ISyE 4803-REV: Advanced Manufacturing Systems Modeling and Analysis
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Homework # 6 Solutions

Problem 4

- FCFS

Sequence	Completion Time	Flow Time	Tardiness
1	1:20	20	0
2	1:34	34	0
3	2:09	69	19
4	2:19	79	49

Table 1: Summary for the results for the FCFS scheduling

Mean flow time $= 202/4 = 50.5$
Average tardiness $= 68/4 = 17$
Number of tardy trucks $= 2$

- SPT

Sequence	Completion Time	Flow Time	Tardiness
4	1:10	10	0
2	1:24	24	0
1	1:44	44	19
3	2:19	79	29

Table 2: Summary for the results for the SPT scheduling

Mean flow time $= 157/4 = 39.25$
Average tardiness $= 48/4 = 12$
Number of tardy trucks $= 2$

- EDD

Sequence	Completion Time	Flow Time	Tardiness
1	1:20	20	0
4	1:30	30	0
2	1:44	44	0
3	2:19	79	29

Table 3: Summary for the results for the EDD scheduling

Mean flow time = $173/4 = 43.25$
Average tardiness = $29/4 = 7.25$
Number of tardy trucks = 1

- CR
  - Time: 1:00 p.m:

Truck	Unloading Time	Due Time	CR
1	20	25	$25/20 = 1.25$*
2	14	45	$45/14 = 3.21$
3	35	50	$50/35 = 1.43$
4	10	30	$30/10 = 3$

  - Time: 1:20 p.m:

Truck	Unloading Time	Due Time	CR
2	14	25	$25/14 = 1.79$
3	35	30	$30/35 = 0.85$*
4	10	10	$10/10 = 1$

  - Time: 1:55 p.m:

Truck	Unloading Time	Due Time	CR
2	14	-10	-10/14 = -0.71
4	10	-25	-25/10 = -2.5*

Sequence	Completion Time	Flow Time	Tardiness
1	1:20	20	0
3	1:55	55	5
4	2:05	65	35
2	2:19	79	34

Table 4: Summary for the results for the CR scheduling

$$\text{Mean flow time} = 219/4 = 54.75$$
$$\text{Average tardiness} = 74/4 = 18.5$$
$$\text{Number of tardy trucks} = 3$$

Problem 5

- The SPT sequence is : 3-1-5-2-4.

Sequence	Completion Time	Promised Time	Tardiness (hours)
3	10:20 a.m.	2:00 p.m.	0
1	11:00 a.m.	11:00 a.m.	0
5	12:30 p.m.	4:00 p.m.	0
2	3:00 p.m.	2:00 p.m.	1
4	7:00 p.m.	1:00 p.m.	6

Table 5: Summary for the results for the SPT scheduling

$$\text{Average tardiness} = 7/5 = 1.4\text{hours}$$

- The EDD sequence is : 1-4-2-3-5 (or 1-4-3-2-5).

Sequence	Completion Time	Promised Time	Tardiness (hours)
1	10:40 a.m.	11:00 a.m.	0
4	2:40 p.m.	1:00 p.m.	5/3
2	5:10 p.m.	2:00 p.m.	19/6
3	5:30 p.m.	2:00 p.m.	3.5
5	7:00 p.m.	4:00 p.m.	3

Table 6: Summary for the results for the EDD scheduling

$$\text{Average tardiness} = 2.265\text{hours}$$

Problem 6

a. SPT minimizes mean flow time. The SPT sequence is 4-2-1-3.

b. EDD minimizes maximum lateness. The EDD sequence is 1-4-2-3.

c. Start with EDD solution:

Truck	Time	Tardiness
1	20	0
4	10	0
3	14	0
2	35	29

The method calls for rejecting the job with the longest processing time and placing it at the end of the sequence. Since job 3 already has the longest time, the EDD sequence is the final solution.

Problem 9

a. SPT minimized mean flow time. The SPT sequence is 6-4-2-1-3-5.

b. We first add 15 minutes (0.25 hours) to each processing time to account for the time required to make deliveries.

Job	Time	Promised Time
1	1:27	11:30 a.m.
2	0:55	10:00 a.m.
3	2:27	11:00 a.m.
4	0:45	1:00 p.m.
5	3:21	12:00 noon
6	0:40	2:00 p.m.

First order the jobs in EDD sequence : 2-3-1-5-4-6.

Job	Processing Time	Completion Time	Promised Time	
2	0:55	8:55 a.m.	10:00 a.m.	
3	2:27	11:22 a.m.	11:00 a.m.	Stop.

The first tardy job is job 3 which has the largest processing time between the first two. Job 3 is placed at the end of the current sequence.

Job	Processing Time	Completion Time	Promised Time	
2	0:55	8:55 a.m.	10:00 a.m.	
1	1:27	10:22 a.m.	12:30 a.m.	
5	3:21	1:43 p.m.	12:00 noon	Stop.

