

# Solution

## Problem 1:

Lane/unit-load width	$x$	3
Unit-load depth	$y$	3
Unit-load height	$z$	3
No. different items	$N$	3,600
Down aisle width	$A$	10
No. levels for stacking	$H$	5
No. of rows (lane depth)	$D$	4
Est. max no. total units	$M$	100,000
Optimal lane depth	$(D^*)$	4
Number of lanes	$L(D)$	6,710
Total area (2-D)	$TA(D)$	342,210
Item area (2-D)		180,000
Cube utilization (2-D)		53%
Cross aisle percentage		20%
Total WH area (2-D)		410,652

## Problem 2:

Lane/unit-load width	$x$	3.5						
Unit-load depth	$y$	3						
Unit-load height	$z$	3						
No. different items	$N$	3						
Down aisle width	$A$	10						
No. levels for stacking	$H$	4						
No. of rows (lane depth)	$D$	9						
<b>SKU</b>		<b>Total</b>	<b>A</b>	<b>B</b>	<b>C</b>			
Max no. units of SKU $i$	$M_i$	600	70	150	380	<b>Randomized</b>		
<b>Dedicated</b>						Est. max no. total units	$M$	300
Number of lanes	$L(D)$	18	2	5	11	Number of lanes	$L(D)$	10
		Dedicated		Random				
		A	B	C	ABC			
Slots		2	5	11	10			
$f$		40	60	12	112			
$f/M$		20.00	12.00	1.09	11.20			
I/O		0	0	0	0			
Offset		0	2	7	0			
E(SC)		2	9	25	10			
TDi		80	540	300	1120			
TD (slots)				920	1,120			
TD (ft)				3,220	3,920			

**Problem 3:**

	UCB	NAR
r	0.10	0.10
N (yrs)	15	15
IV (\$)	25,000	30,000
SV (%)	25	25
SV (\$)	6,250	7,500
Iveff (\$)	23,504	28,205
Ccr (\$/yr/veh)	3,090	3,708
A	12	8
M	120,000	120,000
N	5,000	5,000
x	4.00	4.00
y	3.33	3.33
z	3.00	3.00
H	6	6
D	4	3
L(D)	7,396	9,028
TS(2-D)	571,957	505,568
Cross Aisle %	15%	15%
CS(2-D)	85,794	75,835
TS = TS + CS	657,751	581,403
Perimeter Cost	0	0
Perimeter	3,441	3,235
Area Cost	5	5
Bldg Cost (\$)	3,288,755	2,907,016
CcrBldg (\$/yr)	328,875	290,702
sft/yr	250	250
hr/sft	8	8
Speed (mph)	7	7
(ft/min)	616	616
TA (ft^2)	657,751	581,403
d_Slots,0 (ft)	1147	1078
d_I/O,0 (ft)	0	0
d_SC (ft/mov)	1147	1078
L/U time (s)	25	35
T(SC) (min/mov)	2.695270505	2.91721052
Annual Demand (mov/yr)	500,000	500,000
(hr/yr)	22460.59	24310.09
Fuel (\$/hr)	2.00	2.00
Fuel Cost (\$/yr)	44,921	48,620
Labor (\$/hr)	12.00	12.00
No. Oper	15	16
Hrs/Yr/Oper	2,000	2,000
Labor Cost (\$/yr)	360,000	384,000
Oper Cost (\$/yr)	404,921	432,620
Annual Demand (mov/hr)	250	250
Peak Demand (mov/hr)	312.5	312.5
T(SC) (hr/mov)	0.044921175	0.04862018
No. vehicles (m)	15	16
Peak Util (u)	0.935857814	0.9496128
Avg Util (u)	0.748686251	0.75969024
Ccr (\$/yr)	46,352.00	59,330.56
Total Cost (\$/yr)	780,148.64	782,652.33
Average Cost (\$/mov)	1.560297283	1.56530467

	A	B	C	D
1			UCB	NAR
2	r	0.1		0.1
3	N (yrs)	15		15
4	IV (\$)	25000		30000
5	SV (%)	25		25
6	SV (\$)	=C4*C5/100		=D4*D5/100
7	Iveff (\$)	=C4-C6*(1+C2)^(-C3)		=D4-D6*(1+D2)^(-D3)
8	Ccr (\$/yr/veh)	=C7*(C2/(1+(C2)^(-C3)))		=D7*(D2/(1+(D2)^(-D3)))
9				
10	A	12		8
11	M	120000		120000
12	N	5000		5000
13	x	4		4
14	y	=40/H2		=40/H2
15	z	3		3
16	H	6		6
17	D	=FLOOR(SQRT((C10*(2^C11-C12))/(2^C12*C14*C16)) + 0.5,1)		=FLOOR(SQRT((D10*(2^D11
18	L(D)	=CEILING((C11+C12*C16)/((C17-1)/2) + C12*(C16-1)/2)/(C17*C16),1)		=CEILING((D11+D12*D16)/(D
19	TS(2-D)	=C13*C18*(C14*C17+C10/2)		=D13*D18*(D14*D17+D10/2)
20	Cross Aisle %	0.15		0.15
21	CS(2-D)	=C19*C20		=D19*D20
22	TS = TS + CS	=C19+C21		=D19+D21
23	Perimeter Cost	0		0
24	Perimeter	=SQRT(C22/2)^6		=SQRT(D22/2)^6
25	Area Cost	5		5
26	Bldg Cost (\$)	=C23*C24+C25*C22		=D23*D24+D25*D22
27	CcrBldg (\$/yr)	=C26*C2		=D26*D2
28				
29	sft/yr	250		250
30	hr/sft	8		8
31	Speed (mph)	7		7
32	(ft/min)	=C31*5280/60		=D31*5280/60
33	TA (ft^2)	=C22		=D22
34	d_Slots,0 (ft)	=SQRT(2*C33)		=SQRT(2*D33)
35	d_I/O,0 (ft)	0		0
36	d_SC (ft/mov)	=C34 + 2*C35		=D34 + 2*D35
37	L/U time (s)	25		35
38	T(SC) (min/mov)	=C36/C32 + 2*(C37/60)		=D36/D32 + 2*(D37/60)
39	Annual Demand (mov/yr)	500000		500000
40	(hr/yr)	=C39*(C38/60)		=D39*(D38/60)
41	Fuel (\$/hr)	2		2
42	Fuel Cost (\$/yr)	=C40*C41		=D40*D41
43	Labor (\$/hr)	12		12
44	No. Oper	=C52		=D52
45	Hrs/Yr/Oper	=C29*8		=D29*8
46	Labor Cost (\$/yr)	=C43*C44*C45		=D43*D44*D45
47	Oper Cost (\$/yr)	=C42+C46		=D42+D46
48				
49	Annual Demand (mov/hr)	=C39/(C29*C30)		=D39/(D29*D30)
50	Peak Demand (mov/hr)	=1.25*C49		=1.25*D49
51	T(SC) (hr/mov)	=C38/60		=D38/60
52	No. vehicles (m)	=FLOOR(C50*C51+1)		=FLOOR(D50*D51+1)
53	Peak Util (u)	=C50*C51/C52		=D50*D51/D52
54	Avg Util (u)	=C49*C51/C52		=D49*D51/D52
55				
56	Ccr (\$/yr)	=C52*C8		=D52*D8
57				
58	Total Cost (\$/yr)	=C47+C56 + C27		=D47+D56 + D27
59	Average Cost (\$/mov)	=C58/C39		=D58/D39