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MSDS 460 – Decision Analytics

MSDS 460 – HW #2: DECISION ANALYTICS

1.

This how my decision variables and setting up the problem looks:

The objective function can be figured: by figuring out the profit off each product – the cost for each material. For example:

101-(7*3 + 2*5 + 4*15) is the profit for product A – cost for Material 1

When computing all these the Objective function is

10*X1 + 10*X2 + 10*X3

The constraints are:

3*X1 + 1*X2 + 5*X3 <= 300

2*X1 + 4*X2 + 0*X3 <= 400

4*X1 + 2*X2 + 3.5*X3 <= 200

X1 >= 0

X2 >= 0

X3 >= 10

Decision Var	X1	X2	X3
Solution	0	0	0
Objective	0		
Constraint1	0	<=	300
Constraint2	0	<=	400
Constraint3	0	<=	200
Constraint 4	0	>=	0
Constraint 5	0	>=	0
Constraint 6	0	>=	10

After solving the problem using Solver, I got X1 =0 , X2 = 82.5 , X3 =10

Decision Var	X1	X2	X3
Solution	0	82.5	10
Objective	925		
Constraint1	132.5	<=	300
Constraint2	330	<=	400
Constraint3	200	<=	200
Constraint 6	10	>=	10
Profit for X1	10		
Profit for X2	10		
Profit for X3	10		

I got a maximum profit of $925.

2.

We know from that we need to find objective function for morning and evening. We know the cost of making a football and baseball in the morning and evening differ. So we have to make 4 decision variables: two for morning – M1 AND M2 representing football and basketball, two for evening representing football and baseball. E1 and E2, then the objective function and constraints are shown below:

Objective function

$20M1 + 20M2 + 25E1 + 25E2$

Constraints:

$0.75M1 + 2M2 =< 5{,}000$

$0.75E1 + 2E2 =< 2{,}000$

$7M1 + 15M2 =< 15{,}000$

7E1 + 15E2 =< 14,000

0.5M1 + 2M2 =< 2,000

0.5E1 + 2E2 =< 1,500

M1 + E1 >= 1500

M2 + E2 >= 1200

M1, M2, E1, E2 >= 0

This is how to setup the problem in excel:

Solution	M1	M2	E1	E2
Solution				
Objective	0			
Constraint 1	0	<=	5000	
Constraint 2	0	<=	2000	
Constraint 3	0	<=	15000	
Constraint 4	0	<=	14000	
Constraint 5	0	<=	2000	
Constraint 6	0	<=	1500	
Constraint 7	0	>=	0	
Constraint 8	0	>=	0	
Constraint 9	0	>=	0	
Constraint 1	0	>=	0	
Constraint 1	0	>=	1500	
Constraint12	0	>=	1200	

After setting up the problem; the solution is:

Solution	M1	M2	E1	E2
Solution	807.69231	623.07692	692.30769	576.92308
Objective	60346.154			
Constraint 1	1851.9231	<=	5000	
Constraint 2	1673.0769	<=	2000	
Constraint 3	15000	<=	15000	
Constraint 4	13500	<=	14000	
Constraint 5	1650	<=	2000	
Constraint 6	1500	<=	1500	
Constraint 7	807.69231	>=	0	
Constraint 8	623.07692	>=	0	
Constraint 9	692.30769	>=	0	
Constraint 1(	576.92308	>=	0	
Constraint 1	1500	>=	1500	
Constraint12	1200	>=	1200	

With the answer in the morning we get that the minimum cost we can get is 60,346.15, with 808 footballs, 623 baseballs made in the morning, and 692 footballs and 576 baseballs made in the evening.

3.Let the decision variables be A, B, C, D, E, F be decision variables

The objective function is

A + B + C + D + E +F where A-F is number of shifts

A – Midnight shift – 4 AM

B - 4 AM- 8 AM

C – 8 AM – 12 Noon

D – 12 Noon – 4 pm

E – 4 pm – 8 pm

F – 8 pm – 12 am

With the following information we can then figure out constraints

A + B >= 6 Since everyone need to get in 8 hours A will overlap with the B shift AND SO ON.

B + C >= 10

C + D >= 12

D + E > = 8

E + F >= 5

F + A >= 5

A-F >= 0

With this information we can setup our Excel spreadsheet:

Decision Var	A	B	C	D	E	F		
Solution	0	0	0	0	0	0		
Objective	0							
Constraint 1	0	>=	6					
Constraint 2	0	>=	10					
Constraint 3	0	>=	12					
Constraint 4	0	>=	8					
Constraint 5	0	>=	5					
Constraint 6	0	>=	5					
Constraint 7	0	0	0	0	0	0	>=	0

The solution to this problem is shown below

Decision Var	A	B	C	D	E	F		
Solution	5	1	9	3	5	0		
Objective	23							
Constraint 1	6	>=	6					
Constraint 2	10	>=	10					
Constraint 3	12	>=	12					
Constraint 4	8	>=	8					
Constraint 5	5	>=	5					
Constraint 6	5	>=	5					
Constraint 7	5	1	9	3	5	0	>=	0

The minimum number of firefighters against all shifts is 23

For shifts A-F We need 5,1,9,3, 5,0 firefighters respectively.

4.

The decision variables are Xi where i is 1-4 representing month and X represents Standard Rotary Pump. Let Y represent be Heavy Duty Rotary Pump and i is 1-4 representing month making Yi. With this information we can make the objective function and we have to take into account the cost will increase every month. Our goal is to minimize cost.:

Z = 125X1 + 135Y1 + 131.25X2 + 141.75Y2 + 137.8125X3 + 148.8375X3 + 144.70X4 + 156.28X4

We will need to add on cost in inventory for each product so we can use two new variables U for Standard and W for Heavy Duty inventory.

