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CT-01

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CT-01

1. a) What is an operating system? What does an Operating system do? 2+2
b) Describe the structure of a Computer System. 4
c) Describe the types of the Operating Systems? 6

2. a) What is Kernel? Describe the types of Kernel. 1+5
b) Difference Between Microkernel and Monolithic Kernel. 4
c) Functions of a Kernel. 4

3. a) What is user space and kernel space? 2
b) What are the Operating System Services ? 4
c) What is a system call and how does it work? 8

4. a) What is process? Give differences between process and program? 1+4
b) Explain the diagram of the process states? 4
c) What is process scheduling? Describe different types of scheduler. 1+4

5. a) What is Thread? Types of Thread. 1+3
b) Write the differences between Process and Thread. 5
c) What is Multithreading? What are the multithreading models? 1+4

6. a) What is the process control block(PCB) ?
b) What is the Process Queue? Types of Process Queue.
c) Explain all types of Time related to the Process.

7. a) What is CPU Scheduling? What are the the Purpose of a Scheduling algorithm
b) What are the Differences Between Preemptive and Non-Preemptive Scheduling?
c) What is Dispatcher?

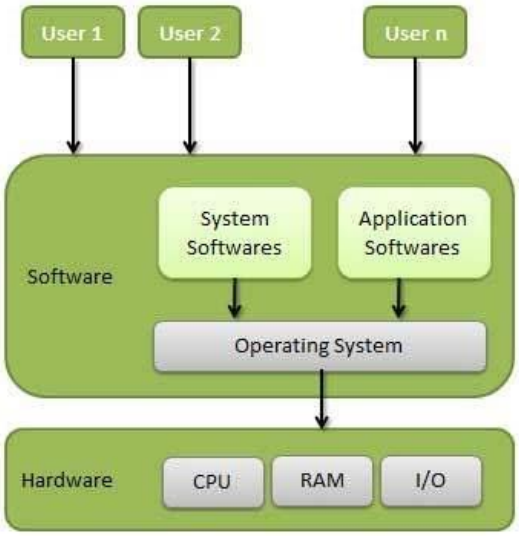
8. a) What are the algorithms of CPU scheduling?
b) What is FCFS? Describe the advantages and disadvantages of FCPS scheduling.
c) Consider the set of 3 processes whose arrival time and burst time are given below

Process	Arrival time	Burst time
P1	0	18
P2	1	3
P3	2	3

If the CPU scheduling policy is FCFS, calculate the average waiting time and average turn around time.

Answer to the question No - 01(a)

An operating system (OS) is a collection of software that manages computer hardware resources and provides common services for computer programs.An Operating System (OS) is a software that acts as an interface between the end-user and computer hardware.



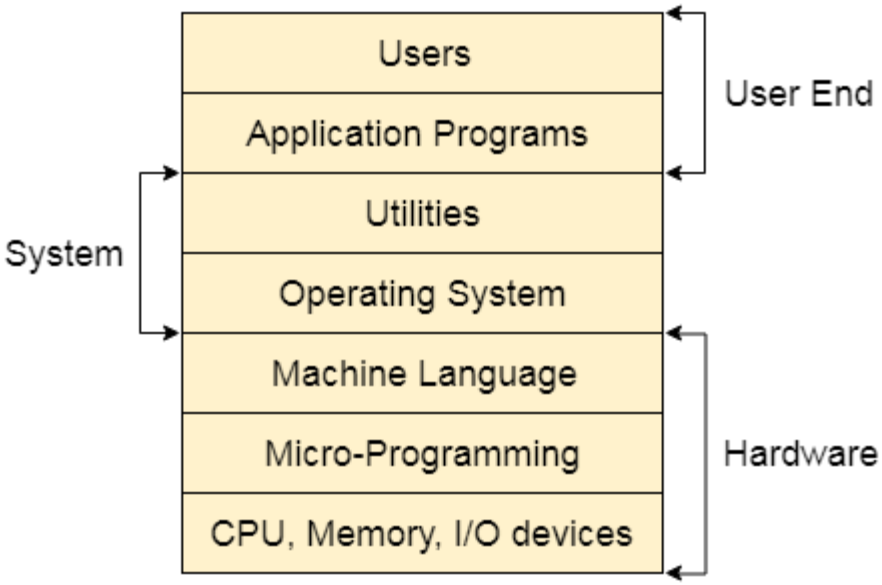
Here is a list of some significant functions of an Operating System, which is found common, is almost all operating system:

1. Memory Management
2. Processor Managing
3. Device Managing
4. File handling
5. Security Handling
6. System performance controlling
7. Job accounting and handling
8. Error detecting and handling
9. Synchronization with other software and users

Answer to the question No - 01(b)

A Computer System consists of:

- **Users** (people who are using the computer)
- **Application Programs** (Compilers, Databases, Games, Video player, Browsers, etc.)
- **System Programs** (Shells, Editors, Compilers, etc.)
- **Operating System** (A special program which acts as an interface between user and hardware)
- **Hardware** (CPU, Disks, Memory, etc)



Answer to the question No - 01(c)

Given below are different types of Operating System:

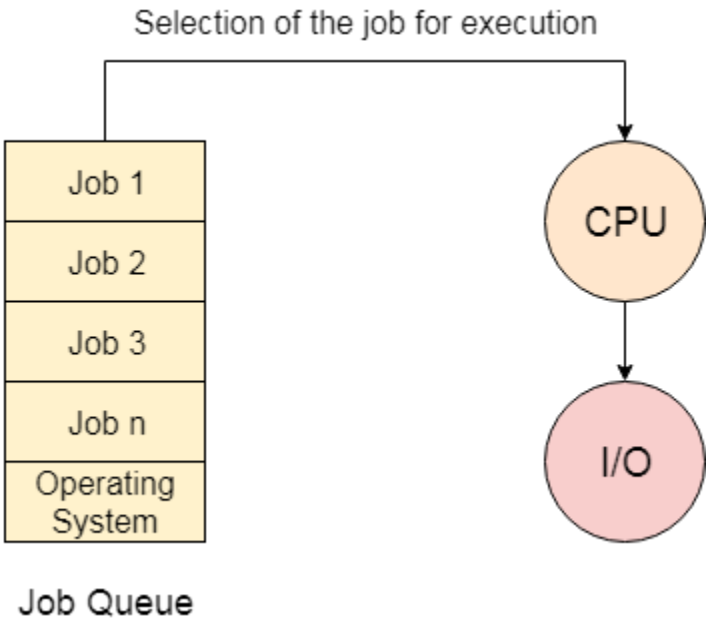
1. Simple Batch System
2. Multiprogramming Batch System
3. Multiprocessor System
4. Desktop System
5. Distributed Operating System
6. Clustered System
7. Realtime Operating System
8. Handheld System

Batch Operating System

In the era of 1970s, the Batch processing was very popular. The Jobs were executed in batches. People were used to have a single computer which was called mainframe.

