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Q1.

(a) Explain clearly the following state transitions for processes and reasons for the transitions:

- running $\rightarrow$ blocked
- blocked $\rightarrow$ blocked-suspend

(b) The traditional UNIX operating system is unsuitable for real-time applications because a process executing in kernel mode may not be preempted. Explain why.

(c) Most round-robin schedulers use a fixed size quantum. Give an argument in favour of a small time quantum. Now give an argument in favour of a large quantum. Compare and contrast the types of systems and jobs to which the arguments apply.

(d) Explain clearly how a new process is created in the UNIX operating system. Explain clearly the sequence of actions taken by the operating system when you execute the `ls` command at a UNIX shell.
Q2.

(a) Explain clearly the connection between multiprogramming and virtual memory in a computer system. Why is virtual memory necessary for implementing multiprogramming effectively?

(b) Why should the page size be a power of 2 in a computer that uses paging for memory management? Explain clearly how a logical address is translated to a physical address in a computer system that uses a two level page table with the following details:

- Each address has 32 bits.
- The lower order 16 bits are used as the offset.
- The higher order 16 bits are divided into two parts of 8 bits each for accessing the two-level page tables.

What is the total number of pages possible in the virtual memory of this computer? What is the size of a page?

(c) What is the principle of referential locality? Give two examples of the use of this principle in memory management of modern operating systems. Explain your examples clearly.

(d) A process $P$ references five pages, A, B, C, D, and E, in the following order:

A; B; C; D; A; B; E; A; B; C; D; E

Assume that $P$ is the only process in the system and the page replacement algorithm is Least Recently Used (LRU). Determine the number of page faults during this sequence of references starting with an empty main memory with three page frames.
Q3.

(a) What is the meaning of the term *critical section* in relation to concurrency? Explain how a *monitor* is used to enforce mutual exclusion in a concurrent program.

(5)

(b) Explain the importance of Direct Memory Access (DMA) for Input/Output management. Explain how DMA works and the term *cycle stealing* in relation to DMA.

(5)

(c) Explain the following disk scheduling policies:

- Shortest Seek Time First (SSTF)
- SCAN
- C-SCAN

Explain how the SSTF policy may create starvation.

(5)

(d) Explain clearly the advantages and disadvantages of using dynamic link libraries in the Windows operating system.

(5)