Technical /Academic Writing

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Contents

Why Write

What would you tell the students to make them understand the value of writing to their future careers?

- Stress to students that writing in particular, and communication in general, are integral parts of professional practice for engineers.

- Students must realize that they will be judged by the quality of their writing and those judgments will influence the direction of their careers in terms of future assignments and responsibility.

- Impress upon the students the personal and intellectual value of the writing process itself.

"A man who has the knowledge but lacks the power clearly to express it is no better off than if he never had any ideas at all"
—Thucydides

WHY?

Introduction

Is there a difference between **Academic** & **Technical** writing? - YES

Knowledge of Topic	
Academic	Resides with evaluator e.g. *Supervisor, Peer Review, Editor*
Technical	Resides with the author

Purpose	
Academic	Demonstrate what is known about a topic
Technical	Execution of a task

Criteria of Evaluation	
Academic	Depth, logic, clarity, coherence, and grammar
Technical	Clear & succinctly as possible, easy to read & professionally presented

Audience	
Academic	Supervisor (Lecturer), Peer Review, Experts, Editors for Journal
Technical	Individual within management and engineers at workplace and clients

The author performs *academic/technical writing* to communicate **pertinent** information that is needed by the audience **to make intelligent decisions.**

Academic/Technical writing conveys specific information about an academic/technical subject to a specific audience for a specific purpose.

The words and graphics of academic/technical writing are meant to be practical: that is, to communicate a body of factual information that will help an audience understand a subject or enable them to execute a task.

Importance of Writing

More Nutshells

Academic/technical writing is a type of expository writing used to convey information for technical or academic purposes.

Highly structured form of writing.

Technical writing is **NOT** used to:

- **entertain;**
- **create suspense; and**
- **invite differing interpretations.**

Adoption of Format

A *technical report* follows a specific *layout* and *format* as specified by the organisation or in accordance with a known standard.

Some examples:

- ANSI/NISO Z39-18-2005 (R2010)
  Scientific and Technical Reports –Preparation, Presentation and Preservation
- IEEE Technical Report Template
- IET Guide to Technical Report Writing
- University Report Writing Guidelines

Writing....

Is it for you?

Is it for the audience?

It's for
THE AUDIENCE

Who Matters?

"Write with the door closed, rewrite with the door open. Your stuff starts out being just for you, in other words, but then it goes out. Once you know what the story is and get it right — as right as you can, anyway — it belongs to anyone who wants to read it or criticize it" –Stephen King

Would YOU be projected in your writings?

- Different individuals have different personalities, and different modes for communicating;

- Do not apply a canned formula to your technical communications, the result may be awkward; and

- Within the general structure of formal technical communication, there is room for your personality to show through.

Do we all see the world the same way: or do we filter facts based on our personal experience, bias & priorities?

Send feedback to check if your message has gotten through.

Being Relevant

Knowledge in the mind of Person A

Message containing information

Knowledge in the mind of Person B

Things to Dwell Upon

Who are my audience / readers?
- Conceive thoughts on their requirements (brief or comprehensive reports)

How familiar are they with the subject matter?

How familiar are they with the technical jargon & concepts?

How will my report be read?
- Hardcopy or computer screen

- .... . / ..-. .. .-. ... - / - --- / -.-
. .-. . - -.-. -- / - .... / --. .
- ... / .- / -.-. .... --- -.-. --- .-..
.- - . / . -- .-. .. .-.. / -- .

Academic/Technical Report Writing- they say...

Lecturers says...

Be **concise, precise & clear**

CEO says...

- is **valuable**
- be **factual**

Engineering Manager says...

remember the KISS Principle –keep it **simple** silly (and keep paragraph short)

Features of Effective Academic /Technical Writing

6Cs

01 **Clarity**
- Should be easily understood by your intended audience.

02 **Conciseness**
- It is clear without excess verbiage.

03 **Correctness**
- It is grammatically correct and text wise, where applicable, it follows convention.

04 **Comprehensiveness**
- All of the necessary information is present.
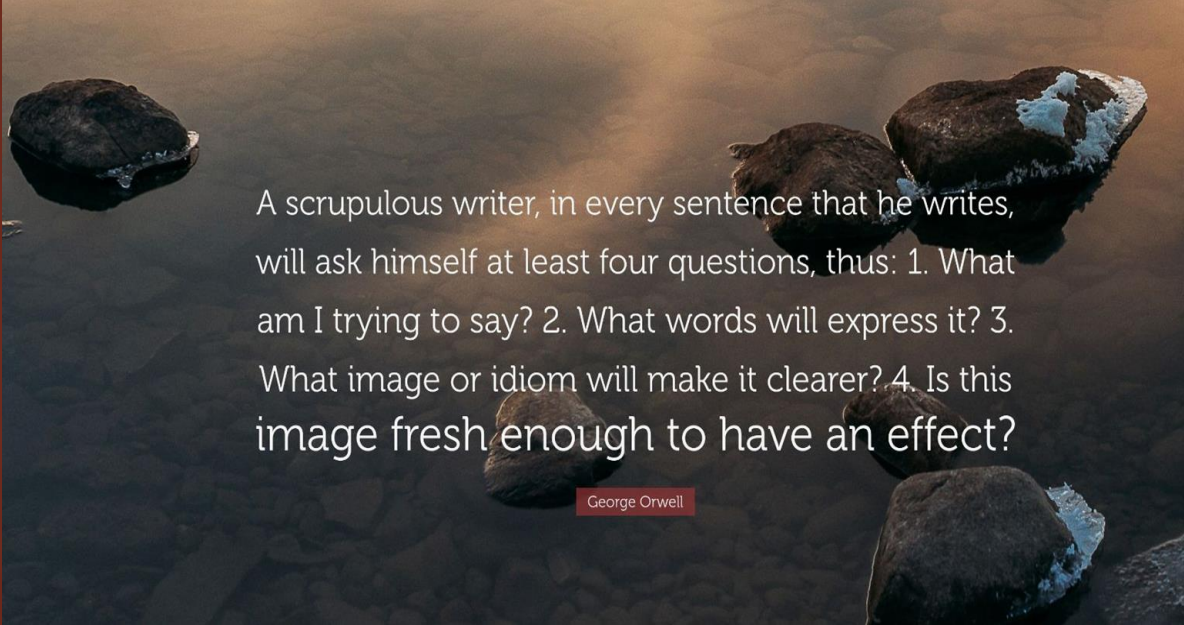
05 **Consistency**
- Create uniformity to a set of linked elements.

