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OPERATING SYSTEM

NOTES

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Operating System

Lec 0

Syllabus of Operating System

1. Basic Introduction → types of OS
   Process diagram ✓ (Main)
   System call

**
2. Process scheduling (CPU scheduling)
   FIFO
   SJF
   Round Robin

3. Process synchronization → Semaphore ✓

4. Deadlocks and threads → Banker's algorithm

5. Memory management → Paging — Virtual memory
   Segmentation
   fragmentation
   Page replacement algo ✓

6. Disk scheduling
   - SCAN
   - CSCAN
   - FCFS

7. Unix commands
   - ls
   - mkdir
   - cd
   - chmod
   - Open system call

8. File mangament & Security
   - Sequential
   - Random
   - Linked

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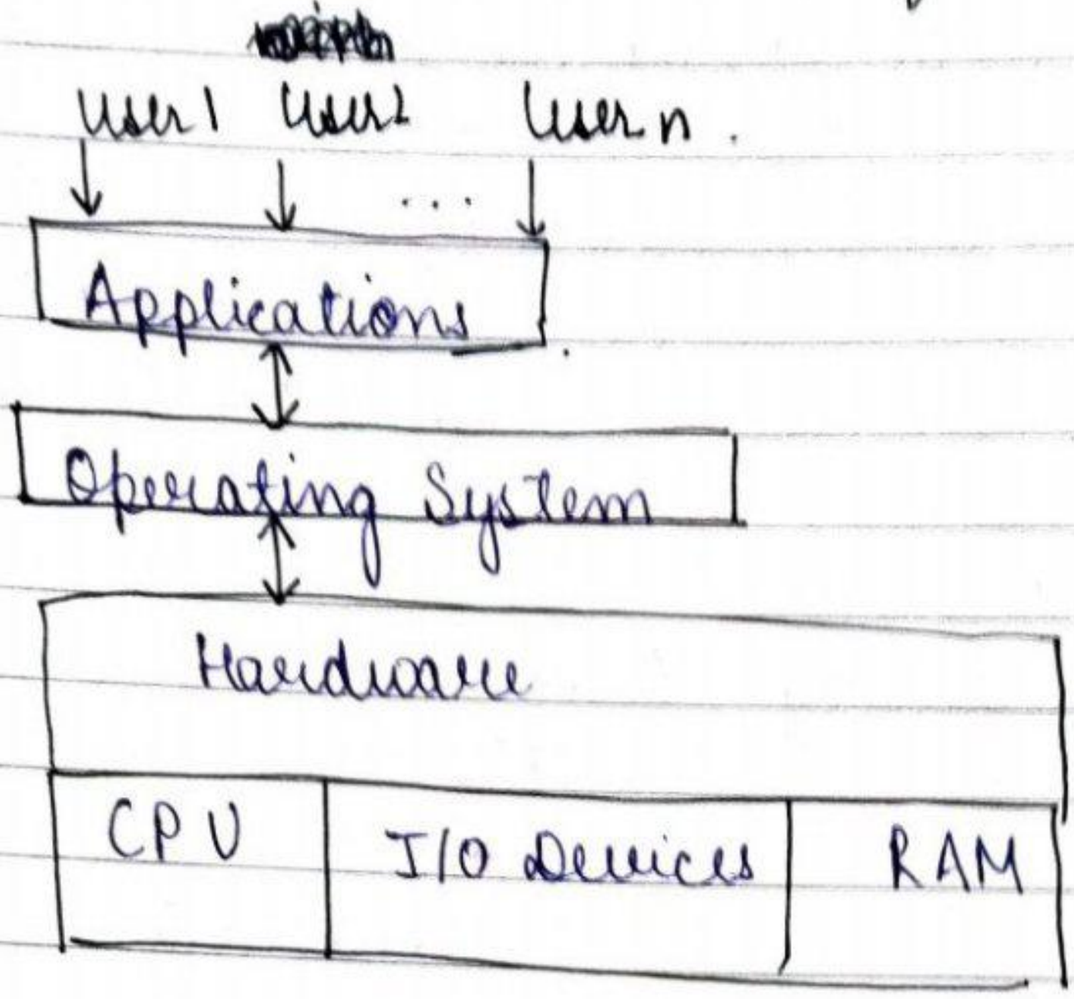
L-1.1

Introduction to OS and its function



Operating System :- It is a system software which works as an interface between users and hardware.

Job (process) :

User
↓
Operating system (interface)
↓
Hardware

Eg: Windows, Macintosh (Mac), Linux

Primary goal → To provide convinience to user.

Throughput → no of tasks executed per unit time. Eg- Linux

Functionality of Operating System

1) Resource management (kis user ko kitne particular time ke liye hardware ko provide krvana hai).

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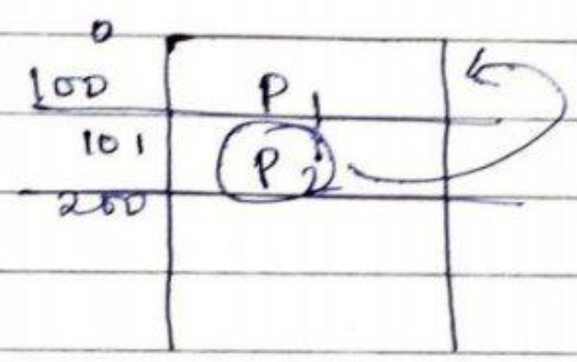
2. Process mangement - Managing & Executing multiple process at a time. We use CPU scheduling

program $\xrightarrow{\text{execute}}$ process

3. Storage management → How to store the data permanently using File system.
Eg - Hardisk.

4. Memory management (RAM) → RAM is limited in system. Every process before execution comes to RAM. Allocation & deallocation takes place.

5. Security and privacy - (Password protection)
Windows uses turbo security protocol.



It provides security betn. the process also.

Windows (Cmd)
Linux (Terminal)

OS works only through system calls.
(Read, Open, write)

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L-1.2

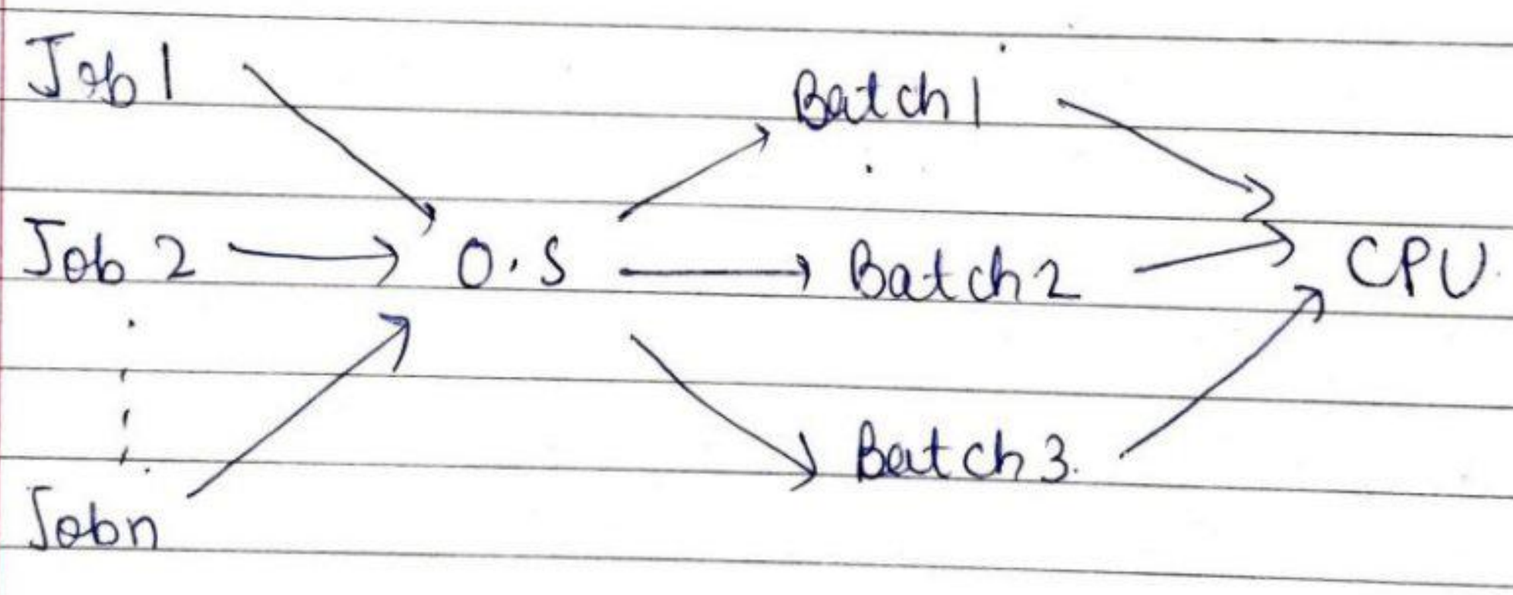
Batch Operating System.

Types of Operating System

1) Batch OS.
2) Multiprogramming OS.
3) Multitasking OS / time Sharing] Imp.
4) Real time OS
5) Distributed OS
6) Clustered OS
7) Embedded OS.

1) Batch OS

Similar (Batch) kind of jobs.



Same type of Jobs batch together and execute at a time.

Demerit: It processes one job at a time till the time CPU remains idle.

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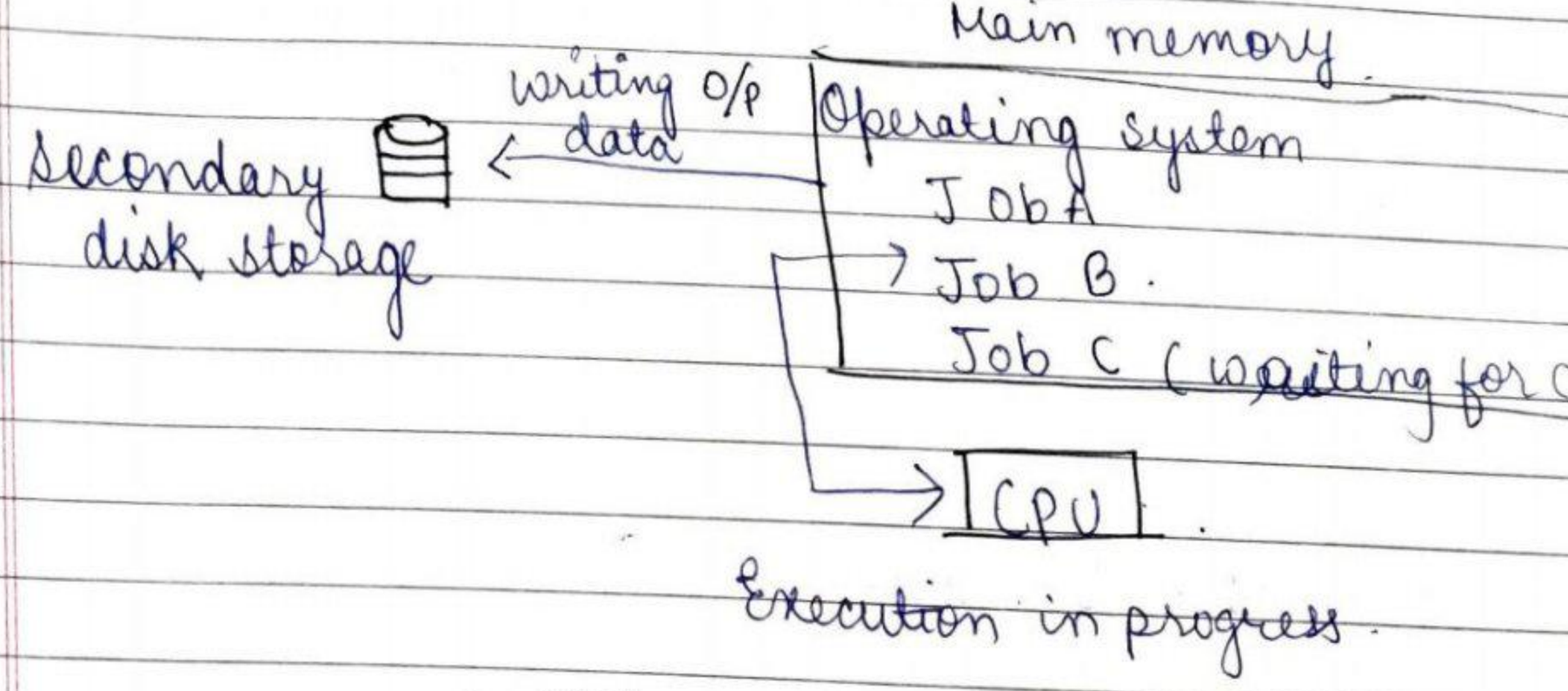
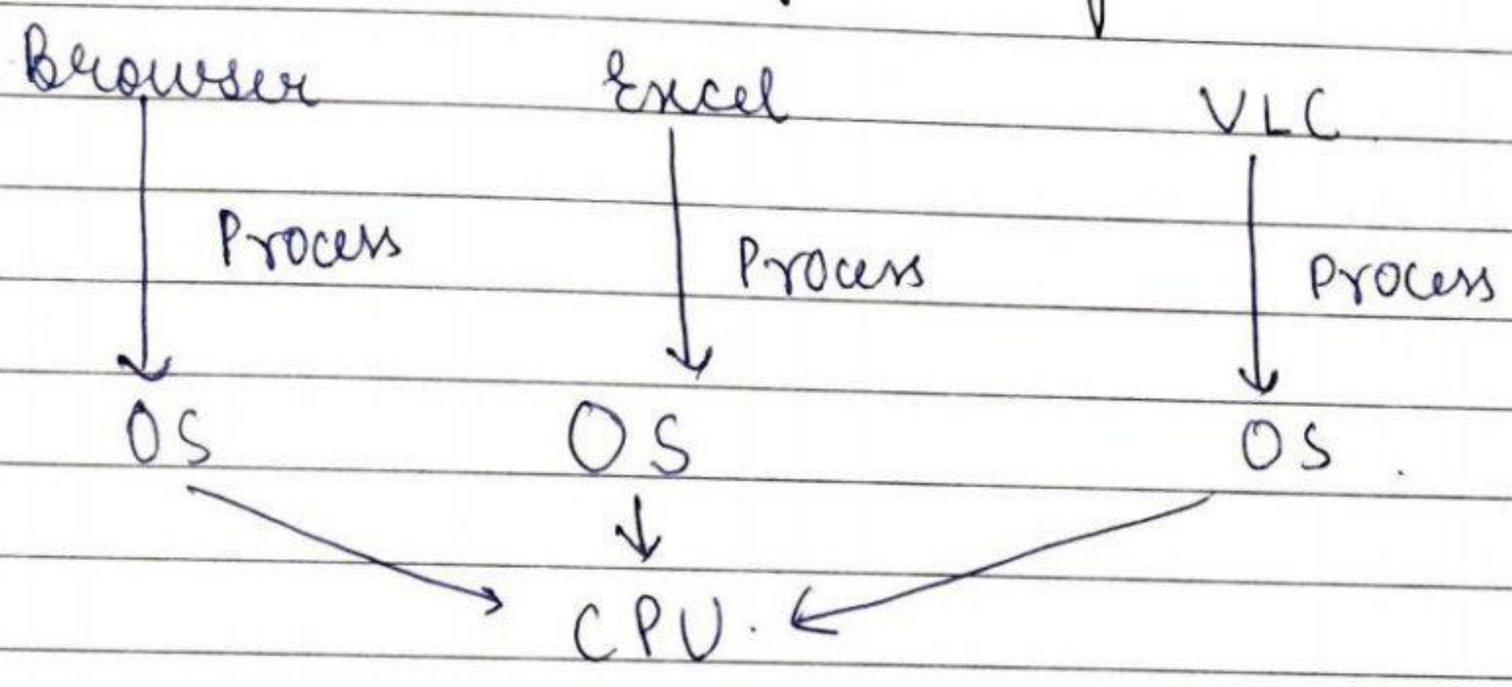
L-1.3 (Multiprogramming & Multitasking System)

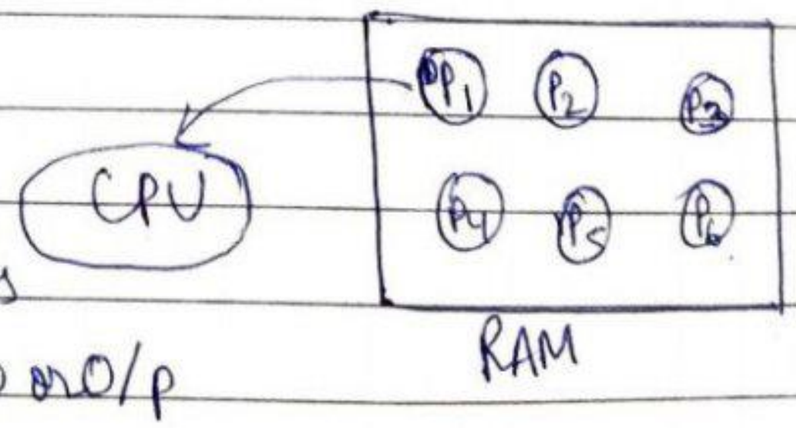


Multiprogramming OS / Time sharing



Multitasking OS

Multiprogramming OS.
Non preemptive
CPU executes a process completely untill or unless process demands any i/p or O/p operation.
Idleness should be removed



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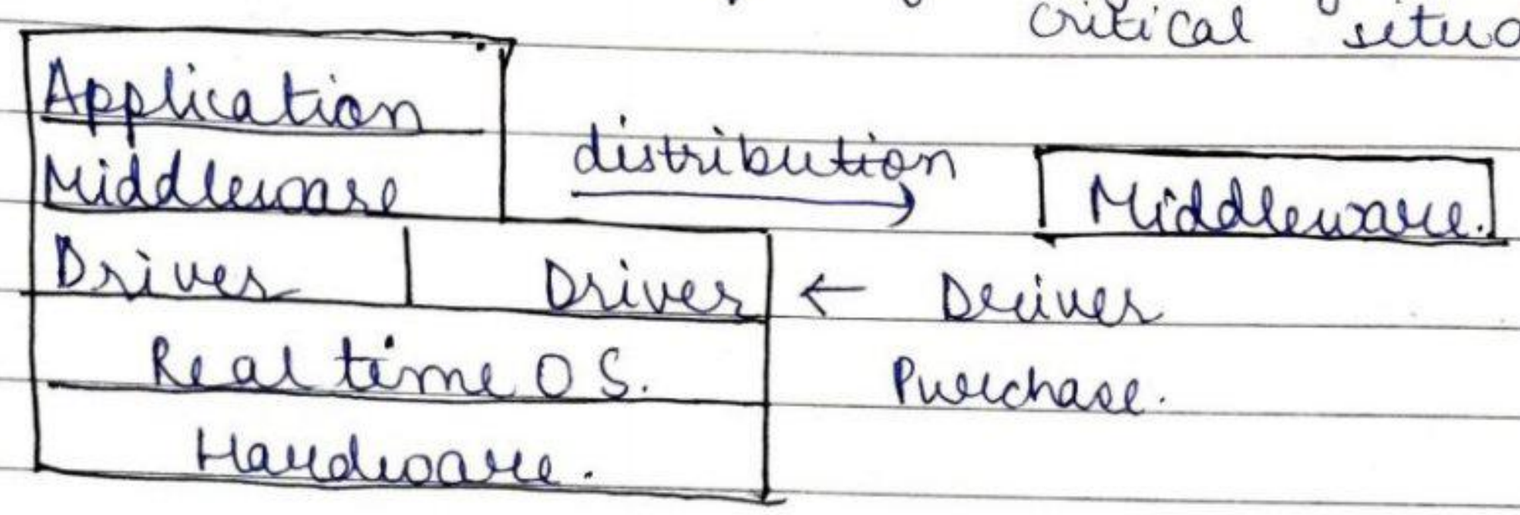
Multitasking / time sharing - Provides particular time for every process. If its complete its great but if not it moves to other process P2 & schedule P1 for further.

Response time is reduced for every process or job. Idleness is not there for CPU.

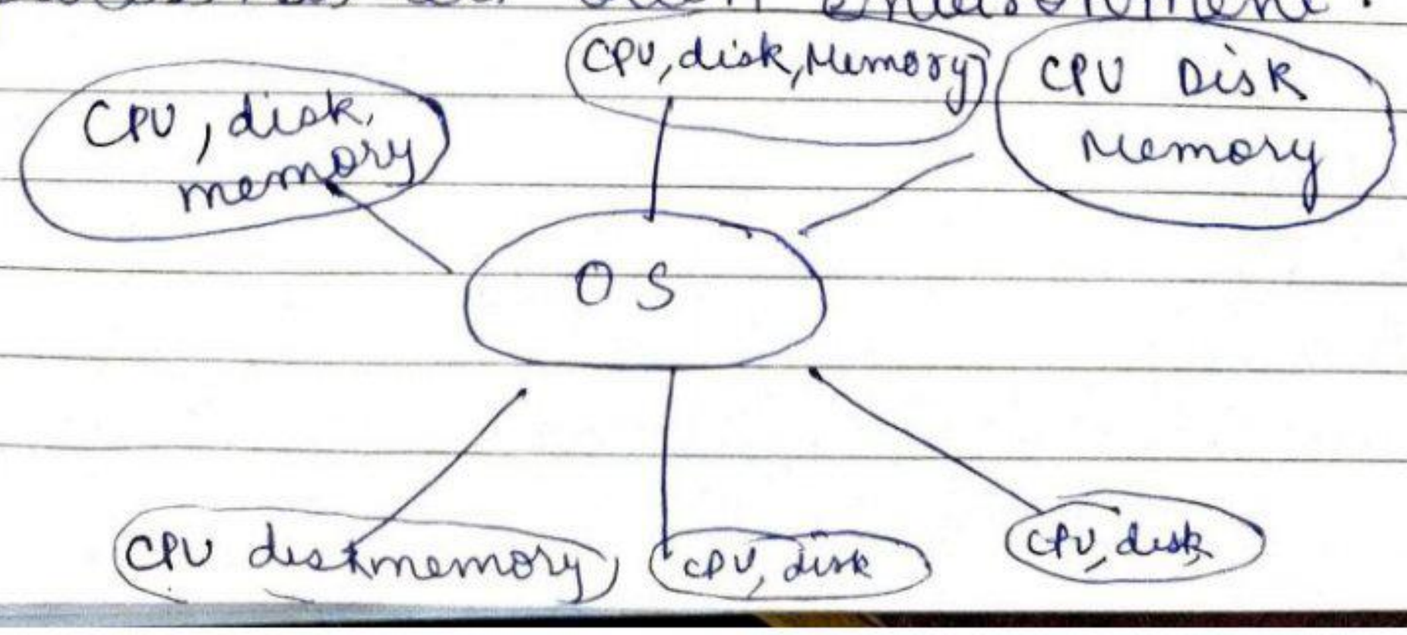
Lec1.4 Types of OS (Real time)

Real time OS → Hard (Restriction on time is more)
→ Soft Eg - In gaming no critical situation



Immediate output
1) No delays

Distributed → Processing environment is distributed all over the world. Every process has its own environment.



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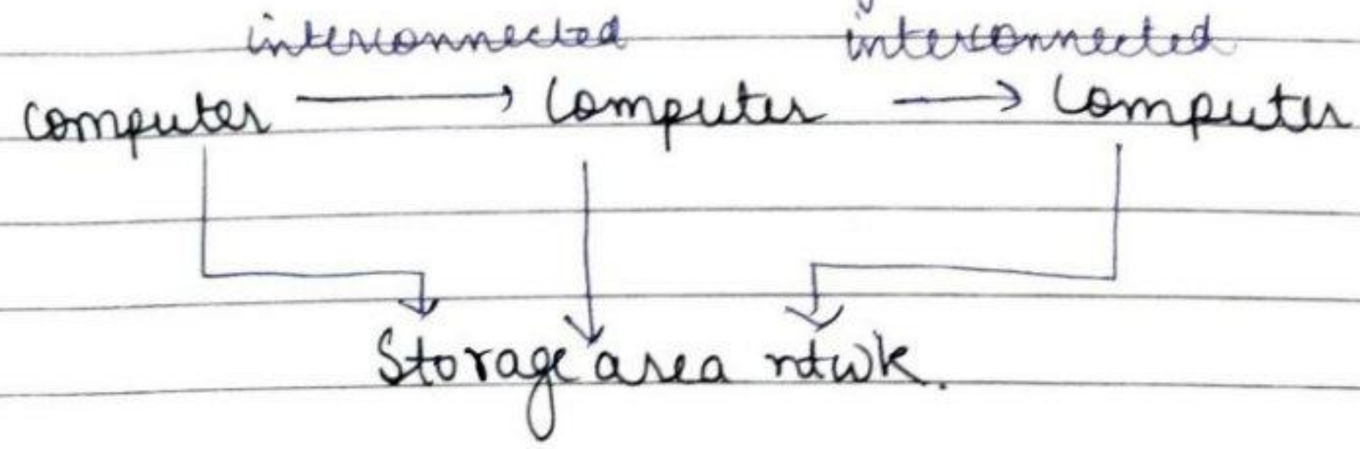
It uses multiple central processors to serve multiple real-time applications & multiple users using telephone wires.

