Question # 1

Consider the following example of a system.

PID	Allocation			Max			Available (Work)			Need (Max − Allocation)		
	A	B	C	A	B	C	A	B	C	A	B	C
P_0	0	1	1	8	5	3	~~4~~	~~4~~	~~2~~	8	4	2
P_1	2	1	3	4	2	2	~~6~~	~~5~~	~~5~~	2	1	-1
P_2	3	0	3	9	0	4	~~9~~	~~5~~	~~8~~	6	0	1
P_3	2	1	3	3	2	3	~~11~~	~~6~~	~~11~~	1	1	0
P_4	1	1	3	5	3	3	~~12~~	~~7~~	~~14~~	4	2	0
							12	8	15			

① Make Need matrix.

$\because Need_{Res} = Max_{Res} - Allocation_{Res}$

(i) Check wether the system is in safe or unsafe state, using banker's algorithm (safety algorithm).

① Make need matrix.

$\because Need_{Res} = Max_{Res} - Allocation_{Res}$

For $P_0 \Rightarrow (8, 5, 3) - (0, 1, 1) = (8, 4, 2)$

For $P_1 \Rightarrow (4, 2, 2) - (2, 1, 3) = (2, 1, -1)$

For $P_2 \Rightarrow (9, 0, 4) - (3, 0, 3) = (6, 0, 1)$

For $P_3 \Rightarrow (3, 2, 3) - (2, 1, 3) = (1, 1, 0)$

For $P_4 \Rightarrow (5, 3, 3) - (1, 1, 3) = (4, 2, 0)$

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(2) if $Need_{Res} \leq Available_{Res}$

$Available_{Res} = Available_{Res} + Allocation_{Res}$.

For $P_0 \Rightarrow (8, 4, 2) \leq (4, 4, 2) \Rightarrow$ False.

For $P_1 \Rightarrow (2, 1, -1) \leq (4, 4, 2) \Rightarrow$ True.

$(4, 4, 2) + (2, 1, 3) = (6, 5, 5)$

For $P_2 \Rightarrow (6, 0, 1) \leq (6, 5, 5) \Rightarrow$ True.

$(6, 5, 5) + (3, 0, 3) = (9, 5, 8)$

For $P_3 \Rightarrow (1, 1, 0) \leq (9, 5, 8) \Rightarrow$ True.

$(9, 5, 8) + (2, 1, 3) = (11, 6, 11)$

For $P_4 \Rightarrow (4, 2, 0) \leq (11, 6, 11) \Rightarrow$ True.

$(11, 6, 11) + (1, 1, 3) = (12, 7, 14)$

For $P_0 \Rightarrow (8, 4, 2) \leq (12, 7, 14) \Rightarrow$ True.

$(12, 7, 14) + (0, 1, 1) = (12, 8, 15)$

The system is in safe state.

(ii) Determine the sequence, if it is in Safe state

Safe Sequence

P_1, P_2, P_3, P_4, P_0.

(iii) If P1 requests (2, 0, 2), determine, if it can be ~~saf~~ granted immediately (resource request algorithm)?

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PID	Allocation			Max			Available (Work)			Need (Max − Allocation)		
	A	B	C	A	B	C	A	B	C	A	B	C
P_0	0	1	1	8	5	3	4	2	2	8	4	2
P_1	2	1	3	4	2	2				2	1	-1
P_2	3	0	3	9	0	4				6	0	1
P_3	2	1	3	3	2	3				1	1	0
P_4	1	1	3	5	3	3				4	2	0

$P_1 \rightarrow R(\overset{A}{2}, \overset{B}{0}, \overset{C}{2})$.

① $Request_{Res} \leq Need_{Res}$.

$(2, 0, 2) \leq (2, 1, -1)$ False.

The requested resources cannot be granted immediately

Question # 2

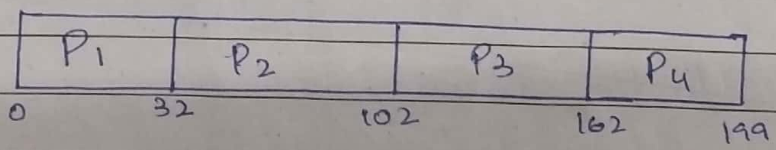
Considering the given table, draw a Gantt Chart and calculate CT, WT, TAT, ATAT, AWT, and average throughput using FCFS, SJF, SRJF and Round Robin (Qt = 4) CPU Scheduling Algorithm.

PID	Arrival Time	Burst Time.
P1	0	32
P2	3	70
P3	5	60
P4	7	37

1. First Come First Serve - FCFS

PID	Arrival Time AT	Burst Time BT	Completion Time CT	Turn Around Time TAT	Waiting Time WT
P1	0	32	32	32	0
P2	3	70	102	99	29
P3	5	60	162	157	97
P4	7	37.	199	192	155

Gantt Chart:



Calculate Completion Time => CT = Finish time of last process + Burst time

Calculate Turn Around Time => TAT = CT + AT

Calculate Waiting Time => WT = TAT - BT

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Calculate Average Turn Around Time.

$$ATAT = \frac{\sum TAT}{\sum P} = \frac{32+99+157+192}{4} = \frac{480}{4}$$

$\boxed{ATAT = 120}$

Calculate Average Waiting Time.

$$AWT = \frac{\sum WT}{\sum P} = \frac{0+29+97+155}{4} = \frac{281}{4} = 70.25$$

$\therefore \boxed{AWT = 70.25}$

Calculate Throughput $\Rightarrow$ Throughput $= \frac{\sum P}{\text{Max CT} - \text{Min AT}}$