In Batch operating system, access is given to more than one person; they submit their respective jobs to the system for the execution.

The system put all of the jobs in a queue on the basis of first come first serve and then executes the jobs one by one. The users collect their respective output when all the jobs get executed.



Disadvantages of Batch OS

1. Starvation

Batch processing suffers from starvation. If there are five jobs J1, J2, J3, J4, J4 and J5 present in the batch. If the execution time of J1 is very high then other four jobs will never be going to get executed or they will have to wait for a very high time. Hence the other processes get starved.

2. Not Interactive

Batch Processing is not suitable for the jobs which are dependent on the user's input. If a job requires the input of two numbers from the console then it will never be going to get it in the batch processing scenario since the user is not present at the time of execution.

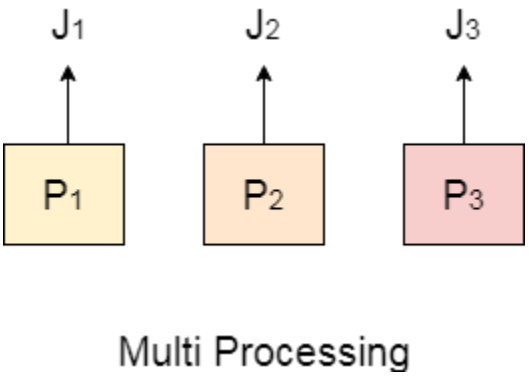
Multiprogramming Operating System

Multiprogramming is an extension to the batch processing where the CPU is kept always busy. Each process needs two types of system time: CPU time and IO time.

In multiprogramming environment, for the time a process does its I/O, The CPU can start the execution of other processes. Therefore, multiprogramming improves the efficiency of the system.

Multiprocessing Operating System

In Multiprocessing, Parallel computing is achieved. There are more than one processors present in the system which can execute more than one process at the same time. This will increase the throughput of the system.



Multi Processing

Time-sharing operating systems

Time-sharing is a technique which enables many people, located at various terminals, to use a particular computer system at the same time. Time-sharing or multitasking is a logical extension of multiprogramming. Processor's time which is shared among multiple users simultaneously is termed as time-sharing.

The main difference between Multiprogrammed Batch Systems and Time-Sharing Systems is that in case of Multiprogrammed batch systems, the objective is to maximize processor use, whereas in Time-Sharing Systems, the objective is to minimize response time.

Multiple jobs are executed by the CPU by switching between them, but the switches occur so frequently. Thus, the user can receive an immediate response. For example, in a transaction processing, the processor executes each user program in a short burst or quantum of computation. That is, if n users are present, then each user can get a time

quantum. When the user submits the command, the response time is in few seconds at most.

The operating system uses CPU scheduling and multiprogramming to provide each user with a small portion of a time. Computer systems that were designed primarily as batch systems have been modified to time-sharing systems.

Advantages of Timesharing operating systems are as follows −

- Provides the advantage of quick response.
- Avoids duplication of software.
- Reduces CPU idle time.

Disadvantages of Time-sharing operating systems are as follows −

- Problem of reliability.
- Question of security and integrity of user programs and data.
- Problem of data communication.

Real Time operating System

A real-time system is defined as a data processing system in which the time interval required to process and respond to inputs is so small that it controls the environment. The time taken by the system to respond to an input and display of required updated information is termed as the response time. So in this method, the response time is very less as compared to online processing.

Real-time systems are used when there are rigid time requirements on the operation of a processor or the flow of data and real-time systems can be used as a control device in a dedicated application. A real-time operating system must have well-defined, fixed time constraints, otherwise the system will fail. For example, Scientific experiments, medical imaging systems, industrial control systems, weapon systems, robots, air traffic control systems, etc.

There are two types of real-time operating systems.

1.Hard real-time systems

Hard real-time systems guarantee that critical tasks complete on time. In hard real-time systems, secondary storage is limited or missing and the data is stored in ROM. In these systems, virtual memory is almost never found.

2.Soft real-time systems

Soft real-time systems are less restrictive. A critical real-time task gets priority over other tasks and retains the priority until it completes. Soft real-time systems have limited utility than hard real-time systems. For example, multimedia, virtual reality, Advanced Scientific Projects like undersea exploration and planetary rovers, etc.

Distributed operating System

Distributed systems use multiple central processors to serve multiple real-time applications and multiple users. Data processing jobs are distributed among the processors accordingly.

The processors communicate with one another through various communication lines (such as high-speed buses or telephone lines). These are referred as loosely coupled systems or distributed systems. Processors in a distributed system may vary in size and function. These processors are referred as sites, nodes, computers, and so on.

The advantages of distributed systems are as follows −

- With resource sharing facility, a user at one site may be able to use the resources available at another.
- Speedup the exchange of data with one another via electronic mail.
- If one site fails in a distributed system, the remaining sites can potentially continue operating.
- Better service to the customers.
- Reduction of the load on the host computer.
- Reduction of delays in data processing.

Network operating System

A Network Operating System runs on a server and provides the server the capability to manage data, users, groups, security, applications, and other networking functions. The

primary purpose of the network operating system is to allow shared file and printer access among multiple computers in a network, typically a local area network (LAN), a private network or to other networks.

Examples of network operating systems include Microsoft Windows Server 2003, Microsoft Windows Server 2008, UNIX, Linux, Mac OS X, Novell NetWare, and BSD.

The advantages of network operating systems are as follows −

- Centralized servers are highly stable.
- Security is server managed.
- Upgrades to new technologies and hardware can be easily integrated into the system.
- Remote access to servers is possible from different locations and types of systems.

The disadvantages of network operating systems are as follows −

- High cost of buying and running a server.
- Dependency on a central location for most operations.
- Regular maintenance and updates are required.

Answer to the question No - 02(a)

A Kernel is a computer program that is the heart and core of an Operating System.Whenever a system starts, the Kernel is the first program that is loaded after the bootloader because the Kernel has to handle the rest of the thing of the system for the Operating System. The Kernel remains in the memory until the Operating System is shut-down.
The Kernel is responsible for low-level tasks such as disk management, memory management, task management, etc. It provides an interface between the user and the hardware components of the system. When a process makes a request to the Kernel, then it is called **System Call**.

In general, there are five types of Kernel. They are:

1. Monolithic Kernel **–**

It is one of types of kernel where all operating system services operate in kernel space. It has dependencies between systems components. It has huge lines of code which is complex.

