Question 1

An FMS consists three types of machines is used to manufacturer five parts family. The process plan, related data, and the set of jobs currently waiting to be completed are given in Tables (1a), (1b), and (1c) respectively. Determine the part types and quantities to be produced.

Table (1a)

Part	Process plans (Process time, min, Tool)			
	OP1	OP2	OP3	OP4
a	25,A1	40,B3	20,A2	-
b	20,A4	40,C2	30,A6	30,B4
c	30,C1	15,B1	25,B2	15,A5
d	25,B3	10,A1	40,C1	-
e	45,B2	15,A4	20,B1	25,C2

Table (1b)

	Machine type		
	A	B	C
No. of M/c	2	3	1
Available time,	10 hr/day		
Tool slots	3		

Table (1c)

Available Jobs		
Part type	Quantity	Due date
a	12	1
b	12	1
e	6	1
a	12	1
c	6	2
d	30	2
b	15	2

Question 2

A) What are the types of flexibility can be offered by FMS? What basis criteria for testing flexibility?

B) An FMS is used to manufacturer six parts family. It consists of two machines of type (A) with 2 slots magazine, three machines of type (B) with 2 slots magazines, and one machine of type (C) with 3 slots magazine. The process plan and the set of jobs currently waiting to be completed are given in Tables (2a) and (2b) respectively.

Plan the launching daily policy of the part types and quantities to be produced on the system considering the daily working hours are 10hr/day**.**

Table (2a)

Part	Process plans (Process time, min, Tool)			
	OP1	OP2	OP3	OP4
a	25,A1	45,B3	20,A2	-
b	20,A4	40,C2	30,A6	36,B4
c	30,C1	15,B1	25,B2	20,A5
d	30,B3	15,A1	24,C1	-
e	45,B2	15,A4	20,B1	25,C2
f	40,A3	20,B5	25,C3	-

Table (2b)

Available Jobs		
Part type	Quantity	Due date
a	10	1
b	9	1
e	6	1
a	10	1
f	12	1
c	12	2
d	8	2
e	6	2

Question 3

A FMS consists three types of machines is used to manufacturer five parts family. The process plan, related data, and the set of jobs currently waiting to be completed are given in Tables (3a), (3b), and (3c) respectively. Determine the part types and quantities to be produced.

Table (3a)

Part	Process plans (Process time, min, Tool)			
	OP1	OP2	OP3	OP4
a	25,A1	30,B3	20,A2	-
b	20,A2	40,C2	30,A1	30,B4
c	30,C1	15,B1	20,B2	15,A5
d	25,B2	10,A1	40,C1	-
e	25,B2	15,A2	20,B1	25,C2

Table (3b)

	Machine type		
	A	B	C
No. of M/c	3	2	2
Available time,	10 hr/day		
Tool slots	2		

Table (3c)

Available Jobs		
Part type	Quantity	Due date
a	10	1
b	15	1
e	8	1
a	15	1
c	10	2
d	20	2
b	15	2

Question 4

A) What does batching for FMS mean?

B) Formulate the batching problem.

C) 12 parts to be processed using several types of tools as given the table below. Find the number of batches required if 7 slots are available.

Part types	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Required tools	t1(1)	t2(1), t3(1)	t1(1), t4(1)	t4(1), t5(1)	t3(1), t5(1)	t4(1), t6(1)	t6(2)	t2(1), t3(1), t7(2)	t4(1), t8(1)	t1(1), t8(1)	t9(2)	t1(1), t4(1), t8(2)

Question 5

12 parts are to be manufactured in a FMS with tool types as given in table (4). The tool magazine capacity is 8 slots in the system. Determine the minimum number of batches and the product type for each batch

Table (4)

Part Type	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Tool Type requirement	T1(2)	T2(1)	T1(1), T3(1)	T3(1)	T1(1), T4(1)	T1(1), T2(1)	T3(1), T5(1)	T6(2)	T1(1), T4(1), T7(2)	T1(1), T6(1)	T2(1), T8(2)	T3(1), T8(2)

Question 6

10 parts are to be manufactured in a FMS. Find the minimum number of batches and the product type for each batch according the data given in table (4). The tool magazine capacity is 5 slots.

