Using Graphical Analysis in Titration Curves

A typical titration curve obtained by plotting the measured pH of a weak acid solution as a strong base is added using graphical analysis for Windows is illustrated as follows:

The equivalence point is halfway up the vertical portion of the curve, about 27 mL for this titration. The pH is about 9 at the equivalence point.
To obtain a better approximation of the volume at the equivalence point, one can do a first derivative plot. This plots the change of pH divided by the change in volume versus the volume of NaOH. This shows the change in slope of the titration curve as a function of the added volume of base.

On the main graphical analysis screen: click on the data icon, the new column field, and the calculated field. The screen will be as follows.
Clicking on the calculated box gives the following New Column screen.

![New Column Screen](image)
Type in **First Derivative** for the new column name. Click in the **New Column Formula** box to place the cursor there. Then click on **Other Functions**. The screen will be as follows.

![Screen capture of spreadsheet with New Column Name: First Derivative, New Column Units: empty, New Column Formula: empty, and Other Functions showing functions like exp, ln, 10^, log, sin, cos, tan, ^2, abs, integral, derivative, delta, smooth.]

**Columns** ▼

<table>
<thead>
<tr>
<th>exp</th>
<th>ln</th>
<th>10^</th>
<th>log</th>
</tr>
</thead>
<tbody>
<tr>
<td>sin</td>
<td>cos</td>
<td>tan</td>
<td>row#</td>
</tr>
<tr>
<td>sin~</td>
<td>cos~</td>
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<td>4</td>
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<td>3</td>
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</tr>
<tr>
<td>0</td>
<td>.</td>
<td>E</td>
<td>+</td>
</tr>
</tbody>
</table>

**Other Functions ▼**

- smooth()
- abs()
- integral()
- derivative()
- delta()
In the **Other Functions** box, click on the **derivative()** option, and then click on the **Columns** box. The screen will be as follows.
Click on the **pH** option in the **Columns** box. The screen will appear as follows. Now click on the **OK** and you are all set.

![New Column dialog box]

On the original titration curve graph, click on the **pH** label on the vertical axis. The **y-axis setup** screen appears. Click on **first derivative** and click off **pH**. Now click **OK**.

![Y-Axis Setup dialog box]
The following graph will appear.

The peak at around 27 mL is the equivalence point of the titration.
By clicking on the **pH** label on the vertical axis and clicking on both the **pH** and **first derivative** options in the **y-axis setup box**, one display both the first derivative and titration plots on one graph as follows.