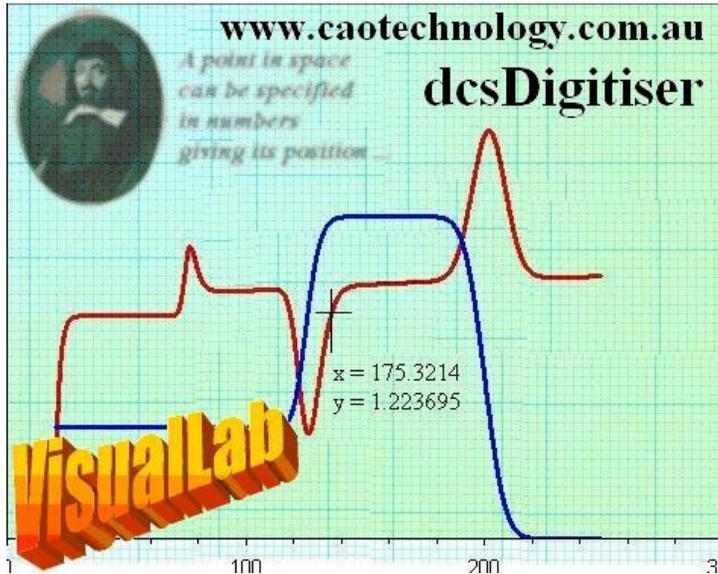


# Smartest calculator — VisualLab



“VisualLab” is a format-free (syntax-free) math software that makes **computations of maths easier than ever!** Type your equations as in a notebook; **VisualLab** knows how to compute. No training is needed – it is visual. **Making one more able and more efficient.** VisualLab covers most math needs in science, engineering and statistics: e.g.

- Matrices and linear eqns;
- Complex numbers;
- Probability and Statistics;
- Equation solving;
- Differentiation;
- Differential equations;
- Equation plotting;
- Transcendental eqns;
- Curve fitting;
- Curve digitization;
- and more and more ...

Write eqns as in a notebook; VisualLab does all.

Format-free, syntax-free, VisualLab is smart.

**Math sheet:**  $\pi e$

**Solutions:**

$$U = q1 q2 / (4\pi e0 r)$$

$$\pi = 3.141592$$

$$q1 = -1.602e-19$$

$$q2 = 1.602e-19$$

$$e0 = 8.85e-12$$

$$5.29e-11 = r$$

1) Type (or copy-paste) eqns here

2) Click "Solve" btn here

3) Solutions are shown here

**Math sheet:**  $\pi e$

**Solutions:**

$$4x^2 + 3x^3 + 15 - 5x = 0$$

$$0 = \exp(a1b2c3) + a1b2c3$$

1) Type (or copy paste) eqns here

2) Click "Solve" btn here

3) Solutions are shown here

$$x_1 = -2.663712$$

$$x_2 = 0.6651894 - 1.197749 i$$

$$x_3 = 0.6651894 + 1.197749 i$$

$$x = -2.663712$$

$$a1b2c3 = -0.5671433$$

VisualLab calculates simultaneous nonlinear eqns.

VisualLab calculates linear eqns, sum of seq's.

**Math sheet:**  $\pi e$

**Solutions:**

$$\ln(x^2 + y^2) + 3x + y = 2$$

$$2x + 5 \sqrt{y} + x^3 + 3y^2 = 3$$

1)

$$x_1 = -22.08121$$

$$y_1 = 59.92997$$

$$x_2 = 0.8025845$$

$$y_2 = 0.03062771$$

$$x = 0.8025845$$

$$y = 59.92997$$

2)

3)

**Math sheet:**  $\pi e$

**Solutions:**

$$3\alpha + 5\beta = 6$$

$$4^\alpha + 7\beta - 14 = 0$$

$$\sum_{n=1}^{100} 2n = s1$$

$$s2 = \sum_{n=1}^{100} n^2$$

$$(3 - 5)^2 / (6 - 3)^6 + 2 = 10$$

$$\alpha = -28$$

$$\beta = 18$$

$$s1 = 10100$$

$$s2 = 338350$$

These two figures show how to eqn computation, and how to show plots of the equations.

The screenshot shows the VisualLab software interface. At the top, the title bar reads "VisualLab - dcsDigitiser ... Points Generation by Equation and Editing".

**Eqns:** A text area contains the following equations:  
 $y = 0.15x^2 + 0.35x + 1$   
 $y = \sin(2\pi x + \delta) + 2 \cos(\pi / 2 x - \delta)$   
 $\delta = \pi / 6$   
 $y = 3 - x$

**Range:** Below the equations, the range is set from  $x_1 = -\pi$  to  $x_2 = \pi$ . The number of intervals is 300, and the step increment is 1.

**Table:** A table displays numerical results for 17 points. The columns are labeled "Pt No.", "x =", "y =", "y =", and "y =".