Example :

```
Unix, Linux, Open VMS, XTS-400 etc.
```

- **Advantage :**

  It has good performance.

- **Disadvantage :**

  It has dependencies between system component and lines of code in millions.

2. Micro Kernel **–**

It is kernel types which has minimalist approach. It has virtual memory and thread scheduling. It is more stable with less services in kernel space. It puts rest in user space.

Example :

```
Mach, L4, AmigaOS, Minix, K42 etc.
```

- **Advantage :**

  It is more stable.

- **Disadvantage :**

  There are lots of system calls and context switches.

3. Hybrid Kernel –

It is the combination of both monolithic kernel and mircrokernel. It has speed and design of monolithic kernel and modularity and stability of microkernel.

Example :

```
Windows NT, Netware, BeOS etc.
```

- **Advantage :**

  It combines both monolithic kernel and microkernel.
- **Disadvantage :**

  It is still similar to monolithic kernel.

4. Exo Kernel –

It is the type of kernel which follows end-to-end principle. It has fewest hardware abstractions as possible. It allocates physical resources to applications.

Example :

```
Nemesis, ExOS etc.
```

- **Advantage :**

  It has fewest hardware abstractions.
- **Disadvantage :**

  There is more work for application developers.

5. Nano Kernel –

It is the type of kernel that offers hardware abstraction but without system services. Micro Kernel also does not have system services therefore the Micro Kernel and Nano Kernel have become analogous.

Example :

```
EROS etc.
```

- **Advantage :**

  It offers hardware abstractions without system services.
- **Disadvantage :**

  It is quite same as Micro kernel hence it is less used.

Answer to the question No - 02(b)

Difference Between Microkernel and Monolithic Kernel

Parameters	Monolithic kernel	MicroKernel
Basic	It is a large process running in a single address space	It can be broken down into separate processes called servers.
Code	In order to write a monolithic kernel, less code is required.	In order to write a microkernel, more code is required
Security	If a service crashes, the whole system collapses in a monolithic kernel.	If a service crashes, it never affects the working of a microkernel.
Communication	It is a single static binary file	Servers communicate through IPC.
Example	Linux, BSDs, Microsoft Windows (95,98, Me), Solaris, OS-9, AIX, DOS, XTS-400, etc.	L4Linux, QNX, SymbianK42, Mac OS X, Integrity, etc.

Answer to the question No - 2(c)

Following are the functions of a Kernel:

Access Computer resource: A Kernel can access various computer resources like the CPU, I/O devices and other resources. It acts as a bridge between the user and the resources of the system.

Resource Management: It is the duty of a Kernel to share the resources between various process in such a way that there is uniform access to the resources by every process.

Memory Management: Every process needs some memory space. So, memory must be allocated and deallocated for its execution. All these memory management is done by a Kernel.

Device Management: The peripheral devices connected in the system are used by the processes. So, the allocation of these devices is managed by the Kernel.

Answer to the question No - 3(a)

A Kernel is provided with a protected Kernel Space which is a separate area of memory and this area is not accessible by other application programs.
So, the code of the Kernel is loaded into this protected **Kernel Space**. Apart from this, the memory used by other applications is called the **User Space**.

Answer to the question No - 3(b)

An Operating System provides services to both the users and to the programs.

- It provides programs an environment to execute.
- It provides users the services to execute the programs in a convenient manner.

Following are a few common services provided by an operating system −

- Program execution
- I/O operations
- File System manipulation
- Communication
- Error Detection
- Resource Allocation
- Protection

Program execution

Operating systems handle many kinds of activities from user programs to system programs like printer spooler, name servers, file server, etc. Each of these activities is encapsulated as a process.

A process includes the complete execution context (code to execute, data to manipulate, registers, OS resources in use). Following are the major activities of an operating system with respect to program management −

- Loads a program into memory.
- Executes the program.
- Handles program's execution.
- Provides a mechanism for process synchronization.
- Provides a mechanism for process communication.
- Provides a mechanism for deadlock handling.

I/O Operation

An I/O subsystem comprises of I/O devices and their corresponding driver software. Drivers hide the peculiarities of specific hardware devices from the users.

An Operating System manages the communication between user and device drivers.

- I/O operation means read or write operation with any file or any specific I/O device.
- Operating system provides the access to the required I/O device when required.

File system manipulation

A file represents a collection of related information. Computers can store files on the disk (secondary storage), for long-term storage purpose. Examples of storage media include magnetic tape, magnetic disk and optical disk drives like CD, DVD. Each of these media has its own properties like speed, capacity, data transfer rate and data access methods.

A file system is normally organized into directories for easy navigation and usage. These directories may contain files and other directions. Following are the major activities of an operating system with respect to file management −

- Program needs to read a file or write a file.
- The operating system gives the permission to the program for operation on file.
- Permission varies from read-only, read-write, denied and so on.
- Operating System provides an interface to the user to create/delete files.
- Operating System provides an interface to the user to create/delete directories.
- Operating System provides an interface to create the backup of file system.

Communication

In case of distributed systems which are a collection of processors that do not share memory, peripheral devices, or a clock, the operating system manages communications between all the processes. Multiple processes communicate with one another through communication lines in the network.

The OS handles routing and connection strategies, and the problems of contention and security. Following are the major activities of an operating system with respect to communication −

- Two processes often require data to be transferred between them
- Both the processes can be on one computer or on different computers, but are connected through a computer network.
- Communication may be implemented by two methods, either by Shared Memory or by Message Passing.

Error handling

Errors can occur anytime and anywhere. An error may occur in CPU, in I/O devices or in the memory hardware. Following are the major activities of an operating system with respect to error handling −

- The OS constantly checks for possible errors.
- The OS takes an appropriate action to ensure correct and consistent computing.

Resource Management

In case of multi-user or multi-tasking environment, resources such as main memory, CPU cycles and files storage are to be allocated to each user or job. Following are the major activities of an operating system with respect to resource management −

- The OS manages all kinds of resources using schedulers.
- CPU scheduling algorithms are used for better utilization of CPU.

Protection

Considering a computer system having multiple users and concurrent execution of multiple processes, the various processes must be protected from each other's activities.

