IE - 7200 - HW-3

Question 1:

Planned order releases (batch quantity and release period), and total cost are given below:

1. **Lot for Lot: Cost($2,200)**

	A	B	C	D	E	F	G	H	I	J
1	**Lot for Lot**									
2									**Setup Cost**	300
3	**Period**	**1**	**2**	**3**	**4**	**5**	**6**		**Holding Cost**	1
4	**Demands**	50	60	90	70	30	100			
5	**Inventory**	50	60	90	70	30	100			
6	**Monthly cost**	300	300	300	300	300	300			
7	**Holding cost**	50	60	90	70	30	100			
8	**Total cost**	2200								
9										

Planned order releases:

Period	**1**	**2**	**3**	**4**	**5**	**6**
Batch Quantity	50	60	90	70	30	100
Release Period	1	2	3	4	5	6

2. **Fixed Order Quantity: Cost($1,070)**

10	**Fixed Order Quantity**									
11										
12	**Period**	**1**	**2**	**3**	**4**	**5**	**6**		**Average Demand**	67
13	**Demands**	50	60	90	70	30	100		**EOQ**	200
14	**Inventory**	150	90	0	130	100	0			
15	**Planned orders**	200	0	0	200	0	0			
16	**Holding cost**	150	90	0	130	100	0			
17	**Total cost**	1070								
18										

Planned order releases:

Period	**1**	**2**	**3**	**4**	**5**	**6**
Batch Quantity	200	0	0	200	0	0
Release Period	**1**			**4**		

3. **Fixed Order Period: Cost($1,130)**

19	**Fixed Order Period**								
20									
21	**Period**	**1**	**2**	**3**	**4**	**5**	**6**	**Period interval**	2
22	**Demands**	50	60	90	70	30	100		
23	**Inventory**	60	0	70	0	100	0		
24	**Planned orders**	110	0	160	0	130	0		
25	**Holding cost**	60	0	70	0	100	0		
26	**Total cost**	1130							
27									

Planned order releases:

Period	**1**	**2**	**3**	**4**	**5**	**6**
Batch Quantity	110	0	160	0	130	0
Release Period	**1**		**3**		**5**	

4. **Wagner-Whitin Algorithm:**

Period (t)	**1**	**2**	**3**	**4**	**5**	**6**
Demand (Dt)	50	60	90	70	30	100
Setup cost (At)	300	300	300	300	300	300
Holding (Ht)	1	1	1	1	1	1

$Z_1^* = A_1 = 300$, $j_1 = 1$

$$Z_2^* = \min \begin{cases} A_1 + h_1 D_2 \\ Z_1^* + A_2 \end{cases}$$

$$\Rightarrow \min \begin{cases} 300 + 1(60) = 360 \\ 300 + 300 = 600 \end{cases}$$

$Z_2^* = 360$, $j_2^* = 1$

$$Z_3^* = \min \begin{cases} A_1 + h_1 D_2 + (h_1 + h_2) D_3 \\ Z_1^* + A_2 + D_3 h_2 \\ Z_2^* + A_3 \end{cases}$$

$$\Rightarrow \min \begin{cases} 300 + 60 + 180 = 540 \\ 300 + 300 + 90 = 690 \\ 360 + 300 = 660 \end{cases}$$

$Z_3^* = 540$, $j_3^* = 1$

$$Z_4^* = \min \begin{cases} A_1 + h_1 D_2 + (h_1 + h_2) D_3 + (h_1 + h_2 + h_3) D_4 \\ Z_1^* + A_2 + h_2 D_3 + (h_2 + h_3) D_4 \\ Z_2^* + A_3 + h_3 D_4 \\ Z_3^* + A_4 \end{cases}$$

$$\Rightarrow \min \begin{cases} 300 + 60 + 180 + 210 = 750 \\ 300 + 300 + 90 + 140 = 830 \\ 360 + 300 + 70 = 730 \\ 540 + 300 = 840 \end{cases}$$

$Z_4^* = 730$, $j_4^* = 3$.