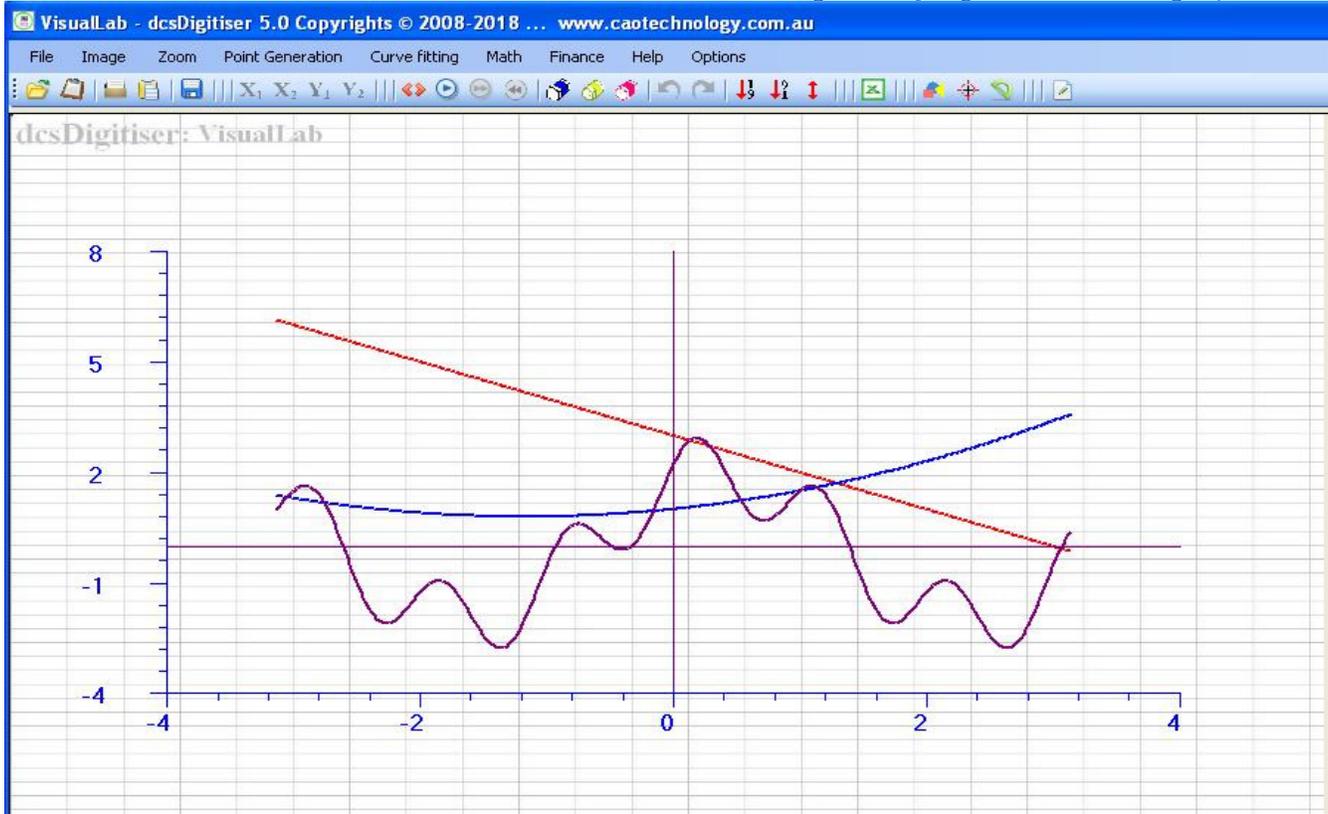
| Pt No. | x =       | y =      | y =      | y =      |
|--------|-----------|----------|----------|----------|
| 1      | -3.141593 | 6.141593 | 1.380883 | 0.999497 |
| 2      | -3.120649 | 6.120649 | 1.36854  | 1.076066 |
| 3      | -3.099705 | 6.099705 | 1.356329 | 1.155236 |
| 4      | -3.078761 | 6.078761 | 1.344249 | 1.234821 |
| 5      | -3.057817 | 6.057817 | 1.332301 | 1.312604 |
| 6      | -3.036873 | 6.036873 | 1.320484 | 1.386378 |
| 7      | -3.015929 | 6.015929 | 1.308799 | 1.453987 |
| 8      | -2.994985 | 5.994985 | 1.297246 | 1.513361 |
| 9      | -2.974041 | 5.974041 | 1.285824 | 1.562553 |
| 10     | -2.953097 | 5.953097 | 1.274533 | 1.599778 |
| 11     | -2.932153 | 5.932153 | 1.263375 | 1.623438 |
| 12     | -2.911209 | 5.911209 | 1.252348 | 1.632157 |
| 13     | -2.890265 | 5.890265 | 1.241452 | 1.624802 |
| 14     | -2.869321 | 5.869321 | 1.230688 | 1.600504 |
| 15     | -2.848377 | 5.848377 | 1.220056 | 1.558677 |
| 16     | -2.827433 | 5.827434 | 1.209555 | 1.499025 |
| 17     | -2.806489 | 5.806489 | 1.199186 | 1.421553 |

**How to type your equations:** A yellow box provides instructions:  
1. In a form of  $y = f(x)$ , or  $x = f(y)$ , e.g.:  
 $y_1 = \sin(2n \omega x + 1) + 3b \cos(2n \omega x + 2)$   
 $y_2 = 2x^2 + 3x - 3$   
 $\omega = 2.5$   
 $b = 2.13$   
2.  $n = 3.14159265358979$  has been built in for this Point Generation application; no need for declaration.  
3. Up to 4 equations can be defined to obtain 4 curves.  
4. Pts no. will be used as  $x$  if there is only one column of data.  
5. To select data, hold and move left mouse button; Ctrl + C to copy selection to clipboard; Click btn 'Paste clipb'c'; Click btn 'Delete sel'n'