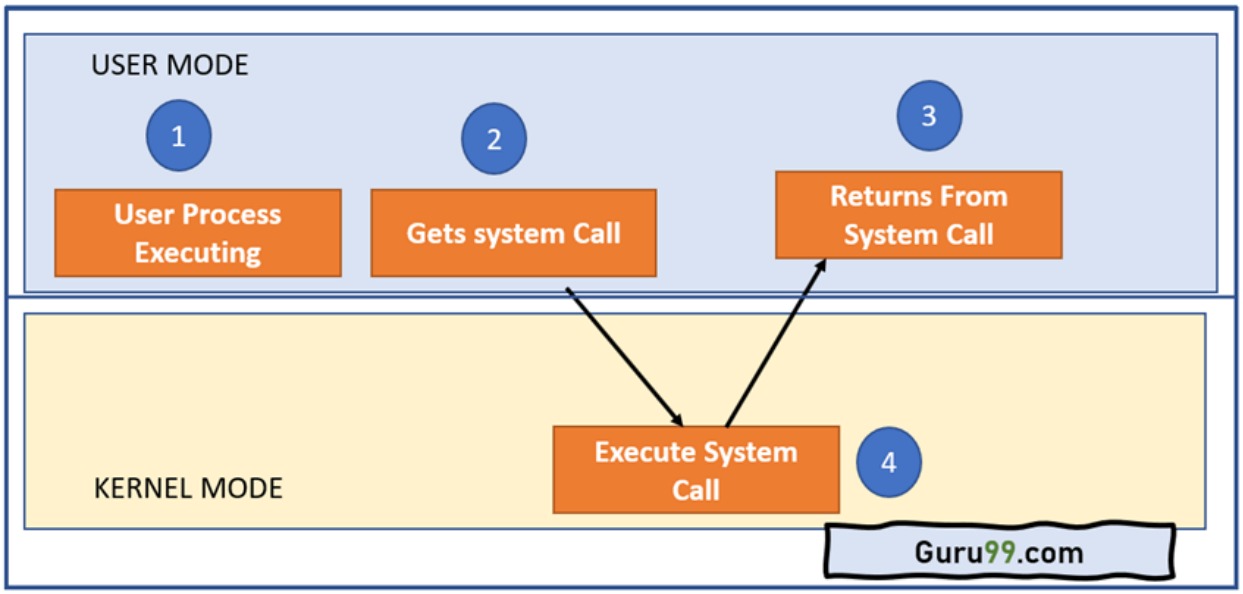
Protection refers to a mechanism or a way to control the access of programs, processes, or users to the resources defined by a computer system. Following are the major activities of an operating system with respect to protection −

- The OS ensures that all access to system resources is controlled.
- The OS ensures that external I/O devices are protected from invalid access attempts.
- The OS provides authentication features for each user by means of passwords.

Answer to the question No - 3(c)

A **system call** is a mechanism that provides the interface between a process and the operating system. It is a programmatic method in which a computer program requests a service from the kernel of the OS.
System call offers the services of the operating system to the user programs via API (Application Programming Interface). System calls are the only entry points for the kernel system.

Here are steps for System Call :



Step 1) The processes executed in the user mode till the time a system call interrupts it.

Step 2) After that, the system call is executed in the kernel-mode on a priority basis.

Step 3) Once system call execution is over, control returns to the user mode.,

Step 4) The execution of user processes resumed in Kernel mode.

Answer to the question No - 4(a)

A process is defined as an entity which represents the basic unit of work to be implemented in the system.

Difference between Program and Process

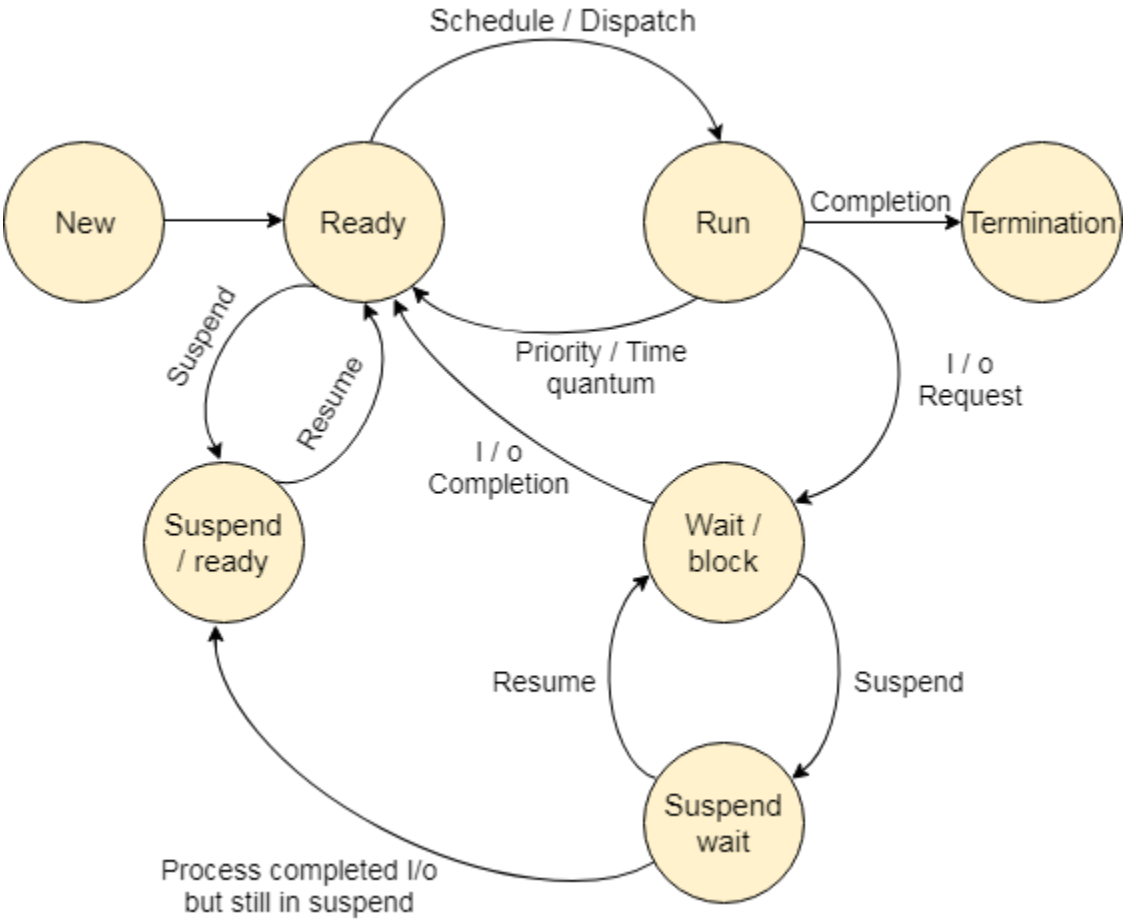
Parameter	Process	Program

Definition	An executing part of a program is called a process.	A program is a group of ordered operations to achieve a programming goal.
Nature	The process is an instance of the program being executing.	The nature of the program is passive, so it's unlikely to do to anything until it gets executed.
Resource management	The resource requirement is quite high in case of a process.	The program only needs memory for storage.
Overheads	Processes have considerable overhead.	No significant overhead cost.
Lifespan	The process has a shorter and very limited lifespan as it gets terminated after the completion of the task.	A program has a longer lifespan as it is stored in the memory until it is not manually deleted.
Creation	New processes require duplication of the parent process.	No such duplication is needed.
Required Process	Process holds resources like CPU, memory address, disk, I/O, etc.	The program is stored on disk in some file and does not require any other resources.

