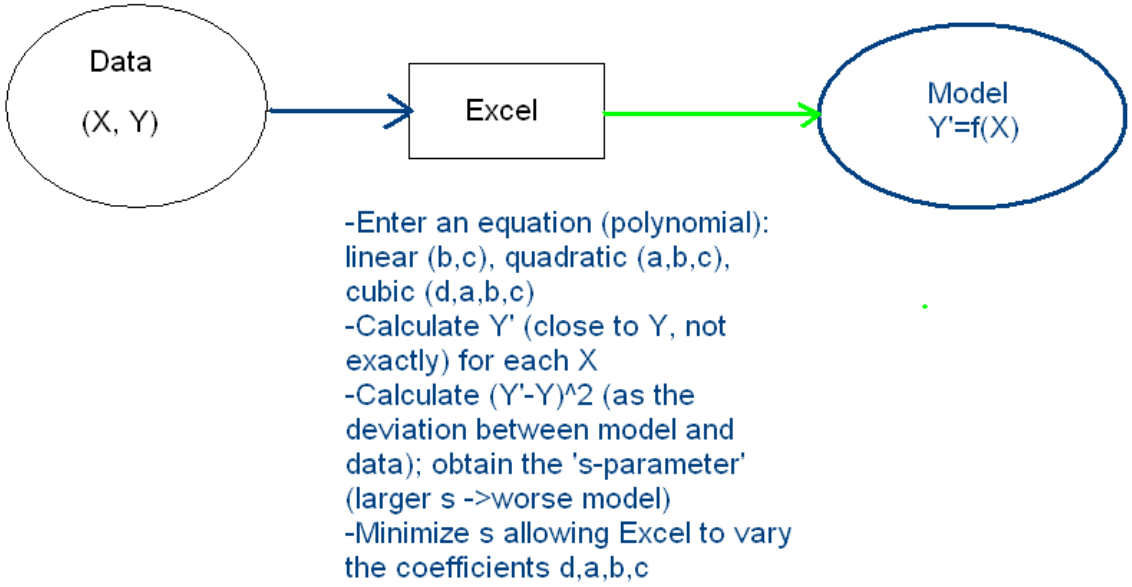
Engin 103 February 24, 2009 back to e-syllabus	Topics: Data Modeling CW3 Logbook questions

Data Modeling



Project 1 requires the use of data modeling with Excel (© Microsoft), this is learned by doing CW3-CW5, a polynomial or exponential curve-fitting or data modeling. **What is data modeling?** When an input X is applied to a system, an output Y is produced. A mathematical model of the system can be obtained by relating Y to X: e.g. Y'=f(X). We have used a Y' to indicate that it is not be possible in general to obtain an equation that relates all measured Y values to all measured X values but approximate Y' values to all measured X values.
To simplify the introduction, we discuss just simple polynomial models, e.g.

$Y'=aX^2+bX+c$
$Y'=\quad bX+c$
$Y'=dX^3+aX^2+bX+c$
$Y'=\exp(-b1*X)/(b2+b3*X)$

How to obtain a model? Perform CW3 by following 7 steps shown in class and repeated below. The process consists of using Solver (get it under Tools/Add-ins if needed) to minimize a "standard deviation" parameter s by allowing the polynomial coefficients to vary. After using Solver, the final values for a, b, c determine our quadratic model that describes the pendulum. In this CW3, to save time, we will be using only 4 pairs of data, however this is not sufficient to obtain a good model in practice: **For your Project 1, please use at least 10 pairs of data.**
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CW3

Open Excel and type your first and last name in cell A1, today's date in cell D1

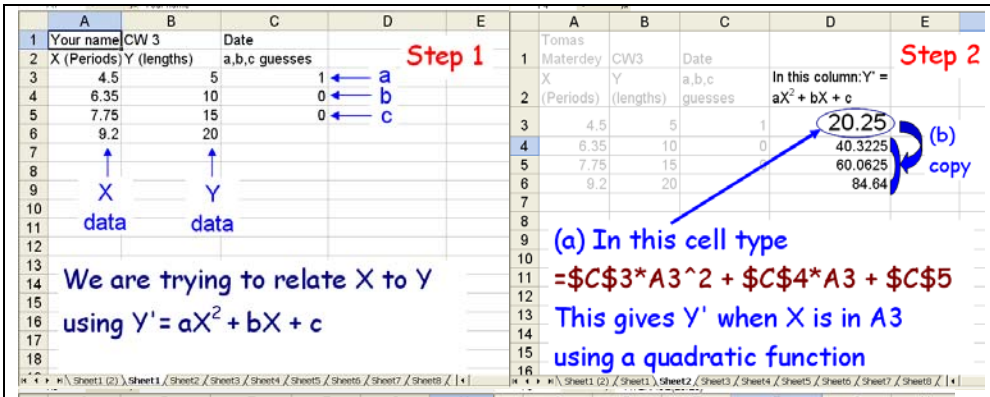
Quadratic curve fitting with Excel:

Use Excel Solver (under Tools) to produce coefficients a,b,c for your quadratic model ($y'=a*x^2+b*x+c$) by minimizing the 'standard deviation' s for the following set of data ($s \equiv \frac{\sum_{i=1}^{n}(y_i' - y_i)^2}{n}$, this is not a conventional standard deviation, and so it is not given by the 'stdev' function in Excel, but it is what we need to model our data; n is the number of data; y' indicates values predicted by our model; y indicates measured values given as data). Use '=' to start the formula for y' in cell D3; click on the corresponding cells to enter the coefficients and variables into the formula (if a is in cell C3, then click on C3, if the first x is in A3, then click on A3, etc.); remember to add a '$' before and after the letter of the cell containing the coefficients (since we don't want these to change for the second, third, and fourth x's); produce similar results for cells D4-D6 by 'copy D2 and paste' into those; produce the squared difference formula between y' and y using another '=' in E3; etc. Produce the average of E3-E6 by writing in E7 '=average(E3..E6)' and hit enter. Click on E7 and pull out 'Solver' under 'Tools'; select 'minimum' and in the 'by changing' box click and drag on the cells containing your guesses for the coefficients. Note that after running 'Solver', the 'standard deviation' or 'how far is our model from the data' is reduced to be a small number (0.1 or less, the smaller the better model you've built for those data). Watch the movies clip 'curve-fitting with Excel' as you follow these instructions.

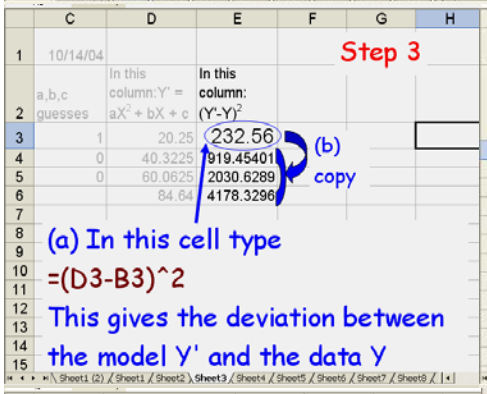
Periods x (s)	***Lengths y (m)***
4.5	**5**
6.35	**10**
7.75	**15**
9.2	**20**

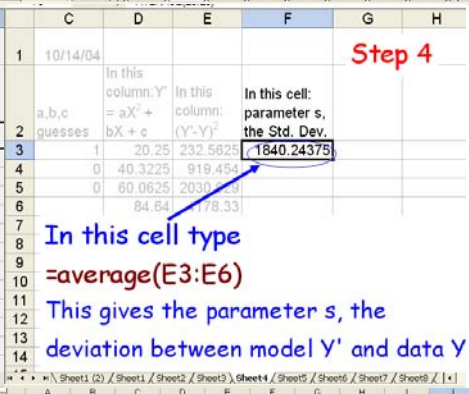
By alphabetical order of the last names, the first two students in each team will submit file cw3_XX_a.html and folder cw3_XX_a_files, the next two students will submit file cw3_XX_b.html and folder cw3_XX_a_files, to the *files* folder in the server. These files need to be uploaded to the server on the due date to receive credit.

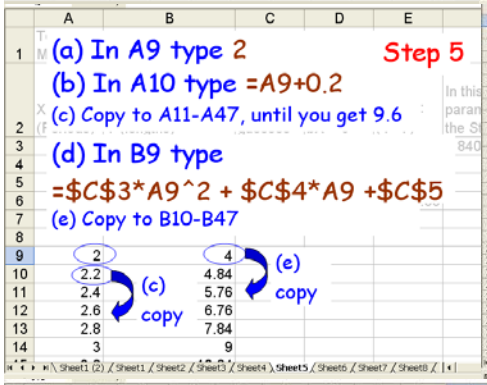
Follow these 7 steps to perform CW3:

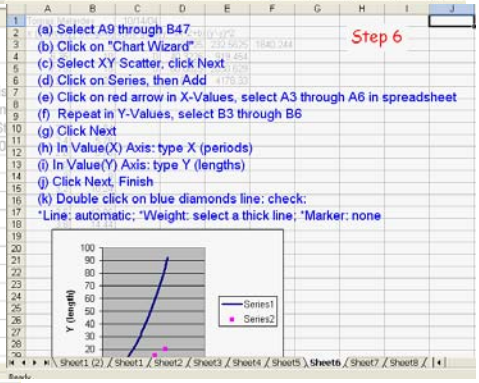

Step 1
Your name
CW 3
Date
X (Periods)
Y (lengths)
a,b,c guesses
a
b
c
X data
Y data
We are trying to relate X to Y
using Y'= aX² + bX + c

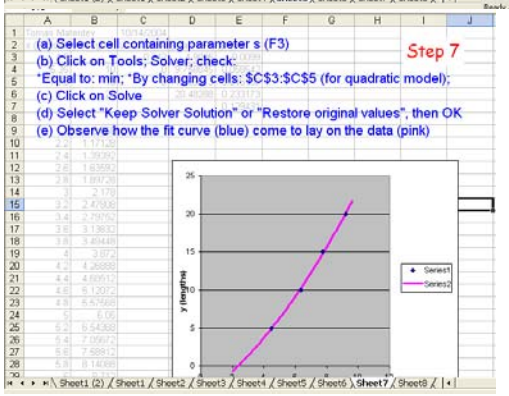
Step 2
Tomas Materdey
CW3
Date
X (Periods)
Y (lengths)
a,b,c guesses
In this column:Y' = aX² + bX + c
20.25
40.3225
60.0625
84.64
(b) copy
(a) In this cell type
=$C$3*A3^2 + $C$4*A3 + $C$5
This gives Y' when X is in A3
using a quadratic function


Step 3
10/14/04
a,b,c guesses
In this column:Y' = aX² + bX + c
In this column: (Y'-Y)²
232.56
919.45401
2030.6289
4178.3296
(b) copy
(a) In this cell type
=(D3-B3)^2
This gives the deviation between
the model Y' and the data Y


Step 4
10/14/04
a,b,c guesses
In this column:Y' = aX² + bX + c
In this column: (Y'-Y)²
In this cell: parameter s, the Std. Dev.
1840.24375
In this cell type
=average(E3:E6)
This gives the parameter s, the
deviation between model Y' and data Y


Step 5
(a) In A9 type 2
(b) In A10 type =A9+0.2
(c) Copy to A11-A47, until you get 9.6
(d) In B9 type
=$C$3*A9^2 + $C$4*A9 +$C$5
(e) Copy to B10-B47
(c) copy
(e) copy


Step 6
(a) Select A9 through B47
(b) Click on "Chart Wizard"
(c) Select XY Scatter, click Next
(d) Click on Series, then Add
(e) Click on red arrow in X-Values, select A3 through A6 in spreadsheet
(f) Repeat in Y-Values, select B3 through B6
(g) Click Next
(h) In Value(X) Axis: type X (periods)
(i) In Value(Y) Axis: type Y (lengths)
(j) Click Next, Finish
(k) Double click on blue diamonds line; check:
*Line: automatic; *Weight: select a thick line; *Marker: none
Y (length)
Series1
Series2


Step 7
(a) Select cell containing parameter s (F3)
(b) Click on Tools; Solver; check:
*Equal to: min; *By changing cells: $C$3:$C$5 (for quadratic model);
(c) Click on Solve
(d) Select "Keep Solver Solution" or "Restore original values", then OK
(e) Observe how the fit curve (blue) come to lay on the data (pink)
y (lengths)
Series1
Series2

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LOGBOOK: example of a logbook page

-Use a quadrille notebook; number all pages; date all entries
-Write your notes for all activities, thoughts, problems and solutions, and learning conclusions related to Engin 103. You should write down progress, outcomes, and conclusions on projects and teamwork; conclusions from class work (including LabVIEW) and homework.
-In addition you should answer in the logbook all questions listed in these notes in blue, as shown below:

15) Sketch the Engineering Design Cycle in your logbook, explain specific actions to be taken by you and your team for Project 1 as related to the different steps in the cycle. Be as specific and as detailed as possible.

16) Explain in your own words, steps 1-4 on how to prepare an Excel spreadsheet to obtain the model/equation describing a system. In another words, explain what to do in columns A to E in the spreadsheet. Be as detailed as possible.

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