm makes the most efficient use of memory? 20

(c) What do you mean by terms cohesion and coupling in the context of software design? How are these concepts useful in arriving at a good design of a system? 20

8. (a) Use the languages:

$A = \{ a^n b^n c^m \mid m, n \geq 0 \}$ and

$B = \{ a^n b^m c^m \mid m, n \geq 0 \}$ (20m) 20

together to show that the class of context-free languages is not closed under intersection.

(b) Explain the following: 20

(i) Information flow index.

(ii) Span and average span size for a program.

(c) Discuss in brief on: 20

(i) Segmentation approach of memory management.

(ii) Fragmentation approach.