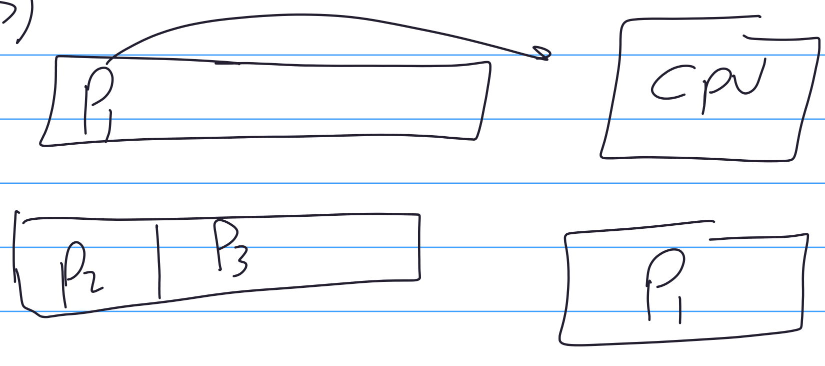
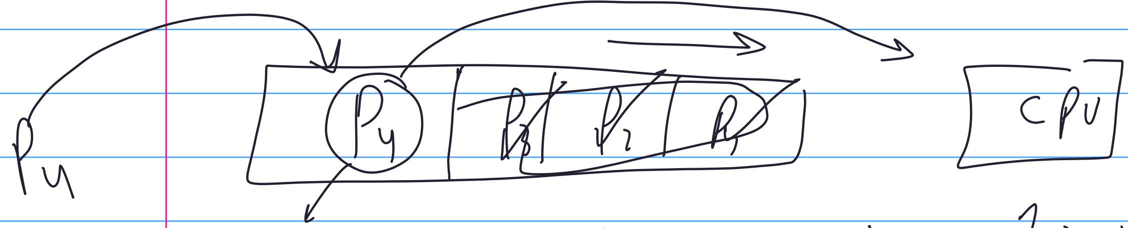
1. what is cpu scheduling, ready queue.
2. what is arrival, brust, waiting and turnaround time
3. what non preemptive and preemptive
4. Gantt chart
5. FCFS, SJF, RR and priority
6. cpu utilization

P_1 : $\boxed{10 \text{ mSec}}$

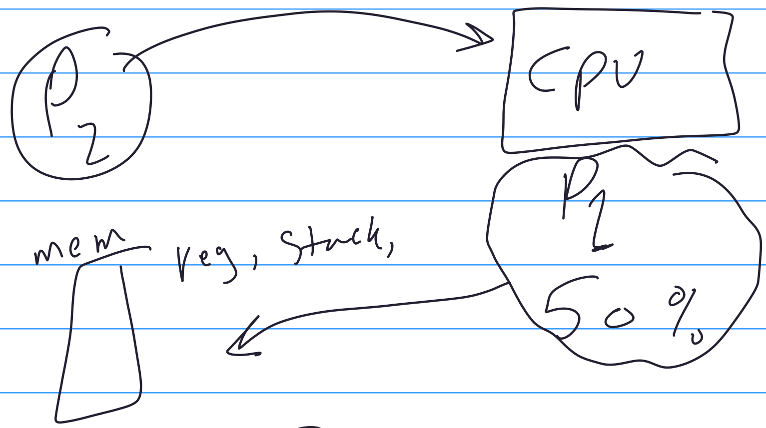
P_1 (10s)

P_2, P_3, (1m)