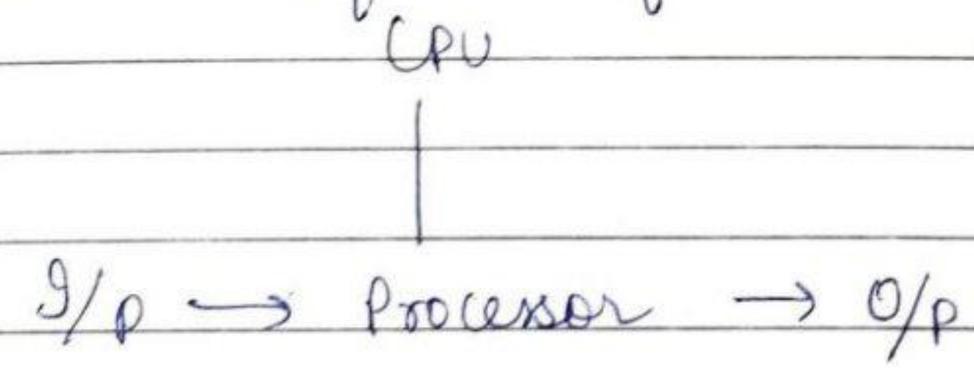
Clustered OS. → ~~Clusters~~ Clustered OS share storage and are closely linked via lan or a faster inter connection.

Group of connected computer

* fault tolerance, scalability

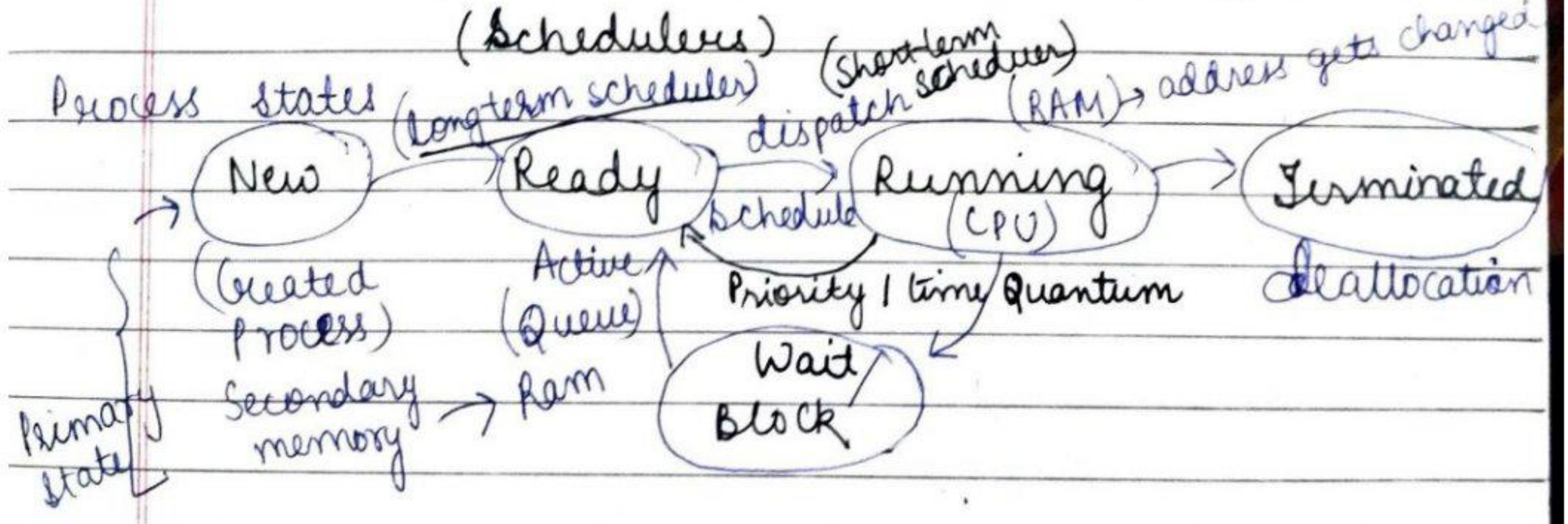


Embedded OS - It is a special purpose computer designed to perform one or few dedicated func^n^s with real time computing. Works on a fixed functionality.



Sec - 1.5 Process states in OS

(Schedulers)



Long term scheduler - Bring more to more process in ready state.

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LTS - long term scheduler
STS - short term scheduler.
Non premptive. Preemptive.

Non preemptive - Running process isn't stopped at middle
Preemptive - Running process stopped at middle

X X

Syllabus of OS.

1. Basic Introduction : What is O/S, Goals, need, System calls, diff^n OS.

2. Process M/g : what is process, Algo - FIFO, SJF, Preemetive, Non premtive, Round Robin

3. Deadlock - Banker Algo

4. Concurrency control - Semaphore, msg passing, race cond^n.

5. Memory - Paging, Segmentation, Fragmentation virtual memory, Page Replacement.

6. Disk M/g - C-look, Algo, FCFS, SSCF, look

7. File m/g : NIFS, FAT32, Seq., Random

8. Unix System : commands.

9. Case study : MSDOS

10. Security - Attacks, Firewalls exceptions

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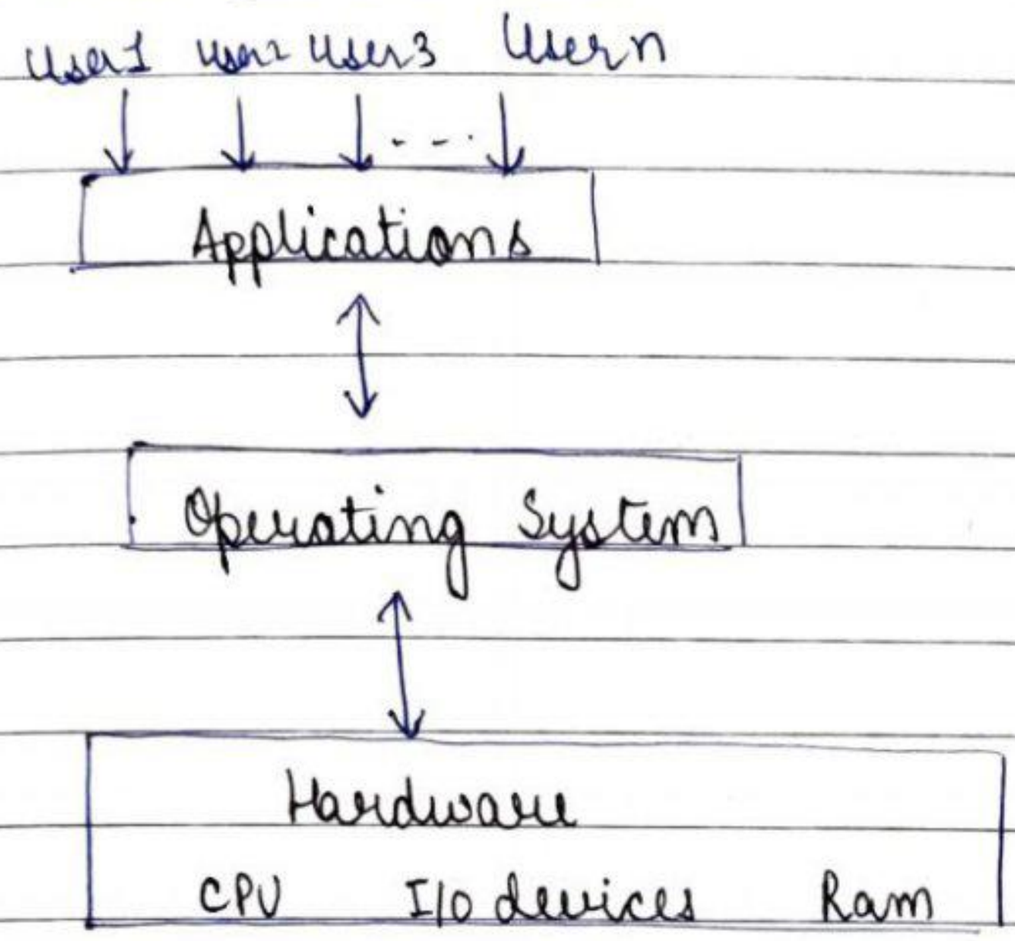
L-1.1

Operating system acts as an interface between user and hardware. If there is no OS user has to write a program to interact with hardware.

Primary goal- Its primary goal is to provide convenience to the user.



Throughput - No of tasks executed per unit time.
eg → linux

Functionalities of OS.

1) Resource management- In case of multiuser managing, OS acts as key to provide hardware among the users for a given time. When many users are sending request at a time so we use OS so that there is no load on system.

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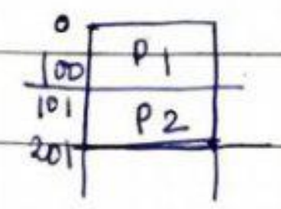
2. ~~Storage~~ Process management → Performing multiple process at an time, OS uses CPU scheduling algorithms for processing & executing in a proper & efficient way

3. Storage management (Hard disk) - How to store data in hardisk using file system management is done by OS.

4. Memory management (RAM) - In RAM we have limited no of size. Every process which gets executed goes in RAM there is allocation & deallocation done by OS in RAM after the process is done.



5. Security & privacy
It provides security & privacy between the process such that it doesn't gets blocked. Password protection

Windows (cmd)
Linux (terminal) } System calls (Read, open, write)

1.2.
Types of OS

1) Batch OS
2) Multiprogramming
3) Multitasking
4) Real time OS
5) Distributed
6) Clustered
7) Embedded

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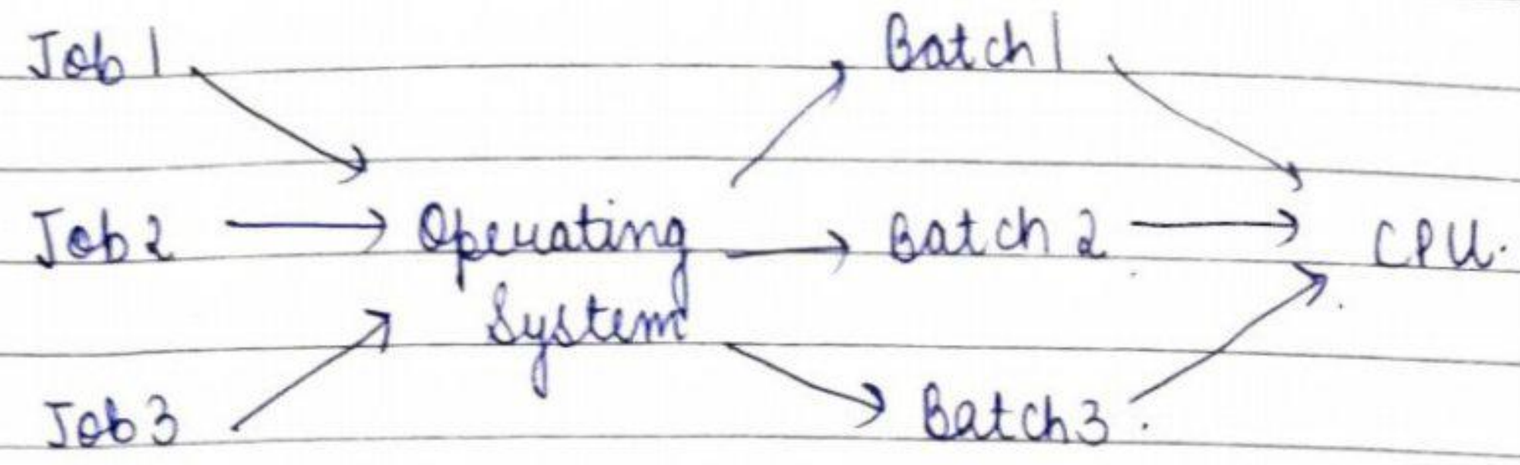
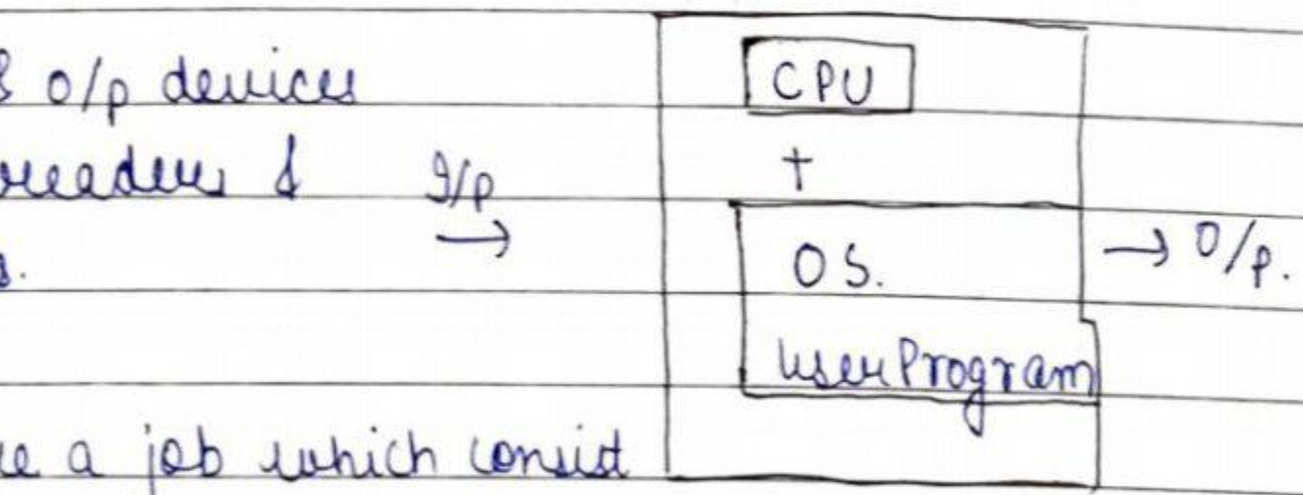
1) Batch OS

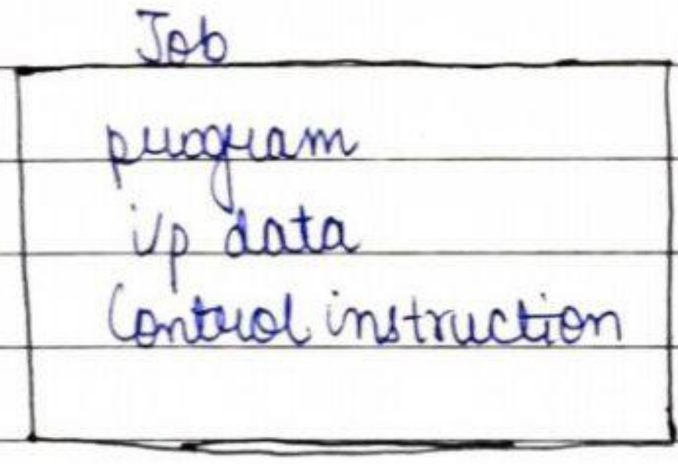


Before batch OS., we used mainframe Computers

1) Common i/p & o/p devices were card readers & tape drivers.



2) User prepare a job which consist of the program I/p data & control instructions.



3) I/p Punch card O/p (punch card)

Major problem was.

1) Speed mismatch (user & CPU)
2) Less memory
3) Every job has diff^n req^m

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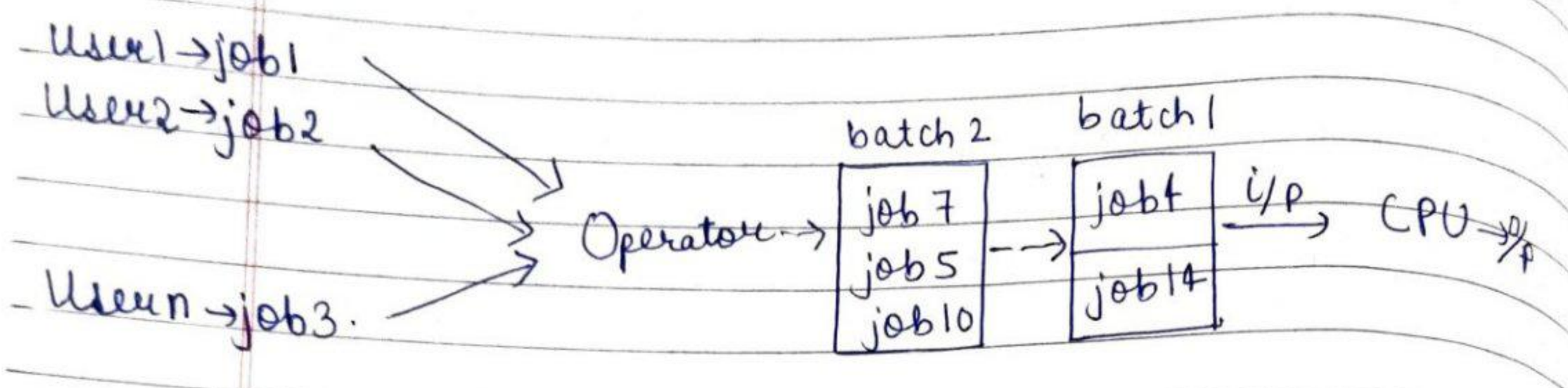
1. Batch processing OS (Eg : payroll system)



1) Jobs with similar needs are batched together and executed through the processor as a group

2) Operator sorts job as a deck of punch cards in a batch with similar needs.
Eg - FORTAN batch, COBOL batch etc.

3) first jobs → batch (with same req) → CPU

Advantages
1) In batch job execute one after another saving time for activities like loading compiler.
2) During a batch execution no manual intervention is needed.

Disadvantage
1) Memory limitation
2) Interaction of i/p & o/p devices directly with CPU.
3) CPU remains idle during loading & unloading

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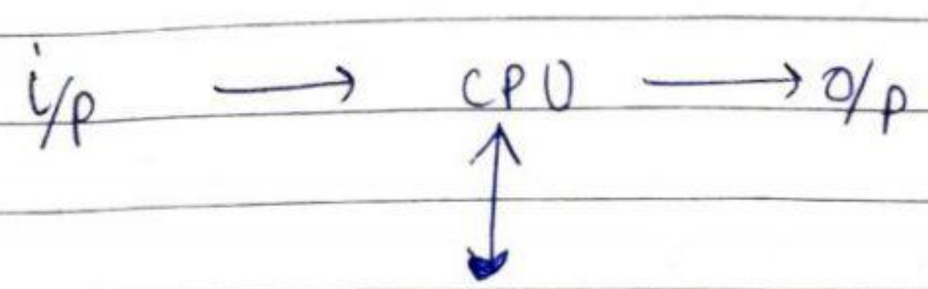
Spooling (Simultaneous preipheral device)
i/p or o/p



Secondary storage.

temporarily process is storage in secondary storage.

Advantages
1) Increase the system performance
2) Spooling resolve the problem of speed mistratch of diff^n. device
3) I/O of one job is overlapped with the computation of other jobs.
4) Spooling use the disk as a huge buffer.

Spooling	Buffering
Uses the hard disk as a large spool (spool is a temporary storage area in hard disk)	Uses limited memory space in RAM usually called buffer (Buffer is a temporary storage area in RAM)

1.3

2. Multiprogramming OS

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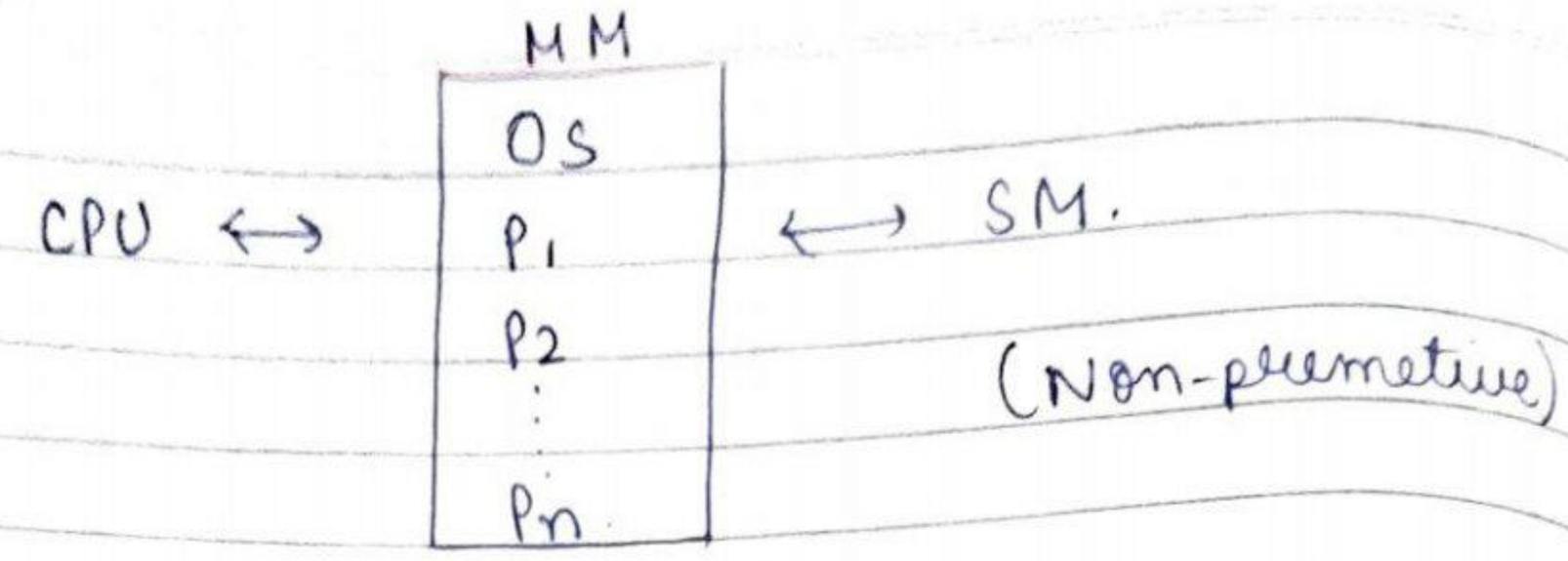

1) Maximize CPU ultization
2) Multiprogramming means more than one proces in main memory which are ready to execute.
3) Process generally requires CPU time & I/O time. So if running process perform i/o or some other event which don't require CPU then instead of sitting idle, CPU make a context switch & pick some other process & this idea will continue.
4) CPU never remains idle unless there is no process ready to execute or at the time of context switch

Advantage	Disadvantage
1) High CPU utilization.	1) Difficult Scheduling
2) less waiting time, response time etc	2) Main memory management is required
3) May be executed to multiple users	3) Memory fragmentation
4) Now a days usefull when load is more	4) Paging (non contiguous memory allocation)

3. Multitasking OS. (Eg Unix)

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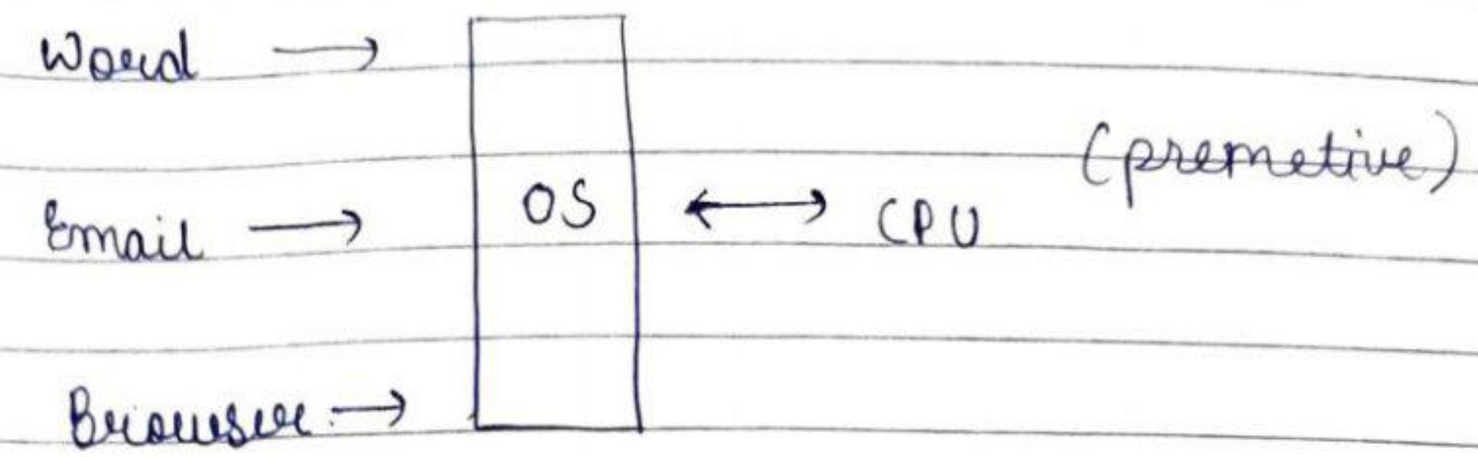
Time sharing / Fair share / RR



1. Multitasking is multiprogramming with time sharing
2. Only one CPU but switches betn process so quickly that it gives illusion that all executing at same time.
3. the task in multitasking may refer to multiple threads of the same program
4. Main idea is better response time & executing multiple process together.

4. Real-time OS - It is used in environment where a large no of events mostly external to system must be accepted & processed in a short time within certain deadlines. The time interval required to process & response to input is very small.
Hard RTOS - It guarantees critical task to be completed within a range of time.
Eg - a robot hierd to weld a car body

Soft RTOS - It provides some relaxation in time.