Table (4)

Part Type	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Tool Type requirement	T1(1)	T2(1)	T1(1), T3(1)	T3(1)	T1(1), T4(1)	T1(1), T2(1)	T3(1), T5(1)	T6(2)	T1(1), T4(1), T7(2)	T1(1), T6(1)

Question 7

12 parts are to be manufactured in a FMS with tool types as given in table (3). The tool magazine capacity is 6 slots in the system. Determine the minimum number of batches and the product type for each batch**.**

Table (3)

Part Type	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Tool Type requirement	T1(1)	T2(1)	T1(1), T3(1)	T3(1)	T1(1), T4(1)	T1(1), T2(1)	T3(1), T5(1)	T6(2)	T1(1), T4(1), T7(2)	T1(1), T6(1)	T2(1), T4(2)	T3(1), T5(1)

Question 8

12 parts are to be manufactured in a FMS with tool types as given in table (4). The tool magazine capacity is 8 slots in the system. Determine the minimum number of batches and the product type for each batch**.**

TABLE (4)

Part types	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Types of tools required	t1(1)	t2(1), t3(1)	t1(1), t3(1)	t4(1), t5(1)	t3(1) , t5(1)	t4(1), t6(1)	t6(2)	t1(1) , t2(1) , t7(2)	t4(1), t8(1)	t1(1), t8(1)	t9(2)	t1(1) , t4(1) , t8(2)

Question 9

A) Formulate the economic criterion for selecting part type for current assignment to a FMS.

B) An FMS consists of 2 turning center and 3 machining centers. The system will run 12 hr/day, 6 days/week, and the machines are available are 90% of the time. Machines will cost 150 SR/hr to operate. Using the data in table (2), determine the set of part families to be produced on the FMS.

Table (2)

Part Family	1	2	3	4	5	6	7	8
Weekly Demand	20	25	30	55	30	15	15	20
Subcontracting cost SR/unit	750	620	700	900	900	750	500	600
Material cost SR/unit	125	100	180	400	350	200	150	110
Turning time, hr	0	0.7	1.2	0	3	1.3	1.5	2.5
Machining Center, hr	2	1.2	1.7	1.6	0	1.6	1.5	0

Question 10

An FMS consists of 2 turning center and 3 machining centers. The system will run 12 hr/day, 6 days/week, and the machines are available are 90% of the time. Machines will cost 150 SR/hr to operate. Using the data in table below, determine the set of part families to be produced on the FMS.

Part Family	1	2	3	4	5	6	7	8	9	10
Weekly Demand	22	25	30	50	30	15	14	18	20	30
Subcontracting cost SR/unit	800	620	700	1200	900	750	500	400	800	850
Material cost SR/unit	125	100	180	400	350	200	150	110	130	450
Turning time, hr	0.0	0.7	1.2	0.0	3.0	1.3	1.5	2.5	1.4	2.3
Machining Center, hr	2.0	1.2	1.7	1.6	0.0	1.6	1.5	0.0	2.2	2.2

Question 11

An FMS consists of 3 turning centers and 2 machining centers. The system will run 12 hr/day, 6 days/week, and the machines are available are 90% of the time. Machines will cost 150 SR/hr to operate. Using the data in table (3), determine the set of part families to produce on the FMS.

