



Week 11: Excel for Engineering Applications 2

BJ Furman

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The Plan for Today

- Excel for engineering applications
 - Macros
 - Curve fitting to data
 - Solving simultaneous equations
 - Solver



Learning Objectives

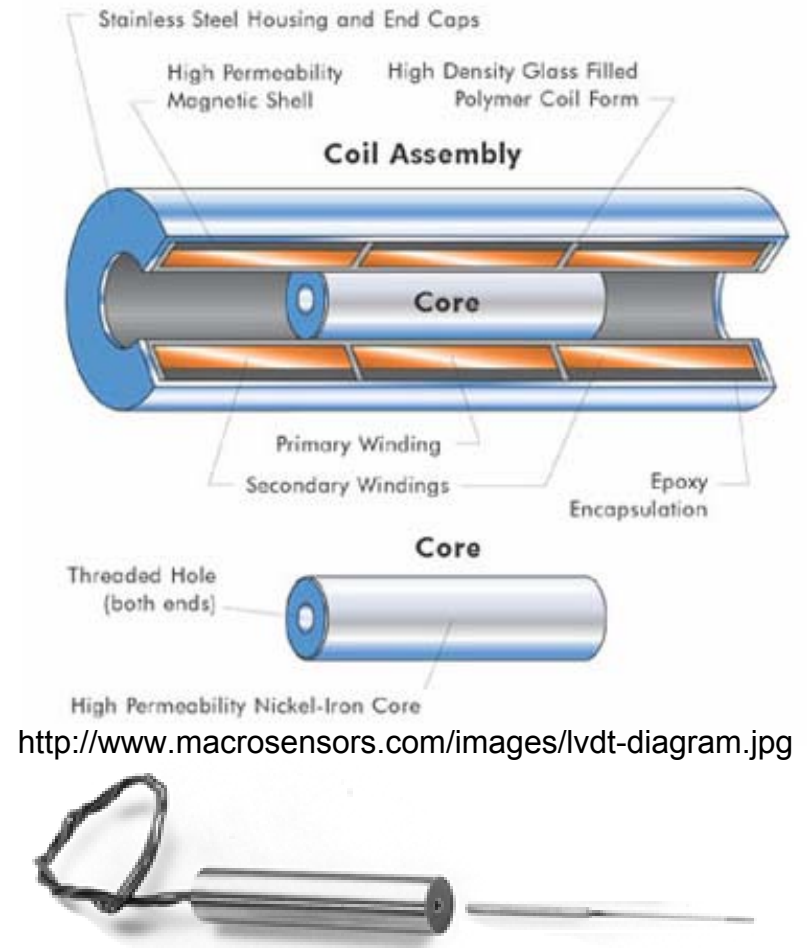
- Use trend line function to fit experimental data
- Regress data using Solver
- Solve simultaneous equations using matrix methods (linear equations) and using the solver (linear or non-linear equations)
- Create a macro to automate tasks

Fitting a Mathematical Function to Data

- Often would like to come up with a mathematical description of a the behavior of a physical system
 - Measure system behavior under controlled conditions
 - Perform regression analysis
 - Process of finding the 'best fit' by minimizing the sum of the squared error between the measured values of the dependent variable and that predicted by the regression equation
- Regression in Excel
 - Using regression functions (for linear function)
 - Adding a trendline (linear regression, but various functions available)
 - Using regression analysis package (linear regression with lots of extra information)
 - Using Solver to solve for regression coefficients (general method)