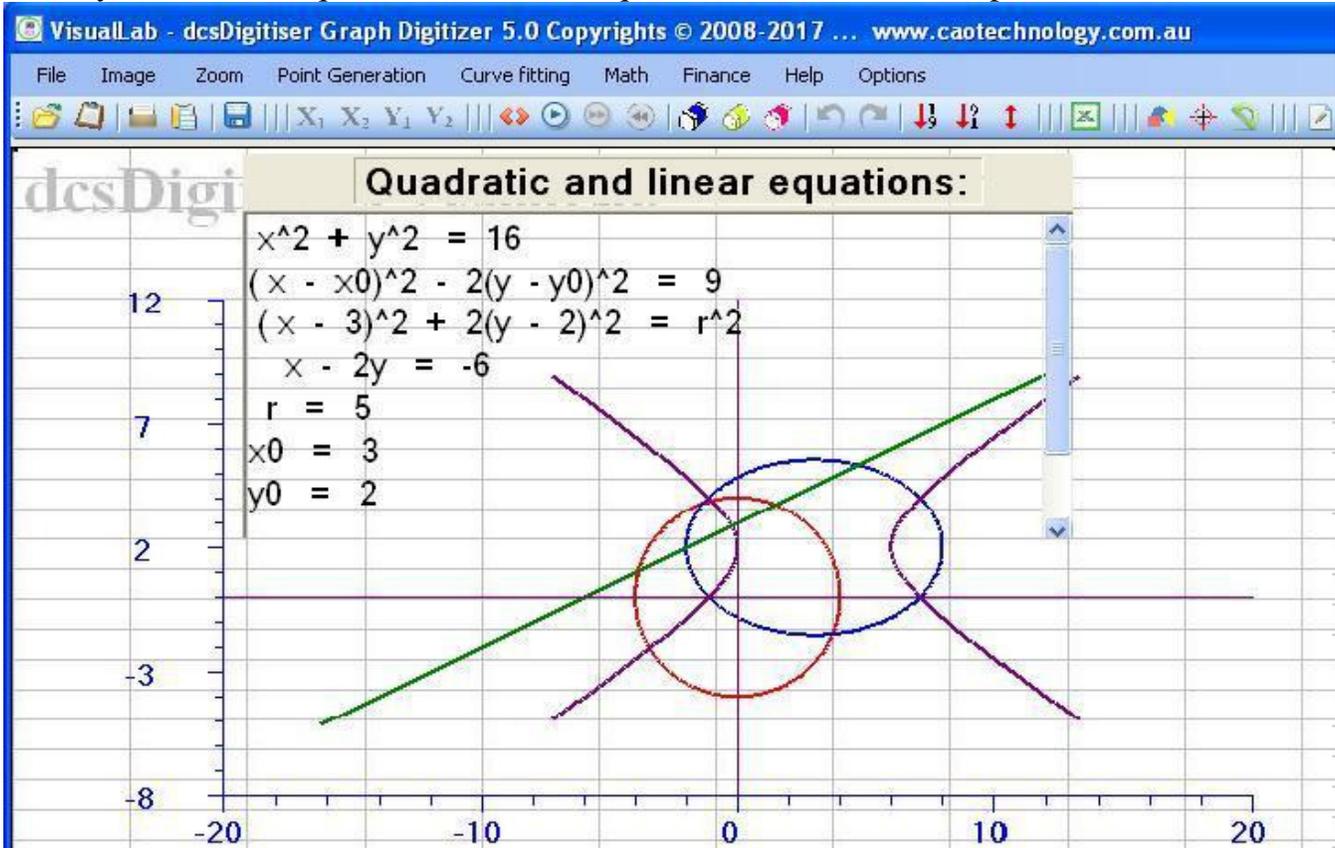
**Buttons:** At the bottom, there are buttons for "Clear Eq.", "Paste clipb.", "Calculate", "Plot", "Clear X-Y ntc", "Delete col'n", "Save all", and "Exit".

**Annotations:** Red boxes and arrows highlight the equation input area (1), the "Calculate" button (2), the numerical results table (3), and the "Plot" button (4).

When btn "Plot" is clicked, three curves for three corresponding equations are displayed.



Freely write several quadratic and linear equations; a click to see the plots.



VisualLab makes matrix computations and solve linear equations, easy and straightforward.

**Equation**

$$C = A^{-1} * B + (A B)^3 * (A - B)$$

|           |          |          |          |         |           |
|-----------|----------|----------|----------|---------|-----------|
| -159685   | -470876  | 12011000 | -2396120 | 6593290 | -134231   |
| -186896   | -551107  | 140547   | -2801010 | 7717190 | -157039   |
| -145754   | -4297990 | 10962600 | -2186570 | 601840  | -122508   |
| -20510700 | -604791  | 154284   | -307819  | 846726  | -172437   |
| -19532200 | -5758740 | 14687500 | -292482  | 806079  | -164108   |
| -184254   | -5432730 | 13859600 | -276452  | 7604820 | -15490500 |