Table (3)

Part Family	1	2	3	4	5	6	7	8	9	10
Weekly Demand	10	15	15	12	20	20	15	20	10	12
Subcontracting cost SR/unit	450	800	720	840	950	675	950	600	1200	900
Material cost SR/unit	100	90	80	150	120	90	175	190	100	120
Turning time hr/unit	-	2.3	2.1	4.5	2.5	2.4	3.3	-	4.3	3.0
Machining Center hr/unit	1.5	1.2	1.4	-	2.5	1.1	1.7	2.0	1.7	-

Question 12

An FMS consists of 3 turning centers and 2 machining centers. The system will run 12 hr/day, 6 days/week, and the machines are available are 90% of the time. Machines will cost 250 SR/hr to operate. Using the data in table (4), determine the set of part families to produce on the FMS

Table (4)

Part Family	1	2	3	4	5	6	7	8
weekly Demand	10	15	15	12	20	20	15	20
Purchasing cost SR/unit	600	400	900	1000	700	850	400	350
Material cost SR/unit	40	20	45	35	80	40	25	30
Turning time hr/unit	0	2.8	4.2	6.5	2.4	3.5	4.4	0
Machining Center hr/unit	2.2	1	1.4	0	2.5	1.1	1.2	2

Question 13

An FMS consists of 2 turning center and 3 machining centers. The system will run 10 hr/day, 6 days/week, and the machines are available are 90% of the time. Machines will cost 400 SR/hr to operate. Using the data in table below, determine the set of part families to be produced on the FMS.

Part Family	1	2	3	4	5	6	7	8	9	10
Weekly Demand	400	800	400	400	800	200	400	400	800	200
Subcontracting cost SR/unit	100	80	140	115	250	75	95	42	88	78
Material cost SR/unit	42	23	49	34	84	38	26	30	62	14
Turning time, min	0	48	58	46	28	62	40	35	24	35
Machining Center, min	20	35	38	45	52	18	22	48	22	25

Question 14

A) Discuss the loading issue on FMS pointing out the objectives of loading problem.

B) A FMS consists of three stations is used to manufacturer two parts. The relative data is given in Table (3). Solve the loading of the stations in the FMS**.**

Table (3)

Part	Daily Demand	Operation	Machine Processing time, min			Tool type
			A	B	C	
a	10	1	20	20	-	T1
		2	25	35	25	T2
		3	-	25	30	T3
		4	-	-	20	T4
b	20	1	-	30	25	T5
		2	35	-	-	T6
		3	25	-	30	T7
Number of machines			1	2	1	
Number of tool's slot			2	3	3	
Available time, min/day			800			

Question 15

A FMS consists of three stations is used to manufacturer three parts. The relative data is given in Table (2). Solve the loading of the stations in the FMS.

Table (2)

Part	Weekly Demand	Operation	Machine Processing time, min			Tool type
			A	B	C	
a	75	1	20	20	-	T1
		2	24	34	20	T2
		3	-	-	30	T3
b	50	1	-	30	25	T4
		2	35	-	-	T3
		3	25	-	30	T2
c	125	1	16	20	22	T1
		2	-	20	16	T7
Number of machines			1	2	1	
Number of tool's slot			3	2	3	
Available time, hr/day			12			

Question 16

A- List the factors should be considered for planning a FMS.

B- A FMS consists of four stations is used to manufacturer four parts. The relative data is given in Table (2).

i) Formulate a loading model for the FMS stating your objective.

ii) Solve machine loading in the FMS.

Table (2)

Part	Demand	Operation	Machine Processing time, min				Total
			A	B	C	D	
a	40	1	15	20	-	20	a
		2	25	35	40	30	b
b	50	1	-	30	-	40	c
		2	20	35	35	-	a
c	60	1	20	35	35	-	a
d	40	1	15	20	20	13	a
		2	20	25	25	20	b
		3	-	10	15	15	c
Number of machines			1	2	1	2	
Available time, hr			80	60	80	60	
No. of tools slot			3	2	3	2	

Question 17

A- List the types of the flexibilities to be considered for a FMS.

B- A FMS consists of four stations is used to manufacture four parts. The relative data is given in Table (2).

iii) State your objectives for formulating a loading model the FMS.

iv) Solve machine loading in the FMS.

