Systems Design Engineering

Technical Report

Style Manual

Fifth Edition

G. R. Heppler

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Abstract

The standards and practices that are to be followed by students enrolled in the Department of Systems Design Engineering at the University of Waterloo when preparing reports for courses, workshops, and work terms are presented. Introductory comments on the philosophy and techniques of report writing, required elements of the report style, and formatting issues are covered. Additionally, issues related to figures, tables and references are discussed. The grading standards and practices to be followed by course instructors and faculty members when they are evaluating a technical report in the Department of Systems Design Engineering are presented. The requirements that must be met in keeping design project and course laboratory notebooks are included.

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Introductory Remarks

The principal purpose of this style manual is to state the standards students must follow when preparing a technical report or a work report for submission in the Department of Systems Design Engineering (SYDE). By defining structure, layout, writing quality, and citation styles, a style manual ensures consistency within a report and a series of reports. This manual defines the SYDE style.

As students and future professional engineers you will encounter many style manuals and guides devoted to technical publications (for example: [1]–[6]). Technical publications include: technical reports, progress reports, journal papers, conference papers or extended abstracts, to name just a few. Each scientific or engineering discipline has a different style requirement. These differences may be quite substantial and may vary depending on the type of publication. For example, you may wish to investigate the style requirements of the American Institute for Aeronautics and Astronautics[7], the American Society of Civil Engineers[8], the Human Factors and Ergonomics Society[9], the American Society of Mechanical Engineers[10], the The Institute of Electrical and Electronics Engineers[11], the Canadian Society of Civil Engineers[12] and NASA[13]. All of these style guides provide detailed instructions on their particular style requirements for preparing articles and reports for publication.

Conforming to the guidelines contained in this style manual will provide you with the opportunity to become familiar with and to practice using some of the common report preparation standards used by professional engineers.

Why do I have to write a report?

Writing reports is a very important part of an engineer's job. The four work reports and numerous course project reports that you will prepare are intended to provide you with the opportunity to learn how to write technical reports. The four work reports are a degree requirement because the Faculty of Engineering and industry want us to, graduate people who can write effectively. As future engineers, you will need to write effectively to, convince potential customers that they should award the company the contract; convince the public that the product or design is safe; environmentally responsible, efficient, and user friendly; to convince regulators that regulations have been met; to convey correct specifications to a supplier; and to convince your immediate superiors that you actually know what you are doing and should keep your job.

Why bother to do it well?

It is important to write the best report you can each and every time you are required to do so. By making the best effort to write the best report you can, you will develop the skill to write an engineering report that will reflect well on you as its author, on the University which helped educate you, and ultimately on the employer who hires you. A well written report enhances the credibility of both you and the results.

What is the purpose of the report?

The principal purpose of preparing a technical report is to communicate information to others. Technical reports are primarily used by the reader to understand a situation of concern that is to be, or has been, addressed so that they can make informed decisions concerning the next step of a project (*e.g.* continuation of the project, funding, design changes, etc). A technical report puts forward defensible conclusions and recommendations based on well defined modelling, accurate technical descriptions, thorough analysis, and logical conclusions. For the most part your purpose will be to describe a process, a design, an engineering study or an analytical result, as opposed

to persuade an audience to adopt a position; a technical report is not a marketing brochure. Be aware of the message you are trying to convey and what you want your readers to be left with after having read your report.

Who am I writing for?

Who the intended reader of the report is should perhaps be the most important question to answer at the outset. The audience you are writing for will set the tone for every part of the report. A report written for senior management will not have many, if any, technical details, but will rather concentrate on the options available, the consequences of the choices made, the feasibility, and most likely, the cost. A report to senior management will be unlikely to have any references or citations. On the other hand, a report written for your colleagues may well be very technically detailed with many equations, graphs, tables and citations because their needs are different from those of senior management. A report for general public consumption might have to explain complicated technical matters in a fashion that the layman can understand and appreciate. Again, in this latter example, citations are not likely to be appropriate.

What to present and how to present it is driven by your audience as well as by your objectives. Different audiences will be comfortable with different types of content. While engineers are comfortable with equations and graphs, accountants may appreciate graphs, provided one of the axes has the units of $, but not partial differential equations, and the general public may appreciate neither. Each audience may require a different focus and emphasis in the report. It is not uncommon for a public advocacy group to write a different report or position paper for each member of the legislature based on their knowledge of each member's background, interests and biases.

The audience will most probably include people who are less (perhaps much less) familiar with the topic than you are; consequently, it is important to write as simply and as concisely as possible, avoiding highly specific technical terms and phrases unless they are absolutely necessary. If technical terms and phrases are necessary,

they should be adequately explained and defined. Remember that you are writing for the reader (grader), not for yourself. The phrase, "But it is perfectly clear to me." is meaningless if your reader's rejoinder is "But it's not to me."

How long does it have to be?

The underlying philosophy to be followed in preparing a technical report is that the reader should be able to reproduce everything reported without having to guess about anything. The accuracy of all the information contained in the report must be checked with the utmost care. A slight inaccuracy may result in a serious (costly, life threatening) error on the part of anyone who may later use that information.

To be complete, a report does not necessarily have to be long. An excessively long report is always an indication of the author's failure to write concisely and is often evidence of the author's lack of understanding of the material that is being reported. Writing a complete, but yet concise, report is a difficult skill to master.

How do I begin?

The process of writing a report has much in common with executing an engineering design[6]. Begin by analyzing the needs (constraints and acceptance criteria) of your readers and make a note of the requirements you identify. Next, design a report that will meet those requirements and determine how well the report meets the acceptance criteria. Remember it must not violate the constraints (*e.g.*, number of pages). Plan the report by creating a working outline to help organize the structure of your report. The outline may actually evolve into chapter, section and subsection headings. It will probably be necessary to iterate your report design to get the structure which best meets the acceptance criteria. After the outline, write a draft. Write the report sentence by sentence, paragraph by paragraph, section by section, chapter by chapter; building each out of well assembled quality components. Again, iteration will be required. Finally, package the report by preparing it according to the standards set out in this style guide.

Professionalism and Ethics

Regardless of how many guidelines, rules, or edicts are presented here or in any other style manual, it is not possible to cover all possible situations. For these cases, you will have to exercise your engineering judgment. When you write a report, you will be engaging in an activity that puts individual facts into a context. The context is important and how you handle it is an issue of professionalism. Professionalism, in turn, is an issue of honesty, objectivity, attitude and integrity.

Honesty is often more than simply telling the truth. It means reporting all the experimental data, even that which you think may be in error (and if you think it is in error explain why) or which does not support your hypothesis or desired outcome. Dishonesty by omission is as unacceptable as dishonesty by commission. Engineering reports are not advertising literature no matter how wonderful you think your project or design may be. In reports, all claims must be substantiated with supporting evidence; and any possible negative outcomes, such as potential dangers, health and safety risks, or costs beyond budget must be disclosed to the reader. As a professional, you have an ethical obligation to be honest with your readers, whoever they may be.

Objectivity is a laudable goal but, many would argue, is not fully attainable in practice. Everyone is shaped by their life experiences, their culture, their religion, and so on. The best that can be expected is for you to be aware of your biases and try to avoid having them influence your writing. Avoid phrases that editorialize your statements, and avoid phrases which evoke strong emotional responses on issues which have nothing to do with the topic of your report. For example, including a comment on the 'excessive use of the automobile stemming from western self-indulgence' is not an appropriate addition to a report on ways to reuse tires. Other examples of practices that can detract from the objective presentation of information are the use of different left-hand and right-hand scales on graphs, graphs that use a scale that does not begin at zero, de-emphasizing material by relegating it to an appendix or footnote, omitting discussion of problems, errors, inconsistencies or deficiencies in a

design, process, experiment or test, drawing a smooth curve through data for which there is no continuous relationship, and the incorrect or inappropriate use of statistics.

The attitude conveyed by the writing style in your report should be polite, respectful and confident. It is important that you guard against conveying an overly cautious attitude by the excessive use of mitigating qualifiers such as, would, could, might, may, possibly, probably and normally. As a professional you will be expected, based on the information at hand, to make defensible recommendations and to stand by them. Only make recommendations you can defend and claims that you can substantiate. On a similar note, avoid conveying a negative, sarcastic or pessimistic attitude and avoid the use of pretentious prose.

Integrity encompasses honesty, objectivity and attitude. It also includes giving credit where credit is due (see Chapter 5).

Being a 'professional' means conducting yourself in a manner that, for your clients or employer, the phrase *let the buyer beware* does not apply. The quality of your written reports, both their content and style, speaks very loudly of your professionalism and reflects as well or as badly on you as your effort decides. It takes effort to produce a quality report, but effort alone is not a guarantee of quality.

What is unacceptable?

Narrative or Descriptive Reports: For the purpose of work report submission, reports that are narrative or simply descriptive are not acceptable. A narrative or descriptive report is one which could be described as being in the "What I did on my work term" category and which has no specific engineering design or analysis content. The absence of an appropriate level of engineering analysis and technical content in a work report is sufficient cause for a 'Resubmit' decision and may generate a 'Failure' decision.

User Manuals: For the purpose of work report and workshop report submission, reports that are essentially User Manuals (*i.e.* a set of instructions for how to do something) are not acceptable. The style requirements presented in this guide are

not suitable for use in preparing user manuals.

What is acceptable?

Experimental or Evaluative Projects: An engineering study is an acceptable topic for a work report. In this type of report it is important to, include an appropriate background or literature review; specify equipment, materials and methods used in the investigation; explain why you used the method or methods that you did; note other methods that were considered; and explain why they were rejected. Explain how and why you arrived at the experimental design that was used, and how it satisfied the needs or purpose of the study. Remember, your investigative process should be repeatable without any uncertainty.

Design Projects: An engineering design project is also an acceptable topic for a work report provided that the engineering design solutions are clearly evaluated against one or more alternatives with respect to previously established design criteria.

For a report on a design project you must precisely describe and define the problem, design constraints, and performance criteria that were used to evaluate the different designs. You must also justify the criteria and their relative weighting. Discuss the significant design alternatives that were considered with regard to how well they satisfied the design objectives, constraints and criteria. Clearly identify and justify the reasons why the winning design was chosen; use figures, graphs and tables as necessary.

Written reports are an important form of communication, the success of which depends on both the content and the presentation. Your written work is an opportunity to convey to others your professionalism, challenges and successes. In the following chapters each of the basic elements of the report will be discussed with respect to their purpose and style.

2

Basic Format

Every report will have the same fundamental structure: it will begin with a title page, abstract, and table of contents, followed by an introduction chapter, a chapter (or possibly chapters) which forms the main body of the report, and a summary chapter, a list of references and finally some appendices if appropriate.

2.1 Paper

The use of a good quality white letter size paper that measures 8 1/2 inches by 11 inches (21.5 cm by 28 cm) is required. The paper must be heavy enough to be opaque, especially for reports printed on both sides of a page.

2.2 Page format

Prepare the report with 1.5 line spacing on white standard letter size paper (see above). If double sided printing is used ensure that the margins on the bound edge are 1.5 inches. A right-hand page is illustrated in figure 1. The use of a 12 point (pt) font for the main body of the report is preferred (refer to the font requirements set out in Table 1). Except for paragraph indentation and headings the text should be left and right justified (*i.e.*, have flush left and right edges) as in this manual.

