CS2210 – OPERATING SYSTEM TEST I –

SEMESTER: IV | TOTAL MARKS: 50 | DURATION: 2 HOURS

PART A (7 x 2 = 14 Marks)

1. What is an operating system (OS)?

An operating system is the **core software** that manages computer hardware and software resources, and provides services for computer programs. It acts as a **bridge between the user and hardware**.

- Examples: Windows, Linux, macOS

2. Write one difference between process and thread?

- **Process:** Independent execution unit with its own memory.
- **Thread:** Lightweight part of a process; shares memory with other threads.

3. What is process management in an operating system?

Refer to the process that involves **creation, scheduling, and termination** of processes. The OS allocates CPU time, memory, and I/O resources while ensuring concurrency and synchronization.

4. What are distributed systems?
A distributed system is a network of independent computers that **work together as a single system**. Resources and processes are distributed but appear unified.

- Examples: Cloud computing, Hadoop clusters

5. Define a virtual machine?
A virtual machine (VM) is an **simulated computer environment** that runs on a physical system. It provides the functionality of a physical computer but is isolated from the host machine.

- Examples: VMware, VirtualBox

6. What is the system boot process?
Booting is the process of **starting up a computer and loading the operating system**. It includes:

1. Power-On Self-Test (POST)

2. Loading bootloader from BIOS
3. Bootloader loads OS kernel
4. OS initializes services and user interface

PART B (3 x 4 = 12 Marks)

8(a). Write the advantages and disadvantages of the Shortest Job First (SJF) scheduling algorithm. (reference ya madam page 7 – unit 2 **)**

Shortest Job First refer to the process scheduling algorithm where by process with the shortest execution time is executed first.

Advantages:

- Minimizes average waiting time
- Highly efficient for batch processing

Disadvantages:

- Requires exact knowledge of job length
- Starvation of long jobs (not fair)
- Difficult to implement since it requires exact knowledge of length of next CPU burts.

OR

8(b). Explain the types of thread scheduling.

Thread scheduling is process done in OS to determine which thread to be runned next

1. **Preemptive Scheduling:** OS can interrupt a thread to assign CPU to another thread.
2. **Non-preemptive Scheduling:** Thread runs until it finishes or yields voluntarily.
3. **Priority Scheduling:** Threads with higher priority are scheduled first.
4. **Round Robin:** Threads are scheduled in time slices.

9(a). What is the goal of a good scheduling algorithm?

- Maximize CPU utilization
- Minimize waiting and turnaround time
- Ensure fairness among processes
- Reduce response time
- Meet system and user goals (deadlines, throughput)

OR

9(b). What are the basic concepts of process scheduling?

1. **Scheduling Queue:** Maintains all ready and waiting processes
2. **Dispatcher:** Component that assigns CPU
3. **Context Switching:** Switching CPU between processes
4. **Burst Time & Waiting Time:** Key scheduling metrics
5. **Throughput & Turnaround Time:** Efficiency indicators

Key Concepts in Process Scheduling:

- Context Switching: The act **of saving the state of a running process** and **loading the state of another process**. Frequent context switching can add overhead.
- CPU Bound vs I/O Bound:
  - o CPU-bound processes require heavy computation and consume a lot of CPU time.
  - o I/O-bound processes spend more time performing input/output operations than using the CPU.
- Preemptive vs Non-Preemptive Scheduling:
  - o Preemptive Scheduling: The OS can interrupt a running process to give CPU time to another.
  - o Non-preemptive Scheduling: The OS waits for a process to voluntarily release the CPU.