Entity type	A process is a dynamic or active entity.	A program is a passive or static entity.
Contain	A process contains many resources like a memory address, disk, printer, etc.	A program needs memory space on disk to store all instructions.

Answer to the question No - 4(b)

Process States - State Diagram



The process, from its creation to completion, passes through various states. The minimum number of states is five.

The names of the states are not standardized although the process may be in one of the following states during execution.

1. New

A program which is going to be picked up by the OS into the main memory is called a new process.

2. Ready

Whenever a process is created, it directly enters in the ready state, in which, it waits for the CPU to be assigned. The OS picks the new processes from the secondary memory and put all of them in the main memory.

The processes which are ready for the execution and reside in the main memory are called ready state processes. There can be many processes present in the ready state.

3. Running

One of the processes from the ready state will be chosen by the OS depending upon the scheduling algorithm. Hence, if we have only one CPU in our system, the number of running processes for a particular time will always be one. If we have n processors in the system then we can have n processes running simultaneously.

4. Block or wait

From the Running state, a process can make the transition to the block or wait state depending upon the scheduling algorithm or the intrinsic behavior of the process.

When a process waits for a certain resource to be assigned or for the input from the user then the OS move this process to the block or wait state and assigns the CPU to the other processes.

5. Completion or termination

When a process finishes its execution, it comes in the termination state. All the context of the process (Process Control Block) will also be deleted the process will be terminated by the Operating system.

6. Suspend ready

A process in the ready state, which is moved to secondary memory from the main memory due to lack of the resources (mainly primary memory) is called in the suspend ready state.

If the main memory is full and a higher priority process comes for the execution then the OS have to make the room for the process in the main memory by throwing the lower priority process out into the secondary memory. The suspend ready processes remain in the secondary memory until the main memory gets available.

7. Suspend wait

Instead of removing the process from the ready queue, it's better to remove the blocked process which is waiting for some resources in the main memory. Since it is already waiting for some resource to get available hence it is better if it waits in the secondary memory and make room for the higher priority process. These processes complete their execution once the main memory gets available and their wait is finished.

Operations on the Process

1. Creation

Once the process is created, it will be ready and come into the ready queue (main memory) and will be ready for the execution.

2. Scheduling

Out of the many processes present in the ready queue, the Operating system chooses one process and start executing it. Selecting the process which is to be executed next, is known as scheduling.

3. Execution

Once the process is scheduled for the execution, the processor starts executing it. Process may come to the blocked or wait state during the execution then in that case the processor starts executing the other processes.

4. Deletion/killing

Once the purpose of the process gets over then the OS will kill the process. The Context of the process (PCB) will be deleted and the process gets terminated by the Operating system.

Answer to the question No - 4(c)

The process scheduling is the activity of the process manager that handles the removal of the running process from the CPU and the selection of another process on the basis of a particular strategy.

Operating system uses various schedulers for the process scheduling described below.

1. Long term scheduler

Long term scheduler is also known as job scheduler. It chooses the processes from the pool (secondary memory) and keeps them in the ready queue maintained in the primary memory.

Long Term scheduler mainly controls the degree of Multiprogramming. The purpose of long term scheduler is to choose a perfect mix of IO bound and CPU bound processes among the jobs present in the pool.

If the job scheduler chooses more IO bound processes then all of the jobs may reside in the blocked state all the time and the CPU will remain idle most of the time. This will reduce the degree of Multiprogramming. Therefore, the Job of long term scheduler is very critical and may affect the system for a very long time.

2. Short term scheduler

Short term scheduler is also known as CPU scheduler. It selects one of the Jobs from the ready queue and dispatch to the CPU for the execution.

A scheduling algorithm is used to select which job is going to be dispatched for the execution. The Job of the short term scheduler can be very critical in the sense that if it selects job whose CPU burst time is very high then all the jobs after that, will have to wait in the ready queue for a very long time.

This problem is called starvation which may arise if the short term scheduler makes some mistakes while selecting the job.

3. Medium term scheduler

Medium term scheduler takes care of the swapped out processes.If the running state processes needs some IO time for the completion then there is a need to change its state from running to waiting.

Medium term scheduler is used for this purpose. It removes the process from the running state to make room for the other processes. Such processes are the swapped out processes and this procedure is called swapping. The medium term scheduler is responsible for suspending and resuming the processes.

It reduces the degree of multiprogramming. The swapping is necessary to have a perfect mix of processes in the ready queue.

Answer to the question No - 5(a)