06 **Coherence**
- Sentences and ideas are connected and flow together smoothly.

Features of Effective Academic /Technical Writing

A scrupulous writer, in every sentence that he writes, will ask himself at least four questions, thus: 1. What am I trying to say? 2. What words will express it? 3. What image or idiom will make it clearer? 4. Is this image fresh enough to have an effect?

George Orwell

- "**The difference between** the **almost right word** and the **right word** is really a large matter—it's **the difference between** the lightning bug and the lightning" – Mark Twain

- "If you can't explain it simply, you don't understand it well enough" – Einstein

- "Simplicity is the ultimate sophistication" – Leonardo Da Vinci

Clarity

- should be easily understood by your intended audience.
- straightforward, logical, unambiguous

Avoid Jargon

- Jargon: a vocabulary particular to a place of work **(abbreviations, slang); and**
- **Audience familiarity** with the topic determines appropriate use of jargon.

Define the unfamiliar

- If you must abbreviate, define the term in its first occurrence, and *put abbreviations in parentheses; and*
- *Italicize first occurrence* of unfamiliar terms and define them right away.

The 6 C's

Conciseness

it is clear without excess verbiage.

- Use only necessary words and illustrations;
- Omit everything irrelevant to the results and conclusions;
- Report quality is inversely related to the report length;
- Quick / rapid access to conclusions and supporting evidence; and
- Not interested in any problem you had in getting the result (if do, this would hide the important aspects of the report).
- Do not condense reports at the expense of your reader's understanding;
- Do not assume that they will remember details of a previous report –or have even read it;
- Include all details needed to understand the current report; and
- Don't give the entire lecture module.

The 6 C's

Correctness

is grammatically correct and text wise, where applicable, it follows convention.

Free from grammatical errors, punctuations mistakes.

Appropriate format standard; and
- If the report is sloppy and has grammar errors –the reader may doubt the accuracy of your information, or at least lose their concentration.

Professionalism and ethical reporting

The 6 C's

Comprehensiveness

all of the necessary information is present.

- Provides all information the readers will need;
- Clearly describes the methods used to carry out the task, state principal findings, results and conclusion;
- Self-contained discussion;
- Clear awareness of the aspects that needs to be communicated; and
- Most important first.

The 6 C's

Consistency

Create uniformity to a set of linked elements.

- Consistency of naming conventions;
- Consistency of formatting & style; and
- Inconsistency can confuse your reader.

The 6 C's

Coherence

sentences and ideas are connected and flow together smoothly.

- Requires rigorous thought process;
- Logical ordering;
- Linking paragraphs;
- Linking Sections and Chapters; and
- A complete unit.

The 6 C's

Improving Writing Skills

- Writing is a skill that is developed and enhanced through practice.

- Be clear, direct and brief.

- Learn to revise and edit.

- Reviewing your own writing with a critical eye, and continually asking yourself, "Is this what I really meant to say?".

- Many students mistakenly believe that the first draft of a piece of writing is the final draft. In fact, a first draft should be viewed as the starting point of an alchemical process: the transmutation of something worthless into something of great value.

- The best way to learn to write decent technical report is to read good material.

Purpose & Planning

Define the **subject**, **purpose** and **audience**–may not seem like writing, but clarifying these items will help you write better and more efficiently.

Subject

Planning

Subject defines the **scope of the project**, defines the **boundaries of your work** –the kind of issues your project addresses and those it does not.

Purpose explains what the project will do

e.g.

- "The purpose of this project is to ….."
- "The objective is to …"
- "The primary aim of this project is to …"

Purpose contain for example the following:

- To explain problems or issues studied;
- Identify data collection, evaluation or research requirements;
- Identify key deliverables.

Purpose & Planning

Understanding your audiences will help you craft your documents more effectively and help you write more efficiently

Audience

01	**Primary Audiences (Actions Takers)**	• Report is addressed to them • Information provided will allow them to do something or make a decision
02	**Secondary Audiences (Advisors)**	• Secondary audiences are people who advise the primary audiences • Experts or those with special knowledge *e.g. Engineers, technicians and others to whom the primary audiences will turn for advice*
03	**Tertiary Audiences (Evaluators)**	• Include anyone else who may have an interest in your document's information • These are evaluators of you, your team or your company *e.g. Environmentalists, local reporters, or perhaps your company's competitors, therefore avoid saying anything that could put you or your company at risk*
04	**Gatekeepers (Supervisors)**	• People who will need to look over your document before it is sent to the primary audiences • Most common gatekeeper is your immediate supervisor

Purpose & Planning

6 Basic Questions

Audiences 6 Basic Questions	
What will we gain from reading your report?	Audience's responsibility, interests & goals
Are your facts reliable?	Must give sound basis for the decisions or actions
What do you know that is useful to us?	Not interested in what you know but only want to know information that is pertinent to the subject
How do you interpret those facts from our point of view?	Facts without relevancy are meaningless, so **you must** interpret them & identify the relationships or patterns among them, rather than leaving the work to them
How are those facts significant to us?	Not just interpretation, explain in terms of their interests and goals
What do you think we should do?	Since you wrote the report, there is presumption that you are qualified to make recommendation.

Purpose & Planning

Audience use only the summary or abstract

Audience check for specific sections of information

Audience scan the document, pausing at key words phrases

Audience study the document from beginning to end

Audience evaluate the document critically

Purpose & Planning

You know your PURPOSE, now

- Know your subject matter;
- Understand the writing task; and
- Organise your thoughts and materials.

Strategic Planning

- List all objectives;
- Identify the objectives in order of primary, secondary and etc.;
- Turn objectives into "outcomes" and "deliverables";
- Outcome: results of your projects; and
- Deliverables: tangible products or services that you will deliver to the client during the project and when it is completed.

e.g. of a Table

Objectives	Outcomes	Deliverables

Planning

- Check for any requirements for layout / presentation style. Are there specific instructions to observe? If the report is going to be published, e.g. type-set requirement by publisher. Are there any presentation rules and requirements?

- Check that you have gathered all data, pictures/ images that you consider relevant.

- Ensure you do not include unnecessary information (e.g. read your requirements which may given guidance on what is not expected).

