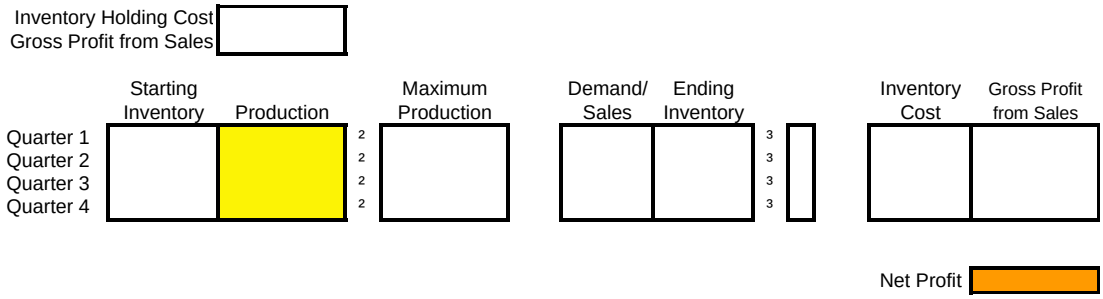
Assignment 2
Answers
Introduction to Management Science
2003

3.3 a. Top management will need to know how much to produce in each quarter. Thus, the decisions are the production levels in quarters 1, 2, 3, and 4. The objective is to maximize the net profit.

b. Ending inventory(Q1) = Starting Inventory(Q1) + Production(Q1) – Sales(Q1)
= 1,000 + 5,000 – 3,000 = 3,000
Ending inventory(Q2) = Starting Inventory(Q2) + Production(Q2) – Sales(Q2)
= 3,000 + 5,000 – 4,000 = 4,000
Profit from sales(Q1) = Sales(Q1) * ($20) = (3,000)($20) = $60,000
Profit from sales(Q2) = Sales(Q2) * ($20) = (4,000)($20) = $80,000
Inventory Cost(Q1) = Ending Inventory(Q1) * ($8) = (3,000)($8) = $24,000
Inventory Cost(Q2) = Ending Inventory(Q2) * ($8) = (4,000)($8) = $32,000

c.



d.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Inventory Holding Cost		$8										
2	Gross Profit from Sales		$20										
3													
4		Starting			Maximum		Demand/	Ending				Inventory	Gross Profit
5		Inventory	Production		Production		Sales	Inventory				Cost	from Sales
6	Quarter 1	1,000	2,000	2	6,000		3,000	0	3	0		$0	$60,000
7	Quarter 2	0	4,000	2	6,000		4,000	0	3	0		$0	$80,000
8											Totals	$0	$140,000
9													
10												Net Profit	$140,000

e.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Inventory Holding Cost		$8										
2	Gross Profit from Sales		$20										
3													
4		Starting			Maximum		Demand/	Ending				Inventory	Gross Profit
5		Inventory	Production		Production		Sales	Inventory				Cost	from Sales
6	Quarter 1	1,000	3,000	2	6,000		3,000	1,000	3	0		$8,000	$60,000
7	Quarter 2	1,000	6,000	2	6,000		4,000	3,000	3	0		$24,000	$80,000
8	Quarter 3	3,000	6,000	2	6,000		8,000	1,000	3	0		$8,000	$160,000
9	Quarter 4	1,000	6,000	2	6,000		7,000	0	3	0		$0	$140,000
10											Totals	$40,000	$440,000
11													
12												Net Profit	$400,000

3.5 a. Web Mercantile needs to know each month how many square feet to lease and for how long. The decisions therefore are for each month how many square feet to lease for one month, for two months, for three months, etc. The objective is to minimize the overall leasing cost.

b. Total Cost = (30,000 square feet)($190 per square foot)
+ (20,000 square feet)($100 per square foot)
= $7.7 million.

c.

	Month Covered by Lease?															Total		Space
Month of Lease:	1	1	1	1	1	2	2	2	2	3	3	3	4	4	5	Leased		Required
Length of Lease:	1	2	3	4	5	1	2	3	4	1	2	3	1	2	1	(sq. ft.)		(sq. ft.)
Month 1																	>=	
Month 2																	>=	
Month 3																	>=	
Month 4																	>=	
Month 5																	>=	

Cost of Lease (per sq. ft.)

Lease (sq. ft.)

Total Cost

d.