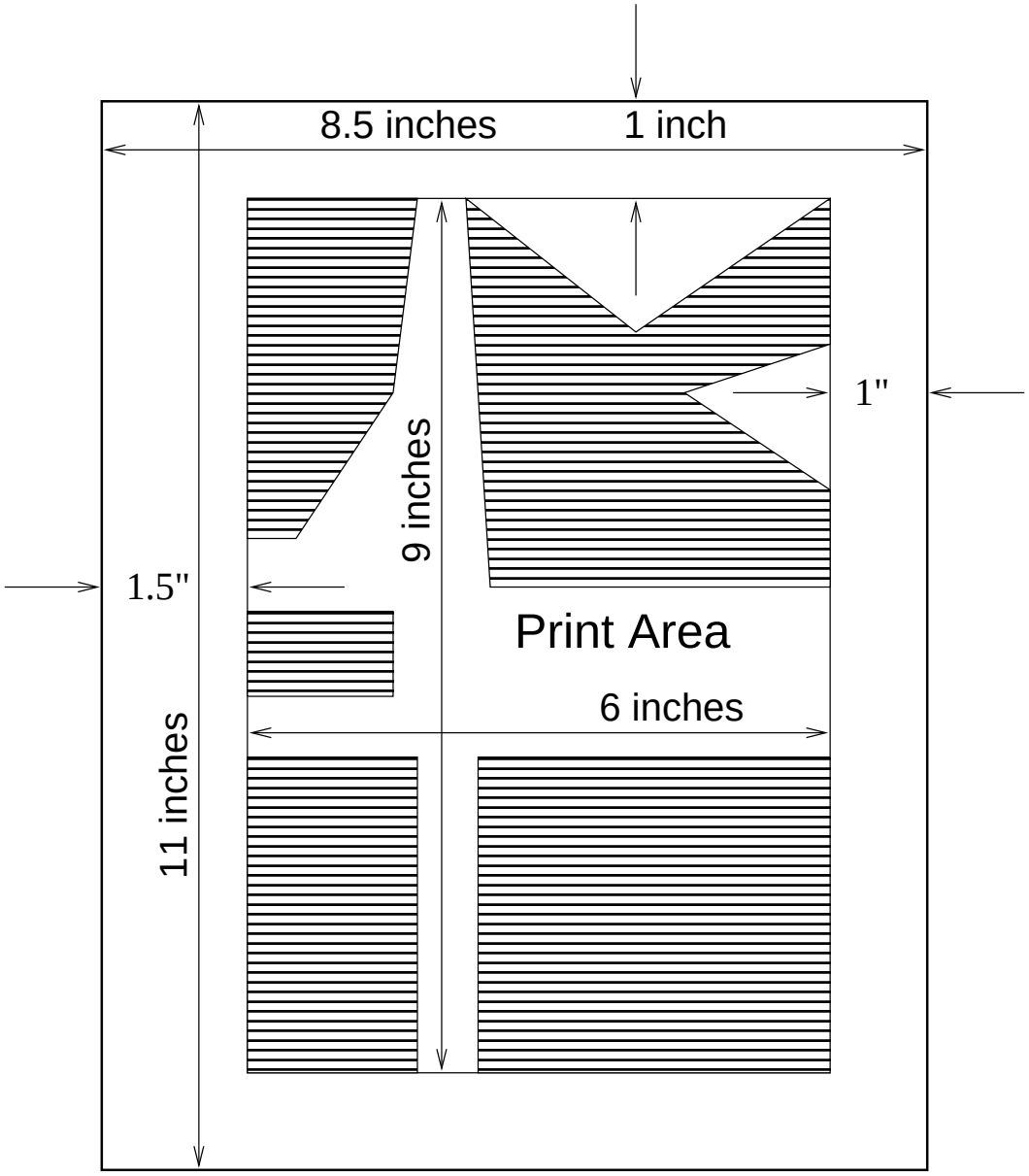

Figure 1: The required page layout for a Systems Design Engineering Report.

Table 1: Font Requirements

Usage	**Font Style**	Choice 1 **Size** [pt]	Choice 2 **Size** [pt]	Choice 3 **Size** [pt]
Main Text	Times New Roman or, Times (LaTeX) or Computer Modern (LaTeX)	12	11	10
Report Title	Boldface. Times New Roman or, Times or Computer Modern (LaTeX)	24	23	22
Chapter Title	Boldface. Times New Roman or Times or Computer Modern (LaTeX)	22	20	18
Section Heading	Boldface. Times New Roman or Times or Computer Modern (LaTeX)	16	15	14
Sub-Section Heading	Boldface. Times New Roman or Times or Computer Modern (LaTeX)	14	13	12
Sub-Sub-Section Heading	Boldface. Times New Roman or Times or Computer Modern (LaTeX)	12	11	10
Figure and Table Captions	Times New Roman or Times or Computer Modern (LaTeX)	12	11	10
Footnotes	Boldface. Times New Roman or Times or Computer Modern (LaTeX)	10	9	8

2.3 Pagination

All pages must be numbered consecutively and all page numbers should be placed centred at the bottom of the page. The pages of the front matter of the report are numbered differently from those of the main body of the report. The page numbers of the front matter are numbered with lower case Roman numerals beginning with the title page, which is page "i" but the page number is not printed on the title page. The body of the report is numbered with Arabic numerals beginning with the Introduction as page 1. This style guide follows this page numbering convention.

In reports that are printed double-sided, the right-hand pages must have odd numbers while the left-hand pages must have even numbers. It is often necessary to have a blank left-hand page preceding a new chapter (which must always start on a right-hand page); these blank pages are also numbered.

2.4 Headings

Chapters

Technical reports are, in the first instance, divided into chapters that are numbered sequentially with Arabic numerals beginning from 1. The chapter heading is printed flush left at the top of a new page in a boldface font as prescribed in Table 1. Each major word in the chapter heading is to be capitalized.

Running heads

The use of running heads is optional. If used, they are to be used only to reflect chapter information (*e.g.*, the chapter number and possibly the chapter title or a chapter keyword).

Sections

Chapters may be divided into sections, provided there are two or more sections in a chapter. Number the sections in the same manner as is used in this manual, (*i.e.*, *chapter number.section number*), positioned flush left on their own line and printed in a boldface font as prescribed in Table 1. Only the leading word (and any proper nouns that may be present) is capitalized in the section headings. Do not start a new page for each new section.

Sub-sections

Just as sections are related to chapters, sub-sections are related to sections; they should only be used if there are two or more in a section. Do not number sub-sections; print their headings flush left and alone on a new line in a boldface font as prescribed in Table 1. Only capitalize the first letter in the leading word (and any proper nouns that may be present) in the sub-section headings.

Paragraphs

Paragraphs are not numbered. The first line of the first paragraph in a chapter is not to be indented. All subsequent paragraphs must have the first line indented three spaces. Do not insert extra blank lines between paragraphs.

Footnotes and end-notes

The use of footnotes is optional. They must not be used for the purposes of citation and they are to be used sparingly. End-notes are not to be used at all.

2.5 Units

One consistent unit system must be used throughout the report as the primary unit system. In most cases you should use the SI (Système International d'unités) units throughout the report; in addition to SI units, you may include American Standard

units parenthetically. For information on the SI Units, see the Canadian Metric Practice Guide[15] or the Système international d'unités[16]. However, because of the strong influence of the United States in many Canadian industries, situations may occur where the use of American Standard units is more appropriate and in those cases their use is acceptable. If American Standard units are used, SI units may be included parenthetically (*e.g.*, the paper size specification in section 2.1).

2.6 Grammar

This style manual is not intended to be a primer on English composition or grammar. Many books are available on this topic; consider for example [18]-[25]. However, some practices are not acceptable in technical reports and are worth explicitly mentioning here. Some of the more common failings are discussed below.

The standard reference for spelling is the Oxford English Dictionary in any one of its many editions [26]-[32]. For the purposes of reports submitted to the Department of Systems Design Engineering, Canadian spelling is to be used. Because of the excellent spell-check features on contemporary word processors, the appearance of an excessive number of spelling or grammatical errors may result in a *Resubmit* or *Failure* decision; set your word processor language to Canadian English.

The use of profanity, slang and colloquialisms is unacceptable in a technical report. The proscription of profanity should be obvious, but examples of unacceptable slang and colloquialisms, taken from actual undergraduate reports, include the following: "On this project, the marketing department really dropped the ball.", "Get an eyeful of that idiot on the dance-floor.", "Bell got the idea to build the hydro-foil ...", "Make it snappy!", "What are you into?", "Basically, ...', "Well, the reason we ...", and "the real McCoy." Another more subtle form of colloquialism is the contraction, *e.g.* can't, don't, it's, which should be avoided as well.

2.7 Binding

Bind reports with either Cerlox or Spiralastic bindings and use a clear cover page and opaque back cover. Instructors of non-workshop courses may relax this requirement for course project reports.

3

Essential Components

As mentioned in the previous chapter, each report must begin with a title page, a table of contents and an abstract. These are followed by an introduction chapter, one or more chapters which form the main body of the report, and a summary chapter followed by a list of references and possibly some appendices. It is also good practice (necessary for a work report) to have a letter of submittal accompany the report. Most of these parts of the report are discussed in this chapter; figures, tables and photographs are dealt with separately in Chapter 4, and references are covered in Chapter 5.

3.1 Letter of submittal

In accordance with the Co-op Student Reference Manual, which may be found on the web at

http://www.cecs.uwaterloo.ca/manual/work_reports/9_9.php#Letter_of_Submittal ,

the letter of submittal must follow the format of a standard business letter. If this is your first report, address your letter to Ms. P. Jarvie, Executive Director, Co-operative Education & Career Services.

In the case of second, third and fourth work reports, the report must be accompanied by a letter of submittal addressed to the Department Chair. Check that all names

are spelled correctly. Use either your employer's letterhead, with their permission, or use your home address on plain paper.

Your letter must contain the following information:

(a) Report title
(b) Report number (your first, second, and so on)
(c) Name of your employer
(d) Academic term completed prior to this work term
(e) Name(s) of your supervisor(s)
(f) Department(s) in which you worked
(g) Main activity of the employer and department
(h) Purpose of the report
(i) Full acknowledgment and explanation of any assistance you received in preparing the report or its contents
(j) Statement of endorsement (in the form and words shown below)
(k) Statement of Confidentiality (if required by your employer)
(l) Your name, ID number, and **signature**

The statement of endorsement shall read:
"I have prepared this report, "[title]," as my [term] Work Report for the [company department] at [company name]. This report is the [first,second,third,fourth] of four that I must submit as part of my degree requirements, and it has not received any previous academic credit. This report was entirely written by me and has not received any previous academic credit at this or any other institution."

With the exception of the statement of endorsement, do not slavishly follow the example at the Co-operative Education & Career Services web site. Compose your own letter, be original, be creative.

3.2 Title pages

According to Kerkut[17], for every person who reads the whole text of a scientific paper, five hundred only read the title. The title should be accurately descriptive but

also concise; each word in the title should work to convey meaningful information. Examples of wasted title words include titles that begin with[8], "Analysis of ...," "A Note on ...," "The Theory of .....," "On the ...," "A New ...," "Some ...," or "Toward a ...".

Use words in the title that your audience would logically employ as "keywords" if they were searching a database or index to find a report on this subject. Avoid the use of acronyms, abbreviations, formulas, and specialized jargon in the title. Capitalize the major words in the title, just as with chapter headings.

Workshop and course project reports

In addition to the title, the title page (which also serves as the cover page) must include the date, the names and student numbers of all authors, your term of registration, the course number for which the report was prepared, and the name of the workshop project supervisor or course instructor. This information must be presented in the following order:

1. Title
2. "A Report Submitted in Partial Fulfillment of the Requirements for [course number, *e.g.*, SYDE 361]"
3. Your name(s), student number(s) and academic term
4. Faculty of Engineering
5. Department of Systems Design Engineering
6. Date
7. "Project Supervisor: [*title and name of supervisor*]" or "Course Instructor: [*title and name of supervisor*]"

Work reports

Work reports may have both a cover page and a title page, the cover page being unnecessary if a transparent cover is used. The work report title page contains different information than a workshop report and the information is given in a different order. Beginning at the top of the page, present the required information in the following order[33]:

1. University of Waterloo
2. Faculty of Engineering
3. Report title (50 characters, including spaces, or less)
4. Name and address of your employer
5. Prepared by

   Your name,

   student number,

   previous academic term Department of Systems Design Engineering,

6. Date

Example of a course project report title page.

Design and Analysis of a Cardboard Bridge

A Report Submitted in Partial Fulfillment
of the Requirements for SYDE 281

Group Number 45

John Smith, 20030227, 2A
Jane Doe, 20029116, 2A

Faculty of Engineering
Department of Systems Design Engineering

March 15, 2005.
Course Instructor: Professor A. B. Zee

Example of a work report title page.

University of Waterloo

Faculty of Engineering

Pulse Width Modulated Speed Control of a DC Motor

Electric Yacht Co.

Toronto, ON M3J 5R6

Prepared by

I. R. Power

ID 97324697

3A Department of Systems Design Engineering

September 2, 2007.

3.3 Abstract

The abstract appears on the first numbered page of the report and begins with the title "Abstract", unnumbered and centred above the body of the abstract. The body of the abstract is a 100–200 word synopsis of the entire content of the report. It should be able to stand alone and be comprehensible in isolation from the rest of the report. No reference citations, equations, acronyms or abbreviations are included in the Abstract, and it is not an introduction.

