Sequencing Models

TD Week 7

Single Machine Scheduling & Priority Rules

Institute of Technology of Cambodia

1 Basic FCFS and SPT Comparison

Exercise 1: Printing Services
A copy center has 5 print jobs waiting at 8:00 AM:

Job	Pages (Processing Time, min)	Due Time (min from now)
A	12	30
B	6	20
C	18	45
D	8	25
E	10	35

Tasks:

1. Create complete scheduling tables for both FCFS (arrival order: A-B-C-D-E) and SPT sequences.
2. Calculate mean flow time for each rule.
3. Calculate mean tardiness for each rule.
4. What is the percentage improvement in mean flow time when using SPT compared to FCFS?
5. What is the percentage improvement in mean tardiness when using SPT compared to FCFS?
6. How many jobs are tardy under each rule?

Exercise 2: Automotive Repair Shop
A mechanic has 6 cars to service. All arrive at 9:00 AM:

Car	Service Time (hours)	Promised Completion (hours)
1	3.5	8
2	1.5	4
3	4.0	10
4	2.0	5
5	5.0	12
6	2.5	6

Tasks:

1. Apply FCFS (order: 1-2-3-4-5-6) and calculate all performance metrics.
2. Apply SPT and calculate all performance metrics.
3. Calculate the percentage improvement in mean flow time using SPT vs FCFS.
4. Which rule results in fewer tardy jobs? By how many?
5. Calculate maximum tardiness for both rules. Which performs better?

2 FCFS, SPT, and EDD Three-Way Comparison

Exercise 3: Laboratory Testing
A quality control lab processes 5 chemical tests:

Test	Testing Time (hours)	Deadline (hours)
T1	4	10
T2	2	6
T3	6	15
T4	3	8
T5	5	12

Tasks:

1. Create complete schedules for FCFS (T1-T2-T3-T4-T5), SPT, and EDD.
2. Calculate mean flow time for all three rules.
3. Calculate mean tardiness for all three rules.
4. What is the percentage improvement of SPT over FCFS for mean flow time?
5. What is the percentage improvement of EDD over FCFS for mean tardiness?
6. Which rule minimizes maximum tardiness? What is the value?

Exercise 4: Software Development Tasks
A programmer has 7 coding tasks:

Task	Coding Hours	Sprint Deadline (hours)
A	8	20
B	4	12
C	12	30
D	6	15
E	10	25
F	5	18
G	7	22

Tasks:

1. Determine sequences for FCFS (arrival: A-B-C-D-E-F-G), SPT, and EDD.
2. Create complete scheduling tables for all three rules.
3. Calculate mean flow time and mean tardiness for each.
4. Compare SPT vs FCFS: percentage improvement in both metrics.
5. Compare EDD vs FCFS: percentage improvement in both metrics.
6. Which rule would you recommend and why?

3 SPT vs EDD Direct Comparison

Exercise 5: Manufacturing Production
A CNC machine has 6 parts to produce:

Part	Machining Time (min)	Customer Deadline (min)
P1	45	120
P2	30	80
P3	60	150
P4	25	70
P5	40	100
P6	35	90

Tasks:

1. Apply SPT rule and create complete schedule.
2. Apply EDD rule and create complete schedule.
3. Calculate mean flow time for both. Which is better and by what percentage?
4. Calculate mean tardiness for both. Which is better and by what percentage?
5. Calculate maximum lateness for both. Which rule performs better?
6. How many jobs are tardy under each rule?

Exercise 6: Hospital Emergency Department
Non-critical patients await treatment:

Patient	Treatment Time (min)	Triage Target (min)
1	25	60
2	15	40
3	30	75
4	10	35
5	20	50
6	18	45

Tasks:

1. Sequence using SPT. Calculate mean flow time and mean tardiness.
2. Sequence using EDD. Calculate mean flow time and mean tardiness.
3. What is the percentage difference in mean flow time (SPT vs EDD)?
4. What is the percentage difference in mean tardiness (SPT vs EDD)?
5. Which rule better achieves the hospital's goal of meeting triage targets?

4 Weighted Jobs (WSPT)

Exercise 7: Priority Customer Orders
An electronics repair shop has jobs with different customer priorities:

Job	Repair Time (hrs)	Due Date (hrs)	Priority Weight
J1	3	10	5
J2	5	15	2
J3	2	8	8
J4	4	12	3
J5	6	18	4

Tasks:

1. Calculate w_i/p_i ratio for each job.
2. Determine WSPT sequence (highest ratio first).
3. Create complete schedule and calculate weighted mean flow time: $\sum w_i F_i / \sum w_i$
4. Apply regular SPT and calculate weighted mean flow time.
5. What is the percentage improvement of WSPT over SPT for weighted mean flow time?
6. Why does WSPT perform better than SPT in this case?

