NOTES ON WRITING A LAB REPORT

Report Format
Technical reports follow a standardized format and as technical writers you must also use this format. Although specific requirements vary by discipline and type of publication the general format for reports is:

- Title page
- Abstract
- Introduction
- Results
- Discussion
- Conclusion
- References
- Appendix

We are asking you to follow a specific format for this course. Each of your lab reports will contain some of these elements. Each section of the report, except the title page, is titled with the appropriate heading, e.g. Abstract. Specific lab report instructions are located at the front of each lab background unit. Your reports will not all contain each of the sections listed above; your lab report score is based on the point distribution shown in the report instructions for that lab.

The report instructions for each lab are at the front of each lab background unit. Refer to this section for more specific instructions on each part of the lab when preparing your reports. Appearance, neatness, spelling, etc. matter and count toward your lab report score.
THE TITLE PAGE

The title page should contain all the important details of the who, what, and when of when the work was done. A sample format is shown.

Title
Course and Section number
Lab instructor’s name
Date Experiment performed

Your name
Lab Partners
Report Due Date
THE ABSTRACT

An abstract is not a summary. An abstract is a brief statement of the contents of a scientific or technical work. It is one of the most important parts of the paper because a prospective reader will look at the abstract and then decide whether or not to read the entire paper. Some professionals say they don’t have time to read entire papers. Instead, they skim over the abstract and decide on that basis whether to read the paper or not. The writer must, therefore, select the most important points and express them clearly and concisely. Specifically, the abstract should include brief statements of the objective, results, conclusions and implications of the work.

The format is traditionally one paragraph with a maximum of about 200 words. It is a very condensed account of why the work was done, what was done, and specific results and/or conclusions.

Sample 1

Abstract

A tensile test was performed on a standard 0.505 inch 4140 steel sample. The hardness was measured as 96 R<sub>B</sub>. Properties determined from the data include: Young’s Modulus (29.5 x 10<sup>6</sup> psi), yield strength (92 x 10<sup>3</sup> psi), ultimate tensile strength, UTS, (147 x 10<sup>3</sup> psi), breaking strength (108 x 10<sup>3</sup> psi), % reduction in area (46%), and % elongation (20%). The experimental values agree well (within 10%) with literature data. The UTS was predicted from the measured Rockwell hardness. The predicted value agreed well with both the experimental and literature data. Hardness can be used as an indicator for metal strength.

Sample 2

Abstract

A portion of a lead-“unknown” phase diagram was constructed from cooling curves of three alloy samples with different compositions. The micro-structure was examined for each of the samples. From these data, the unknown element was determined to be tin. The region of the Pb-Sn phase diagram surrounding the eutectic and including the sample compositions was constructed. This procedure demonstrates a method by which phase diagrams for binary alloy systems can be constructed.
THE INTRODUCTION

The introduction defines the basic problem and the scope of the investigation being reported. It includes background information and answers such questions as: Why was this experiment performed?, What information can be generated from the results of this experiment?, and How would an engineer find this information useful? The introduction also includes a brief statement of what was done in the lab. For E 45 purposes the Introduction may be as short as a paragraph or as long as a page. (Keep it as short as possible.)

Example:

Introduction
Metallographic studies are often performed to more completely characterize material systems. Grain size, phase distribution and phase amount can be determined and used to predict the material's physical properties such as strength and electrical conductivity.

There are various methods for determining grain size, including the intercept method and optical comparator. Both of these methods were used to determine an average grain size for a BCC transformer iron specimen and an FCC 70-30 brass specimen.

Phase distribution and phase amount are important aspects of many metallographic studies. The point count method can be used to determine phase amount as a volume fraction. By using the volume fraction and the densities of each phase, the alloy density can be determined. A ferritic nodular cast iron (FNCI) specimen was examined and the average graphite particle size was measured. Using the point count method, the phase amounts of iron and graphite were calculated.

An important step in any microscopic study is to determine the actual specimen dimensions. Specimen dimensions can be obtained by knowing the magnification. An electronic microcircuit on a silicon wafer was examined and calculations of the actual dimensions were made.
RESULTS

The results section is a summary and may consist of your completed data sheets and/or a table of your important results with a verbal description of how they were obtained. This section contains the significant results obtained from the data collected in the experiment. You would not include long lists of numbers (raw data); those data belong in an appendix.

