ABE 201
Biological Thermodynamics 1

Lab 4:

Linear Programming and Optimization Tools

Outline

- Linear Programming vs Linear Algebra
- Optimization Approaches
- Optimization Tools

Linear Programming

- AKA Linear Optimization
- Used to find “best” or “optimal” solutions to a linear function subject to constraints
- The linear function (called objective function) usually describes an overall property of a complex system.
- Has wide applications in engineering, economics, and business

Linear Programming in Econ

$$\text{minimize: } \begin{bmatrix} L & M & C \end{bmatrix} \begin{bmatrix} y_L \\ y_M \\ y_C \end{bmatrix}$$

$$\text{subject to: } \begin{bmatrix} y_L \\ y_M \\ y_C \end{bmatrix} \geq 0$$

Where L = labor, M = materials, C = capital, and y is cost for each

Linear Programming in Engineering

- Approach is similar to economics, but more often used to <u>estimate values of parameters for a model</u>.

- Use statistics to estimate “goodness of fit” between the model and actual measurements

- Objective function is then to <u>minimize</u> error between prediction (model) and data

Statistical Measures of Error

- SSE = sum of squares for error
- Basis for finding linear regressions.
- Can be used with the right tools to estimate more complex models

SSE Example

t	Data	Model Output	Error^2
0	4.1	1	9.61
1	12.6	3	92.8525
2	19.9	7	167.0039
3	41.3	13	801.0032
4	45.3	21	589.3242
5	64.3	31	1108.557
		SSE	2768.351

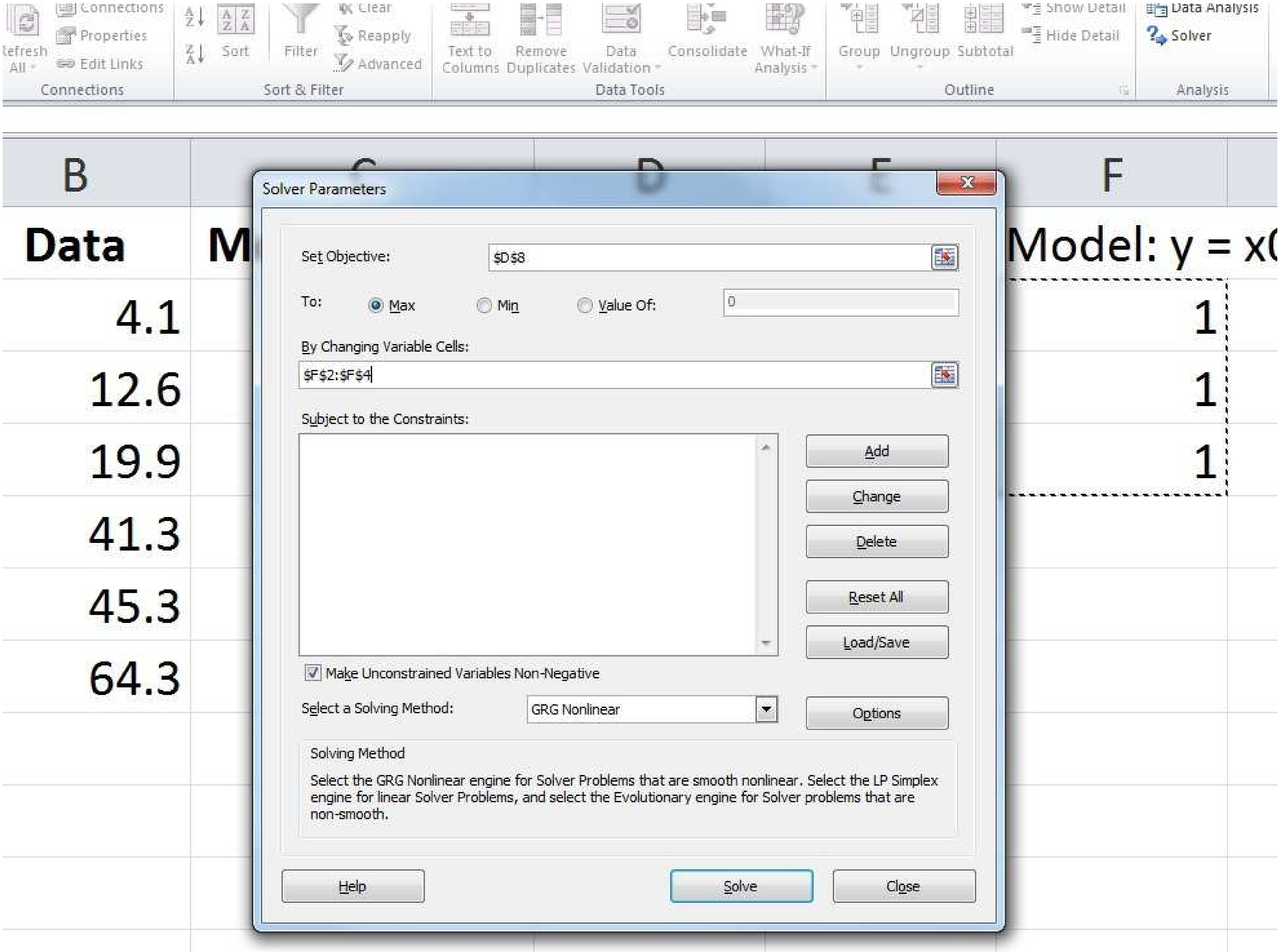
$$y = x_0 + x_1 * \mathrm{t} + x_2 * t^2$$