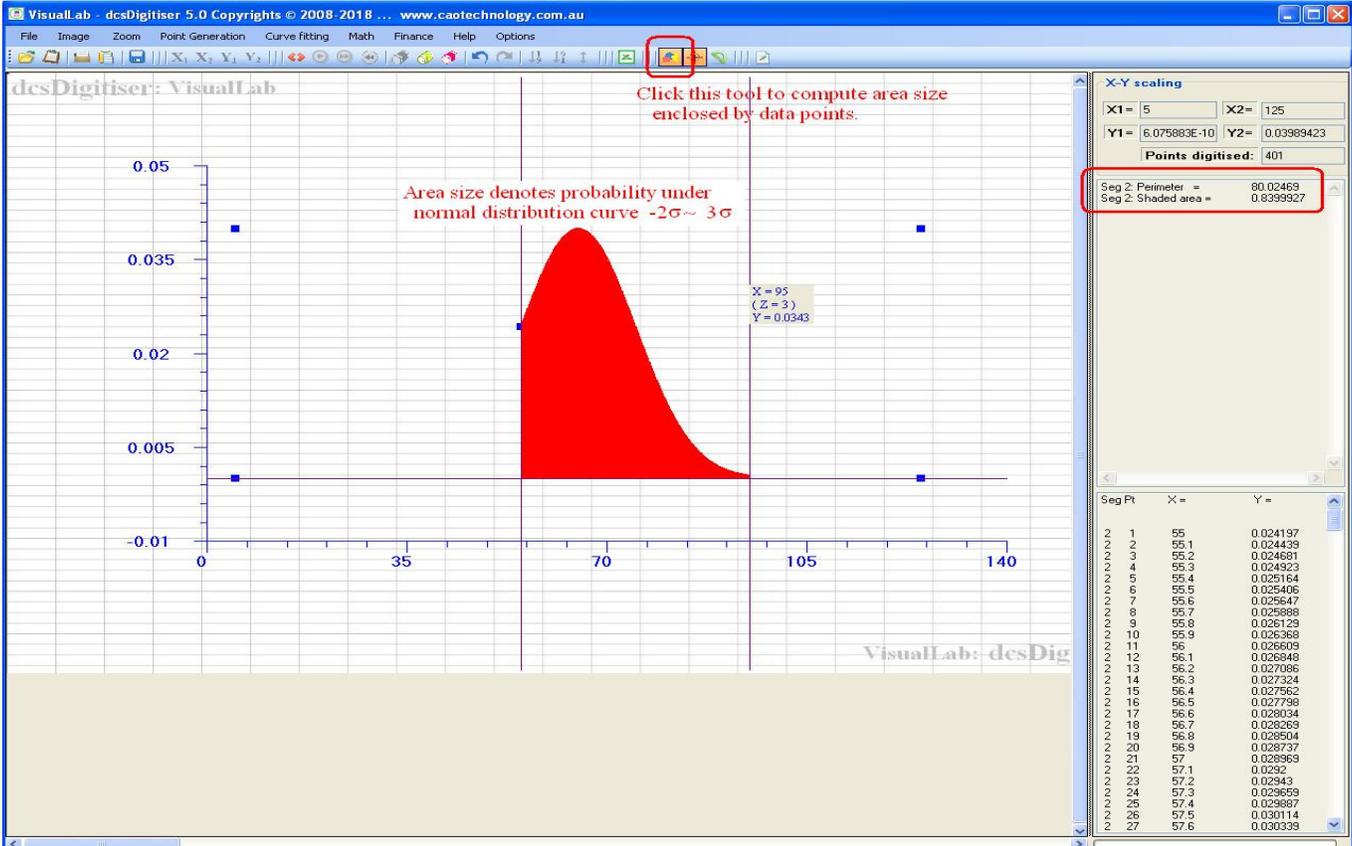
**Linear equation**

$$Ax = B$$

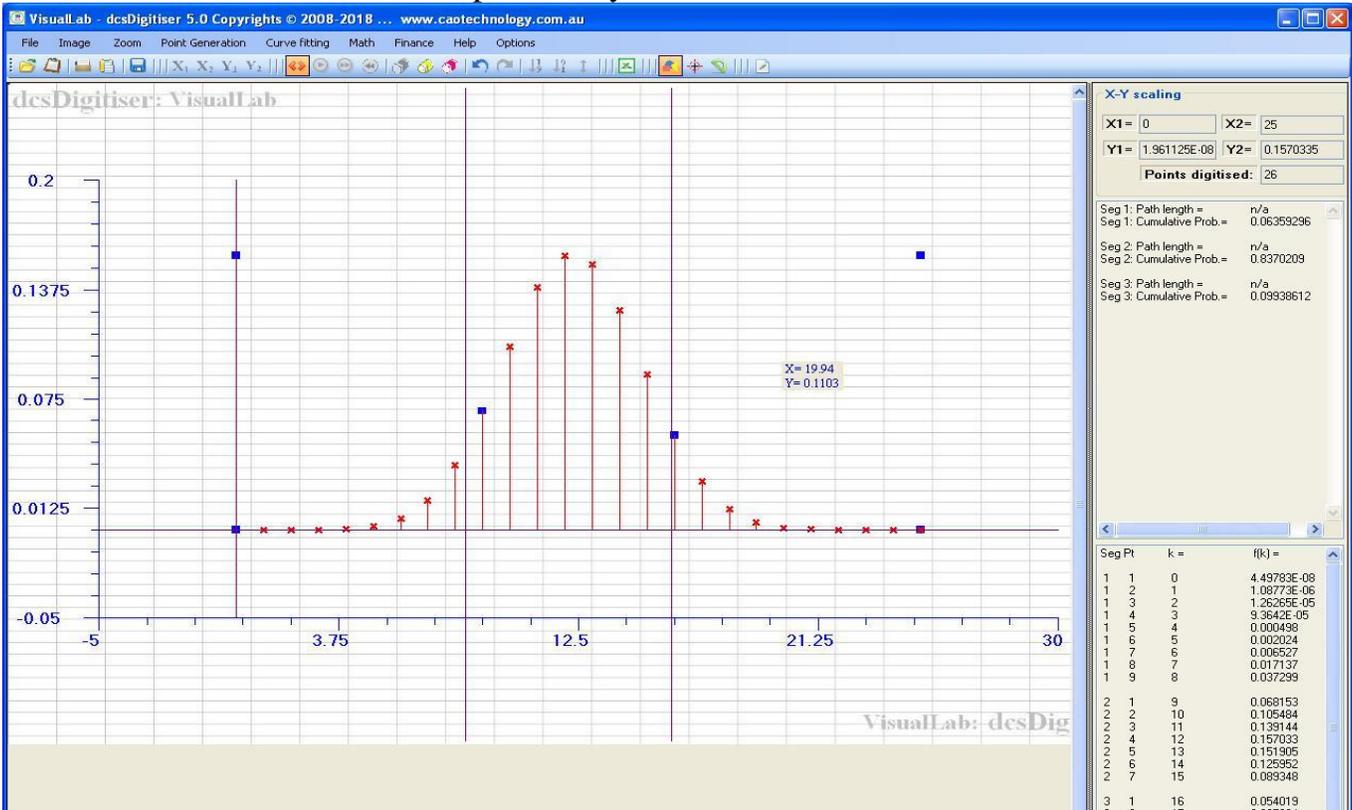
**Answer**

$$x = \begin{matrix} -6.05762 \\ -2.54054 \\ 1.68485 \\ 0.534421 \\ 3.64202 \\ -0.872004 \end{matrix}$$

VisualLab integrates area size to compute probability value for the Gaussian distribution curve.



VisualLab calculate cumulative probability value for a binominal distribution model.



An example how VisualLab solves a second order ordinary differential equation.

