

Solution

1.

		(a)	(b)
Cost of Capital	(i)	4%	4%
Economic Life	(N , yr)	5	5
Annual Demand	(q /yr)	15,000	15,000
Sale Price	(p , \$/q)	30	30
Investment Cost	(IV , \$)	100,000	100,000
Salvage Percentage		25%	25%
Salvage Value	(SV , \$)	25,000	25,000
Eff. Investment Cost	(IV^{eff} , \$)	79,452	79,452
Cost Cap Recovery	(K , \$/yr)	17,847	17,847
Annual Operating Hours	(H , hr/yr)	2,000	2,000
Known Departure Rate	(r_d , q/hr)	7.50	7.50
Estimated Utilization	(u)	0.95	0.95
Estimated Capacity	(r_e , q/hr)	7.89	7.89
Capital Cost per Unit	(k , \$/q)	1.13	1.13
Operating Cost	(OC , \$/yr)	300,000	300,000
Oper Cost per Unit	(c , \$/q)	20	20
Unit Sales Price	(p , \$/q)	30	30
Unit Operating Cost	(c , \$/q)	20	20
Unit Capital Cost	(k , \$/q)	1.13	1.13
Delay Time	(t_g , hr)	0.50	0.50
Percent Price Reduction	(x_g)	0.2	0.2
Discount Factor	(g)	1.20	1.20
Obsolescence time	(t_h , hr)	8	1
Percent Value Reduction	(x_h)	0.8	0.8
Inventory Carrying Rate	(h)	0.1	0.8
Annual Demand	(q /yr)	24,000	24,000
Demand Rate	(r_d , q/hr)	12.00	12.00
Effective Production Rate	(r_e , q/hr)	16.21	23.29
Maximum FGI	(q^{max}_{FG})	4	0
Probability Out of FGI	(π_0)	0.100299	1
Cycle Time	(t_{CT})	0.23753	0.088574
Average FGI Level	(q_{FG})	2.579077	0
Total Profit	(TP , \$)	92.80	80.92
Upper Bound on TP	(TP_{UB} , \$)	106.4363	106.4363
Utilization	(u)	0.740284	0.515243

2.

		LO		HI		
		1	2	1	2	LO - HI WS 1
W/S						
Arrival Rate (r_a , q/hr)		29.6296	22.2222	23.6407	22.2222	5.988968
Natural Process Time (t_0 , hr)		0.2	0.1	0.2	0.1	0
MTTF (hr)						0
MTTR (hr)		0	0	0	0	0
Availability (A)		1	1	1	1	0
Effective Process Time (t_e , hr)		0.2	0.1	0.2	0.1	0
Number of M/C (m)		6	3	5	3	1
Utilization (u)		0.98765	0.74074	0.94563	0.74074	0.042028
Yield (y)		0.75	0.9	0.94	0.9	-0.19
Departure Rate ($r_a * y$) (r_d , q/hr)		22.2222	20	22.2222	20	0
RM Unit Savings (q/hr)		5.98897				
H (hr/yr)		2500				
RM Unit Savings (q/yr)		14972.4				
RM Cost (\$/q)		4.25				
RM Savings (\$/yr)		63632.8				
Labor Unit Savings (oper/hr)		1				
Labor Unit Savings (oper-hr/yr)		2500				
Labor Rate (\$/oper-hr)		21				
Labor Savings (\$/yr)		52500				
RM + Labor Savings (\$/yr)		116133	OP			
Unit IV (\$)		27500				
IV (\$)		137500				
Unit SV0 (\$)		50000				
SV0 (\$)		50000				
Net IV (\$)		87500	IV0			
RM+Labor Payback Period (yr)		0.75345				
RM Payback Period (yr)		1.37508				

3.

