Engin 103 September 30, 2008 back to e-syllabus	Topics: Engineering Design Cycle Systems CW2 Data Modeling CW3 Logbook questions

Introduction to Project 1

Design and build a simple system, a system produces a measurable output Y for each measurable input X. Model the system by relating a sufficient number of (X,Y) pairs using Excel to obtain the best fit. Test system predictability by comparing actual output for a new input with the model prediction. Read complete project specifications in the course e-syllabus.

FAQ:

1) Should we bring the system into class or do we need to make a video?
   The system needs to be brought in for the presentations
2) Can the money limit exceed twenty dollars a little?
   No
3) What kind of design we are supposed to look at? Anything specific?
   -This is the main difference between a project and a homework, there is not a unique answer to a project. However the project specifies certain things that need to be satisfied.
   Are there any previous models from the previous class that we can take a look at?
   - A rollercoaster track was shown in class
4) What are we going to be measuring?
   -This is a good question, you will be doing two types of measurements in this project: a) Raw measurements of the inputs X's and outputs Y's for the system you built. (These raw measurements will be used to obtain a model or equation describing the system, you will create an Excel spreadsheet to do this); b) Once you have the equation/model in hand, you will use it to measure the predictability of your system by comparing a new measurement (done during the second day of presentation) with the prediction from your equation.
5) What type of materials are we limited to?
   -No, just the $20 limit
6) What kind of systems could we build?
   -See answer to 3)
7) Is there any size constraint to the system?
   -No, but it should not cause any damage to the lab, or pose a danger to the class
8) Can we use items we obtain for free or already own?
   -Yes
9) How do we get a model/equation for our system?
   -Work through CW3-5
10) Where can we find a device capable of measuring the frequency
   -Measure lengths, weights, times, not frequency
11) How to build a pendulum? Should the ball be metal or plastic
   -See answer to 3)

12) Do we need a PowerPoint presentation?
-No, but if one is made, it can be uploaded as the team web page for Project 1

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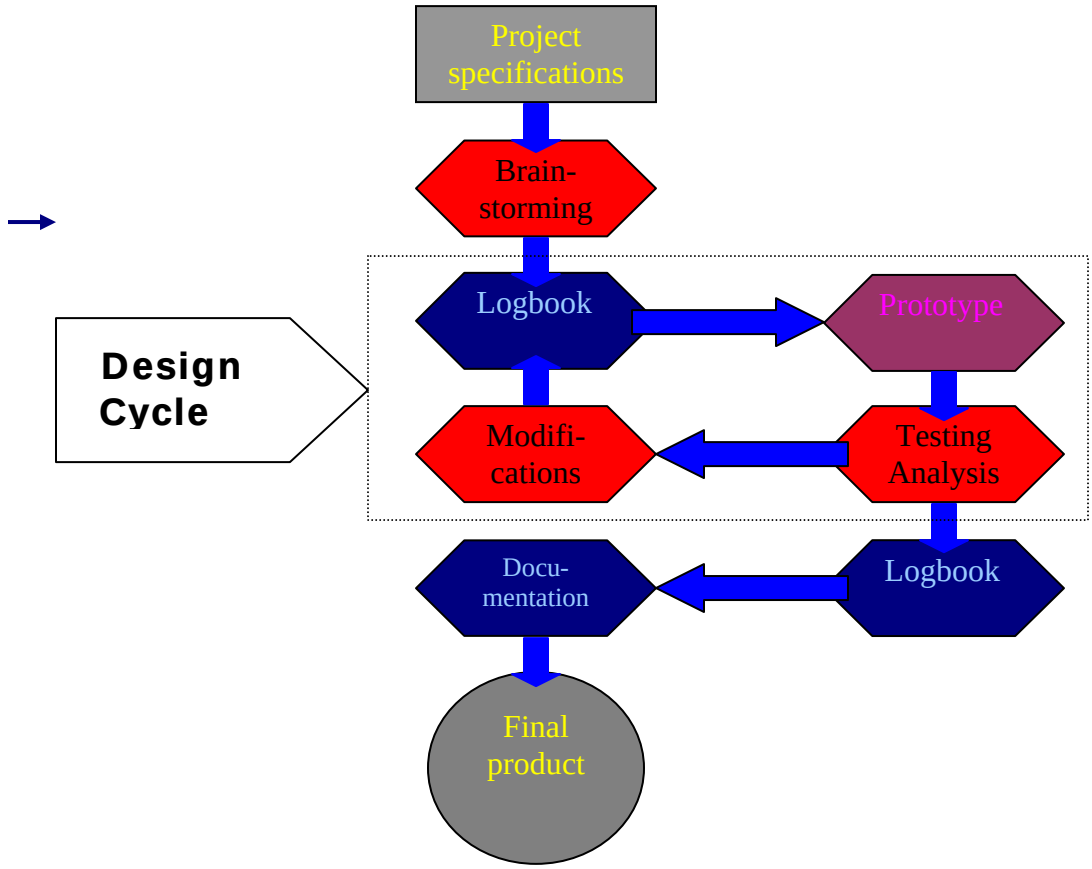
Engineering Design Cycle:

The cycle is shown within the dotted box below. The cycle is repeated until the system satisfies the Project Specifications, before it is developed into the Final Product and the Documentation is produced.



In Project 1, the Specifications include predictability for the system, that is, if the actual system follows the equation or model you obtain by relating its inputs X's and outputs Y's in Excel.

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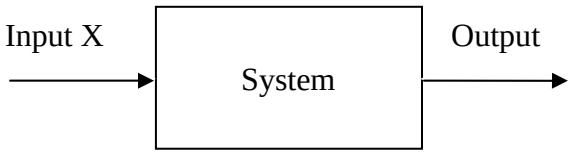
Systems

A system is a physical object that produces a measurable output (Y) for every measurable input (X).



Y'= f(X)

Examples of a system could be a catapult (X=initial height of a weight; Y=range for a clay ball), a pendulum (X=period; Y=length needed to produce that period), or a car on an inclined ramp (X=ramp angle; Y=distance traveled in 2s). When random factors affecting the system are controlled (task of the engineering design team), it can be described with an equation or model, that is, using this model it is possible to predict the output given an input.

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CW2

1) Why do we have cycles in engineering design? Draw a flow chart with four most important steps in an engineering design cycle.
2) Draw a flow chart for an in-out system. Label the input and output variables as X and Y, respectively, and explain what are they for at least two simple systems based on gravity. Given a value for an input X, is it possible to determine exactly the value of the output, yes or no, explain why.

In each team, students working together at a computer numbered between 1 and 10 will submit file cw2_XX_a.html and folder cw2_XX_a_files, students working at a computer numbered between 11 and 20 will submit file cw2_XX_b.html and folder cw2_XX_b_files, to the *files* folder in the server. Replace XX by 01 if team 1, etc. Include your names within the files.

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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:

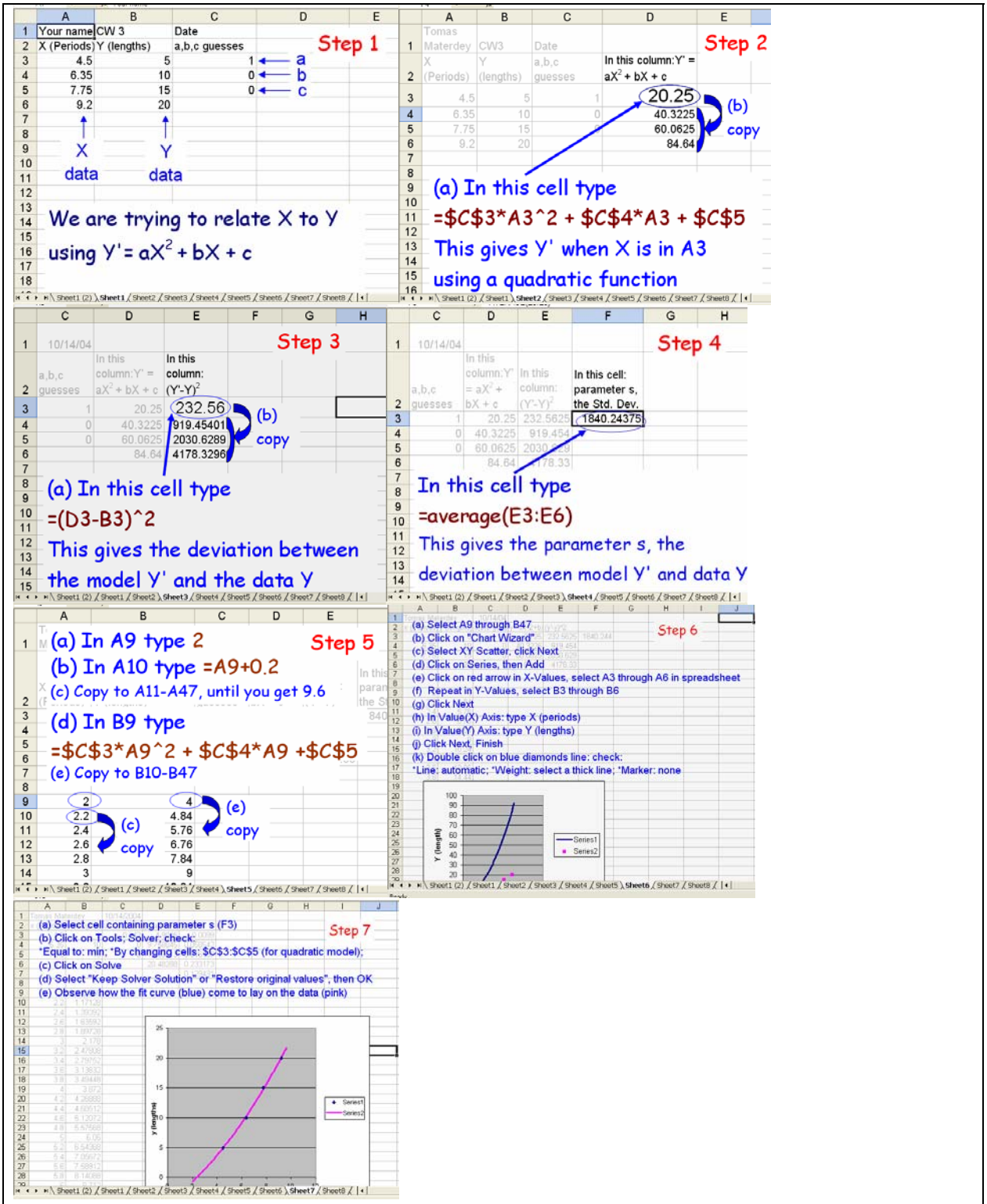
Use Excel Solver (under Tools) to produce coefficients a,b,c for your quadratic model ($y'=a*x^2+b*x+c$) by minimizing the 'standard deviation' s for the following set of data

($s \equiv \frac{\sum_{i=1}^{n}(y_i' - y_i)^2}{n}$, 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**

In each team, students working together at a computer numbered between 1 and 10 will submit file cw3_XX_a.html and folder cw3_XX_a_files, students working at a computer numbered between 11 and 20 will submit file cw3_XX_b.html and folder cw3_XX_b_files, to the *files* folder in the server. Replace XX by 01 if team 1, etc. Include your name within the files.

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
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$5
This gives Y' when X is in A3
using a quadratic function
Step 3
In this column:Y' = aX² + bX + c
In this column: (Y'-Y)²
232.56
919.45401
2030.6289
4178.3296
(b) copy
(a) In this cell type
=(D3-B3)^2
This gives the deviation between
the model Y' and the data Y
Step 4
In this cell: parameter s, the Std. Dev.
1840.24375
In this cell type
=average(E3:E6)
This gives the parameter s, the
deviation between model Y' and data Y
Step 5
(a) In A9 type 2
(b) In A10 type =A9+0.2
(c) Copy to A11-A47, until you get 9.6
(d) In B9 type
=$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)

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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:

11) 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.

12) 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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