Exercise 8: Investment Banking Deals
An analyst must process 5 client deals with different revenue values:

Deal	Analysis Time (days)	Deadline (days)	Revenue ($M)
D1	4	12	8
D2	6	18	15
D3	3	10	6
D4	5	15	12
D5	2	8	10

Tasks:

1. Use revenue as weight. Calculate w_i/p_i for each deal.
2. Sequence using WSPT rule.
3. Calculate weighted mean flow time and weighted mean tardiness.
4. Compare with SPT sequence (calculate same weighted metrics).
5. What percentage improvement does WSPT provide over SPT for weighted metrics?

5 Minimum Slack (MS) Rule

Exercise 9: Construction Project Tasks
A contractor has 5 tasks to complete:

Task	Duration (days)	Deadline (days)
A	6	18
B	4	12
C	8	20
D	5	14
E	7	22

Tasks:

1. Calculate initial slack for each task at t = 0 using formula: $Slack = d_i - p_i - t$
2. Apply MS rule: process job with minimum slack, then recalculate slack for remaining jobs after each completion.
3. Create complete schedule showing slack calculations at each decision point.
4. Calculate mean flow time and mean tardiness for MS rule.
5. Apply EDD rule and calculate same metrics.
6. Compare MS vs EDD: which performs better for mean tardiness and by what percentage?

Exercise 10: Aircraft Maintenance Scheduling
Five aircraft need maintenance:

Aircraft	Maintenance Time (hrs)	Flight Schedule (hrs)
AC1	8	24
AC2	5	15
AC3	12	30
AC4	6	18
AC5	10	28

Tasks:

1. Calculate slack for each aircraft at t = 0.
2. Apply MS rule with step-by-step slack recalculation.
3. Calculate mean flow time and number of tardy jobs.
4. Apply SPT and calculate same metrics.
5. What is the percentage improvement in mean flow time (SPT vs MS)?
6. Which rule results in fewer aircraft missing flight schedules?

6 Critical Ratio (CR) Rule

Exercise 11: Restaurant Kitchen Orders
A chef has 6 orders at 12:00 PM:

Order	Prep Time (min)	Promised Time (min from now)
O1	15	30
O2	10	20
O3	20	45
O4	8	18
O5	12	25
O6	18	40

Tasks:

1. Calculate Critical Ratio at t = 0 for each order: $CR = (d_i - t)/p_i$
2. Apply CR rule: process lowest CR first, recalculate after each order.
3. Show CR calculations at each decision point (t = 0, and after each completion).
4. Create complete schedule with tardiness calculations.
5. Apply EDD and calculate mean tardiness.
6. Compare CR vs EDD for mean tardiness. Which performs better and by what percentage?

7 Comprehensive Comparisons

Exercise 12: Data Center Job Processing
A server processes computational jobs:

Job	CPU Time (min)	Deadline (min)
J1	20	50
J2	12	35
J3	30	80
J4	15	40
J5	25	60
J6	10	30
J7	18	45

Tasks:

1. Apply FCFS (order: J1-J2-J3-J4-J5-J6-J7), SPT, EDD, and MS rules.
2. Create a comparison table with: Mean Flow Time, Mean Tardiness, Max Tardiness, Number of Tardy Jobs.
3. Calculate percentage improvement of SPT over FCFS for mean flow time.
4. Calculate percentage improvement of EDD over FCFS for mean tardiness.
5. Which rule would you recommend if: (a) throughput is critical? (b) meeting deadlines is critical?

Exercise 13: Manufacturing Cell Production
Eight parts await processing:

Part	Processing Time (min)	Due Date (min)
P1	35	90
P2	20	60
P3	45	120
P4	15	50
P5	40	100
P6	25	70
P7	30	85
P8	28	75

Tasks:

1. Calculate and compare all four rules: FCFS, SPT, EDD, MS.
2. For each rule, calculate: mean flow time, mean tardiness, maximum lateness.
3. Create a summary table showing all metrics for all rules.
4. Calculate percentage improvements: SPT vs FCFS (flow time), EDD vs FCFS (tardiness).
5. Identify which rule performs best for each metric.
6. If flow time and tardiness are equally important, which rule provides the best balance?

8 Performance Metric Focus

Exercise 14: Maximum Lateness Minimization
A production line has 6 orders:

Order	Production Time (hrs)	Contract Deadline (hrs)
1	4	12
2	7	18
3	3	10
4	9	25
5	5	15
6	6	20

Tasks:

1. Apply SPT and calculate maximum lateness (L_{max}).
2. Apply EDD and calculate maximum lateness.
3. What is the percentage reduction in maximum lateness when using EDD vs SPT?
4. Calculate mean tardiness for both rules. Which performs better and by what percentage?
5. If contract penalties are \$1000 per hour of lateness on the worst job, how much is saved using EDD vs SPT?