Advantages
1) Max^m. utilization of devices & system
2) Better task shifting
3) Systems are error free

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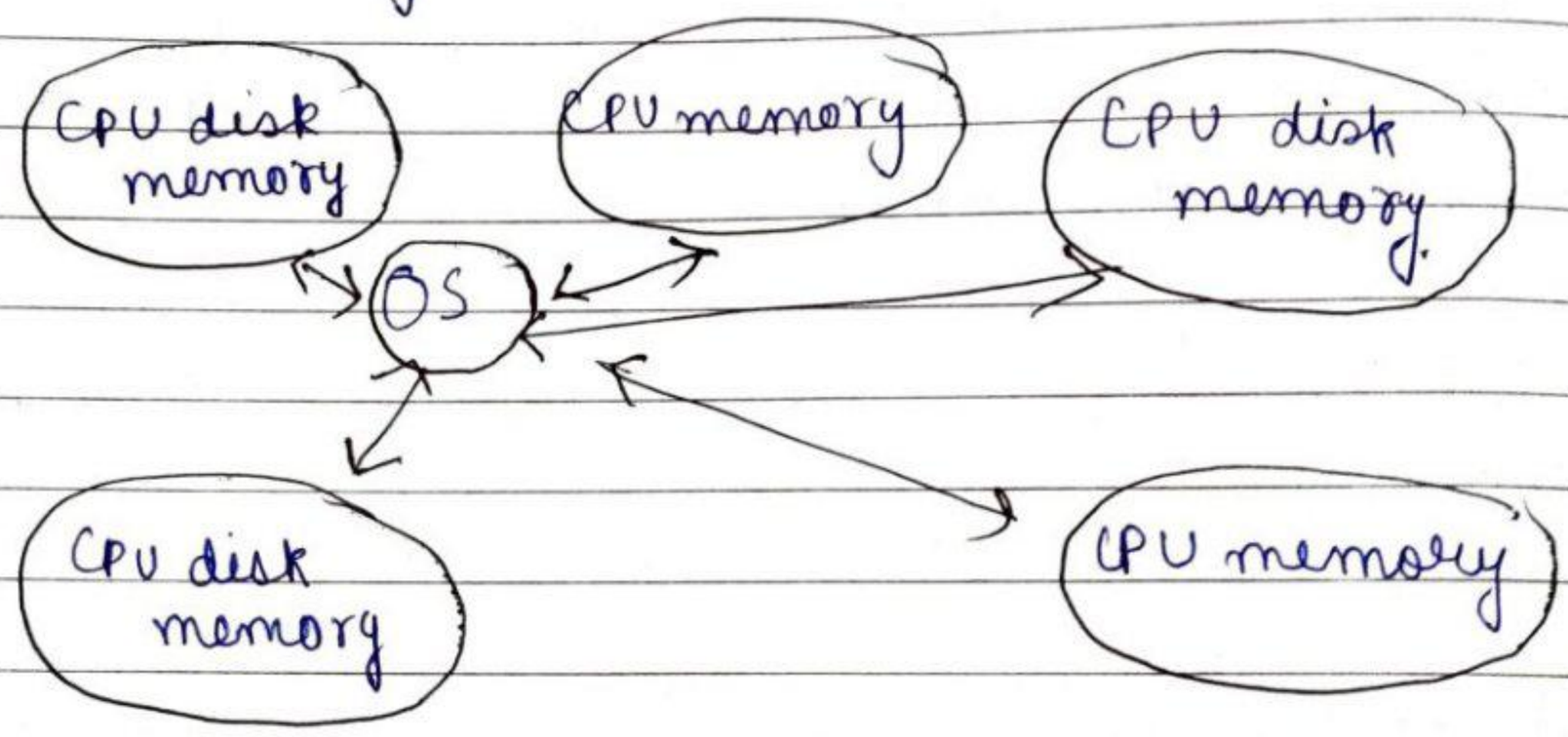
Disadvantages
1) Limited tasks
2) Complex algorithms
3) Use heavy system resources

5) Distributed OS. (Eg - LOCUS)
Distributed system uses multiple central processors to serve multiple real time application & multiple users. Data processing jobs are distributed among the processors accordingly.

Processors communicate with each other through various communication lines (such as high speed buses or telephone lines). These are referred as loosely coupled systems or distributed system.



Advantages
1) Failure of one ntwk connection doesn't affect other
2) Delay in data processing reduces.

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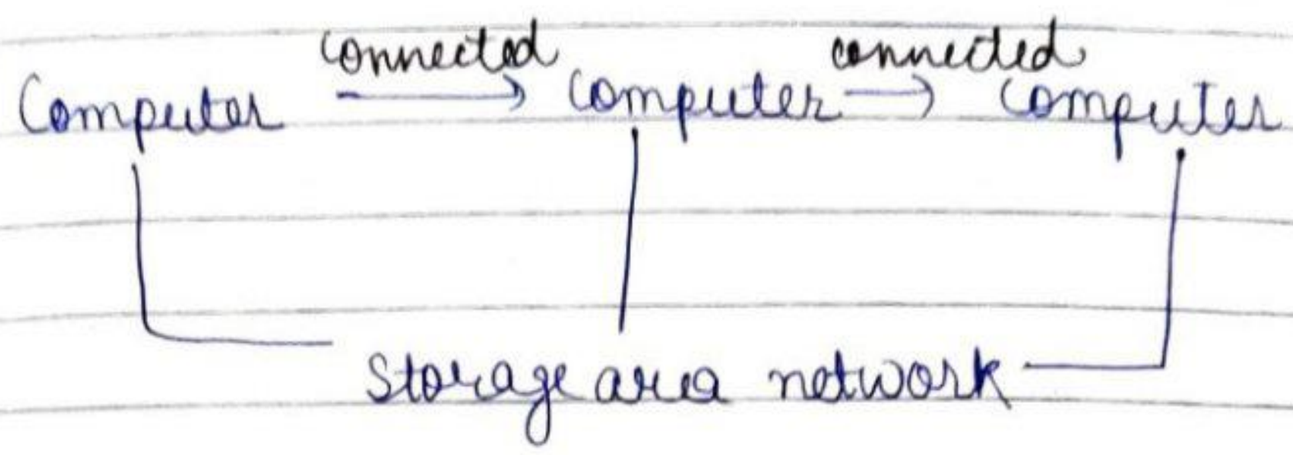
Disadvantages

1) Failure of main ntwk will stop entire communication

6) Clustered OS

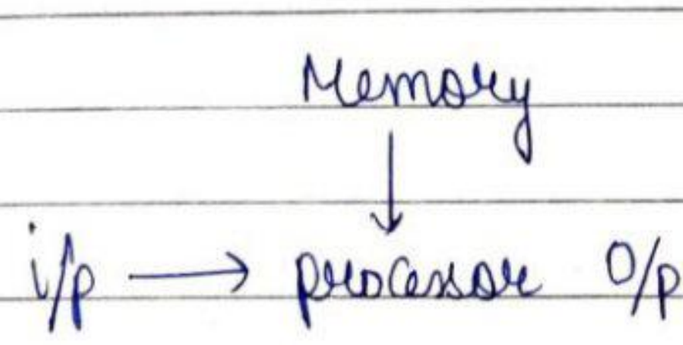
1) Clustered computers share storage & are closely linked via LAN or faster connection.

2) Combⁿ of multiprocessor + distributed OS



7) Embedded OS. - An OS in which we work on embedded systems. It is designed to perform a specific task for a device that is not in computer

Eg - ATM



1.5

Process states in OS

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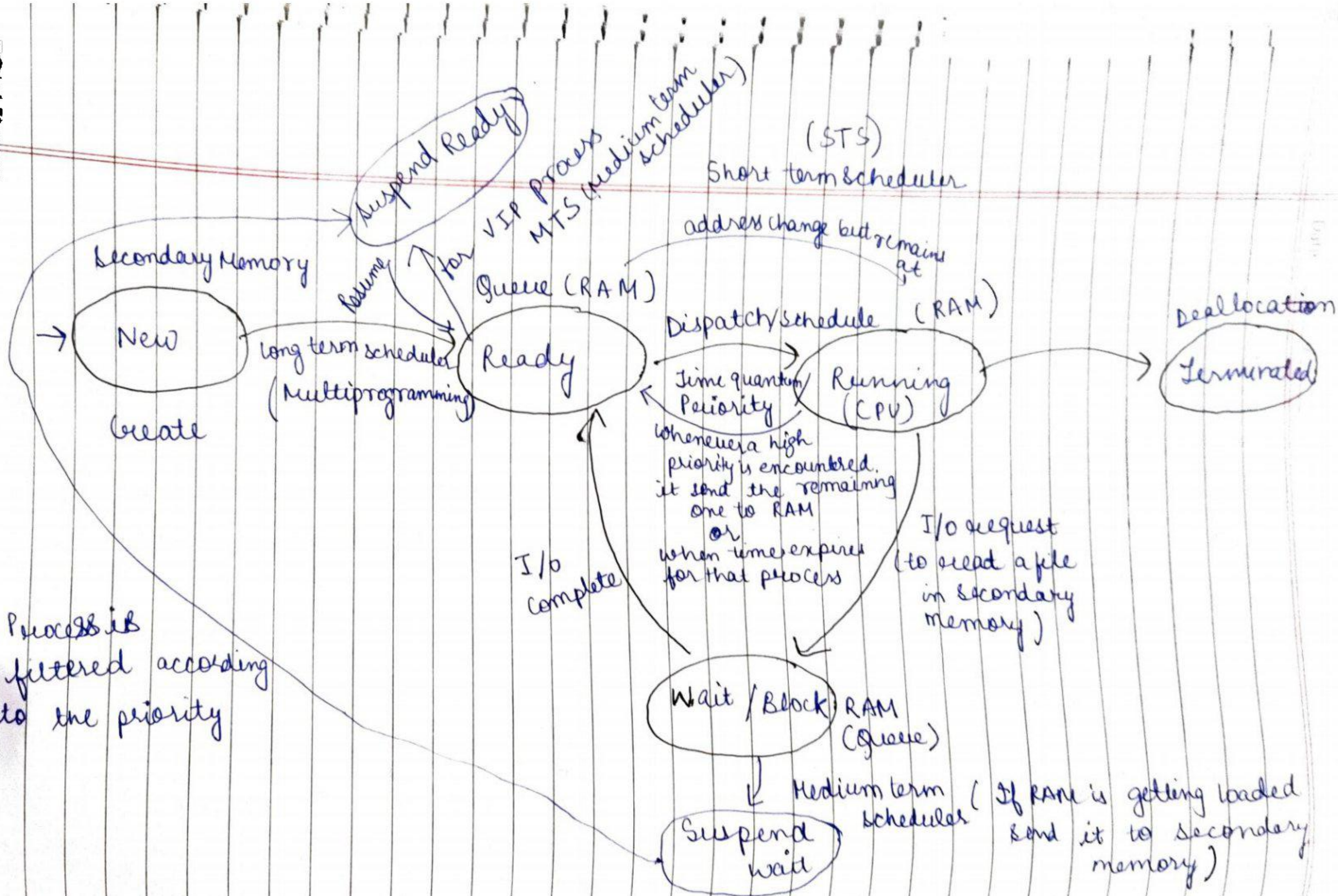

Date / /

* Non preemptive - No time quantum, no process can jump in between
* premptive - We stop the running process in midway due to high priority process

L-1.6

Linux Commands.

Q. which command is used to assign only Read permission to all three categories of file 'note'.

a) chmod a- rw
b) chmod go+ r note
c) chmod ugo = r note
d) chmod. u+ r, g+ r, o-x note

chmod - change mode

r w x r w - r w x

user group others

u - user
g - group
o - others.

rx rwx
6 7

r - read 4
w - write 2
x - execute 1

Q. Chmod ugo+rw note command can represented in octal notation as

1) Chmod 555 note
2) Chmod 666 note
3) chmod 333 note
4) chmod 444 note

r+w = 4+2 = 6.

Q. Suppose you have a file "f1" whose contents are

1234567890abcdefghij

here lseek is used 2 times sequentially.

lseek (n, 10, SEEK_CUR);
lseek (n, 5, SEEK_SET);

n is file descriptor. After applying lseek 2 times, what will be the current position of R/W head? (Index starts from 0)

a) 0.
b) 5
c) 10
d) 15.

lseek - system call (To move read write head we use lseek command)
by default read write head is at 0.

lseek1

1234567890abcdefghij

lseek2

10, seek_cur → move to the given no from the current
5, seek_set → set the current pos at given
-2, seek_end → Count from the end towards left.

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L-1.7

System Calls in OS.

User mode $\xrightarrow{\text{system call}}$ Kernel mode

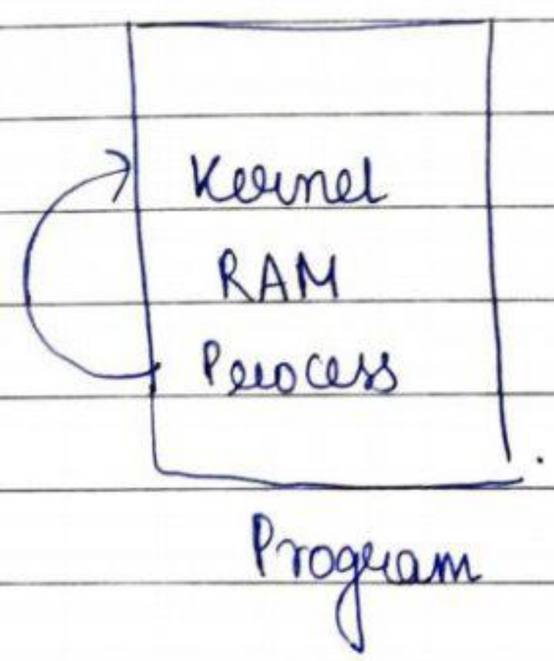
2+4 $\xrightarrow{\text{monitor}}$, print (6)

In linux we can use system call directly.

printf() $\longrightarrow$ accessing system call

System calls.

1) File related SC → open(), Read(), write(), close() create file etc.



2) Device related → Read, write, reposition ioctl(i/p o/p control), fcntl(file related control)

for hardware devices

3) Information → Process or regarding devices attributes

For eg:- getPid, attributes, get system time & data.

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4) Process control → Program being loaded
→ load, Execute, abort, fork, wait, signal, allocate etc.

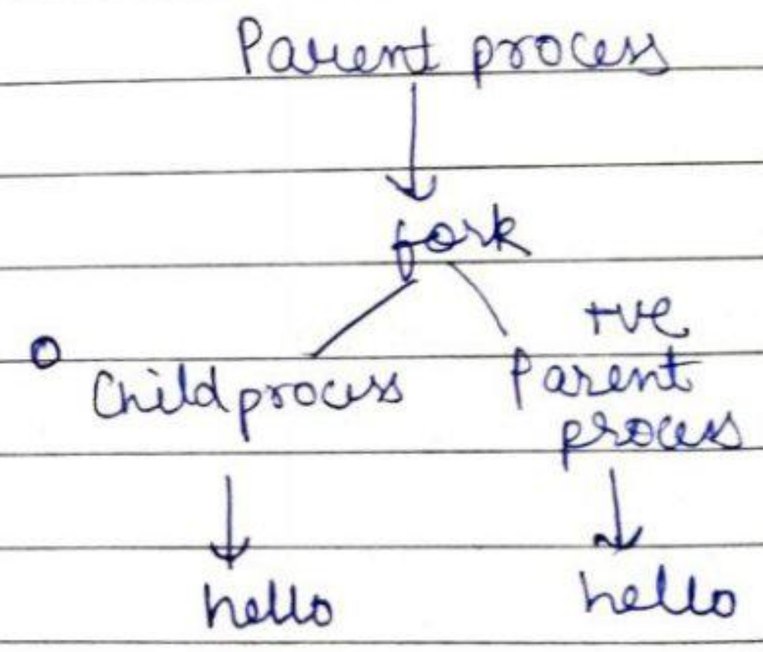
5) Communication control- Interprocess communication
→ Pipe(), create/delete connections, Shmgt()

L-1.8
Fork system call

To create a child process from parent process we can use fork() or thread.

fork()
- 0 child process
- +1 parent process
- -1 child process not created

```
main() {
fork();
printf("hello");
}
```




```
main() {
 fork();
 fork();
printf("hello");
 }
```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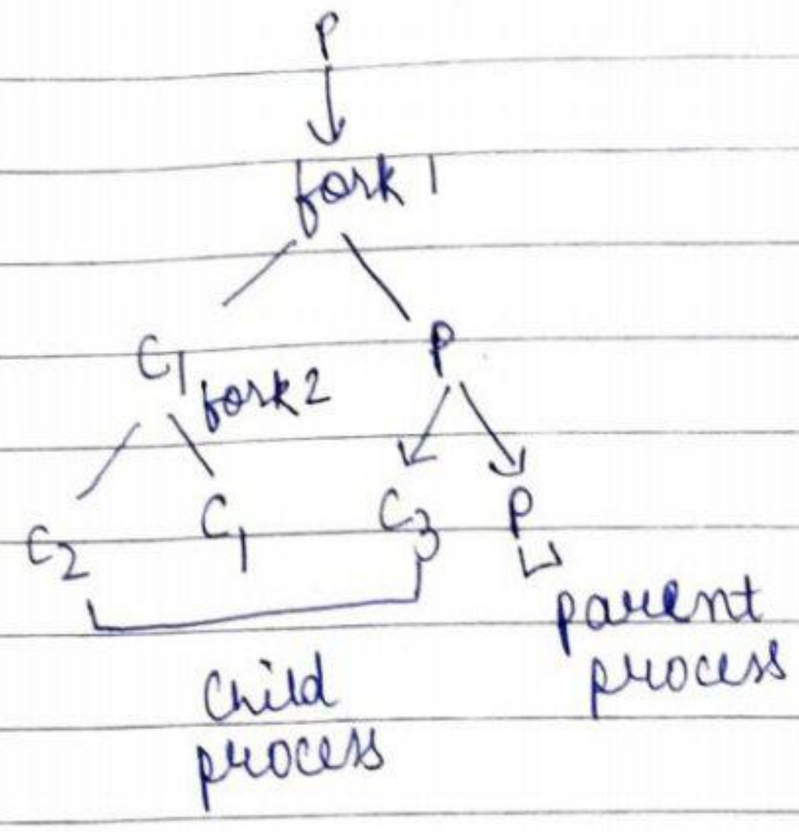
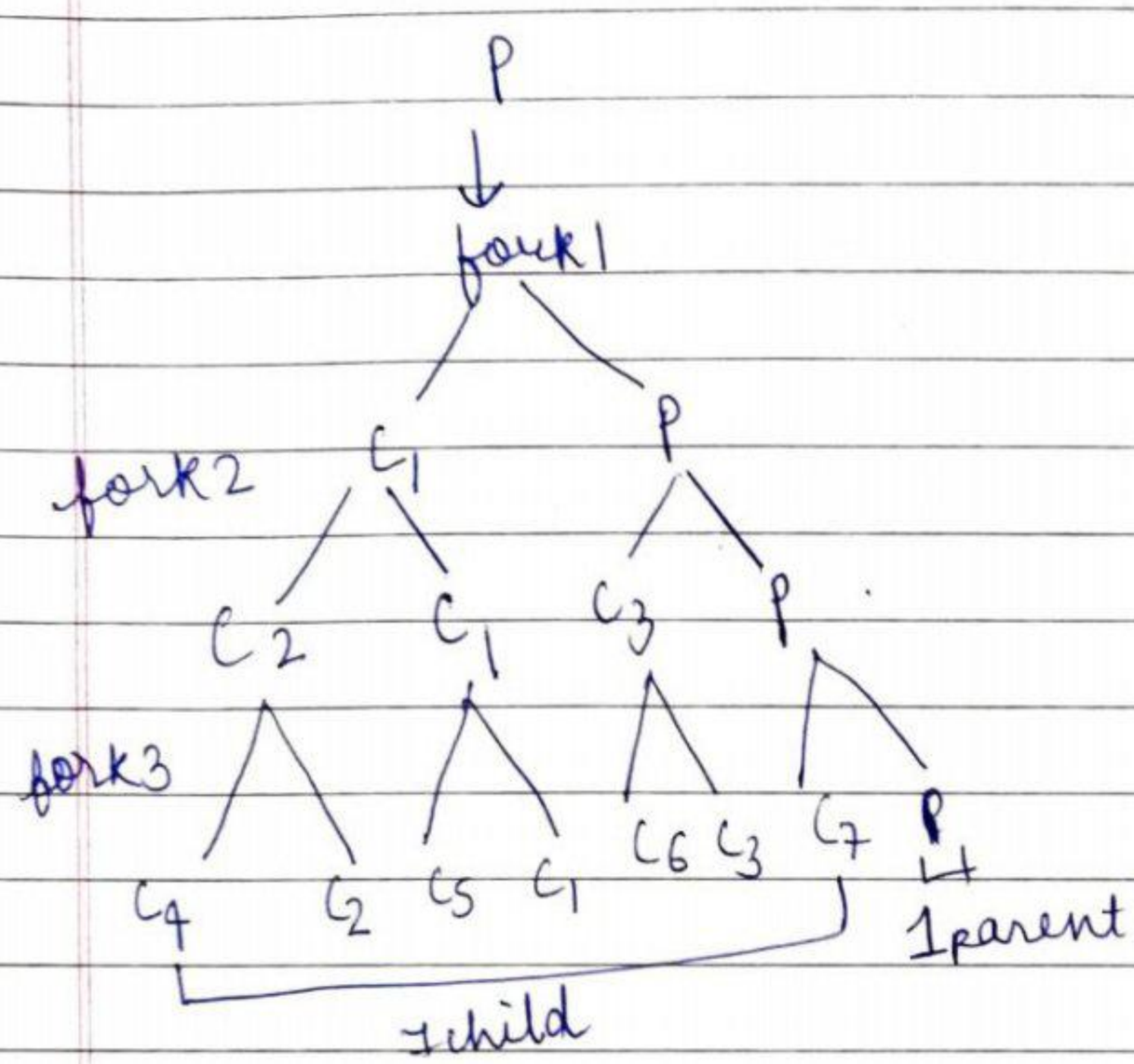


4 times Hello.



8 times hello.

$= 2^n$ $n =$ no of fork.

$2^n - 1 \Rightarrow$ child process

L-1.9

Questions on fork System Call

```
# include <stdio.h>
# include <unistd.h>

int main ()
  {
   if (fork() && fork())
      fork();
   printf("Hello");
   return 0;
```

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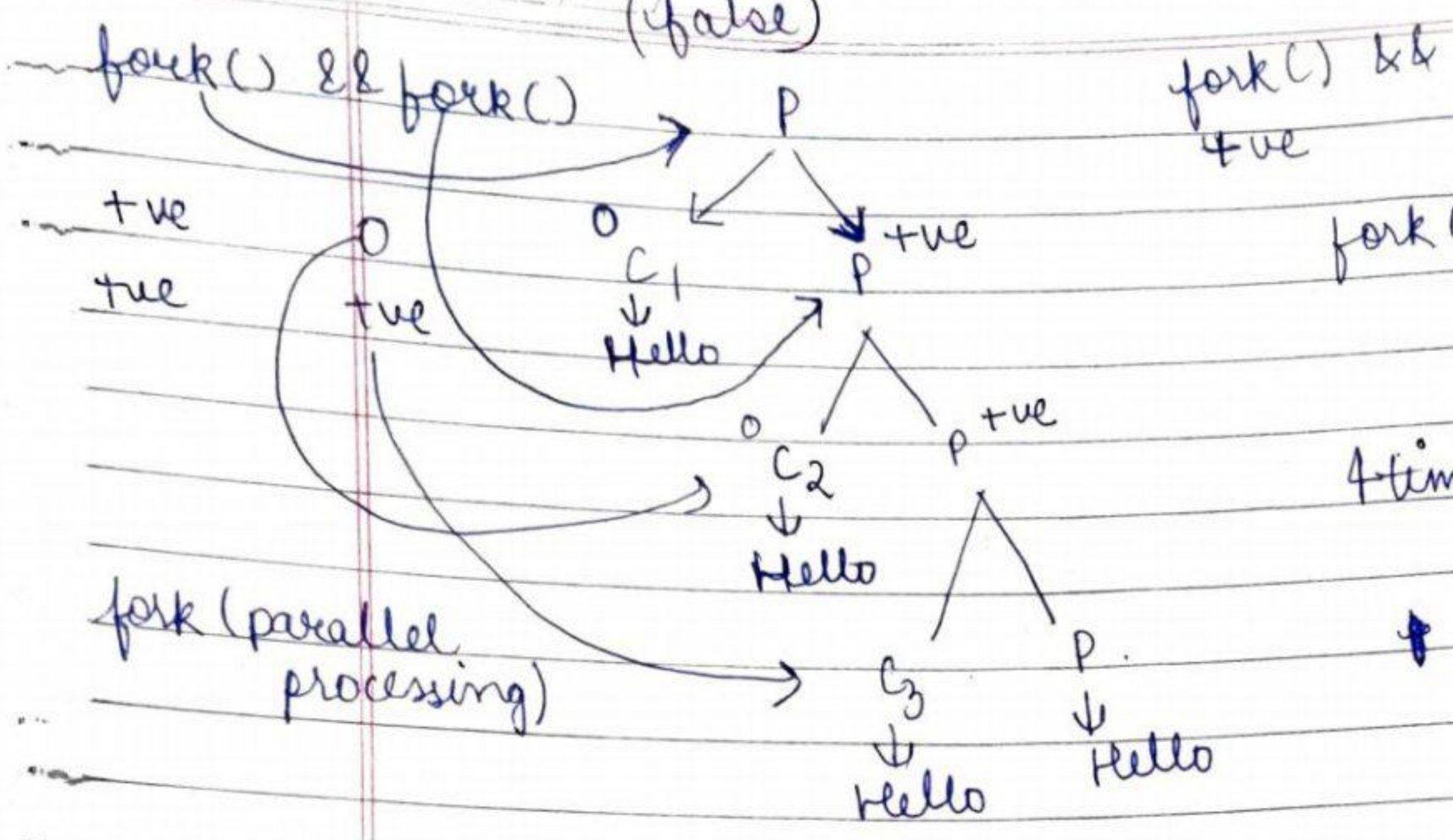
fork() && fork()
0 +ve
(false)

fork() && fork()
+ve 0

fork() && fork()



fork() && fork()
+ve +ve

fork();

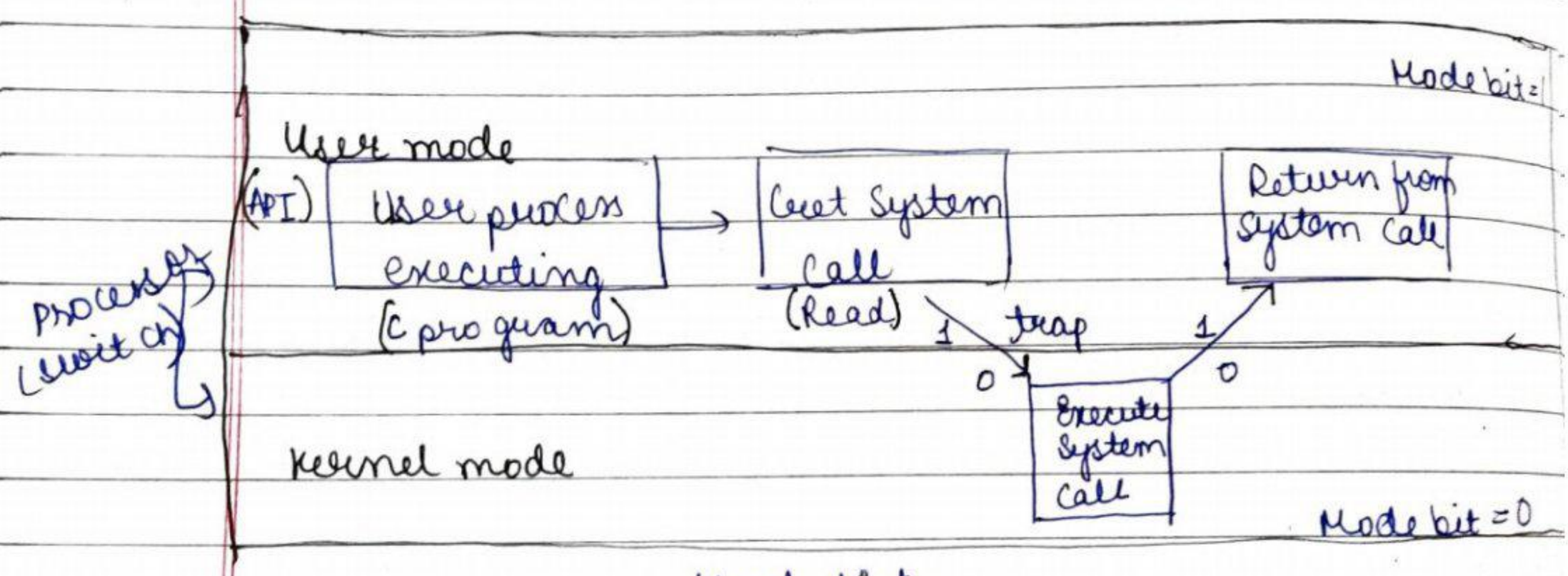
4 times hello.

fork (parallel processing)

L-1.10

User mode & Kernel mode.