You should compare your experimental results to literature values. The data you collect are the best available for your sample. Literature data are not theoretical but are measured data obtained at many different places, from many different specimens, over many years. For example, properties of 4140 steel made today will not be identical to properties of 4140 steel made in 1960. Literature data give engineers a reasonable idea of the properties they can expect from a material, but if critical components are being designed (i.e. if failure of the component would result in people getting hurt or other major damage) the properties of the actual materials that are being used must be determined experimentally.

Most of your data should be within about 20% of the literature values. Look to see if the differences are consistent, e.g. a stronger sample may show lower ductility. You must use proper citations for your literature values. If all literature values are from the same source one citation is sufficient, otherwise they should be cited individually.

To calculate the % difference in your data compared to the literature data use the following formula:

\[
\% \text{ difference} = \frac{\text{experimental value} - \text{literature value}}{\text{literature value}} \times 100\%
\]

If the experimental value is larger than the literature value the % difference will be positive; if the experimental value is smaller than the literature value the % difference will be negative.
**Constructing a Table:**

Tables are commonly used in scientific and technical reporting to display a large amount of information in a small area. A table should be neatly constructed and titled with the entries clearly labeled so that a reader can easily spot the values of interest or any significant trends in the data.

**Example:**

**Results**

Table I

Experimental and Literature Data for 1100 Aluminum

<table>
<thead>
<tr>
<th>Property</th>
<th>Experiment (O-Temper)</th>
<th>Literature* (O-Temper)</th>
<th>% difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elastic Modulus (psi)</td>
<td>9.5 x 10^6</td>
<td>10 x 10^6</td>
<td>5.0</td>
</tr>
<tr>
<td>Yield Strength (psi)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2% offset</td>
<td>4.6 x 10^3</td>
<td>5 x 10^3</td>
<td>8.0</td>
</tr>
<tr>
<td>Ultimate Tensile Strength (psi)</td>
<td>11.9 x 10^3</td>
<td>13 x 10^3</td>
<td>8.5</td>
</tr>
<tr>
<td>% Elongation over 2 in.</td>
<td>43</td>
<td>45.2</td>
<td>4.4</td>
</tr>
</tbody>
</table>


In general, the experimental results agreed well (within 10%) with the literature data. The elastic modulus was obtained from the stress-strain curve \((E = (s/e))\) and was calculated to be 9.5 x 10^6 psi. The literature value, 10 x 10^6 psi\(^1\), is only 5% different from the experimental result. The 0.2% offset yield strength and the ultimate tensile strength (max. load/\(A_0\)) were read directly from the stress-strain diagram and were found to be 4.6 x 10^6 psi and 11.9 x 10^6 psi, respectively. The literature value for the yield strength was 5 x 10^6 psi\(^2\), only 8% different from the experimental result. The literature value for the ultimate tensile strength, 13 x 10^6 psi\(^2\), was 8.5% different from the experimental result. The % elongation was calculated from the initial length (2 in.) and the final length of the specimen, and was 43%. The literature value, 45%\(^2\), differed from the experimental result by 4.4%. The close agreement of the literature and experimental data indicates that the sample was the correct alloy, was prepared properly, and that the test was performed accurately.
PREPARING GRAPHS:

Graphing conventions are not immutable laws, they are preferred standards. Deviating from such standards may be necessary or sensible occasionally, but if the rules are broken too often, others get confused or doubtful of the rule breaker’s common sense. To avoid having people raise eyebrows in confusion (or derision) over your graphs, use the following notes which outline some common conventions for preparing graphs. Most graphs are simple plots of two variables using standard or logarithmic graph paper. These notes are designed specifically for this type of graph.

Labeling Axes and Graph

1. Generally the independent (controlled) variable is plotted on the abscissa: the dependent (observed or measured) variable is plotted on the ordinate.
2. Note that, alphabetically, the words abscissa, x-axis, and horizontal all go before the matching words ordinate, y-axis, and vertical.
3. Use the unabbreviated form of the variable for labeling the axes. Include its symbol and units if applicable.
4. Use consistent units for all variables.
5. Write the axis label for the ordinate along the edge of the ordinate from bottom to top so that it would read left to right if the page were rotated 90º clockwise.
6. Arrange the plot so that it is approximately centered on the page. Use a slightly larger left hand and bottom margin to account for binding, stapling, page numbering, etc. In any case, a margin of at least one inch must be provided.
7. The title should not just restate the axes, yet it should be fairly brief. “Variation of Pressure with Depth in Tank B” is much better than “P vs. Z” or “Pressure vs. Depth”.
8. For the axes and graph title, all capitals or capitalized/lower case writing is preferred.
9. If the data fit it is usually most convenient to construct your graph so it can be mounted with the abscissa on the short edge of the paper and the ordinate on the long edge (Fig. 1) – it is more convenient if you don’t have to turn the page to look at the graph.

