

**Quiz 1 (50 minutes)**

Date: September 30, 2013

Instructor: Trani

**Open book and notes, use of computer is allowed**

Your Name ---- Solution to Quiz 1 -----

## Problem 1 (30 Points)

The data provided in the spreadsheet (see enclosed file) contains construction equipment information for a medium size company located in Chantilly, Virginia.

- a) Create a Pivot table that shows a summary of how many vehicles of each type the company owns at all locations and also the condition of the vehicles by vehicle type.

*Table 1. Pivot table with summary of number of vehicles owned by the company at all locations and parsed by vehicle condition.*

Construction Site	(All)			
Count of Years in Fleet	Column Labels			
Row Labels	Komatsu BR380JG-1 Crusher	Komatsu D39PX-23 Dozer	Komatsu PC78US-8 Excavator	Grand Total
Excellent	13	31	5	49
Good	24	44	19	87
Poor	5	8	1	14
<b>Grand Total</b>	<b>42</b>	<b>83</b>	<b>25</b>	<b>150</b>

- b) Find the average age of the Komatsu PC78US-8 Excavators in “Good” condition at the Manassas construction site.

*Table 2. Pivot table with summary of number of vehicles owned by the company at all locations and parsed by vehicle condition.*

Construction Site	Manassas			
Average of Years in Fleet	Column Labels			
Row Labels	Komatsu BR380JG-1 Crusher	Komatsu D39PX-23 Dozer	Komatsu PC78US-8 Excavator	Grand Total
Excellent	2.00	4.00	5.50	3.85
Good	5.46	4.72	5.83	5.16
Poor	4.33	4.00		4.25
<b>Grand Total</b>	<b>4.74</b>	<b>4.38</b>	<b>5.75</b>	<b>4.67</b>

The average age of the Excavators in “Good” condition at the Manassas construction site is **5.83 years**. There are 6 excavators at the Manassas construction site with ages: 5,10,8,6,3 and 3 years of age. The average of these excavators is verified to be 5.83 years.

## Problem 2 (40 Points)

A formula used in Geotechnical Engineering to estimate the void ratio - a measure of the compaction level of soil - is given in Equation (1),

$$e = \frac{G_s \gamma_w (1 + w / 100)}{\gamma} - 1 \quad (1)$$

where:

$e$  = void ratio (dimensionless)

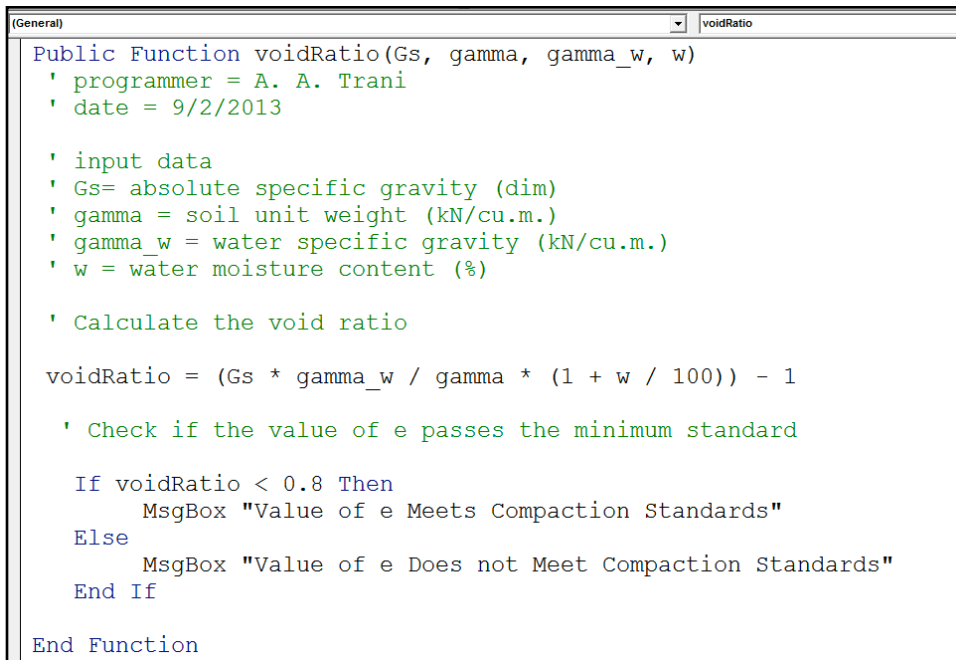
$G_s$  = Absolute specific gravity of soil material (dimensionless)

$\gamma$  = soil material unit weight ( $\text{kN/m}^3$ )

$\gamma_w$  = water specific gravity ( $9.81 \text{ kN/m}^3$ )

$w$  = is the water (or moisture) content of the soil (%)