Kernel is the central component of an OS that manages operations of computer and hardware.
It basically manages operat^n's of memory & CPU time



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Date 1 ⟶ 0

bank ⇆ window ⇆ money

usermode Kernelmode

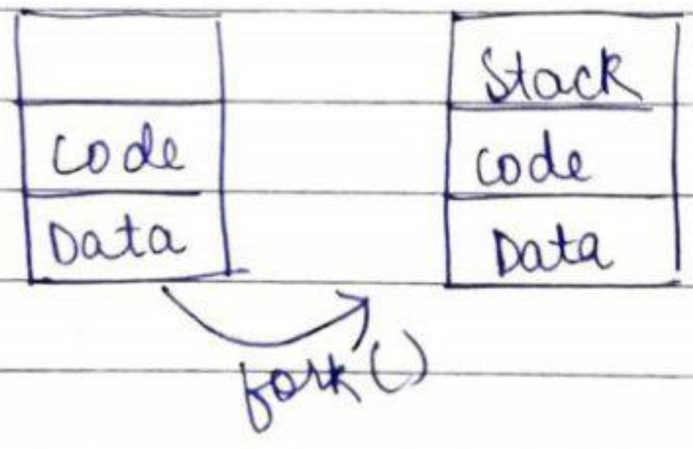
1 ⟵ 0

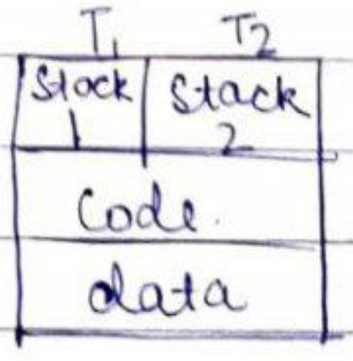
L-1.11

Process Vs Threads in OS

Process - It is a heavy weight task
Thread - It is a light weight task
] multitasking environment

Process	Thread (User level)
1) System calls involved	1) No system call involved
2) OS treats diff^n. process differently.	2) All user level threads treated as single task for OS.
3) Diff^n process have diff^n copies of data, files, cache	3) Threads share same copy of code
4) Context switching is slow	4) Context switch is fast
5) Blocking a process - not block other	5) Blocking a thread - block entire process
6) Independent	6) Interdependent





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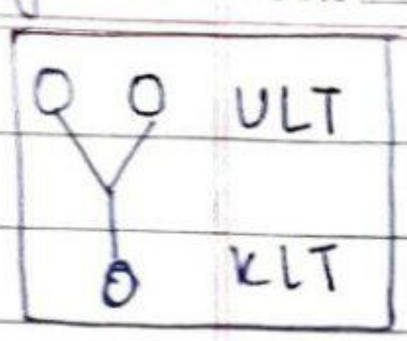
Hybrid environment



L-1.12

User level & Kernel level thread

code & data is shared
have own stack but

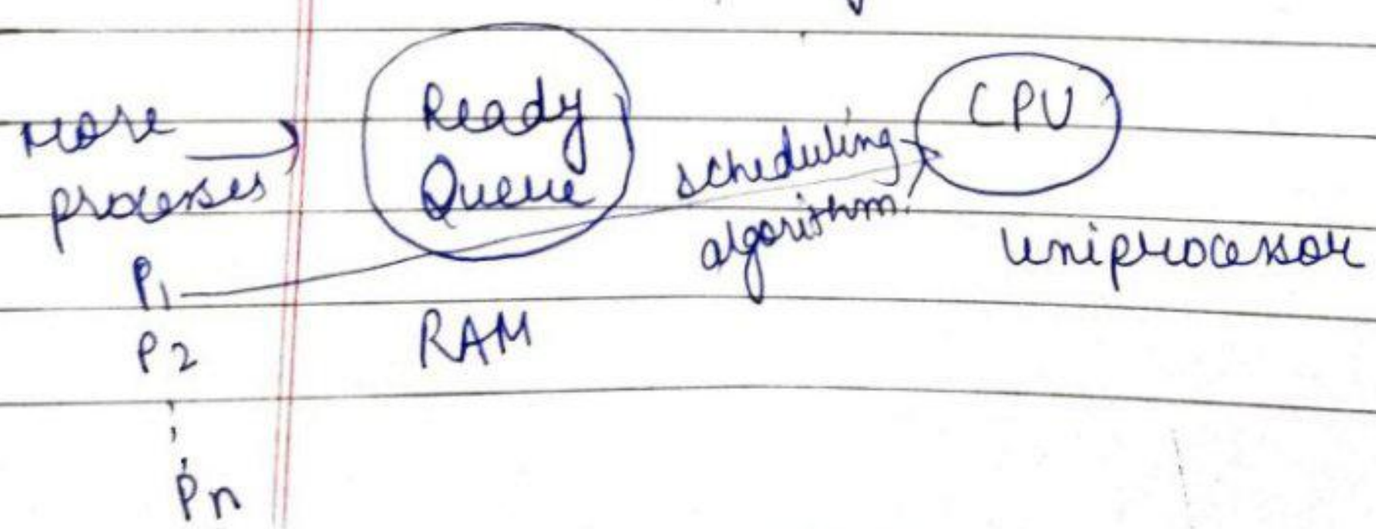
User level thread	Kernel level thread
1) User level thread are managed by user level library.	1) Kernel level threads are managed by OS (system calls)
2) User level threads are typically fast	2) Kernel level threads are slower than user level
3) Context switching is faster.	3) Context switching is slower.
4) If one user level threads perform blocking operation then entire process get blocked	4) If one kernel level thread blocked no affect on others.

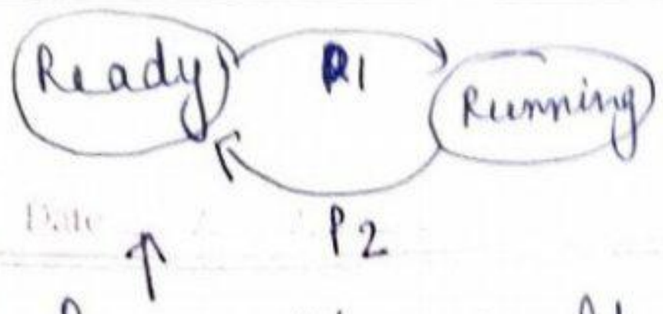
(Context Switch) Process > KLT > ULT

L - 2.1

Process scheduling Algorithms

A way of selecting an algorithm from ready queue & putting it on the CPU.

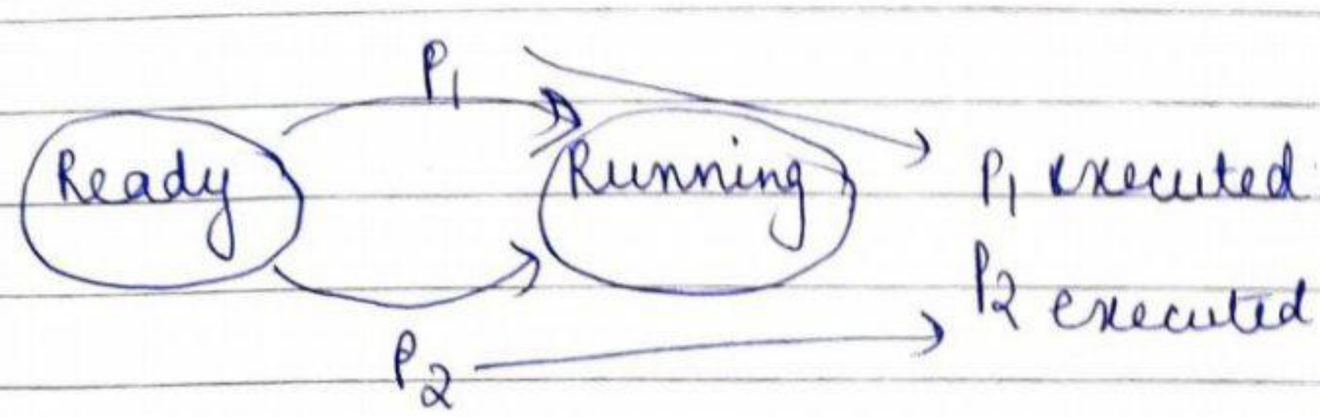




Reasons
1) Time quantum (provided time for P_1)
2) Priority process

* Preemptive → If a process is taken out from ready queue or RAM and is put in running process (queue) (CPU). Then we can stop the process P_1 & give another process p2 & send p1 to ready queue. It provides responsiveness

* Non preemptive ⇒ If a process is taken out from ready queue it would be processed till its burst time, after then only new process can be introduced.



Scheduling Algorithms

Preemptive	Non preemptive
BT ← 1) SRTF (Shortest Remaining time first)	1) FCFS (First come first serve) → AT
BT ← 2) LRTF (Longest remaining time first)	2) SJF (Shortest Job first) → BT
TQ ← 3) Round Robin → placed in ready queue in descending order of burst time	3) LJF (Longest Job first) → BT
4) Priority based → Priority given	4) HRRN (High response ratio next).
	5) Multilevel Queue
	6) Priority based

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L-2.2

Diff^{n} times in CPU scheduling

Arrival time - The time at which process enters the ready Queue or stack.

Burst time - Time required by a process to get executed on CPU.

Completion time - The time at which process completes its execution

Turnaround time - Completion - Arrival time

Waiting time - Turn around - Burst time

Response time - (The time at which process get CPU - (Arrival time))

Arrival time → process execution duration → completion time
(point of time) (point of time)

Arrived Bank → Create new account → left Bank

L-2.3

First Come first Serve (FCFS)

FCFS is an OS scheduling algorithm that automatically executes queued requests and process in order of their arrival.

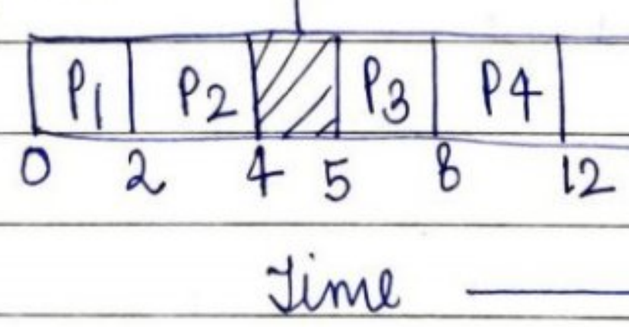
ii) The process which requests the CPU first get the CPU allocation first.

iii) Managed using FIFO queue.

	Process No	AT Arrival time	BT Burst time	CT Completion time	TAT (CT-AT)	WT (TAT-BT)	RT
0	P_1	0	2	2	2	0	0
2	P_2	1	2	4	3.	1	1
5	P_3	5	3	8.	3.	0.	0
8.	P_4	6	4	12	6	2.	2

Criteria: arrival time
Mode : Non preemptive

Grantt chart



At t=12, all the processes got executed

$$\text{Avg TAT} = \frac{14}{4}$$

$$\text{Avg WAT} = \frac{3}{4}$$

L-2.4
SJF

SJF - (Shortest Job first) → SJF is an algorithm in which the process having the smallest execution time is choosen for next execution.

ii) It can be preemptive or non-preemptive

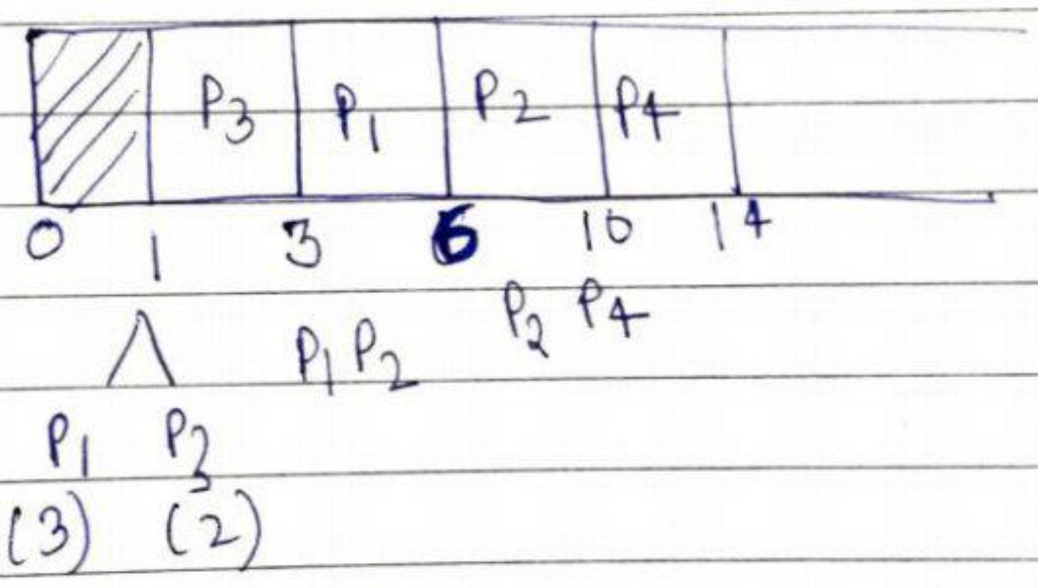
iii) It reduces the waiting time for other process.

iv) It is a greedy Algo.

Ko sure hua	Process No	AT	BT	CT	TAT	WT	RT
3	P_1	1	3	5	5	2	2
6	P_2	2	4	10	8	4	4
1	P_3	1	2	3	2	0	0
10	P_4	4	4	14	10	6	6

Criteria - Burst time
Mode - Non-preemptive

Gantt chart



when bT is same see the one having low arrival time else can use process id.

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L-2.5

Shortest Remaining Time First

↓

(Shortest job first + preemptive)

Process no	AT	BT	CompT	TAT	WT	RT	CPU first time
P_1	0	~~5~~ 4	9	9	4	0	0
× P_2	1	~~3~~ 2	4	3	0	0	1
P_3	2	4	13	11	7	7	9
× P_4	4	1	5	1	0	0	4

Criteria : "Burst time"
Mode : "Preemptive"

Gantt Chart

P_1	P_2	P_2	P_2	P_4	P_1	P_1	P_1	P_1	P_3

0 1 2 3 4 5 6 7 8 9 13

Time ⟶

0 → P_1
1 → P_1, P_2
2 → P_1, P_2, P_3
3 → P_1, P_2, P_3
4 → P_1, P_3, P_4
5 → P_1, P_3
6 → P_1, P_3
7 → P_1, P_3
8 → P_1, P_3
9 → P_1, P_3

P_1 ↓

$P_1 \to \cancel{5}\ 4$
$\cancel{P_2 \to 3\ 2\ 1\ 0}$
$P_3 \to 4$
$\cancel{P_4 \to 1}$

Avg TAT $= \frac{24}{4} = 6$

Avg WT $= \frac{11}{4} = 2.75$

Avg RT $= \frac{7}{4} = 1.75$

P_1	P_2	P_2	P_4	P_1	P_3

0 1 2 4 5 9 13

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Date ___/___/___

L-2.6

SJF with preemption ex.

Process	AT	BT	CT	TAT	WT	RT
P_1	0	7 ~~6~~ ~~5~~				
P_2	1	4 ~~3~~ ~~2~~ ~~1~~				
P_3	2	8				

Criteria : Burst time
Mode : preemptive.

Gnantt chart

7-2=5
13
15=2

P_1	P_2	P_2	P_2	P_2	P_1	P_1	P_3

0 1 2 3 4 5 6 11 19

$0 \rightarrow P_1$
$1 \rightarrow P_1, P_2$
$2 \rightarrow P_1, P_2, P_3$
$3 \rightarrow P_1, P_2, P_3$
$4 \rightarrow P_1, P_2, P_3$
$5 \rightarrow P_1, P_3$

P_1	P_2	P_1	P_3

0 1 5 11 19

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L-2.7

Round Robin Scheduling Algo.

Round robin is preemptive process scheduling algorithm each process is provided a fix time to execute, it is called quantum. Once a process is executed for a given time period, it is preempted & other process executes for a given time period.

Process no	AT	BT	CT	TAT	WT	RT	CPU first time
P_1	0	~~8~~ 3 1	12	12	7	0	0
→ P_2	1	0 ~~4~~ 2	~~4~~ 1	10.	6	1	2
→ P_3	2	~~2~~ 0	6	4	2	2	4
P_4	4	~~1~~	9	5.	4	4	8.

TQ=2

Criteria : "Time Quantum"
Mode : "Preemptive" (we have to resume the process not restart it)

Ready $\xrightarrow{2}$ Running

~~4~~ 3, 2, 1.

Sequence of process in Ready queue

~~P_1~~	~~P_2~~	~~P_3~~	~~P_1~~	~~P_4~~	~~P_2~~	P_1

0

context switching (save running process & welcome new process)

Running queue

P_1	P_2	P_3	P_1	P_4	P_2	P_1

0 2 4 6 8 9 11 12.

time →

Context Switches = 6.

L-2.8 Scheduling algo.

Pre emptive Priority ~~Queue~~.

In pre emptive scheduling, the tasks are mostly assigned with their priorities.

Priority scheduling is a method of scheduling process that is based on priority. In this algorithm, the scheduler selects the task to work as per the priority.

Equal priority - Round Robin or FCFS.

Priority	Process No	AT	BT	CT	TAT	WT	RT	CPU first
10	P_1	0	4 ~~5~~	12	12	7	0	0
20	P_2	1	3 ~~4~~	8	7	3	0	1
30	P_3	2	~~1~~ 2 0	4	2	0.	0	2
40	P_4	~~2~~ 4	0 ~~1~~	5	1	0	0	4

Higher the no. higher the priority.

P_1	P_2	P_3	P_3	P_4	P_2	P_1

0 1 2 3 4 5 8 12

time →

0 → P_1
1 → P_1, P_2
2 → P_1, P_2, P_3
3 → P_1, P_2, P_3
4 → P_1, P_2, P_3, P_4
5 → P_1, P_2

L-2.9

Example of Mix Burst Time (CPU & I/O both) in CPU

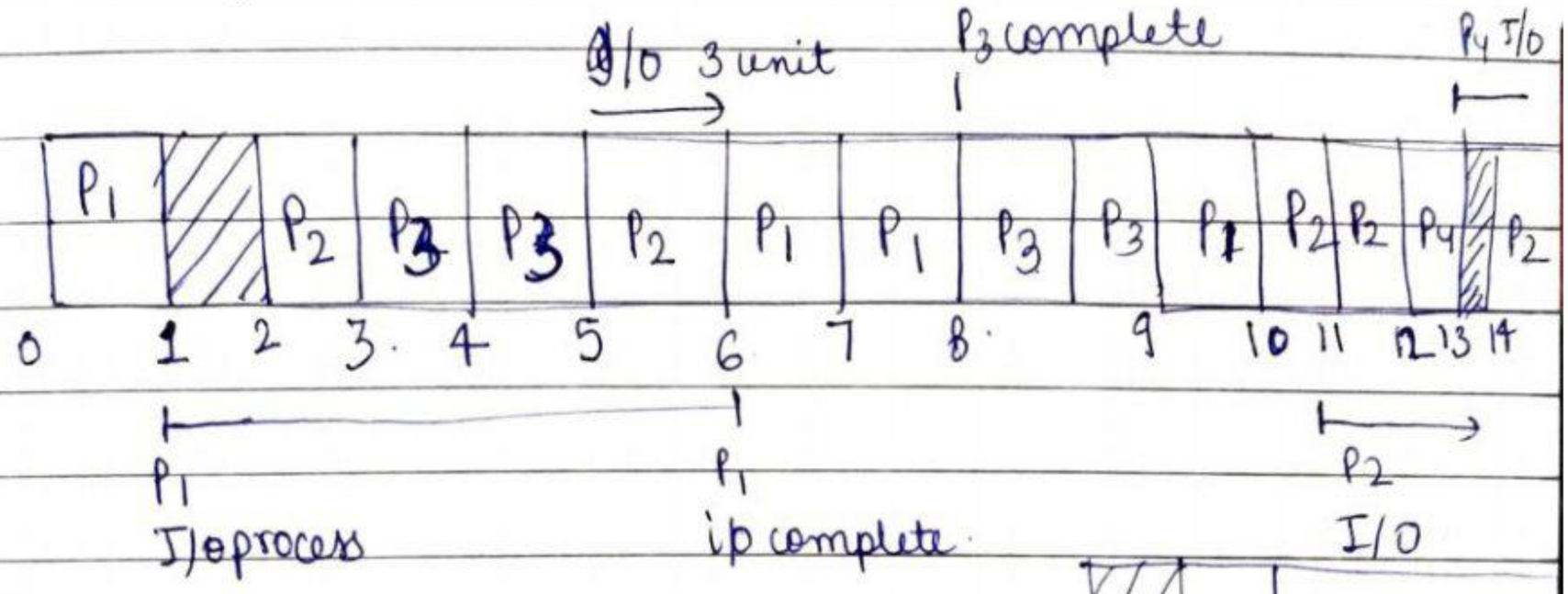
Process	AT	Priority	CPU	I/O	CPU
P_1	0	2	~~1~~ 0	~~5~~ 0	~~3~~ ~~2~~ ~~1~~ 0
P_2	2	~~4~~ 3	~~3~~ ~~2~~ 1	3	1
P_3	3	1	~~2~~ ~~1~~ 0	~~3~~ 0	~~1~~ 0
P_4	3	4	2	4	1

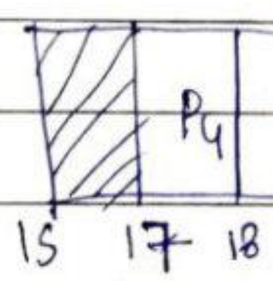
Lowest the no. highest the priority.