$$Z_5^* = \min \begin{cases} A_1 + h_1 (D_2) + (h_1 + h_2) D_3 + (h_1 + h_2 + h_3) D_4 + (h_1 + h_2 + h_3 + h_4) D_5 \\ Z_1^* + A_2 + h_2 D_3 + (h_2 + h_3) D_4 + (h_2 + h_3 + h_4) D_5 \\ Z_2^* + A_3 + h_3 D_4 + (h_3 + h_4) D_5 \\ Z_3^* + A_4 + h_4 D_5 \\ Z_4^* + A_5 \end{cases}$$

$$\Rightarrow \min \begin{cases} 300 + 60 + 180 + 210 + 120 = 870 \\ 300 + 300 + 90 + 140 + 90 = 920 \\ 360 + 300 + 70 + 60 = 790 \\ 540 + 300 + 30 = 890 \\ 730 + 300 = 1030 \end{cases}$$

$Z_5^* = 790$.

$j_5^* = 3$.

$$Z_6^* = \min \begin{cases} A_1 + h_1 D_2 + (h_1 + h_2) D_3 + (h_1 + h_2 + h_3) D_4 + (h_1 + h_2 + h_3 + h_4) D_5 + (h_1 + h_2 + h_3 + h_4 + h_5) D_6 \\ Z_1^* + A_2 + h_2 D_3 + (h_2 + h_3) D_4 + (h_2 + h_3 + h_4) D_5 + (h_2 + h_3 + h_4 + h_5) D_6 \\ Z_2^* + A_3 + h_3 D_4 + (h_3 + h_4) D_5 + (h_3 + h_4 + h_5) D_6 \\ Z_3^* + A_4 + h_4 D_5 + (h_4 + h_5) D_6 \\ Z_4^* + A_5 + h_5 D_6 \\ Z_5^* + A_6 \end{cases}$$

$$\Rightarrow \min \begin{cases} 300 + 60 + 180 + 210 + 120 + 500 = 1370 \\ 300 + 300 + 90 + 140 + 90 + 400 = 1320 \\ 360 + 300 + 70 + 60 + 300 = 1090 \\ 540 + 300 + 30 + 200 = 1070 \\ 730 + 300 + 100 = 1130 \\ 790 + 300 = 1090 \end{cases}$$

$Z_6^* = 1070$

$j_6^* = 4$

Total Cost = \$1,070

Production (PO releases): 1st & 4th period.

5. **A consultant was hired who recommended reducing the batch sizes to 10 units. How would you comment on this recommendation? What would you recommend changing to be able to reduce batch sizes?**

Batch sizes of 10 units could be reduced to better accommodate the variability of demand while also increasing flexibility and lowering holding costs. However, when the $300 setup fee for each order is taken into account, this method dramatically increases overall expenses. It is essential to conduct a thorough analysis to determine whether setup costs can be decreased before implementing such a reduction. Smaller batches would probably result in a less cost-effective operation if the setup costs stay the same. A balanced evaluation of setup, holding, and demand patterns should be part of batch size optimization in order to maintain financial responsibility and responsiveness to market demands.

Question - 2:

1. **Using Short Processing Time (SPT):**

Shortest Processing Time:

Job sequence	Process time	Flow time	Job due date	Tardiness	Lateness
3	1	1	5	0	-4
7	2	3	6	0	-3
2	6	9	10	0	-1
1	8	17	19	0	-2
4	9	26	22	4	0
5	12	38	30	8	0
6	15	53	50	3	0
	53	147		15	-10

Mean flow	21
Average lateness	-1.42857143
Average tardiness	2.14285714
Maximum tardiness	8

Mean Flow	21
Average Lateness	-1.43
Average Tardiness	2.14
Maximum Tardiness	8

2. **Using Earliest Due Date (EDD):**

Earliest Due Date:

Job sequence	Process time	Flow time	Job due date	Tardiness	Lateness
3	1	1	5	0	-4
7	2	3	6	0	-3
2	6	9	10	0	-1
1	8	17	19	0	-2
4	9	26	22	4	0
5	12	38	30	8	0
6	15	53	50	3	0
	53	147		15	-10

Mean flow	21
Average lateness	-1.42857143
Average tardiness	2.14285714
Maximum tardiness	8