The purpose of the Abstract is to provide, in as concise a fashion as possible, the essential details of the contents of the report, thus allowing readers to decide whether or not they need or want to read the entire report. Two commonly encountered types of Abstracts are the descriptive abstract and the informative abstract, also called an Executive Summary. Either form is acceptable.

A descriptive abstract simply describes what the report includes without giving specific results or conclusions. It should also briefly describe the problem that led to the project and hence to the report.

The informative abstract, or Executive Summary, not only describes the report contents, but also includes the most significant findings, results, recommendations and conclusions, often in addition to a very brief overview of the problem, purpose, scope and methods used in reaching the findings, etc. The informative abstract is not simply a concatenation of the Introduction and the Summary; it is a distillation of these two report chapters.

The writing of the abstract is best left to the end, after the rest of the report is completed. There is no need to write the report in the same order that it will be assembled in. It is often easier to write the abstract after the rest of the report has been written because, by that time, you will know what is actually in the report.

3.4 Table of contents

Number every page except the title page. The Table of Contents should include every chapter, section and subsection, with the title left justified and the page number for that section right justified.

Following the Table of Contents include, as necessary, a List of Tables, a List of Figures, and a Table of Nomenclature. Number each figure and table (except the Table of Nomenclature which is part of the Table of Contents) in order of appearance and put a caption on each one. Identify each appendix ordinally by upper case letters; *e.g.*, Appendix A, Appendix B, etc.

The Table of Contents of this Style Manual is an example of an acceptable format. Another example of a Table of Contents, List of Tables, and List of Figures is given in Table 2.

Table 2: Sample Table of Contents

Table of Contents

Table 2: Concluded.

List of Tables

List of Figures

3.5 Acknowledgments

Acknowledgments are optional; if you wish to thank people who have been instrumental in the completion of the project, you may briefly acknowledge them here. You are encouraged to acknowledge anybody that has been a significant mentor (*e.g.* your supervisor, or colleagues who have provided guidance). You are required to acknowledge any person or agency that has provided financial assistance unless they have requested that you not do so.

3.6 Introduction

The purpose of the Introduction is to explain the motivation for your work (*i.e.*, why this project, why it is significant or important), to indicate its scope (*e.g.*, relate it to the other parts of a larger problem), and to establish the context in which the project was done. Establishing the context may involve a review of the current literature related to the problem at hand, or it may involve discussing prior attempts to solve the problem.

The Introduction should set the stage by outlining what is to follow and by explaining why that content was chosen. It should also briefly discuss what the goals of the project were, what the approach to solving the problem was, and why that approach was chosen. It should also mention the criteria used to define 'success'.

Many report writers tend to make the introduction too long. As with every other section of a report, the Introduction should not include unnecessary material of minor significance. It should cover the most significant background material, appropriately cited, in a succinct fashion.

3.7 Body of the report

This body of the report can vary quite substantially, depending on the nature of the project. Regardless of the specific nature of the project, construct the main body of

the report around a well thought-out framework or outline that presents the report material in a logically ordered progression.

The developed framework of the report should lead to the main body being naturally organized into sections or chapters. Because you have defined your aim or purpose and have identified the problem to be solved in the Introduction chapter, the first section (or perhaps chapter) of the main body should elaborate and expand on the problem definition in rigorous and precise engineering terms.

After you have rigorously defined the problem present the means of solution in the following sections or chapters.

3.8 Equations

Use a word processor to create all mathematical expressions and choose the symbols that are consistent with contemporary practice in the discipline most closely related to the topic of the report. Do not use symbols that may be confused, *e.g.*, zero (0) and the letter (O), the numeral (1) and the letter (l).

A letter representing a vector should be printed with an arrow above or below it. (*e.g.*, $\vec{a}_i$, or $\underset{\rightarrow}{a}_1$) In the event that over or under arrows are not available, designate the vector quantity by the use of boldface type. (*e.g.*, $\mathbf{a_i}$)

It is not necessary to number all the equations in the report but those that are important to the discussion and which will be referred to in the text must be numbered. Some styles require numbering *only* those equations that are referred to in the text; we are not so stringent in our requirements. They are to be numbered in parentheses; either sequentially throughout the entire report as (1), (2), (3a), (3b) or sequentially throughout each chapter, in which case the chapter number must be added as a prefix to the equation number (*e.g.*, (4.1), (4.2), etc.). In appendices, the appendix letter must always precede the equation number, for example, (A.1), (A.2), (B.1a), (B.1b). The equation number is to appear to the right of the equation and flush with the right margin. If an equation has more than one part then it is referred to in the plural. In the text refer to equations as "equation (1)," etc., or "Equation

(1)," etc., at the beginning of a sentence. When including an equation in the text, write fractions using a solidus (/), *e.g.*, $1/(a+b)$, rather than in the over-under format of $\frac{1}{(a+b)}$ which is used only in displayed equations. The following report extract provides several examples of how to present equations.

The system kinetic energy T is composed of three components, the contributions from the beams and the contribution of the tip mass, so that

$$T = T_1 + T_2 + T_t \tag{1}$$

where

$$T_i = \frac{1}{2}\rho_i A_i \int_0^{L_i} \left(\dot{u}_i^2 + \dot{v}_i^2 + \dot{w}_i^2\right) dx_i + \frac{1}{2}\rho_i J_i \int_0^{L_i} \dot{\psi}_i^2 dx_i \quad \text{for} \quad i = 1, 2 \tag{2}$$

(rotatory inertia has been ignored) and

$$T_t = \frac{1}{2} m_t \left(\dot{u}_2^2(L_2, t) + \dot{v}_2^2(L_2, t) + \dot{w}_2^2(L_2, t)\right) \tag{3}$$

The system potential energy U is composed of a contribution from each beam segment and is given by

$$U = U_1 + U_2 \tag{4}$$

where

$$\begin{aligned} U_i \;=\; & \frac{1}{2}\int_0^{L_i} E_i A_i \left(\frac{\partial u_i}{\partial x_i}\right)^2 dx_i + \frac{1}{2}\int_0^{L_i} E_i I_{yy}^{(i)} \left(\frac{\partial^2 w_i}{\partial x_i^2}\right)^2 dx_i \\ & + \frac{1}{2}\int_0^{L_i} E_i I_{zz}^{(i)} \left(\frac{\partial^2 v_i}{\partial x_i^2}\right)^2 dx_i + \frac{1}{2}\int_0^{L_i} G_i J_i \left(\frac{\partial \psi_i}{\partial x_i}\right)^2 dx_2 \quad \text{for} \quad i = 1, 2 \end{aligned} \tag{5}$$

Define symbols and abbreviations (especially acronyms) the first time they are used, or include a Table of Nomenclature (symbols and abbreviations) in the Table of Contents (see section 3.4). Ensure that symbols and abbreviations used in figures and tables are also defined. List them in alphabetical order beginning with all the uppercase Roman letters, followed by the lowercase Roman letters and then the Greek

letters in the same order as for the Roman letters. List special symbols or notation that have been used at the end of the table. A sample Table of Nomenclature appears in Table 3.

3.9 Summary, conclusions and recommendations

The report's conclusions, recommendations, and summary must flow logically from the rest of the report and be able to stand on their own without reference to other portions of the report. They must make sense and be realistic. It is not necessary to have all of these sections; depending on the circumstances it may be appropriate to have only a Summary or only a Conclusions chapter.

Conclusions and recommendations

While brevity is one goal, students often write conclusions that are too short. It is unsatisfactory, for example, to write "The conclusions may be found in the report." The conclusions and recommendations chapter should be devoted to reporting how well, in what manner, and with what consequences the project goals were met. Simply reporting the results is the easy part, the interpretation of those results, the deduction of the consequences of the results, and the drawing of logical conclusions from the results is the important (and the most difficult) part of report writing. These cannot be achieved without having done an analysis and used your expertise to reach a defensible set of conclusions and recommendations. No new or previously ignored results should appear in the conclusions and recommendations chapter. It is as important to discuss the goals that were not met as it is to discuss those that were met. Describe what was learned and what should be done differently the next time.

Summary

If you end the report with a summary chapter it should summarize the entire report in one to two pages. Begin with a description of the problem and include parts of

Table 3: Table of Nomenclature

A_i	cross sectional area of the ith beam
E_i	Young's modulus of the ith beam
$I_{yy}^{(i)}$	second moment of the area of the ith beam about yy axis
$I_{zz}^{(i)}$	second moment of the area of the ith beam about zz axis
J_i	area polar moment of inertia of the ith beam
L_i	length of the ith beam
M_t	non-dimensional tip mass
T	system kinetic energy
U	system potential energy
$U_i(x_i)$	axial displacement eigenfunctions of the ith beam
$V_i(u_i)$	out-of-plane displacement eigenfunctions of the ith beam
$W_i(u_i)$	transverse displacement eigenfunctions of the ith beam
$\Psi_i(u_i)$	torsion eigenfunctions of the ith beam
m_t	tip mass
t	time
$u_i(x_i,t)$	axial displacement of the ith beam
$v_i(x_i,t)$	out-of-plane displacement of the ith beam
$w_i(x_i,t)$	transverse displacement of the ith beam
x_i	co-ordinate of the ith beam
θ	orientation of the second beam relative to the first
σ	ratio of extensional force of the second beam to the first beam
ξ_i	non-dimensional co-ordinate of the ith beam
ρ_i	volume mass density of the ith beam
ν	slenderness ratio
ω	natural frequency
$\dot{(\ )}$	time derivative
$(\ )'$	spatial derivative

the Introduction but without repeating the Introduction. Then include parts of the main body and finally end with a synopsis of the conclusions and recommendations.

From the main body include, in general terms, how the problem was solved, what, why and how many tests were done, and what their outcomes were.

For a design problem, discuss the evaluation criteria and how they were met. If the final design was built and tested, describe how well it performed.

3.10 Appendices

The purpose of Appendices is to allow supporting material to be included. Supporting material is material which provides useful information but which would be distracting to the reader if it were included in the main body, either by disrupting the flow of ideas or by being excessively long. Novice report writers often over-use appendices; use them sparingly.

Examples of material that could likely be put into an appendix include the following: special mathematical results or derivations used in the report, detailed testing procedures, lists of experimental equipment (make, model and serial number), parts specification sheets, computer programs and their documentation, tables of unreduced data, tables of reduced data if that data has been presented graphically in the main body of the report, and large figures such as blueprints.

Frequently, there is a strong temptation or need to use acronyms or abbreviations in the report and this presents a difficulty for a reader who is not familiar with industry specific acronyms (abbreviations). In this case it is strongly advised that the first Appendix be a Glossary that alphabetically lists and defines all the acronyms and abbreviations used in the report. They should still be defined at first use in the text but the Glossary provides the reader with a single place to look for forgotten definitions.

Designate Appendices as A, B, C in order of their mention in the main text. Appendices have titles which appear on the line following the heading "Appendix" as follows:

Appendix A
Useful Laplace Transforms

Appendix B
Experimental Data

Appendix C
Code Listings

4

Figures, Illustrations and Tables

While figures, illustrations and tables can help clarify meaning and are sometimes necessary to demonstrate results properly, keep them to a practicable minimum. Omit, or put in an Appendix, detailed drawings, lengthy test data and calculations, and photographs that may be interesting, but which are not integral to the understanding of the subject.

Include the figures and tables in the body of the report as close as possible to their first mention in the text. Ideally they should appear after their first reference in the text but occasionally due to layout considerations they may appear slightly before they are referenced. For example, a large figure may appear on the left hand page facing the page where it first referenced; while the figure strictly precedes the reference, it is visible to the reader at the time of referencing. On pages where both text and a figure or a table appear, consistently attempt to do one of the following: place the text at the top of the page and the figure or table at the bottom or place the figure or table at the top of the page and the text at the bottom of the page.

4.1 Figures and illustrations

Figures, illustrations, and tables should be used to clarify meaning and should be used where it would be difficult for the reader to follow the text without it (*e.g.* a complex device consisting of many interacting parts). Figures should be well labelled and the

labels should match the keywords used in the text. The important information that the figures help to explain should still be described in the text. The number of figures should be kept to a practical minimum.

