
MAE 171A
Mechanical Engineering Laboratory

Laboratory Report Writing

Lecture Notes

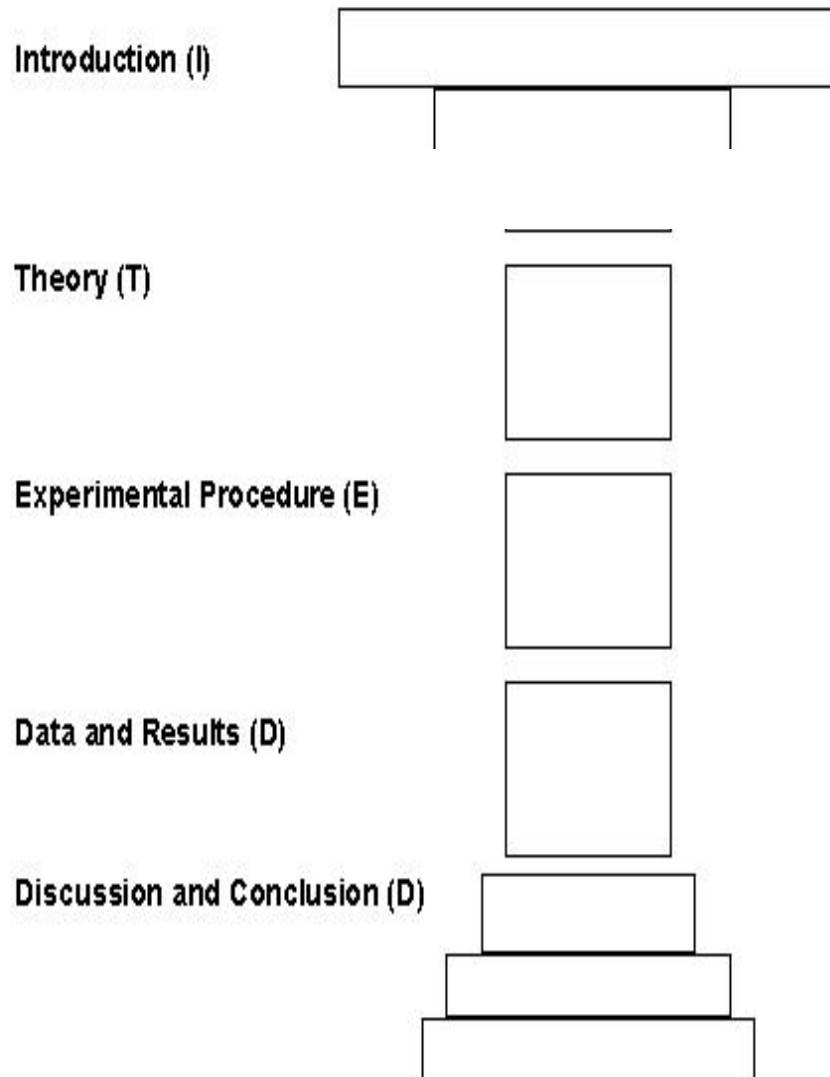
Introduction to lab report writing

- Concepts related to readers and writers
 - Why are you writing this document?
 - The goals are to persuade, inform and document
 - The academic purpose is the display of knowledge
- Concepts related to text
 - Features of
 - Content
 - Organization
 - Language
 - Format
 - determined by your audience and your purpose

Concepts related to text

- Content
 - the information contained in your document
- Organization
 - How the information is organized within the document
 - Paragraph organization
 - Sentence organization in the paragraph
- Language
 - Grammatical structures appropriate
 - Concise language (father's advice in the movie "A river runs through it")
 - Appropriate word choice
 - Error-free language ("good buy" and "goodbye", both will pass a spelling check)
- Format
 - Refers to the general appearance of the document (look at published papers/books/reports in your specific (e.g. medical, aerospace) area!)
 - Informative headings
 - Fonts used, bullets, bold, italics, etc.

