Assignment

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Question B)

Outdoors, Inc has, as one of its product lines, lawn furniture.

They currently have three items in that line: a lawn chair, a standard bench, and a table. These products are produced in a two-step manufacturing process involving the tube-bending department and the welding department. The time required by each item in each department is as follows:

	Product			Present Capacity
	Lawn Chair	Bench	Table	
Tube Bending(hrs)	1.2	1.7	1.2	1000 hrs.
Welding(hrs)	0.8	0	2.3	1200 hrs.
Tubing(lbs.)	2	3	4.5	2000 lbs.

The contribution that Outdoors, Inc. receives from the manufacture and sale of one unit of each product is $3 for a lawn chair, $3 for a bench and $5 for a table.

The company is trying to plan its production mix for the current selling season. It feels that it can sell any number it produces, but unfortunately production is further limited by available material, because of a prolonged strike. The company has on hand 2000 lbs. of tubing. The three products require the following amounts of this tubing: 2 lbs. per chair, 3 lbs. per bench, and 4.5 lbs. per table.

Question and Answers:

1. Formulate LP model for this problem?

A) We should Maximize the sales per unit item, that will be our objective function, and the constraints according to the given table and information will be the items that can be manufactured under given capacity and material.

Let's take number of Lawn Chairs = x1,
Number of Benches = x2,
Number of Tables = x3.

As per the information

Objective function,

Maximize Z = 3x1 + 3x2 + 5x3

Subject to:

1.2x1 + 1.7x2 + 1.2x3 <= 1000 (M1)
0.8x1 + 0x2 + 2.3x3 <= 1200(M2)
2x1 + 3x2 + 4.5x3 <= 2000(M3)
X1, x2, x3 >= 0

2. Solve the problem by SOLVER?

A) Solution in Excel

		x1	x2	x3		Optimum	
Max	Z	3	3	5		2766.667	RHS
	soln	700	0	133.3333			
M1		1.2	1.7	1.2	1000	<=	1000
M2		0.8	0	2.3	866.6667	<=	1200
M3		2	3	4.5	2000	<=	2000

The Maximum Profit it can make is 2766.667 $ by selling 700 Lawn Chairs ,0 Benches, 133 Tables under given constraints.

Solution: Z = 2766.667, x1 = 700, x2 = 0, x3 = 133.3333

3. What is the optimal production mix? What contribution can the firm anticipate by producing this mix?

A) As from the solution above the optimal production mix is 700 Lawn Chairs, 0 Benches 133 Tables and Profit that can be made is 2766.667.

The firm need not produce or spend money or materials for manufacturing the Benches since the optimum profit is made by not selling any benches.

4. What is the value of one unit more of tube-bending time? Of welding time? Of metal tubing?

A) <u>1 more unit of Tube-Bending Time:</u>

		x1	x2	x3		Optimum	
Max	Z	3	3	5		2236.364	RHS
	soln	18.18182	0	436.3636			
M1		2.2	2.7	2.2	1000	<=	1000
M2		0.8	0	2.3	1018.182	<=	1200
M3		2	3	4.5	2000	<=	2000

The Z = 2236.364, x1 = 18.18, x2 = 0, x3 = 436.36.

If there is increase in one more unit of Tube Bedding time the profit gained is 2236.364 $
By selling 18 chairs and 0 benches and 436 tables.

In this case in sensitivity analysis,

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
F5	M1	1000	0.636363636	1000	1200	22.22222222
F6	M2	1018.181818	0	1200	1E+30	181.8181818
F7	M3	2000	0.8	2000	45.45454545	1090.909091

So, if we increase 1 unit of tube bending time.
We are observing the shadow price for Tube Bending is 0.6363 and for Tubing is 0.8.
And the Allowable Increase is:
Metal-Tubing – 1200 i.e. RHS value can be till 2200.
Tubing – 45.45 i.e. RHS value can be till 2045.