	A	B	C	D	E	F	G
1		Month Covered by Lease?			Total		Space
2	Month of Lease:	1	1	2	Leased		Required
3	Length of Lease:	1	2	1	(sq. ft.)		(sq. ft.)
4	Month 1	1	1		30,000	3	30,000
5	Month 2		1	1	20,000	3	20,000
6							
7	Cost of Lease	$65	$100	$65			
8	(per sq. ft.)						
9							Total Cost
10	Lease (sq. ft.)	10,000	20,000	0			$2,650,000

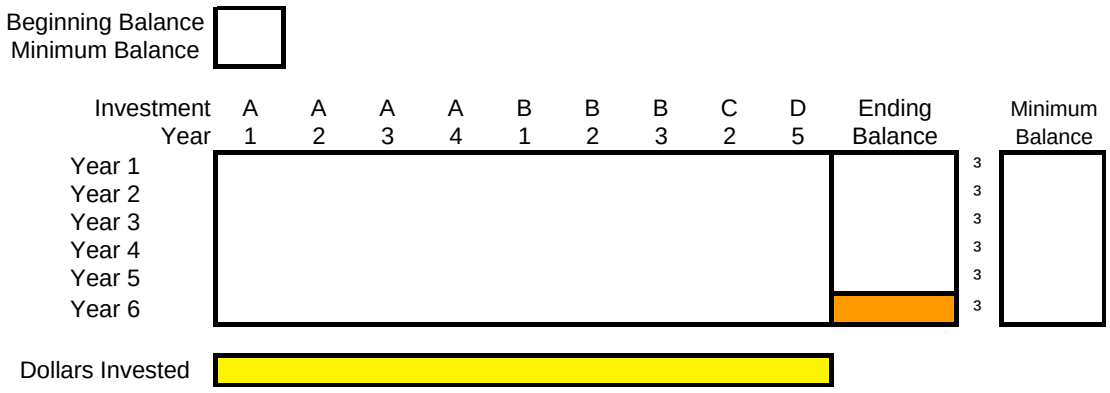
e.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1							Month Covered by Lease?										Total		Space
2	Month of Lease:	1	1	1	1	1	2	2	2	2	3	3	3	4	4	5	Leased		Required
3	Length of Lease:	1	2	3	4	5	1	2	3	4	1	2	3	1	2	1	(sq. ft.)		(sq. ft.)
4	Month 1	1	1	1	1	1											30,000	3	30,000
5	Month 2		1	1	1	1	1	1	1	1							30,000	3	20,000
6	Month 3			1	1	1		1	1	1	1	1	1				40,000	3	40,000
7	Month 4				1	1			1	1		1	1	1	1		30,000	3	10,000
8	Month 5					1				1			1		1	1	50,000	3	50,000
9																			
10	Cost of Lease	$65	$100	$135	$160	$190	$65	$100	$135	$160	$65	$100	$135	$65	$100	$65			
11	(per sq. ft.)																		
12																			Total Cost
13	Lease (sq. ft.)	0	0	0	0	30,000	0	0	0	0	10,000	0	0	0	0	20,000			$7,650,000

3.7 a. Al will need to know how much to invest in each possible investment each year. Thus, the decisions are how much to invest in investment A in year 1, 2, 3, and 4; how much to invest in B in year 1, 2, and 3; how much to invest in C in year 2; and how much to invest in D in year 5. The objective is to accumulate the maximum amount of money by the beginning of year 6.

b. Ending Cash (Y1) = $60,000 (Starting Balance) – $20,000 (A in Y1) = $40,000
Ending Cash (Y2) = $40,000 (Starting Balance) – $20,000 (B in Y2)
– $20,000 (C in Y2) = $0
Ending Cash (Y3) = $0 (Starting Balance) + $20,000(1.4) (for investment A) = $28,000
Ending Cash (Y4) = $28,000 (Starting Balance)
Ending Cash (Y5) = $28,000 (Starting Balance) + $20,000(1.7) (investment B)
= $62,000
Ending Cash (Y6) = $62,000 (Starting Balance) + $20,000(1.9) (investment C)
= $100,000

c.



d.

	A	B	C	D	E	F	G	H	I	J	K
1	Beginning Balance	$60,000									
2	Minimum Balance	$0									
3											
4	Investment	A	A	A	B	B	B	C	Ending		Minimum
5	Year	1	2	3	1	2	3	2	Balance		Balance
6	Year 1	-1			-1				$0	3	$0
7	Year 2		-1			-1		-1	$0	3	$0
8	Year 3	1.4		-1			-1		$84,000	3	$0
9											
10	Dollars Invested	$60,000	$0	$0	$0	$0	$0	$0			

e.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Beginning Balance	$60,000											
2	Minimum Balance	$0											
3													
4	Investment	A	A	A	A	B	B	B	C	D	Ending		Minimum
5	Year	1	2	3	4	1	2	3	2	5	Balance		Balance
6	Year 1	-1				-1					$0	3	$0
7	Year 2		-1				-1		-1		$0	3	$0
8	Year 3	1.4		-1				-1			$0	3	$0
9	Year 4		1.4		-1	1.7					$0	3	$0
10	Year 5			1.4			1.7			-1	$0	3	$0
11	Year 6				1.4			1.7	1.9	1.3	$152,880	3	$0
12													
13	Dollars Invested	$60,000	$0	$84,000	$0	$0	$0	$0	$0	$117,600			