TABLE (2)

Part	Demand	Operation	Machine Processing time, min				Tool type
			A	B	C	D	
a	50	1	15	12	-	-	a
		2	18	16	20	15	b
b	75	1	-	16	-	14	c
		2	12	15	14	-	d
c	100	1	7	10	10	-	e
d	100	1	10	8	-	9	a
		2	-	10	-	12	c
Number of machines			1	2	1	2	
Available time, hr			50	60	50	60	
No. of tools slot			2	1	2	1	

Question 18

A. Discuss briefly the factors should be considered when solving the loading problem.

B. On FMSA FMS consists of four stations is used to manufacturer four parts. The relative data is given below. Solve machine loading in the FMS.

Part	Demand	Operation	Machine Processing time, min				Tool
			A	B	C	D	
1	90	1 2 3	15 25 -	20 35 32	16 - 25	20 - -	a b c
2	120	1 2	- 20	35 35	- 35	35 -	c d
3	200	1	25	-	35	-	a
4	90	1 2 3	15 - -	- - 14	20 25 -	25 20 18	b d e
Number of machines			1	2	2	1	
Available time, hr			12				
No. Of tools slot			2	1	2	1	

Question 19

A FMS consists of four stations is used to manufacturer four parts. The relative data is given Table (4).

A) Find machine loading in the FMS.
B) After loading the machines, use the result to find the following:
   i) The bottle neck station in the FMS.
   ii) The overall production rate and the rate of each part at full capacity.
   iii) The overall utilization of the FMS.
   iv) The relationship for production rate and MLT each as function of the parts in the system. Plot and explains the results.

Table (4)

Part	Demand	Operation	Machine Process time, min				Tool
			A	B	C	D	
a	120	1	15	20	-	20	a
		2	25	35	40	-	b
		3	-	30	20	-	c
b	110	1	-	30	-	35	c
		2	20	35	25	-	d
c	100	1	20	-	35	-	a
d	120	1	15	-	20	13	b
		2	-	-	25	20	d
		3	-	15	-	15	e
Number of machines			1	2	2	1	
Available time, hr			60				
No. Of tools slot			2	1	2	1	

Question 20

A- Why flexibility is an important issue in manufacturing? Point out the main types of flexibility.

B- A FMS consists of five-workstations. From-To data for machines is given in table (3) below. **Determine:-**

   i) The most logical sequence of the workstations.
   ii) The flow diagram showing where and how parts enter and exit the system.
   iii) The number of AGV, if an AGV system is being proposed to deliver parts between the five machines located as single line according to the logical sequence with equal distance between them of 10m. AGV moves at speed = 40 m/min. and takes 1 minute to load and unload. Anticipated traffic load factor = 0.85 and availability =0.9.

Table (3)

FROM	TO				
	A	B	C	D	E
A		10	80		
B				85	
C					
D	70		20		
E		75		20	

Question 21

A) A six-workstations FMS is used to produce six product according the data given in table below. Determine:-
   i) The most logical sequence of the workstations.
   ii) The flow diagram showing where and how parts enter and exit the system.

iii) The proper placement of the stations, if they will be placed in one raw 8mt apart from centre of stations.

Part	Weekly Demand	Unit Load	Process Sequence
1	240	4	A → C → B → D
2	300	5	A → B → D → E → F
3	100	2	B → C → D → E → F
4	195	3	A → E → F → D
5	250	5	B → A → D → E → D
6	150	2	B → D → E → F

Question 22

A- i) What is a FMS? ii) On what bases the FMS can be classified?

B- A six stations FMS is used to produce seven product according the data given in table below. Determine:-

i) The most logical sequence of the stations.

ii) The flow diagram showing where and how parts enter and exit the system.