B) <u>1 more unit of Welding Time:</u>

		x1	x2	x3		Optimum	
Max	Z	3	3	5		2347.475	RHS
	soln	290.9091	303.0303	113.1313			
M1		1.2	1.7	1.2	1000	<=	1000
M2		1.8	1	3.3	1200	<=	1200
M3		2	3	4.5	2000	<=	2000

Z = 2347.475, x1=290.9091, x2=303.03, x3 = 113.13.

If there is increase in one more unit of Welding time the profit gained is 2347.475 $
By selling 290 chairs and 303 benches and 113 tables.

In this case in sensitivity analysis,

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
F5	M1	1000	0.74747475	1000	164.705882	266.666667
F6	M2	1200	0.83838384	1200	500	355.555556
F7	M3	2000	0.2969697	2000	326.530612	301.075269

So, if we increase 1 unit of welding time.
We are observing the shadow price for Metal-Tubing is 0.7474, Welding is 0.8383 and Tubing is 0.2969.
And the Allowable Increase is:
Metal-Tubing – 164.70 i.e. RHS value can be till 1164.70.
Welding – 500 i.e. RHS value can be till 1700.
Tubing – 326.53 i.e. RHS value can be till 2326.53.

C) <u>1 more unit of Metal Tubing Time:</u>

		x1	x2	x3		Optimum	
Max	Z	3	3	5		2000	RHS
	soln	666.6667	0	0			
M1		1.2	1.7	1.2	800	<=	1000
M2		0.8	0	2.3	533.3333	<=	1200
M3		3	4	5.5	2000	<=	2000

Z=2000, x1 = 666.6667, x2 = 0, x3 =0.

If there is increase in one more unit of Metal Tubing time the profit gained is 2000$
By selling 666 chairs and 0 benches and 0 tables.

In this case in sensitivity analysis,

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
F5	M1	800	0	1000	1E+30	200
F6	M2	533.3333333	0	1200	1E+30	666.6666667
F7	M3	2000	1	2000	500	2000

So, if we increase 1 unit of tubing time.
We are observing the shadow price for Metal-Tubing is 0, Welding is 0 and Tubing is 1.
And the Allowable Increase is:
Metal-Tubing – No Allowable Increase.
Welding – No Allowable Increase.
Tubing – 500 i.e. RHS value can be till 2500.

5. A local distributor has offered to sell Outdoors, Inc some additional metal tubing for $ 0.60/lb. Should Outdoors buy it? If yes, how much would the firm's contribution increase if they bought 500 lbs. and used it in an optimal fashion?

A)

		x1	x2	x3		Optimum	
Max	Z	3	3	5		3166.667	RHS
	soln	500	0	333.3333			
M1		1.2	1.7	1.2	1000	<=	1000
M2		0.8	0	2.3	1166.667	<=	1200
M3		2	3	4.5	2500	<=	2500

As we can see from the above tableau, If Outdoors Buy 500 lbs more of Metal Tubing of 1 lb for $0.60.

So, for Metal Tubing we have 500 lbs extra resources, we can have profit of 3166.667$ and 500 chairs and 0 Benches and 333 Tables can be sold.

So, the cost for 500 lbs. of metal tubing is 300 $.
Profit made = 3166.667$ - 300$ = 2866.667$.
Before we were making 2766.667$ without these 500 lbs. of metal tubing.
Now we are making 100$ more than the earlier time.
So, it's advisable.

6. If Outdoors, Inc. feels that it must produce at least 100 benches to round out its product line, what effect will that have on its contribution?

