

Assignment 3: Excel Functions and Linear Programming

Solution

Date Due: February 12, 2015

Instructor: Trani

Problem 1

Task 1

```

Public Function RailNoise(SELref, Ncars, S, V)
'Function used to estimate the noise generated by a rail vehicle

'Programmer: Moises Bobadilla
'Date: February 10, 2015
'
' Inputs:
'SELref = equivalent noise level (dBA)
'Ncars = number of cars in the train
'S = train speed (mph)
'V = hourly average train volume (trains/hr)

RailNoise = SELref + 10 * (Log(Ncars) / Log(10)) + 20 * (Log(S / 50) / Log(10)) + 10 * (Log(V) / Log(10)) - 31.4

End Function

```

NOTE: Taking the natural log in VBA can be done using two methods: a) as shown in the solution to Task 1 (divide $\text{Log}(x)/\text{log}(10)$) or b) using the Excel function (`Application.WorksheetFunction.Ln`). This last statement used Excel to do the computation of \ln .

Task 2

Inputs		
SELref	73	dBA
Ncars	8	# of cars
S	49	mph
V	28	cars/hr
Output		
Leq	64.9270	dBA

Task 3

Train Speed (mph)	Leq (dBA)
0	0
5	45.102
6	46.686
9	50.208
12	52.707
15	54.645
18	56.229
21	57.567
24	58.727
27	59.750
30	60.666
33	61.493
36	62.249
39	62.944
42	63.588
45	64.187
48	64.748
51	65.274
54	65.771
57	66.241
60	66.686
63	67.110
66	67.514
69	67.900

NOTE: Sanity check. The higher the train speed, the higher the noise.

Task 4

# of cars	Leq (dBA)
2	58.906
3	60.667
4	61.917
5	62.886
6	63.678
7	64.347
8	64.927

NOTE: Sanity check. The larger the train size (i.e., transit unit), the more noise is produced.

Problem 2

a) Formulate the problem as a Linear programming problem

Decision variables:

x_1 = cubic meters of material from Site 1

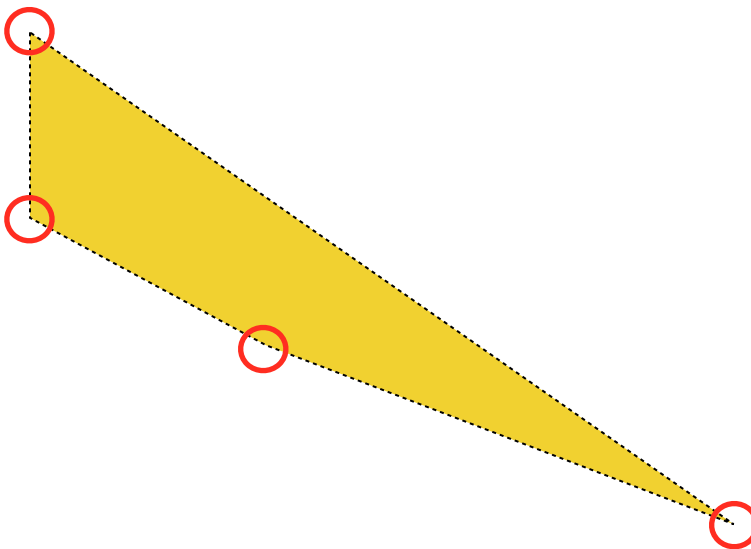
x_2 = cubic meters of material from Site 2

Objective:

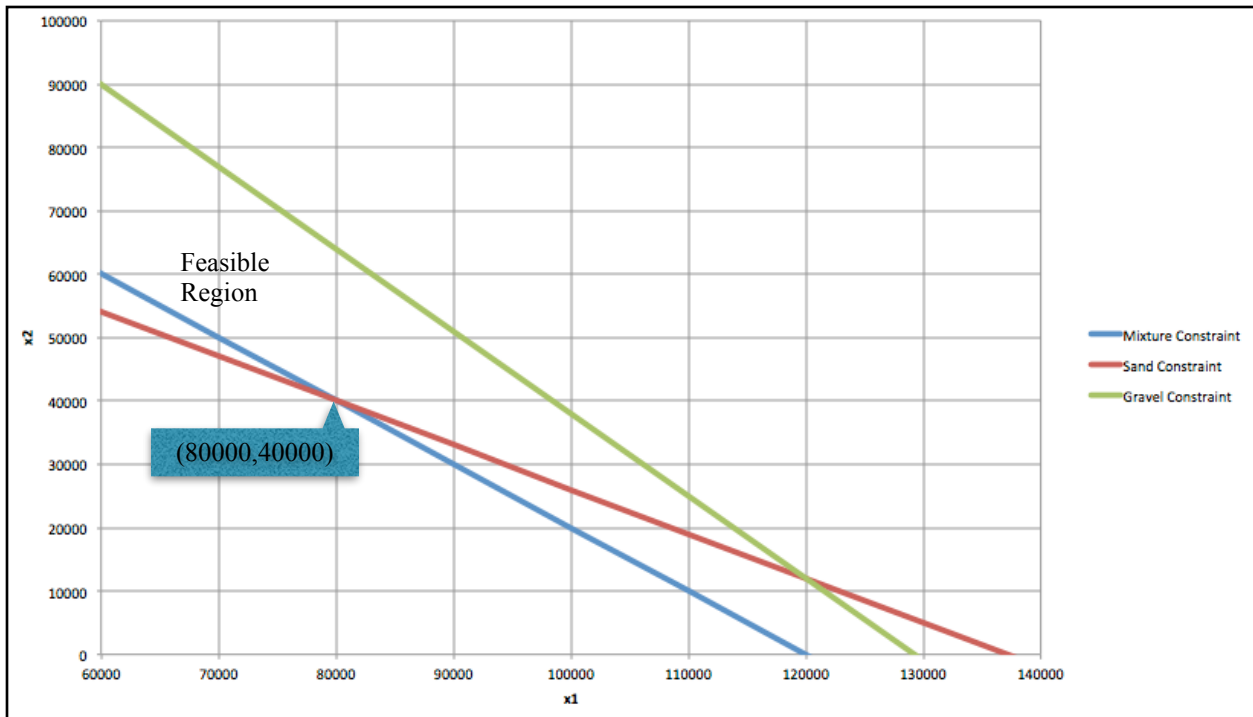
- “Minimize the cost of transporting/obtaining the material needed”
- $\text{Min } z = 350x_1 + 420x_2$

Constraints:

- *Mixture requirements (total)*
 $x_1 + x_2 \geq 120,000$
- *Sand requirement constraint:*
 $(.35)x_1 + (.5)x_2 \geq (0.4)(120,000)$
- *Gravel requirement constraint:*
 $(.65)x_1 + (.5)x_2 \leq (0.7)(120,000)$
- *Non-negativity*



b) Solve the problem graphically



c) Solve the problem using Solver

The screenshot shows an Excel spreadsheet with the following data:

Decision Variables			
x_1	80000	Cubic meters of material from Site 1	
x_2	40000	Cubic meters of material from Site 2	

Objective Function			
Min $z = 350x_1 + 420x_2$	44800000		

Constraints			
$x_1 + x_2 \geq 120000$	120000	\geq	120000
$.35x_1 + .5x_2 \geq 48000$	48000	\geq	48000
$.65x_1 + .5x_2 \leq 72000$	72000	\leq	72000

The Solver Parameters dialog box is open, showing the following settings:

- Set Objective:** $\$D\14
- To:** Max Min Value Of: 0
- By Changing Variable Cells:** $\$C\$8:\$C\9
- Subject to the Constraints:**
 - $\$D\$19 \geq \$F\19
 - $\$D\$20 \geq \$F\20
 - $\$D\$21 \leq \$F\21
- Make Unconstrained Variables Non-Negative
- Select a Solving Method:** Simplex LP

d) Setup the first tableau of the Simplex procedure

1) Reformulate. Convert original constraints to equalities by adding surplus/slack variables (depending on > or <) and its respective M variables in the objective function:

Objective:

$$\text{Max } -z = -350x_1 - 420x_2$$

$$\text{Max } -z + 350x_1 + 420x_2 + Mx_4 + Mx_7 = 0$$

Subject to:

$$(.35)x_1 + (.5)x_2 - x_3 + x_4 = 48,000$$

$$(.65)x_1 + (.5)x_2 + x_5 = 84,000$$

$$x_1 + x_2 - x_6 + x_7 = 120,000$$

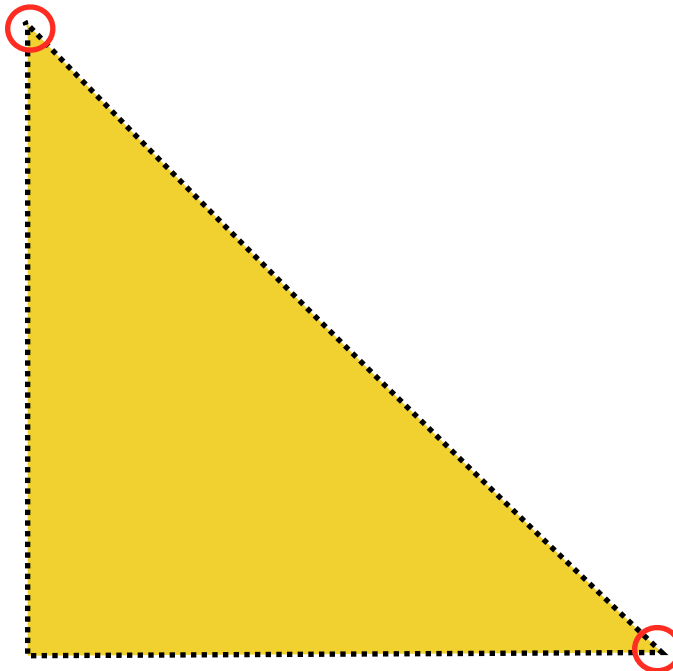
2) Convert to Standard Format. Only list artificial variables

	z	x_1	x_2	x_3	x_4	x_5	x_6	x_7	RHS
	-1	350	420	0	M	0	0	M	0
x_4 row	-M *	0	.35	.5	-1	1	0	0	48,000
x_5 row	-M *	0	1	1	0	0	-1	1	120,000
z BV row	-1	-1.35M + 350	-1.5M + 420	M	0	0	M	0	-168,000M

3) Initial Tableau

BV	z	x_1	x_2	x_3	x_4	x_5	x_6	x_7	RHS
z	-1	-1.35M + 350	-1.5M + 420	M	0	0	M	0	-168,000M
x_4	0	.35	.5	-1	1	0	0	0	48,000
x_5	0	.65	.5	0	0	1	0	0	84,000
x_7	0	1	1	0	0	0	-1	1	120,000

Problem 3



a) Formulate the problem as a linear programming problem

Decision variables:
 x_1 = Amount of product A produced/day
 x_2 = Amount of product B produced/day

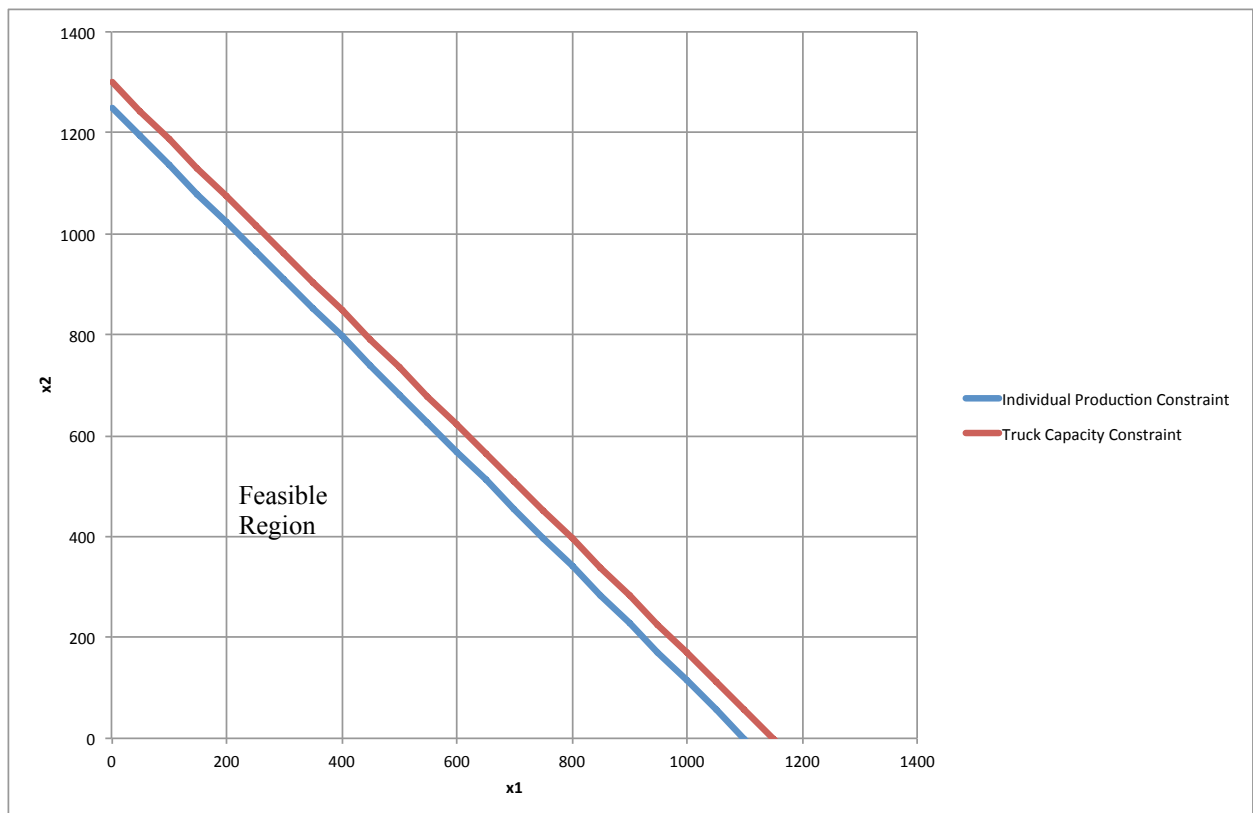
Objective:

- “Maximize revenue”
- $\text{Max } z = 120x_1 + 97x_2$

Constraints:

- *Individual production constraint*
$$\frac{x_1}{1100} + \frac{x_2}{1250} \leq 1$$
- *Truck capacity constraint:*
$$\frac{x_1}{1150} + \frac{x_2}{1300} \leq 1$$
- *Non-negativity*

b) Solve the problem graphically



c) Solve the problem using Solver

The image shows an Excel spreadsheet with a Solver Parameters dialog box overlaid. The spreadsheet contains the following data:

Decision Variables		
X1	1100	Cubic Meters of Product A/day
X2	0	Cubic Meters of Product B/day

Objective Function	
Max Z: 120X1 + 97X2	132000

Constraints			
X1/1110 + X2/1250 <= 1	1 <=		1
X1/1150 + X2/1300 <= 1	0.95652174 <=		1

The Solver Parameters dialog box is configured as follows:

- Set Objective: \$D\$19
- To: Max
- By Changing Variable Cells: \$C\$8:\$C\$9
- Subject to the Constraints:
 - \$D\$19 <= 1
 - \$D\$20 <= 1
- Make Unconstrained Variables Non-Negative:
- Select a Solving Method: Simplex LP

Problem 4

a) Formulate the problem as a linear programming problem

Problem 4

Decision variables:

- x_1 = Amount of pollutants removed from Trinity River (kg)
- x_2 = Amount of pollutants removed from Humbolt River (kg)
- x_3 = Amount of pollutants removed from the city (kg)
- x_4 = Amount of pollutants removed from the airport (kg)

Objective:

- “Minimize the cost of pollutant removal”
- Min $z = 53x_1 + 51x_2 + 67x_3 + 56x_4$

Constraints:

- 40% Removal goal

$$\sum_{i=1}^4 x_i \leq [(0.40) * (15,8000 + 29,200 + 15,400 + 17,400)]$$

$$x_1 + x_2 + x_3 + x_4 \leq 31,120$$
- Processing Plant 1/4 removal constraint:
 - Trinity River: $15,800 \geq x_1 \geq (.25) * (15,800)$
 - Humbolt River: $29,200 \geq x_2 \geq (.25) * (29,200)$
- Non-negativity

b) Solve the problem using Excel Solver

Decision Variables			
X1	3950	Amount of pollutants removed from Trinity River	
X2	27170	Amount of pollutants removed from Humbolt River	
X3	0	Amount of pollutants removed from the city	
X4	0	Amount of pollutants removed from the airport	

Objective Function	
Min $z = 53x_1 + 51x_2 + 67x_3 + 56x_4$	1595020

Constraints			
$\sum(x_i) \leq (.40) * 77800$	31120	\geq	31120
$15800 \geq x_1$	15800	\geq	3950
$x_1 \geq (.25 * 15800)$	3950	\geq	3950
$29200 \geq x_2$	29200	\geq	27170
$x_2 \geq (.25 * 29200)$	27170	\geq	7300

Solver Results

Solver found a solution. All constraints and optimality conditions are satisfied.

Keep Solver Solution
 Restore Original Values

Return to Solver Parameters Dialog
 Outline Reports

Reports
 Answer Sensitivity Limits