Exercise 15: Makespan and Throughput
A testing facility processes quality inspections:

Test	Inspection Time (min)	Target Completion (min)
T1	22	50
T2	18	45
T3	28	70
T4	15	40
T5	25	60
T6	20	55

Tasks:

1. Calculate makespan (C_{max}) for FCFS, SPT, and EDD. What do you notice?
2. Calculate mean flow time for all three rules.
3. What is the percentage improvement in mean flow time from FCFS to SPT?
4. Calculate the average time tests spend in the system (mean flow time) under each rule.
5. If the facility wants to maximize daily throughput (minimize average time in system), which rule should they use?

9 Real-World Application Problems

Exercise 16: E-commerce Order Fulfillment
An online retailer's warehouse has orders to pick and pack:

Order	Pick Time (min)	Shipping Cutoff (min)	Express?
O1	12	60	No
O2	8	30	Yes
O3	18	90	No
O4	10	40	Yes
O5	15	75	No
O6	6	35	Yes

Express orders have weight = 3, Regular orders have weight = 1.
Tasks:

1. Apply FCFS (order shown) and calculate weighted mean tardiness: $\sum w_i T_i / \sum w_i$
2. Apply WSPT using weights and calculate weighted mean tardiness.
3. Apply EDD and calculate weighted mean tardiness.
4. What is the percentage improvement of WSPT over FCFS?
5. What is the percentage improvement of EDD over FCFS?
6. Which rule best serves express customers? Support with calculations.

Exercise 17: Medical Imaging Center
A radiology center schedules MRI scans:

Patient	Scan Time (min)	Appointment (min)	Urgency (1-5)
P1	30	60	2
P2	20	45	4
P3	40	90	1
P4	25	55	3
P5	35	75	2
P6	15	40	5

Tasks:

1. Apply SPT and calculate: mean flow time, mean tardiness, number of patients seen late.
2. Apply EDD and calculate same metrics.
3. Apply WSPT using urgency as weight and calculate weighted mean flow time.
4. Compare SPT vs EDD: percentage difference in mean tardiness.
5. Compare WSPT vs SPT: percentage difference in weighted mean flow time.
6. Which scheduling rule would you recommend for this medical facility? Justify with calculations and ethical considerations.

Exercise 18: IT Help Desk Tickets
A support team has tickets to resolve:

Ticket	Resolution Time (min)	SLA Target (min)	Customer Tier
T1	25	60	Standard
T2	15	40	Premium
T3	35	90	Standard
T4	20	50	Premium
T5	30	75	Standard
T6	18	45	Premium

Premium customers have weight = 5, Standard = 1.
Tasks:

1. Apply FCFS and calculate: number of SLA violations, weighted mean tardiness.
2. Apply SPT and calculate same metrics.
3. Apply WSPT and calculate same metrics.
4. What is the percentage improvement in SLA violations: SPT vs FCFS, WSPT vs FCFS?
5. What is the percentage improvement in weighted mean tardiness: WSPT vs SPT?
6. If SLA violations cost \$100 for Standard and \$500 for Premium customers, calculate total penalty cost for each rule. Which minimizes cost?

10 Advanced Mixed Scenarios

Exercise 19: Multi-Criteria Decision
A job shop has 7 jobs with multiple considerations:

Job	Process Time (hrs)	Due Date (hrs)	Profit ($)
J1	6	18	400
J2	4	12	600
J3	10	28	300
J4	5	15	800
J5	8	22	500
J6	7	20	450
J7	9	25	350

Late jobs incur penalty of 10% of profit per hour late.
Tasks:

1. Apply SPT: calculate total profit minus total penalties.
2. Apply EDD: calculate total profit minus total penalties.
3. Apply WSPT using profit as weight: calculate total profit minus penalties.
4. Which rule maximizes net profit? Show all calculations.
5. Calculate percentage improvement of best rule over worst rule in terms of net profit.
6. What is the mean flow time under each rule? Is there a trade-off between profit and efficiency?

Exercise 20: Complex Scheduling Challenge
A semiconductor fab has wafers to process:

Wafer	Process (hrs)	Due (hrs)	Priority	Customer
W1	8	24	High (3)	A
W2	5	18	Medium (2)	B
W3	12	35	Low (1)	C
W4	6	20	High (3)	A
W5	10	30	Medium (2)	D
W6	7	22	High (3)	A
W7	9	28	Low (1)	E
W8	4	16	Medium (2)	B

Tasks:

1. Apply four rules: FCFS, SPT, EDD, WSPT (using priority as weight).
2. Create a comprehensive comparison table with all metrics for all rules.
3. Calculate percentage improvements for: SPT vs FCFS (mean flow time), EDD vs FCFS (mean tardiness), WSPT vs SPT (weighted mean flow time).
4. Determine how many high-priority wafers are late under each rule.
5. Calculate weighted mean tardiness (using priority weights) for all rules.
6. Based on all calculations, write a recommendation: which rule should the fab use and why? Consider efficiency, deadline performance, and customer priority.