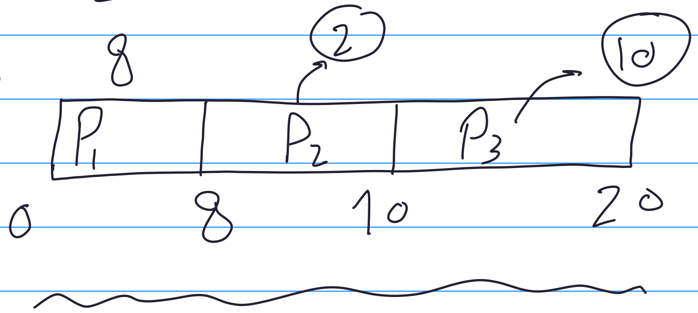


turn around = wait + 100 mSec



Context switch

P_1, P_2, P_3



20 t Unit

P_1 , P_2 , P_3

0 0.4 1

Brust

P_1	5
P_2	10
P_3	2

FCFS

P_1	P_2	P_3

0 t_1 t_2 t_3

SJF

P_3	P_1	P_2

0 2

RR quantum $t = \boxed{10}$

$P_1 = \cancel{20}$, $\cancel{10}\ 0$, $P_2 = \cancel{30}$, $\cancel{20}$, $\cancel{10}$, 0

P_1	P_2	P_1	P_2	P_2

0 10 20 30 40 50

$P_1 = 5$ $P_2 = 25$

P_1	P_2	---- -

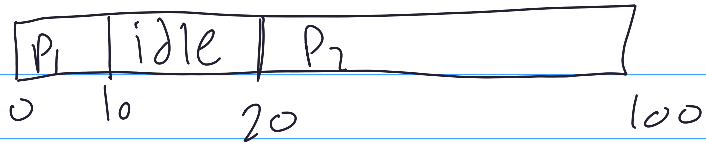
0 5 15

Priority

P_1	100	0	3
P_2	20	1	2
P_3	50	2	1
		3	0

P_1	P_3	P_2

P_2 arrive 20



IO
CPU

$$\frac{90}{100} = 90\%$$

FCFS

SJF

pr

6.1 A CPU-scheduling algorithm determines an order for the execution of its scheduled processes. Given n processes to be scheduled on one processor, how many different schedules are possible? Give a formula in terms of n.

$n!$

$n = 1 \rightarrow 1$

$n = 2 \rightarrow 2$ $\quad P_1, P_2$

P_2, P_1

$n = 3 \rightarrow 6$

$3 * 2 * 1$

P_1, P_2, P_3

1 2 3
1 3 2
2 1 3
2 3 1
3 2 1
3 1 2

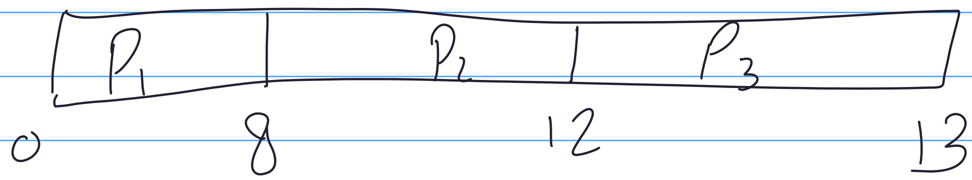
$n \longrightarrow n * (n-1) * (n-2) \ldots$

$= n!$

6.3 Suppose that the following processes arrive for execution at the times indicated. Each process will run for the amount of time listed. In answering the questions, use nonpreemptive scheduling, and base all decisions on the information you have at the time the decision must be made.

Process	Arrival Time	Burst Time
P_1	0.0	8
P_2	0.4	4
P_3	1.0	1

a. What is the average turnaround time for these processes with the FCFS scheduling algorithm?



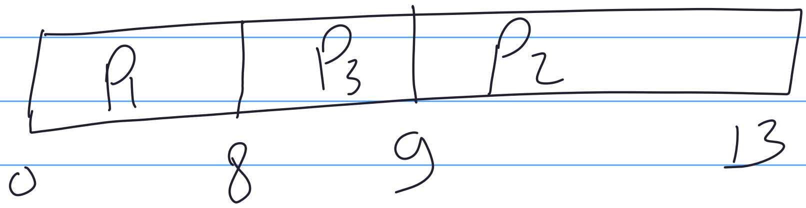
avg turnaround time

$$= \frac{(8-0)+(12-0.4)+(13-1)}{3} = 10.53$$

6.3 Suppose that the following processes arrive for execution at the times indicated. Each process will run for the amount of time listed. In answering the questions, use nonpreemptive scheduling, and base all decisions on the information you have at the time the decision must be made.