The Shape of a Laboratory Report



Writing as one of a team

- If different people are writing different sections
 - One person should edit the final draft (a good report may come after many drafts) (**examples of great writers**)
- Team writing needs careful planning
- Groups should agree on the outline of the report before drafting starts
- **All the authors should read and approve the final version, each of them is responsible for the entire document (bad examples)**

The writing process

- Pre-writing
 - Generate ideas and organizing them via outlining, free writing and/or concept maps (personal approach is OK, handwriting is desirable, may be not well organized)
- Writing
 - Prepare draft to be compiled with the rest of the report for team members to review
- Revising
 - Each team member should have recommendations for changes in content, organization, language and format
- Editing
 - Reviewing the document for mechanical errors, unclear sentences, language that is not concise or is ungrammatical

The writing process - outline

First thing to do - outline your report

- Write each heading at the top of a sheet of paper
- Write all the points you can think of under each heading
- Find all your notes, figures, tables
 - It is very important to write every detail of the experiment which **others may need to repeat your experiment (negative example of paper on cold fusion)**
- Sort these out and put them with relevant sections

Structure of your laboratory report


- All pages must be numbered
- All figures and tables must have legends that describe them
 - *You should be able to look at a figure and table and understand what is being shown without having to refer to the text.*
- All references must be fully cited in reference sections
- As a rule no verbatim quotes allowed
 - Such as: Arnez stated in 1998 that “Fracture mechanics is a method for predicting failure of a structure containing a crack. It uses methods of analytical solid mechanics to calculate the driving force on a crack and those of experimental solid mechanics to characterize the material's resistance to fracture.”

Structure of laboratory report

- 20 page maximum
 - Including text, figures and tables
 - Double-spaced
 - Except for figure and table captions
 - 1 inch margins around each page
 - Use 12 point Times or Times New Roman font or 11 point Ariel or Georgia font
- Do NOT use a double-column page format (use single column)
- Appendix must include raw data. Why?

The structure of your laboratory report must have these major headings

- Title page separate sheet
- Abstract separate sheet
- Table of contents separate sheet
- List of tables separate sheet
- List of figures separate sheet
- Introduction
- Theory
- Experimental procedures
- Experimental results
- Discussion of results
- Conclusions
- Error analysis (can be part of discussion)
- References separate sheet(s)
- Appendices and raw data separate sheet(s)



20 pages
maximum
including
figures
and tables

Title page

- The title answers the question (compare to hologram)
 - What is the report about?
- The title should be
 - Interesting and inviting (*Gone with the Wind*)
 - Concise (*War and Peace*, even order of words is important)
 - Informative
 - Accurate
 - Include all group members, group number, group time

Examples of good and bad titles in outstanding classical scientific papers

- *Report on Waves*, by J. Scott Russel (1844, 92 pages)
- *On the Change of Form of Long Waves Advancing in a Rectangular Canal, and on a New Type of Long Stationary Waves*, by D.J. Korteweg and G. de Vries (1895, 22 pages).
- Try to improve this title. What about *New Type of Long Stationary Waves*?

Title page example

Water Tunnel **Measurement of the Drag Coefficient of a Cylinder** **(no words can be removed!)**

Presented to the
University of California, San Diego
Department of Mechanical and Aerospace Engineering
MAE 171A
Date

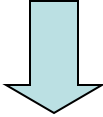
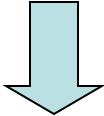
Prepared by:
Group X, Section A0X, Thursday afternoon
Names of group members

Abstract

- Is an abbreviated, accurate representation of the content of the report
 - Usually one paragraph
 - Why the experiment was done
 - How the experiment was performed
 - What pertinent results were obtained
 - Conclusion obtained from data analysis
 - Informative, quantitative, short, concisely written
- Do not refer in the abstract to information that is not in the report
- Use the third person
- Write this first section LAST!

Table of contents

- Each heading (see slide 10) must be listed
- Each heading must have a page number

Table of Contents	
List of Figures	Page 4
List of Tables	5
Introduction	6
	

List of figures

- Figures should be in numerical order, using the same legend as what is on the figure
- Figures need a page number

Figure	Description	Page number
1	Variation of the elastic modulus as a function of temperature	4

List of tables

- Tables should be in numerical order, using the same legend as what is on the figure
- Tables need a page number

Table	Description	Page number
1	Fracture toughness values as a function of tip radius for polycarbonate	6

Introduction

- Statement of the problem
 - Why did you do this work?
 - What is its purpose?
 - Why is it important?
- Tell the readers briefly what you examined
- Indicate your experimental approach
- Cite published work- demonstration of depth of your expertise
 - Who has studied this in the past and what results did they obtain?