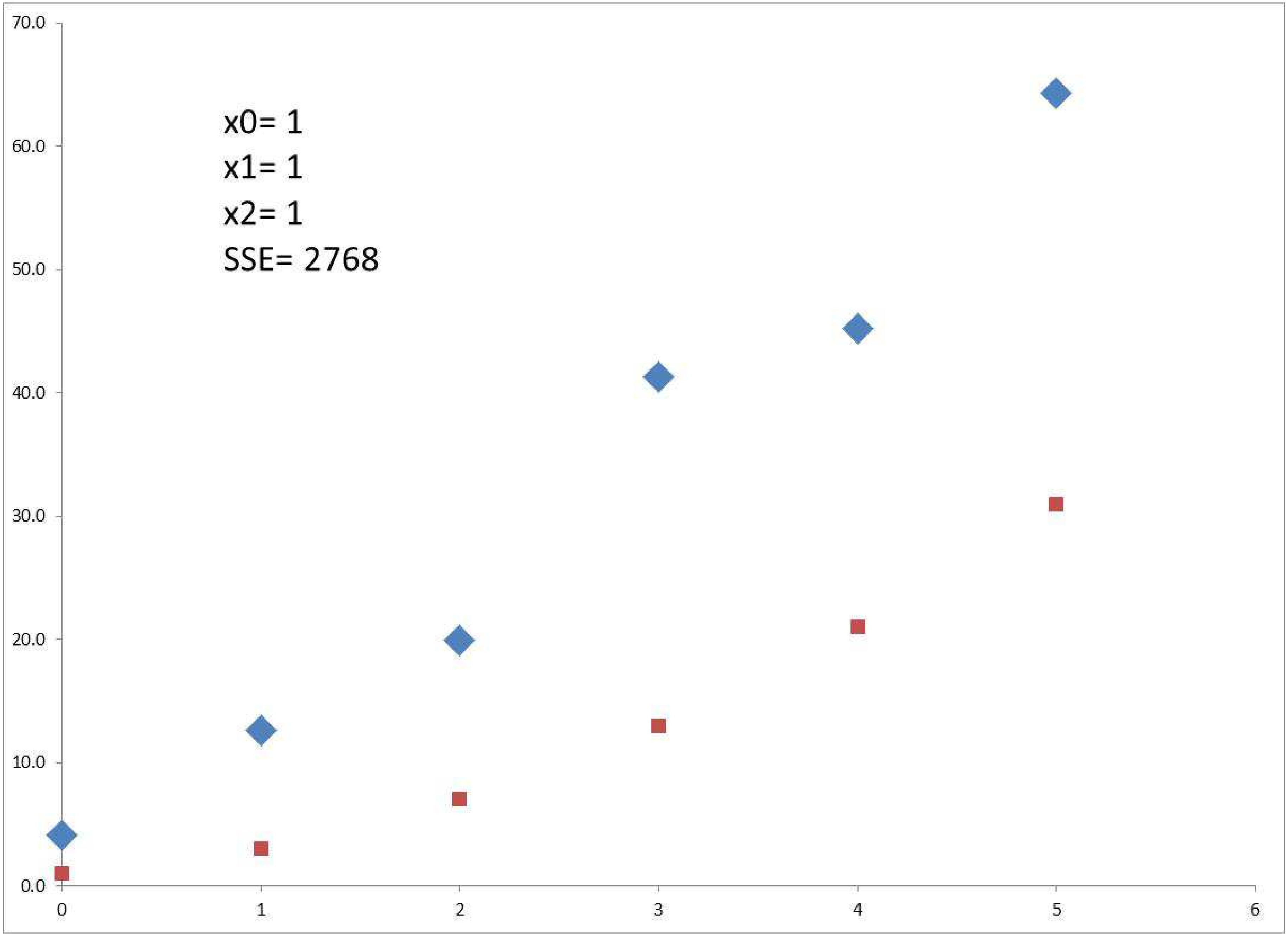
$$where\ x = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}$$