Process	Arrival Time	Burst Time
P_1	0.0	8
P_2	0.4	4
P_3	1.0	1

b. What is the average turnaround time for these processes with the SJF scheduling algorithm?



$$\frac{(8-0)+(9-1)+(13-0.4)}{3}$$

$$= 9.53$$

6.3 Suppose that the following processes arrive for execution at the times indicated. Each process will run for the amount of time listed. In answering the questions, use nonpreemptive scheduling, and base all decisions on the information you have at the time the decision must be made.

Process	Arrival Time	Burst Time
P_1	0.0	8
P_2	0.4	4
P_3	1.0	1

c. The SJF algorithm is supposed to improve performance, but notice that we chose to run process P_1 at time 0 because we did not know that two shorter processes would arrive soon. Compute what the average turnaround time will be if the CPU is left idle for the first 1 unit and then SJF scheduling is used. Remember that processes P_1 and P_2 are waiting during this idle time, so their waiting time may increase. This algorithm could be called future-knowledge scheduling.

idle	P_3	P_2	P_1

0 1 2 6 14

$$\frac{(2-1)+(6-0.4)+(14-0)}{3}$$

$= 6.87$

6.16 Consider the following set of processes, with the length of the CPU burst given in milliseconds:

Process	Burst Time	Priority
P_1	2	2
P_2	1	1
P_3	8	4
P_4	4	2
P_5	5	3

The processes are assumed to have arrived in the order P_1, P_2, P_3, P_4, P_5, all at time 0.

a. Draw four Gantt charts that illustrate the execution of these processes using the following scheduling algorithms: FCFS, SJF, nonpreemptive priority (a larger priority number implies a higher priority), and RR (quantum = 2).

b. What is the turnaround time of each process for each of the scheduling algorithms in part a?

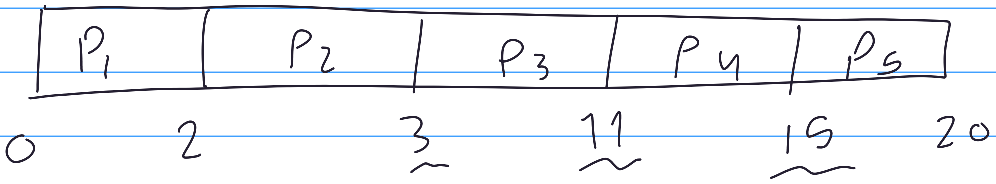
c. What is the waiting time of each process for each of these scheduling algorithms?

d. Which of the algorithms results in the minimum average waiting time (over all processes)?

FCFS

Process	turn	Burst Time	Priority
P_1	2	2	2
P_2	3	1	1
P_3	11	8	4
P_4	15	4	2
P_5	20	5	3

a. Draw Gantt.
b. Turnaround time.
c. Waiting time.
d. Which has minimum average waiting time?



P_1 0

P_2 2

P_3 3

P_4 11

P_5 15

$$avg = \frac{0+2+3+11+15}{5}$$

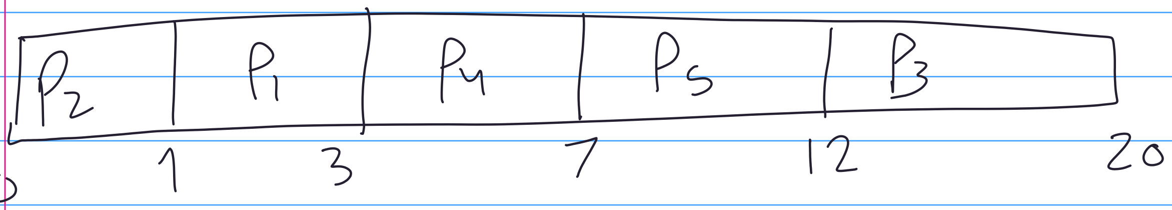
$$= 6.2$$

SJF

Process	Burst Time	Priority
P_1	2	~~2~~
P_2	1	~~1~~
P_3	8	~~4~~
P_4	4	~~2~~
P_5	5	~~3~~

a. Draw Gantt.
b. Turnaround time.
c. Waiting time.
d. Which has minimum average waiting time?

