1. The following data are collected in an experiment in which the absorption of light at a wavelength of 535 nm by solutions of various concentrations of iron(II) sulfate in water is measured. Assume that the concentration of iron(II) sulfate is the independent variable and that it is measured in moles/Liter. The dependent variable, the absorbance of the solution at light of wavelength 535 nm, has no units.

<table>
<thead>
<tr>
<th>CONCENTRATION</th>
<th>0.000</th>
<th>0.001</th>
<th>0.002</th>
<th>0.005</th>
<th>0.010</th>
<th>0.020</th>
<th>0.030</th>
<th>0.050</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSORBANCE</td>
<td>0.00</td>
<td>0.04</td>
<td>0.08</td>
<td>0.19</td>
<td>0.35</td>
<td>0.79</td>
<td>1.10</td>
<td>1.85</td>
</tr>
</tbody>
</table>

a. What will be the values of concentration and absorbance at the origin of the graph?

The origin of the graph will be at the point (0.000,0.000)

b. What are the ranges of the concentration and absorbance measurements?

The range of concentration is \(0 - 0.05\) mol/L

The range of absorbance is \(0 - 1.85\)

c. Which variable will be plotted as the abscissa (x-axis)?

It is traditional to display the independent variable on the abscissa. Therefore, the x-axis will display the concentration.

d. Assuming graph paper with a grid of 1 mm × 1 mm boxes, with dimensions 180 mm × 250 mm, what should you chose for the number of boxes per unit for concentration? For absorbance?

Since the range of absorbance is 1.85, we would not be able to include the last point of the data if we use 1 cm for 1 unit of Absorbance. We also cannot use 1 cm for 1 unit of concentration along the 180 mm axis for the same reason.

We will need to use 1 cm for at least 2 units of either absorbance or concentration.

Suppose we use 1 cm for 2 units of Absorbance. The full range of absorbance will then require ~ 9 cm which can fit on either axis of the graph paper.

If we use 1 cm for 2 units of concentration, the full range will require 25 cm. That will fit along the longer axis of the paper, but not the shorter axis.

Since we wish to use as much of the graph paper as possible, we can stop the analysis at this stage. The next stage would examine 1 cm for 5 units of concentration (which would reduce the concentration axis to 10 cm) or 1 cm for 5 units of absorbance (which reduces the absorbance axis to only 3 cm in length). This clearly would have the graph cover only a small percentage of the entire available graph paper.
SUPL-004 – Problems

e. In which orientation should the graph be plotted, portrait or landscape?

The calculations in part d have already fixed this choice. We must place the concentration (the independent variable) on the 25 cm axis, so the graph will be in landscape mode.

f. What proportion of the total grid area (45,000 mm²) will the graph occupy?

The minimum area the graph will cover is 90 X 250 = 22,500 mm² which is 22,500/45,000 = ½ of the available area.

g. Plot the graph including all of the appropriate elements (title, labels, units, etc.). Draw tick marks at appropriate places on both the abscissa and ordinate. Draw the best estimated straight line which passes through the origin of the graph.

h. Do any experimental points appear to be irregular?

No
SUPL-004 – Problems

i. What is the slope of the graph?
The point on the line at (0.0400,1.48) is circled.

Note that we can read the scale on the concentration axis with much greater precision than our experimental measurements of concentration. Therefore, we can determine the coordinates of point in the graph with greater precision. From that point we get a slope:

\[
\text{Slope} = \frac{1.48}{0.0400} = 37.0 \text{ L / mg}
\]

j. What equation represents the relationship between absorbance and concentration?

\[
\text{Abs} = 37.0 \times c \quad \text{(where } c \text{ is in L/mg)}
\]

It is interesting to see the graph that Excel produces with the same data.
The following features are worth noting:

1. The Excel graph fills the available space fully whereas the hand drawn graph utilizes only 50% of the available paper.

2. Excel limits the Grid lines to those shown above. This reduces the ability to interpolate data from the graph. The 1 mm X 1 mm grid of the graph paper in the manual provides much greater precision in interpolation.

3. The trend line, which is the best least squares fit to the data, is represented by an equation with significant figures that are beyond those justified by the data.

4. The slope is consistent with that calculated from the graph in question i.

Using the curve in Figure 1, what is the density of a water solution of glycerol whose weight fraction of glycerol is 0.75?

"Using the curve" can mean two things. It can mean determine the answer (density):

1.) graphically. (using the actual graph by erecting a perpendicular on the weight fraction axis at 0.75 and reading the value of density at which that line intersects the drawn line.

2.) determine the answer analytically (i.e., using the mathematical parameters that define the graph, if any)
SUPL-004 – Problems

In this case, we have not determined an analytical representation of the data, so we are limited to the first procedure. Process 1 depends on how carefully the line is drawn and with what precision we can read values along the x and y axes.

The weight fraction axis is marked at 1/10\textsuperscript{th}s of a unit, so our rule of thumb specifies that we can read it to the nearest 0.02 unit, which amounts to 2 decimals.

The density axis has tick marks at 2/100\textsuperscript{th}s of a unit so we can read it to the nearest 0.004 units which amounts to 3 decimals.

We erect a line perpendicular to the x-axis at as close to $x = 0.75$ as we can estimate (the red line) and drop a perpendicular to the density axis from the intersection of the red line with the density curve (the green line). We estimate the point at which it intersects the y-axis to be 1.135 g / mL.

3. If you have a graphing calculator, find the equation of the best straight line approximation for the data in Exercise 1 above. How does it agree with your estimated equation in question 1j?

We have shown the Excel results earlier.

4. The histogram in Figure 7 is based on real data collected by students as part of the exercise SUSB-003. Can you think of an explanation for the peculiar distribution of weights?

The alloy from which the penny is made has varied considerably over the years. E.g., see:

http://www.usmint.gov/about_the_mint/fun_facts/index.cfm?flash=yes&action=fun_facts2