4.1 a)

	A	B	C	D	E	F	G	H
1		TV Spots	Magazine Ads	Radio Ads	SS Ads			
2	Exposures per Ad	1300	600	900	500			
3	(thousands)							
4						Budget		Budget
5		Cost per Ad ($thousands)				Spent		Available
6	Ad Budget	300	150	200	100	4000	≤	4000
7	Planning Budget	90	30	50	40	1000	≤	1000
8								
9								Total Exposures
10		TV Spots	Magazine Ads	Radio Ads	SS Ads			(thousands)
11	Number of Ads	0	10	10	5			17,500
12		≥		≥				
13	Max TV Spots	5		10	Max Radio Spots			

Data cells: B2:E2, B6:E7, H6:H7, B13, and D13
Changing cells: B11:E11
Target cell: H11

	F
4	Budget
5	Spent
6	=SUMPRODUCT(B6:E6,$B$11:$E$11)
7	=SUMPRODUCT(B7:E7,$B$11:$E$11)

	H
9	Total Exposures
10	(thousands)
11	=SUMPRODUCT(B2:E2,B11:E11)

b) This is a linear programming model because the decisions are represented by changing cells that can have any value that satisfy the constraints. Each constraint has an output cell on the left, a mathematical sign in the middle, and a data cell on the right. The overall level of performance is represented by the target cell and the objective is to maximize that cell. Also, the Excel equation for each output cell is expressed as a SUMPRODUCT function where each term in the sum is the product of a data cell and a changing cell.

c) Let T = number of commercials on TV
M = number of advertisements in magazines
R = number of commercials on radio
S = number of advertisements in Sunday supplements.

Maximize Exposures (thousands) = $140T + 60M + 90R + 50S$

subject to $300T + 150M + 200R + 100S \leq 4{,}000$ ($thousands)
$90T + 30M + 50R + 40S \leq 1{,}000$ ($thousands)
$T \leq 5$ spots
$R \leq 10$ spots

and $T \geq 0, M \geq 0, R \geq 0, S \geq 0$.

4.4 a & c)

	A	B	C	D	E	F	G	H
1		Activity 1	Activity 2	Activity 3	Activity 4			
2	Contribution per unit	$11	$9	$8	$9			
3								
4			Resource Usage			Resource		Resource
5			per Unit of Activity			Used		Available
6	Resource P	3	5	-2	4	400	≤	400
7	Resource Q	4	-1	3	2	300	≤	300
8	Resource R	6	3	2	-1	400	≤	400
9	Resource S	-2	2	5	3	300	≤	300
10								
11		Activity 1	Activity 2	Activity 3	Activity 4			Total Contribution
12	Level of Activity	39.421	41.953	37.071	36.528			$1,436.53

b) Below are five possible guesses (many answers are possible).

(x_1, x_2, x_3, x_4)	Feasible?	P	
(30,30,30,30)	Yes	$1110	
(40,40,40,40)	No		
(35,39,30,40)	Yes	$1336	
(35,39,34,40)	Yes	$1368	
(37,39,35,40)	Yes	$1398	Best

4.12 a) The activities are leasing space in each month for a number of months. The benefit is meeting the space requirements for each month.

b) The decisions to be made are how much space to lease and for how many months. The constraints on these decisions are the minimum required space. The overall measure of performance is cost which is to be minimized.

c) Month 1: (M1 1mo lease) + (M1 2mo lease) + (M1 3mo lease) + (M1 4mo lease) + (M1 5 mo lease) ≥ 30,000 square feet.

Month 2: (M1 2mo lease) + M1 3 mo lease) + (M1 4 mo lease) + (M1 5mo lease) + (M2 1 mo lease) + (M2 2 mo lease) + (M2 3 mo lease) + (M2 4 mo lease) ≥ 20,000 square feet.

Month 3: (M1 3mo lease) + (M1 4mo lease) + (M1 5mo lease) + (M2 2mo lease) + (M2 3mo lease) + (M2 4mo lease) + (M3 1mo lease) + (M3 2mo lease) + (M3 3mo lease) ≥ 40,000 square feet.