P_2 1
P_1 2
P_4 4
P_5 5
P_3 8



turn around
$P_2 : 1$, $P_3 : 3$, $P_4 : 7$, $P_5 : 12$
$P_3 : 20$

waiting
P_2 0
P_1 1
P_4 3
P_5 7
P_3 12

avg = 4.6

RR (quantum = 2)

a. Draw Gantt.
b. Turnaround time.
c. Waiting time.
d. Which has minimum average waiting time?

Process	Burst Time	Priority
~~P_1~~	~~2~~ 0	~~2~~
~~P_2~~	~~1~~ 0	~~1~~
P_3	~~8~~ ~~6~~ ~~4~~ ~~2~~	~~4~~
~~P_4~~	~~4~~ ~~2~~ 0	~~2~~
P_5	~~5~~ ~~3~~ ~~1~~	~~3~~

turn around ←

wait →

P1	P2	P3	P4	P5	P3	P4	P5	P3	P5	P3

0 2 3 5 7 9 11 13 15 17 18 20

$P_3 \Rightarrow 20$ | $P_5 \Rightarrow 18$ | $P_4 \Rightarrow 13$ | $P_2 \Rightarrow 3$

turn around $P_1 \Rightarrow 2$

waiting

$P_1 \quad (0)$

$P_2 \quad (2)$

$P_3 \quad (3 + (9-5) + (15-11) + (18-17))$

$3 + 4 + 4 + 1 = 12$

$P_4 \quad (5 + 4) = 9$

$P_5 \quad (7 + 4 + 2) = 13$

$$\text{avg} = \frac{0 + 2 + 12 + 9 + 13}{5} = 7.2$$

nonpreemptive priority

(a larger priority number implies a higher priority)

Process	Burst Time	Priority
P_1	2	2
P_2	1	1
~~P_3~~	~~8~~	~~4~~
P_4	4	2
~~P_5~~	~~5~~	~~3~~

a. Draw Gantt.
b. Turnaround time.
c. Waiting time.
d. Which has minimum average waiting time?

P_3	P_5	P_1	P_4	P_2

0 8 13 15 19 20

turn around

P_1	15
P_2	20
P_3	8
P_4	19
P_5	13

waiting

P_1	13
P_2	19
P_3	0
P_4	15
P_5	8

avg = 11

6.17 The following processes are being scheduled using a preemptive, round-robin scheduling algorithm. Each process is assigned a numerical priority, with a higher number indicating a higher relative priority. In addition to the processes listed below, the system also has an ***idle task*** (which consumes no CPU resources and is identified as P_{idle}). This task has priority 0 and is scheduled whenever the system has no other available processes to run. The length of a time quantum is 10 units. If a process is preempted by a higher-priority process, the preempted process is placed at the end of the queue.

Thread	Priority	Burst	Arrival
P_1	40	20	0
P_2	30	25	25
P_3	30	25	30
P_4	35	15	60
P_5	5	10	100
P_6	10	10	105

a. Show the scheduling order of the processes using a Gantt chart.

b. What is the turnaround time for each process?

c. What is the waiting time for each process?

d. What is the CPU utilization rate?

P_1	P_1	P idle	P_2	P_3	P_2	P_3	P_4	P_4	P_2	P_3	P idle	P_5	P_6	P_5

0 10 20 25 35 45 55 60 70 75 80 90 100 105 115 120

waiting

P_1 0

P_2 (10+20)

P_3 (5+10+20)

P_4 (0)

P_5 (0+10)

P_6 (0)

P	Priority	Brust

P	Priority	Brust

P	Priority	Brust

total = 120 $\Rightarrow \dfrac{120-(10+5)}{120}$

turnaround

P_1 (20 − 0) = 20

P_2 (80 − 25) =

P_3 (90 − 30) =

P_4 (75 − 60) =

P_5 (120 − 100) =

P_6 (115 − 105) =