Figures and illustrations must be sharp, noise-free, and of good contrast. Print them on a good quality laser or ink-jet printer at 300 dots per inch (dpi) or more. If the figures are hand-drawn use black drafting ink. It is very important that the lettering be large enough to be legible; a font size no less than 10 point (pt) is recommended. Sans-serif fonts are a good choice for figures, and each figure should employ the same font. If figures are produced on a laser or ink-jet printer, use line weights greater than 0.5 pt (1 pt is recommended) and use fill patterns with more than 30 percent black (Figure 2 is a sample graph showing proper use of line weight, font, labelling, and caption).

In the case of graphs (see Figure 3), it is a good practice to include only the coordinate axes with tick marks showing the principal (numbered) and possibly secondary axis graduations. At most, include only the major grid lines to avoid a cluttered and illegible result. Label the axes to identify the parameter associated with the axis. The unit of measurement in brackets (*e.g.*, Wheel Mass [kg] or Wheel Mass (kg)) must follow after the parameter.

Where the graph displays experimental results, identify the experimental data points by the use of data point symbols such as $\bullet$, $\circ$, $\times$, $*$, $\diamond$ or $\triangle$. If more than one curve or set of data is included in one figure, distinguish the curves by the use of lines of different colours, by different weights, or by solid, dashed, dotted, or dash-dotted lines. You must include a figure legend that identifies the case associated with each line type, line weight or symbol.

In the same manner as for equations, number and place all figures in the order they are mentioned (*e.g.*, Figure 1, Figure 2, or Figure 3(a) or Figure 2.1, Figure 2.5, or Figure 6.3(a)). It is good practice to place the figures as close as possible to where they are first mentioned and if a figure or table is not discussed or mentioned in the text it should not be in the report. You are permitted to place more than one figure on a page, but the spacing between figures must be even. Figures should not extend

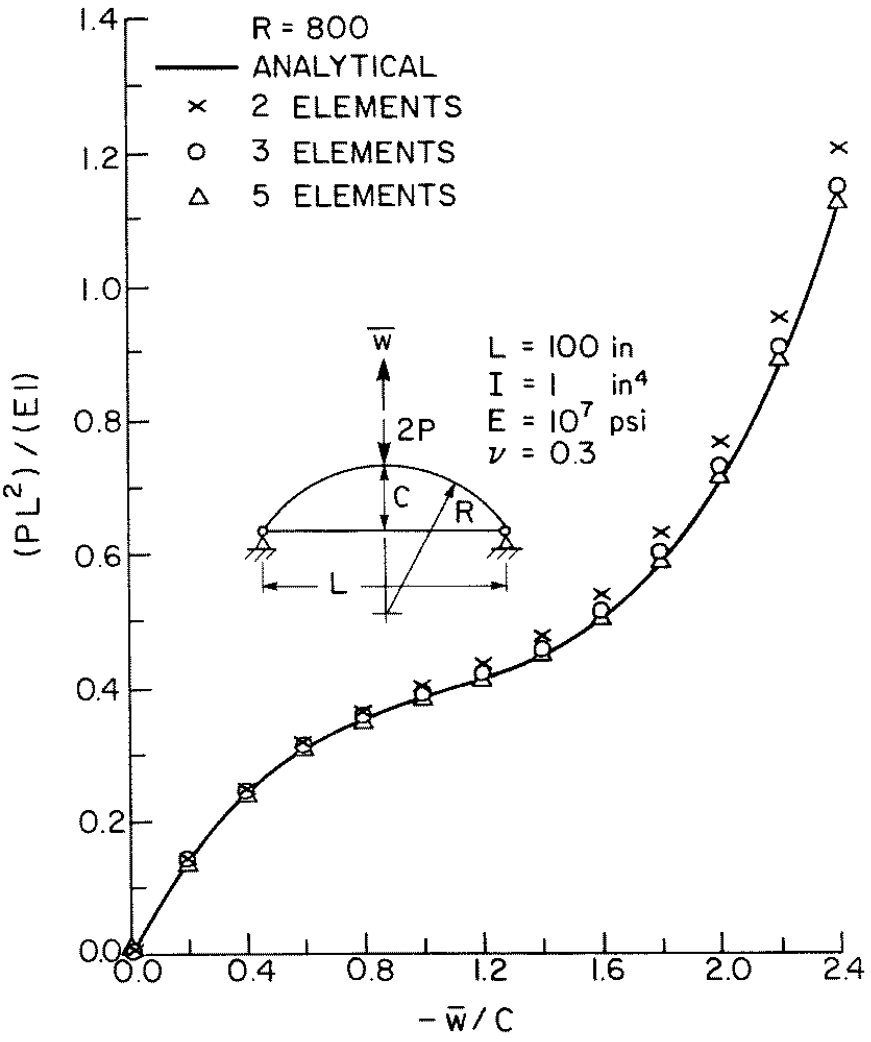

Figure 2: Nonlinear analysis of a pinned-pinned circular arch; trigonometric basis functions.

beyond the printing area defined in section 2.2.

Make figure captions very brief, but descriptive, and place them **below** the figure. Capitalized the first letter of the first word and end the caption with a period. See the examples in Figures 2 and 3.

It is unusual for figures to span more than one page. However, if a figure has several parts that extend over several pages, the caption for the second and succeeding pages of the multi-page figure should be, with the exception of the final part:

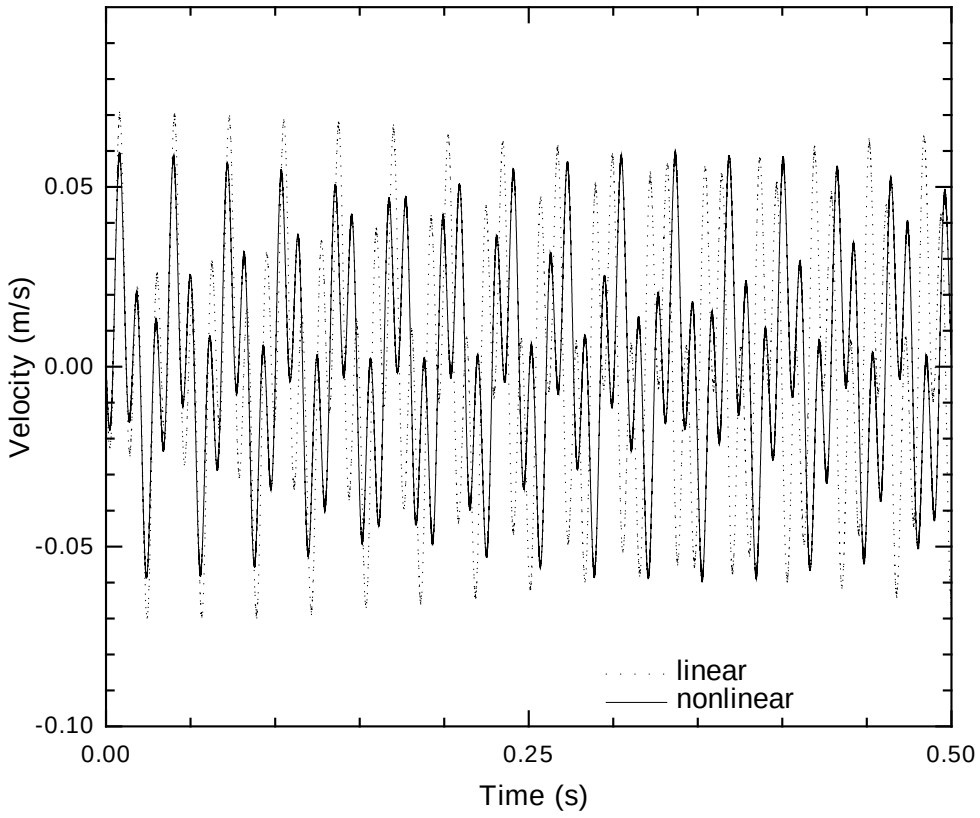

Figure 3: Tip velocity for $\dot{\theta} = 50$ rad/s and $h/L = 0.01$.

Figure 1. Continued.

The caption for the final page of a multi-page figure should be:

Figure 1. Concluded.

4.2 Tables

Number tables, like figures and equations, with Arabic numerals in order of their mention (*e.g.*, Table 1, Table 2(a), or Table 2(b) or Table 7.1, Table 6.2(a), or Table 6.2(b)). Their order of appearance must correspond to their order of mention. Make table captions brief, but descriptive, and place them centred **above** the table. Capitalize all major words of the captions, as illustrated in Table 4. Each table column must have a descriptive heading. If the column data has units, you must include them in the column heading.

It is not sufficient to simply write "The data is given in Table 2." Explain each table, explain why it is there, explain the features you want the reader to notice the most, and explain why it is in the format you have used.

Table 4: Harmonic Drive Characteristics

Drive	**Mass** (kg)	**Rated Output Power** (W)	**Rated Voltage** (V)	**Rated Output Torque** (N-m)	**Maximum Output Torque** (N-m)
Shoulder Motor (RFS-32-6030)	11.9	308	85	49	187
Elbow Motor (RFS-25-6018)	6.8	185	75	29.4	85.1

It is not uncommon for tables to span more than one page. If a table does extend over several pages, the caption for the second and succeeding pages of the multi-page table should be, with the exception of the last part:

Table 1. Continued.

The caption for the final page of a multi-page table should be:

Table 1. Concluded.

You can either integrate tables into the text or place them after the text. For tables placed after the text, place more than one table on a page, if size permits. Be sure to place tables so that the spacing between them is even, and they do not exceed the image area described in section 2.2.

4.3 Photographs

Photographs should be glossy prints, of good contrast and gradation. Bitmap images obtained from a digital camera or by scanning a photograph must also have good

contrast and gradation. Paste down original photographs and include a descriptive caption following the styles discussed in the "Figures" section. The photograph and caption must fit within an image area of 6 inches wide by 9 inches long.

4.4 Lists

On occasion, you may wish to present a set of constraints, criteria, or some other set of items as a numbered list so that you can easily refer to a particular list item in your discussion. You may also wish to make the list stand out visually. Use lists sparingly so as not to debase their effectiveness; do not use them as a substitute for paragraph form. The items in the list are to be numbered (*e.g.*, (1), (2), (3), or (a), (b), (c), etc.) and are not to be distinguished with bullets. The use of bullets is strongly discouraged in favour of enumerated lists because the item labels in an enumerated list allow easy reference to a specific entry in the list.

The excessive use of bullets and point form, where proper paragraph form should have been used, is unacceptable especially when the point form statements approach the length and content of sentences but are not actually complete sentences. Removing the bullets and using one sentence paragraphs is not an acceptable solution.

The reason that the use of bullets is strongly discouraged is that students attempt to legitimize point-form writing by using bullets. Point-form writing, with or without the use of bullets, is not acceptable in technical reports.

5

References

It is an extremely rare occurrence that everything written in a technical report is the original creation of the author. Due to the importance that standard engineering practice places on proper citation in all technical reports, all material, including equations, facts, specifications, opinions, data or other information, used by, but not created by, the author must be acknowledged as having come from the proper source.

For example, statements such as "90% of software companies need..." or "... our software programmers have problems with testing..." must be substantiated either by the use of an appropriate reference or by a description of the investigation the author conducted to obtain the data that was used to reach these conclusions. The method of data reduction must also be included. If a statement such as this is an estimate (guess), then justify it by explaining how it was arrived at.

Acknowledgment of the source of material used in the report is achieved through the use of references. References must be unambiguous, consistent, clear and complete so that readers may confirm the information included in the report and so they can, potentially, turn to the references for a more complete discussion on a particular matter. In the case of a report on an activity that is part of a much larger project, the references can be a valuable source of information to other people working on other aspects of the larger project.

5.1 Plagiarism

The sixth edition of the Oxford English Dictionary [26] defines "plagiarize" as:

> "**plā'ǧiar|ĭze,** *v.t.* Take and use another persons (thoughts, writings, inventions or abs.) as one's own; so ∼ism (1), ∼ist (1), ... "

Broadly interpreted, plagiarism is expressing another person's ideas as your own. The most blatant form of plagiarism is to copy, word for word, the work of another author without citation. This is all too easy to do nowadays with electronic documents and word processors. It can happen *accidentally* as a result of poor record keeping, but whether deliberate or accidental, it is an Academic Offence at the University of Waterloo and at every other reputable university in the world (refer to University Policy 71: Student Academic Discipline Policy) [34]. It is not a legal offence, the way copyright violation is, but is rather a failure of moral integrity and a violation of professional ethical standards. Reputable corporations look as dimly on plagiarism, as do universities.