Part	Weekly Demand	Unit Load	Process Sequence
1	100	2	A → B → C → D
2	200	4	A→B → C→D→F
3	50	2	B → C → D → F
4	75	3	A → E → F→D
5	150	3	B→A→D → E → D
6	100	2	B → D → E →F
7	75	3	A → D →C →F

Question 23

An FMS consists of four stations and a part handling system. The workloads of the station are given in table (2). The system operates 12 hr/day and the system availability is 95%. Annual production is 60,000 parts. Determine the following: -

a) The number of machines of each station required satisfying production requirement.
b) The utilization of each station.
c) The maximum possible production rate of the system if the bottleneck stations operate at 100% utilization.

Table 2

Workstation	1	2	3	4	5
Work load WL_i, min	8.5	25.2	18.6	10.9	8.6

Question 24

An FMS consists of six stations and a part handling system. The workloads of the station are given in table (4). The system operates 10 hr/day and the system availability is 85%. Annual production is 60,000 parts. Determine the following: -

a) The number of machines of each station required satisfying production requirement.
b) The maximum possible production rate of the system.
c) Average and overall utilization of the FMS.
d) The relationship for production rate and MLT as function of the parts in the system. Plot and explains the results.

Table (4)

Workstation	S1	S2	S3	S4	S5	S6	H7
Work load WLi, min	6.37	7.25	6.66	4.98	4.38	5.25	3.15

Question 25

A) Discuss briefly the meaning of flexibility of the manufacturing system.

B) An FMS consists of five stations and a part handling system. The workloads of the station are given in table (2). The system operates 12 hr/day and the system availability is 90%. Annual production is 60,000 parts. Determine: -

a) The number of machines of each station required satisfying production requirement.

b) The maximum possible production rate of the system.

c) The average and overall utilizations of the system.

d) MLT and WIP

Table (2)

Workstation	1	2	3	4	5	6
Work load WL_i, min	12.0	14.2	22.6	19.9	10.6	7.8

Question 26

An FMS consists of five stations and a part handling system. The workloads of the station are given in table (4). The system operates 10 hr/day and the system availability is 85%. Annual production is 40,000 parts. Determine the following: -

a) The number of machines of each station required satisfying production requirement.
b) The maximum possible production rate of the system.
c) Average and overall utilization of the FMS
d) The relationship for production rate and MLT as function of the parts in the system. Plot and explains the results.

Table (4)

Workstation	1	2	3	4	5	6
Work load WLi, min	7.3	9.2	6.2	5.2	4.3	8.1

Question 27

A five stations FMS is used to produce five parts according the data given in table (4).

a. Determine a layout of the FMS with one array. Assuming equal clearance, dimension, and cost.
b. Find: -
   i. The bottleneck station in the FMS.
   ii. The overall production rate and the rate of each part at full capacity.
   iii. The average station utilization.
   iv. The overall utilization of the FMS.
c. Develop the relationship for production rate and MLT each as function of the parts in the system. Plot and explains the results.

TABLE (4)

Part	Weekly Demand	Process Sequence	Operation Time, min.					
			Load	Process Station				Unload
			A	B	C	D	E	A
1	240	A → C → B → D → A	4	8	7	18	0	2
2	300	A → B → D → E → A	4	10	14	0	12	2
3	100	A → C → D → A	4	0	6	16	12	2
4	190	A → E → B → A	4	12	0	15	15	2
5	150	A → B → E → C → A	4	14	0	0	10	2
Number of machines per station			2	3	2	3	3	
Number of AGV's in system			4					
Mean travel time of AGV, min			3.5					

Question 28

A) What is the FMS? On what basis it can be classified?

B) A four stations FMS is used to produce four parts according the data given in table (2).

a) Determine the number of machines of each station and the number of AGV required satisfying production. Assume that the FMS operates 17 hr/day, six days a week.

b) Find: -

i. The bottleneck station in the FMS.
ii. The overall production rate and the rate of each part at full capacity.
iii. The average station utilization.
iv. The overall utilization of the FMS.

c) Develop the relationship for production rate and MLT each as function of the parts in the system. Plot and explains the results.

