# Sequencing Models: N Jobs on M Machines

Practice Exercises

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## Parallel Machine Scheduling

**Problem 1.** Three identical printing machines are available to process 6 print jobs. The processing times (in hours) are given below:

| Job | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| Time | 8 | 5 | 12 | 3 | 10 | 7 |

(a) Use the LPT rule to assign jobs to machines.

(b) Calculate the makespan.

(c) What is the theoretical minimum makespan? How does your solution compare?

**Problem 2.** A computer server farm has 4 identical processors. Eight jobs arrive simultaneously with the following processing times (in minutes):

| Job | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Time | 15 | 8 | 20 | 12 | 6 | 18 | 10 | 14 |

(a) Apply the LPT rule to schedule these jobs.

(b) What is the resulting makespan?

(c) Calculate the utilization rate of each processor.

(d) If we used SPT instead, would the makespan be better or worse? Explain why.

**Problem 3.** A workshop has 2 identical CNC machines. Five parts need to be machined with processing times and due dates as shown:

| Part | Processing Time (hrs) | Due Date (hrs) | Weight |
|---|---|---|---|
| A | 6 | 10 | 3 |
| B | 4 | 8 | 2 |
| C | 8 | 15 | 4 |
| D | 3 | 6 | 1 |
| E | 5 | 12 | 2 |

(a) Schedule the parts using LPT rule.

(b) Calculate the weighted completion time $\sum w_i C_i$.

(c) How many parts are tardy?

(d) What is the maximum tardiness?

**Problem 4.** A bakery has 3 identical ovens. Six batches of bread need to be baked with the following times (in minutes): 25, 35, 20, 30, 15, 40.

(a) Assign batches using LPT.

(b) What is the makespan?

(c) If the bakery operates for 60 minutes, will all batches be completed?

(d) Calculate the total idle time across all ovens.

**Problem 5.** Compare LPT and SPT rules for parallel machines. Given 3 machines and jobs with times: 20, 15, 10, 8, 6, 4, 2.

(a) Schedule using LPT and find makespan.

(b) Schedule using SPT and find makespan.

(c) Which rule gives better makespan? Explain why.

(d) Calculate total completion time $\sum C_i$ for both methods.

## Flow Shop Scheduling (2 Machines)

**Problem 6.** Five jobs must be processed through 2 machines in sequence. Processing times are:

| Job | A | B | C | D | E |
|---|---|---|---|---|---|
| Machine 1 | 7 | 5 | 9 | 4 | 8 |
| Machine 2 | 6 | 8 | 4 | 7 | 3 |

(a) Apply Johnson's Rule to find the optimal sequence.

(b) Draw the Gantt chart for your sequence.

(c) Calculate the makespan.

(d) What is the total idle time on Machine 2?

**Problem 7.** A car wash has 2 stages: Wash and Dry. Six cars are waiting with processing times (in minutes):

| Car | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Wash | 8 | 6 | 10 | 4 | 7 | 5 |
| Dry | 5 | 7 | 4 | 8 | 6 | 9 |

(a) Use Johnson's Rule to determine the optimal sequence.

(b) Calculate the makespan.

(c) At what time does each car complete the entire process?

(d) What is the utilization of the Dry stage?

**Problem 8.** Four jobs go through cutting and assembly operations:

| Job | W | X | Y | Z |
|---|---|---|---|---|
| Cutting | 12 | 8 | 15 | 6 |
| Assembly | 9 | 14 | 7 | 11 |

(a) Apply Johnson's Rule step by step, showing your reasoning.

(b) Create the schedule and calculate makespan.

(c) Compare with the sequence W-X-Y-Z. How much improvement does Johnson's Rule provide?

**Problem 9.** A printing company processes jobs through Printing then Binding machines:

| Job | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| Printing | 10 | 6 | 8 | 4 | 12 | 5 |
| Binding | 7 | 9 | 5 | 11 | 6 | 8 |

(a) Find optimal sequence using Johnson's Rule.

(b) Calculate completion time for each job.

(c) What is the mean flow time?

(d) Identify any bottleneck in the system.

## Flow Shop Scheduling (3+ Machines)

**Problem 10.** Three jobs must pass through 3 machines in sequence (M1 $\rightarrow$ M2 $\rightarrow$ M3):

| Job | Machine 1 | Machine 2 | Machine 3 |
|---|---|---|---|
| A | 5 | 4 | 6 |
| B | 7 | 3 | 5 |
| C | 4 | 6 | 4 |

(a) Calculate total processing time for each job.

(b) List all possible sequences (there are 6).

(c) Evaluate the sequence A-B-C: draw Gantt chart and find makespan.

(d) Evaluate the sequence C-B-A and compare.

**Problem 11.** Four products go through 3 production stages with times (in hours):

| Product | Stage 1 | Stage 2 | Stage 3 | Total Time |
|---|---|---|---|---|
| P1 | 8 | 5 | 7 | ? |
| P2 | 6 | 9 | 4 | ? |
| P3 | 10 | 4 | 6 | ? |
| P4 | 5 | 7 | 8 | ? |

(a) Complete the total time column.

(b) Apply the NEH heuristic: sort by total time (descending).

(c) Starting with the longest two jobs, determine which order is better.

(d) Insert the third job in the best position.

## Mixed Problems and Analysis

**Problem 12.** A factory has 2 identical machines in parallel. Four jobs arrive with processing times: 10, 6, 8, 4 hours and due dates: 12, 10, 14, 8 hours respectively.

(a) Schedule using LPT rule.

(b) Calculate total tardiness.

(c) Schedule using EDD rule instead.

(d) Which method gives less total tardiness?

**Problem 13.** Compare scheduling approaches. Six jobs with times (in minutes): 15, 8, 20, 12, 6, 18 need processing.

(a) If we have 1 machine, what is the makespan?

(b) If we have 2 identical machines using LPT, what is the makespan?

(c) If we have 3 identical machines using LPT, what is the makespan?

(d) Plot makespan vs. number of machines. What do you observe?

**Problem 14.** A hospital has 3 operating rooms. Five surgeries with times (hours): 4, 2.5, 3, 5, 1.5 and importance weights: 3, 1, 2, 4, 1.

(a) Calculate the priority ratio $w_i/p_i$ for each surgery.

(b) Assign surgeries using WSPT.

(c) What is the weighted completion time $\sum w_i C_i$?

(d) Compare with LPT assignment.

**Problem 15.** Three parts go through grinding (G) and polishing (P):

| Part | Grinding | Polishing | Due Date |
|---|---|---|---|
| X | 12 | 8 | 25 |
| Y | 8 | 10 | 22 |
| Z | 10 | 6 | 20 |

(a) Use Johnson's Rule to find optimal sequence.

(b) Calculate lateness for each part.

(c) What is the maximum lateness?

(d) Suggest how to reduce lateness.