Our new objective function:

$125X1 + 135Y1 + 131.25X2 + 141.75Y2 + 137.8125X3 + 148.8375Y3 + 144.70X4 + 156.28Y4$

$5U1 + 5U2 + 5U3 + 5U4 + 5W2 + 5W3 + 5W4$

Now our constraints:

We know only 1800 of both can be in inventory

$U2 + W2$,$U3 + W3$, $U4 + W4 <= 1,800$

$U4 >= 800$

$W4 >= 850$

$1000 =< 0.45X1 + 0.52Y1 =< 1200$ADD 200 for 200 extra months

$1000 =< 0.45X2 + 0.52Y2 =< 1200$

$1000 =< 0.45X3 + 0.52Y3 =< 1200$

$1000 =< 0.45X4 + 0.52Y4 =< 1100$ Add only 100

To keep track of inventory

$U1 = 0 + X1 – 650$

$U2 = U1 + X2 – 875$

$U3 = U2 +X3 – 790$

$U4 = U3 + X4 -1300$

$W1 = 0 + Y1 – 900$

$W2 = W1 + Y2 -350$

$W3 = W2 + Y3 -1200$

$W4 = W3 + Y4 -1300$

Now we set up the following in Excel:

Decision Var	X1	X2	X3	X4	Y1	Y2	Y3	Y4	U1	U2	U3	U4	W1	W2	W3	W4
Solution																
Objective	0															
Constraint 1	0	<=	1800													
	0	<=	1800													
	0	<=	1800													
	0	<=	1800													
Constraint 2	0	>=	800													
Constraint 3	0	>=	850													
Constraint 4	0	>=	1000	<=	1200											
	0	>=	1000	<=	1200											
	0	>=	1000	<=	1200											
Constraint 5	0	>=	1000	<=	1100											
Inventory	0	=	-650													
	0	=	-875													
	0	=	-790													
	0	=	-1300													
Inventory He	0	=	-900													
	0	=	-350													
	0	=	-1200													
	0	=	-1300													
Constraint 6	0	0	0	0	>=	0										
Constraint 7	0	0	0	0	>=	0										
Constraint 8	0	0	0	0	>=	0										
Constraint 9	0	0	0	0	>=	0										

After we solve we get the following solution:

Decision Var	X1	X2	X3	X4	Y1	Y2	Y3	Y4	U1	U2	U3	U4	W1	W2	W3	W4
Solution	735	230.555556	790	2040	1287.01923	1723.55769	1239.42308	350	85	0	0	740	387.019231	1760.57692	1800	850
Objective	1211541.93															
Constraint 1	472.019231	<=	1800													
	1760.57692	<=	1800													
	1800	<=	1800													
	1590	<=	1800													
Constraint 2	740	>=	800													
Constraint 3	850	>=	850													
Constraint 4	1000	>=	1000	<=	1200											
	1000	>=	1000	<=	1200											
	1000	>=	1000	<=	1200											
Constraint 5	1100	>=	1000	<=	1100											
Inventory	85	=	85													
	0	=	0													
	0	=	0													
	740	=	740													
Inventory He	387.019231	=	387.019231													
	1760.57692	=	1760.57692													
	1800	=	1800													
	850	=	850													
Constraint 6	735	230.555556	790	2040	>=	0										
Constraint 7	1287.01923	1723.55769	1239.42308	350	>=	0										
Constraint 8	85	0	0	740	>=	0										
Constraint 9	387.019231	1760.57692	1800	850	>=	0										

This solution tells us that the minimal cost is $1,211,541.93 assuming the constraints and demand.

5.

A. The number of small and large offices the developer should build are 3 small offices and 44 large offices.

B. The total optimal monthly revenue is: 600*3 + 750*3 + 44*1000 = 1800 + 2250 + 44,000 = 48050.

C. 100,000 – 48,200 = 51,800 square footage will be remained unused.

D. Increasing the rent will not change the allocations; however, it will change the objective function only because we will make more money off the increase rent. We do not want to increase number of small and medium rooms as will lose money as determined by shadow price; however, our profit function will increase by 2400+2250 + 44,000 = 48,650 – 48,050 = 600 dollars. So, this is what increasing rent will have.

E. The additional square footage of 52,800 will have no impact on the optimal solution and office units. We will have more unused area.

F. 48,050 - 650*3 + 750*3 + 800*44 = 8,650

An increase in rent for small offices and decrease in rent in large office rents will have no impact on the optimal solution as it will remain the same. The profit will go down to 39,400, which is a 8,650 decrease.

Extra Credit:

For the solution I first setup the solution in Excel:

Decisonn Var	X1	X2	X3		
	0	0	0		
Objective	0				
Constraint 1	0	<=	5		
Constraint 2	0	<=	6		
Constraint 3	0	0	0	>=	0

From this the extreme points is when the objective function is maximized at X1 = 3.3, X2 = 0, and X3 = 1.67 as shown below:

Decisonn Var	X1	X2	X3		
	3.33333333	0	1.66666667		
Objective	5				
Constraint 1	5	<=	5		
Constraint 2	0	<=	6		
Constraint 3	3.33333333	0	1.66666667	>=	0

And the extreme points is when objective function is minimized at X1, X2, X3 all = 0.

Decisonn Var	X1	X2	X3		
	0	0	0		
Objective	0				
Constraint 1	0	<=	5		
Constraint 2	0	<=	6		
Constraint 3	0	0	0	>=	0