Question 1 (35 Marks)

12-station flow line performs processing operations with cycle time of 1.0 minute. Each station operats 225 cycle and then fails. During the observed period, fuilure occurred on the average 10 times with average repair time 15 cycles.Determine the following:

A) The period of observation ***(2 .5 marks)***

B) The number of parts completed ***(2.5 marks)***

C) Failure and repair rate of stations ***(6 marks)***

D) Failure Frequency per cycle ***(4 marks)***

E) If the system operate 75% under upper bound approach and 25% under lower bound approach:- Find (1) Production rate; (2) Line efficiency; (3) Acceptable number of parts; (4) Defect parts., (5) cost of the line, if the operating cost is equal 50 SR/hr and ignoring other costs. ***(10 marks)***

F) If the line is to be divided to 2, 3 & 4 stages, find the cost if the buffer cost is 900 SR/hr for parts produced during the studied period of production. Explain what the trend of the cost and efficiency values ***(10 marks)***

A) & B)

Cycle time,Tc =	1	min
Number of failure (breakdown), N =	10	
Number of stations, n =	12	
Operating cycle, MTTF =	225	min
Repair cycle, MTTR =	15	min
Period of observation, AT = (MTTF +MTTR) * N = (225+15) =	2400	min
Total down time of line , TD = Tc * (MTTR) * (n) * (N) =	1800	min
Up time of the line, U = AT- TD =	600	min
Number of part produced = U/Tc =	600	parts

C) & D)

Failure rate,p = 1/MTTF =1/225 =	0.0044	
Repair rate,r = 1/MTTR = 1/15 =	0.066667	
station efficiency, % = r/(r + p) =	93.75	

E)

Frequency of line stop for each station, *p* = N/Np = 10/600 =	0.0167	
Upper bound frequency, Fu = 0.75 * n *p = 0.75 *12 * 0.0167 =	0.15	
Lower bound frequency, Fl = 0.25 *(1-(1- *p*)n = 0.25 * (1- (1 - 0.0167)12 =	0.046	
Frequency of line stop for line, F =Fu+Fl = 0.0167+.046 =	0.196	
Production time, Tp = Tc+ F * Td = 1 + 0.083 * 15 =	3.935	min
1- Production Rate, Rp = (1-Fl)/Tp = (1 - 0.024)/3.935 =	14.5518	pc/hr
2- Line efficiency = Tc * Rp = (1/60) * 14.7888 =	24.25	%
3- Number of parts produced = AT * Rp = (2400/60) *14.7888 =	582	parts
4- Number of defects =	18	parts
5- Line cost = Operating cost(Co)/ Rp =	3.43	SR/pc

50/14.5518 = 6

F- Find the optimum number of the infinite buffers, and Line efficiency. Cost of buffer Cb =900 SR

i) Two Stages: A Buffer after 6, n1 =6, n2 =6 - Number of buffer Nb=1

Stage 1, 2				
Frequency of failure per stop **F1 = F2 =6*p**				0.1000
Production Time, **(TP)=TC+F1*Td =**			**2.5000**	**min**
Production Rate, **(RP)= 60/TP =**			**24.000**	**part/hr**
Efficiency, ***(E1) = = E2= TC*RP =***			**40%**	

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Number of parts Na = AT * Rp = **960** **parts**

Cost of line = Nbr * (Cb)/Na + Co /Rp = **3.02** **SR/pc**

This is the optimum since it give the minimum cost

stages	cost	Eff
0	3.4360	24.25
2	***3.0208***	***40.00***
3	3.1667	50.00
4	3.4271	57.14
12	6.6667	80.00

ii) Three Stages: A Buffer after 4 & 8 , all has n =4 then all equal

Stage 1,2, 3				
Frequency of failure per stop **F1 =F2=F3= 4*p**				0.0667
Production Time, **(TP)=TC+F1*Td =**			**2.0000**	**min**
Production Rate, **(RP)= 60/TP =**			**30.000**	**part/hr**
Efficiency, ***(E1) =E2=E3= TC*RP =***			**50%**	

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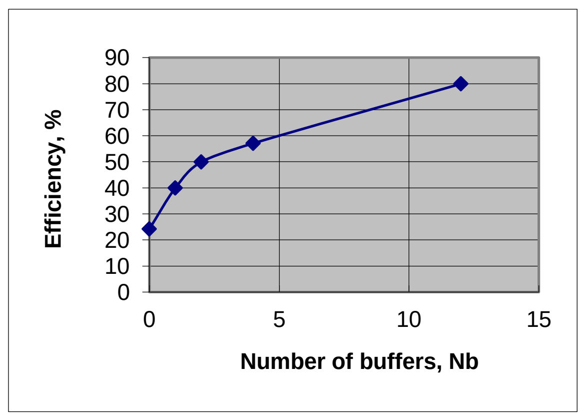

Number of parts Na = AT * Rp = **1200** **parts**

Cost of line = Nbr * (Cb)/Na + Co /Rp = **3.17** **SR/pc**

iii) 4 Stages: A Buffer after 3 & 6 & 9 , all has n =3 then all equal

Stage 1,2, 3, 4				
Frequency of failure per stop **F1 =F2=F3= 3*p**				0.0500
Production Time, **(TP)=TC+F1*Td =**			**1.7500**	**min**
Production Rate, **(RP)= 60/TP =**			**34.286**	**part/hr**
Efficiency, ***(E1) =E2=E3= TC*RP =***			**57%**	

