The "solutions" discussed below are for the first worksheet (graphing worksheet) in EGR270 – Materials Science Laboratory. Creating a "good" graph is an art – which means there isn't really a correct answer, but some answers are better than others.

The purpose of this worksheet (and the solutions provided below) is to help you think more about formatting results to most effectively communicate your message. If your graphs or tables look different, I encourage you to look objectively at the "solutions" provide to determine how data can be presented in different ways to communicate the results more meaningfully. Your way may be as good or better than what is shown below, but maybe not.

What type of graph? This is probably the most critical question regarding how your data will be communicated. There are many types of graphs: bar, column, line, scatter, pie charts, etc. However, it is most likely that one type of graph will be best for what you are trying to tell the reader. The vast majority of engineering data is displayed as a scatter plot or in tables (look through your engineering textbooks to see this is true). None the less, other types of graphs are occasionally appropriate.

Trendlines: trendlines are generally preferred rather than "connect the dots". They show expected trends based on the data collected.

Creating trendlines: once the graph is made, remove the "connect the dot" lines by right clicking on the data points (on the graph) and select "Format data series…", then select "line color" then select "no line." If "Format data

series…" does not show up when you right click it means you've clicked on the graph, not the data. Try again.

After removing the graph lines (but not the markers – you want to show the actual data points) right click on the data points and select "Add trendline" and proceed as logic dictates.

Unfortunately, Excel does not always do a good job or creating trendlines. If that is the case, "free hand" (using the drawing package in Excel) a curved line through the data – "eyeball" it.

Logarithmic scale: some data is best displayed with one or both of the axes being logarithmic scale. To create log scale, first create the graph, then right click on the axis numbers, select "Format axis" then select the "Axis options" tab. Select the box by "Logarithmic scale".

2. *The purpose of this laboratory was to determine the Young's Modulus of various pure metals.*

Is there a linear relation between gold and molybdenum? Would an alloy of 50%Au and 50%Mo have a stiffness of 200GPa? It's not likely, so don't imply that it is (Fig. 1).
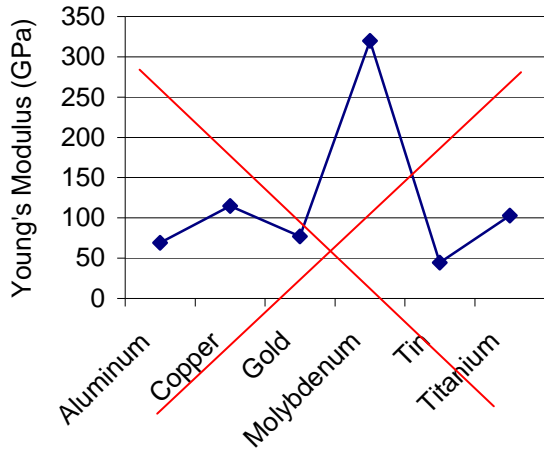

Figure 1 –Line chart of stiffness.

Figure 2 effectively communicates relative magnitudes of independent parameters. Logically organize the order of presentation (ex. least to greatest).
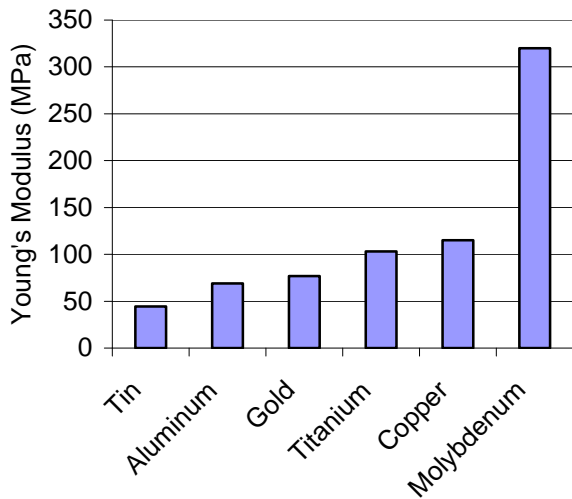

Figure 2 – Column chart of stiffness.

A table, such as Table 1, effectively communicates specific values relevant for engineering analysis.

Table 1 – tabulated stiffness.