TABLE (2)

Part	Weekly Demand	Process Sequence	Operation Time, min.					
			Load	Process Stations			Inspection station	Unload
			A	B	C	D	Frequency, f	A
1	250	A → B → C → D→ A	5	30	24	18	0.5	3
2	350	A → C → B → D → A	5	25	20	20	0.3	3
3	150	A → B → C → B → D → A	5	25	22	20	0.5	3
4	250	A → C → B → C → D → A	5	35	15	28	0.4	3
Mean travel time of AGV, min			2.5					

Question 29

A four stations FMS is used to produce five products according the data given in table (3).

B) Determine a layout of the FMS with two arrays. Assuming equal clearance, dimension, and cost.

C) Find: -

i. The bottleneck station in the FMS.
ii. The overall production rate and the rate of each part at full capacity.
iii. The average station utilization.
iv. The overall utilization of the FMS.

D) Develop the relationship for production rate and MLT each as function of the parts in the system. Plot and explains the results.

Table (3)

Part	Weekly Demand	Process Sequence	Operation Time, min.				
			Load/ Unload Station A	Process Station B	Process Station C	Inspection Station D	
						Time	frequency
1	240	A → C → B → D → A	3	30	20	15	0.5
2	150	A → B → C → D → A	3	25	24	15	0.5
3	260	A → C → D → A	2	0	15	10	0.3
4	100	A → B → D → A	2	35	0	12	0.3
5	250	A → C → D → C →D→ A	2	0	20	12	0.3
Number of machines per station			2	1	2	1	
Number of AGV's in system			4				
Mean travel time of AGV, min			3				

Question 30

Four stations FMS is used to produce three parts. The relevant data is given in table (5).

A- Find:-

i) The bottle neck station in the FMS.
ii) The overall production rate and the rate of each part at full capacity.
iii) The overall utilization of the FMS.

B- What is your recommendation to improve the efficiency of the system?

C- Develop the relationship for production rate and MLT each as function of the parts in the system. Plot and explains the results.

TABLE (5)

Part	Product mix	Process Sequence	Process Time, in				
			A	B	C	D	A
1	0.25	A -> B -> C -> D -> A	4	8	7	18	2
2	0.35	A -> C -> B -> A	4	10	14	0	2
3	0.40	A -> B -> D -> C -> A	4	6	12	16	2
Number of machines per station			2	2	3	3	
Number of AGV's in system			3				
Mean travel time of AGV, min			4				

Question 31

Four stations FMS is used to produce four parts. The relevant data is given in table (2). The station (D) is an inspection station and the parts (1, 2, 3, and 4) visit this station at frequency of (0.3, 0.25, 0.23, and 0.3) respectively.

A- Find:-

i) The bottle neck station in the FMS.
ii) The overall production rate and the rate of each part at full capacity.
iii) The overall utilization of the FMS.

B- Develop the relationship for production rate and MLT each as function of the parts in the system. Plot and explains the results.

C- Find the stations which can be resized without affecting the production and their new size.

Table (2)

Part	Product mix	Process Sequence	Process Time, in				
			A	B	C	D	A
1	0.15	A→B → C→ D → A	4	9	8	18	2
2	0.2	A → C → D → A	4	0	14	20	2
3	0.35	A → C → B → D → A	4	9	12	16	2
4	0.3	A → B → D → A	4	12	0	18	2
Number of machines per station			2	2	3	1	
Number of AGV's in system			3				
Mean travel time of AGV, min			4				

Question 32

A six stations FMS is used to produce five products according the data given in table below.

A) Determine the number of machines of each station and the number of AGV required satisfying production. Assume that the FMS operates 16 hr/day and weekly production is 900 pieces.

B) Find: -
   i. The bottleneck station in the FMS.
   ii. The overall production rate and the rate of each part at full capacity.
   iii. The average station utilization.
   iv. The overall utilization of the FMS.

C) Develop the relationship for production rate and MLT each as function of the parts in the system. Plot and explains the results.