Mode: Preemptive

Criteria: Priority based

Find CT of P_1, P_2, P_3, P_4





0 → P_1

1 → no process

2 → P_2

3 → P_3, P_4
high priority

4 → P_1, P_2, P_3, P_4

5 →

6 → P_1, P_2, P_4

8 → P_3, P_1

9 → P_1, P_2, P_4

	CT
P_1	10
P_2	15
P_3	9
P_4	18

CPU idleness = 4/18

usage = 14/18

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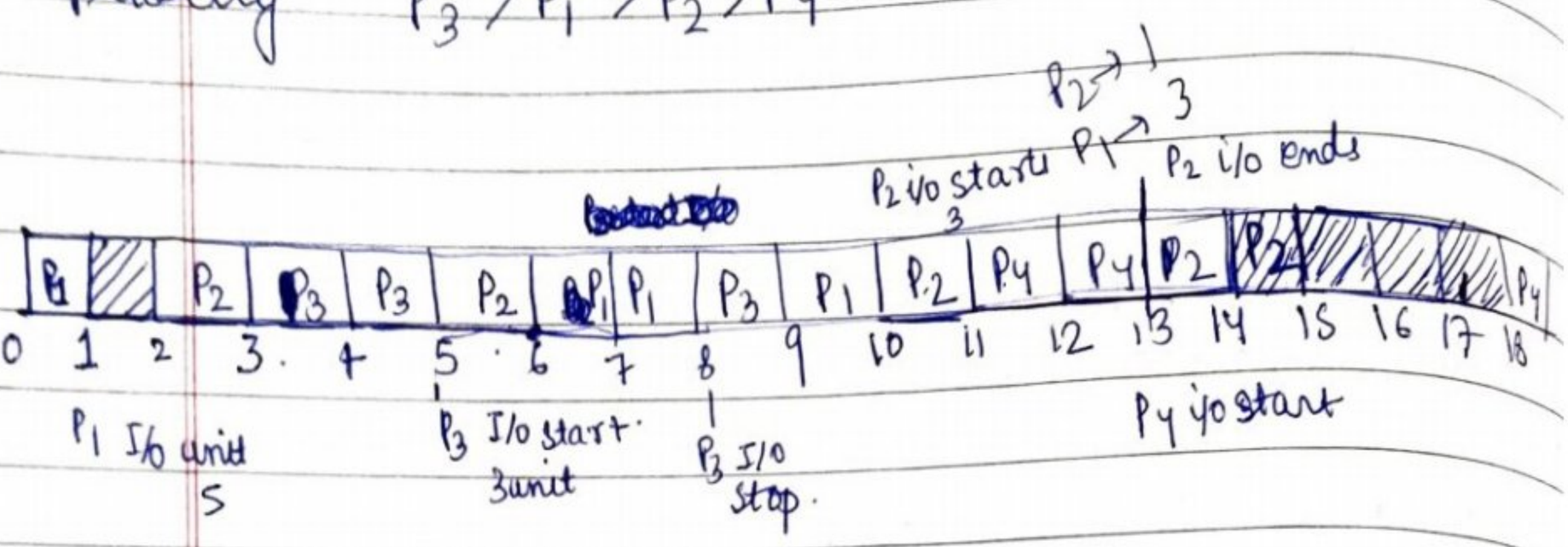
Priority	AT	Priority	CPU	I/O	CPU
P_1	0	2	10	5	3 ~~2~~ ~~1~~ 0
P_2	2	3	3	3	1
P_3	3	1	2 ~~1~~ 0	3	1 ~~0~~
P_4	3	4	2 ~~1~~ 0	4	1

Mode: Preemptive
Criteria Priority based.

Priority $P_3 > P_1 > P_2 > P_4$



In Ready queue.

I/O Process
$P_1 \to 6$
$P_3 \to 5$

$6 \to P_1, P_2, P_4$
$7 \to P_1, P_2, P_4$
$8 \to P_1, P_2, P_3, P_4$
$9 \to P_1, P_2, P_4$
$10 \to P_2, P_4$

$13 \to P_2$

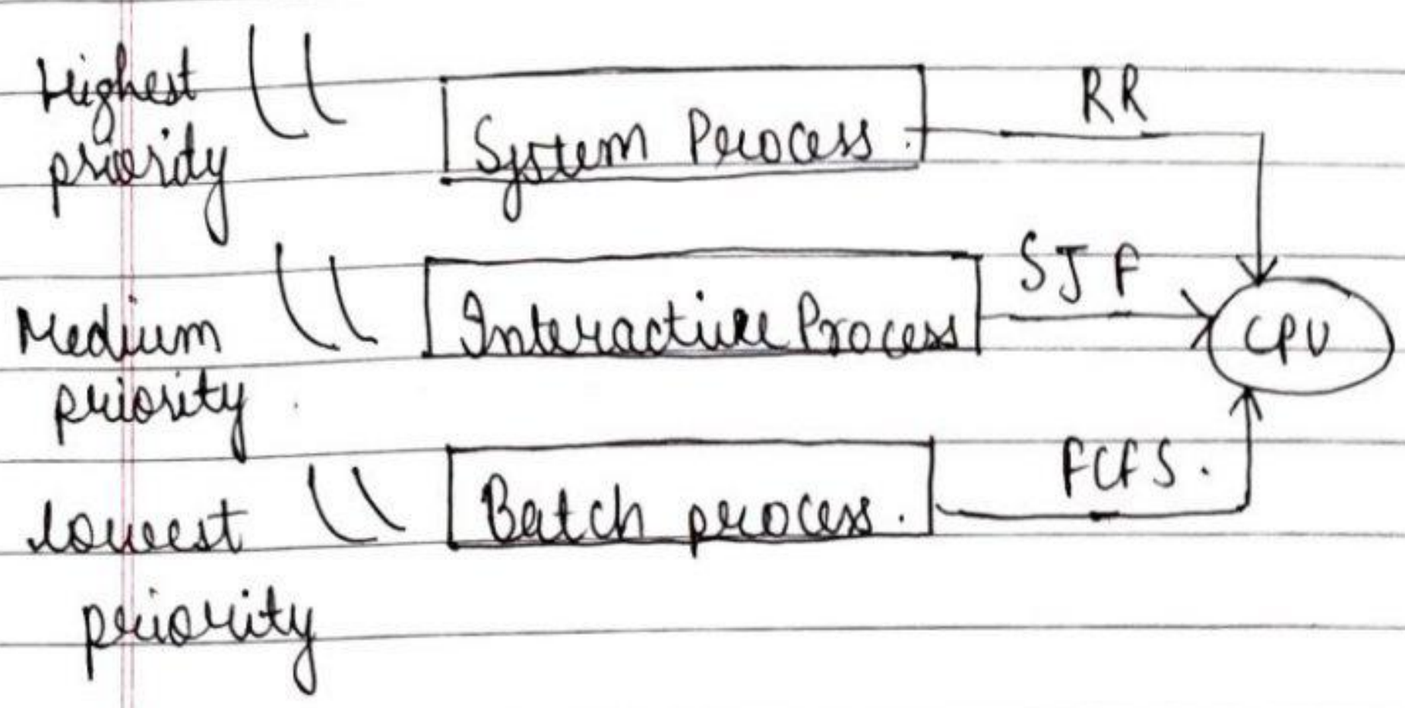
L-2.10
Multilevel queue scheduling

Date __/__/____

In every scheduling algorithm till now we have taken one queue.

i) There must be different queue for diff^n. process
ii) Every process can have their own algorithms.

1) Systems calls - Round robin
2) Interactive calls - SJFS.



Problem:
Lower level or lower priority may experience starvation due to more no of calls on higher priority

It can be resolved using multilevel feedback queue.

L-2.11

Multilevel Feedback Queue

More System process - lowest priority waits

lowest priority - feedback.

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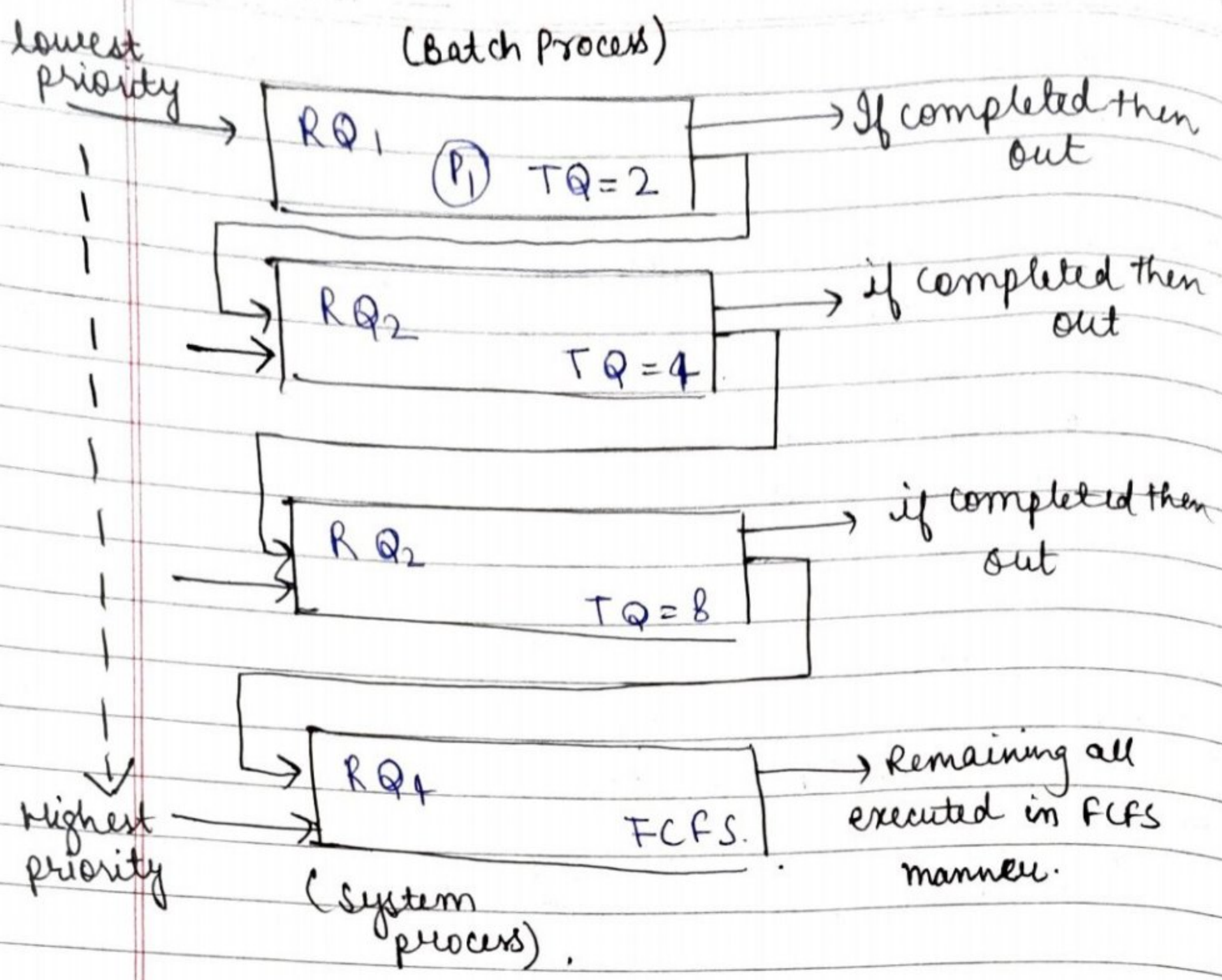

P_1	19	17	13.	5
		TQ=2	TQ=4	TQ=8

Process Synchronization

Processes

Cooperative process	Independent process
One's execution affects the other as they share same or common variable, memory/buffer, code, resources	One's execution doesn't affects other. They have nothing in common.

Ex – IRCTC.

PCB → Process control Block

Date

Process Synchronization is used to solve the problems of co operative process.

int shared = 5 ~~6~~ 4

P_1	context switching P_2
1. int X = Shared; 5	int y = shared;
2. X++; (x=~~5~~6)	y--; (y = ~~5~~ 4)
3. Sleep(1); pause	Sleep(1)
4. shared = x; ← 6	Shared = y;

(Terminated)

gets saved in PCB

When they are parallel.

Uniprocessor

Processes aren't Synchronized as the process at last gives either 4 & 6. but it should give 5.

This is called race cond^n.

L-3.2

Producer = Consumer Problem

Co-operative process.

There is one producer that is producing something and there is one consumer that is consuming the products produced by producer. The producer & consumer share the same memory buffer.

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Consumer

```
void consumer (void)
  {
    int item c;
    while (true)
    {
      while (count = = 0);
      item c = Buffer (out);
      Out = (Out + 1) mod n;
      count = count - 1;
      Process - item (item c)
    }
  }
```

Buffer empty

1. load R_c, m[count]
2. DECR R_c
3. Store m[count], R_c

OUT

R_p → Registers

INCR → increment

Producer

```
int count = 0.
  void producer (void)
  {
    int item p;
    while (true){
      produce_item(item p);
      while (count = = n);
      Buffer[in] = item p;
      in = (in + 1) mod n
      count = count + 1;
    }
  }
```

local variable

out

in

Buffer full so its overflow

1. load R_p, m[count];
2. INCR R_p;
3. Store m[count], R_p

gets from the buffer

gives to buffers

n = 8

Buffer [0 . . . . . n-1]

index

0	x_1
1	
2	
3	
4	
5	
6	
7	

n = size of buffer

COUNT

IN → (next empty slot address)

0

COUNT

Case I. x_1 (producer is processing x_1)

Out	(0+1) mod 8	in	count
~~0~~ 1	1 mod 8 = 1	~~0~~ 1	~~0~~ ~~1~~ 0

(0+1) mod 8 = 1

count = 1 - 1 = 0

It forms a circular queue so we used mod n.

Consumer.

Out
~~0~~ 1

0	x_1
1	x_2
2	x_3
3	x_4
4	
5	
6	
7	

Producer

Count In
~~3~~ ~~4~~ 2 ~~3~~ 4

Let x_4 be inserted in the in value.

Producer:

$R_p = 3$. load R_p, m[count] I_1 (3)
$R_p = 4$ INCR R_p. I_2
If after INCR R_p the process gets preempt
Resuming $R_p = 4$ I_3

Let x_1 be consumed.

load R_c, m[count] $R_c = 3$ I_1 (3)
DEC R_c $R_c = \cancel{3}\,2$ I_2
Resuming $R_p = 2$ I_3

I_1 I_2 Consumer I_1 I_2 Producer I_3 Consumer I_3.

There are 3 items in buffer but count says only 2 values is there, there is race condn. so we can't acheive process synchronization.

L-3.3.

Printer-Spooler Problem

↓

multiple programs → spooler → take items sequentially → Gives to the printer

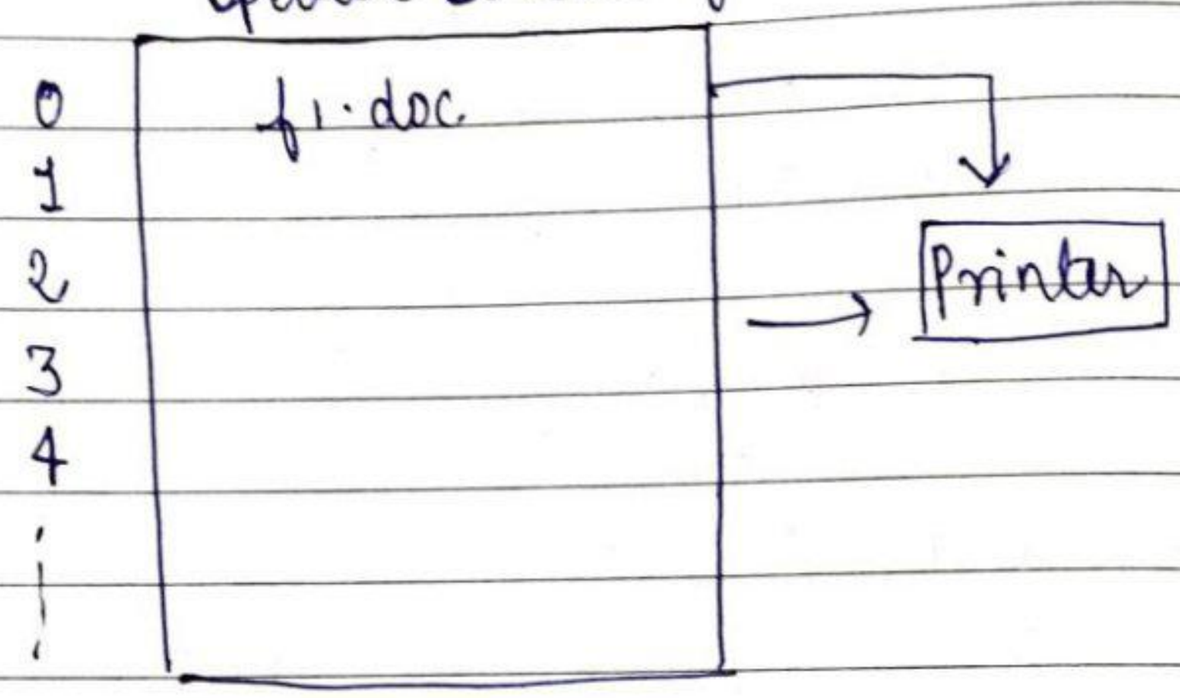
1. Load Ri, m[in]

2. store SD[Ri], "F-N"
   f1.doc

3. INCR Ri

4. Store m[in], Ri

Spooler Directory



IN $\boxed{\emptyset 1}$

↳ Empty slot

Case 1: f1.doc P_1

R_1 $\boxed{\emptyset 1}$

f4.DOC f5.DOC

Case 2: Two process P_1 & P_2

Cooperative process

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Date ___/___/___

In

0	f1.doc.
1	f2.doc
2	f3.doc
3	~~f4.doc~~ f5.doc
4	
⋮	

→ Printer.

In $\boxed{\cancel{3}4}$ 4

R_1 $\boxed{\cancel{3}}$ 4 R_2 $\boxed{\cancel{3}4}$

$P_1 \cdot I_1\ I_2\ I_3 \mid P_2\ I_1\ I_2\ I_3\ I_4 \mid I_4$

P_1 & P_2 due to non synchronisation put the file in the same index. So there is loss of data. When 2 processes share the same code, same data there is a problem created.

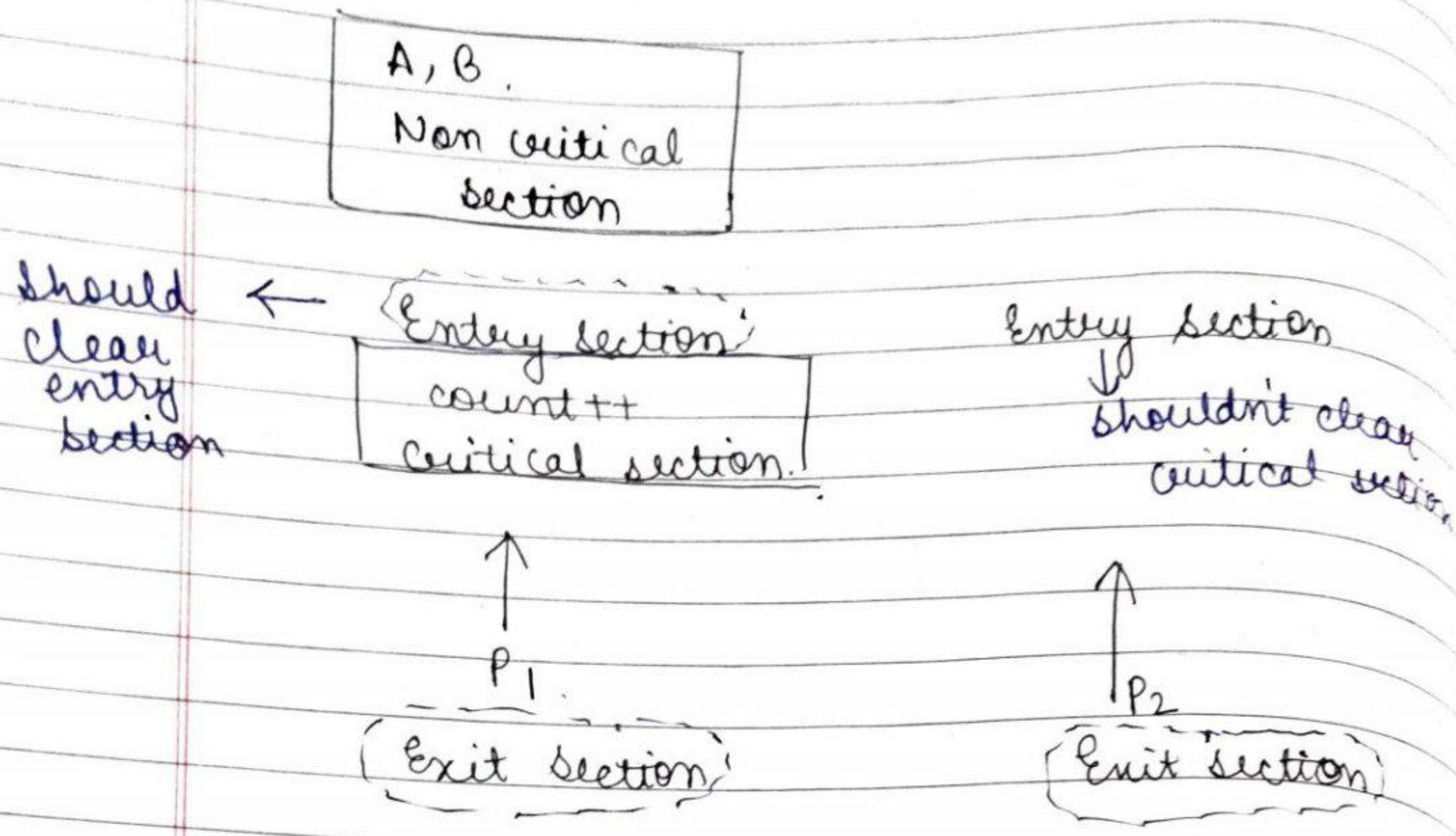
3.4

Critical Section Problem

" It is the part of program where shared resources are accessed by various processes "
↓
Co operative

P_1	P_2	
#include ___	#include ___	
main()	main() {	//common code → non-critical section
A, B → non critical section →	X, Y	
___	___	Common code → critical section
count → critical section →	count	

main ()

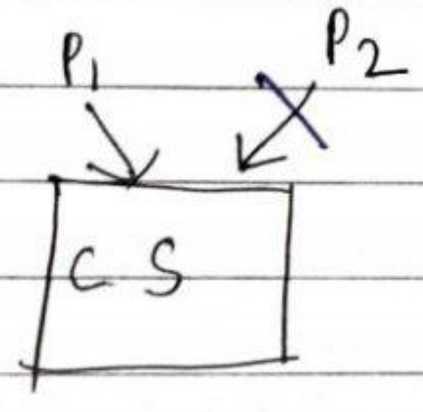


Different solⁿ for process synchronization

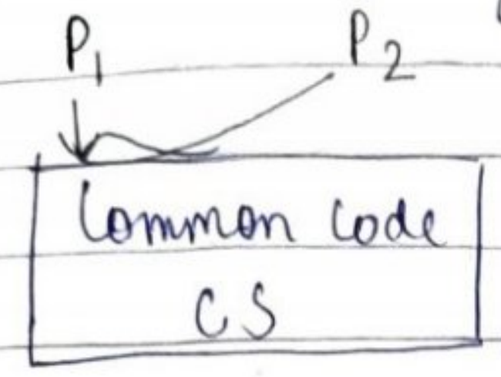
4 conditions

1) Mutual Exclusion } Primary
2) Progress
3) Bounded wait } Secondary
4) No assumption related to H/W speed

Mutual Exclusion → If P_1 or P_2 is inside critical section the P_2 or P_1 is not allowed to enter in critical section.

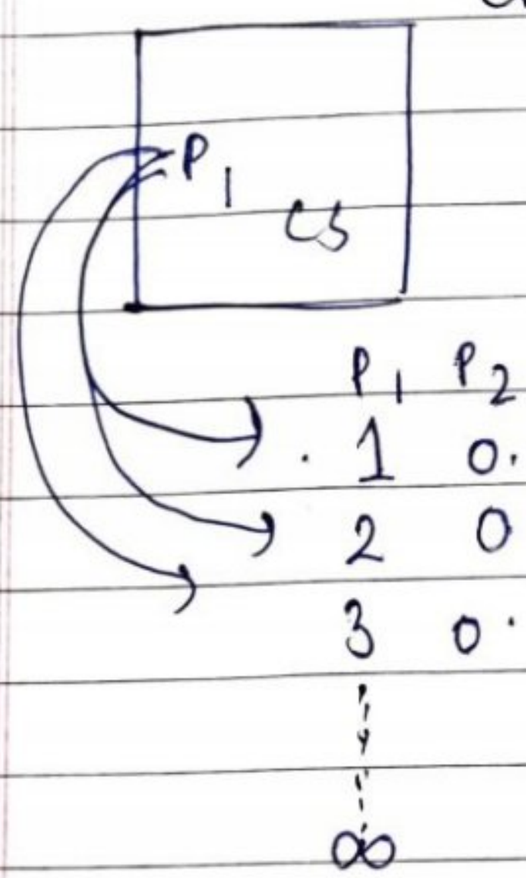


2. Progress → when both can use common code there is progress.



P_1 can't enter due to some code written in P_2 so there is no progress.

3. Bound Wait - There shouldn't be a condition of Starvation as one process uses the CPU every time. Let every process use the CPU.



If P_1 uses only the CS it will go in infinite loop

4) H/W speed - Every solution should be portable and universal. There shouldn't be anything dependent on H/W speed.

Now solution to critical Problem
L-3.5

Critical section Sol^n using LOCK.

CS - critical section

Date ___/___/___

```
do {
  acquire lock.
    CS
  release lock
}.
```

Entry code

1. while(LOCK==1);
2. LOCK = 1
3. Critical section
4. LOCK = 0.

Exit Code.

* Execute in User Mode.
* Multiple process solution.
* No mutual Exclusion
* Guarantee

Case 1 : P_1 P_2

lock = 0 → CS is vaccant
lock = 1 → CS is full

P_1	P_2
1 2 3	
P_2 [1]	

lock ~~0~~ ~~1~~ ~~0~~ 1

Case 2:

P_1	P_2
1 2 3	1 2
	CS.

L = ~~0~~ ~~1~~ 1

[P_2 P_1] → No mutual exclusion.
CS

3.6 Test and Set Instruction

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preemptive

1. while (LOCK == 1);
2. LOCK = 1

Entry code

3. Critical section

4. LOCK = 0

Exit code

It combines 1 & 2

```
while (test_and_set (&lock));
  CS
  lock = false;
boolean test_and_set (boolean * target)
  {
    boolean r = * target ;
    * target = TRUE ;
    return r1 ;
  }
```

lock — false — 1000 — True

target — 1000

e — false

P1	P2
1* 2	1

Mutal Exclusion as well as Progress acheieved.

3.7 Turn variable

1) 2 process solution

2) Run in user mode

Process "P0"	Process "P1"
Entry code → while(turn != 0)	while (turn != 1)
CS	CS
Exit code → turn = 1 ;	turn = 0 ;

int turn = 0. 1

P_0 CS	P_1 ✗	1) Mutual exclusion is satisfied
P_1 CS	P_0 ✗	

2) Progress (there is no progress)

CS
P_1 ✗ when turn = 0

3) Bounded wait → so there is bound wait as turn value changes.