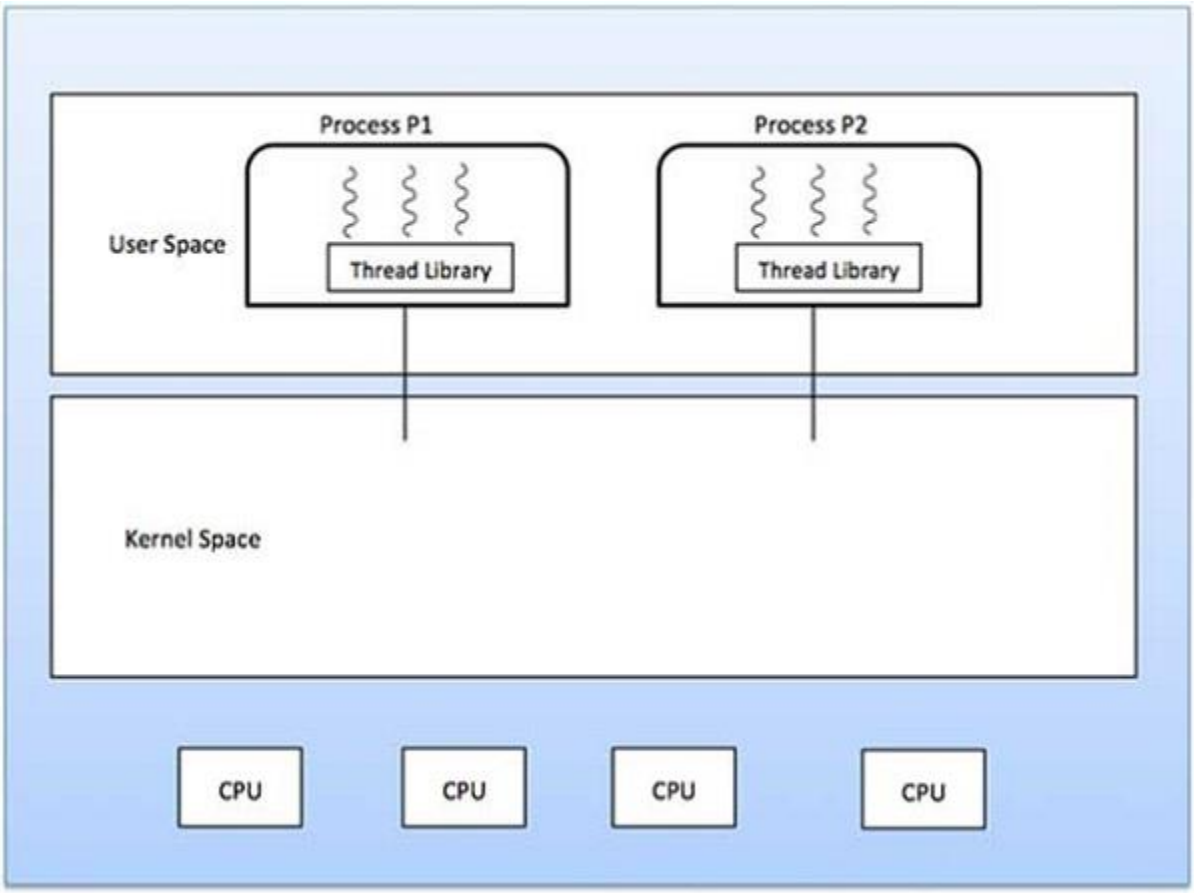
Thread is an execution unit that is part of a process. A process can have multiple threads, all executing at the same time.

We can implement threads in three different ways:

1. Kernel-level threads
2. User-level threads
3. Hybrid threads

User Level Threads

In this case, the thread management kernel is not aware of the existence of threads. The thread library contains code for creating and destroying threads, for passing message and data between threads, for scheduling thread execution and for saving and restoring thread contexts. The application starts with a single thread.



Advantages

- Thread switching does not require Kernel mode privileges.
- User level thread can run on any operating system.
- Scheduling can be application specific in the user level thread.
- User level threads are fast to create and manage.

Disadvantages

- In a typical operating system, most system calls are blocking.
- Multithreaded application cannot take advantage of multiprocessing.

Kernel Level Threads

In this case, thread management is done by the Kernel. There is no thread management code in the application area. Kernel threads are supported directly by the operating system. Any application can be programmed to be multithreaded. All of the threads within an application are supported within a single process.

The Kernel maintains context information for the process as a whole and for individuals threads within the process. Scheduling by the Kernel is done on a thread basis. The Kernel performs thread creation, scheduling and management in Kernel space. Kernel threads are generally slower to create and manage than the user threads.

Advantages

- Kernel can simultaneously schedule multiple threads from the same process on multiple processes.
- If one thread in a process is blocked, the Kernel can schedule another thread of the same process.
- Kernel routines themselves can be multithreaded.

Disadvantages

- Kernel threads are generally slower to create and manage than the user threads.
- Transfer of control from one thread to another within the same process requires a mode switch to the Kernel.

Answer to the question No - 5(b)

Difference between Process and Thread

Parameter	Process	Thread
Definition	Process means a program is in execution.	Thread means a segment of a process.
Lightweight	The process is not Lightweight.	Threads are Lightweight.
Termination time	The process takes more time to terminate.	The thread takes less time to terminate.

Creation time	It takes more time for creation.	It takes less time for creation.
Communication	Communication between processes needs more time compared to thread.	Communication between threads requires less time compared to processes.
Context switching time	It takes more time for context switching.	It takes less time for context switching.
Resource	Process consume more resources.	Thread consume fewer resources.
Treatment by OS	Different process are tread separately by OS.	All the level peer threads are treated as a single task by OS.
Memory	The process is mostly isolated.	Threads share memory.
Sharing	It does not share data	Threads share data with each other.

Answer to the question No - 5(c)

Multithreading is the ability of a central processing unit (CPU) (or a single core in a multi-core processor) to provide multiple threads of execution concurrently, supported by the operating system.

Multithreading Models: The user threads must be mapped to kernel threads, by one of the following strategies:

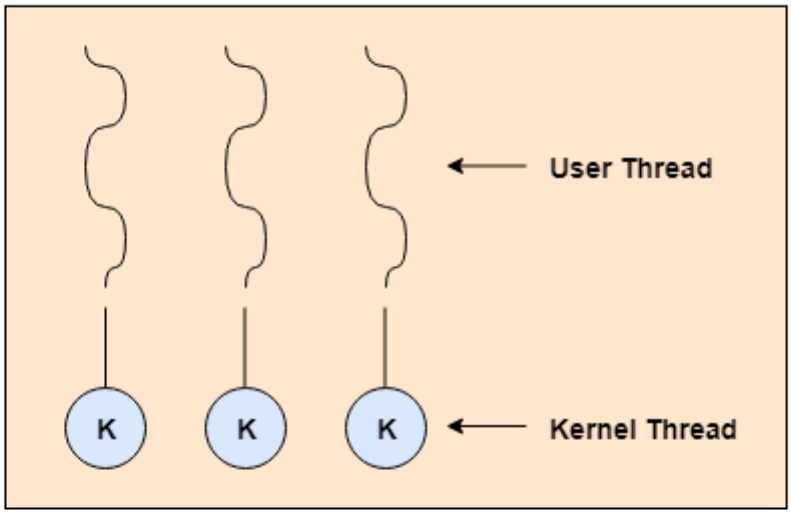
1. Many to One Model
2. One to One Model
3. Many to Many Model

One to One Model

The one to one model maps each of the user threads to a kernel thread. This means that many threads can run in parallel on multiprocessors and other threads can run when one thread makes a blocking system call.

A disadvantage of the one to one model is that the creation of a user thread requires a corresponding kernel thread. Since a lot of kernel threads burden the system, there is restriction on the number of threads in the system.