W/S			
Arrival Rate	$(r_a, \text{q/hr})$	26.66666667	
Arrival STD	(σ^a, hr)	0.083333333	
Arrival SCV	(c_a^2)	4.938271605	
Natural Process Time	(t_0, hr)	0.183333333	
Natural Process SCV	(c_0^2)	0	
MTTF	(hr)	24	
MTTR	(hr)	3	
Repair Time SCV	(c_r^2)	1	
Availability	(A)	0.888888889	
Effective Process Time	(t_e, hr)	0.20625	
Eff Process Time SCV	(c_e^2)	3.232323232	
Number of M/C	(m)	6	
Utilization	(u)	0.916666667	
Yield	(y)	0.75	
Departure Rate $(r_a * y)$	$(r_d, \text{q/hr})$	20	
Departure SCV	(c_d^2)	2.394810043	
Cycle Time in Queue	(CT_q, hr)	1.327530004	
WIP in Queue $(r_a * CT_q)$	(q)	35.4008001	
Hours per Shift	(H)	10	
$r_a * (t_e - t_0) * H * 60$	(min)	366.6666667	(a)
$\text{sqrt}(c_e^2) \times t_e$	(hr)	0.370809924	(b)
Space per M/C	(ft^2)	64	
M/C space	(ft^2)	384	
Space per Unit WIP	(ft^2)	16	
2 x WIPq space	(ft^2)	1132.825603	
Minimum total W/S space	(ft^2)	1516.825603	(c)

Formulas

1.

	A	B	C	D
			(a)	(b)
1				
2	Cost of Capital (i)	0.04		0.04
3	Economic Life (N , yr)	5		5
4	Annual Demand (q /yr)	15000		15000
5	Sale Price (p , \$/q)	30		30
6	Investment Cost (IV , \$)	100000		100000
7	Salvage Percentage	0.25		0.25
8	Salvage Value (SV , \$)	=C6*C7		=D6*D7
9	Eff. Investment Cost (IV^{eff} , \$)	=C6-C8*(1+C2)^(-C3)		=D6-D8*(1+D2)^(-D3)
10	Cost Cap Recovery (K , \$/yr)	=C9*(C2/(1-(1+C2)^(-C3)))		=D9*(D2/(1-(1+D2)^(-D3)))
11	Annual Operating Hours (H , hr/yr)	2000		2000
12	Known Departure Rate (r_d , q/hr)	=C4/C11		=D4/D11
13	Estimated Utilization (u)	0.95		0.95
14	Estimated Capacity (r_e , q/hr)	=C12/C13		=D12/D13
15	Capital Cost per Unit (k , \$/q)	=(C10/C11)/C14		=(D10/D11)/D14
16	Operating Cost (OC , \$/yr)	300000		300000
17	Oper Cost per Unit (c , \$/q)	=C16/C4		=D16/D4
18				
19	Unit Sales Price (p , \$/q)	=C5		=D5
20	Unit Operating Cost (c , \$/q)	=C17		=D17
21	Unit Capital Cost (k , \$/q)	=C15		=D15
22	Delay Time (t_d , hr)	0.5		0.5
23	Percent Price Reduction (x_p)	0.2		0.2
24	Discount Factor (g)	=(C19*C23)/((C19-C20)*C22)		=(D19*D23)/((D19-D20)*D22)
25	Obsolescence time (t_h , hr)	8		1
26	Percent Value Reduction (x_h)	0.8		0.8
27	Inventory Carrying Rate (h)	=C26/C25		=D26/D25
28	Annual Demand (q /yr)	24000		24000
29	Demand Rate (r_d , q/hr)	=C28/C11		=D28/D11
30	Effective Production Rate (r_e , q/hr)	16.21		23.29
31	Maximum FGI (q^{max}_{FG})	4		0
32	Probability Out of FGI (π_o)	=(1-C30/C29)/(1-(C30/C29)^(C31+1))		=(1-D30/D29)/(1-(D30/D29)^(D31+1))
33	Cycle Time (t_{CT})	=(C29/(C30-C29))*(1/C30)+(1/C30)		=(D29/(D30-D29))*(1/D30)+(1/D30)
34	Average FGI Level (q_{FG})	=avgFGI(C29,C30,C31)		=avgFGI(D29,D30,D31)
35	Total Profit (TP , \$)	=(C19-C20)*(1-C32+C32*(1-C24*C33))*C29-(C20+C21)*C27*C34-C21*C30		=(D19-D20)*(1-D32+D32*(1-D24*D33))*D29-(D20+D21)*D27*D34-D21*D30
36	Upper Bound on TP (TP_{UB} , \$)	=(C19-C20-C21)*C29		=(D19-D20-D21)*D29
37	Utilization (u)	=C29/C30		=D29/D30

2.