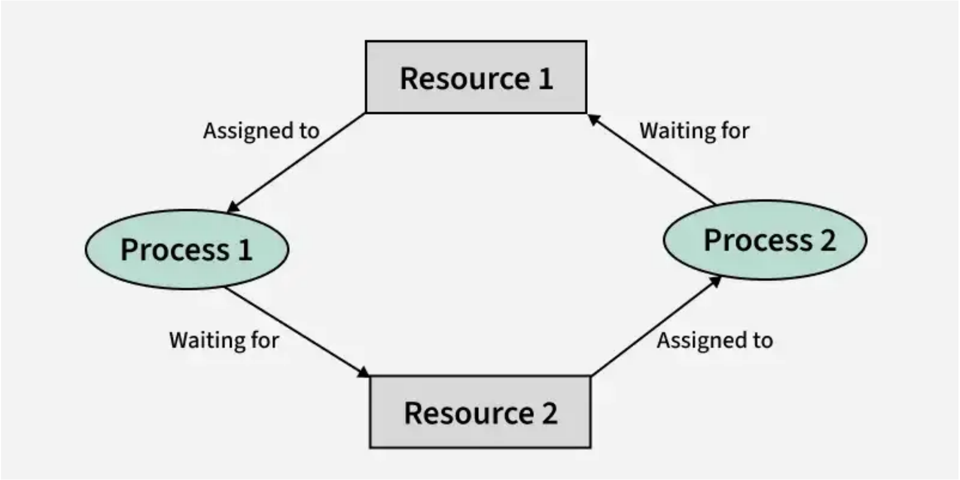
10(a). What are the advantages of using threads?

- Faster context switching than processes
- Shared memory within process = efficient communication
- Ideal for parallel processing and UI responsiveness

OR

10(b). List the four necessary conditions for deadlock. (reference ya mwalimu page 5 unit 2**)**

A deadlock is a situation where two or more processes are blocked indefinitely, each waiting for the other to release a resource that it needs to proceed.



1. **Mutual Exclusion** – One process at a time
2. **Hold and Wait** – Holding one resource while waiting for another
3. **No Preemption** – Resources can’t be forcibly taken
4. **Circular Wait** – Circular chain of processes each waiting on the next

PART C (2 x 12 = 24 Marks)

11(a). What are the challenges in multiple processor scheduling?

Refer to the process or concept for managing systems with more than one processor or core.

- Load balancing among processors
- Processor affinity (binding process to CPU)
- Shared cache contention
- Synchronization between processors (complexity of managing multiple processors)
- Deciding global vs local scheduling policies

Key Challenges in Multiple-Processor Scheduling

- Load Balancing: Ensuring that the workload is evenly distributed across all processors so that no processor is overburdened while others are underutilized.
- Processor Affinity: Some systems may prefer or require that certain processes or threads run on the same processor to take advantage of data locality (known as cache affinity).
- Synchronization: Managing processes and threads that need to communicate or synchronize, as multiple processors can lead to complexities in managing shared resources.