Part	Weekly Demand	Process Sequence	Operation Time, min.						
			Load	Process Station			Inspection station		Unload
			A	B	C	D	E	Frequency, f	A
1	250	A → B → C → D → E→ A	4	18	22	20	12	0.5	2
2	200	A → C → B → E → A	4	15	14	-	15	0.2	2
3	100	A → C → D → E → A	4	-	16	25	10	0.3	2
4	200	A → B → D → C → E → A	4	20	18	25	14	0.5	2
5	250	A → C → D → E → A	4	-	16	20	12	0.4	2
Mean travel time of AGV, min			3						

Question 33

A four stations FMS is used to produce four parts according the data given in table (2)

a) Determine the number of machines of each station and the number of AGV required satisfying production. Assume that the FMS operates 16 hr/day, six days a week.

b) Is any of these station works at 100%?

c) What is the product mix which makes station **C** a bottle-neck station? Then find: -
   i. The overall production rate and the rate of each part at full capacity.
   ii. The average station utilization.
   iii. The overall utilization of the FMS.

d) Develop the relationship for production rate and MLT each as function of the parts in the system. Plot and explains the results.

TABLE (2)

Part	Weekly Demand	Process Sequence	Operation Time, min.					
			Load	Process Stations		Inspection station		Unload
			A	B	C	D	Frequency, f	A
1	250	A → B → C → D→ A	5	28	21	12	0.5	3
2	350	A → C → B → D → A	5	22	19	13	0.3	3
3	150	A → B → C → B → D → A	5	20	20	14	0.5	3
4	250	A → C → B → C → D → A	5	30	15	18	0.4	3
Mean travel time of AGV, min			2.5					

Question 34

A five stations FMS is used to produce five parts according the data given in table (3). [Hint: parts after being processed on station (D), a ratio (f) goes for station (E) before it goes to unload station (A)]

a) Determine a layout of the FMS with one array and two arrays. Assuming equal clearance, dimension, and cost
b) Determine the following
   i. The bottleneck station in the FMS.
   ii. The overall production rate and the rate of each part at full capacity.
   iii. The average station utilization.
   iv. The overall utilization of the FMS.
c) Develop the relationship for production rate and MLT each as function of the parts in the system. Plot and explains the results

TABLE (4)

Part	Weekly Demand, ***D***	Process Sequence	Operation Time, ***t*** , min.					
			Load/ unload	Process Station			Inspection station	
							E	Frequency, ***f***
			A	B	C	D		
1	250	A →C→B →D→E→ A	6	28	21	12	12	0.5
2	300	A→B→C→D→E→ A	6	22	19	13	10	0.3
3	125	A →C→ D→E→ A	6	0	20	14	14	0.4
4	175	A →B→D→E → A	6	30	0	20	15	0.4
5	150	A →B→C→D→E→ A	6	25	25	0	18	0.4
Number of machines per station			2	3	2	3	2	
Number of AGV's in system			4					
Mean travel time of AGV, min			3.5					

Question 35

A four stations FMS is used to produce four parts according the data given in table (3)

a. Determine the number of machines of each station and the number of AGV required satisfying production. Assume that the FMS operates 16 hr/day, six days a week.
b. Find: -
   v. The overall production rate and the rate of each part at full capacity.
   vi. The average station utilization.
   vii. The overall utilization of the FMS.
c. Develop the relationship for production rate and MLT each as function of the parts in the system. **Plot and explains** the results.

TABLE (3)

Part	Weekly Demand	Process Sequence	Operation Time, min.					
			Load	Process Stations		Inspection station		Unload
			A	B	C	D	Frequency, f	A
1	250	A →C → D→ A	5		21	14	0.5	3
2	350	A → B →D → A	5	22		14	0.3	3
3	150	A → B → C → D → A	5	20	22	15	0.5	3
4	250	A → C → B → C → D → A	5	15	20	14	0.4	3
Mean travel time of AGV, min			2.5					