	A	B	C	D	E	F	G
2	W/S	1	2	1	2		LO - HI WS 1
3	Arrival Rate (r_a , q/hr)	=C12/C11	=D12/D11	=E12/E11	=F12/F11		=C3-E3
4	Natural Process Time (t_0 , hr)	=12/60	=6/60	=C4	=D4		=C4-E4
5	MTTF (hr)						=C5-E5
6	MTTR (hr)	0	0	0	0		=C6-E6
7	Availability (A)	=IF(ISBLANK(C5), 1, C5/(C5 + C6))	=IF(ISBLANK(D5), 1, D5/(D5 + D6))	=IF(ISBLANK(E5), 1, E5/(E5 + E6))	=IF(ISBLANK(F5), 1, F5/(F5 + F6))		=C7-E7
8	Effective Process Time (t_e , hr)	=C4/C7	=D4/D7	=E4/E7	=F4/F7		=C8-E8
9	Number of M/C (m)	=FLOOR(C3*C8 + 1,1)	=FLOOR(D3*D8 + 1,1)	=FLOOR(E3*E8 + 1,1)	=FLOOR(F3*F8 + 1,1)		=C9-E9
10	Utilization (u)	=C3*C8/C9	=D3*D8/D9	=E3*E8/E9	=F3*F8/F9		=C10-E10
11	Yield (y)	0.75	0.9	0.94	0.9		=C11-E11
12	Departure Rate (r_d , q/hr)	=D3	=50000/(10*250)	=F3	=D12		=C12-E12
13							
14	RM Unit Savings (q/hr)	=G3					
15	H (hr/yr)	=250*10					
16	RM Unit Savings (q/yr)	=C14*C15					
17	RM Cost (\$/q)	4.25					
18	RM Savings (\$/yr)	=C16*C17					
19	Labor Unit Savings (oper/hr)	=G9					
20	Labor Unit Savings (oper-hr/yr)	=C15*C19					
21	Labor Rate (\$/oper-hr)	21					
22	Labor Savings (\$/yr)	=C20*C21					
23	RM + Labor Savings (\$/yr)	=C18+C22	OP				
24	Unit IV (\$)	27500					
25	IV (\$)	=E9*C24					
26	Unit SV0 (\$)	50000					
27	SV0 (\$)	=G9*C26					
28	Net IV (\$)	=C25-C27	IV0				
29	RM+Labor Payback Period (yr)	=C28/C23					
30	RM Payback Period (yr)	=C28/C18					

3.

	A	B	C	D
1	W/S			
2	Arrival Rate (r_a , q/hr)	=C16/C15		
3	Arrival STD (σ^a , hr)	=5/60		
4	Arrival SCV (c_a^2)	=C3*2*C2*2		
5	Natural Process Time (t_0 , hr)	=11/60		
6	Natural Process SCV (c_0^2)	0		
7	MTTF (hr)	24		
8	MTTR (hr)	3		
9	Repair Time SCV (c_r^2)	1		
10	Availability (A)	=IF(ISBLANK(C7), 1, C7/(C7 + C8))		
11	Effective Process Time (t_e , hr)	=C5/C10		
12	Eff Process Time SCV (c_e^2)	=C6+(1+C9)*C10*(1-C10)*C8/C5		
13	Number of M/C (m)	=FLOOR(C2*C11 + 1,1)		
14	Utilization (u)	=C2*C11/C13		
15	Yield (y)	=3/4		
16	Departure Rate (r_d , q/hr)	20		
17	Departure SCV (c_d^2)	=1 + (1 - C14*2)*(C4 - 1) + (C14*2/SQRT(C13))*(C12 - 1)		
18	Cycle Time in Queue (CT_q , hr)	=((C4 + C12)/2)*((C14*(SQRT(2*(C13 + 1)) - 1))/(C13*(1 - C14)))*C11		
19	WIP in Queue (r_a * CT_q) (q)	=C2*C18		
20				
21	Hours per Shift (H)	=10		
22	r_a *(t_e - t_0)* H *60 (min)	=C2*(C11 - C5)*C21*60		(a)
23				
24	$\text{sqrt}(c_e^2) \times t_e$ (hr)	=SQRT(C12)*C11		(b)
25				
26	Space per M/C (ft ²)	64		
27	M/C space (ft ²)	=C13*C26		
28	Space per Unit WIP (ft ²)	16		
29	2 x WIP q space (ft ²)	=2*C19*C28		
30	Minimum total W/S space (ft ²)	=C27+C29		(c)