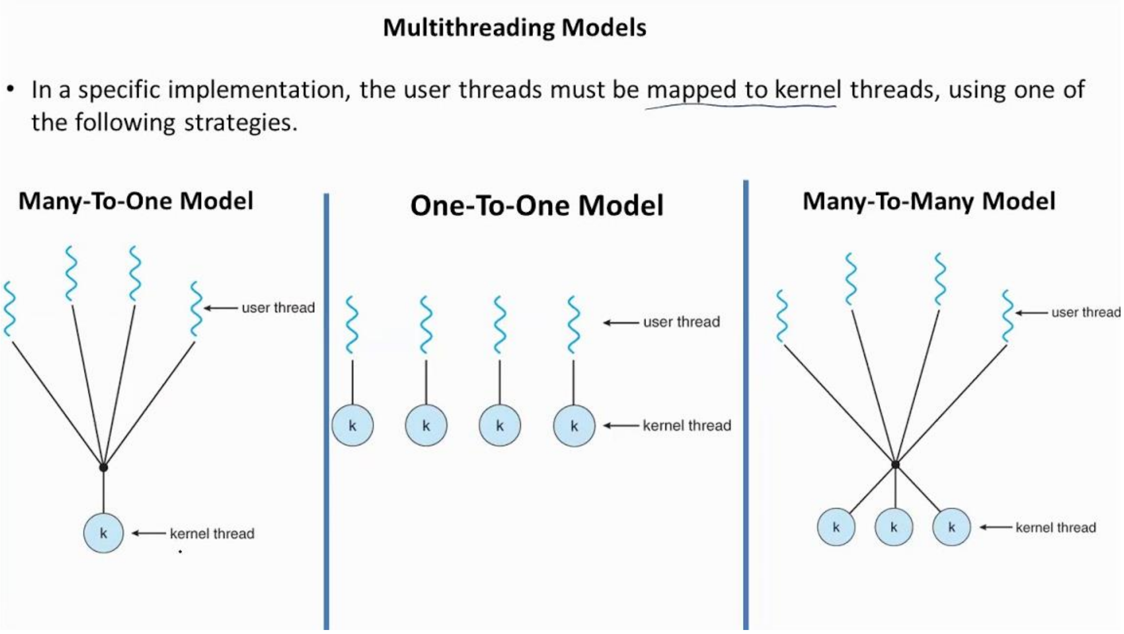
OR

11(b). What are the common scheduling algorithms in operating systems? (reference ya mwalimu page ya 7)

1. **FCFS (First-Come-First-Served):** Simple, non-preemptive
2. **SJF (Shortest Job First):** Optimal but hard to predict job lengths
3. **Round Robin (RR):** Preemptive and fair
4. **Priority Scheduling:** Based on process priority
5. **Multilevel Queue Scheduling:** Different queues for different priority classes or Processes are grouped into multiple queues.

12(a). What are the different multithreading models?

Multithreading models describe how **user-level threads** are mapped to **kernel-level threads**. These models determine how efficiently the OS can manage concurrency, CPU utilization, and responsiveness.



Multithreading Models

- In a specific implementation, the user threads must be mapped to kernel threads, using one of the following strategies.

1. **Many-to-One:** Many user threads mapped to one kernel thread (low concurrency)
2. **One-to-One:** Each user thread maps to a kernel thread (better concurrency)
3. **Many-to-Many:** User threads multiplexed to a set of kernel threads (flexible)
4. **Two-Level Model (Hybrid Model):** Combines many-to-many with one-to-one features

OR

12(b). Describe the criteria used for process scheduling.

The effectiveness of a scheduling algorithm can be judged based on several criteria:

1. **CPU Utilization**: Maximizing the use of the CPU.
2. **Throughput**: The number of processes completed per unit of time.
3. **Turnaround Time**: The total time taken for a process to complete (from arrival to completion).
4. **Waiting Time**: The total time a process spends waiting in the ready queue.
5. **Response Time**: The time taken from submitting a request to receiving the first response.
6. **Fairness:** Avoid starvation and ensure balanced use

CS2210 – OPERATING SYSTEM TEST II –

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PART A (7 x 2 = 14 Marks)

1. **What is the critical-section problem? (reference ya Mwalimu, page 1 unit 3)**

   Refer to the issue in concurrent programming where multiple processes or threads attempt to access shared resources simultaneously.

   The goal is to design a protocol so that **only one process executes in its critical section at a time**, ensuring:

- **Mutual exclusion**
- **Progress** (no unnecessary waiting)
- **Bounded waiting** (no process waits indefinitely)

2. What are semaphores? (Reference Mwalimu page 2 unit 3**)**
Semaphores are **integer-based synchronization tools** used to control access to shared resources. Two main operations:

- `wait()` (P): Decreases semaphore; blocks if result < 0
- `signal()` (V): Increases semaphore and wakes waiting process

Types:

- **Binary Semaphore**: Acts as a simple lock (0 or 1)
- **Counting Semaphore**: Allows multiple processes

3. What is demand paging?

Demand paging is a memory management technique where **pages are loaded only when needed**.

Paging is a memory management scheme that eliminates the problems of contiguous memory allocation by dividing physical memory into fixed-size blocks called pages.

Advantages:

- Eliminates fragmentation issues.
- More flexible memory allocation.
- Processes can be allocated non-contiguous blocks of memory.

Disadvantages:

- Page table overhead:
- Page Faults:

4. Page Replacement

Page replacement refer to the process when memory is full, these algorithms decide which page to exit to load a new one.

Page replacement occurs when memory is full, and the OS must choose a page to remove to load a new one.

Algorithms used:

- FIFO (First-In-First-Out)
- LRU (Least Recently Used)
- Optimal (Theoretically best, but not implementable)

5. What is mass storage in an operating system?

Mass storage refers to **non-volatile long-term storage devices** like hard disks, SSDs, and USB drives. The OS handles:

- File organization
- Block management
- Disk scheduling

6. Name any two disk scheduling algorithms.

Disk Scheduling algorithm refer to the process where by algorithm decide the order of I/O requests.