- These considerations will determine your report's content, organisation, textual and visual design.

- All these serve as a plan in place for the first DRAFT.
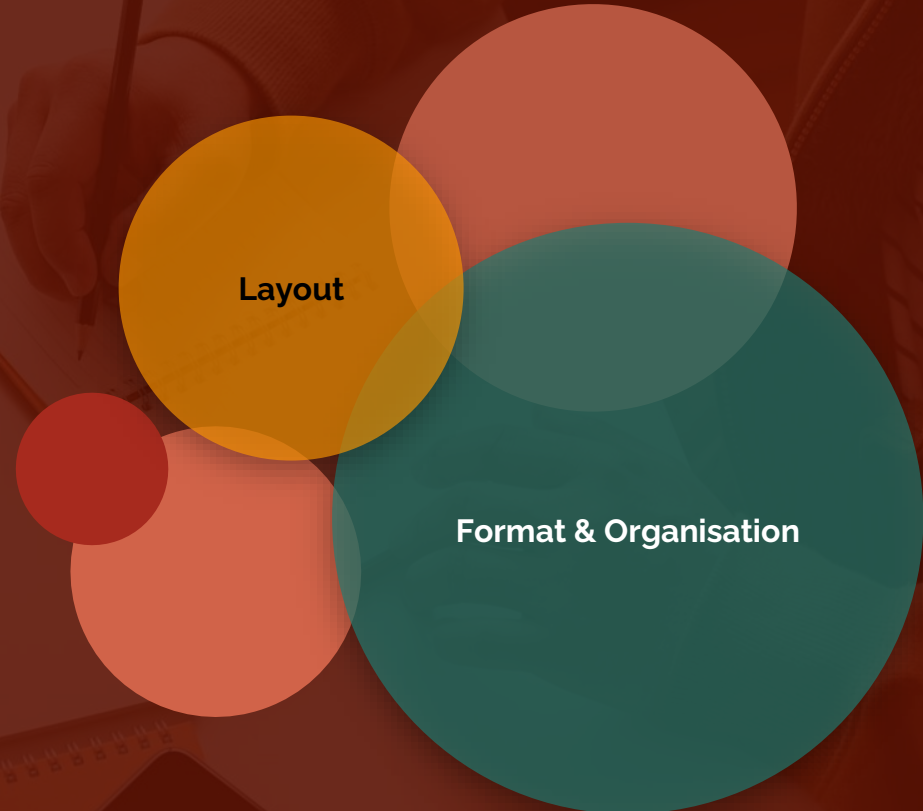
Purpose & Planning

First Draft

Revised Draft

Final Draft

Writing is a Process

- Good writing doesn't happen overnight; *it requires planning, drafting, rereading, revising, and editing.*

- Learning and improvement requires *self-review, peer-review, subject-matter expert feedback, and practice*.

Report Layout

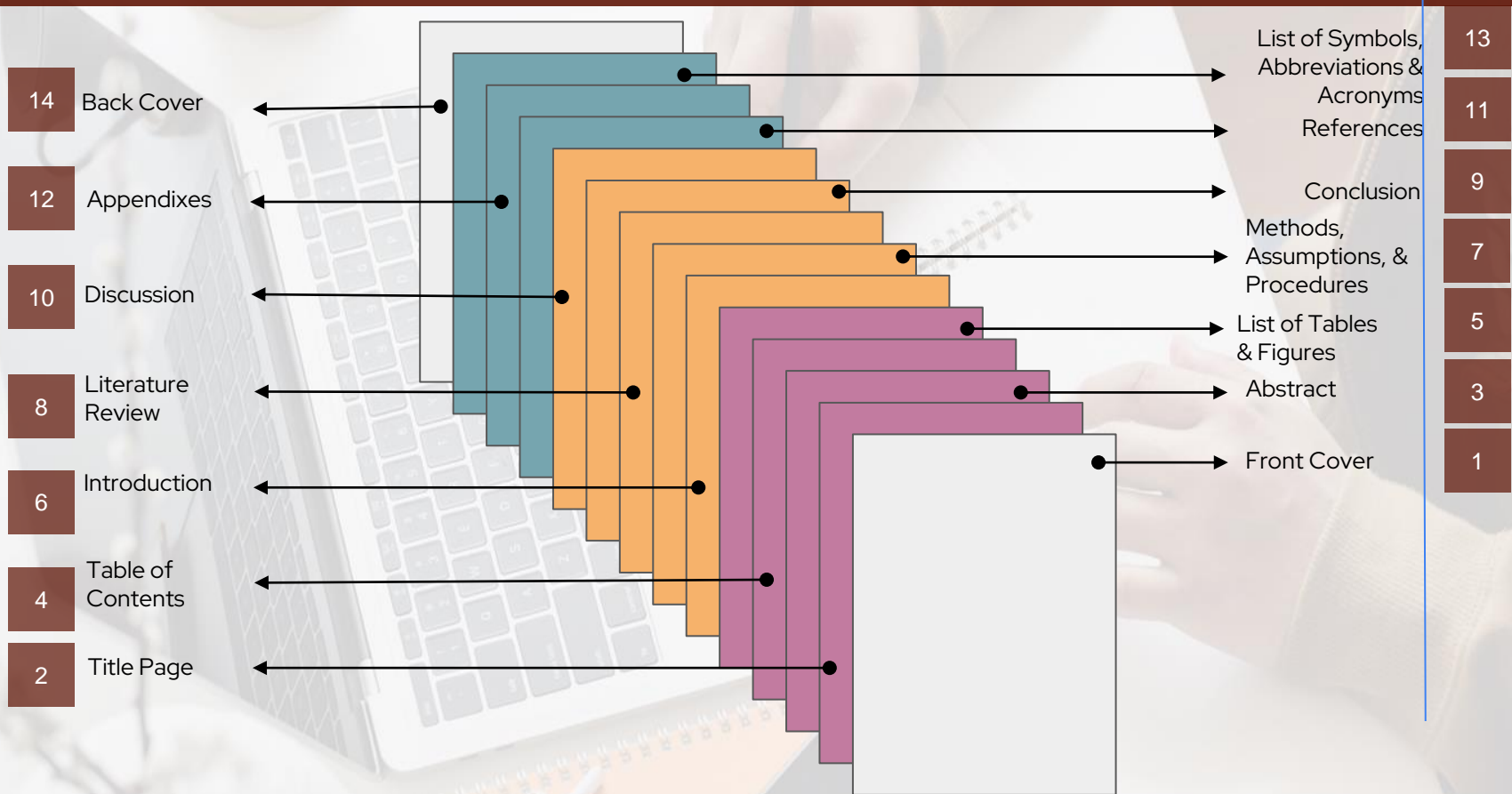Layout

Format & Organisation

Format & Organisation

Report Layout: Format & Organisation

Front Matter

Components of the Cover Page

Front Cover

Title Page

The purpose of the cover page is to protect and identify the report

Must Contain:
- the title;
- initials and surnames of the author(s);
- date of submission;
- name of the institution or company; emblem of the institution or company.