As of September 2009 all University of Waterloo course outlines and/or websites must contain the following statement:

"**Academic Integrity:** In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility.

(Check www.uwaterloo.ca/academicintegrity/ for more information.)

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4, www.adm.uwaterloo.ca/infosec/Policies/policy70.htm.

When in doubt please be certain to contact the departments administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity (check www.uwaterloo.ca/academicintegrity/)

to avoid committing an academic offence, and to take responsibility for his/her ac-

tions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about rules for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline, www.adm.uwaterloo.ca/infosec/Policies/policy71.htm.

For typical penalties check Guidelines for the Assessment of Penalties, www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm.

Appeals: A decision made or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals) www.adm.uwaterloo.ca/infosec/Policies/policy72.htm.

Note for Students with Disabilities: The Office for Persons with Disabilities (OPD), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the OPD at the beginning of each academic term."

While all forms of plagiarism are unacceptable, it is possible to make distinctions between various forms of plagiarism. Gordon *et al.*[35] identify five forms of plagiarism, these are: complete plagiarism, near-complete plagiarism, patchwork plagiarism, lazy plagiarism and self plagiarism. In each case the name of the form of plagiarism is quite descriptive. They represent regions on a continuum that ranges from claiming authorship of something that has been wholly written by someone else to the adoption of selected phrases from another author's work without citation and the use of quotation marks. An example of self plagiarism would be submitting the same project report, or a modified version of the report, to two separate courses or to the same course twice.

5.2 Copyrighted material

Copyright in Canada is a rapidly changing legal issue. At any given time it is not completely clear what may be copied or how much may be copied. For guidance consult the University's web page at
http://www.lib.uwaterloo.ca/copyright/copying.html

5.3 Citations and References

Citations are what are used within the body of the text to let the reader know that you are making use of someone else's words or ideas (*i.e.* you are citing their work). Direct quotes must be in quotation marks. The references are works that are cited.

Follow the body of your report with an unnumbered chapter entitled 'References' and then the appendices. Only documents that you have actually used may be referenced, and under no circumstances should an author represent another's work as his or her own.

Acceptable references include books, journal articles, published conference proceedings or other conference publications, papers from published conference proceedings or other conference publications, patents, technical memoranda including manufacturers product specification sheets, technical notes, technical reports, theses, and private communications. Reference to unpublished work or information acquired through personal communication, such as conversations or E-mail, is not encouraged and should be avoided unless absolutely necessary. When used, you must clearly identify it as such, and must not represent it as published information, even if publication is pending. Identify unpublished work by including a parenthetical note in the text with an appropriate notation such as "unpublished," "to be published," or "personal communication," whichever the case may be. If E-mail is referenced, a copy of the correspondence should be retained for future examination or reference. Course notes should not be cited as a reference unless the material being cited cannot be found in any published book or journal. References to material found on internet discussion

groups are pointless and should not be used.

You may use government classified or restricted distribution documents as background references without explicitly including any of their content in the report. If it is necessary to include data from any restricted document, you must obtain **written** permission to reference the document, from the organization controlling the restricted document, and include the original letter of permission with submission of the report. Likewise proprietary company documents or data may only be referenced or included in the report if **written** permission from the company has been obtained.

Do not use trade or manufacturer's names unless a product cannot be described generically. If you must use a trade name, use it as an adjective and give credit to the owner (*e.g.*, use snowmobile rather than "Skidoo", a registered trademark of Bombardier Inc.)

A bibliography is not the same as a list of References; it is a list of references not actually cited in the report but which provide useful ancillary information. If you present a bibliography, in addition to the references, list the entries alphabetically according to author and without numbers.

5.4 Citation conventions

The purpose of the citation and accompanying reference is to inform your reader as to the source of an idea or words; and where the reader can locate the document for further follow-up. Correct citation of a reference is an important responsibility and you should carefully check the final draft of the report to make certain there are no errors in the reference list. Two different methods of referencing or citing are outlined below; use one style exclusively in your report; do not mix styles in the same report.

Citation by author

In this citation convention, the references are cited in the text by giving the last name of the author(s) and the year of publication of the reference. For example, "Recent work (D'Eleuterio and Hughes, 1987) has ...", or "Recently D'Eleuterio and Hughes

(1987) have ...". In the event that there are more than two authors, use the form "Bellezza et al. (1990) report the ..." in the text. When two or more references would have the same text identification, as would occur if the same author(s) published two or more papers in the same year, distinguish them by appending "a," "b," etc., to the year of publication, *e.g.*, "Wong et al. (1994a) confirmed ...".

List the references in alphabetical order, according to the last name of the first author, at the end of the report but before the Appendices.

Examples of how to reference these various forms of reference may be found in Tables 5 through 8 (underlining can be used in place of italics).

Table 5: Citation by Author Reference Format Examples:
Books

Book:	Author (last name followed by first name or initials), year. *title*. edition, **Volume number**, Location: publisher. [chapter, and page numbers (if desired)].
First edition:	Huseyin, K., 1978. *Vibrations and Stability of Multiple Parameter Systems*. Alphen aan den Rijn: Noordhoff International Publishing.
Later edition:	Hibbeler, R. C., 1997. *Mechanics of Materials*. 3rd Edition, Englewood Cliffs: Prentice-Hall, 1997.
One volume of a series:	Carey, Graham F., and Oden, J. Tinsley, 1983. *Finite Elements: A Second Course*. Volume II of The Texas Finite Element Series, Englewood Cliffs: Prentice-Hall.
Translation:	Gradshteyn, I. S., and Ryzhik, I. M., (Alan Jeffrey, transl.), 1965. *Table of Integrals, Series and Products*. Fourth Edition, New York: Academic Press.
Edited book:	Tapley, Byron D., ed., 1990. *Eshbach's Handbook of Engineering Fundamentals*. Fourth Edition, New York: John Wiley & Sons.

Table 5: Citation by Author Reference Format Examples: Books

Book:	Author (last name followed by first name or initials), year. *title*. edition, **Volume number**, Location: publisher. [chapter, and page numbers (if desired)].
Section of an edited collection:	Bernadou, M., 1986. *Some Finite Element Approximations of Thin Shell Problems*. Finite Element Methods for Plate and Shell Structures, **1**. Thomas J. R. Hughes and Ernest Hinton eds. Swansea: Pineridge Press, 62-84.
Part of a book:	Roark, Raymond J., and Young, Warren C., 1975. *Formulas for Stress and Strain*, Part Three Formulas and Examples, New York: McGraw-Hill, 73-588.
Corporate or Organizational Author:	Battelle Memorial Institute, Columbus Ohio 1941. *Prevention of the Failure of Metals Under Repeated Stress*. New York: John Wiley & Sons.

Table 6: Citation by Author Reference Format Examples: Journals

Journal Articles:	Author (last name followed by first name or initials), year. title in quotations, *periodical*, **volume** (number), [month], page numbers.
Single Author:	Inman, D. J., 1988. "A sufficient Condition for the Stability of Conservative Gyroscopic Systems", *J. of Applied Mechanics*, **55**(4), 895-898.
Multiple Authors:	D'Eleuterio, G. M. T., and Hughes, P. C., 1987. "Dynamics of Gyroelastic Spacecraft", *J. Guidance, Control and Dynamics*, **10**(4), 401-405.

Table 7: Citation by Author Reference Format Examples: Conference Proceedings

Conference Proceedings:	Authors (last name followed by first name or initials), year. title in quotations, *proceedings*, date, location, **volume** (number), page numbers.
Single Author:	Heppler, G. R., 1990. "On the Vibration of Unrestrained Curved Timoshenko Beams", *Proceedings of the CSME FORUM90*, June 3-8, Toronto, **4**, 103-108.
Multiple Authors:	Bellezza, F., Lanari L., and Ulivi, G., 1990. "Exact Modelling of the Flexible Slewing Link", *Proceedings of the 1990 IEEE International Conference on Robotics and Automation*, May 13-18, Cincinnati, **3**, 734-739.

Table 8: Citation by Author Reference Format Examples: Technical Reports, and other documents

Technical Reports:	Author (last name followed by first name or initials), year. title in quotations, report number, organization.
Single Author:	Leissa, Arthur W., 1973. "Vibration of Shells", NASA SP-288, National Aeronautics and Space Administration.
Multiple Authors:	Ballentine, J. R., Plumblee, H. E., and Schneider, C. W., 1966. "Sonic Fatigue in Combined Environment", AFFDL-TR-66-7, U.S. Air Force.
Government Reports:	McConnell, David, 1988. *British Smooth Bore Artillery: A Technological Study*, Ottawa: Environment Canada - Parks.
Patent:	Clemens, Melville, 1869. *The Pivoted Crank-Shaft Coupler.* U.S. Patent 96,395.
Thesis:	Damaren, C. J., 1987. *Optimal Control Formulation for Lightly Damped Gyroelastic Continua*, M.A.Sc. Thesis, University of Toronto.
Private Communication:	Jones, A. B., 1999. Private Communication, Acme Widget Ltd., Kitchener ON.

These references would appear in the References Chapter as follows:

Ballentine, J. R., Plumblee, H. E., and Schneider, C. W., 1966. "Sonic Fatigue in Combined Environment", AFFDL-TR-66-7, U.S. Air Force.

Battelle Memorial Institute, Columbus Ohio 1941. *Prevention of the Failure of Metals Under Repeated Stress.* New York: John Wiley & Sons.

Bellezza, F., Lanari L., and Ulivi, G., 1990. "Exact Modelling of the Flexible Slewing Link", *Proceedings of the 1990 IEEE International Conference on Robotics and Automation*, May 13-18, Cincinnati, **3**, 734-739.

Bernadou, M., 1986. *Some Finite Element Approximations of Thin Shell Problems.* Finite Element Methods for Plate and Shell Structures, **1**. Thomas J. R. Hughes and Ernest Hinton eds. Swansea: Pineridge Press, 62-84.

Carey, Graham F., and Oden, J. Tinsley, 1983. *Finite Elements: A Second Course.* Volume II of The Texas Finite Element Series, Englewood Cliffs: Prentice-Hall.

Damaren, C. J., 1987. *Optimal Control Formulation for Lightly Damped Gyroelastic Continua*, M.A.Sc. Thesis, University of Toronto.

D'Eleuterio, G. M. T., and Hughes, P. C., 1987. "Dynamics of Gyroelastic Spacecraft", *J. Guidance, Control and Dynamics*, **10**(4), 401-405.

Gradshteyn, I. S., and Ryzhik, I. M., (Alan Jeffrey, transl.), 1965. *Table of Integrals, Series and Products.* Fourth Edition, New York: Academic Press.

Heppler, G. R., 1990. "On the Vibration of Unrestrained Curved Timoshenko Beams", *Proceedings of the CSME FORUM90*, June 3-8, Toronto, **4**, 103-108.

Hibbeler, R. C., 1997. *Mechanics of Materials.* 3rd Edition, Englewood Cliffs: Prentice-Hall, 1997.

Huseyin, K., 1978. *Vibrations and Stability of Multiple Parameter Systems.* Alphen aan den Rijn: Noordhoff International Publishing.

Inman, D. J., 1988. "A Sufficient Condition for the Stability of Conservative Gyroscopic Systems", *J. of Applied Mechanics*, **55**(4), 895-898.

Jones, A. B., 1999. Private Communication, Acme Widget Ltd., Kitchener ON.

Leissa, Arthur W., 1973. *Vibration of Shells*, NASA SP-288, National Aeronautics and Space Administration.

McConnell, David, 1988. *British Smooth Bore Artillery: A Technological Study*, Ottawa: Environment Canada - Parks.

Tapley, Byron D., ed., 1990. *Eshbach's Handbook of Engineering Fundamentals.* Fourth Edition, New York: John Wiley & Sons.

Ordinal citations

Just as in the citation by name case, the references should appear in a separate unnumbered chapter at the end of the report but before the Appendices. The items cited in the text are referred to by the use of numerals in square brackets and are given in order of first mention in the text. This method of citation is used in this Style Manual.

Examples of how to format various forms of reference may be found in Tables 9 through 12 (underlining can be used in place of italics).