4) Not H/W dependent

3.8 Semaphore

Semaphore (It is a tool to prevent race cond)
↓
Running cooperative process side by side

Counting (∞ to ∞)

Binary. (0, 1)

Semaphore is an integer variable which is used in exclusive manner by various concurrent cooperative process in order to achieve synchronization

Entry section

```
Down (semaphore s)
 {
 s.value = s.value -1;
 if (s.value < 0)
   {
   put process (P(B) in
   suspended list Sleep();
   }
 else.
   {return;
   }.
```

Exit section

```
UP (semaphore s)
 {
 s.value = s.value+1
 if (s.value ≤ 0)
   {
   Select a process
   from suspended list
   wake up();
   }
 }.
```

P() , Down, wait
V() , UP, (signal , post , Release)

P_1 P_2 P_3

Entry code

$\boxed{CS \ldots}$

Exit section

P_1 P_2 P_3 P_4 (Process control block)
P_5

$\boxed{CS \ P_1 \ P_2 \ P_3}$

Block list (sleep())
P_4
P_5.

S
$\boxed{3}$ ~~2~~ ~~1~~ ~~0~~ ~~-1~~
-2 (s.value < 0)

Entry code

P_1 P_2 P_3 P_4

wakeup

P_4 P_5

(Ready Queue)

C_S	P_1
	P_2
	P_3

Block list (Sleep)

P_4
P_5 } FIFO

Down

S

$\boxed{-4}$

↓

4 processes are there which is in CS.

S

$\boxed{\cancel{3}\ \cancel{2}\ \cancel{1}}$ $\cancel{0}$ $\cancel{-1}$ $\cancel{-2}$ $\cancel{0}$ $\cancel{-1}$ 1

S

$\boxed{0}$

↓

Further no process can come in CS.

Up

S

$\boxed{0}$ No process in suspend list

S

$\boxed{10}$ How many process can succesfully come in CS.

S = 10

Successful operation = 10

S	6 P	final value of S?
$\boxed{10}$	4 V	

$10 - 6 = 4 + 4 = 8$

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S 5P 3V 1P

$\boxed{17}$

$= 17 - 5 + 3 - 1$

$= 12 + 3 - 1$

$= 15 - 1$

$= 14$

3.9 Binary Semaphore (integer variable shared by a lot of process in mutual exclusive manner).

0 1

Semaphores $-\infty$ to ∞.

Binary Semaphore $\rightarrow$ 0, 1

```
Down (Semaphore S)
{
 if (value==1)
   {
    S.value = 0;
   }
 else
   {
    Block this Process.
    And place in suspend
      list sleep();
   }
}
```

```
Up(Semaphore S)
{
 if (suspend list is
        Empty)
  {
   S.value=1;
  }
  else {
   Select a process from
   suspend list &
   wake up ();
  }
}.
```


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Down, p, wait
Up, v, signal

S = 1 Down S = 0	successful operⁿ.	S = 0 sleep(); block	unsuccessful operⁿ.

S = 0	S = 1
Up	Up
S = 1	S = 1

In up we check if the block queue is empty or not (S = ∅ 1)
If empty (S = ∅ 1)
If not empty → It will being process from block state to unblock state.

S = 1

P_1	P_2
Down(s)	Down(s)
CS	CS
Up(s)	Up(s)

Q. Each process Pi {i = 1 to 9} execute the following code.

P_i {i=1 to 9}

```
repeat
P(mutex)
[CS]
V(mutex
forever.
```

Entry section → P(mutex)

Exit section → forever.

mutex

[1]

P_{10}

```
Heapeat
V(mutex)
[CS]
V(mutex)
forever.
```

What is the max^m no of process that may present in CS at any point of time?

Case 1.

P(mutex)

mutex 1

mutex 0.

[CS.]

V(mutex)

mutex = 1.

Case 2:

P(mutex)

mutex

1

0

P_2 P_3 P_4 (block)

[CS. P_1]

for P_{10}

mutex: ~~0~~ ~~1~~ ~~0~~ ~~1~~ ~~0~~ ~~1~~ 0 P_1 P_{10} P_2

CS

[P_1 P_{10} P_2]

$\xrightarrow{P_3}$ P_1 P_2 P_3 P_{10}

$\xrightarrow{P_4}$ P_1 P_2 P_3 P_4 P_{10}

$\xrightarrow{-P_{10}}$ P_1 P_2 P_3 P_4.

$\xrightarrow{P_5}$ P_1 P_2 P_3 P_4 P_5

P_{10}

Block

P_3

P_4

P_5

P_6

P_7

P_8

P_9

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max^m no of process can be 10 but putting P_{10} in and out of critical Section.

Soultion of Producer Consumer using Binary Seamaphore

Counting Seamphore
- full — 0 = No of filled slots
- Empty — N → No of empty slots

```
Produce_item(itemp);
1) down(Empty);
2)  down (s);
3)  Buffer[IN]= itemp;
4)  In = (In+1) mod n;
5)  up(s);
6)  up(full);
{
```

Consumer.

```
1) down (full);
2) down (s);
3) item c= Buffer[out];
4) out =(out+1) mod n
5) up(s);
6) up(Empty);
```

N=8

0	a	
1	b	
2	c	
3	d	
4		
5		
6		
7		

IN: 3

OUT: 0

Empty = ~~5~~ 4 S = ~~X~~ ~~0~~ 1 In = (3+1) mod 8
full = ~~3~~ 4 = 4 mod 8
= 4

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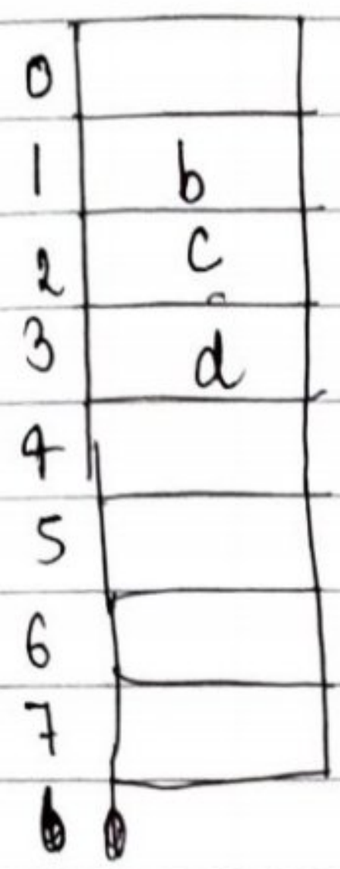
For consumer.

Empty = ~~0~~ ~~4~~ 5 In = 4
full = ~~4~~ 3 Out = ~~0~~ 1 ((0+1) mod 8)
S = ~~1~~ ~~0~~ 1

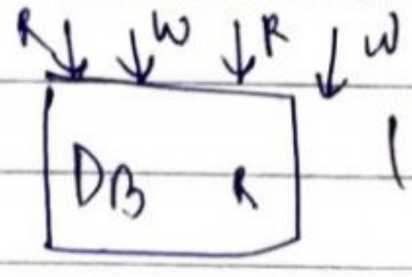


With preemption (context switching)

Empty = ~~5~~ ~~4~~ 5
full = ~~3~~ 2 (Consumer in CS)
S = ~~1~~ ~~0~~ ~~1~~ 0
Out = ~~0~~ 1 ↳ consumer can't do down of s.
In = ~~3~~ 4

3.12 → Solution of Readers writers problem

We have a database used by Reader & writer
Reader - Who only reads the data
Writer - Who wants to update the data also.



(Same data)

R-W (problem) R-R (no problem)
W-R (Problem)
W-W (Problem)

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```
int rc = 0;
Semaphore mutex = 1;
Semaphore db = 1;
void Reader( void)
  {
   while (true)
    {
     down(mutex);
      rc = rc+1;
     if (rc == 1) then
        down(db);
     up(mutex)
```

entry code

C.S. [DB]

exit

```
     down(mutex)
      rc = rc-1;
     if (rc == 0) then up(db);
      up(mutex)
      Process_data
    }
  }

void writer(void)
  {
   while (true)
    {
     down(db);
      [ DB ]
      up(db);
    }
  }.
```

To synchronise problem we used Semaphores.

Case 1: R_1 comes first

$RC = \cancel{0}\,1$ mutex $= \cancel{1}\,\cancel{0}\,1$ db $= \cancel{1}\,0$

down(mutex)

[DB R_1]

For writer

$RC = 1$ mutex $= 1$ db $= 0$

down(db) → db $\neq -1$ so the process gets blocked.

Case 2: W_1 comes first

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$R_c = \cancel{0}\ 1$ mutex $= \cancel{1}\ 0$. db $= \cancel{1}\ 0$

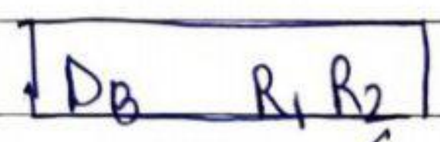
down (db) → db $\neq -1$ can't be negative so r_1 gets blocked.

Case 3: write-write problem

When writer w_1 comes down(db) db $= \cancel{1}\ 0$.
When w_2 comes db $\neq -1$ so it gets blocked

Case 4: Read-Read

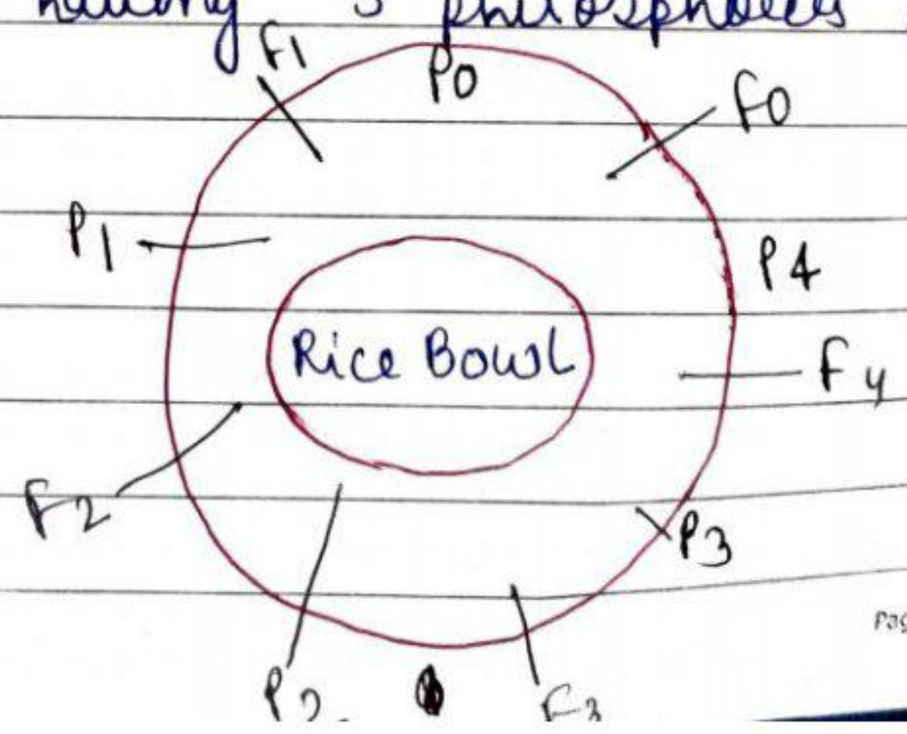
$R_c = \cancel{0}\ \cancel{1}\ 2$ mutex $= \cancel{1}\ \cancel{0}\ \cancel{1}\ \cancel{0}\ 1$ db $= \cancel{1}\ 0$



$2 == 1$ no
down(~~mutex~~ db); X
up(mutex)

3.13 Dining Philosophers Problem.

A dining table having 5 philosophers & 5 forks



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```
void Philosopher (void)
{
  while (true)
  {
    Thinking ();
    table_fork (i);   ← left fork
    table_fork ((i+1) % N);  ← Right fork
    EAT ();
    Put fork (i);
    Put fork ((i+1) % N);
  }
}
```

Philosopher → think
→ Eat

Case 1: P_0 comes

$i = 0$

left fork = 0 (f_0)

Right fork = $((0+1) \% N) = 1$ (f_1)

Eating

f_0

f_1

end.

Case 2: P_1

$i = 1$

left fork = 1 (f_1)

Right fork = 2 (f_2)

Eating

f_1

f_2

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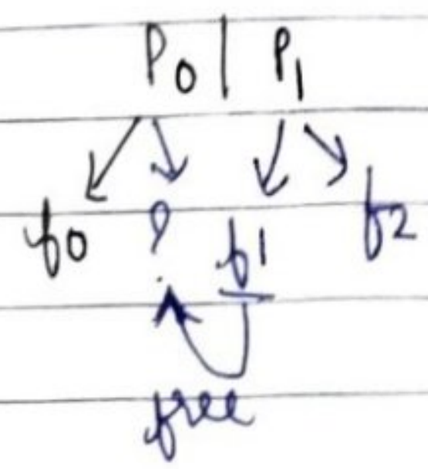
Case 3:



problem of race cond^n occurs.

S[i] → use array of semaphores

	S_0	S_1	S_2	S_3	S_4
Initially →	~~1~~ 0	~~1~~ 0	1	1	1
Now	1	1			

(Initialize every semaphore with as when initalized with 0. it waits & get blocked)

```
void philosopher (void)
{
  while (True)
  {
   Thinking ();
   Wait (table_fork(si))
   Wait ( table_fork (i+1) modN)

   EAT();
   Signal (Put fork(i));
   Signal (Put fork((i+1)%.N)
  }
}.
```

$P_0 \to S_0 \quad S_1$
$P_1 \to S_1 \quad S_2$
$P_2 \to S_2 \quad S_3$
$P_3 \to S_3 \quad S_4$
$P_4 \to S_4 \quad S_0$

But in db P_0 & P_2 can come. It is a special case of mutual exclusion as P_1 & P_2 are independent of eachother.

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Case3:

$S_0 \downarrow 1$ $S_1 \downarrow 1$ $S_2 \downarrow 1$ $S_3 \downarrow 1$ $S_4 \downarrow 1$

P_0 comes first

$S_0 \downarrow 0$

It gets preempt

P_1 comes $S_1 \downarrow 0$ preempt

P_2 comes $S_2 \downarrow 0$ preempt

P_3 comes $S_3 \downarrow 0$ preempt

P_4 comes $S_4 \downarrow 0$ preempt

for right fork (blocked)

The take left hand side fork but gets blocked for the right one. This situation is called deadlock (All process gets blocked)

Q. How to remove deadlock?
On changing the sequence of one process.

P_4 S_0 S_4

S_0	S_1	S_2	S_3	S_4
↓	↓	↓	↓	↓
~~1~~	~~1~~	~~1~~	~~1~~	1
0	0	0	0	

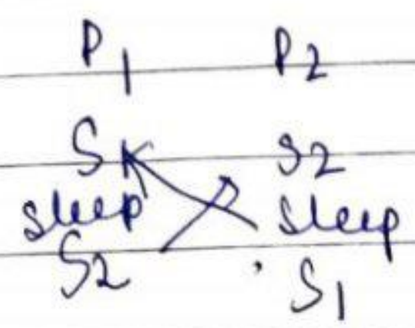
blocked → P4 $\quad S_0 \quad S_4$

We can change sequence of any philosopher.

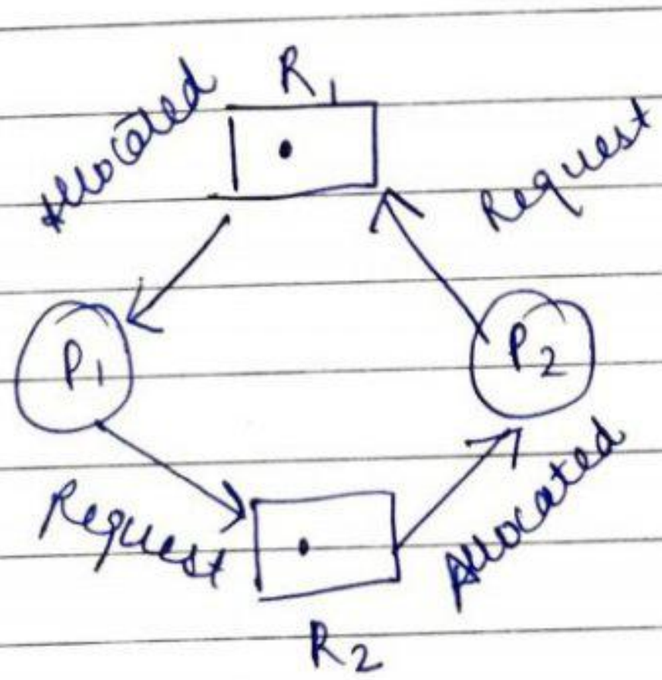
N^{th} philosopher.

```
wait (take_fork (S(i+1) mod N))
wait (take_fork (si));
```

4.1 Deadlock concept



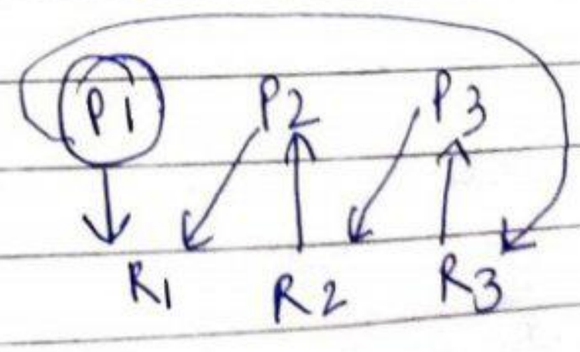
If two or more process are waiting on happening of some event which never happened we say these processes are involved in a deadlock then that state is called deadlock.



$R_1 \rightarrow P_1$

R_1 is allocated to P_1

P_2 request for R_1



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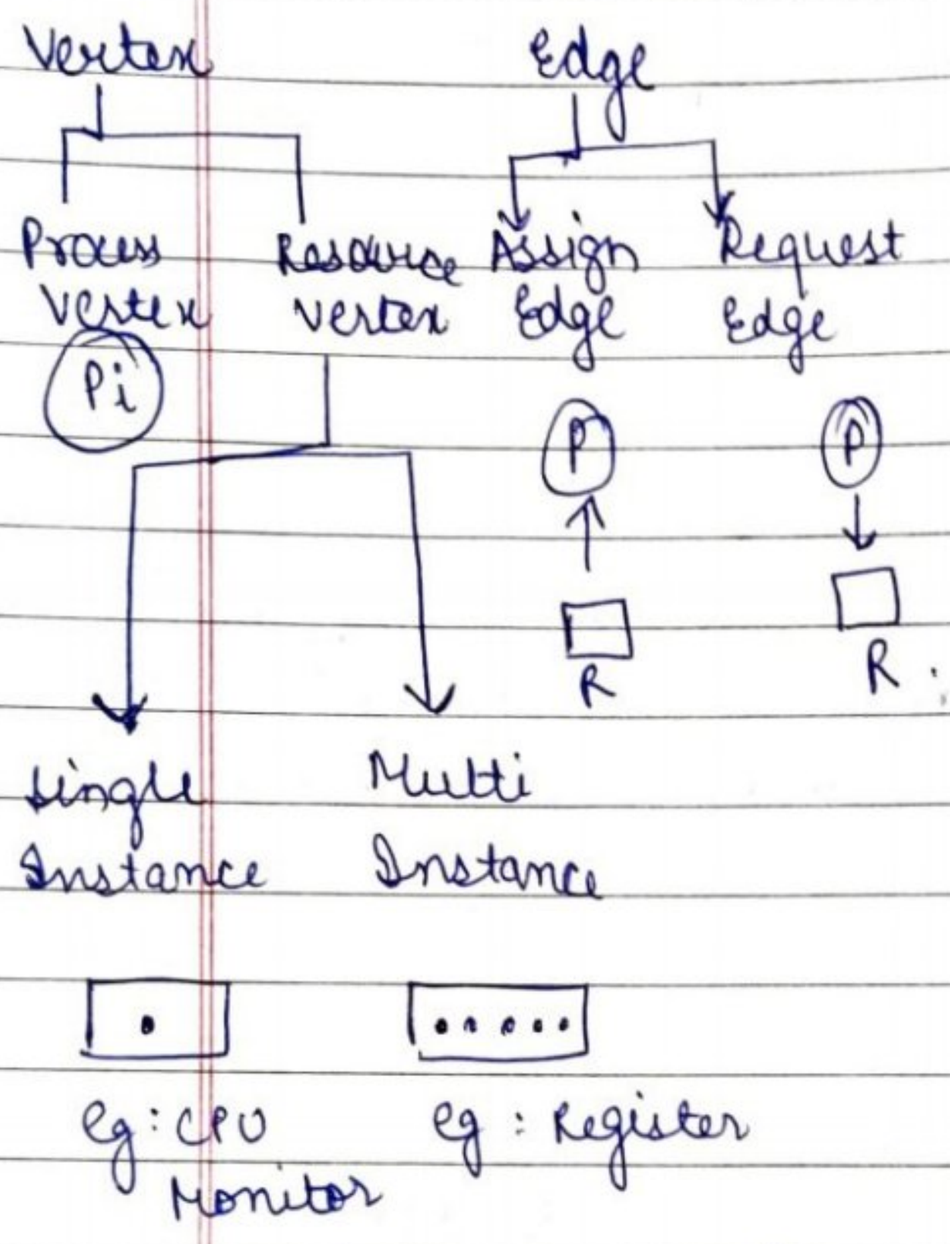
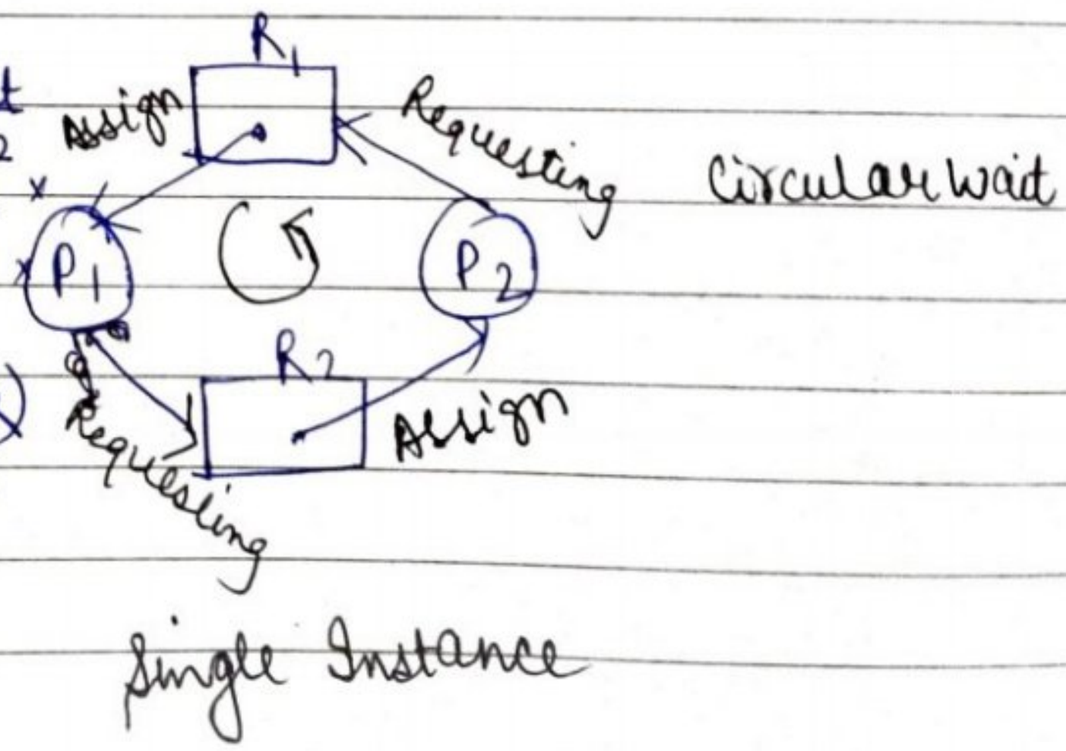
Necessary Conditions for deadlock.

1) Mutual Exclusion
2) No Preemption
3) Hold & wait
4) Circular wait

4.2 Resource Allocation Graph in Deadlock (RAG)



	Allocate		Request	
	R_1	R_2	R_1	R_2
P_1	1	0	0	1
P_2	0	1	1	0

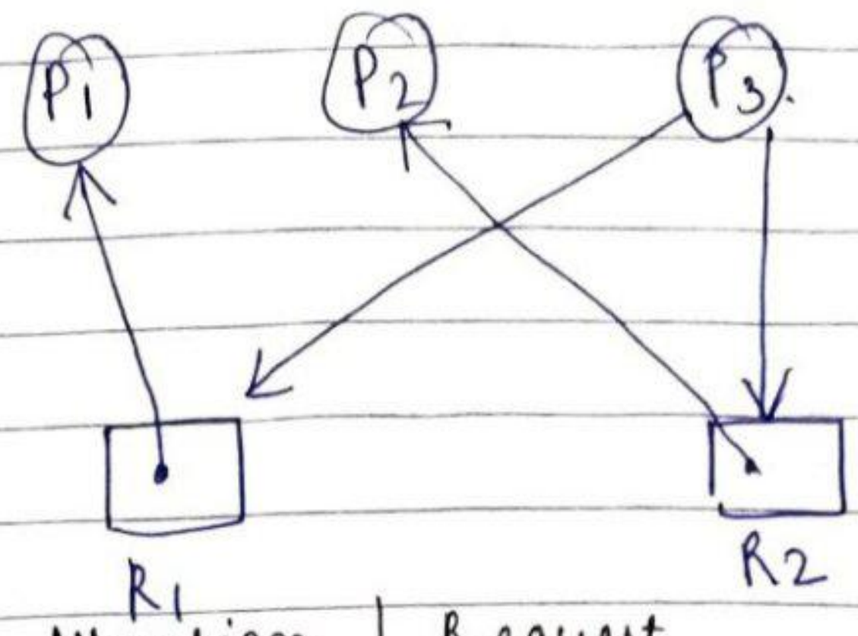


Circular wait

Availability (Deadlock) method

(0, 0)
R_1 R_2

Date ___/___/_____



	Allocation		Request		
	R_1	R_2	R_1	R_2	
P_1	1	0	0	0	✓ Terminate
P_2	0	1	0	0	✓ Terminate
P_3	0	0	1	1	✓

Availability (0, 0)
(1, 0) → after P_1 terminate
(1 1) → after P_2 terminate

No deadlock occurs.