The title page **contains all the information given on the cover page (except for the emblem),** as well as the **status of the report**,

E.g.:

"Experimental Techniques Report: Project 1" or "Final Report for ..".

If an individual project is done under the guidance of a lecturer (for example a final year project or thesis), the supervisor must also be indicated, for example "Supervisor: Dr. X".

Abstract & Executive Summary

Key components because they allow readers to quickly decide whether or not they need / want to read the entire document

Whether or not the document is relevant

What are the main conclusions of the document

Difference between Abstract & Executive Summary

	Executive Summary	Abstract
Focus	Problem (esp. Financial aspects), Progress (esp. Results of implementing)	Focus: Solution, Evaluation
Language	Less technical, more financial	Technical, less background
Length	Often longer than abstract to reflect different focus, need for background & higher likelihood that readers will only read this summary	Less than a page, usually one paragraph long

Abstract & Executive Summary

Both stand-alone documents, meaning that they should be thought of as being independent from the report.

Key Elements

01	**Situation**	• Provide importance of the work/research.
02	**Problem**	• Define the problem that the paper addresses
03	**Methodology**	• Describe the specific approach – its key characteristics, fundamental principles, and how it solves the problem
04	**Results**	• Present the main results obtained
05	**Implications**	• How did this work add to the body of knowledge on the topic? Are there any practical or theoretical applications from the findings or future works?

Abstract & Executive Summary

On a technical level:

- Less than 350 words

- Single-spaced; single paragraph

- Written in 3rd person

- Contains no undefined symbols, abbreviations, or acronyms

- Makes no reference by number to any references or illustrative material

- The last part to be written.

Example of Written Abstract

(1) At this time, power utilities major techniques of monitoring their distribution systems are after-the-fact indicators such as interruption reports, meter readings, and trouble alarms. (2) This system is inadequate in that it fails to provide the utility with an accurate picture of the dynamics of the distribution system, and it is expensive. (3) This report describes a project to design a radio-based system for a pilot project. (4) The basic system, which uses packet switching technology, consists of a base unit (built around a personal computer), a radio link, and a remote unit. (5) The radio-based distribution monitoring system is more accurate than after-the-fact indicators used, small enough to replace the existing meters, and is simple to use. (6) We recommend installing the basic system on a trial basis.

Commentary: This abstract almost demonstrates a sentence-component correspondence. (1) = situation, (2) = problem, (3) + (4) = solution, (5) = evaluation, (6) = recommendation.

Table of Contents

- Help readers find the information they want

- Should use the same headings as the document, thereby employing parallel structure. If the document uses sub-headings, so should the table of contents

- Not listed as an entry on the table of contents and not numbered but creates page e.g. iii.

- It is part of the Front Matter which is numbered using Roman Numerals

List of Tables & Figures

- These lists, arranged according to the table and figure number, each begin on a new page

- Indicate the relevant page number in the right-hand column.

- The titles of tables and figures must be descriptive enough so that a specific figure or table can be identified in the list and must correspond to the title used for the figure or table in the text.

- If a report has many tables and few figures or few tables and many figures, they can be combined into a single list (List of Illustrations).

- If the report contains fewer than 5 figures, 5 tables, or some combination totaling less than five, then a *List of Figures and Tables* is not required.

List of Tables & Figures

A *figure* is any drawing, photograph, graph, or chart that is used to explain and support the technical information in the text.

Writing Figures

The figure number and title will appear below the image

Refer to a figure or table within the text, and place the image close to the reference.
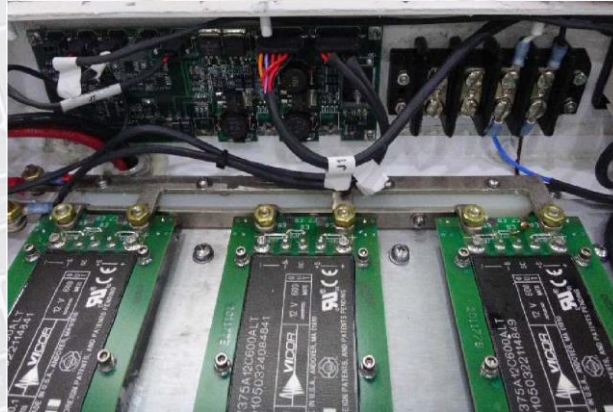

Figure 2. Current monitoring, and DC/DC converter board.

Fig. 2:   Current monitoring,   and DC/DC converter board.

List of Tables & Figures

A *table* is an arrangement of detailed facts or statistics that are arranged in a row-and-column format.

The table number and title appear above the table.

Table 2. Field Strength Normalisation Frequency Range and *n* factor.

Frequency Range	n
0.15 MHz to 0.40 MHz	1.80
0.40 MHz to 1.60 MHz	1.65
1.60 MHz to 110 MHz	1.20
110 MHz to 1000 MHz	1.00

Structure of Front Matter

Title page

Abstract – i

Abstract is a concise summary of the research. It should be able to stand alone in representing why and how you did what you did, and what the results and implications are. Maximum one page long.