Table 9: Ordinal Citation Reference Format Examples: Books

Book:	Author, *title*. Volume number, edition, Location: publisher, year. [chapter, and page numbers (if desired)].
First edition:	K. Huseyin. *Vibrations and Stability of Multiple Parameter Systems.* Alphen aan den Rijn: Noordhoff International Publishing, 1978.
Later version:	R. C. Hibbeler.*Mechanics of Materials.* 3rd Edition, Englewood Cliffs: Prentice-Hall, 1997.
Translation:	I. S. Gradshteyn, I. M. Ryzhik (Alan Jeffrey, transl.). *Table of Integrals, Series and Products*, Fourth Edition. New York: Academic Press, 1965.
One volume of a series:	Graham F. Carey, J. Tinsley Oden. *Finite Elements: A Second Course*, Volume II of The Texas Finite Element Series. Englewood Cliffs: Prentice-Hall, 1983.
Edited book:	Byron D. Tapley, ed. *Eshbach's Handbook of Engineering Fundamentals*, Fourth Edition. New York: John Wiley & Sons, 1990.
Section of an edited collection:	M. Bernadou. *Some Finite Element Approximations of Thin Shell Problems.* Finite Element Methods for Plate and Shell Structures, **1**. Thomas J. R. Hughes and Ernest Hinton eds. Swansea: Pineridge Press, 1986, 62-84.
Part of a book:	Raymond J. Roark and Warren C. Young, 1975. *Formulas for Stress and Strain*, Part Three Formulas and Examples, New York: McGraw-Hill, 73-588.
Corporate Author:	Battelle Memorial Institute, Columbus Ohio. *Prevention of the Failure of Metals Under Repeated Stress.* New York: John Wiley & Sons, 1941.

Table 10: Ordinal Citation Reference Format Examples: Journal Articles

Journal Articles:	Author (first name or initials followed by last name), title in quotations, *journal name*, **volume** (number), page numbers, [month], year.
Single Author:	D. J. Inman, "A Sufficient Condition for the Stability of Conservative Gyroscopic Systems", *J. of Applied Mechanics*, **55**(4), 895-898, 1988.
Multiple Authors:	G. M. T. D'Eleuterio and P. C. Hughes, "Dynamics of Gyroelastic Spacecraft", *J. Guidance, Control and Dynamics*, **10**(4), 401-405, 1987.

Table 11: Ordinal Citation Reference Format Examples: Conference Proceedings

Conference Proceedings:	Authors, first name or initials followed by last name. title in quotations, *proceedings*, date, location, **volume** (number), page numbers, year.
Single Author:	G. R. Heppler. "On the Vibration of Unrestrained Curved Timoshenko Beams", *Proceedings of the CSME FORUM90*, June 3-8, Toronto, **4**, 103-108, 1990.
Multiple Authors:	F. Bellezza, L. Lanari, G. Ulivi. "Exact Modelling of the Flexible Slewing Link", *Proceedings of the 1990 IEEE International Conference on Robotics and Automation*, **3**, May 13-18, Cincinnati, 734-739, 1990.

Table 12: Ordinal Citation Reference Format Examples: Technical Reports, and other documents

Technical Reports:	Author, first name or initials followed by last name, title in quotations, report number, organization, date.
Single Author:	Arthur W. Leissa, "Vibration of Shells", NASA SP-288, National Aeronautics and Space Administration, 1973.
Multiple Authors:	J. R. Ballentine, H. E. Plumblee and C. W. Schneider, "Sonic Fatigue in Combined Environment", AFFDL-TR-66-7, U.S. Air Force, 1966.
Government Reports:	David McConnell, *British Smooth Bore Artillery: A Technological Study*, Ottawa: Environment Canada - Parks, 1988.
Patent:	Melville Clemens. *The Pivoted Crank-Shaft Coupler.* U.S. Patent 96,395. 1869.
Thesis:	C. J. Damaren, *Optimal Control Formulation for Lightly Damped Gyroelastic Continua*, M.A.Sc. Thesis, University of Toronto, 1987.
Private Communication:	A. B. Jones, Private Communication, Acme Widget Ltd., Kitchener ON., 1999.

These references would appear, if the above was their order of mention in the report, in the References chapter as follows:

1. K. Huseyin. *Vibrations and Stability of Multiple Parameter Systems.* Alphen aan den Rijn: Noordhoff International Publishing, 1978.
2. R. C. Hibbeler. *Mechanics of Materials.* 3rd Edition, Englewood Cliffs: Prentice-Hall, 1997.
3. Graham F. Carey, J. Tinsley Oden. *Finite Elements: A Second Course*, Volume II of The Texas Finite Element Series. Englewood Cliffs: Prentice-Hall, 1983.
4. I. S. Gradshteyn, I. M. Ryzhik (Alan Jeffrey, transl.). *Table of Integrals, Series and Products*, Fourth Edition. New York: Academic Press, 1965.
5. Byron D. Tapley, ed. *Eshbach's Handbook of Engineering Fundamentals*, Fourth Edition. New York: John Wiley & Sons, 1990.
6. M. Bernadou. *Some Finite Element Approximations of Thin Shell Problems.* Finite Element Methods for Plate and Shell Structures, **1**. Thomas J. R. Hughes and Ernest Hinton eds. Swansea: Pineridge Press, 1986, 62-84.
7. Raymond J. Roark and Warren C. Young, 1975. *Formulas for Stress and Strain*, Part Three Formulas and Examples, New York: McGraw-Hill, 73-588.
8. Battelle Memorial Institute, Columbus Ohio. *Prevention of the Failure of Metals Under Repeated Stress.* New York: John Wiley & Sons, 1941.
9. D. J. Inman, "A Sufficient Condition for the Stability of Conservative Gyroscopic Systems", *J. of Applied Mechanics*, **55**(4), 895-898, 1988.
10. G. M. T. D'Eleuterio, P. C. Hughes, "Dynamics of Gyroelastic Spacecraft", *J. Guidance, Control and Dynamics*, **10**(4), 401-405, 1987.

11. G. R. Heppler. "On the Vibration of Unrestrained Curved Timoshenko Beams", *Proceedings of the CSME FORUM90*, June 3-8, Toronto, **4**, 103-108, 1990.

12. F. Bellezza, L. Lanari and G. Ulivi, 1990. "Exact Modelling of the Flexible Slewing Link", *Proceedings of the 1990 IEEE International Conference on Robotics and Automation*, **3**, May 13-18, Cincinnati, 734-739, 1990.

13. Arthur W. Leissa, "Vibration of Shells", NASA SP-288, National Aeronautics and Space Administration, 1973.

14. J. R. Ballentine, H. E. Plumblee and C. W. Schneider, "Sonic Fatigue in Combined Environment", AFFDL-TR-66-7, U.S. Air Force, 1966.

15. David McConnell, *British Smooth Bore Artillery: A Technological Study*, Ottawa: Environment Canada - Parks, 1988.

16. Melville Clemens. *The Pivoted Crank-Shaft Coupler.* U.S. Patent 96,395. 1869.

17. C. J. Damaren, *Optimal Control Formulation for Lightly Damped Gyroelastic Continua*, M.A.Sc. Thesis, University of Toronto, 1987.

18. A. B. Jones, Private Communication, Acme Widget Ltd., Kitchener ON., 1999.

5.5 Electronic document references

Citation of electronic documents (*e.g.*, web pages) is discouraged but may occasionally be unavoidable (*e.g.* electronic journals). It is discouraged because there is very weak editorial oversight on web content and consequently the accuracy of web based information should always be viewed with suspicion. On those occasions when you do need to cite an electronic source, you must save the electronic document that is used

as a reference, preferably on paper or on disk to preserve a copy of the document as referenced and to guard against the document becoming unavailable.

Many companies are now providing internal company documents on-line, often only for internal use. Unless it it publicly available this type of electronic document should be viewed in the same manner as a restricted, confidential or classified paper document and is an inappropriate citation for a work report.

References for electronic documents must conform as closely as possible in content and punctuation to the style of References for paper references. The electronic address must be the last item in the reference, must be started on a new line and must be the only item on that line. If it becomes necessary to break an electronic address at the end of a line, do so after a slash (/), dot (.) or colon (:) but not after hyphens (-), and do not introduce a hyphen at the break because it could create confusion. The reference for electronic documents must include all colons, slashes, dots, and other marks of punctuation as given. Ensure that punctuation marks that are not part of the electronic address are not mistakenly included in the electronic address. **It must be the address of the actual page where the information was obtained.**

For example, in the report you may wish to write "An excellent selection of home built kayak kits and plans may be found on the Chesapeake Light Craft web site [1]." In this case giving the electronic address of the company home page is sufficient. However if you want to site a more specific document (*e.g.*, ... the specifications of the Motorola Integrated Baseband Processor Development IC [5] are ...) it is necessary to reference the specific page where that information may be found.

Do not use informal documents such as personal e-mail and information from discussion groups as references unless it is absolutely necessary (this is expected to be a very rare occurrence) and there is reasonable confidence regarding the integrity of the source. Such documents are not editorially vetted, their credibility is questionable, and you cannot present them as scholarly or professional information.

Table 13: Citation Format Examples: Electronic Documents

General Web Sites:	Company or Organization Name, date. (New Line) Web site address
Example 1:	Chesapeake Light Craft, August 10, 2000. http://www.clcboats.com/
Example 2:	Intel Corporation, August 10, 2000. http://www.intel.com/
Specific Web Documents:	Company or Organization Name. *Document Title.* date. (New Line) Web site address
Example 3:	American Institute for Aeronautics and Astronautics. *Information for Contributors to AIAA Journals*, September 17, 1999. http://www.aiaa.org/publications/journals/contributors.html
Example 4:	American Society of Civil Engineers. *Instructions for Preparation of Electronic Manuscripts*, September 17, 1999. http://www.pubs.asce.org/authors/oddsends.html#si
Example 5:	Motorola, Inc., *Integrated Baseband Processor Development IC*, August 10, 2000. http://ebus.mot-sps.com/ProdCat/psp/ 0,1250,DSP56651 M98592,00.html
Articles from E-journals:	Author (first name or initials followed by last name), title in quotations, *journal name*, **volume** (number), page numbers, [month], date. Date accessed. (New Line) Web site address
Example 6:	Y.-H. Chen, Z.-C. Hong, C.-H. Lin, J.-S. Chern, "Aerodynamic and gravity gradient stabilization for microsatellites", *Acta Astronautica* **46**(7), 441-500, April 1, 2000. Accessed August 10, 2000. http://journals.library.utoronto.ca:9501/elsevier/00945765/v0046i07/ 99001915.html

6

Grading

Whether it be a workshop report or a work report, instructors must take into account the students' level of academic experience when they are grading the report. More is expected of a fourth year student than of a third year student, etc. The purpose of assigning a grade to a report is to provide the student with an indication of how effective their efforts have been. It is important for the student to remember that spending a large amount of time preparing the report is not necessarily the same as putting in a large effort and that a large effort does not necessarily produce a high quality report.

In addition to supplying a grade for the report, it is also expected that the grader will provide constructive criticism by way of annotating the report where appropriate. This constructive criticism may be as simple as correcting simple spelling or grammar errors or it may involve more detailed comments about several aspects of the report.

6.1 Workshop report grading

Workshop report grades are to be submitted as numerical grades, whereas work report grades are, for the time being, to be submitted as letter grades from a smaller set of possibilities. Table 14 is derived from the University of Waterloo standard mapping of letter grades to numerical grades[36]. Letter grades no longer exist at the University of Waterloo, but this table is included here because grading workshop reports is often

very subjective, and a grader may feel more comfortable assessing a report as a B than as a 75 or vice versa. In addition to the letter-grade/numerical grade relationships, Table 14 gives an abbreviated statement regarding the level of performance associated with each grade level. It cannot be over-emphasized that the grade should be based on the results obtained and on how well those results are presented in the report.

The results should be judged against the original statement of work or project proposal. An unambitious project that meets all its goals may not receive a higher (or even the same) grade as an ambitious project that has not met all its goals. The number of students in the workshop group must also be considered when evaluating the progress made during the workshop.

Table 14: Workshop Grade References and Interpretation

Letter Grade	Numerical Grade	Interpretation to be based, in part, on the student's level of academic achievement and work experience.
A+	95	A workshop project and report graded at this level should reflect a quality of project and report that, with a few modifications of style in the report, would be a patentable design or an article publishable in an archival journal. It substantially exceeds the course expectations in every way. Grades at this level are expected to occur only on rare occasions. Workshops graded by a supervisor at this level must be reviewed by the workshop coordinator.
A- to A	80 – 89	These grades recognize exceptional projects and reports wherein every aspect is impressive. The report exceeds the expectations and demands of the course by a very large margin. There is evidence of superior engineering skills (reasoning, problem solving, analysis, synthesis, creativity) and innovation in the design.
B to B+	75 – 79	These grade levels should be assigned to a report which is a strong response to the requirements of the course, meets all and exceeds some of the expectations of the project. The engineering skills (reasoning, problem solving, analysis, synthesis, creativity) are in strong evidence.
C+ to B-	66 – 74	All the course requirements for the report are met, but nothing goes beyond the minimum requirement.