Waiting
- finite (Starvation)
- Infinite (Deadlock)

If RAG (circular wait) (cycle) → Always in Deadlock
↓
A single instance

Single instance + Circular weight = Deadlock.
Multi instance + CW = Possible (may or may not)

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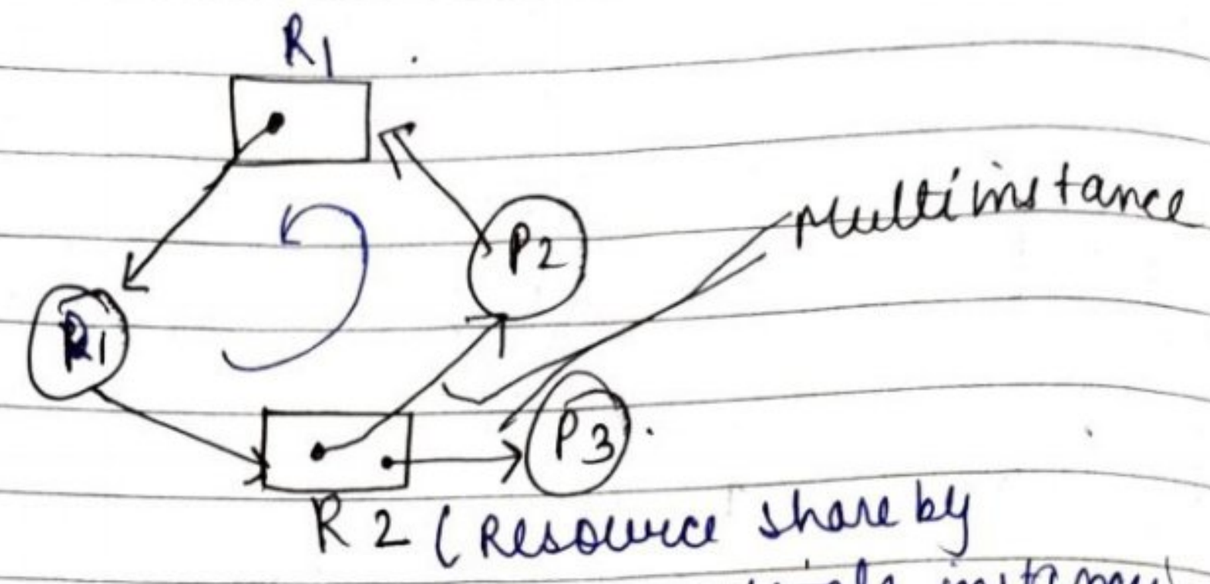
4.3 Multiinstance RAG.

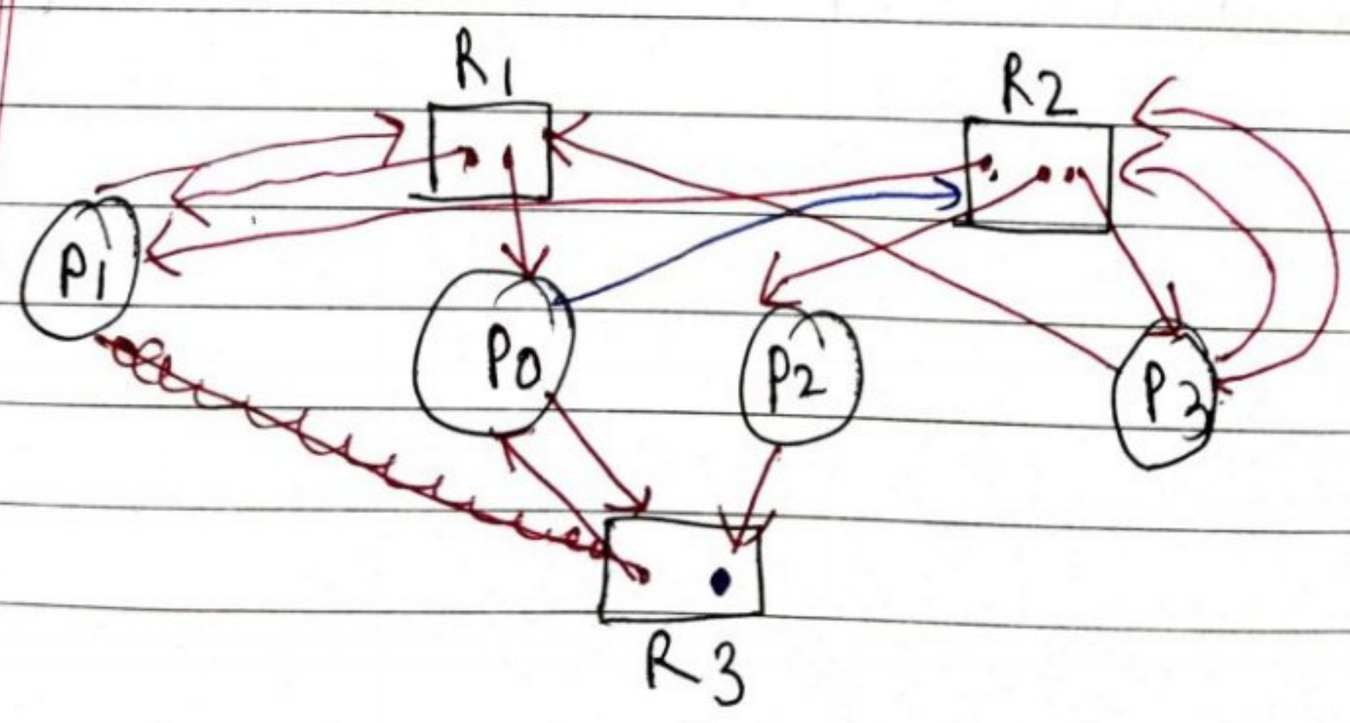


Multi instance RAG.

Process	Allocate R_1	Allocate R_2	Request R_1	Request R_2
P_1	1	0	0	1 ✓
P_2	0	1	1	0
P_3	0	1	0	0 ✓

Current avai → (0, 0) ✓
0 1 ✓
1 0. ✓

No deadlock



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	Allocate		Request	
	R_1	R_2	R_1	R_2
P_0	1	1		
P_1				
P_2				
P_3				

	Allocate			Request		
	R_1	R_2	R_3	R_1	R_2	R_3
P_0	1	0	1	0	1	1
P_1	1	1	0	1	0	0
P_2	0	1	0	0	0	1
P_3	0	1	0	1	2	0

curr av = R_1 R_2 R_3
(0 0 1)

$P_2 \rightarrow$ 0 1 0

0 1 1

$P_0 \rightarrow$ 1 0 1

1 1 2

	R_1	R_2	R_3
	1	1	2
P_1	1	1	0
	2	2	2
P_3	0	1	0
	2	3	2

– curr availability

→ No deadlock in the system.

$P_2 \rightarrow P_0 \rightarrow P_1 \rightarrow P_3$

4.4 Deadlock Handling methods

1. Deadlock ignorance (Ostrich method)
2. Deadlock prevention
3. Deadlock avoidance (Banker's Algo)
4. Deadlock Detection & Recovery

Deadlock ignorance
↓
(Just ignore the deadlock)

Deadlock occurs very rare. Windows has lots of code in this. We want more & more speed so we don't write any code for deadlock, so it's easy to avoid as its rare.

Why ostrich method called?
Whenever there is a sand storm ostrich puts its head in the sand assuming no sand. In the same way we ignore deadlock so that the performance & speed doesn't gets degraded.

Deadlock prevention

Before the deadlock occurs find the prevention 4 necessary conditions for deadlock

1) Mutual Exclusion
2) No preemption
3) Hold & wait
4) Circular wait

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Either remove all the condition or try to false any one of the situation.

1) Mutual Exclusion (there should be no sharing betn diffn process at same time).

So, if we make all resources sharable we can remove mutual exclusion but some resources like printer can't be made shareable.

2) No preemption (there should be any preemption in betn the resources)

So, if we make the process preempted using timestamp or TQ we can prevent deadlock.

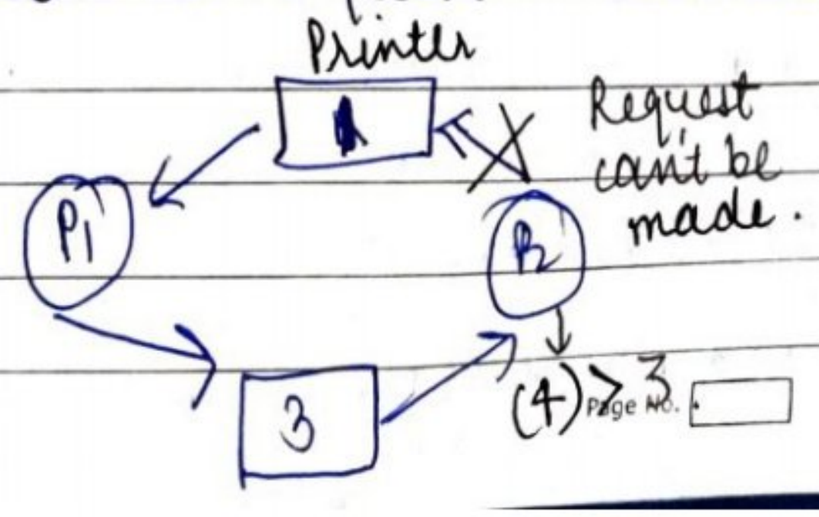
3) Hold wait (Holding some resource & waiting for some resources).

Before the process starts, give all the resources to the process.

4) Circular wait

Order all the resources (like numbering). Whenever a process request for a resource it would be ordered in increasing order. A process can request in increasing order.

1. Printer
2. Scanner.
3. CPU
4. Register



Deadlock Avoidance
While giving the resource to the process check its safe or not.

Deadlock detection & Recovery.

Step 1: Firstly check whether there is a deadlock or not using RAG (Resource Allocation graph).

Step 2: After detection do some recovery
1) Kill the processes or a process (lower priority process)
2) Resource preemption (preempt the resource it is holding)

4.5 Deadlock Avoidance (Banker's Algorithm)

Deadlock Avoidance Algorithm

While providing the resources to the process we check if deadlock occurs or not. It is also called Deadlock prevention

CPU (A) = 10 (7)
Memory (B) = 5 (2)
Printer (C) = 7 (5)

(Total AT) Allocation → how much is allocated
Max Need → how much is needed
(Total AT - A) Availability → how much resource is available
(Max Need - Allocation) Remaining Need

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4

Process	Allocation			Max Need			Available (10-7)	(5-2)	(5-3)	Remaining need Max - Allocation		
	A	B	C	A	B	C	A	B	C	A	B	C.
→ P1	0	1	0	7	5	3.	3 (2)	3 (0)	2 (0)	7	4	3 ✓
→ P2	2	0	0	3	2	2.	5 (2)	3 (1)	2 (1)	1	2	2 ✓
→ P3	3	0	2.	9	0	2	7 (0)	4 (0)	3 (2)	6	0	0
→ P4	2	1	1	4	2	2.	7 (0)	4 (1)	5 (0)	2	1	1 ✓
→ P5	0	0	2.	5	3	3.	7 (0)	5 (0)	5 (2)	5	3	1 ✓
+							10	5	7			
	7	2	5									

If we can't fulfil need of every process it is called deadlock.

$P_2 \rightarrow P_4 \rightarrow P_5 \rightarrow P_1 \rightarrow P_3$ (safe sequence)

(sequence having no deadlock)

In real life it is not possible.

4.6. Gate Question

Process	Allocation			Max			Available			Remaining need		
	A	B	C	A	B	C	A	B	C	A	B	C
P_0	1	0	1	4	3	1	3 (1)	3 (0)	0 (1)	3	3	0 ✓
P_1	1	1	2	2	1	4	4 (1)	3 (0)	1 (2)	1	0	2 ✓
P_2	1	0	3	1	3	3	5 (1)	4 (0)	3 (3)	0	3	0 ✓
P_3	2	0	0	5	4	1	6 (2)	4 (0)	6 (0)	3	4	1 ✓
+							8	4	6			
	5	1	6									
	8	4	6									

$P_0 \rightarrow P_1 \rightarrow P_2 \rightarrow P_3$ No deadlock

Date ___/___/___

4.7 Question Explanation on Deadlock

Q A system requires 2 units of Resources having 3 process. The min^m. no of units of 'R' such that no deadlock will occur.

a) 3
b) 5
c) 6
d) 4

P_1 P_2 P_3

$3 \times 2 = 6$ resources

but we need minimum no of resources.

$R = 2$

P_1	P_2	P_3
1	1	
need 1 more	need 1 more	

} deadlock.

P_1	P_2	P_3
1		
1		

$P_1 \rightarrow P_2 \rightarrow P_3$

but not always true

P_1	P_2	P_3
~~1~~	1	1
~~1~~		

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R = 3

P_1	P_2	P_3
1 } x	1 } x	1 } x
1	1	1

P_1	P_2	P_3
1	1	1

→ deadlock can occur

R = 4

P_1	P_2	P_3
1 }	1 }	1 }
1 }	1 } x	1 } x
x		

→ Deadlock never occurs.

(min req) + 1

3 + 1 = 4

Max^m resources allocated still deadlock - 1

P_1	P_2	P_3
3	4	5
2	3	4

(min req)

$= (4+3+2) + 1$

$= 10$

Max^m resources allocated still deadlock = 9

Date / /

4.8 Create Question on Deadlock.

Q. Consider a system with 3 processes that share 4 instances of same resource type. Each process can request a max. of 'K' instances. The largest value of 'K' that will always avoid deadlock is ? → 2.

R = 4 units of R

K = 1

P_1	P_2	P_3
1	1	1

K = 2

P_1	P_2	P_3
1	1	1
1	1	1

K = 3.

P_1	P_2	P_3
1	1	1
1	1	1
1	1	1

K = 3

P_1	P_2	P_3
1	1	1
1	-	-
-	-	-

Deadlock

Ans. 2.

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Another method to find

'R' resources
'n' processes $(P_1, P_2, P_3 \ldots P_n)$
'd' demand $(d_1\ d_2\ d_3 \ldots d_n)$

max^m resources but still deadlock

P_1	P_2	P_3	
2	2	2	= 6.
1	1	1	= 3 + 1 = 4 (free from deadlock

$(d_1 - 1)\ (d_2 - 1)\ (d_3 - 1)$

$R \leq \sum_{i=1}^{n} d_i - n$. (there will be a deadlock)

$R \geq \sum_{i=1}^{n} d_i - n$ (there will be no deadlock)

$R + n > \sum_{i=1}^{n} d_i$ → total demand

total resource

total processes.

$4 + 3 > 3 \times 2$

$7 > 6$ → True

4 processes
4 resources

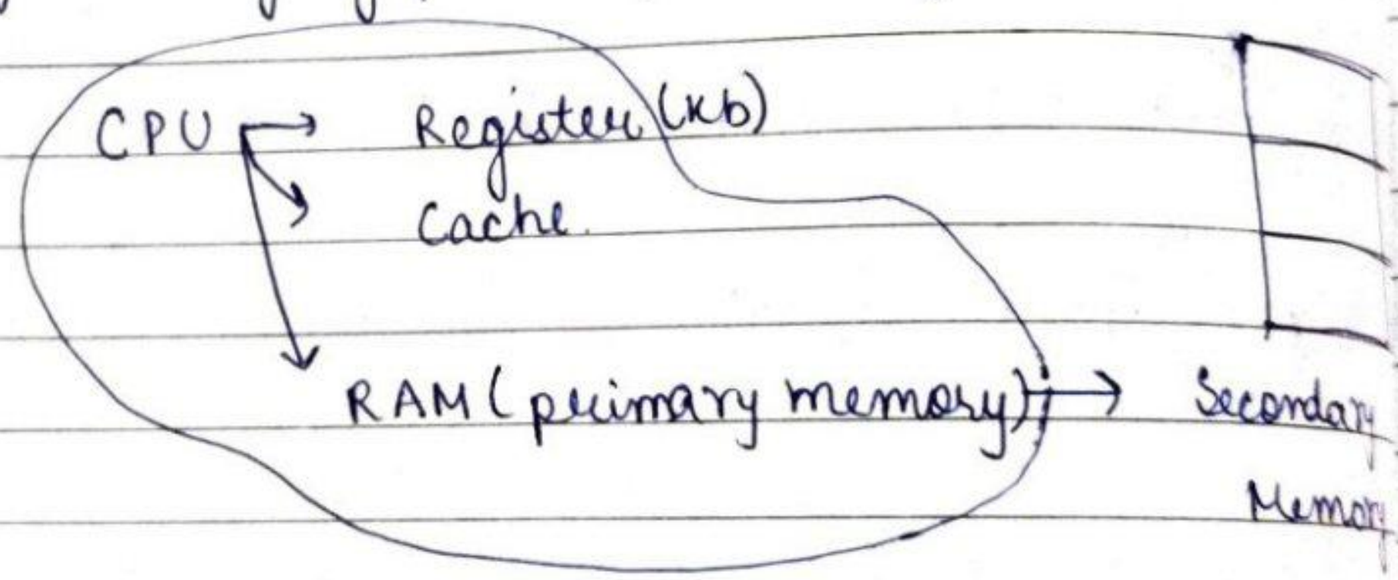
$4+4 > 4\times1$
$8 > 4$ (Valid)

$4+4 > 4\times2$
$8 > 8$ (false)

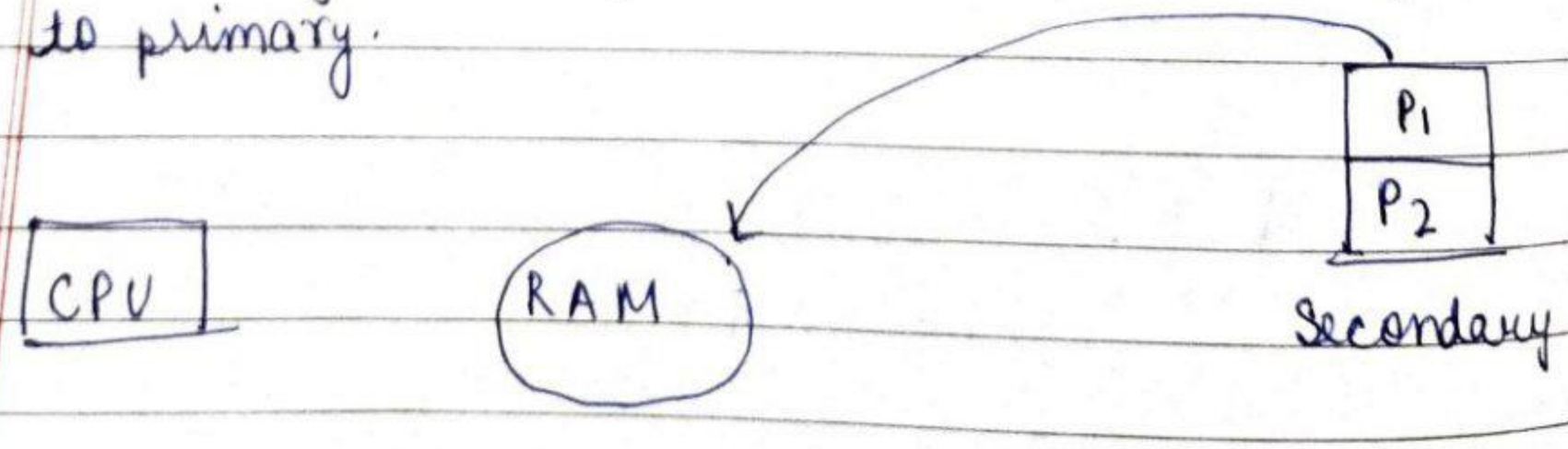
5.1 Memory Management and Degree of Multi programming

It is a kind of functionality to manage all the memory resources in a more & more efficient manner.

Method of managing primary memory.



Secondary memory is not directly connected with CPU because secondary memory is a bit slower in comparision to primary.



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Multiprogramming - Whenever we are giving the programms in RAM bring more process in main memory.

More process in RAM, degree of multiprogramming increases.
(More & more processes in RAM to increase efficiency)

RAM
↙ ↘
CPU I/O

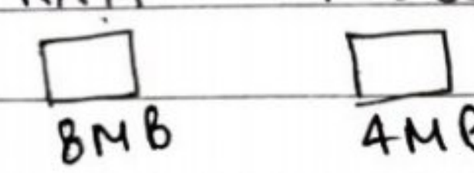
When we bring a processes. P_1 & if it wants to have some i/p then CPU shouldn't be idle.

RAM Process

$\frac{4}{4} = 1$

$k \rightarrow$ i/o operation (70%)
CPU = $(1-k)$ (30%)
utilization.

RAM Process

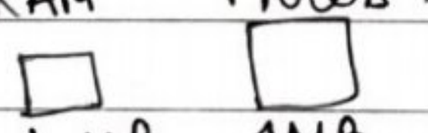


$\frac{8}{2} = 2$ Process.

$k = 70\%$

$k^2 \rightarrow$ i/o operat^n.
CPU utilization $= (1-k^2)$
$= 1-(0.7)^2$
$= 76\%$.

RAM Process.



$\frac{16}{4} = 4$

$k^4 \rightarrow$ i/o operat^n.
CPU utilization $= 1-(0.7)^4$
$= 93\%$ approx
↓
Efficiency increases

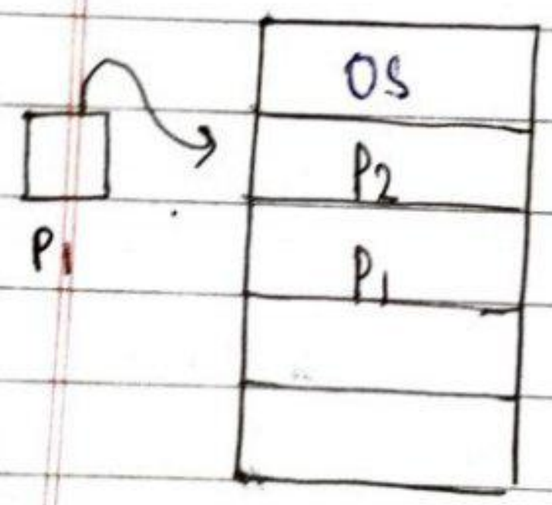
* Increase the no of processes as well as RAM of the OS
* OS needs to pay attention to allocation & deallocation

5.2 Contigious and non contigious.

Memory management Techniques

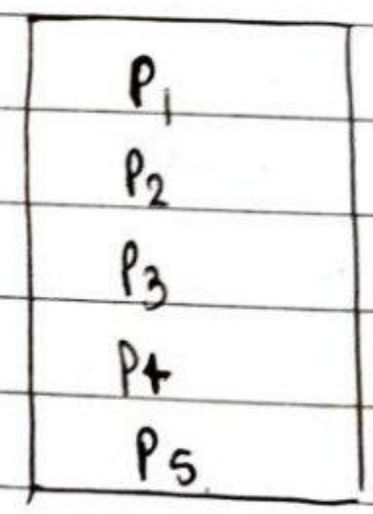
- (Continuous memory (address) allocation) — Contiguous
  - Fixed Partion (Static) (Make fixed slots)
  - Variable partition. (Dynamic) (provide at run time)
- (Non continuous memory allocation) — Non-contiguous
  - Paging
  - Multilevel Paging
  - Inverted paging
  - Segmentation
  - Segmented Paging

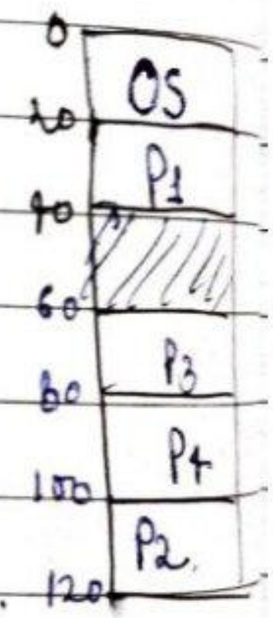
Ready state process & CPU utilization (efficiency)



Memory Blocks (RAM)

Contiguous allocation





Memory Block

Non-contiguous allocation

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Date ___/___/___

5.3 Internal fragmentation / Fixed size Partitioning

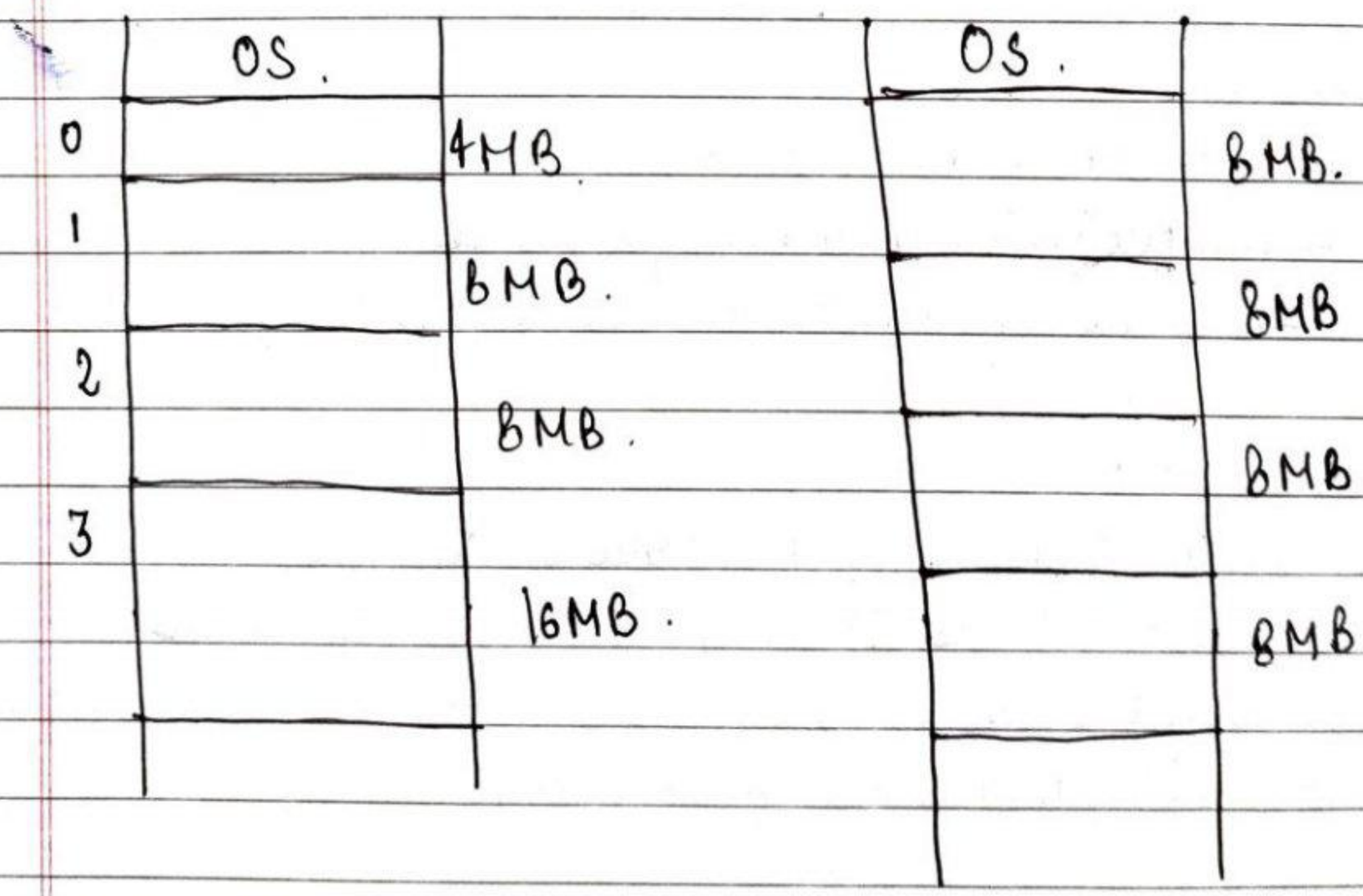
Whenever the process are coming into RAM, how we are allocating it the space.