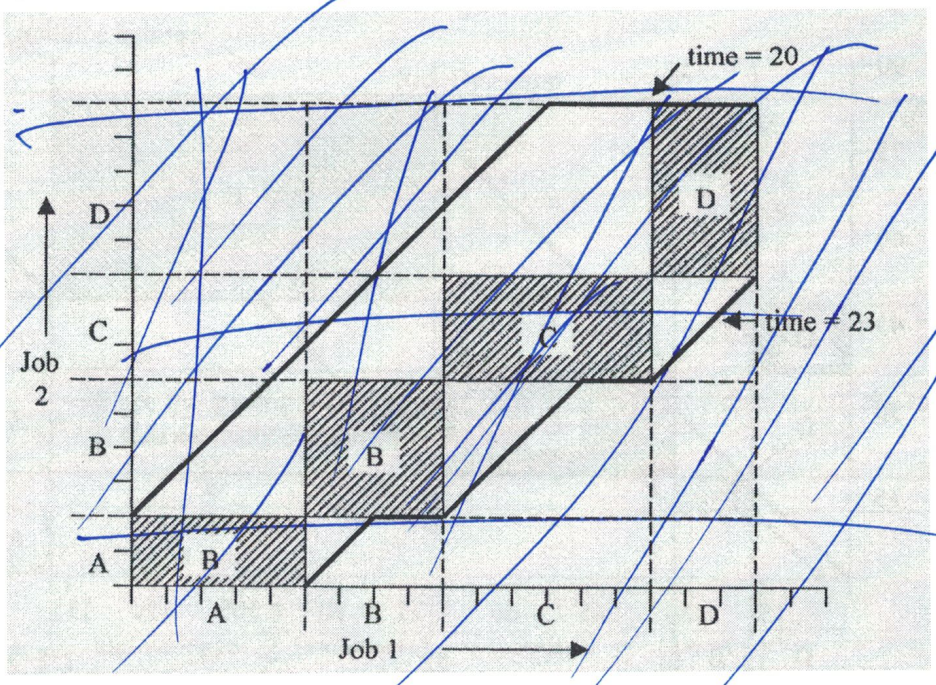
Among 2,1 and 5, the job with the largest processing time is job 5. This is now placed at the end of the current sequence.

Job	Processing Time	Completion Time	Promised Time
2	0:55	8:55 a.m.	10:00 a.m.
1	1:27	10:22 a.m.	12:30 a.m.
4	0:45	11:07 a.m.	1:00 p.m.
6	0:40	11:47 a.m.	2:00 p.m.

None of the remaining jobs are tardy so we stop. The sequence is 2-1-4-6-3-5 (or 2-1-4-6-5-3) which results in 2 tardy jobs.

c. EDD minimizes maximum lateness. The sequence is 2-3-1-5-4-6.

Problem 16



The first tardy job is job 3 which has the largest processing time between the first two. Job 3 is placed at the end of the current sequence.

Job	Processing Time	Completion Time	Promised Time	
2	55 min.	8:55 a.m.	10:00 a.m.	
1	1 hr. 27 min.	10:22 a.m.	11:30 a.m.	
5	3 hrs. 21 min.	1:43 p.m.	12:00 noon	Stop.

Among 2-1-5, the one with the largest processing time is job 5. This is now placed at the end of the current sequence.

Job	Processing Time	Completion Time	Promised Time
2	55 min.	8:55 a.m.	10:00 a.m.
1	1 hr. 27 min	10:22 a.m.	11:30 a.m.
4	45 min.	11:07 a.m.	1:00 p.m.
6	40 min.	11:47 a.m.	2:00 p.m.

None of the remaining jobs are tardy so we stop. The sequence is 2-1-4-6-3-5 (or 2-1-4-6-5-3) which results in 2 tardy jobs

c) EDD minimizes maximum lateness. The sequence is 2-3-1-5-4-6.

8 10 a) SPT sequence minimizes mean flow time It is 6-5-1-4-2-7-3.

b) First order by EDD which is 1-2-5-3-4-7-6.

Job	Processing Time	Completion Time	Due Date	
1	3	3	4	
2	6	9	8	* Stop.

Place job 2 at the end of the current sequence.

Job	Processing Time	Completion Time	Due Date	
1	3	3	4	
5	2	5	11	
3	8	13	12	* Stop.

Place job 3 at the end of the current sequence.

Job	Processing Time	Completion Time	Due Date	
1	3	3	4	
5	2	5	11	
4	4	9	15	
7	7	16	21	
6	1	17	25	* Stop

The optimal sequence is 1-5-4-7-6-2-3 (or 1-5-4-7-6-3-2). Jobs 2 and 3 are tardy.

c) The maximum lateness is minimized by EDD which is 1-2-5-3-4-7-6.

d) The makespan is the sum of the processing times which is 31.

8.11 The jobs 1 - 4 - 5 in the sequence may be permuted in any order since the times for those jobs are the same. Hence, the optimal solutions are

1-4-5-2-3
4-1-5-2-3
4-5-1-2-3
5-4-1-2-3
5-1-4-2-3
1-5-4-2-3

8.12 $(n!)^m = (12!)^6 = 1.2079 \times 10^{52}$

The time required to evaluate all schedules is 1 2079 x 10^{50} seconds which is an enormous number

There are 60 x 60 x 24 x 365 x 100 = 3.1536 x 10^9 seconds in a century. Hence, it would require 3.8302 x 10^{40} centuries to evaluate all schedules.

8.13 This is an example of scheduling n jobs (the five subjects) on two machines (John and Marsha) and so Johnson's algorithm applies.

Subject	Job	A(Marsha)	B(John)
Contracts	1	1.8	1.2
Torts	2	0.8	2.2
Civil	3	3.1	0.7
Corporate	4	1.1	0.5
Patents	5	2.3	1.5