Acknowledgements - ii

Table of Content –iii

List of Tables

List of Figures

List of Abbreviations (if applicable)
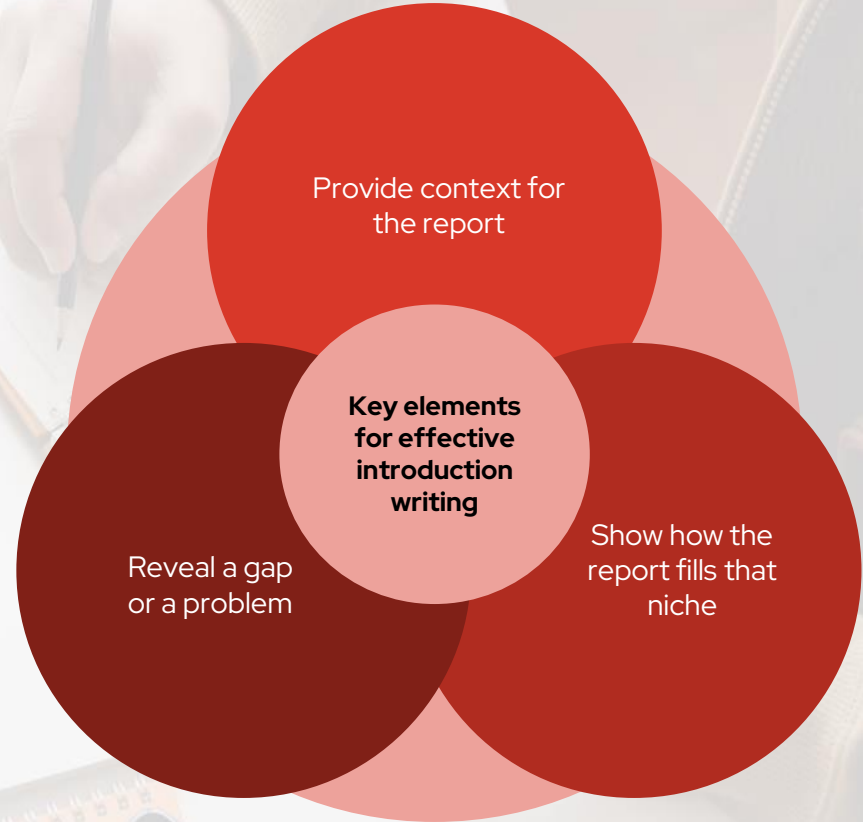
List of Symbols (if applicable)

Body Text

Comprises the following:
- Chap 1:Introduction;
- Chap 2: Literature Review;
- Chap 3: Methodologies;
- Chap 4: Results and Discussion;
- Chap 5: Conclusion; and
- References.

Introduction

Important because audiences rely on them to establish the topic and purpose of the document.

Provide context for the report

Key elements for effective introduction writing

Show how the report fills that niche

Reveal a gap or a problem

Context

Introduction

- Involves establishing why the report is being written and the background information necessary to understand the problem; and
- How much and what type of context we provide in the introduction will depend on the audience.

A knowledgeable and in-the-loop audience – such as an immediate supervisor or an engineer who is working on the same project – may already possess much of the necessary context knowledge: they are known as High Context readers. Low Context readers – such as clients – have less knowledge of the immediate field and situation, and will need you to establish the framework for the paper.

- The section should provide a general introduction to the topic, a review of the relevant literature, the specific aims and objectives of the project, and the structure of the project.8

- The review of the relevant literature isa limited ONLY to set the background and context for your work and present the current state of knowledge and ideas around the topic and what their strengths and weaknesses are.

- You can put this material into more than one chapter or divide one chapter into sections. Writing the text is likely to be an iterative process and it may need to be substantially revised after the results of your work are available.

- **The context will show the gaps in information and so the need for the study.**

Introduction - Gap

Identifying the gap involves establishing the problem that the report deals with.

In many cases, the "problem" is relatively easy to identify. For example, a proposal for a bridge design involves a real, physical gap and the need (to accommodate traffic patterns, for safety reasons, etc.) for a bridge. However, in some genres of engineering writing, such as undergraduate lab reports, no practical problem is actually solved.

Identifying Gaps

- Sometimes the gap is a practical problem

- In some cases, the "problem" is to confirm known knowledge: this is often the case in undergraduate lab reports, where the goal is the validation of engineering theory through experimentation

- There may also be multiple levels of the problem.

Niche

- a **purpose statement**; and
- a projection on how we plan to address the niche.

Introduction

E.g. of **Purpose Statement:**

- Confirm the composition of a known sample using a scanning electron microscope (SEM).
  (Problem = confirm known sample composition)

- Explores the feasibility of using synthetic polymers as scaffolding in bone tissue engineering (BTE).
  (Problem = scaffolding with other materials in BTE)

- The projection provides an overview explanation of how the paper accomplishes its purpose.

- An introduction should be relatively short; it is, after all, an introduction, and you will have the opportunity to discuss the gap further in the literature review or background. However, it still needs to be persuasive – establish the significance of the problem – and provide sufficient and appropriate context information for the audience.

- Putting the purpose statement at the beginning means that your audience knows the goal of the report early.