A) If Outdoors, Inc. feels it must manufacture at least 100 benches then a new constraint will be added. Since x2 corresponds to number of benches to be manufactured, So the new constraint will be
X2 >= 100 (M4)
If we include this in the simplex algorithm.

		x1(lawn chairs)	x2(bench)	x3(table)		Optimum	
Max	Z	3	3	5		0	RHS
	soln	0	0	0			
M1		1.2	1.7	1.2	0	<=	1000
M2		0.8	0	2.3	0	<=	1200
M3		2	3	4.5	0	<=	2000
M4		0	1	0	0	>=	100

Constraints (not including Variable Bounds) Which Make the Problem Infeasible

Cell	Name	Cell Value	Formula	Status	Slack
F8	M4	0	F8>=H8	Violated	-100

Here when solving the simplex problem, the solution is infeasible, because it is not able to satisfy all the constraints. So, with the given constraints at least 100 benches cannot be manufactured so there is no feasibility.
Here we add slack variables to convert inequality to equation form, slack is negative which cannot be possible.
Hence The contribution by Outdoors, Inc. will have 0 contribution of any product.

7. The R&D department has been redesigning the bench to make it more profitable. The new design will require 1.1 hours of tube-bending time, 2.0 hours of welding time, and 2.0 lbs. of metal tubing. If it can sell one unit of this bench with a unit contributing of $3, what effect will it have on overall contribution?

A) For this question the constraint values will be changing as follows:

		x1(lawn chairs)	x2(bench)	x3(table)		Optimum	
Max	Z	3	3	5		2800	RHS
	soln	457.1428571	285.71429	114.2857			
M1		1.2	1.1	1.2	1000	<=	1000
M2		0.8	2	2.3	1200	<=	1200
M3		2	2	4.5	2000	<=	2000

So, If the R&D decides the given changes for manufacturing benches, the optimum value is 2800$.
The objective function remains the same, since the product price was decided for 3$.
Here,
457 lawn chairs, 285 benches and 114 tables are getting manufactured and the profit increased is 33.33$.
So, it's advisable.

9. Outdoors, Inc. has a chance to sell some of its capacity in tube bending at cost + $1.50 per hour. If it sells 200 hours at that price, how will this affect contribution?

A) The above question means the amount of resources we have for tube-bending will increase by 200.
Means we will be investing $1.50 per hour to increase the tube-bending time.
To increase time, we should spend $1.50*200 = 300$.
So, our total tube bending time will be 1200 hours.

		x1(lawn chairs)	x2(bench)	x3(table)			Optimum	
Max	Z	3	3	5			3000	RHS
	soln	1000	0	0				
M1(Tube Bending)		1.2	1.7	1.2		1200	<=	1200
M2(Welding)		0.8	0	2.3		800	<=	1200
M3(Tubing)		2	3	4.5		2000	<=	2000

So, our resource (Tube-Bending) time got increased to 1200 hours. So, we can reap a profit of 3000$ with given resources by manufacturing 1000 lawn chairs, 0 benches and 0 tables.

But we spent 300$ to increase 200 hours of tube bending. So that makes our profit 3000$ - 300$ = 2700$.

But Earlier we were making profit of 2766.667$ manufacturing 700 lawn chairs and 133 tables.

This time we are making 66.67$ less profit, and our production is only 1000 lawn chairs.
So, in this manner the contribution is made.
This is not much advisable.

10. If the contribution on chairs were to decrease to $2.50, what would be the optimal production mix and what contribution would this production plan give?

A) If the contribution on chairs were to decrease to $2.50, then the simplex table would be as follows:

		x1(lawn chairs)	x2(bench)	x3(table)			Optimum	
Max	Z	2.5	3	5			2416.667	RHS
	soln	700	0	133.3333				
M1(Tube Bending)		1.2	1.7	1.2		1000	<=	1000
M2(Welding)		0.8	0	2.3		866.6667	<=	1200
M3(Tubing)		2	3	4.5		2000	<=	2000

In this we can see that the profit obtained is 2416.667 $ and products manufactured are 700 lawn chairs, 0 benches and 133 tables.

So, this is not a good contribution from the lawn chairs. Since the profit got decreased from 2766.667$ to 2416.667 i.e. (-350$).
So, Outdoors Inc. will give 350$ less profit in this production plan!

Note: Refer to the Excel Sheet for Corresponding Solution.

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