Introduction

- Indicate the need for testing/experimental analysis
 - Include
 - A statement of the problem that is being investigated and any sub-problems **or**
 - A question that needs to be answered about the phenomenon under study
- Answer the need for testing/experimental analysis
 - Include
 - The method you'll employ to answer the question or solve the problem identified (i.e., What are you going to do?)
 - A description of the specific objective of the experiment
 - A statement of what will be covered in the report

Introduction editing worksheet

Area	Question	Y/ N	Comments
Content	1. Does the writer establish/identify the phenomenon studied and state its importance to the field of engineering? 2. Does the writer avoid <i>excessive</i> discussion of real-world applications? 3. Does the writer clearly state the objectives of the experiment?		
Organization	1. Does the introduction appear to be clearly organized? 2. Does the writer avoid unnecessarily long paragraphs?		<div data-bbox="1159 885 1787 1092" style="background-color: #e0f2f1; padding: 10px;"> Posted handout "Introduction" in Report Writing on website </div>
Language	1. Does the writer put old information before new information? 2. Does the writer use concise but specific language? 3. Does the writer avoid mechanical and grammatical errors?		

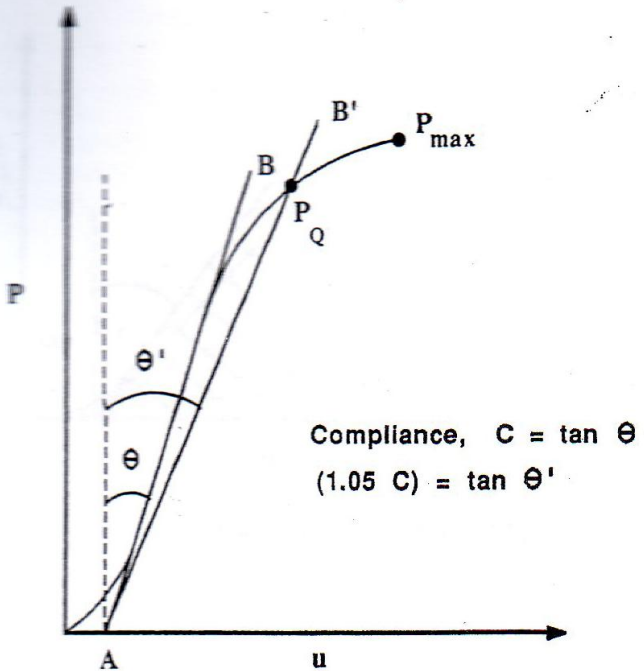
Theory

- Summarize the key theory concepts that are being used, examined, or tested in the experiment
 - Also summarize key theory equations used in data analysis
- Clearly state assumptions that are used in theory (*ALL theories have a limited range of application*)
- Point out possible regimes where assumptions might be violated in experiment
- Use figures or schematics as appropriate
- Cite relevant references to guide readers who need or want additional information

Experimental procedure

- Apparatus/Experimental
 - apparatus name
 - model numbers (serial numbers not necessary)
 - clearly-labeled diagrams
 - relevant measurements of items related to apparatus
 - table of experimental equipment used (refer to this in procedure, but place table in appendix),
 - UCSD-made equipment receives a descriptive name, and its origin (UCSD) is mentioned. (dept. requirement).
 - Procedure - step by step organization
 - *Procedure should be explained in enough detail to allow another researcher to duplicate your experiment.*
 - Carefully document the conditions of your experiment
 - Calibrations used
 - Methods used to obtain data (refer to appropriate ASTM standards)
- (*ALL experiments have limitations*)

Interpretation of results



NOTE 1— C is the inverse slope of line AB .

FIG. 5 Determination of C and P_Q

1. Draw a straight line AB
2. Draw a second line AB' with a compliance 5% greater than that of line AB
3. If maximum load that the specimen was able to sustain, P_{\max} , falls within lines AB and AB' use P_{\max} to calculate K_Q
4. If falls outside line AB and line AB' then use the intersection of line AB' and the load curve as P_Q , furthermore if $P_{\max} / P_Q < 1.1$ use P_Q in the calculation of K_Q
5. However if $P_{\max} / P_Q > 1.1$ the test is invalid

Did you get a valid value for K_{IC} ?

The following size criteria must be satisfied to accept value of K_Q (the conditional or trial K_{IC}) as K_{IC}

$$B, a, (W-a) > 2.5 (K_Q/\sigma_y)^2 ,$$

Where:

σ_y is the yield stress of the material in the condition of testing.

Otherwise the test is not a valid K_{IC} test.

The criteria require that B must be sufficient to ensure plane strain and that $(W-a)$ be sufficient to avoid excessive plasticity in the ligament

Procedure editing worksheet

Area	Question	Y/N	Comments
Content	1. Does the writer state the location of the experiment? 2. Does the writer describe the apparatus or experimental setup? 3. Is the procedure described in enough details to be repeated if necessary, without adding irrelevant information?		
Organization	1. Are there enough informative headings? 2. Does the section have clear paragraphs covering one topic?		<div data-bbox="1304 892 1818 1229" style="background-color: #e0f2f1; padding: 10px;"> Posted handout "Experimental Procedure" in Report Writing on website </div>
Language	1. Does the writer avoid the use of "we" and use the passive voice? 2. Does the writer avoid mechanical and grammatical errors (e.g., dangling modifiers)?		