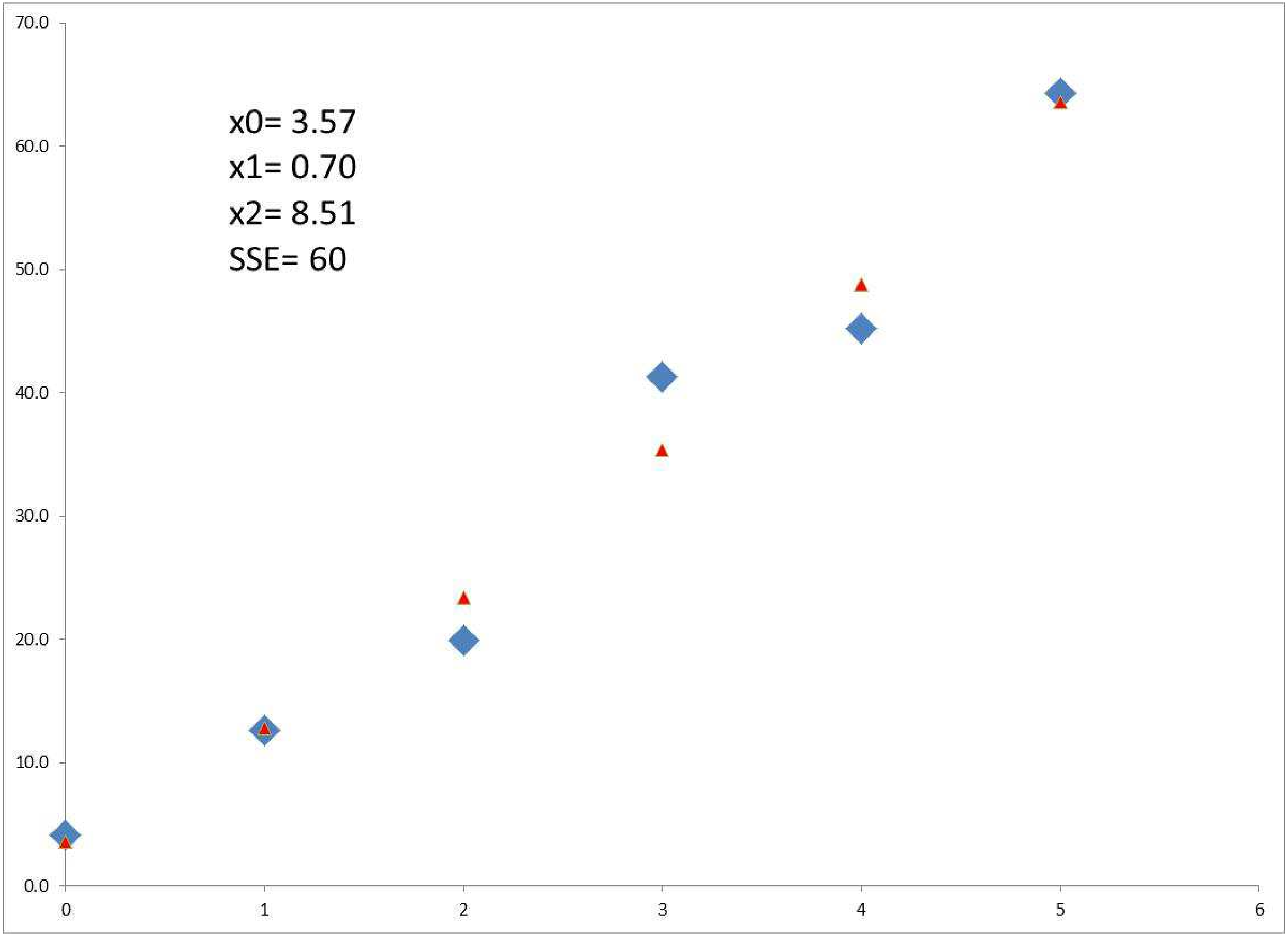
Data

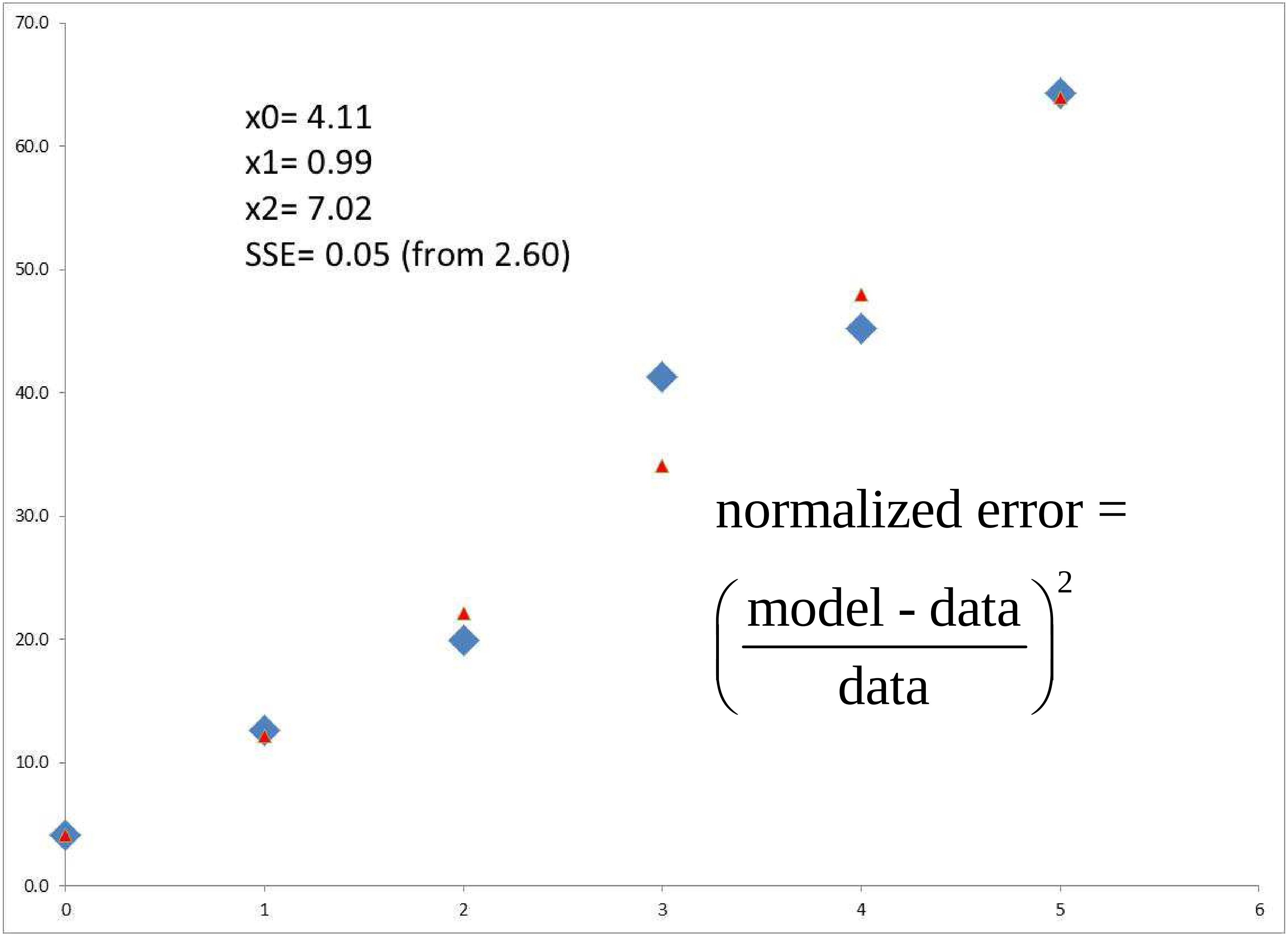
Solver

	A	B	C	D	E	F	G	H
1	**t**	**Data**	**Model Output**	**Error^2**		Model: y = x0 + x1*t + x2*t^2		
2	0	4.1	1	9.61	x0	1		
3	1	12.6	3	92.8525	x1	1		
4	2	19.9	7	167.004	x2	1		
5	3	41.3	13	801.003				
6	4	45.3	21	589.324				
7	5	64.3	31	1108.56				
8			**SSE**	2768.35				
9								
10								
11								
12								
13								
14								
15								
16								


Connections
Properties
Edit Links
Refresh All
Connections
Sort
Filter
Clear
Reapply
Advanced
Sort & Filter
Text to Columns
Remove Duplicates
Data Validation
Consolidate
What-If Analysis
Data Tools
Group
Ungroup
Subtotal
Show Detail
Hide Detail
Outline
Data Analysis
Solver
Analysis
B
F
Data
Model: y = x(
4.1
12.6
19.9
41.3
45.3
64.3
1
1
1
Solver Parameters
Set Objective:
$D$8
To:
Max
Min
Value Of:
0
By Changing Variable Cells:
$F$2:$F$4
Subject to the Constraints:
Add
Change
Delete
Reset All
Load/Save
Make Unconstrained Variables Non-Negative
Select a Solving Method:
GRG Nonlinear
Options
Solving Method
Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.
Help
Solve
Close


x0= 1
x1= 1
x2= 1
SSE= 2768
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
1
2
3
4
5
6


x0= 3.57
x1= 0.70
x2= 8.51
SSE= 60
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
1
2
3
4
5
6



$$\text{normalized error} = \left(\frac{\text{model - data}}{\text{data}}\right)^2$$