Month 4: (M1 4mo lease) + (M1 5mo lease) + (M2 3mo lease) + (M2 4mo lease) + (M3 2 mo lease) + (M3 3mo lease) + (M4 1mo lease) + (M4 2mo lease) ≥ 10,000 square feet.

Month 5: (M1 5mo lease) + (M2 4mo lease) + (M3 3mo lease) + (M4 2 mo lease) + (M5 1mo lease) ≥ 50,000 square feet.

Nonnegativity: (M1 1mo lease) ≥ 0, (M1 2mo lease) ≥ 0, (M1 3 mo lease) ≥ 0, (M1 4 mo lease) ≥ 0, (M1 5mo lease) ≥ 0, (M2 1mo lease) ≥ 0, (M2 2mo lease) ≥ 0, (M2 3 mo lease) ≥ 0, (M2 4mo lease) ≥ 0, (M3 1mo lease) ≥ 0, (M3 2mo lease) ≥ 0, (M3

3mo lease) ≥ 0, (M4 1mo lease) ≥ 0, (M4 2mo lease) ≥ 0, (M5 1mo lease) ≥ 0.

Cost = ($650)[(M1 1mo lease) + (M2 1mo lease) + (M3 1mo lease) + (M4 1mo lease) + (M5 1mo lease)] + ($1,000)[(M1 2mo lease) + (M2 2mo lease) + (M3 2mo lease) + (M4 2mo lease)] + ($1,350)[(M1 3mo lease) + (M2 3mo lease) + (M3 3mo lease)] + ($1,600)[(M1 4mo lease) + (M2 4mo lease)] + ($1,900)[M1 5mo lease]

d)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1							Month Covered by Lease?										Total		Space
2	Month of Lease:	1	1	1	1	1	2	2	2	2	3	3	3	4	4	5	Leased		Required
3	Length of Lease:	1	2	3	4	5	1	2	3	4	1	2	3	1	2	1	(sq. ft.)		(sq. ft.)
4	Month 1	1	1	1	1	1											30,000	³	30,000
5	Month 2		1	1	1	1	1	1	1	1							30,000	³	20,000
6	Month 3			1	1	1		1	1	1	1	1	1				40,000	³	40,000
7	Month 4				1	1			1	1		1	1	1	1		30,000	³	10,000
8	Month 5					1				1			1		1	1	50,000	³	50,000
9																			
10	Cost of Lease	$65	$100	$135	$160	$190	$65	$100	$135	$160	$65	$100	$135	$65	$100	$65			
11	(per sq. ft.)																		
12																			Total Cost
13	Lease (sq. ft.)	0	0	0	0	30,000	0	0	0	0	10,000	0	0	0	0	20,000			$7,650,000

Data cells: B4:P8, B10:P10, and S4:S8
Changing cells: B13:P13
Target cell: S13
Output cells: Q4:Q8

	Q
1	Total
2	Leased
3	(sq. ft.)
4	=SUMPRODUCT(B4:P4,$B$13:$P$13)
5	=SUMPRODUCT(B5:P5,$B$13:$P$13)
6	=SUMPRODUCT(B6:P6,$B$13:$P$13)
7	=SUMPRODUCT(B7:P7,$B$13:$P$13)
8	=SUMPRODUCT(B8:P8,$B$13:$P$13)

	S
12	Total Cost
13	=SUMPRODUCT(B10:P10,B13:P13)

e) Let x_{ij} = square feet of space leased in month i for a period of j months.
for $i = 1, \ldots, 5$ and $j = 1, \ldots, 6-i$.

Minimize $C = \$650(x_{11} + x_{21} + x_{31} + x_{41} + x_{51}) + \$1{,}000(x_{12} + x_{22} + x_{32} + x_{42}) + \$1{,}350(x_{13} + x_{23} + x_{33}) + \$1{,}600(x_{14} + x_{24}) + \$1{,}900x_{15}$

subject to
$x_{11} + x_{12} + x_{13} + x_{14} + x_{15} \geq 30{,}000$ square feet
$x_{12} + x_{13} + x_{14} + x_{15} + x_{21} + x_{22} + x_{23} + x_{24} \geq 20{,}000$ square feet
$x_{13} + x_{14} + x_{15} + x_{22} + x_{23} + x_{24} + x_{31} + x_{32} + x_{33} \geq 40{,}000$ sq. feet
$x_{14} + x_{15} + x_{23} + x_{24} + x_{32} + x_{33} + x_{41} + x_{42} \geq 10{,}000$ square feet
$x_{15} + x_{24} + x_{33} + x_{42} + x_{51} \geq 50{,}000$ square feet

and $x_{ij} \geq 0$, for $i = 1, \ldots, 5$ and $j = 1, \ldots, 6-i$.