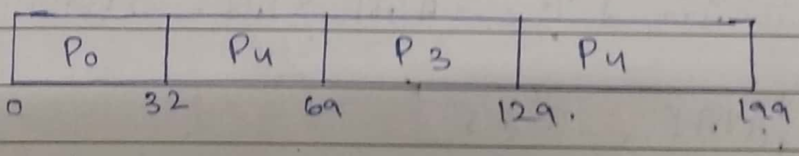
Throughput $= 4/199-0 = 4/199.$

$\boxed{\text{Throughput} = 0.201 \text{ or } 2.01\%}$

2. SHORTEST JOB FIRST - SJF

PID	Arrival Time AT	Burst Time BT	Completion Time CT	Turn Around Time TAT	Waiting Time WT
P_1	0	32	32	32	0
P_2	3	70	199	196	126
P_3	5	60	129	124	64
P_4	7	37	69	62	25

Gantt Chart:



Calculate Completion time $\Rightarrow$ CT

Calculate Turn Around time $\Rightarrow$ TAT = CT - AT

Calculate Waiting Time $\Rightarrow$ WT = TAT - BT.

Average Turn Around Time $\Rightarrow$ $ATAT = \frac{\sum TAT}{\sum P} = \frac{32+196+124+62}{4}$

$\boxed{ATAT = \frac{207}{2} = 103.5}$

~~Calculate~~ Average Waiting Time => $AWT = \frac{\Sigma WT}{\Sigma P} = \frac{0+126+64+25}{4}$

$\boxed{AWT = 53.75}$

Throughput $= \frac{\Sigma P}{\text{Max CT} - \text{Min AT}} = \frac{4}{199-0} = \frac{4}{199}$

$\boxed{\text{Throughput} = 0.0201 \text{ or } 2.01\%}$

3. SHORTEST REMAINING JOB FIRST - SRJF

PID	Arrival Time AT	Burst Time BT	Completion Time CT	Turn Around Time TAT	Waiting Time WT
P_1	0	32	39	32	0
P_2	3	70	199	196	126
P_3	5	60	129	124	64
P_4	7	37	69	62	25

Gantt Chart:

P_1	P_1	P_1	P_1	P_1	P_1	P_1	P_1	P_4	P_3	P_2
0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–32	32–69	69–129	129–199

P_1 ~~32 31 30 29 28 27 26~~ 25
P_2 70
P_3 60
P_4 37

Calculate Completion time => CT

Calculate Turn Around Time => TAT = CT − AT

Calculate Waiting Time => WT = TAT − BT

Average Turn Around Time => $ATAT = \frac{\Sigma TAT}{\Sigma P} = \frac{32+196+124+62}{4}$

$\boxed{ATAT = 103.5}$

Average Waiting Time => $AWT = \frac{\Sigma WT}{\Sigma P} = \frac{0+126+64+25}{4}$

$\boxed{ATAT = 53.75}$

Throughput $= \Sigma P / \text{Max CT} - \text{Min AT} \Rightarrow 4/199-0$

$\boxed{\text{Throughput} = 0.201 \text{ or } 2.01\%}$

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4. ROUND ROBIN - RR

Time Quantum = Qt = 4.

PID	Arrival Time AT	Burst Time BT	Completion Time CT	Turn Around Time TAT	Waiting Time WT
P1	0	32	116	116	84
P2	3	70	199	196	126
P3	5	60	189	184	124
P4	7	37	149	142	105

Gantt chart:

P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3

0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60

P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2

60 64 68 72 76 80 84 88 92 96 100 104 108 112 116 120

P3	P4	P2	P3	P4	P2	P3	P4	P2	P3	P2	P3	P2	P3	P2

120 124 128 132 136 140 144 148 149 153 157 161 165 169 173 177

P3	P2	P3	P2	P2	P2

177 181 185 189 193 197 199

BT

P1	~~32~~ ~~28~~ ~~24~~ ~~20~~ ~~16~~ ~~12~~ ~~8~~ ~~4~~ 0
P2	~~70~~ ~~66~~ ~~62~~ ~~58~~ ~~54~~ ~~50~~ ~~46~~ ~~42~~ ~~38~~ ~~34~~ ~~30~~ ~~26~~ ~~22~~ ~~18~~ ~~14~~ ~~10~~ ~~6~~ ~~2~~ 0.
P3	~~60~~ ~~56~~ ~~52~~ ~~48~~ ~~44~~ ~~40~~ ~~36~~ ~~32~~ ~~28~~ ~~24~~ ~~20~~ ~~16~~ ~~12~~ ~~8~~ ~~4~~ 0
P4	~~37~~ ~~33~~ ~~29~~ ~~25~~ ~~21~~ ~~17~~ ~~13~~ ~~9~~ ~~5~~ ~~1~~ 0

Calculate Completion time through Gantt Chart ⇒ CT

Calculate Turn Around time ⇒ TAT = CT − AT

Calculate Waiting time ⇒ WT = TAT − BT

Average Turn Around Time ⇒ ATAT $= \frac{\Sigma TAT}{\Sigma P} = \frac{116+196+184+14}{4}$

$\boxed{ATAT = 159.5}$

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Average Waiting Time $\Rightarrow$ AWT $= \dfrac{\Sigma WT}{\Sigma P} = \dfrac{84+126+124+105}{4}$.

$\boxed{AWT = 109.75}$

Throughput $= \dfrac{\Sigma P}{\text{Max CT} - \text{Min AT}} = \dfrac{4}{199-0} = \dfrac{4}{199}$

$\boxed{\text{Throughput} = 0.0201 \text{ or } 2.01\%}$