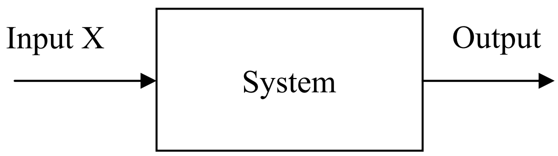
Meeting 12:

Project 2 requires the use of data modeling with Excel (© Microsoft), this is learned by doing CW3, a quadratic curve-fitting or data modeling. **What is data modeling?** When certain input data X is applied to a system, certain output data Y is produced by that system. 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 may not be possible to obtain an equation that relates Y to X for every pair of data, but just a best model.

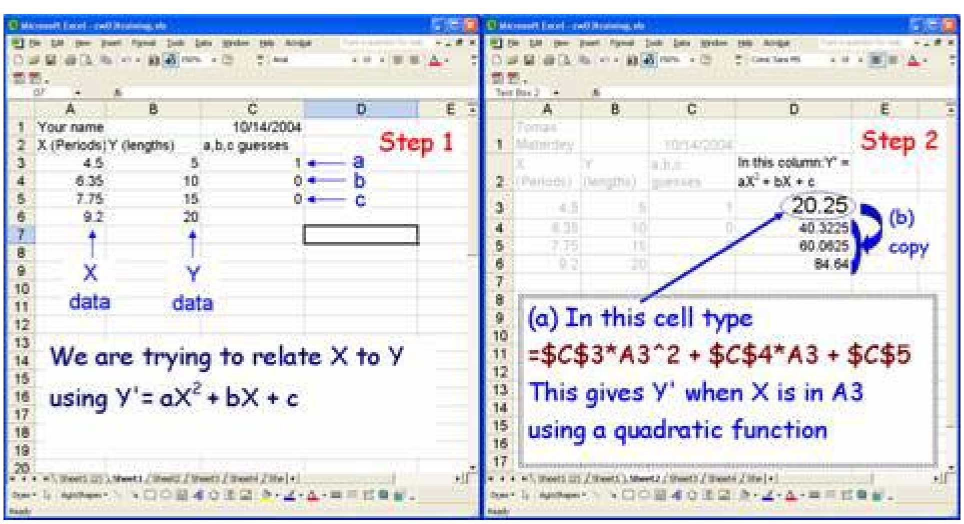


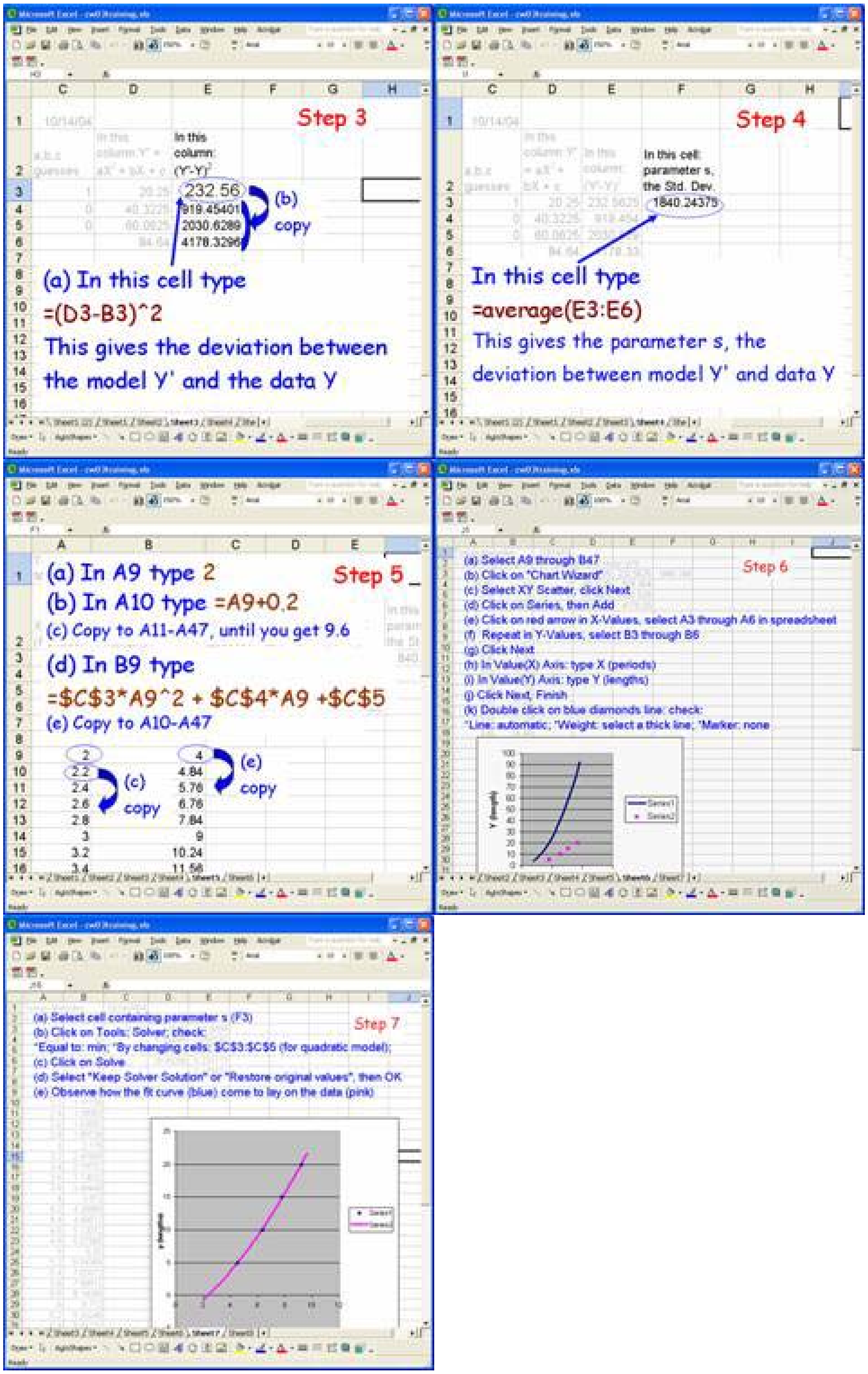
Y'= f(X)

Examples of the 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). To simplify the introduction, we discuss just simple polynomial models, e.g.

$Y'=aX^2+bX+c$
$Y'= \qquad bX+c$
$Y'=dX^3+aX^2+bX+c$

How to obtain a model? CW3 can be done by following these 7 steps. The process consists of using Solver (get it through Tools/Add-ins if needed) to minimize a "standard deviation" parameter s by allowing the polynomial coefficient to vary. After using Solver, the final values for a, b, c determines our quadratic model that represents our pendulum.





How to find the best model?

Suppose we would like to make instead a linear model Y'=bX+c. This can be done on the same Excel sheet by setting a=0, and without touching it, use Solver to minimize the parameter s by changing only cells $C$4:$C$5. Try it yourself, note that the final s parameter for a linear model is 0.13, larger than that for the quadratic model 0.024. This means that our data fit better into a quadratic model than a linear model. In deed, for those who took Fundamentals of Physics I, the period of an ideal pendulum (mass of string is negligible, bob is not so large, no friction involved) is given by

$$T = \sqrt{\frac{L}{g}} \quad \text{or} \quad L = gT^2$$

To test how ideal is our pendulum (represented by the pairs of data we started with), let do a quadratic curve-fitting by setting b=c=0 and letting the coefficient a change so as to minimize the standard deviation, **check how well the final value for a agrees with g=9.81m/s^2.**

Why we need to find the best model?

A better model allows you to make better predictions.

Does the model you found for your particular device apply to another device?

No, the models are device-specific, since it was obtained using a specific set of data associated with a specific device. If getting a different device, new data need to be measured and the curve-fitting needs to be redone.

What is the difference between science and engineering?

Science extracts the simplicity and universality that are behind a wide range of devices or situations by ignoring many specific factors such as frictions, fluid motions, etc. Engineering includes more parameters into a model that produces excellent predictions, but that is only valid for that particular device.