- a) Write a **function** in Visual Basic for Applications (VBA) to calculate the value of  $e$  given the values of all four variables in the right hand side of Equation (1). The VBA function should produce a single value ( $e$ ) as output. The values of the four input variables are to be entered in the worksheet and should be read by your Visual basic code. Write back the result for  $e$  obtained in the Visual Basic code worksheet. Label all inputs and outputs appropriately. To check that the value of  $e$  meets compaction standards, use a message box and write a message "Meets Compaction Standards" if the value of  $e$  is less than 0.8. If not, write "Does Not Meet Compaction Standards".



```
Public Function voidRatio(Gs, gamma, gamma_w, w)
' programmer = A. A. Trani
' date = 9/2/2013

' input data
' Gs= absolute specific gravity (dim)
' gamma = soil unit weight (kN/cu.m.)
' gamma_w = water specific gravity (kN/cu.m.)
' w = water moisture content (%)

' Calculate the void ratio

voidRatio = (Gs * gamma_w / gamma * (1 + w / 100)) - 1

' Check if the value of e passes the minimum standard

If voidRatio < 0.8 Then
    MsgBox "Value of e Meets Compaction Standards"
Else
    MsgBox "Value of e Does not Meet Compaction Standards"
End If

End Function
```

Figure 1. VBA Function to calculate void ratio.

b) Test your function using the following values:  $\gamma = 18.6 \text{ kN/m}^3$ ,  $w = 13.3\%$ ,  $\gamma_w = 9.81 \text{ kN/m}^3$  and  $G_s = 2.65$ .

The screenshot shows an Excel spreadsheet with the following content:

	A	B	C	D
1				
2	Calculation of void ratio		Quiz 1 2013	
3	Using a simple Function			
4	Programmer: A. Trani			
5	Date	10/3/2013 21:09		
6	Purpose:	Calculate void ratio of compacted soil		
7				
8	<b>Parameter</b>	<b>Value</b>	<b>Units</b>	<b>Variable</b>
9	Abs. Specific Gravity	2.65	dim	Gs
10	Soil unit weight	18.6	kN/cu.m.	gamma
11	Water specific gravit	9.81	kN/cu.m.	gamma_w
12	Water moisture cont	13.3	%	w
13				
14				
15	<b>Results</b>	<b>Value</b>	<b>Units</b>	<b>Variable</b>
16	Void ratio	=voidRatio(B9,B1	dim	e
17				
18				
19				
20				
21				
22				

A message box titled "Microsoft Excel" is displayed in the foreground, containing the text "Value of e Meets Compaction Standards" and an "OK" button.

Figure 2. Use of VBA Function to calculate void ratio for given set of parameters. Note the Message bos displaying if the compaction meets standards.

### Problem 3 (30 Points)

An engineer formulates a linear programming with two decision variables as follows:

$$\text{Maximize } Z = 72x_1 + 54x_2$$

Subject to:

$$x_2 - 0.62x_1 \leq 40$$

$$1.2x_1 + x_2 \leq 75$$

$$x_1 \leq 50$$

and the non-negativity constraints  $x_1 \geq 0$  and  $x_2 \geq 0$ .

a) Use **Excel Solver** to obtain the optimal solution. State the optimal value of the objective function.

The optimal solution is  $x_1 = 50$  and  $x_2 = 15$  units. The value of the objective function Z is 4410 units (see Figure 3). The Solver panel is shown in Figure 4.

Optimization Problem for Problem 3			
<b>Decision Variables</b>			
x1	50.00		
x2	15.00		
<b>Objective Function</b>			
72 x1 + 54 x2	4410.00		
<b>Constraint Equations</b>			
	Formula		
-0.62 x1 + x2 <= 40	-16 <=		40
1.2 *x1 + x2 <= 75	75 <=		75
x1 <= 50	50 <=		50

Figure 3. Use of Excel Solver to obtain optimal solution.

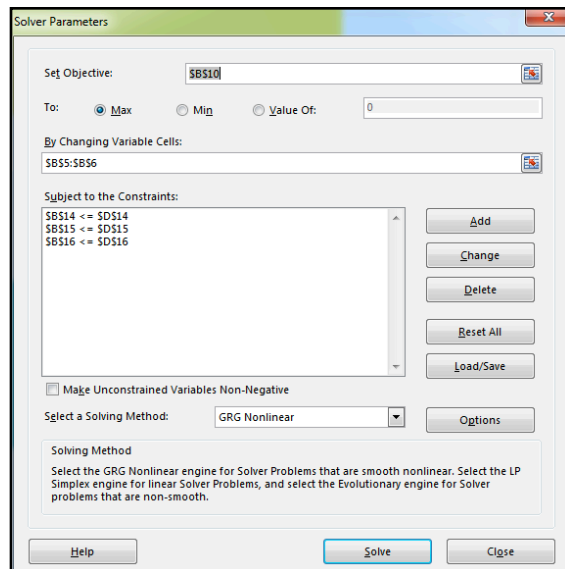


Figure 4. Excel Solver panel to obtain optimal solution.

b) Write down the first table to solve the problem using the Simplex method. In the table indicate what is the Initial Basic Feasible Solution (IBFS) including the values of all variables (both original and slacks, if any).