Points to remember.

1) No of partitions are fixed
2) Size of each partition may or may not be same.
3) Contiguous allocation so spanning is not allowed.

* No of size of partitions may differ or be same. No of partition is always same.

We can put process in any partition taking into consideration its size should be less than partition size.



When we allocate any process to the partition. But after allocating process we get some extra memory which is wasted. It is called Internal fragmentation.

Although we having extra extra memory for diff n. partition we couldn't accomodate a process in pieces for that fragments.

Limitations

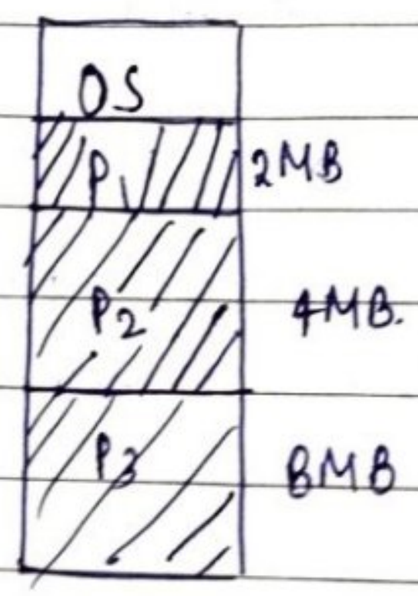
1) Internal fragmentation
2) Limit in process size.
3) Limitation on degree of multiprogramming. We can't bring more and more processes.
4) External fragmentation

5.4 Variable Size Partitioning

Ram is empty. At run time processes are allocated to the Ram at runtime.

$P_1 = 2MB$

$P_2 = 4MB$



Notes

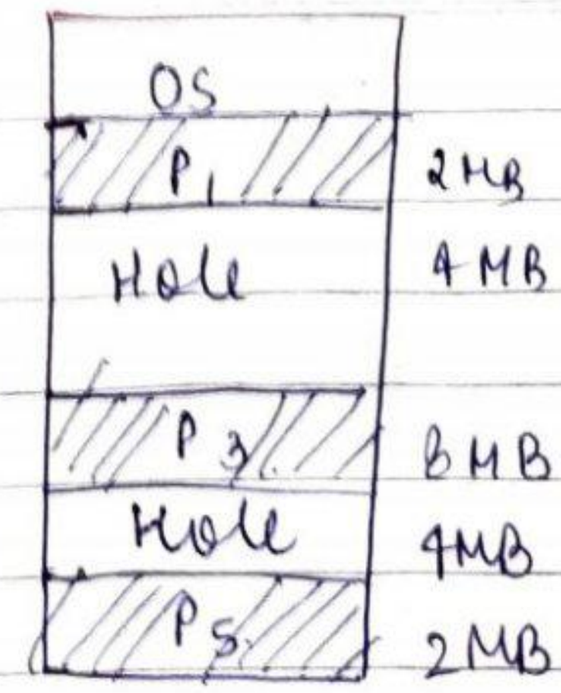
1) No internal fragmentation
2) No limitation on number of processes.
3) There is no limitation on the process size.

Limitations

1) External fragmentation occurs. We can remove it using compaction (one process is copied & pasted to other location) but it takes very much time.

2) Deallocation creates Hole. Allocation & deallocation is difficult.

3) Lot of Holes is created



In which we should put which process.

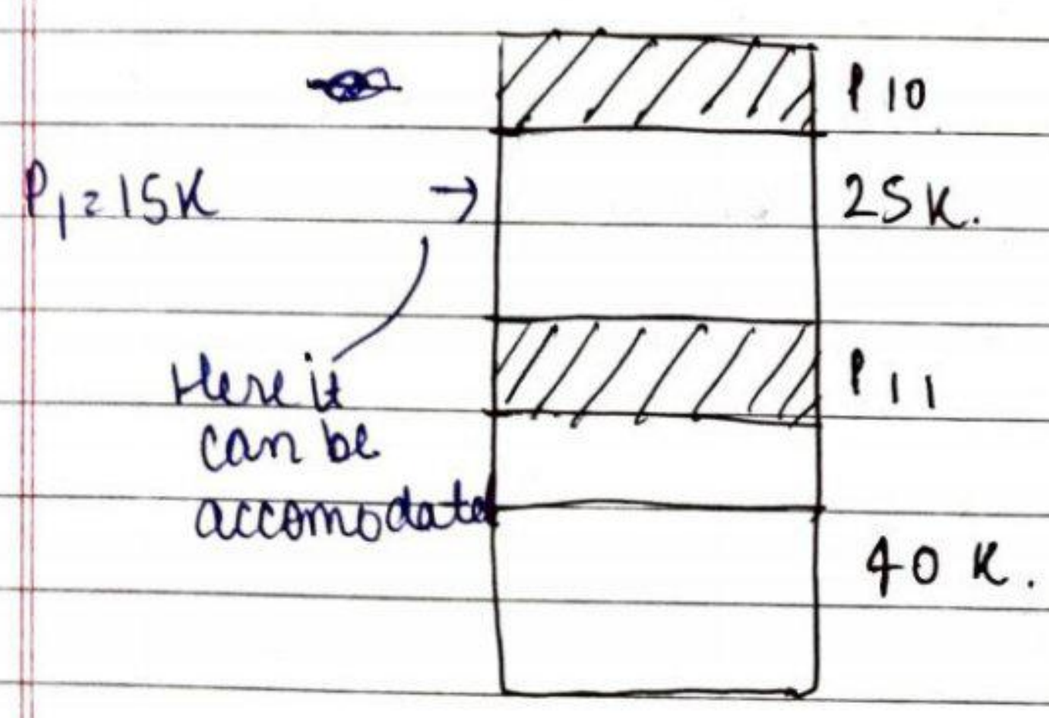
5.5 First fit, Next fit, Best fit
Worst fit

First fit → Allocate the first hole that is big enough

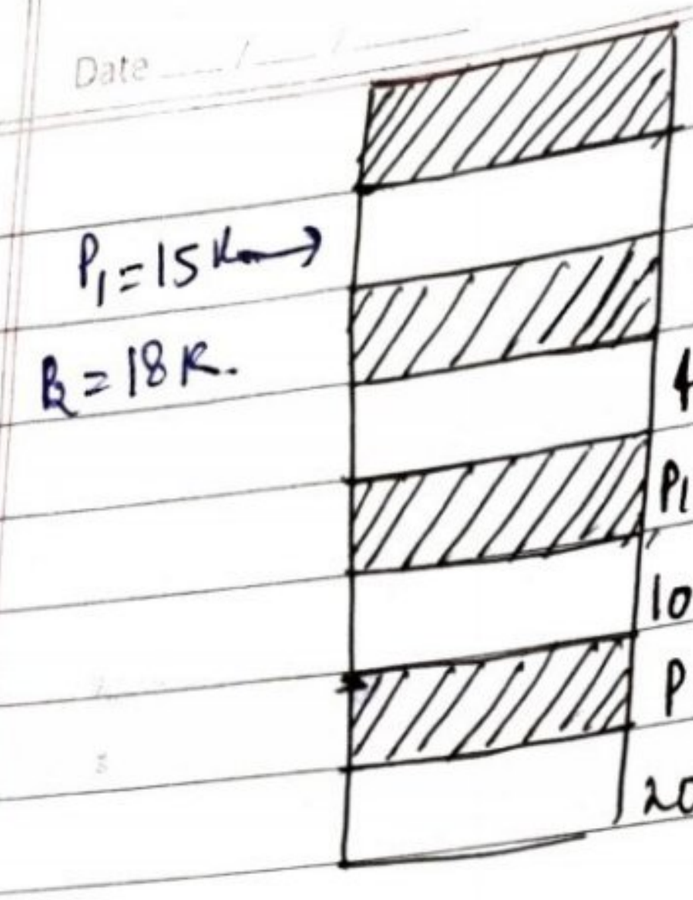
Next fit → Same as first fit but start search always from last allocated hole.

Best fit → Allocate the smallest hole that is big enough

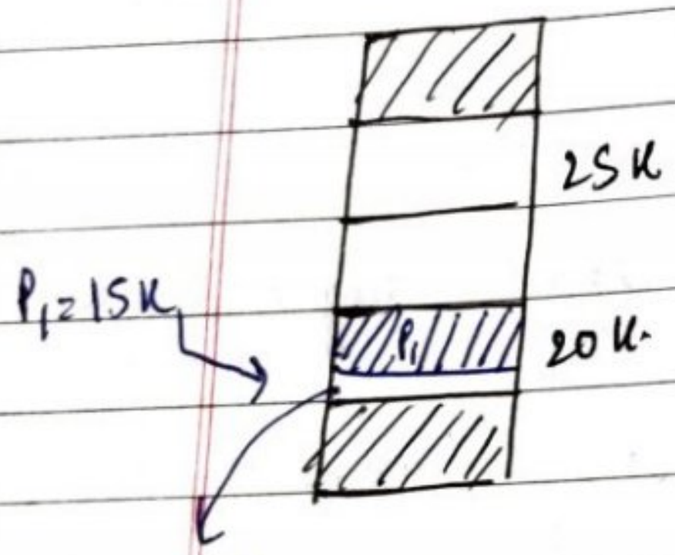
Worst fit → Allocate the largest hole.



first fit
(find the best possible large locn. which could accomodate process & place it in the RAM)



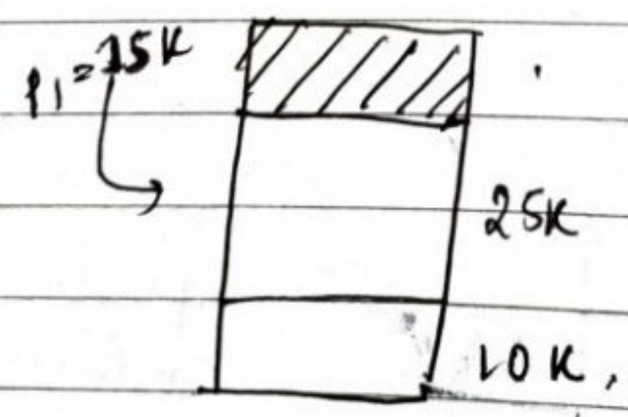
Next fit
(we place a pointer at last allocated first fit & start searching for next empty hole. We don't need to start from begining.



Internal fragmentation is least

Best fit
It would search the entire list & then return the hole where there is min^m fragmentation
It is slow

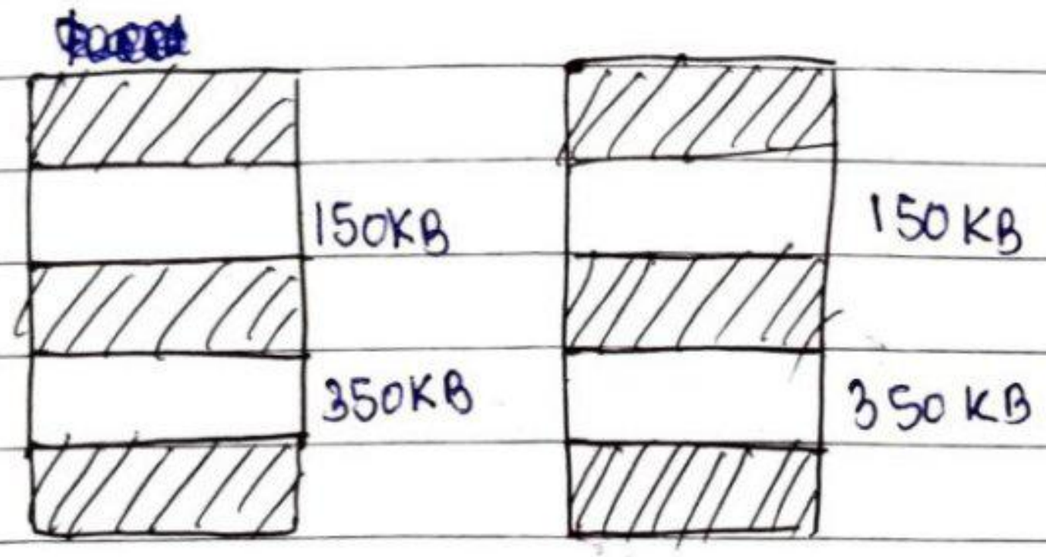
Worst fit - It would search the entire list but would search the biggest hole among every partitions. (Slow due to searching of entire list).



5.6. Gate Question On fits

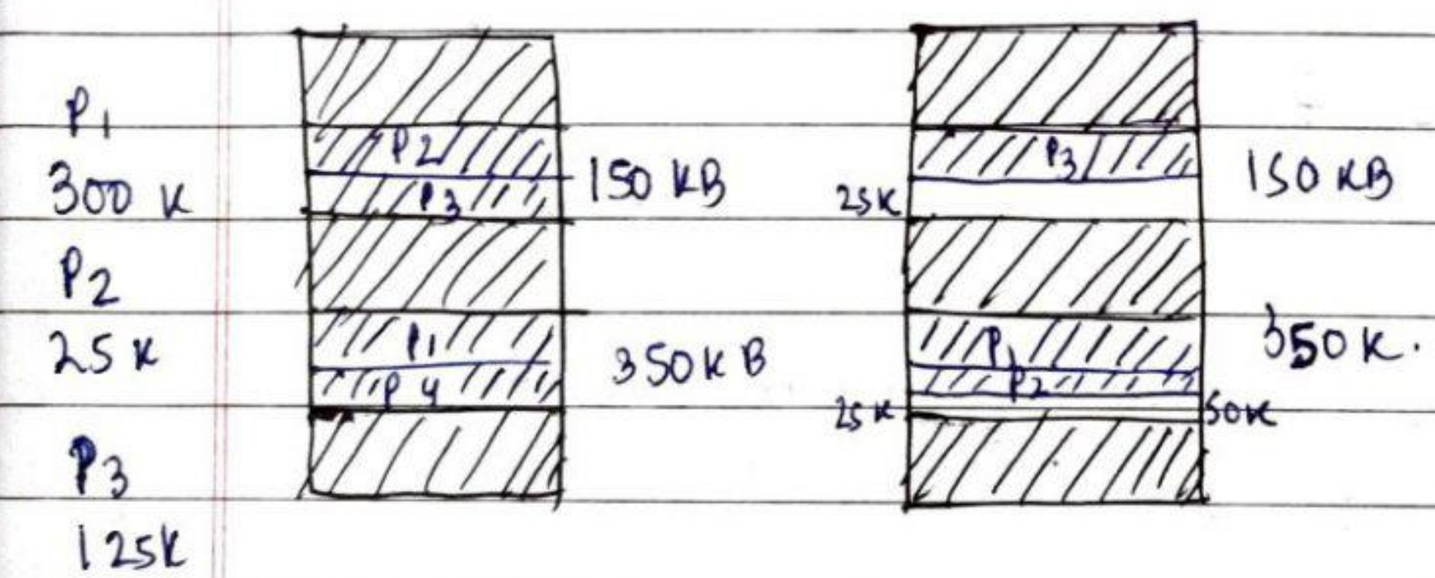
Q. Request from processes are 300K, 25K, 125K, 50K respectively. The above req. could be satisfy with.

a) best fit but not first fit.
b) First fit but not best fit
c) Both
d) None.



For first fit

For best fit



P_1	P_2	P_3	P_4
300	25	125	50

P_4 can't be accomodated

5.7 Gate 2007 Question on fits

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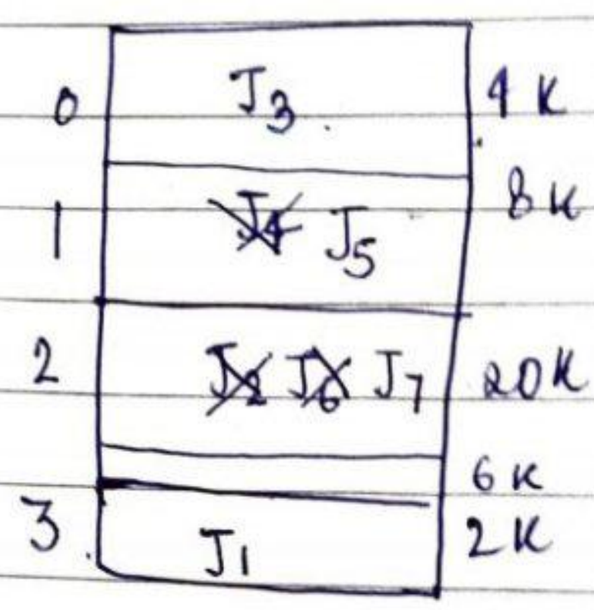
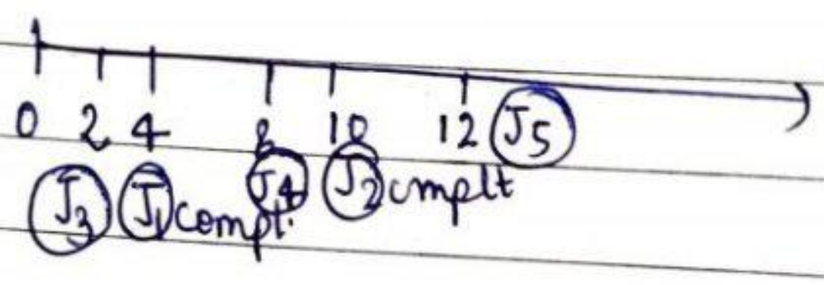
Date ____ Best fit

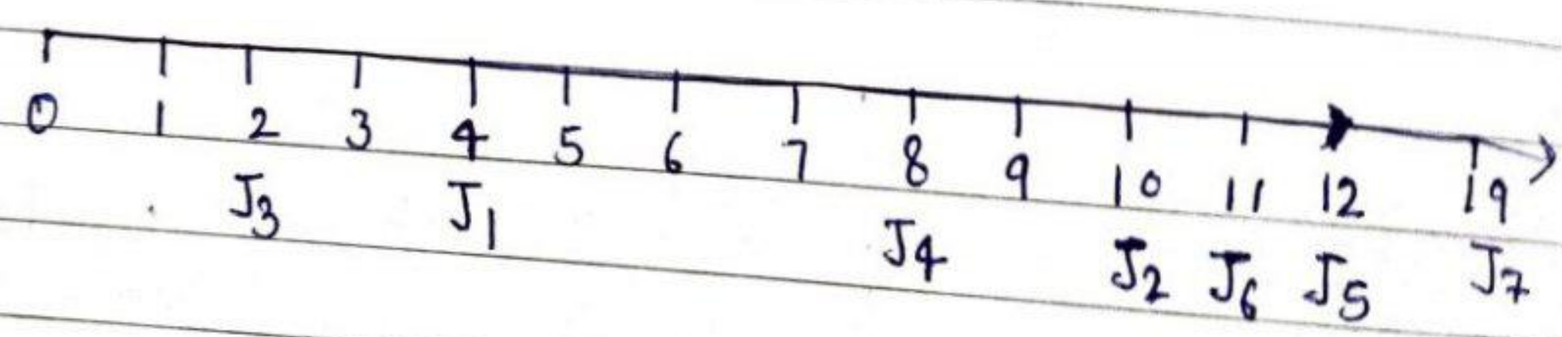
Req. No	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8
Request size	2K	19K	3K	6K	6K	10K	7K	20K
Usage time	4	10	2	8	4	1	8	6.

Calculate the time at which J_7 will be completed

a) 17 b) 21 c) 19 d) 20







In case of J_5 & J_6 we would take out the one which is completed first. And then put it & calc. the final time by initial + usage time.

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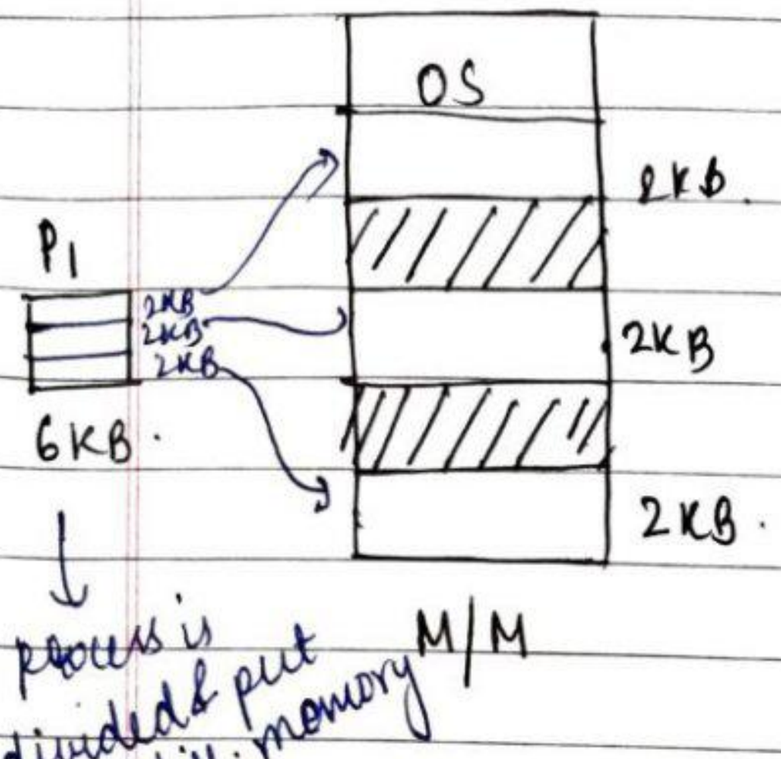
Date ___/___/___

5.8 Need of Paging (Non contiguous Memory Allocation)

A process can be spanned & put up in fragments in different memory location.

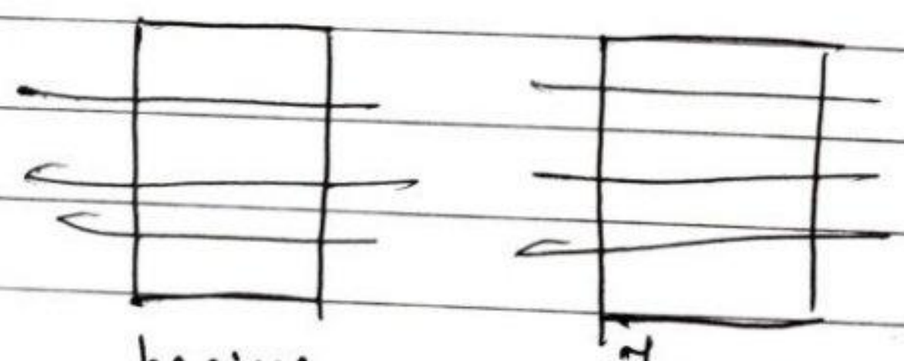


process is divided acc^n to the hole size but the hole size changes on runtime so its a bit time consuming (division of process)

process is divided & put up in diff. memory locations.

So a process is divided before its gets memory in pages.

When we do partition of process in secondary memory it's called <u>paging</u> while when we do partition of process in RAM it is called <u>framing</u>.



paging (Secondary memory)

Frames. M/M (RAM)

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