Mean Flow	21
Average Lateness	-1.43
Average Tardiness	2.14
Maximum Tardiness	8

3. Using Critical Ratio (CR):

32	**Critical Ratio:**									
33		**Job**	**Process time**	**Job due date**	**Critical Ratio**	**Sequence**				
34		1	8	19	2.375	2			**Time now**	0
35		2	6	10	1.66666666667	1				
36		3	1	5	5	4				
37		4	9	22	2.44444444444	5				
38		5	12	30	2.5	7				
39		6	15	50	3.33333333333	6				
40		7	2	6	3	3				
41										
42		**Job sequence**	**Process time**	**Flow time**	**Job due date**	**Tardiness**	**Lateness**			
43		2	6	6	10	0	-4			
44		1	8	14	19	0	-5		**Mean flow**	31.4285714
45		4	9	23	22	1	0		**Average lateness**	-1.28571429
46		5	12	35	30	5	0		**Average tardiness**	12.4285714
47		7	2	37	6	31	0		**Maximum tardiness**	48
48		6	15	52	50	2	0			
49		3	1	53	5	48	0			
50			53	220		87	-9			
51										

Mean Flow	31.43
Average Lateness	-1.3
Average Tardiness	12.43
Maximum Tardiness	48

4. Using Moore's Algorithm to minimize number of Tardy jobs:

52	**Moore's Algorithm:**		**Considering EDD Sequence**							
53		**Job sequence**	**Process time**	**Flow time**	**Job due date**	**Tardiness**	**Lateness**			
54		3	1	1	5	0	-4			
55		7	2	3	6	0	-3			
56		2	6	9	10	0	-1		**Mean flow**	21
57		1	8	17	19	0	-2		**Average lateness**	-1.42857143
58		4	9	26	22	4	0		**Average tardiness**	2.142857143
59		5	12	38	30	8	0		**Maximum tardiness**	8
60		6	15	53	50	3	0			
61			53	147		15	-10			
62										
63		First tardy job	4							
64		Longest job (3,7,2,1)	1							
65										

Mean Flow	21
Average Lateness	-1.43
Average Tardiness	2.14
Maximum Tardiness	8

5. **Comment on the performance of the dispatching rules applied. Did any perform best in all criteria?**

The data indicates that no dispatching rule performs better than any other in every criterion. For the given metrics, the results of SPT, EDD, and Moore's Algorithm are identical, while CR produces slightly better average lateness but a higher mean flow and tardiness.

Question - 3

1. **Using Johnson's rule, schedule the 6 jobs to minimize makespan. What is the sequence? What is the makespan?**

Sequence: E (Fabricating) – F (Painting) – A (Painting) – C (Painting) – D (Fabricating) – B (Fabricating)

Makespan: It is maximum of total time, which is 39.

Fabricating		**Painting**	
E	**2**	**E**	**6**
F	**6+2=8**	**F**	**3+6=9**
A	**6+8=14**	**A**	**4+9=13**
C	**7+14=21**	**C**	**5+13=18**
D	**8+21=29**	**D**	**9+18=27**
B	**9+29=38**	**B**	**12+27=39**

2. **How many possible ways are there to schedule the 6 jobs on the 2 machines?**

$$P(n,r) = \frac{n!}{(n-r)!}, \text{ and } n = 6, r = 2$$

$$P(6,2) = \frac{6!}{(6-2)!} = \frac{6!}{4!} = 6 * 5 * \frac{4!}{4!} = 30$$

3. **Comment on why a heuristic approach is applicable to scheduling problems.**

For scheduling problems, heuristic methods are frequently preferred because they provide a workable compromise between computational efficiency and solution quality. They address the high dimensionality and inherent complexity of scheduling tasks, offering quick, adequate solutions—a critical quality when working under time constraints. In addition to being easier to apply and understand than exhaustive algorithms, heuristics are also more adaptable and user-friendly, making them suitable for a wide range of constraints and goals that frequently occur in dynamic scheduling environments. Heuristics are superior to exact methods because they navigate the search space more effectively and take advantage of problem-specific knowledge, even though exact methods may become unfeasible due to computational demands, particularly with large-scale problems. In many real-world scenarios, where the need for prompt and reliable decision-making in the face of uncertainties and changes outweighs the advantages of a perfectly optimal solution, they produce solutions that are typically near-optimal, a trade-off that is acceptable.