Table 14 Concluded.

Letter Grade	Numerical Grade	Interpretation to be based, in part, on the student's level of academic achievement and work experience.
		The engineering skills in evidence are adequate but not exceptional. The student displays a reasonable understanding of the problem and has attempted, with some success, to integrate the relevant ideas and applications into the design.
C- to C	60 – 65	A report graded in this range is incomplete, the engineering skills are weak or inadequate, and the apparent level of comprehension is low. The design objectives have not been reasonably met.
D- to D+	50 – 59	These grades should be assigned to a marginal project outcome and report with several significant shortcomings, including an inadequate level of achievement in terms of engineering content, report presentation, or overall design project progress. Few, or only the simplest, of the design objectives have been met.
F- to F+	32 – 45	A failing report or design project; one which fails to meet the standards expected of a student at this academic level.

Workshop reports should be graded with respect to both style and content. The style should conform to the style guidelines presented in this document. Questions to ask yourself when you are assessing a report are discussed below.

Presentation Style: Does the report satisfy the requirements set out in this style manual regarding such things as the title page, table of contents, use of figures and tables, structure of the chapters and appendices?

Writing Style: Is the prose grammatically correct? Is the document free of spelling errors, slang, undefined acronyms, sentence fragments, run-on sentences, clichés, malapropisms, and colloquialisms? Does the report have a professional tone? Is the report well organized, logical and easy to follow? Is it free of unnecessary poetic or passionate prose, embellished phrases, pretentious wording or other devices of obfuscation? Is the writing clear and concise, and is the report complete? Have tables and figures been used to advantage in explaining the design, analysis or results?

The content should be judged with respect to the following criteria.

Topic Suitability: The project must be an 'engineering project' that makes use of the engineering sciences and design principles. The topic and scope of the project should be appropriate for the academic level of the report author. For example, designing and building a laser-gyro in the 4A/B workshop sequence (an actual proposal) is an unrealistic topic and should never have been allowed to advance to the report evaluation phase. Topics may also err on the side of simplicity or inadequate scope.

Originality: The report should identify to what extent the solution or analytical methods employed are original creations of the author or are attributable to other sources. Are the other sources adequately and properly cited? There is, in general, no expectation of an original or fundamental contribution to the engineering sciences, but there should be some degree of creativity and synthesis in the proposed solution.

Analytical Content, Methodology and Techniques: The report is to be assessed for both the quantity and quality of the engineering analysis present. This assessment should take the students' academic level into account. Does the report have an over-reliance on computer simulations? Reaching a conclusion based on hundreds of numerical simulations rather than a closed form solution (when that solution should have been within reach of the student) is poor analytical technique. Have parameter studies been done? Would a sensitivity analysis be appropriate? Has the student exploited dimensional analysis techniques to reduce the analytical burden?

If experiments have been done, has a thorough error analysis been performed? Were the experiments well designed?

Engineering Judgment: The report should discuss the assumptions that have been made in terms of why they were made and to what degree they are valid for the system under consideration. Does the discussion of the assumptions reflect good engineering judgment?

Thoroughness of the Treatment: The report should discuss the design objectives, constraints and evaluation criteria. Are the design objectives reasonable (not too meek and not too ambitious)? Are the identified constraints legitimate and have they been justified? How complete are the evaluation criteria? Is the weighting of the evaluation criteria adequately justified? Have several competing designs been compared? Has the best design been chosen and has that choice been fully justified with supporting analysis? Have the pros and cons of even the best design been discussed? Has a reasonable course of action been recommended that would allow someone else to do further refinement of the design or follow-up on the project or research?

Quality: Is the overall quality of the report good, bad or indifferent?

6.2 Work report grading

Work reports are graded on the basis of the presentation and analysis. Within the scope of 'presentation' are the issues discussed in Chapters 1 through 5, such as the proper pagination, headings, binding etc. These items are assessed in what is referred to below as the 'Level 1 Evaluation'. Also within the scope of 'presentation' is the organization, clarity, grammar, and conciseness of the report; these items are assessed in the 'Level 2 Evaluation', described below. Evaluation with respect to 'Analysis' lies entirely within the scope of the 'Level 2 Evaluation' where the engineering content is considered with respect to the quality and extent of the engineering analysis described, the quality of the engineering judgment that is in evidence, and the completeness of

Table 15: Work Report Grade References and Interpretation

Letter Grade	Numerical Grade	Interpretation to be based, in part, on the student's level of academic achievement and work experience.
A+	95	Outstanding – The report exceeds expectations in every way and by a very wide margin.
A	89	Excellent – An exceptional report that exceeds expectations and where everything about it is impressive. There is evidence of superior engineering analytical skills and innovation for the student's level of academic achievement and work experience.
B	75	Very Good – A report which clearly meets all, and exceeds some, of the expectations for an engineering report.
C	65	Satisfactory – The report is adequate but not exceptional. The student displays a reasonable understanding of engineering design and analysis and has attempted, with some success, to integrate the relevant ideas and applications.
F	38	Unsatisfactory – A failing report which fails to meet the standards expected of a student at their academic level.

analysis including its evaluation and justification.

Work report evaluation: level 1

A cursory inspection of the report may uncover obvious errors of style that should result in a "resubmit" decision. Table 16 summarizes the circumstances which may result in a resubmit decision, regardless of report content.

Table 16: Errors that may be Cause for Work Report Resubmission

	Error	Example
1.	Improper page format	incorrect margins
2.	Improper pagination	failure to use Roman numerals and Arabic numerals as required
3.	Improper units	use of mixed American Standard and SI units
4.	Improper binding	stapled, use of a paper-clip, non-clear cover
5.	Improper Letter of Submittal	misspelled or incorrect name of the department chair, failure to include the statement of endorsement, failure to sign letter of submittal
6.	Improper or missing title page	missing any item of information that is required on the title page
7.	Missing abstract	
8.	Improper or missing Table of Contents	
9.	Missing introduction	
10.	Improper figures	no captions, too large on the page, no figure numbers
11.	Improper tables	no captions, too big on the page, no table numbers
12.	Improper photographs	no captions, too large on the page, no figure numbers
13.	Obviously improper or missing references	no citations in the text of the report or no References
14.	Use of an improper citation convention	

Work report evaluation: level 2

With reference to the term in which the student is enrolled and also with reference to the degree of ambition exhibited in the report topic evaluate the report for:

1. writing style
2. organization,
3. clarity and conciseness,
4. suitability of the topic chosen,
5. originality,
6. significance,
7. engineering judgment,
8. analytical content,
9. analysis techniques,
10. engineering validity,
11. experimental or analytical methodology,
12. problem complexity,
13. thoroughness of the treatment,
14. relevance,
15. quality.

6.3 Confidential work reports

The student should consult their supervisor after approximately four to five weeks of employment regarding the topic of their work report. The student is urged to find a topic that will not require a confidential work report.

Occasionally, an employer will request that all the work performed by a student on the work term be kept confidential so as to protect the company's intellectual property or trade secrets. Under these circumstances, a student may elect to do one of two things: (a) write a work report on a subject that does not compromise the employer's interests, or (b) write the report as a 'Confidential Work Report' and have it graded by their employer.

Students are strongly urged not to submit a confidential work report.

Alternate topic work reports

In lieu of a confidential work report, a student may submit a report on an independently researched topic that has been **approved in advance** by the Associate Chair for Undergraduate Studies. The topic of the report may, or may not, have a direct relationship to the student's job experiences. The evaluation criteria are the same for this type of work report as they are for a conventional non-confidential work report.

Evaluation of a confidential work report

The Department of Systems Design Engineering has the following rules and procedures regarding confidential work reports.

1. No more than **one** confidential work report is allowed for academic credit.
2. A confidential work report cannot be assigned a grade of 'Outstanding' (A+, 95).
3. Confidential work reports are not eligible for prizes or awards.
4. The request that a work report be graded as confidential by the student's employer must be received before the first day of lectures in the term that the work report is due. Failure to do so will result in the student being required to submit an 'Alternate Topic Work Term Report'.
5. The student must inform the company of the possibility of writing an 'Alternate Topic Work Term Report'.
6. The company must request permission from the Associate Chair for Undergraduate Studies, in writing (not email and not fax), that a work report be treated as confidential. The request should be in the form of a letter on company stationery stating:

   (a) the company's desire to keep the contents of the report confidential,

   (b) their willingness to act as an agent for the University of Waterloo Faculty of Engineering by way of grading the report according to our guidelines,

(c) their acceptance of the responsibility of adhering to the University Policies in so far as they apply to the grading of the report and any academic appeals that may subsequently ensue,

(d) they have been advised by the student of the possibility of the student writing an 'Alternate Topic Work Term Report',

(e) the name and position of the person doing the grading.

Upon receiving a timely request to grade the work report as a confidential report the Department will send the grader a Confidential Work Term Report Evaluation kit.

7. If the company fails to return the Confidential Work Term Report Evaluation before the work report grades are to be submitted, or if the Confidential Work Term Report Evaluation has not been completed to the satisfaction of the Department Associate Chair for Undergraduate Studies, a grade of **F** will be assigned.
8. The student must submit a six to eight page summary of the report. The summary must be accompanied by the usual letter of submission plus a letter from the student's supervisor. This letter must confirm that the supervisor has read the summary report and agrees that while it does not compromise the company's interests it as nearly as possible reflects the contents of the full report submitted to the company.
9. The student is responsible for any fee that the company may wish to charge for grading the report.

7

Laboratory and Design Project Notebooks

Learning how to keep an engineering notebook, and getting into the habit of keeping one properly, is an important part of an engineering student's undergraduate education. It is, unfortunately, frequently the case that many students fail to appreciate the importance of this and do not develop the habit and learn the techniques until they have had a bad experience because they had not kept a proper engineering notebook. The bad experience may be something relatively minor like having to redo an experiment because the data that was recorded on a loose sheet of paper got lost, or it might be far more serious such as losing a patent dispute because of inadequate documentation of the design work.

Engineering notebooks have three important purposes[37]:

1. They provide a permanent record of activity for the engineer to refer to for their own use.

2. They provide a permanent record of activity for the engineer's colleagues to refer to if they have to take over the project.

3. They provide a permanent record of activity for use as evidence in court proceedings.

For the purpose of your undergraduate activities it is probably the first purpose which is the most significant. By having a complete record of your activities in a laboratory or on a design project it is easy to find previously recorded data, references, calculations etc., and it makes producing a final report much easier.

However, it is possible that the other two purposes will be of importance in some undergraduate design projects. Engineering notebooks used in university and industrial research are legal documents used to establish patent and professional precedence, and professional due diligence.

To meet the legal requirements for evidence, engineering notebooks must meet certain criteria. The engineering notebook itself must be constructed with permanent binding (not loose-leaf or spiral bound), must have numbered pages, and the pages must be of good quality, preferably acid-free, paper. They are usually cloth-bound (hard-cover) and expensive.

Engineering design and experimental research activities are iterative processes, often with several mis-starts and revisions. It is because of this that engineering notebooks are used to record "everything" of significance. The pages are systematically signed by the engineer and are witnessed as "read and understood" by disinterested colleagues.

The entries in the engineering notebook must be made in permanent ink (**not** pencil), must be legible, must have factually complete entries, and must describe all experimental conditions and procedures. After entering the data or completing a page, the page must be signed and dated by the author and witnessed as soon as possible. The witness should be someone who understands the area of research or design but who is not directly involved and who cannot be considered to be under the control of the author. The witness must observe the work that is done, and have sufficient knowledge to understand what they have read. Names of everyone present during any demonstration or experiment should be recorded. Do not leave any pages un-dated, unsigned or unwitnessed. An example of a typical page from an industrial engineering notebook is shown in Figure 4. Notice the page number (27), the places reserved for, the signature of the notebook keeper, the signature of the witness, and

for the dates.

