Problem Set 2—Linear Programming Applications
MSIS 504—Professor Hillier
Individual Submission due Sunday, July 6, 11:59pm
Team Submission due Monday, July 7, 11:59pm

Instructions

1. Solve each of the following three problems in three tabs in a single Excel file. Label the tabs by problem number (i.e., 1, 2, and 3). It is fine (even encouraged) to discuss and/or get help from classmates. Any help provided should be via discussion only and should *not* include sending or copying of files or portions of files. Everything in your individual submission should be entered by you, based on your understanding of the material.
2. Submit your individual solution to Canvas no later than the date and time shown above.
3. Meet with your study team. Compare and discuss your various solutions. Help teammates who struggled, as needed. Create a single submission for the team. At this stage (after everyone on the team has submitted their individual submissions), sharing of files is permitted. **If you copy models from one worksheet to another to create the team submission, right-click on the tab and use Move or Copy Sheet, or control-click/option-click (PC/Mac) and drag the tab to copy the whole worksheet; don't just copy and paste the cells as this does not carry over the Solver information.**
4. One member of your team should submit the file to Canvas no later than the due date and time shown above.

1. Library Staffing at Scripps College

Scripps College is trying to schedule the staffing of its main library. The library is open from 8 a.m. until midnight. They have monitored the usage of the library at various times of the day, and determined that the following number of staff are required:

Time of Day	Minimum Staff Required
8am – 12pm	5
12pm – 4pm	6
4pm – 8pm	9
8pm – 12am	9

Two types of staff can be hired: full-time and part-time. The full-time staff work for 8 consecutive hours in any of the 3 following shifts: morning (8am–4pm), afternoon (12pm–8pm), and evening (4pm–12am). Full-time staff are paid $22 per hour. Part-time staff work any of the following 4 shifts: (1) 8am–12pm, (2) 12pm–4pm, (3) 4pm–8pm, and (4) 8pm–midnight. Part-time staff are paid $16 per hour. An additional requirement is that during every time period, there must be at least 3 full-time staff on duty for every part- time staff on duty. Scripps College would like to determine how many full-time and how many part-time staff should work each possible shift (3 shifts for FT, 4 shifts for PT) at the library so as to meet the above requirements at the minimum possible cost. Build a linear programming spreadsheet model and solve it using Solver.

2. Optimizing a Distribution System

A distribution system consists of three factories, three regional warehouses, and four retailers. Production costs are $51.50 per unit at Factory 1, $53 per unit at Factory 2, and $52 per unit at Factory 3. Costs of shipping from the factories to the regional warehouses are given in Table 1, and costs of shipping from the warehouses to the retailers are given in Table 2. Factory 1 can produce up to 2900 units per month, Factory 2 up to 4100 units per month, and Factory 3 up to 3900 units per month. The four retailers require at least 2500, 2900, 3000, and 2200 units per month, respectively. You must decide how much to produce and ship to each regional warehouse from each factory, and how much to ship from each regional warehouse to each retailer to minimize total monthly costs. Build a linear programming spreadsheet model and solve it using Solver.

	Warehouse 1	Warehouse 2	Warehouse 3
Factory 1	$4.75	$3.70	$7.60
Factory 2	$7.15	$6.15	$5.75
Factory 3	$4.70	$5.00	$6.10

Table 1. Shipping Cost per Unit from Factories to Warehouses

	Retailer 1	Retailer 2	Retailer 3	Retailer 4
Warehouse 1	$2.25	$3.05	$3.05	$4.45
Warehouse 2	$3.00	$4.35	$3.25	$2.05
Warehouse 3	$3.80	$2.70	$3.20	$2.55

Table 2. Shipping Cost per Unit from Warehouses to Retailers

3. Fairwinds Development Corporation

The Fairwinds Development Corporation is considering taking part in one or more different development projects—A, B, and C—that are about to be launched. Each project requires a significant investment over the next few years and then would be sold upon completion. The projected cash flows (in millions of dollars) associated with each project are shown in the table below.

Year	Project A	Project B	Project C
1	-10	-10	-14
2	-12	-11	-11
3	-14	-8	-10
4	46	-10	-10
5	0	50	-8
6	0	0	67

Fairwinds has $20 million cash on hand now and also expects to receive $9 million in other income at the start of each year (year 1 through year 6) that would also be available for investments (therefore, a total of $29 million is available for projects in year 1). Assume that money not spent in a given year is available in future years, and also earns 1% interest. For example, if the ending balance in year 1 is $1 million, then $1.01 million will be available for projects at the start of year 2, along with the $9 million from other income for year 2. Assume no interest earned for year 1 as it is already included in the $20 million starting balance. For simplicity, you may assume that all cash flows (including interest earned, other income received, and project cash flows) occur simultaneously at the start of each year.

The company may participate in each project either fully, fractionally (with other development partners), or not at all. If Fairwinds participates at less than 100%, then all the cash flows associated with that project are reduced proportionally. For example, if Fairwinds participates in *Project A* at 50%, the cash flows associated with that project would be –5, –6, –7, and $23 million in years 1 through 4, respectively. Company policy requires ending each year with a cash balance of at least $800 thousand. (Interest is earned on all remaining cash, including the $800 thousand minimum balance.)

Which projects should Fairwinds take part in and at what fraction of participation, so as to end year 6 with as much cash as possible? Formulate and solve a linear programming spreadsheet model.