Convert the objective function and constraint equations by adding slack variables for each  $\leq$  constraint equation. For three constraint equations we add three slack variables.

$$Z - 72x_1 - 54x_2 = 0$$

$$-0.62x_1 + x_2 + x_3 = 40$$

$$1.2x_1 + x_2 + x_4 = 75$$

$$x_1 + x_5 = 50$$

The first tableau of the Simplex Method solution is shown in Table 3.

Table 3. First Tableau of the Simple Method to solve the optimization problem.

BV	Z	$x_1$	$x_2$	$x_3$	$x_4$	$x_5$	RHS
Z	1	-72	-54	0	0	0	0
$x_3$	0	-0.62	1	1	0	0	40
$x_4$	0	1.2	1	0	1	0	75
$x_5$	0	1	0	0	0	1	50

The Initial Basic Feasible Solution (IBFS) to start the Simplex Method solution is:

$$x_1 = 0$$

$$x_2 = 0$$

$$x_3 = 40$$

$$x_4 = 75$$

$$x_5 = 50$$

Note that the Basic Variables (BV)  $x_3$ ,  $x_4$  and  $x_5$  are those that are non-zero:

The Non Basic Variables (NBV) are  $x_1$  and  $x_2$  (those that are zero in the current solution).

The feasible region and the optimal solution are shown in Figure 5.

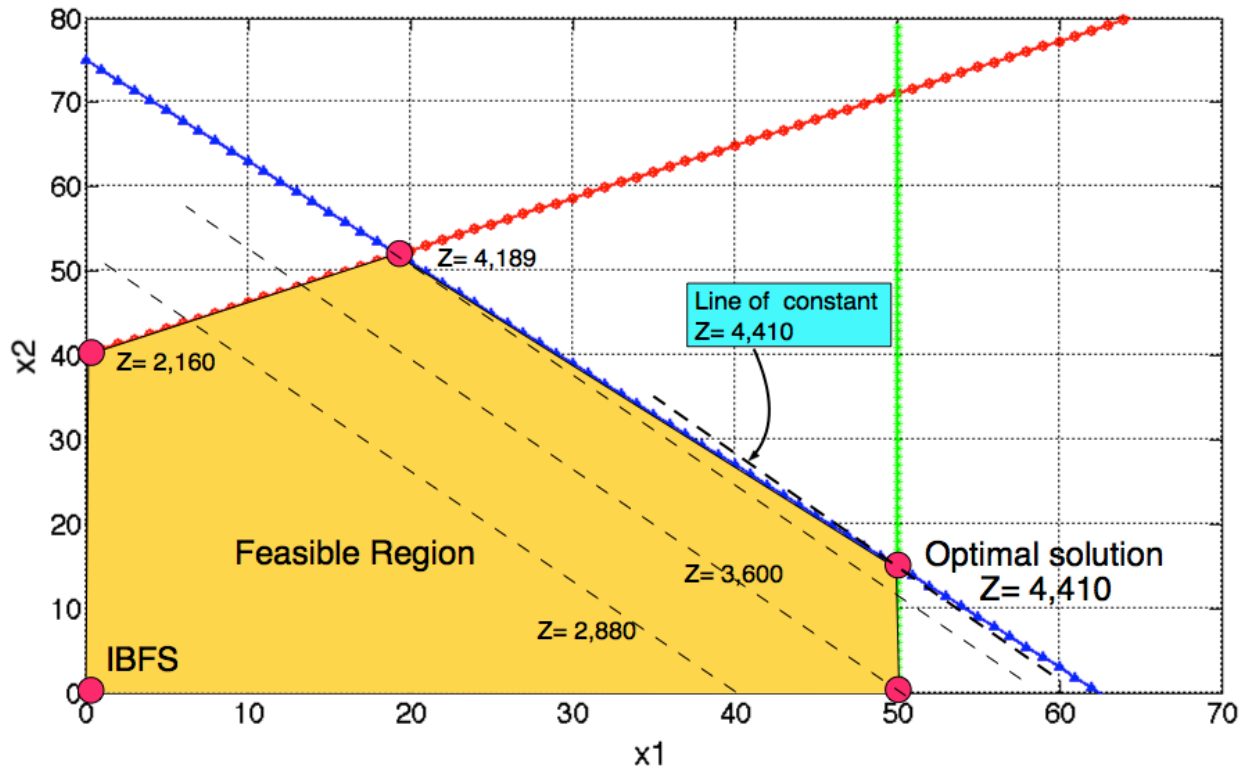


Figure 5. Feasible region, corner points and optimal solution.