Structure of Introduction
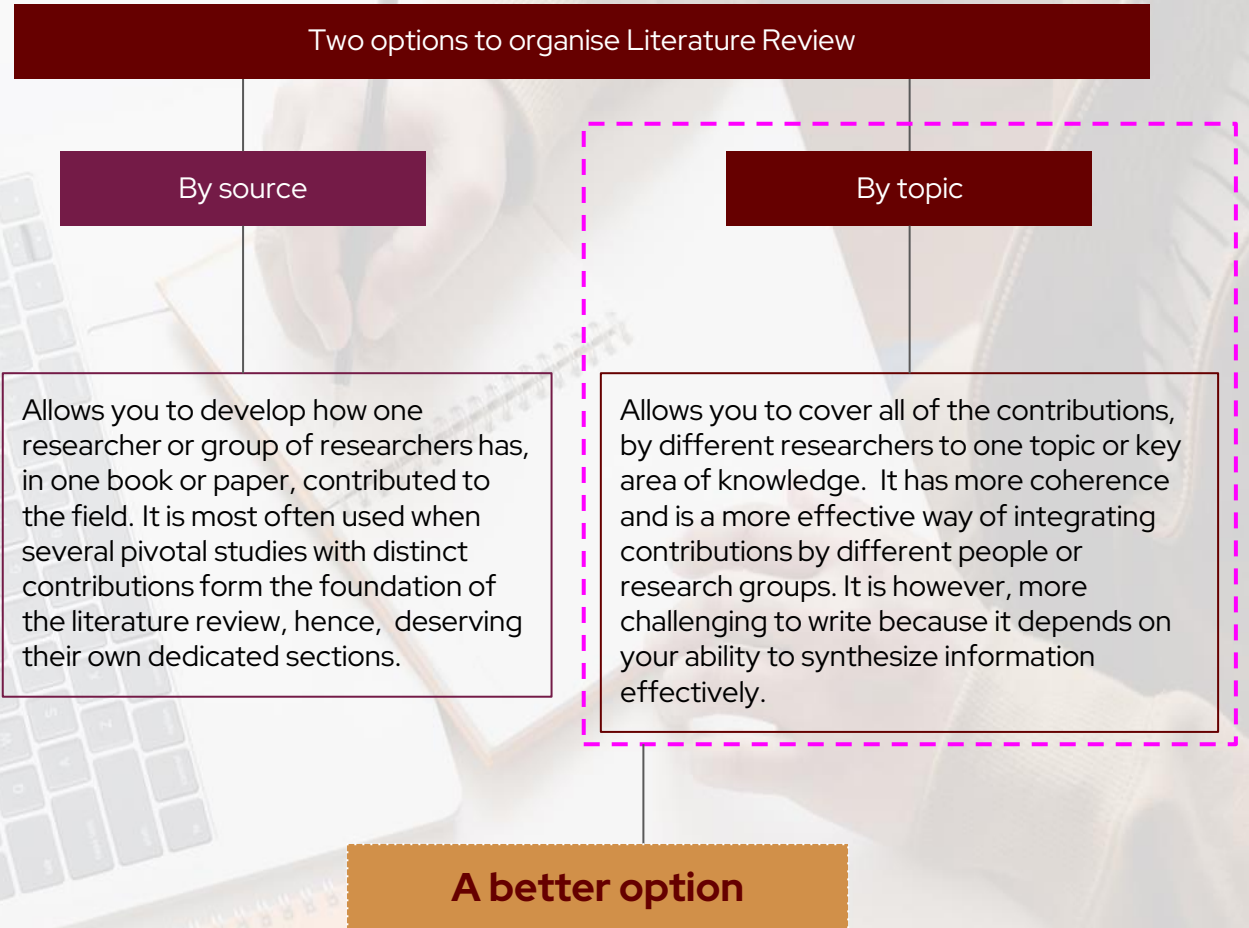
Chapter 1: Introduction

Literature Review

One of the most important and poorly understood components of a document.

Role of Literature Review

1. Primarily to collect and examine the state of current knowledge in a field by examining the work of scholars and researchers whose work has been recognised as valuable.

1. Ultimately, a well researched and written literature review accomplishes three goals. It:
   a. establishes context for your work by showing what has been done in the area;
   b. exposes the gap in current knowledge; and
   c. shows your supervisors that you have done your research

1. The literature review might be considered a more detailed, elaborated and well-supported version of the introduction. In the literature review, the gap is developed in significantly greater detail and supported by references.

Literature Review

Two options to organise Literature Review

By source

By topic

Allows you to develop how one researcher or group of researchers has, in one book or paper, contributed to the field. It is most often used when several pivotal studies with distinct contributions form the foundation of the literature review, hence, deserving their own dedicated sections.

Allows you to cover all of the contributions, by different researchers to one topic or key area of knowledge. It has more coherence and is a more effective way of integrating contributions by different people or research groups. It is however, more challenging to write because it depends on your ability to synthesize information effectively.

A better option

Strategies for Writing Literature Review

a) Organising:

The first step is to develop a framework for the review: this can be done by identifying the key articles or the key areas of knowledge (depending on the organisational structure chosen), and associating papers with specific areas of knowledge. This set of topics or papers should form the sections of your literature review; however, you'll need to organise these topics logically, and develop transitions between the sections.

b) Summarising:

The second step involves identifying each article's contribution to the area of knowledge. You may be summarising an entire article, or just including a brief reference to the article. When summarising an article, ask the following questions:
- What are the author's purpose and assumptions?
- What are the author's main claims (conclusions)? How are they supported; how have they been qualified?

This should leave you with a clear idea of what the author is saying.

Strategies for Writing Literature Review

c) Organising:

In the final step, you need to assess the work done in the key area of knowledge or by the pivotal paper, in order to establish:
- How previous work has left a gap, because of either inadequate assumptions or inconclusive findings;
- How previous research will be applied in a new context; or
- How general disagreement or different views on the subject create a need for a solution.

In evaluating each article, consider the following questions:
- Could the problem have been approached more effectively from another perspective or with different assumptions?
- Are the paper's conclusions well warranted by evidence from research? Is the evidence from the research conclusive? Or are there limitations to the research?
- How does this paper contribute to our understanding of the problem/issue?
- How does the paper relate to your research?

In evaluating several papers on a specific topic, ask these questions:
- What are the significant points of agreement between articles?
- Where the research disagrees, is one researcher more conclusive than another?
- **How can you fit the articles together to build a logical argument that furthers your purpose.**

Literature Review

In writing the literature review, your purpose besides enlarging your knowledge about the topic, is that it lets you gain and demonstrate skills in three areas:

- information seeking: the ability to scan the literature efficiently, using manual or computerized methods, to identify a set of useful articles, books, published data, reports etc.

- critical appraisal: the ability to identify unbiased and valid studies.

- synthesis of information/evidence: the ability to draw the information and evidence together to provide an appropriate and relevant summary of the key points, including areas where the current evidence supports or contradicts any ideas or hypotheses that you are testing in your project.

Methodologies

One of the most important & neglected sections in engineering writing.

- In some documents, such as an undergraduate lab report, the methodology section can be as short as a one-sentence reference to relevant section of the lab manual.

- In more advanced labs, the methodology can be a very significant part of the report.

- It is often the product of engineering related research: researchers are often looking for appropriate ways of testing or evaluating products, forces, etc., or new methods for accomplishing a required task.

attention to detail and precision

precision

In a proposal, the methodology can even be the most important part of the document – *the proposal argues that its method for achieving a certain task is the best.*

Methodologies

Should allow readers to, if necessary, reproduce your experiment, design, or method for achieving a task

Should help readers to anticipate your results.

Example

We poured out some distilled water into the container. We then added some of mixture A. We shook the mixture and observed what happened, taking some measurements.

What is missing?

Essential informations:
- **How much distilled water did you pour?**
- **How much of the mixture A did you add?**
- **How did you shake it (length, technique)?**
- **What did you observe, measure?**

Key details:
- **What was the container made of?**
- **How big was it?**
- **Did you let it settle?**

How should it be?