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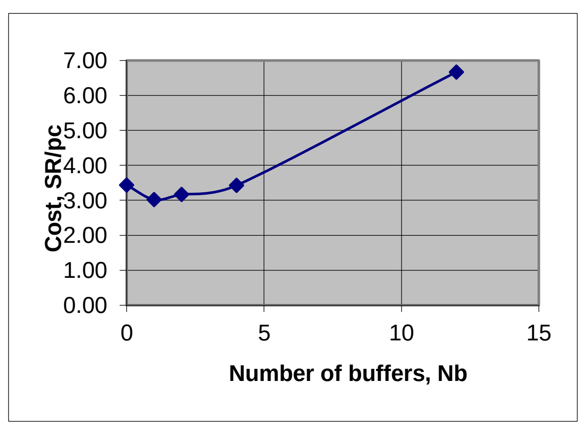

Number of parts Na = AT * Rp = **1371.429** **parts**

Cost of line = Nbr * (Cb)/Na + Co /Rp = **3.43** **SR/pc**

iii) 12 Stages: A Buffer after each station, all has n =1then all equal

Stage 1,2, 3, 4,…12				
Frequency of failure per stop **F1 =F2=F3= 3*p**				**0.0167**
Production Time, **(TP)=TC+F1*Td =**			**1.2500**	**min**
Production Rate, **(RP)= 60/TP =**			**48.000**	**part/hr**
Efficiency, ***(E1) =E2=E3= TC*RP =***			**80%**	

Number of parts Na = AT * Rp = **1920** **parts**
Cost of line = Nbr * (Cb)/Na + Co /Rp = **6.67** **SR/pc**

Question 4 (35 Marks)
A) 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. ***(25 marks)***

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	0.7	1.2	0	3	1.3	1.5	2.5	1.4	2.3
Machining Center, hr	2	1.2	1.7	1.6	0	1.6	1.5	0	2.2	2.2

Solution

Available Time TA - M/c center, hr/week = 129.6
Available Time TA - turning, hr/week = 194.4
Process Cost = (process time of turning + process time of M/c centre) x 150, SR/unit
Unit Saving, US = Purchase Cost - Material cost - Processes cost, SR/unit
Total process time, TT = Process time x weekly Demand, hr/week
Saving/hr, SH = unit saving/process time for a unit, SR/hr

Part family	1	2	3	4	5	6	7	8	9	10
Unit saving, US, SR/unit	375	235	85	560	100	115	-100	-85	130	-275
Turning Total process Time, hr	0	17.5	36	0	90	19.5	21	45	28	69
M/c Centre Total process Time, hr	44	30	51	80	0	24	21	0	44	66
Unit saving/ unit process time, SR/hr	187.5	123.7	29.3	350	33.3	39.7	-33	-34	36.1	-61.1

Step 1, Order (rank):,= 4, 1, 2, 9, 6, 5, 3

Step 2, Selection	Turning Time, hr		M/c Centre time ,hr	
	used	Remain	used	Remain
4	0	0	80	114.4
1	0	0	44	70.4
2	17.5	112.1	30	40.4
6	19.5	92.6	24	16.4
5	90	2.6	0	16.4
∴ The set of part family to be produced **4,1,2,6,5**				

B) 12 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 below. The tool magazine capacity is 8 slots. ***(10 marks)***

Solution

$$Maxi \sum_{i=1}^{N}\left(\sum_{c=1}^{C} b_{ic} d_c\right) z_i = 2z_1 + z_2 + 2z_3 + 2z_4 + 2z_5 + 2z_6 + 2z_7 + 3z_8 + 4z_9 + 2z_{10} + 3z_{11} + 3z_{12}$$

$$Subject\ to: \sum_{c=1}^{t} d_c y_c \le t,\ y_1 + y_2 + 2y_3 + 2y_4 + 2y_5 + 2y_6 + 2y_7 \le 8$$

Max z for one batch = 28

Tools slot require 12 slot this greater than 8, hence require batching.

First Trial:	No. of parts	No. of slot used
Batch 1: P1,P2,P3,P4,P5,P6,P7,P11,P12	z= 19	y =8
Batch 2: P8,P9,P10	z= 9	y = 6

Question 5B

B) A FMS consists of three stations is used to manufacturer three parts. The relative data is given in Table (3). Solve the loading of the stations in the FMS. ***(15 marks)***

Table (3)

Part	Weekly Demand	Operation	Machine Processing time, min A	B	C	Tool type
a	75	1	20	20	-	T1
		2	24	34	20	T2
		3	-	-	30	T3
b	80	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			2	1	2	
Number of tool's slot			2	2	2	
Available time, hr/day			12			

	A	B	C
Total slots	4	2	4
Total time, min	7200	3600	7200

Ittiration	a1	a2	a3	b1	b2	b3	c1	c2	Assigned Operation	Assigned Machine	Time remained, min
1	A,B	A,B,C	C	B,C	A	A,C	A,B,C	B,C	b2	A	4400
2	A,B	A,B,C	C	B,C	0	A,C	A,B,C	B,C	a3	C	4950
3	A,B	A,B,C	0	B,C	0	A,C	A,B,C	B,C	c1	C	2200
4	A,B	A,B,C	0	B,C	0	A,C	0	B,C	c2	C	200
5	A,B	A,B	0	B	0	A	0	0	b3	A	2400
6	A,B	A,B	0	B	0	0	0	0	b1	B	1200

7	A, B	A,B	0	0	0	0	0	0	a2	A	900
8	A, B	0	0	0	0	0	0	0	35/75 a1	A	200
9	B	0	0	0	0	0	0	0	45/75 a1	B	400

Utilization	
A	97.22
B	88.89
C	97.22