Results

- You are answering the question
 - What did you find and see?
- Write this section so that it stands on its own
- Emphasize results that answer the question(s) you are examining
- Put secondary results after primary ones
- Don't repeat in the numbers that are presented in the tables and figures in the text
- Don't repeat the table and figure titles in the text
- **Include error analysis**

Results editing worksheet

Area	Question	Y/N	Comments
Content	<p>1. Does the writer use a location element/summary (with figure number(s)) to introduce a figure (usually at the top of the page)?</p> <p>2. Are <i>appropriate</i> results highlighted? (i.e., those specified in the lab handout)</p> <p>3. Are <i>appropriate</i> explanations of results provided, without going into detail about larger conclusions?</p>		
Organization	<p>1. Are enough informative headings used?</p> <p>2. Does the section have clear paragraphs covering one topic?</p>		
Language	<p>1. Does the writer use a variety of verbs in the location summaries (e.g., shows, indicates, provides, etc.)</p> <p>2. Does the writer use concise but specific language?</p> <p>3. Does the writer avoid grammatical and mechanical errors?</p>		

Posted handout
"Results" in Report
Writing on website

Discussion

- In this section you are answering the question
 - What do your findings mean?
- This section is where you answer specific question(s) you stated in the introduction
- Discuss errors in your methods and assumptions
- Avoid the temptation to refer to every detail of your work again

Discussion

- Restatement of significant results in a more general format, then
 - Citing agreement or disagreement with theory
 - Citing agreement or disagreement with previous studies
 - Admitting difficulties in interpretation
 - Pointing out discrepancies
 - Try to explain anomalous results (*may lead to discovery!*)
 - Commentary on whether results are expected or unexpected
 - Commentary about the significance or implications of the results

Options for opening the Discussion section

- General conclusion
 - Apparently, the area is in the early phases of a classic population explosion
- **Restatement of the original purpose**
 - **The objective of the survey was to quantify the number ofwithin...**
- Summary
 - This report brings together all known records of since 1959.
- **Mention of theory**
 - **The results obtained from this experiment would appear to support the theory which states that.....**
- Use the last sentence of your introduction (if appropriate)

Discussion - limitations of research scope

- This experiment has tested...
- The results of this experiment address only the question of...
- This analysis has concentrated on...
- The results of this experiment are restricted to...

Verbs often used in the discussion section

show

provide

give

present

summarize

illustrate

reveal

display

demonstrate

indicate

suggest

Discussion editing worksheet

Area	Question	Y/ N	Comments
Content	1. Does the writer use points instead of facts (e.g., explanations, interpretations, conclusions) 2. Does the writer discuss the major limitations of the experiment? 3. Are all of the major trends/conclusions made?		
Organization	1. Is the organization of the section (minor conclusions to major conclusions or major to minor) logical? 2. Does the writer use enough informative headings?		
Language	1. Does the writer use concise but specific language? 2. Does the language "flow"; i.e., does the writer put old information before new? 2. Does the writer avoid grammatical and mechanical errors?		

Posted handout "Discussion" in Report Writing on website

Conclusions

- Some readers will only read the conclusions
- Conclusions should be succinct and are a statement of your main findings (not a discussion)
- Conclusions should contain strong verbs
 - Use 'show' and 'indicate'
- Identify speculation by using 'might' with the verb
- After the conclusions
 - At the end, acknowledge briefly any substantial help

References

- Use the AIAA format for references
- References must be easily accessible in libraries or other public sources.
- They are to be numbered in the order in which they are cited in the text.
- Use references to ASTM standards, e.g.,
 - D 5045-99 (Reapproved 2007) – Standard Test Methods for Plane-Strain Fracture Toughness and Strain Energy Release Rate of Plastic Materials
 - D 2990-01 – Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics

Importance of Testing Standards

- **Army recalls 16,000 body armor sets amid testing dispute (CNN, January 28, 2009)**
- **Secretary of the Army disagrees with Defense report citing flawed test procedures**
- **Army and inspector general at odds over a testing step called "first article testing"**
- **Recall represents only about 1.6 percent of the 1.9 million sets in use since 2001**

Reference formatting (all available information)

- ***Journals***

- Walker, R. E., Stone, A.R., and Shandor, M., "Secondary Gas Injection in a Conical Rocket Nozzle," *AIAA Journal*, Vol. 1, No. 2, 1963, pp. 334-338.
 - Note: Title of article is in quotation marks and name of journal is italicized.