Fitting a Mathematical Function to Data

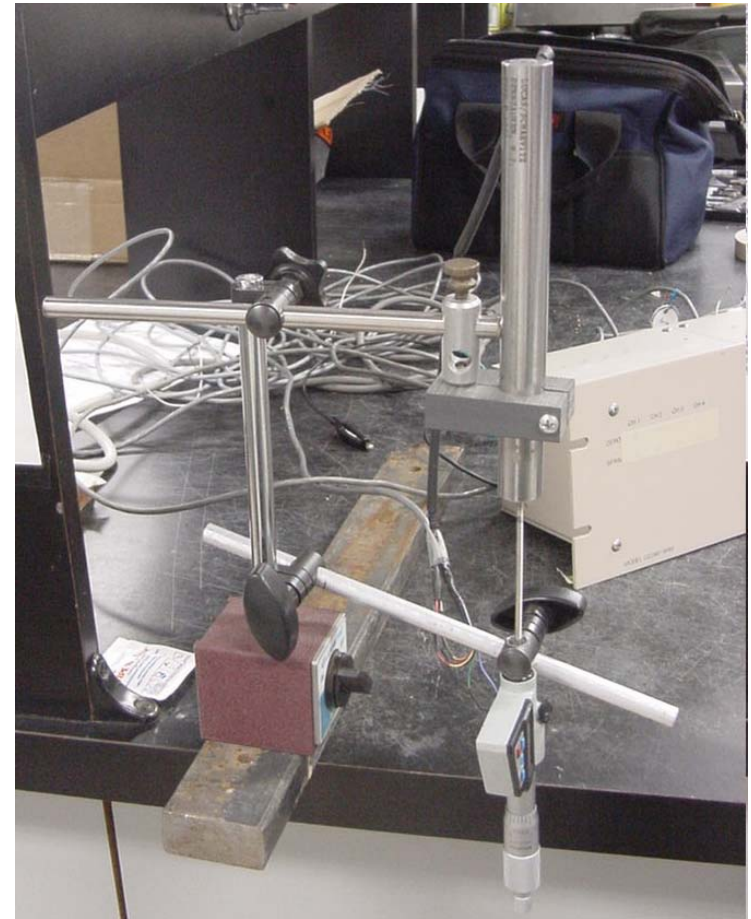
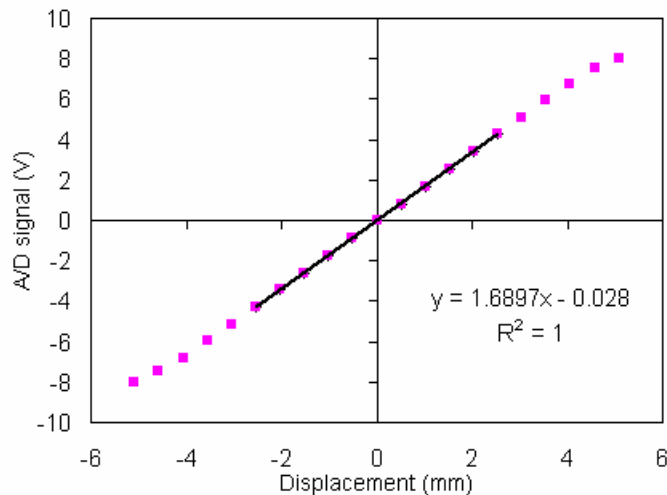
- Ex. calibration of an LVDT sensor
 - Linear Variable Differential Transformer
 - Features:
 - Non-contact
 - Good resolution
 - Robust
 - Relatively inexpensive



Calibration of LVDT Sensor

- Method used by Leroy-Crandall Geotechnical Laboratory

<http://gees.usc.edu/soilab/Calibration.htm>



<http://gees.usc.edu/soilab/Photos/Calibration%20Pictures/mvc-159f.jpg>

Add a Trend Line Using Excel

- See example of fitting LVDT data with a line
 - Linear regression
- Polynomial fit example

Regression Analysis

■ Steps

1. Select a regression model (e.g., $y=mx+b$)
2. Enter the data set (dependent and independent variable values) and initial guesses for the regression model coefficients
3. Calculate the predicted dependent values using the regression model and the independent variable(s)
4. Calculate the 'error' values (actual-predicted)
5. Calculate the squared errors
6. Calculate the sum of the squared errors (SSE)
7. Use Solver to minimize (select 'Min') the SSE (Target Cell) by changing the value of the coefficients (m and b)
8. Test your result by calculating the coefficient of determination (R^2) and fitting your model to the data using

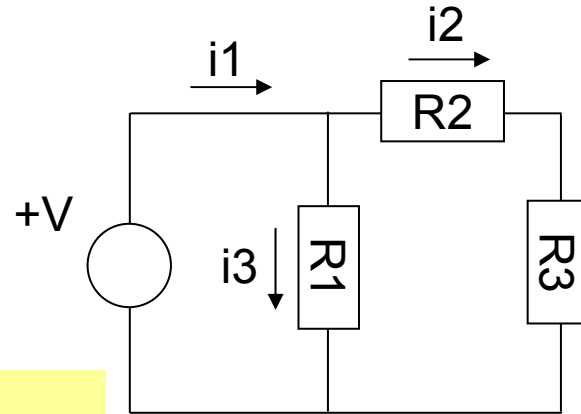
$$R^2 = 1 - \frac{SSE}{TSS} \text{ where TSS is the Total Sum of Squares}$$

$$TSS = \sum_1^N (y_i - \bar{y})^2 \text{ where } \bar{y} \text{ is the average of the dependent variable in the data set}$$

Solving Simultaneous Equations

■ Circuit analysis (EE 98)

- Find the currents



$$i_1 = i_2 + i_3$$

$$i_3 R_1 = V$$

$$i_2 R_2 + i_2 R_3 = V$$

$$i_1 - i_2 - i_3 = 0$$

$$0i_1 + 0i_2 + i_3 R_1 = V$$

$$0i_1 + (R_2 + R_3)i_2 + 0i_3 = V$$

$$\begin{bmatrix} 1 & -1 & -1 \\ 0 & 0 & R_1 \\ 0 & (R_2 + R_3) & 0 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 0 \\ V \\ V \end{bmatrix}$$

Simultaneous Equations with Solver

■ Steps

1. Express equations as $f_i(x_j) = 0$, where $i=1$ to n and $j=1$ to n
2. Form the equation $y = \sum f_i^2$
3. Use Solver by changing the x_j values to drive y (Target Cell) = 0

Macros

- Macro: a set of recorded key strokes or program written in Visual Basic to automate tasks
- Example: Convert lbf to N



Review

References

- Larsen, R. W. (2009). Engineering with Excel, Pearson Prentice Hall, New Jersey. ISBN 0-13-601775-4
- Engineering with Excel companion website:
<http://www.chbe.montana.edu/excel/EngExcel3.htm>. Visited 25OCT2009.