Figure 1
10. If your graph is constructed so it has to be turned to put it in your report, rotate the graph 90° counter-clockwise to mount it in your report (Fig. 2).

**Setting Scales**

1. Start at zero on each axis and continue up from zero. If all of the data would end up clumped together by scaling from zero or if the empirical relationship at the zero point is unimportant, you may indicate a break in the axis near the zero point, and start again with an appropriate value.

2. Choose divisions of 1, 2, or 5, or power of ten multiples of 1, 2, or 5 for the smallest lines on the graph. It is occasionally very tempting to divide 25, 50, 75, or 100 by 4, but don’t succumb to the temptation because later you might want to read the value on the graph at 41, for instance, and it will be hard to do. Don’t let a computer give you difficult divisions – override it if necessary.

3. For logarithmic paper match the number of cycles in log paper to the range of data. For 2 orders of magnitude variation you will need 2 or 3 cycles.

4. Errors will look smaller when plotting on logarithmic paper.

**Plotting Data**

1. For empirical data, every point should have a symbol (?, ?, x are good) and all points representing the same set of data should have the same symbol.

2. Draw a curve which smoothly connects the data, or fits as closely as possible while balancing plus/minus deviations (a “best fit” line). If you are graphing by hand use a French curve or straight edge to get the nicest looking graph. A solid line is used to indicate certainty about the behavior of the sample; a dashed line is used to indicate a “best guess” or interpolation between widely spaced, known data points.

3. If there is more than one curve on the graph, use labels or a symbol key to differentiate between them.

4. When plotting an equation on the graph, draw a smooth curve without any specifically identified points.
**Using the Graph**

1. After your data have been plotted and the best fit line has been drawn, you should use the line you have drawn for any calculations. For instance if you need the slope of the line, you do not pick data points that are close to the line and evaluate the slope using them, but you pick convenient points that the best fit line goes through (not necessarily data points) for your calculations.
THE DISCUSSION

The discussion is the section of a report in which the interesting data and important results derived from the data are discussed; it may contain calculations as well as descriptions. It is usually the longest section of a lab report. You will use multiple paragraphs to elaborate upon your observations and their significance. You should write in clear, usable, everyday prose making use of transitional words and phrases to help the flow. Although you will be addressing a variety of points in your discussions you should attempt to make the descriptions and explanations transition into one another so the section seems to be complete, not just an agglomeration of unrelated topics.

Your discussion should start with a paragraph explaining the importance of the concepts and techniques studied in the experiment, however remember that the discussion is not a summary of what was done and is not an experimental procedure section. The lab report instructions for each experiment have listed several specific points that should be clearly and completely discussed. Although each of the specific points listed in the report instructions must be addressed, your discussion should not be just one line answers to questions or numerical problem solutions. In addition to the specific required answer you should always include a statement explaining what you are discussing and why it is important. Your explanations must always be complete.
SAMPLE CALCULATIONS

Sample calculations are needed to demonstrate how you obtained various quantities through manipulation of your data. You should show one example of each type of calculation: don’t show each repetitive calculation, only the results. The format may vary but you must:

1. Show the equations used.
2. Define the terms in the equation including units.
3. Show through dimensional analysis that the units of the terms in the equations will combine to give the desired units. (see Appendix A for instruction in dimensional analysis.)
4. Show the equation with one set of actual numbers inserted and the calculated result. Make sure you identify the test, sample, data points, etc. that are the source of the numbers.

Example:

Sample Calculations:

stress: \[ \sigma = \frac{F}{A_0} \]

where:
- \( s \) = engineering stress (psi)
- \( F \) = applied load (1bs)
- \( A_0 \) = original cross-sectional area (in\(^2\))
- \( A_0 = \frac{p}{4}d_0^2 \) where: \( d_0 \) = original diameter (in)

From the data collected in the tensile test of 1100 aluminum. data point 13:

\[
\sigma = \frac{7500 \text{lbs}}{\pi \left( \frac{0.505 \text{ in}^2}{4} \right)} = 3.74 \times 10^4 \text{ psi} = 37.4 \text{ ksi}
\]

(ksi = 10\(^3\)psi)