**Differential eqns:**  
 $m \frac{d^2x}{dt^2} + k \frac{dx}{dt} + c x = t \sin(2t)$   
 $m = 2$   
 $k = 0.1$   
 $c = 3$

**Initial values:**  
 $x(0) = 1$   
 $\frac{dx}{dt}(0) = 0$

**Time span:** 20

**Delta increment:**  
 Coarse (fast)  
 Medium  
 Fine (slow)

**Analytical solution for x:**  
 $x = \text{Exp}(-0.025t) [c_1 \text{Cos}(1.22448968962585t) + c_2 \text{Sin}(1.22448968962585t)] + (-0.00798722044728435t - 0.318787065296165) \text{Cos}(2t) + (-0.199680511182109t + 0.0215374251038594) \text{Sin}(2t)$

**How to type your equations:**

- In a form of  $\frac{dy}{dx} = f(x, y)$ ;  $\frac{dz}{dt} = f(t, z)$ ;  $\frac{d^2y}{dt^2} = f(t, y, \frac{dy}{dt})$  for  $\frac{d^2y}{dt^2}$  etc. e.g.  
 $\frac{d^2y}{dx^2} = \frac{dy}{dx} + 2v + x^2 + \text{Sin}(3x)$   
 $\frac{dz}{dt} = a \text{Sin}(2\pi t)$
- Initial value is given in
- For ODEs with third or to first or second order ODEs, e.g.  
 $\frac{d^2z}{dt^2} = a * z^2 - g$   
 $\frac{dy}{dt} = z$
- Variables are case sensitive, e.g.  $b \neq B$ ,  $z1 \neq Z1$ ;
- Computational instability may occur if the span is too large. Narrow the span if necessary.

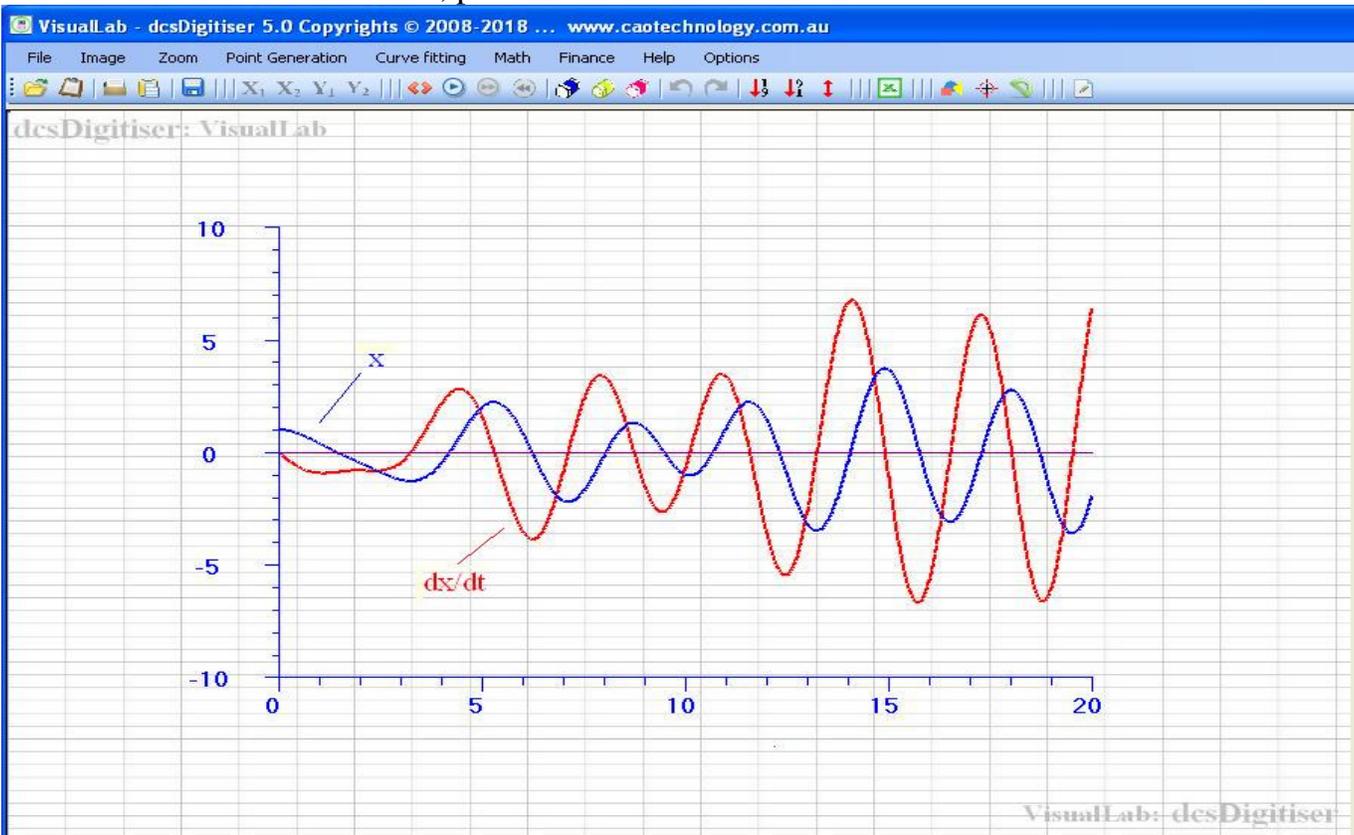
**3) Analytical and numerical solutions are shown here.**

| Pt No. | t =  | dx/dt =     | x =       |
|--------|------|-------------|-----------|
| 1      | 0    | 0           | 1         |
| 2      | 0.02 | -0.02998234 | 0.9994003 |
| 3      | 0.04 | -0.05990075 | 0.9982023 |
| 4      | 0.06 | -0.08972143 | 0.9964079 |
| 5      | 0.08 | -0.1194108  | 0.9940196 |
| 6      | 0.1  | -0.1489354  | 0.9910409 |
| 7      | 0.12 | -0.1782623  | 0.9874756 |
| 8      | 0.14 | -0.2073589  | 0.9833285 |
| 9      | 0.16 | -0.2361931  | 0.9786046 |
| 10     | 0.18 | -0.2647333  | 0.9733099 |
| 11     | 0.2  | -0.2929484  | 0.9674509 |
| 12     | 0.22 | -0.3208082  | 0.9610348 |
| 13     | 0.24 | -0.3482831  | 0.9540691 |
| 14     | 0.26 | -0.3753442  | 0.9465622 |
| 15     | 0.28 | -0.4019638  | 0.9385229 |
| 16     | 0.3  | -0.4281147  | 0.9299606 |
| 17     | 0.32 | -0.4537709  | 0.9208852 |
| 18     | 0.34 | -0.4789074  | 0.911307  |
| 19     | 0.36 | -0.5035003  | 0.901237  |
| 20     | 0.38 | -0.5275267  | 0.8906865 |
| 21     | 0.4  | -0.5509649  | 0.8796672 |
| 22     | 0.42 | -0.5737945  | 0.8681913 |