Metal	Modulus of Elasticity (MPa)
Aluminum	69
Copper	115
Gold	77
Molybdenum	320
Tin	44.3
Titanium	103

3. *The purpose of this laboratory was to determine the effect of carbon content on the hardness of martensitic plain carbon steel.*

To communicate *expected* trends, use trendlines rather than drawing lines through the data points (connect the dots). Note that trendlines do not necessarily go through the data points. Figure 3 is an example of an **inappropriate** trendline (5-th order polynomial). Why is it inappropriate?
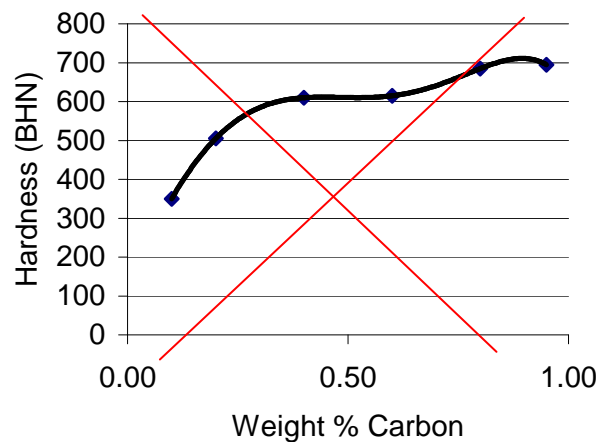

Figure 3 – XY Scatter plot with 5th order polynomial fit. (**Improper** trendline).

A more **appropriate trendlines represents what you expect the behavior to be**. In this example, the results may be logarithmic in nature, so use of a logarithmic trendline is a reasonable selection (Fig. 4). Nature rarely (ever?) behaves as a 5th order polynomial.
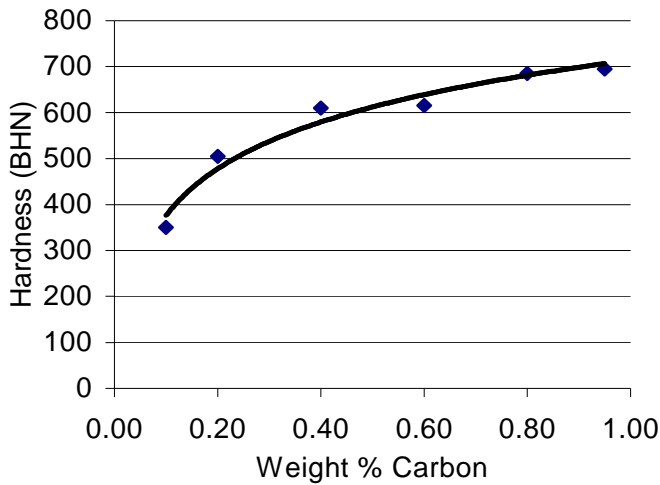
Figure 5 – logarithmic time scale.

Figure 4 – XY Scatter ploy with logarithmic trendline.

Note, Excel's options are limited and do not always allow for adequate trendlines. In such cases, use French curves, neatly free-hand or use curved lines in the Excel drawing package.

Figure 5b – linear time scale

4. The purpose of this laboratory was to determine the effect of tempering time on the hardness of AISI 1080 steel.

Some data is best displayed on logarithmic scales. The trendline created for Figure 5 was logarithmic. It looks like a straight line because of the logarithmic time scale. This allows the small values to be resolved. **Linear time scale (Figure 5b) does not allow for small times to be resolved**.
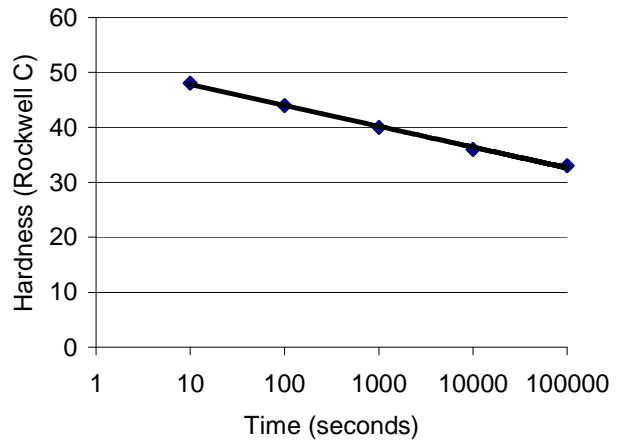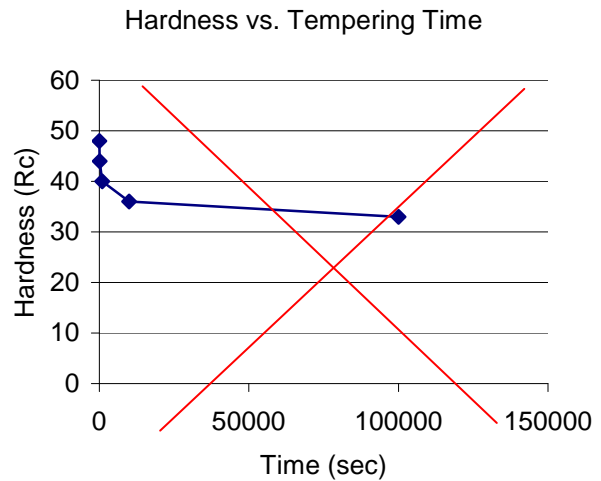
5. *The purpose of this laboratory was to determine the effect of temperature on the yield strength of AISI 1040 steel.*