- ***Books***

- Turner, M.J., Martin, H.C., and Leible, R.C., "Further Development and Applications of Stiffness Method," *Matrix Methods of Structural Analysis*, 1st ed., Vol. 1, Wiley, New York, 1963, pp. 6-10.
 - Note: This is an article published in a book containing a collection of articles. The title of the book is italicized, and the title of the article is given in quotation marks.

Reference formatting

- **Book Series**

- Sutton, K., "Air Radiation Revisited," *Thermal Design of Aeroassisted Orbital Transfer Vehicles*, edited by H.F. Nelson, Vol. 96, Progress in Astronautics and Aeronautics, AIAA, New York, 1985, pp. 419-441.

- **Reports**

- Book, E., and Bratman, H., "Using Compilers to Build Compilers" Systems Development Corp., SP-176, Santa Monica, CA, Aug. 1960.

- **Transactions/Proceedings**

- Soo, S.L., "Boundary-Layer Motion of a Gas-Solid Suspension," *Proceedings of the Symposium on Interaction Between Fluids and Particles*, Vol. 1, Inst. of Chemical Engineers, New York, 1962, pp. 50-63.

Reference formatting

- ***Proceedings Papers***

- Bhutta, V.A., and Lewis, C.H., "Aerothermodynamic Performance of 3-D and Bent-Nose RVs under Hypersonic Conditions," AIAA Paper 90-3068, Aug. 1990.

- AIAA does not give a format for the citation of Web pages. The American Psychological Association publication manual, which is widely used in the social sciences, provides guidelines for citing Web pages. A modified version which you may find helpful is provided below.

- ***Web pages***

- Author, I. (date). "Title of article." *Name of periodical* [Online]. Available: Specify path. Accessed on: date of access.

Appendix

- Lengthy material related to your report
- If you cite published work in the appendix, it must be added to your reference list
- Include your raw data

Preparing effective figures and tables

- Readers often look at figures and tables to see what the report is about
- Each figure and table:
 - **MUST BE CAPABLE OF STANDING ON ITS OWN WITHOUT REFERENCE TO THE TEXT!!**
- Decide if you want to present your data in a figure or a table

Table size and format

- A table consists of a
 - Title
 - Column headings
 - Row or side headings
 - Explanatory notes
- Decide if the data presented in the table could be better presented in a graph
- Keep the structure as simple as possible, but not simpler!

Tables

- Decide what tables you need
- Design separate tables for separate topics
- Do not use tables to show off how much data you have collected
- Don't repeat data in tables if you are using the data in the text or in a figure
- **NEVER INCLUDE A TABLE THAT IS NOT REFERRED TO IN THE TEXT**

Example

Table 1 Diseases in three species of fish in lakes in North Wales

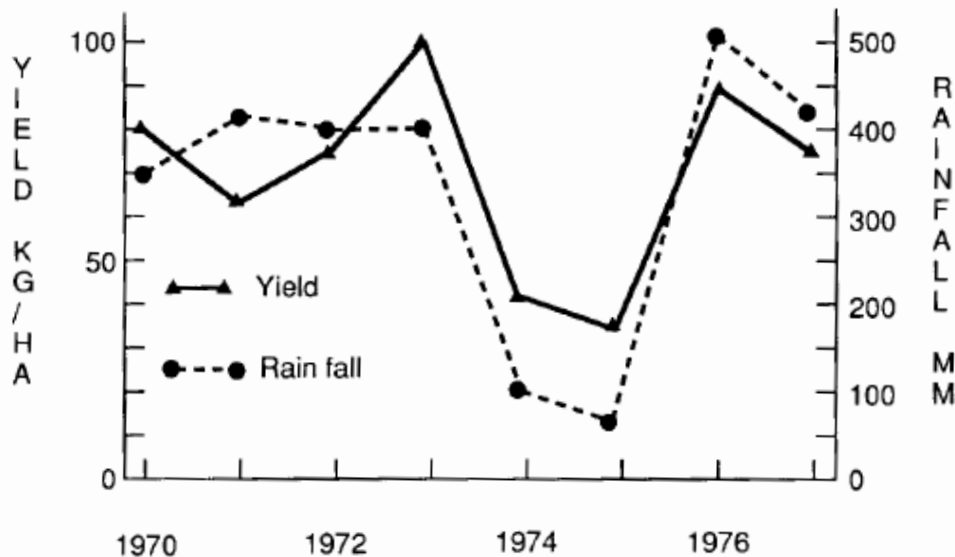
Disease	Species	Habitat
X	A	Lake 1
X	C	Lake 3
Y	A	Lake 1
Y	B	Lake 2
Z	C	Lake 3

We can see that: species A in lake 1 was affected by diseases X and Y, species B in lake 2 by disease Y, and species C in lake 3 by diseases X and Z.