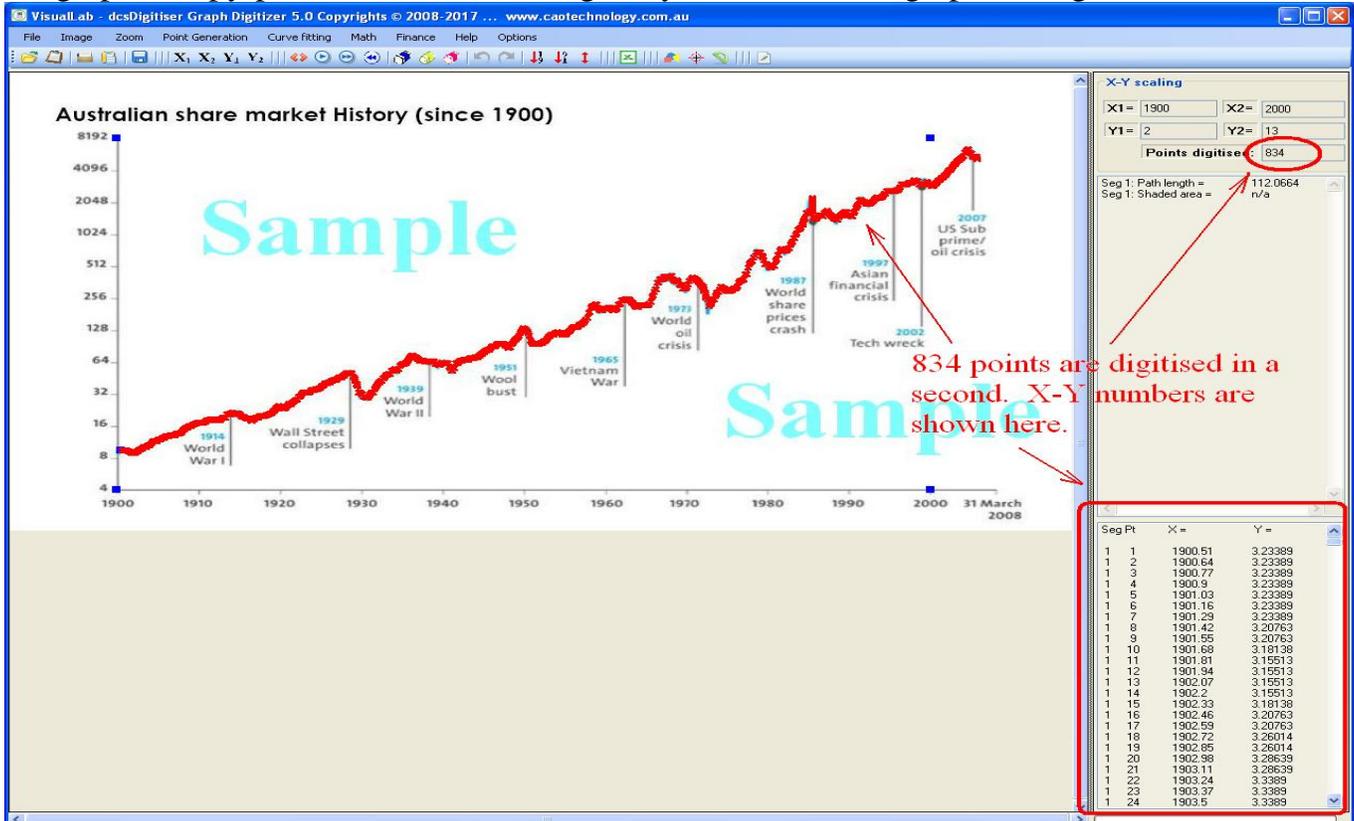
**2) Click "Solve" btn**

**4) Click "Plot" btn to see the plots.**

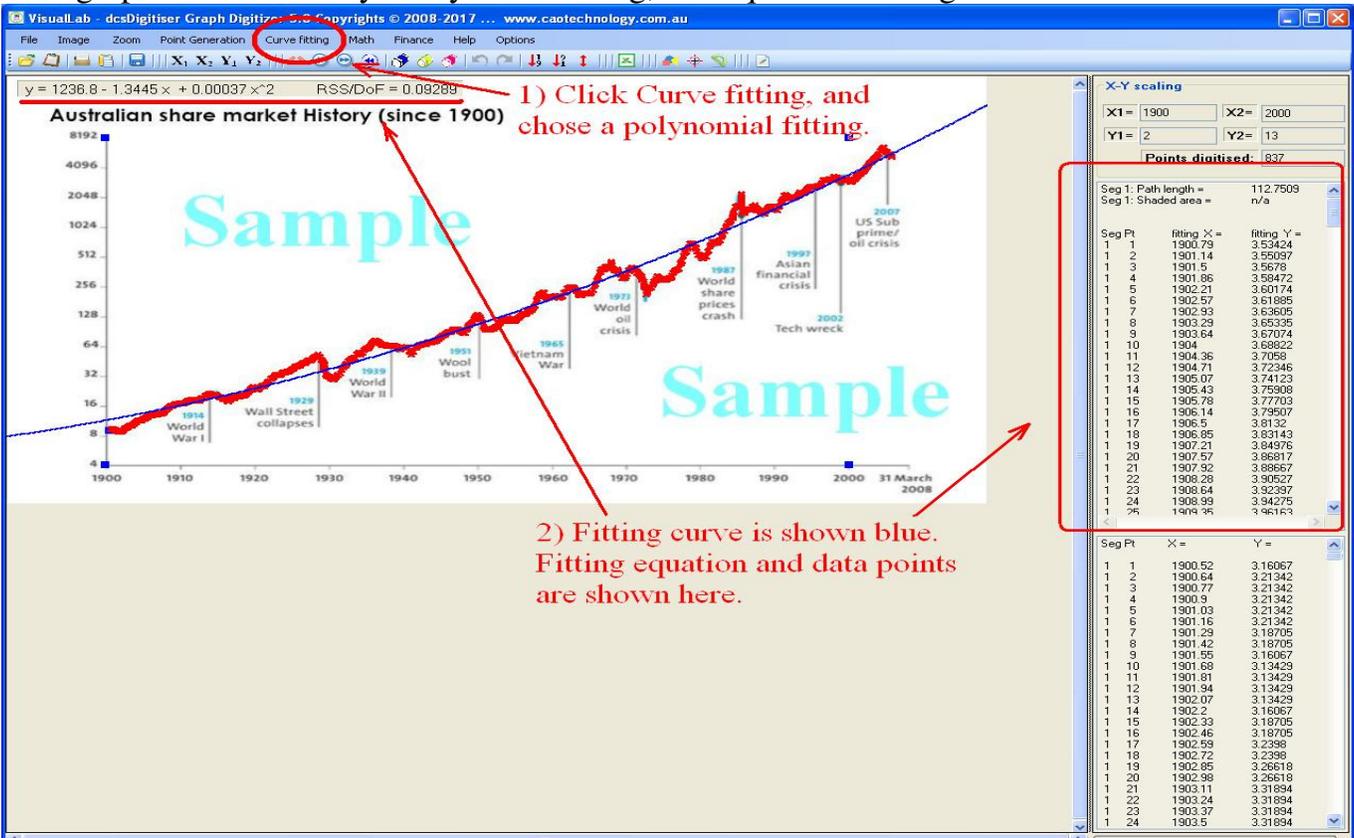
When the btn "Plot" is clicked, plots of x and dx.dt vs time t are shown.