In revising this statement of method, we want to ensure that we include all of these **details to help the reader reproduce the experiment and to anticipate a set of results**:

250 ml of distilled water was poured into a 1000 ml glass beaker. 50 mg of Mixture A was then added to the water. The mixture was gently shaken for two minutes. Changes in mixture colour and transparency during our mixing process were observed and recorded. The colour, translucency, and temperature of the new solution were recorded immediately after shaking, and after five minutes of settling.

Note: Passive versus Active Voice

Passive Voice	Active Voice
Control of the bearing-oil supply is provided by the shutoff valves.	Shutoff valves control the bearing oil supply.
Leaking of the seals is prevented by the use of O-rings	O-rings keep the seals from leaking.
Fuel-cost savings were realized through the installation of thermal insulation.	The installation of thermal insulation cut fuel costs.

"I blew up the lab" (clearly I want to show that I'm responsible, which is active voice) or "The lab was blown up" (passive voice, showing that it's unimportant or unknown who blew up the lab). The point really is to remember that using active or passive voice in technical writing should be a conscious choice that writers make depending on the situation and what should be emphasized and/or de-emphasized.

Active voice should be used when it's important to emphasize the actor, while passive should be used when it's more important to emphasize the action.

Active vs Passive Voice

Active vs Passive Voice

Key difference between **methodology in lab report and other types of reports**:

- in the lab report, the method is often given in the procedure from the manual.

- in research reports and proposals, the method is something you devise on your own.

Two tasks to writing the method

Organisation

Justification

Organisation	Justification
Organization of the methodology section involves: 1. Dividing and subdividing the steps into the appropriate key stages/sub-stages; 2. Choosing headings / keywords that reflect the nature of the stages (i.e. Sample Preparation); and 3. Providing an overview of the entire methodology at the beginning of the section.	Explain clearly why you chose the method that you did e.g.– 1. For accuracy, simplicity, etc.; 2. Identify the implications of using your methods. 3. State why they are acceptable or necessary, and explain the effect they may have on your results (take these into account in your Discussion as well).

Results & Discussion

The "meat" of most engineering reports.

The results and discussions depends on the type of project, for e.g. in a:

- lab report involves correlation of results with fundamental principles;

- design report may involve an evaluation of the design or method used.

- feasibility or case study, would involve measuring the feasibility or evaluating the success of one or more solutions.

- proposals, for example, will likely not have any results to discuss, since it looks forward to action to be done in the future.

- final report, discuss whether or not the project fulfilled the objectives, budget and timeline laid out in the proposal.

Together or Separate?

In writing these components of your report, you are faced with one major decision with significant implications:
  i)   Combine the results and the discussion sections, or
  ii)   Keep them separate? Both require attention to the organization and division into topics and subtopics.

Combining

- Allows for more coherence, because it allows you to discuss results of a particular test or method immediately after presenting them.
- Need to divide your section into appropriate subsections, potentially into different topics or tests: e.g.,
  - Composition of Samples A – D from SEM analysis
  - Strength of Samples A – D
  - Flexibility of Samples A – D

Separate

- Allows you to discuss all of the results at one time.

In the earlier example, it may be more important to discuss the relationships between composition, strength and flexibility of individual samples than it is to compare the features of all four samples. In this case, you may want to hold off on discussing the results until you have presented all of them. The headings for the discussion section, then, may look like this e.g.:

  i.   Relationship between Composition, Strength and Flexibility in Sample A
  ii.   Relationship between Composition, Strength and Flexibility in Sample B

Presenting Results

When using visuals to present results, be sure you do the following:
- Label and title all graphs, charts, and visuals clearly and precisely.
- Introduce the results and visuals in the body of the report (Table 1.1 presents the composition and strength of the samples as determined by the SEM).
- Use sentences to highlight the key result (As seen in Table 1.1, Sample A showed the highest carbon content, and was also the strongest)

Whenever possible, use **visual aids such as tables, charts, or graphs** to represent results in an easy to read and understand format.

Be selective: some material may be more suited to an appendix than the body of the report itself. Ask yourself:
- **whether or not the information is pivotal to the discussion and understanding of the conclusions of the report.**

In the above example, the calculations used to determine strength and flexibility numbers may not play a significant role in the discussion; in that case, they can be placed in the appendix, with possibly one sample calculation placed in the body of the report. If you do include appendices in your report, be sure to refer to them in the body of the report: for example, "(See Appendix 3.1.1 for derivation of strength numbers for samples B-D.)"

Analysis

Key Elements

Interpretation
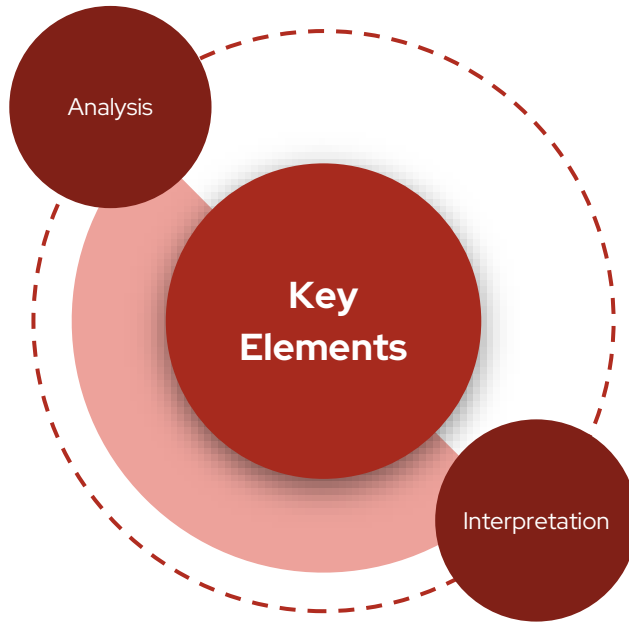
Involves drawing conclusions from the data presented in results.

In doing either, be sure to **clearly link your claims to specific sets of data**, and **logically explain** how the data supports **your claim**.

