Department of Industrial Engineering & Operations Research

IEOR 162: Linear Programming and Network Flows (Fall 2015)

Group project

Due: Friday, Dec 4th

Managing Operations at Golf-Sport.

Golf-Sport is a small-sized company that produces high quality components for people who build their own golf clubs and prebuilt sets of clubs. There are five components – steel shafts, graphite shafts, forged iron heads, metal wood heads, and metal wood heads with titanium inserts made in three plants – Chandler, Glendale, and Tucson – in the Golf-Sport system. Each plant can produce any of the components, al- though each plant has a different set of individual constraints and unit costs. These constraints cover labor and packaging machine time (the machine is used by all components); the specific values for each component-plant combination are given in Tables 1, 2 and 3. Note that even though the components are identical in the three plants, different production processes are used, and therefore the products use different amounts of resources in different plants.

Besides component sales, the company takes the components and manufactures sets of golf clubs. Each set requires 13 shafts, 10 iron heads, and 3 wood heads. All of the shafts in a set must be the same type (steel or graphite), and all of the wood heads must be the same type (metal or metal with inserts). Assembly times for the sets at each plant are given in the following table:

Plant	Time (minutes/set)	Monthly Availability (minutes)
Chandler	65	5,500
Glendale	60	5,000
Tucson	65	6,000

Each plant of Golf-Sport has a retail outlet to sell components and sets, and the specific plant is the only supplier for its retail outlet. The minimum and maximum amounts of demand for each plant-product pair are given in Table 4. These specify the range within which the supply for each plant-product pair must lie; any supply within this range that you decide to sell will get sold at the retail outlet (at the price indicated in Table 6).

This planning problem is for two months. The costs in Table 5 increase by 12% for the second month, and production times are stationary. The costs listed for the sets in Table 5 include the costs incurred for the components of the set.

Table 1: Product-Resource Constraints: Chandler.

	Resources		
Products	Labor (minutes/unit)	Packing (minutes/unit)	Advertising ($/unit)
Steel shafts	1	4	1.0
Graphite shafts	1.5	4	1.5
Forged iron heads	1.5	5	1.1
Metal wood heads	3	6	1.5
Titanium insert heads	4	6	1.9
Monthly availability (min.)	12,000	20,000	—

Table 2: Product-Resource Constraints: Glendale.

	Resources		
Products	Labor (minutes/unit)	Packing (minutes/unit)	Advertising ($/unit)
Steel shafts	3.5	7	1.1
Graphite shafts	3.5	7	1.1
Forged iron heads	4.5	8	1.1
Metal wood heads	4.5	9	1.2
Titanium insert heads	5.0	7	1.9
Monthly availability (min.)	15,000	40,000	—

Inventory of various parts and sets can be held from month 1 to month 2 incurring inventory-storage costs. These storage costs are based on the end-of-period inventory for each product, and are equal to 8% of the cost values given in Table 5. Initially, that is, at the start of month 1, there is no inventory. Table 6 lists the revenue generated by each product.

The corporation controls the capital available for expenses; the cash requirements for each product are given in terms of advertising $s in the last column of Tables 1–3. There is a total of $20,000 available for advertising for the entire system during each month, and any money not spent in a month is not available the next month. The corporation also controls graphite. Each graphite shaft requires 4 ounces of graphite; a total of 1,000 pounds (1 pound = 16 ounces) is available for each of the two months. (The supply of steel and titanium is not a limiting constraint.)

Your Task.

Your job is to make a recommendation for the company and provide a report including a plan for production and sales that satisfies all the constraints of the problem (ignore the constraint that the number of units produced and sold must be integers). The report (10-15 pages) consists of two parts: the first part should be prepared as a consulting report to the management of the company that hired you for this consulting job. As such, it must contain an executive summary, and a main body where you give and explain your results in a very simple way so that anyone can understand it. Your report should include the rationale for your solution strategy.

Table 3: Product-Resource Constraints: Tucson.

	Resources		
Products	Labor (minutes/unit)	Packing (minutes/unit)	Advertising ($/unit)
Steel shafts	3	7.5	1.3
Graphite shafts	3.5	7.5	1.3
Forged iron heads	4	8.5	1.3
Metal wood heads	4.5	9.5	1.3
Titanium insert heads	5.5	8.0	1.9
Monthly availability (min.)	22,000	35,000	—

The second part, the technical part, should be prepared as an appendix to the first part. In this part you must explain all the details of your model(s) and solution to the problem. You must also include all the AMPL files used to solve your problem, including the log file of your AMPL-session showing the information extracted from AMPL that is used to answer the sensitivity questions.

Your report should address the following sensitivity questions:

a) If you could get more graphite or advertising cash, how much would you like, how would you use it, and what would you be willing to pay?

b) At what site(s) would you like to add extra packing machine hours, assembly hours, and/or extra labor hours? How much would you be willing to pay per hour and how many extra hours would you like?

c) Marketing is trying to get Golf-Sport to consider an advertising program that promises a 50% increase in their minimum demand. Can we handle this with the current system or do we need more resources? How much more is the production going to cost if we take on the additional demand?

Your should also use your judgement to address additional sensitivity analysis questions that could be relevant for the company.

Table 4: Minimum and Maximum Product Demand per Month.

	Store (or Plant)		
Products	Chandler	Glendale	Tucson
Steel shafts	[0, 2000]	[0, 2000]	[0, 2000]
Graphite shafts	[100, 2000]	[100, 2000]	[50, 2000]
Forged iron heads	[200, 2000]	[200, 2000]	[100, 2000]
Metal wood heads	[30, 2000]	[30, 2000]	[100, 2000]
Titanium insert heads	[100, 2000]	[100, 2000]	[100, 2000]
Set: Steel, metal	[0, 200]	[0, 200]	[0, 200]
Set: Steel, insert	[0, 100]	[0, 100]	[0, 100]
Set: Graphite, metal	[0, 300]	[0, 300]	[0, 300]
Set: Graphite, insert	[0, 400]	[0, 400]	[0, 400]

Table 5: Material, Production and Assembly Costs ($) per Part or Set.

	Plant		
Products	Chandler	Glendale	Tucson
Steel shafts	6	5	7
Graphite shafts	19	18	20
Forged iron heads	4	5	5
Metal wood heads	10	11	12
Titanium insert heads	26	24	27
Set: Steel, metal	178	175	180
Set: Steel, insert	228	220	240
Set: Graphite, metal	350	360	370
Set: Graphite, insert	420	435	450

Table 6: Revenue per Part or Set ($)

	Plant		
Products	Chandler	Glendale	Tucson
Steel shafts	10	10	12
Graphite shafts	25	25	30
Forged iron heads	8	8	10
Metal wood heads	18	18	22
Titanium insert heads	40	40	45
Set: Steel, metal	290	290	310
Set: Steel, insert	380	380	420
Set: Graphite, metal	560	560	640
Set: Graphite, insert	650	650	720