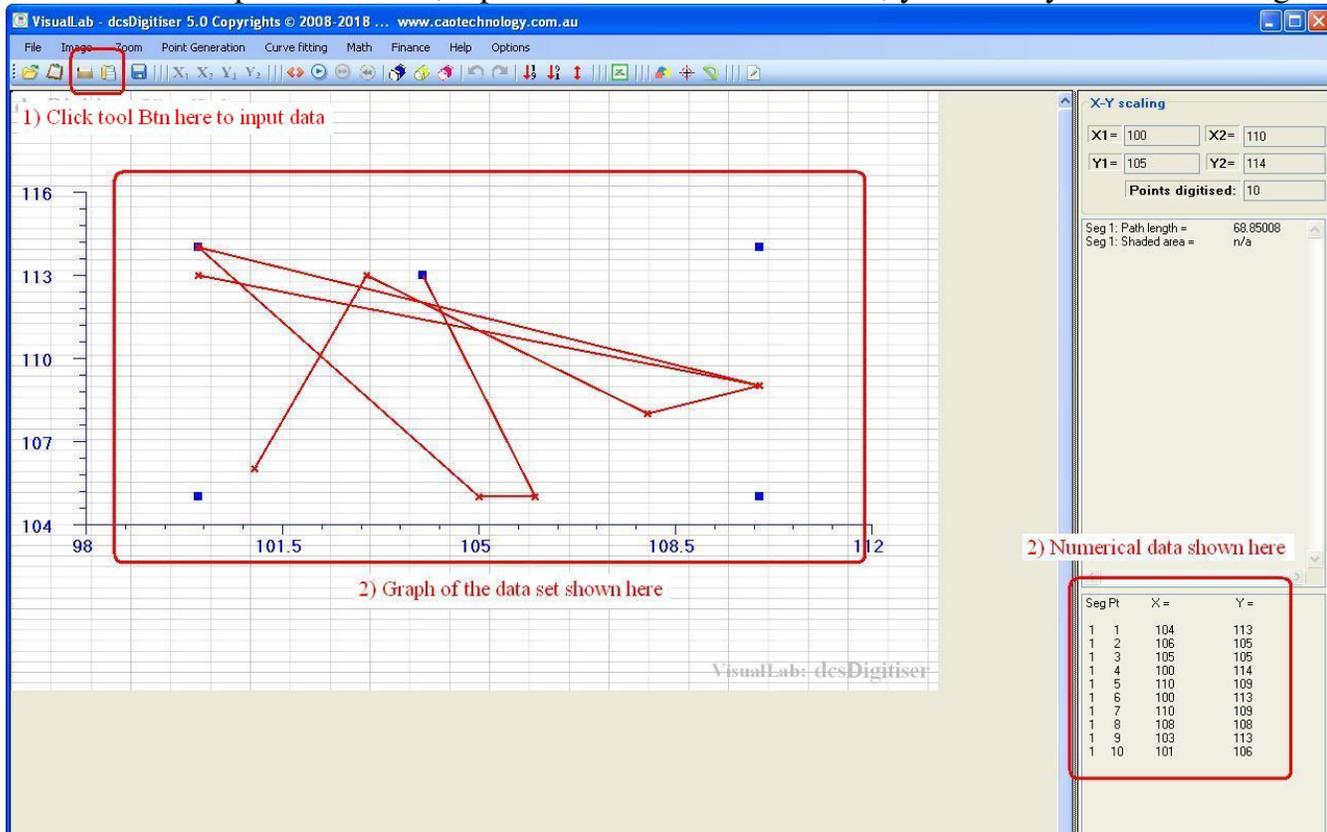
A graph is copy-pasted from a PDF image; x-y numbers of the graph are digitised in a second.



The graph is further analysed by curve fitting, and eqn of the fitting curve is obtained.