A diagram that demonstrates the one to one model is given as follows −



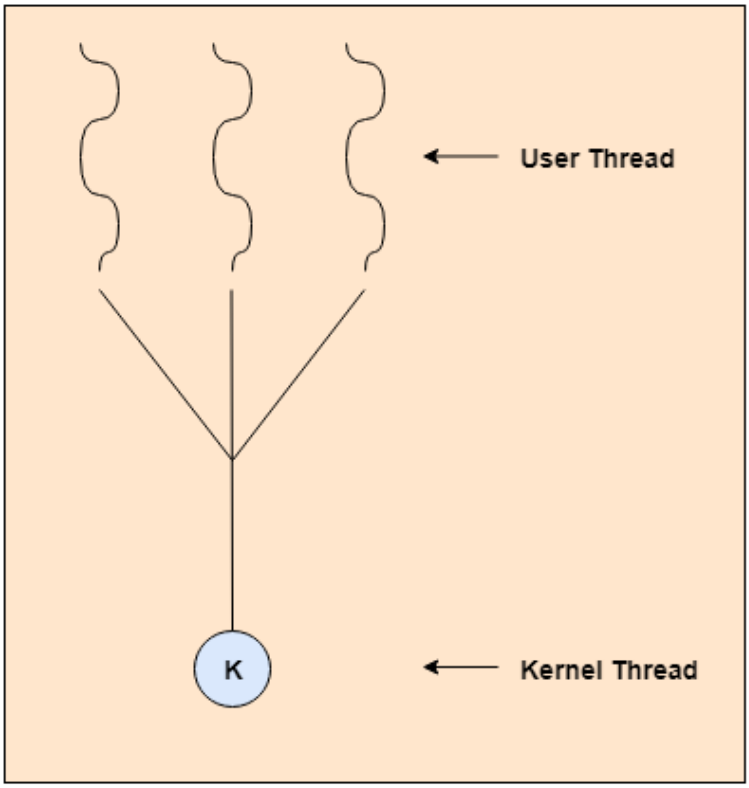
One to One Model

Many to One Model

The many to one model maps many of the user threads to a single kernel thread. This model is quite efficient as the user space manages the thread management.

A disadvantage of the many to one model is that a thread blocking system call blocks the entire process. Also, multiple threads cannot run in parallel as only one thread can access the kernel at a time.

A diagram that demonstrates the many to one model is given as follows −



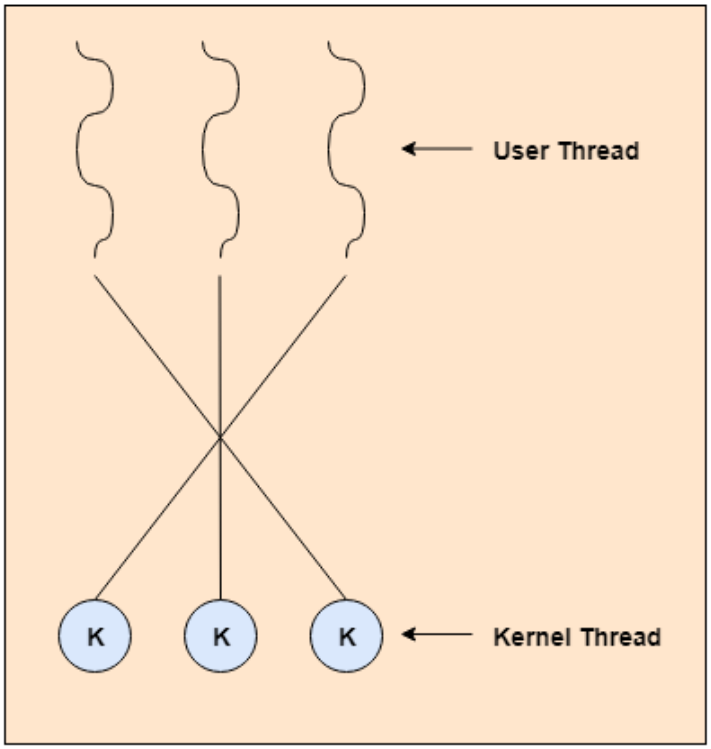
Many to One Model

Many to Many Model

The many to many model maps many of the user threads to a equal number or lesser kernel threads. The number of kernel threads depends on the application or machine.

The many to many does not have the disadvantages of the one to one model or the many to one model. There can be as many user threads as required and their corresponding kernel threads can run in parallel on a multiprocessor.

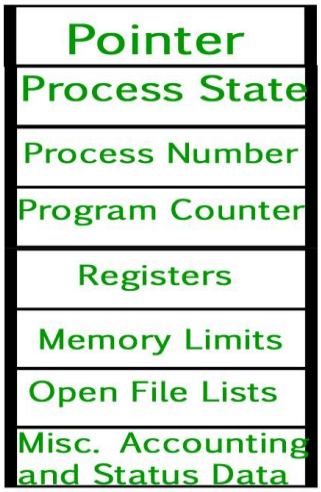
A diagram that demonstrates the many to many model is given as follows −



Many to Many Model

Answer to the question No - 6(a)

A process control block (PCB) contains information about the process, i.e. registers, quantum, priority, etc. The process table is an array of PCB's, that means logically contains a PCB for all of the current processes in the system.



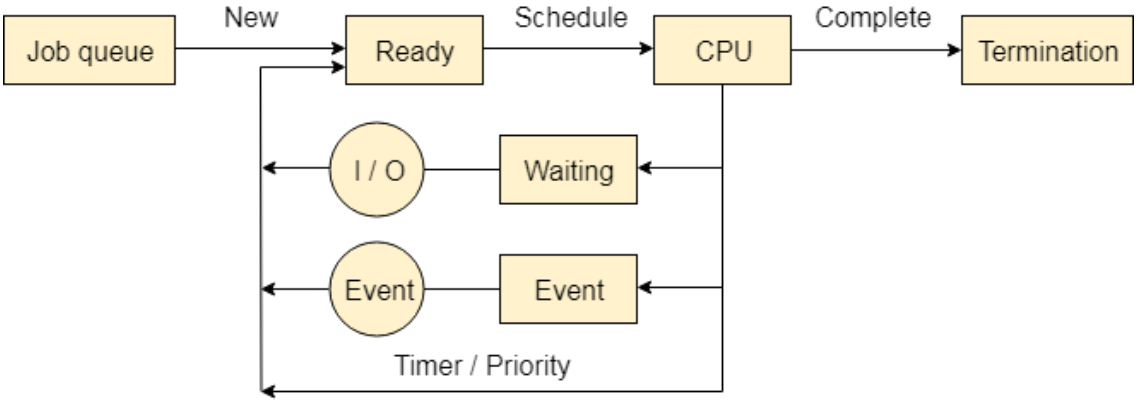
Process Control Block

- **Pointer –** It is a stack pointer which is required to be saved when the process is switched from one state to another to retain the current position of the process.