Figures

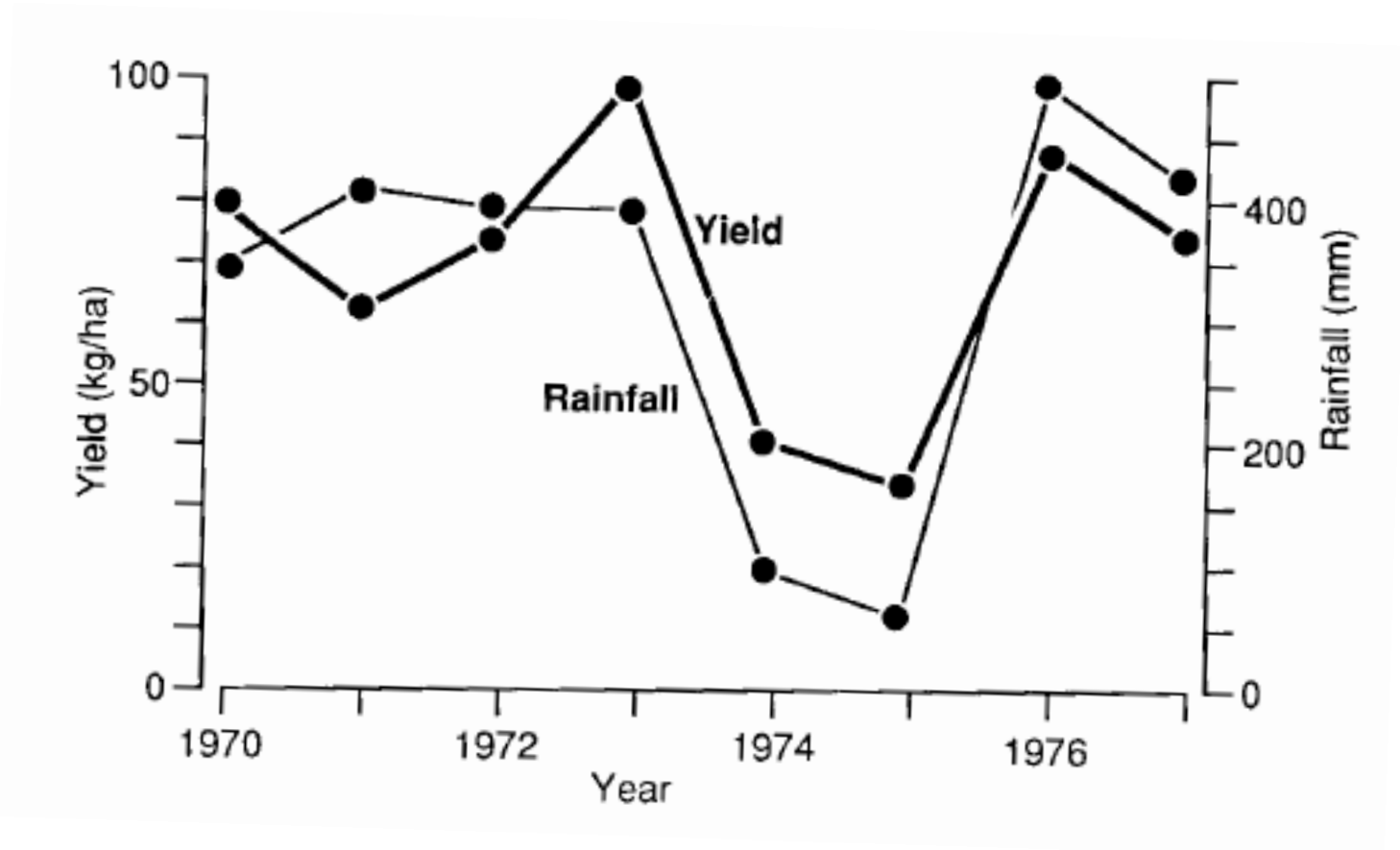
- Decide what figures you need
- Figures are meant to demonstrate evidence vividly
- Springer-Verlag recommends to place figures at the top of the page
- Figures must be simple and clear
 - Label axes simply and clearly
 - Scales should be appropriate, if two scales are present make an insert
 - Mark scale calibrations clearly
 - Make lines and curves clear and label; differentiate them clearly
 - Number and identify the figure in the text
 - **NEVER INCLUDE A FIGURE THAT IS NOT REFERRED TO IN THE TEXT**