Conducting Discussion

involves explaining the significance of these findings, identifying the potential limitations of the experimental method and their effect on the results, and accounting for any potential errors.
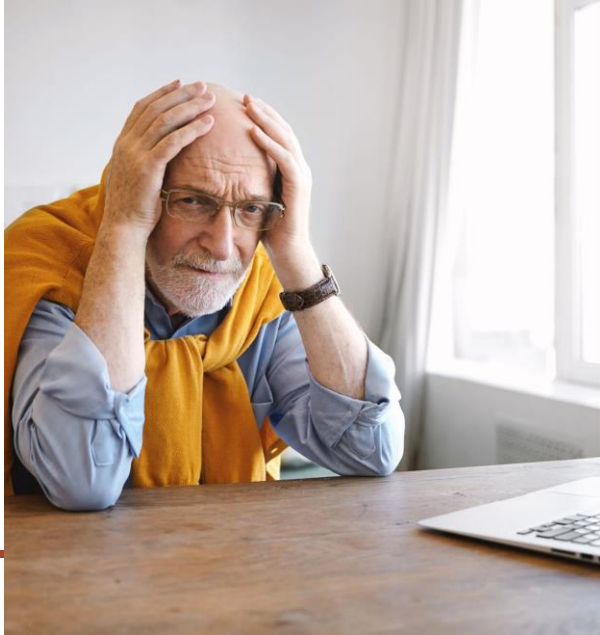

Conducting Discussion

This can involve highlight key results and placing them in the context of other results.

The results for Sample A are as expected, given its composition (75% poly para-phenylenetere-phthalamide, as seen in Figure 3.1. As shown in Tables 3.2 and 3.3, Sample A was both the strongest and most flexible material. These features are typical of a composite with a high level of poly para-phenyleneterephthalamide content [1].

In the above example, the claim is that the results for Sample A are expected, given its composition. The data that supports that claim (from Figure 3.1) is that Sample A is the strongest and most flexible material, and that Sample A is made up of 75% poly para-phenyleneterephthalamide. The logical explanation is that this composite material is known to be flexible and strong (from source [1]).

Involves explaining the results and identifying the conclusions you can draw from them.

Conducting Discussion

This example identifies what the results and the conclusions drawn from them might mean in a wider context:

Of the four samples, Sample A is best suited for use in protective clothing applications. Its high strength allows it to provide sufficient protection while its malleability allows it to be shaped to the contours of the human body.

Second example, identifies a potential limitation of the method, and how they might cast the above conclusion into doubt. Finally, it proposes future work that might help remove this limitation.

However, the way that we evaluated flexibility –measuring the amount of rotational stress before breakage – may not accurately reflect the manufacturing process for the protective clothing or usage patterns. Accounting for this application would involve measuring more and different types of stresses and their impact on the material.

Reporting potential source of error

- Important
- Part of labs & research projects

Conducting Discussion

Students often include list of possible errors without the sense of:

- Their potential impact on the results;
- The likelihood that they played a role in the results, and
- How to avoid them in future studies, as in the below e.g.:

Some potential sources of error are: human error, precision of measurements, testing the same sample for strength and flexibility, etc.

A better account of potential sources of error in this experiment might state the following:

Errors in the measurement of material flexibility may have resulted from our testing method. In all but one case, we tested strength and flexibility on the same sample of the materials. Both tests involved applying stress to the samples. Our measures of flexibility in samples B, C, and D may be lower than actual because of the stress applied to sample beforehand. We were able to obtain two pieces of samples A, and tested strength on one and flexibility on the other. While the effect of testing both properties on one sample is unknown, it is likely that applying strength testing may have reduced the flexibility of the material or made breakage more likely. Unfortunately, we only had access to one sample of B-D.

Conclusions - Summary

for more informed audience

- Different than the introduction
- Strong sense of key concepts

Characteristics

- Different than the introduction
- Strong sense of key concepts
- Could be longer and may acknowledge limitations of this method in current research
  E.g: **However, research on the use of nanoparticles has yet to be conduct in vivo (in any applications) and bone tissue engineering is still in its infancy as a field of science.**
- Do not copy & paste sentences from introduction / other parts of your paper.
- The level of detail you engage in your summary is up to you – a **conclusion can be as short as a few sentences** and **as long as several pages – depending on the length of the paper and the complexity of the subject matter**.

Example:
In a report on bone tissue engineering, your introduction and literature reviews might discuss osteoporosis, along with current methods of treatment and their limitations at length, since this involves developing context and establishing the gap for your paper. It would even likely form a large part of the literature review. Your conclusion, however, might summarize all of this in one sentence, while identifying itself as summary (by virtue of the "as mentioned previously"):

As mentioned previously, current treatments for osteoporosis that attempt to stimulate re-growth of bone are limited because of problems delivering appropriate signalling mechanisms.

The above sentence might not work anywhere else in the paper – since it relies on knowledge developed throughout the paper.

The other role of the conclusion in a scientific paper is, in fact, to introduce new avenues of potential study or to explain the potential impacts of your conclusions. It should be linked to the work described in your paper. In the above example, one might conclude with the following statement:

"As researchers conduct more research into nanoparticles for use in drug delivery systems and bone tissue engineering matures as a field, the potential for finding a cure for osteoporosis increases. Specifically, work on matching growth factors with types of nanoparticle compounds and ways of controlling the release of these factors over time should, in the near future, turn bone tissue engineering from a field of research to an actual treatment method."

Conclusions - Recommendations

The final sentence should provide a strong takeaway statement that allows the audience to remember the main point of the paper – in the above example, the potential for a cure for bone disease and the work that needs to be done to achieve it.

Conclusions

In summary, the two main problems students encounter in writing conclusions are related to the two main functions of that component of a document.

In summarising the paper, the conclusion will exhibit some redundancy: the key is **to aim this summary at audiences who have read your report**. In developing other avenues of study or application, the conclusion may have to introduce new ideas: the key here is **to clearly relate these new applications or directions to the content of your report.**

Referencing

- Enables anyone who reads your work to identify and locate sources quickly and efficiently

- Acknowledges the work of others and protects you from accusations of plagiarism

- Verify quotations

- Demonstrate the depth of your research.

- Follow the IEEE guidelines which are available online here: https://ieee-dataport.org/sites/default/files/analysis/27/IEEE%20Citation%20Guidelines.pdf

Appendixes

Anything that cannot be left out of a report, but is too large for the main part of the report and would serve to distract or interrupt the flow belongs in the *appendixes*, e.g.

- Large tables of data
- Flowcharts
- Mathematical analysis
- Large illustrations
- Detailed explanations and descriptions of test techniques and apparatus
- Technical drawings