- **Process state –** It stores the respective state of the process.
- **Process number –** Every process is assigned with a unique id known as process ID or PID which stores the process identifier.
- **Program counter –** It stores the counter which contains the address of the next instruction that is to be executed for the process.
- **Register –** These are the CPU registers which includes: accumulator, base, registers and general purpose registers.
- **Memory limits –** This field contains the information about memory management system used by operating system. This may include the page tables, segment tables etc.
- **Open files list –** This information includes the list of files opened for a process.

Answer to the question No - 6(b)

The Operating system manages various types of queues for each of the process states. The PCB related to the process is also stored in the queue of the same state. If the Process is moved from one state to another state then its PCB is also unlinked from the corresponding queue and added to the other state queue in which the transition is made.



There are the following queues maintained by the Operating system.

1. Job Queue

In starting, all the processes get stored in the job queue. It is maintained in the secondary memory. The long term scheduler (Job scheduler) picks some of the jobs and put them in the primary memory.

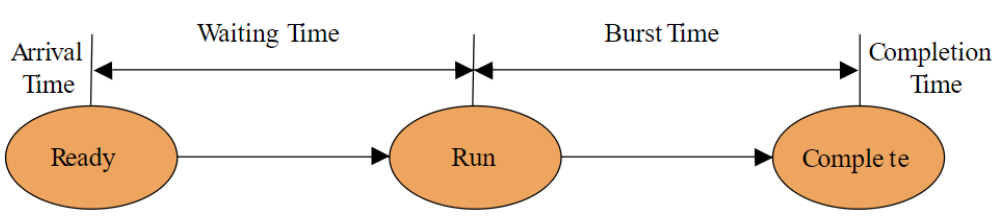
2. Ready Queue

Ready queue is maintained in primary memory. The short term scheduler picks the job from the ready queue and dispatch to the CPU for the execution.

3. Waiting Queue

When the process needs some IO operation in order to complete its execution, OS changes the state of the process from running to waiting. The context (PCB) associated with the process gets stored on the waiting queue which will be used by the Processor when the process finishes the IO.

Answer to the question No - 6(c)



$$CT - AT = WT + BT$$

$$TAT = CT - AT$$

$$\text{Waiting Time} = TAT - BT$$

TAT ⟶ Turn around time

BT ⟶ Burst time

AT ⟶ Arrival time

1. Arrival Time

The time at which the process enters into the ready queue is called the arrival time.

2. Burst Time

The total amount of time required by the CPU to execute the whole process is called the Burst Time. This does not include the waiting time. It is confusing to calculate the execution time for a process even before executing it hence the scheduling problems based on the burst time cannot be implemented in reality.

3. Completion Time

The Time at which the process enters into the completion state or the time at which the process completes its execution, is called completion time.

4. Turnaround time

The total amount of time spent by the process from its arrival to its completion, is called Turnaround time.

5. Waiting Time

The Total amount of time for which the process waits for the CPU to be assigned is called waiting time.

6. Response Time

The difference between the arrival time and the time at which the process first gets the CPU is called Response Time.

Answer to the question No - 7(a)

CPU Scheduling is a process of determining which process will own CPU for execution while another process is on hold. The main task of CPU scheduling is to make sure that whenever the CPU remains idle, the OS at least select one of the processes available in the ready queue for execution. The selection process will be carried out by the CPU scheduler. It selects one of the processes in memory that are ready for execution.

Here are the reasons for using a scheduling algorithm:

- The CPU uses scheduling to improve its efficiency.
- It helps you to allocate resources among competing processes.
- The maximum utilization of CPU can be obtained with multi-programming.
- The processes which are to be executed are in the ready queue.

Answer to the question No - 7(b)

Differences Between Preemptive and Non-Preemptive Scheduling

Paramenter	PREEMPTIVE SCHEDULING	NON-PREEMPTIVE SCHEDULING
Basic	In this resources(CPU Cycle) are allocated to a process for a limited time.	Once resources(CPU Cycle) are allocated to a process, the process holds it till it completes its burst time or switches to waiting state.
Interrupt	Process can be interrupted in between.	Process can not be interrupted until it terminates itself or its time is up.

Starvation	If a process having high priority frequently arrives in the ready queue, low priority process may starve.	If a process with long burst time is running CPU, then later coming process with less CPU burst time may starve.
Overhead	It has overheads of scheduling the processes.	It does not have overheads.
Flexibility	flexible	rigid
Cost	cost associated	no cost associated
CPU Utilization	In preemptive scheduling, CPU utilization is high.	It is low in non preemptive scheduling.
Examples	Examples of preemptive scheduling are Round Robin and Shortest Remaining Time First.	Examples of non-preemptive scheduling are First Come First Serve and Shortest Job First.

Answer to the question No - 7(c)

A **dispatcher** is a special program which comes into play after the scheduler.When the scheduler completes its job of selecting a process, it is the dispatcher which takes that process to the desired state/queue.

The **dispatcher** is the module that gives a process control over the CPU after it has been selected by the short-term scheduler. This function involves the following:

- Switching context
- Switching to user mode
- Jumping to the proper location in the user program to restart that program

Answer to the question No - 8(a)

There are mainly six types of process scheduling algorithms

1. First Come First Serve (FCFS)
2. Shortest-Job-First (SJF) Scheduling
3. Shortest Remaining Time
4. Priority Scheduling
5. Round Robin Scheduling
6. Multilevel Queue Scheduling

Answer to the question No - 8(b)

First come first serve (FCFS) scheduling algorithm simply schedules the jobs according to their arrival time. The job which comes first in the ready queue will get the CPU first. The lesser the arrival time of the job, the sooner will the job get the CPU. FCFS scheduling may cause the problem of starvation if the burst time of the first process is the longest among all the jobs.

Advantages of FCFS

- Simple
- Easy
- First come, First serve

Disadvantages of FCFS

1. The scheduling method is non preemptive, the process will run to the completion.
2. Due to the non-preemptive nature of the algorithm, the problem of starvation may occur.
3. Although it is easy to implement, but it is poor in performance since the average waiting time is higher as compare to other scheduling algorithms.

Answer to the question No - 8(c)

P1	P2	P3

0 18 21 24

Gannt chart

We know that,

Waiting Time(WT)=starting time-arrival time

Turn around Time(TT)=burst time+waiting time

Now,

process	AT	BT	WT
P1	0	18	0-0=0
P2	1	3	18-1=17
P3	2	3	21-2=19

Now ,Average waiting time=(0+17+19)/3=12 unit

Turn around Time=Burst Time+Waiting Time

So Average Turn around Time=(18+20+22)/3=20 unit