Bad Example



- Messy looking
- Key has double symbols
- Vertical lettering difficult to read
- Lettering in all caps produces unrecognizable abbreviations
- Lettering placed too far below x-axis
- No units are given for x-axis
- Ticks inside axes can be confused with data
- No legend

Better example of the same figure



Another bad and good examples

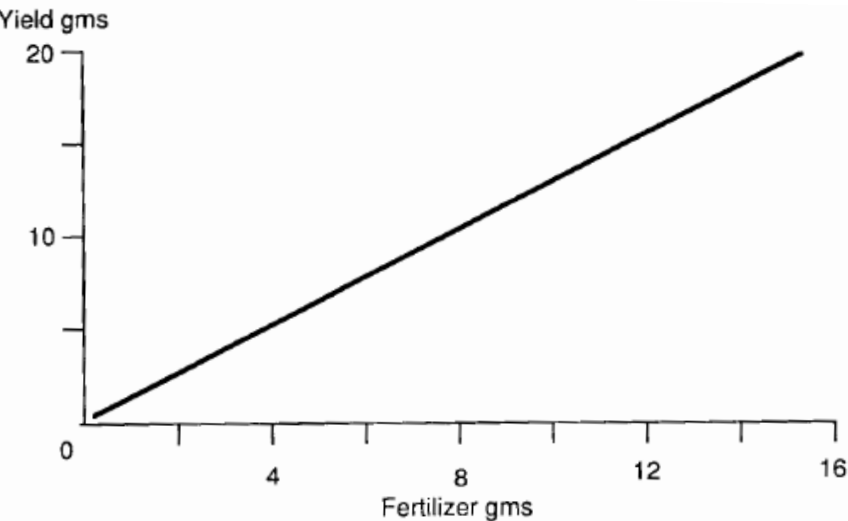


Figure 4.5 Another faulty graph: (1) regression line suggests that yield increases direct proportion to the amount of fertilizer added, but neither the experimental values nor indications of their accuracy are given; (2) 'gms' is not a recognized abbreviation.

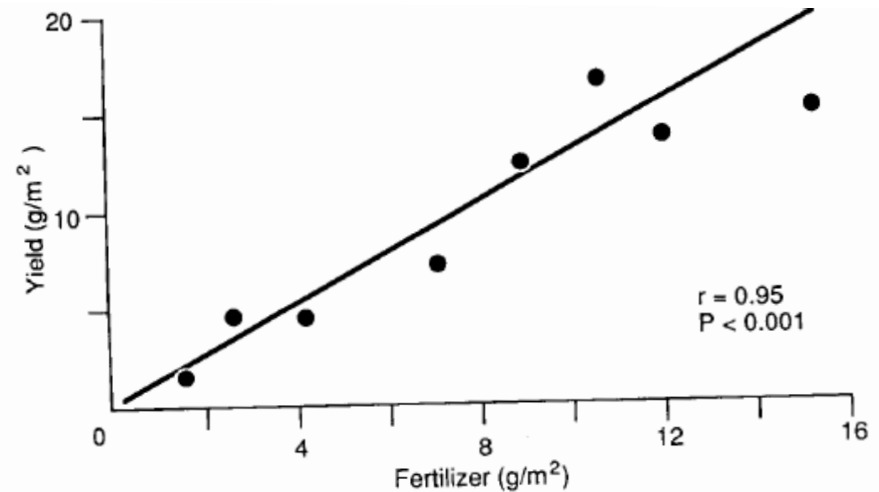


Figure 4.6 Clearer and more informative presentation of Figure 4.5: (1) individual points and regression data are given; (2) units are correctly expressed (in the singular, placed between parentheses); (3) P and r values are included (but may be omitted from slides).