Statistical analysis can be carried out for any data set shown on the screen. For example, one has 10 data points in a file, input the data set to VisualLab; you'll see your data looking like:



Go to menu Maths > t- test..., and chose unpaired two sample test; results are shown as follows:

1) Chose what you want to do

2) Click "Calculate" btn

3) t-test results are shown here

Sample group

95 % confidence interval

Hypothetical mean: 99.5

One sample t-test: Column X

One sample t-test: Column Y

Paired two sample t-test: Columns X-Y

Unpaired two sample t-test: Columns X-Y

Grouping variable: n/a

**Results:**

| Sample group:                | Column X | Column Y |
|------------------------------|----------|----------|
| No., n =                     | 10       | 10       |
| mean, $\mu$ =                | 104.7    | 109.5    |
| variance, $s^2$ =            | 14.45556 | 12.5     |
| std. deviation, $s$ =        | 3.802048 | 3.535534 |
| std. error, $s/\sqrt{n-1}$ = | 1.202313 | 1.118034 |

**Equal variances assumed:**

t value, t = -2.923594

d.o.freedom, df = 18

mean difference = -4.8

std.error difference = 1.641815

significance value = 0.00907077

95% conf. int'l difference: -8.249325 ~ -1.350875

**Equal variances not assumed:**

t value, t = -2.923594

d.o.freedom, df = 17.90578

mean difference = -4.8

std.error difference = 1.641815

significance value = 0.009106739

95% conf. int'l difference: -8.250627 ~ -1.349374

Maths > chi-square test enables one to perform chi-square test. An example is shown below:

**Raw data for chi-square test:**

| No. | Group A | Group B | Group C | Group D | Group E | Group F | Group G | Gro |
|-----|---------|---------|---------|---------|---------|---------|---------|-----|
| 1   | 2       | 3       | 4       |         |         |         |         |     |
| 2   | 3       | 3       | 2       |         |         |         |         |     |
| 3   | 3       | 4       | 5       |         |         |         |         |     |
| 4   |         |         |         |         |         |         |         |     |
| 5   |         |         |         |         |         |         |         |     |
| 6   |         |         |         |         |         |         |         |     |
| 7   |         |         |         |         |         |         |         |     |
| 8   |         |         |         |         |         |         |         |     |
| 9   |         |         |         |         |         |         |         |     |
| 10  |         |         |         |         |         |         |         |     |
| 11  |         |         |         |         |         |         |         |     |

**Obs:**

1) Input data here

**Exp:**

(user input)

**Tips for chi-square test:**

- $\chi^2 = \sum (V_{obs}^2/d - V_{exp}^2/d) / V_{exp}^2/d$
- Input observed raw data only into the data grid box;
- Expected values are values of null hypothesis  $H_0$ ; if known, tick check-box and input its values;
- If chi-square value is less than the critical value, null hypothesis is accepted; otherwise is rejected.
- To select data, hold & move left mouse btn  
Ctrl + C to copy selection to clipboard;  
Click btn 'Paste clipb'd' below to paste data in clipboard  
Click btn 'Delete sel'n' to delete selected

**Results:**

$\chi^2 = 0.9346275$

d.o.f. = 4

Crit'l value (P=0.1) = 7.779

Crit'l value (P=0.05) = 9.488

Crit'l value (P=0.01) = 13.277

Crit'l value (P=0.001) = 18.467

Buttons: Clear data, Paste, Save, Run, Clear res't, Delete selection, Exit

2) Click "Run" btn here

3) Results are shown here

Maths > ANOVA ... An example showing how two way ANOVA is carried out in VisualLab.

**Data for ANOVA:**

| No. | Group A | Group B | Group C | Group D | Group E | Group F |
|-----|---------|---------|---------|---------|---------|---------|
| 1   | 2       | 3       | 5       |         |         |         |
| 2   | 3       | 4       | 5       |         |         |         |
| 3   | 4       | 3       | 6       |         |         |         |
| 4   | 2       | 3       | 3       |         |         |         |
| 5   | 2       | 4       | 4       |         |         |         |
| 6   |         |         |         |         |         |         |
| 7   |         |         |         |         |         |         |
| 8   |         |         |         |         |         |         |
| 9   |         |         |         |         |         |         |
| 10  |         |         |         |         |         |         |
| 11  |         |         |         |         |         |         |

**1:**

| No. | Group A | Group B | Group C | Group D | Group E | Group F |
|-----|---------|---------|---------|---------|---------|---------|
| 1   | 3       | 1       | 4       |         |         |         |
| 2   | 3       | 2       | 5       |         |         |         |
| 3   | 3       | 3       | 6       |         |         |         |
| 4   | 3       | 4       | 3       |         |         |         |
| 5   | 3       | 5       | 2       |         |         |         |
| 6   |         |         |         |         |         |         |
| 7   |         |         |         |         |         |         |
| 8   |         |         |         |         |         |         |
| 9   |         |         |         |         |         |         |
| 10  |         |         |         |         |         |         |
| 11  |         |         |         |         |         |         |

**2:**

1) Input data here

**Tips for ANOVA (analysis of variance):**

- There must be at least two groups of data;
- If no checkbox for 2nd factor is ticked, one-way ANOVA for data in DataGrid No. 1 is computed;
- Two-way ANOVA will be robust if number of data points of each group and number of the 2nd factor groups are all equal;
- Empty cell in each DataGrid is regarded the end of data;
- SS - Sum of Square, MS - Mean Square;
- F value, aka F ratio, is the ratio of a given MS over MS of Error (within groups).
- To select data, hold and move left mouse button;  
Ctrl + C to copy selection to clipboard;  
Click btn 'Paste clipb'd' below to paste data in clipboard  
Click btn 'Delete sel'n' to delete selected data

**ANOVA results:**

|                        | SS    | dof | MS    | F value |
|------------------------|-------|-----|-------|---------|
| Between groups:        | 12.07 | 2   | 6.033 | 4.892   |
| Between 2nd factor:    | 0.3   | 1   | 0.3   | 0.2432  |
| Cross factors:         | 1.4   | 2   | 0.7   | 0.5676  |
| Error (within groups): | 29.6  | 24  | 1.233 |         |
| Total:                 | 43.37 | 29  | 1.495 |         |

Buttons: Clear data, Paste to 1, Save data, Run, Clear result, Paste to 2

2) Click "Run" btn here

3) Results are shown here