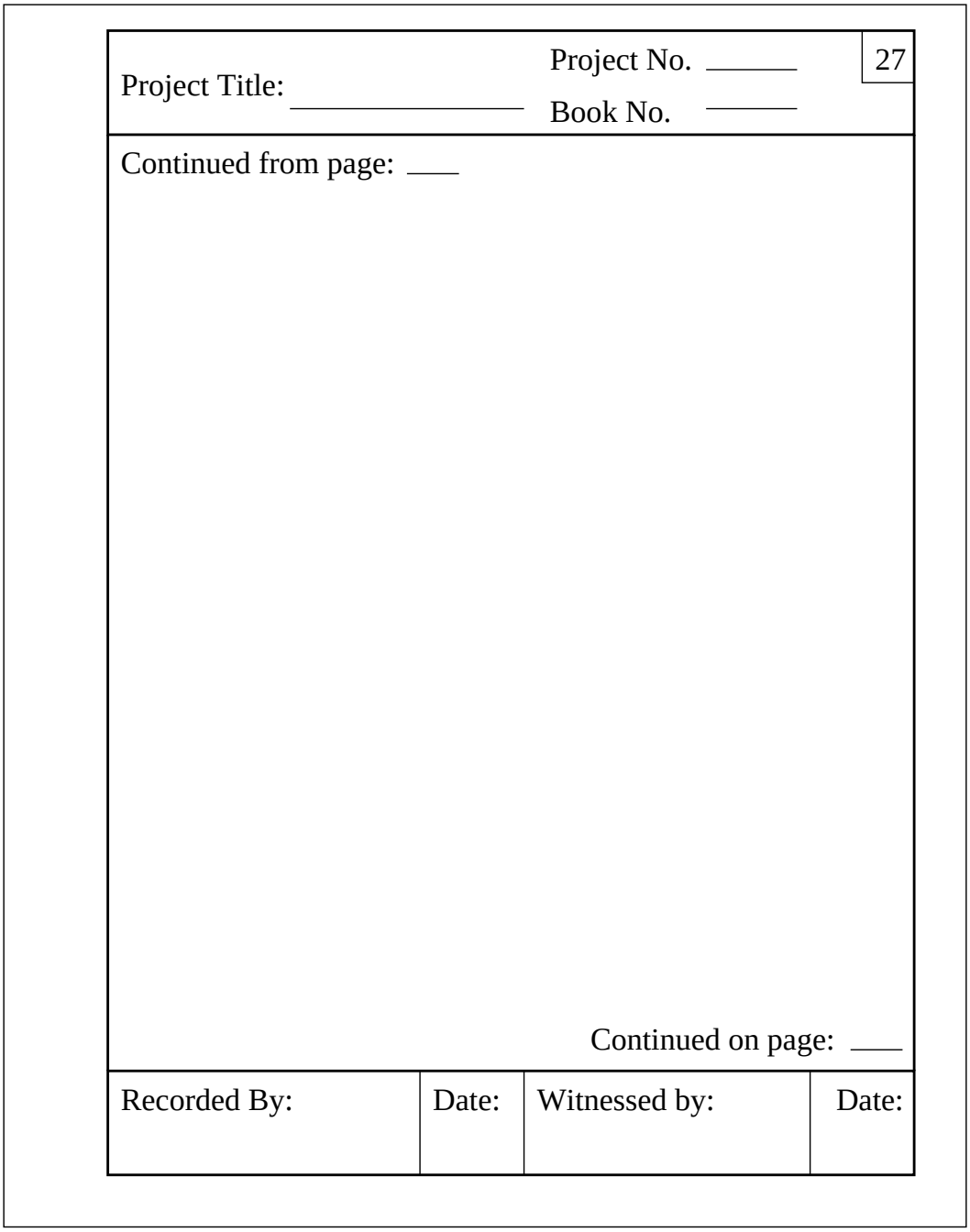

Figure 4: Sample engineering notebook page that would be used in industry.

To establish ownership of an invention, the dates of "conception" and "reduction to practice" are essential. The record must show that there was no abandonment of the idea or project between these dates. In the event that activity on the project ceases for a period of time it must be indicated in the engineering notebook what dates where involved and the reason for the cessation of activity. Examples include, "Attended conference in Toronto, May 15, 1999 - May 18, 1999 inclusive." or "On vacation July 14, 2000 to July 29, 2000 inclusive." or "Activity delayed while we wait for the back ordered spur gear to arrive." Avoid making negative annotations such as "No good", "Doesn't work " in the engineering notebook. These could be interpreted as an abandonment of the idea.

Patent applications and engineering reports are prepared from the information recorded in the engineering notebooks. Even if a patent application is not made on the subject matter contained in your engineering notebook it may become important to prove that you were working on a project before it was patented by someone else who is now suing you for patent infringement. The earlier notebook record would provide a defense.

7.1 Undergraduate engineering notebook requirements

It is not necessary that, in the undergraduate design workshops and laboratory courses, the student follow the complete legal procedures required of practicing engineers, but there are advantages to developing and practicing good engineering notebook habits. The requirements outlined below are consistent with formal engineering notebook practices but are less onerous.

Workshop notebooks

Each student is to keep a separate engineering notebook for each workshop course project and for each design project that is assigned as part of a lecture course. The

following engineering notebook keeping practices must be followed.

You must use bound laboratory notebooks to which pages cannot be added or removed. Number each page consecutively and number each volume sequentially, and never remove pages or portions of a page for any reason. All entries must be made in permanent ink. The ink colour for principal entries may be either blue or black and ball point pens are acceptable. Avoid pens that use water soluble ink. Coloured inks (*e.g.*, red, or green) may be used for secondary entries, to draw attention to particular results, to clarify different curves in graphs, etc. Because your engineering notebook should contain a chronological record of your work you must date each page. It is also necessary to sign the end of each page.

All work is to be done in the engineering notebook; nothing should be done on loose paper. It must be clear what project the engineering notebook applies to; enter the course number, project title and your name on the first page. Record all formulae, calculations, diagrams, sketches of any apparatus and equipment used, built or considered during the project. Sufficient information must be present to clearly identify and explain each entry. Diagrams and sketches should have information to identify and explain the subject matter to the extent that another student, of comparable experience and background, could understand the contents of the engineering notebook and reproduce all the results.

It is essential that you write on every page, front and back. If you decide to skip a page or any space on a page (for example, you get to the end of one calculation near the lower portion of one page and you want to start at the top of the next page), draw a diagonal line through the skipped lines and sign and date the line. Use a narrative style to describe the development of your ideas, designs, methods, outcomes, and conclusions. Tell the story of your design process clearly but write by using only positive statements. Never make an entry that can be interpreted as negative. A test may not have turned out like you wanted it to but the results should still be recorded in a dispassionate manner. Clearly indicate whether a statement is a fact, a theory or a supposition.

In the case of error draw a single line through the incorrect data. Do not erase or

use correction fluid. All corrections should be initialed and dated.

Occasions will arise where information or results have been obtained on loose paper. For example, experimental plots, computer simulation results, or product literature and data sheets may have important information related to your project. In the case of single pages permanently affix (*i.e.*, glue) all computer printouts, diagrams, etc. in the notebook. Do not use staples or paper clips. If the volume of experimental data or computer output is too large to be affixed to the notebook then proceed in one of two ways. For original data (*e.g.*, experimental results) bind the printouts permanently together to form a notebook. Sign and date each entry just as in the traditional bound notebooks and cross reference the notebook of computer printouts in your engineering notebook. For manufacturer's literature or data sheets make a detailed citation entry in the engineering notebook and cross reference it to the file or binder in which you have stored it for future reference.

When there is more than one student working on a design project, each student must keep their notebook as if it were the only record of the design activity. This does not mean that the notebooks must be copies of one another but it will be essential to have cross references to the notebooks of the other design group members. It is necessary to prominently list the design group members in the notebook.

Record the minutes of any group meetings in the notebooks. The minutes must show who was in attendance and exactly what was done at the meeting. The progress or accomplishments of each group member must be clearly indicated and the expectations for each group member over the next reporting period must also be clearly recorded. The group meeting minutes are a log of the design and engineering history of the project and require due care.

Do not use a computer to store your notes or measurement data. There may be times when the size of the data set or the size of the program makes it impractical to generate a hard-copy for reference. In those cases, and only those cases, storing the data on a computer is acceptable, but it is essential that a copy of the data be made on a removable storage medium (*e.g.*, CD, DVD, USB drive). In other words, be sure to create at least one, preferably two, backups! If you use computer programs

to facilitate calculations or as simulations then print out (backup) the programs, the data files and output files regularly (once a week, or after any major changes, is a reasonable schedule). Bind the printouts permanently together to form a notebook. Sign and date each entry just as in the traditional bound notebooks and cross reference the notebook of computer printouts in your engineering notebook.

Notations should be made regarding the progress and completion of each step of the design project. The date of successful testing of a piece of equipment (*i.e.*, the successful reduction to practice of the design) is very important in the event of a patent application. It is important to clearly make note of these tests by identifying what was tested, how it was tested and what the results were.

Laboratory notebooks

Individual course instructors may require slight variations from the following instructions. In those courses that have a laboratory component it is required that each student maintain a laboratory notebook and keep that notebook by adopting the practices outlined below.

Use a bound laboratory notebook to which pages cannot be added or removed. Number each page consecutively, and never remove pages or portions of a page for any reason. Just as with workshop notebooks, all entries in the laboratory notebook must be made in permanent blue or black ink. Because your laboratory notebook will contain a chronological record of your work you must date the top of each page and sign the end of each page. Nothing should be done on loose paper. Do all your work directly in the notebook. Include all the details of the experiment, all calculations performed and all measurements taken. Record the data neatly in tables, include the units of measurement and clearly identify what the data are.

On the first page devoted to a laboratory exercise, record the exercise title or number, the date, your name and the names of the other students who are participating in the laboratory exercise. If a 'Group Number' has been assigned to you, record it as well. The laboratory exercise title, or number, should be written at the top of each page devoted to that exercise.

Do any lab-prep exercises in the notebook and copy the exercise objectives directly from the lab-notes.

Record the identifying information for the instruments used to collect data. Include the instrument name (*e.g.*, oscilloscope, multi-meter etc.), manufacturer, model number, and serial number. It is important to record this information because different instruments have different capabilities and limitations. Do not assume that similar instruments at different lab stations are similarly calibrated. The calibration of each instrument is different and may change from one day to the next.

Record your laboratory observations and data on only the right hand page. The back of each facing page is to be left blank; it may be used for calculations, figures and comments that are needed during the actual laboratory session. Occasionally data for a particular exercise will be much clearer with a two-page presentation. In those cases use both the left and right hand pages. Use consecutive pages, without skipping any pages. There must be enough details recorded in your notebook so someone with a similar background could take your lab book and duplicate your experiment, or could look at your lab book and understand what you did and what your results were.

Permanently affix (*i.e.*, glue) all computer printouts, diagrams, etc. in the notebook and initial them. Do not use staples or paper clips.

Answer questions in the lab-notes as they appear. If the lab-notes ask for your "conclusion" or "observation" about a section of the exercise, write your conclusion as you go. Take the time to reflect on what you have done and observed before proceeding.

In the case of error, draw a single line through the incorrect data. Do not erase or use correction fluid. All corrections should be initialed and dated.

Use significant figures systematically and consistently. Record the data entry with regard to the precision of the measuring instrument being used. For example, a data entry of 1.0V is different from a data entry of 1.000V. The former implies that the voltmeter had a resolution of tenths of a volt while the latter implies that the voltmeter had a resolution of millivolts. The measurement uncertainty should also be recorded (*e.g.*, 2.35 ± 0.05V).

As discussed for workshop notebooks, cross-reference in your laboratory notebook any hard-copy printouts or other records that are not bound into your notebook.

Notebook evaluation

As discussed previously, the main purpose of an engineering notebook is to record and protect intellectual property. The legal requirements concentrate more on when it was written and by whom entries were written than on how they were written. In an effort to encourage the development of good engineering notebook keeping practices your notebooks will be evaluated on the following criteria.

Each student must keep a single hard-bound notebook for each laboratory and each workshop course.

The engineering notebook will be graded at the end of the course for legibility and completeness. Grading will be based on:

1. Appropriate entries.
2. Proper type of notebook.
3. Dates on each page.
4. No blank pages.
5. Signature at the end of each page.
6. Neatness.
7. Use of pen and no pencil.

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