No data points
No error analysis
Units confusing

Notes on language

- Make sentences more specific
 - Usually found during editing
 - Be sure to match the amount of detail with needs of audience
 - “During the test the sample was cooled.”
 - “During the test, the sample was placed in an ice bath.”
 - The information should be enough to repeat the experiment
- Keep your sentences to 10-20 words

Notes on language

- Use only the third person
 - e.g. do not use “We found...” or “We measured”
- Do not use acronyms without first defining them
- Use SI units
 - kg, m, J, N etc.
- Write in the past tense
- Write in an active voice, rather than a passive one
 - Conveys more excitement and is more concise

Passive vs. active verbs

- Use of passive verbs
 - Longwinded
 - Dull
- Long sentences make reading difficult
- Active verbs make your sentences simpler, clearer, less awkward and more concise

Passive and active voice

The experiment was conducted so that the relationship between the two theories could be examined. First, the cultures were prepared and then were examined under the microscope to see if any impurities could be found. Once the purity of the samples could be established, they were used in six independent tests. (51 words)

The experiment examined the relationship between the two theories. First, microscopic examination for impurities isolated pure examples used in six independent tests. (22 words)

Nominalizing

- Avoid excessive nominalizing
 - Forming nouns from verbs
 - When you make the noun 'acceleration' from the verb 'accelerate' you are nominalizing
- Technical writing often contains a lot of these nouns
 - Makes the document harder to read
- Look for ways to make the statement more directly
 - "Regeneration of the resin bed is achieved by a calcium chloride solution."
 - A calcium chloride solution regenerates the resin bed."

Stacked modifiers

- Avoid stacked modifiers (noun stacks)
 - Two or more nouns jammed together in a phrase - makes reading difficult
 - The underground *plant effluent soil contamination* did not threaten the environment.
 - This underground soil contamination by the plant effluent did not threaten the environment.
- To unstack noun stacks, you spread the information out into phrases and clauses and convert some of the nouns to verbs

Dangling modifiers

- Avoid dangling modifiers
 - Modifies a word not clearly stated in the sentence
 - Having finished the lab experiment, the light was turned off
 - Who finished the lab experiment?
 - Having finished the lab experiment, the student turned off the light
- Dangling modifiers leave unanswered questions

Title Page	<i>Part of Overall Impression</i>	
Abstract		5%
Table of Contents	<i>Part of Overall Impression</i>	
List of Tables	<i>Part of Overall Impression</i>	
List of Figures	<i>Part of Overall Impression</i>	
Introduction		10%
Theory		10%
Experimental Procedure		10%
Results		15%
Discussion		20%
Conclusions		10%
Error Analysis (can be part of Discussion)		10%
References	<i>Part of Overall Impression</i>	
Appendices and Raw Data	<i>Part of Overall Impression</i>	
Overall Impression		5%
Presentation and clarity of Figures and Tables		5%
Total Points		100%

Submitting the lab report

- The lab report is due one week after you have finished the entire 3-week lab assignment during your regular lab section
- **Reports are due at 3pm with the TA of their experiment one day BEFORE the start of new experiment**
 - ↳ Late labs will be graded with a significant point reduction!
- *You MUST also submit an electronic version of the report to laboratory staff*

Recommended texts

- ***Writing for Engineers and Scientists***

- ℳ Alley, Michael (1987). The Craft of Scientific Writing. Englewood Cliffs, NJ: Prentice-Hall.

- ℳ Paradis, J.G. and Zimmerman, M. (1997). The MIT Guide to Science and Engineering Communication. Cambridge, Mass.: MIT Press.

- ***Style Guides & Writers' References***

- ℳ Alley, Michael (1999). The Craft of Editing: A guide for managers, scientists and engineers. Englewood Cliffs, NJ: Prentice-Hall.

- ℳ Alred, G., et al. (2000). The Handbook of Technical Writing. St. Martins Press. [New edition to be published February 2003.]

- ℳ Hacker, D. (2000). A Pocket Style Manual. Bedford/St. Martins.

- ℳ Raimes, A. (2002). Keys for Writers: A brief handbook. Houghton Mifflin Publishers.

- ℳ Strunk and White (2000). The Elements of Style, fourth edition. Boston : Allyn and Bacon.

- ***Writing for Research***

- ℳ Locke, L., et al. (1998). Reading and Understanding Research. Thousand Oaks, CA. Sage Publications.

Posted report writing handouts for more information

- On the website maecourses.ucsd.edu/labcourse you can find:
 - Report writing format and key elements of your report and the grading sheet
 - Descriptions and worksheets can be found for:
 - Introduction
 - Experimental Procedures
 - Results
 - Discussion

Plagiarism

- Plagiarism is defined as presenting someone else's work, including the work of other students, as one's own.
- **UCSD POLICY ON INTEGRITY OF SCHOLARSHIP**(<http://www-senate.ucsd.edu/manual/appendices/app2.htm>)
 - "No student shall plagiarize or copy the work of another person and submit it as his or her own work"
 - "The instructor shall determine the student's grade on the assignment and in the course as a whole."
 - **"Any breach of academic honesty may be considered grounds for failure in the course"**