Figure 6 shows three sets of data. There is no relation between the three columns of data. Lines should **not** be used to connect them. This gives the false impression that the samples in the first column are related to each other. Also, "connect the dots" does not communicate expected trends effectively.
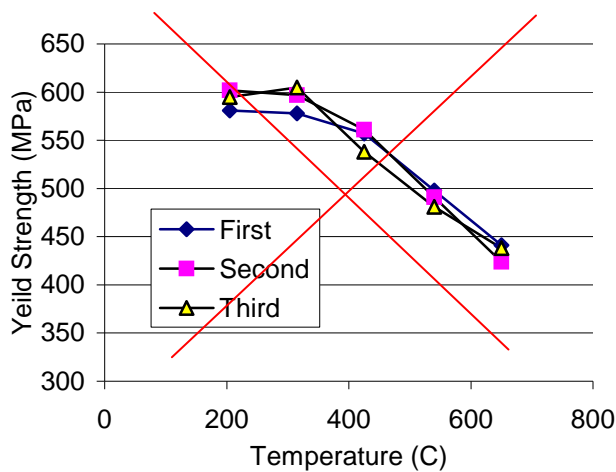

Figure 6 – lines connecting the three columns of data

Figure 7 is a better communication tool for this data. A fourth column was created in Excel consisting of the averages of the three sets of data. All four sets of data (the original data and the averages) were plotted as a function of temperature. The markers for the original data were changed to all be "o" and no line is used to connect them. A trendline (2nd order polynomial) was created for the averaged data (select the average data points, then go to "*charts*" "*add trendline*"). After creating the trendline, *no marker* and *no line* options were selected for the averaged data (so it does not show up). This is a good way to

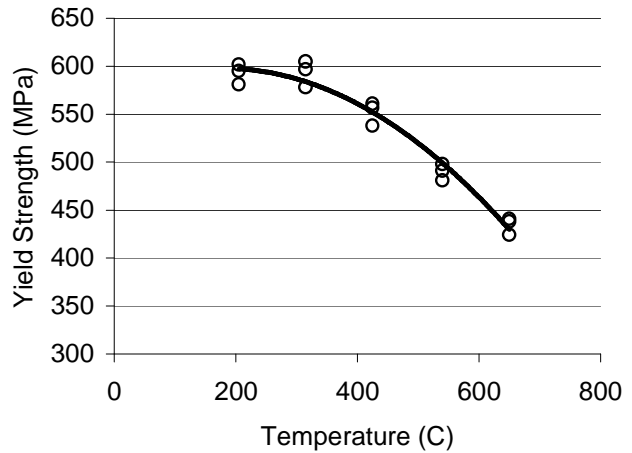represent trends with multiple repeated data points.

Figure 7 – trendline used to show the results.

6. *The purpose of this laboratory was to determine the effect of carbon content on the strength and ductility of plain carbon steel.*

Figure 8 effectively communicates the results. Note that the ductility values are on a secondary axis (since they are much lower magnitude than the strength values). This can be accomplished by right clicking on the data and selecting the "secondary axis" tab.
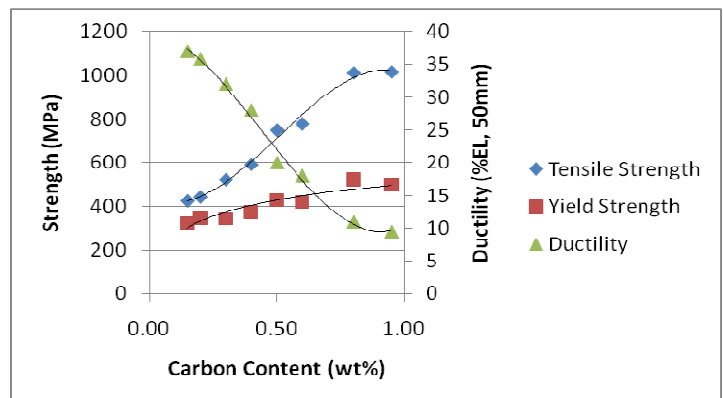

Figure 8 – effect of carbon content on properties of steel.