1. **FCFS (First-Come First-Served)**
2. **SCAN (Elevator Algorithm)**
   Other common Algorithms:
   - FCFS
   - SSTF (Shortest seek Time First)
   - SCAN
   - LOOK

7. What is disk formatting?
Disk formatting refer to process to prepare a disk for use by the OS.

Steps:

1. **Low-Level Formatting:** Divides disk into sectors and tracks
2. **Partitioning:** Divides disk into logical parts
3. **High-Level Formatting:** Creates file system (e.g., NTFS, FAT32)

PART B (3 x 4 = 12 Marks)

8(a). Describe the basic structure of a file system.
A file system organizes data into files and directories.

Core components:

- **Boot Control Block:** Info about OS booting
- **Volume Control Block:** Details about size, file system type
- **Directory Structure:** Hierarchical list of files
- **File Control Block (FCB):** Metadata like file name, size, access rights

OR

8(b). What are the main components of I/O hardware, and what are their functions?

Devices and controllers that manage input/output operations.

1. **I/O Devices:** Hardware like keyboard, printer, disk
2. **Device Controller:** Manages I/O devices
3. **Device Driver:** Software bridge between OS and controller
4. **Buffers & Registers:** Store data during transmission
5. **Interrupts:** Signal CPU upon completion of tasks

9(a). What are the different types of failures that require recovery?

1. **System Crashes:** Power failure or OS malfunction
2. **Disk Failures:** Bad sectors, disk corruption
3. **Transaction Failures:** Invalid or incomplete transactions
4. **Software Errors:** Bugs causing data loss or inconsistency

OR

9(b). Explain how I/O requests are transformed into hardware-level operations.

1. **System call issued** by user-level program
2. **I/O scheduler** prioritizes requests
3. **Device driver** translates request
4. **Device controller** executes command
5. **Interrupt sent** when task completes

   The OS manages all translations from high-level commands to low-level device signals

Example:

The OS converts an application's request (e.g., read a file) into a series of steps: identifying file blocks, locating them on disk, sending commands to the device controller, and returning results. This abstraction allows software to use I/O efficiently without knowing hardware details.

10(a). Explain the concept of demand paging and its advantages.
Demand paging loads memory pages only when needed. Pages not currently in memory cause a **page fault**, and the OS loads them from disk.

Advantages:

- Efficient use of memory
- Faster program loading
- Enables execution of large programs

OR

10(b). What is copy-on-write? Describe its benefits.

Copy-on-write (COW) is a technique where **multiple processes share the same memory pages** until one modifies them. Only then is a copy created.

Benefits:

- Saves memory
- Improves performance in `fork()` operations
- Efficient memory duplication in virtual memory systems

PART C (2 x 12 = 24 Marks)

11(a). Explain demand paging and its advantages and disadvantages?
Advantages:

- Reduces memory usage
- Allows more programs to run simultaneously
- Enables execution of large programs

Disadvantages:

- Page faults cause delays
- Thrashing can occur with excessive page faults
- Requires additional OS overhead (page table, fault handler)

OR

11(b). Describe in detail the structure of I/O systems in an operating system.
I/O system consists of:

- **User-level I/O calls:** e.g., `read()`, `write()`
- **Kernel I/O subsystem:** Handles buffering, caching, spooling
- **Device Drivers:** Convert generic calls into hardware instructions
- **Interrupt Handlers:** Notify CPU of I/O completion
- **DMA (Direct Memory Access):** Moves data directly without CPU

Ensures efficient and safe data transfer between devices and memory

12(a). Explain about semaphores?
Semaphores are variables used for **synchronization and mutual exclusion**.

Operations:

- `wait(S)` – Decrement and possibly block
- `signal(S)` – Increment and possibly wake up a blocked process

Use cases:

- Prevent race conditions
- Solve producer-consumer problem
- Implement critical section protection

OR

12(b). Describe memory-mapped files and what are their uses?
A memory-mapped file maps a file directly into a process's address space.

Advantages and Uses:

- Faster I/O than standard file handling
- Enables file sharing between processes
- Used in databases, multimedia applications
- Reduces number of system calls